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This is volume 2 of your 5-skill level Career Development Course (CDC). The volume contains four units that discuss a variety of areas relevant to your responsibilities as a dental laboratory journeyman. Unit 1 addresses oral anatomy with discussions on hard and soft tissue, tooth morphology, and oral pathology. In unit 2, we examine oral physiology, specifically oral kinesiology, occlusion and its application, as well as articulators and prosthodontic applications. We look at dental materials science in unit 3 by discussing the basics of materials science and color. Finally, unit 4 looks at dental materials; namely, impression materials, gypsum products and investments, waxes, acrylic resins, dental metallurgy, dental porcelains, and other type dental materials.

A glossary is included for your use.

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For Guard and Reserve personnel, this volume is valued at 20 hours and 5 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

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Unit 1. Oral Anatomy

FABRICATING APPLIANCES to meet patient's functional and esthetic needs is challenging. Often, the dental laboratory technician's primary concern is constructing the appliance. However, it is important to remember that patient's anatomical and physiological needs determine the design of the appliance. Understanding the structure of oral anatomy is a prerequisite to fabricate clinically acceptable appliances.

1–1. Hard Tissue

The objective of this section is for you to become familiar with the location of the skull and facial bones. The skull, composing of several bones, protects the brain and supports the face. Correctly identifying and locating both cranial and facial bones is necessary; however, you must also be able to recognize reference points using common terminology.

201. How to distinguish the skull bones

The skull is composed of 22 flattened or irregularly shaped bones. These bones will classify as either cranial or facial bones. See the functions of both groups below:

1. Cranial bones: Protect the brain.
2. Facial bones: Compose the facial skeleton.

During the first two years of life, these bones fuse together with the exception of the mandible. Determining the location of the cranial and facial bones requires you to understand basic terminology.

Terminology

Anatomic, or body, planes provide references for positioning and moving body structures. The table below lists the planes and their functions:

Body Planes and Functions/Locations	
Planes/Surfaces	**Function/Location**
Frontal plane	Divides the front from the back vertically.
Transverse plane	Divides one side from another horizontally.
Sagittal plane	Divides one side from another vertically.
Median plane	Divides the body in equal left and right halves.
Internal or medial surfaces	Closer to the median plane or middle portion of the body.
External or lateral surfaces	Farther from the median plane, or the outside portion, of the body.

For example, skin is external to the skull, while the brain is internal to the skull. Body planes provide geometric references (e.g., top/bottom, left/right, and inside/outside) but not direction. Basic directions are listed in the table below.

Body Plane Directions and Definitions	
Direction	**Definition**
Anterior	Toward the front.
Posterior	Toward the back.
Superior	Surfaces above a transverse plane.
Inferior	Surfaces below a transverse plane.
Mesial surfaces	Toward the midline (middle).
Distal surfaces	Away from the midline.
Proximal surfaces	Next to each other or side-by-side.

In this next portion of the lesson, you will look at how to distinguish the location of cranial and facial bones.

Cranial bones

Cranial bones are either single or paired. Single cranial bones reside in the midline plane of the skull (fig. 1–1 and fig. 1–2). Paired bones occupy either side of this plane and are mirror images of each other. There are eight cranial bones:

1. Frontal (single) (figs. 1–1 and 1–2).
2. Parietal (paired) (figs. 1–1 and 1–2).
3. Occipital (single) (fig. 1–2).
4. Temporal (paired) (figs. 1–1 and 1–2).
5. Sphenoid (single) (figs. 1–1 and 1–2).
6. Ethmoid (single) (figs. 1–1 and 1–2).

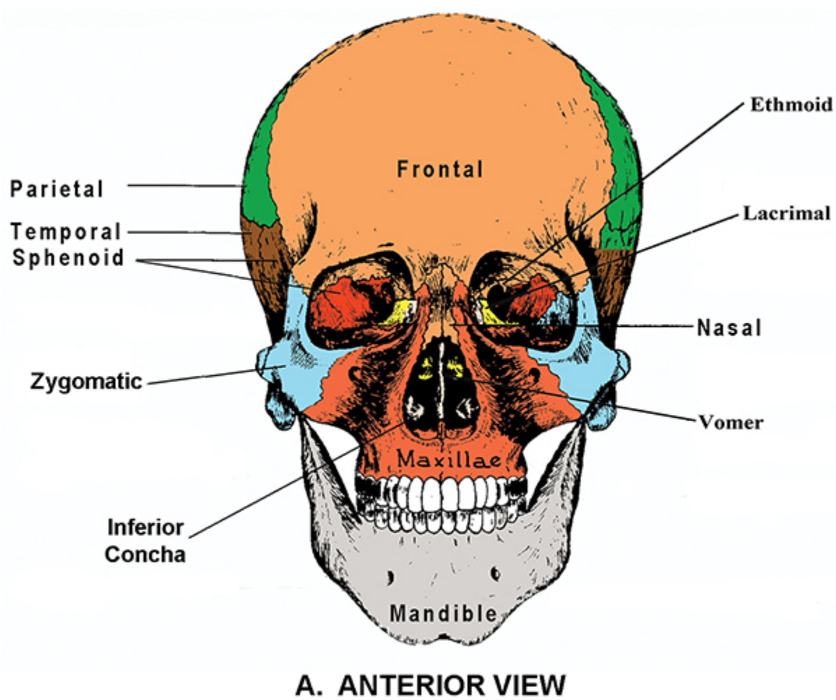


Figure 1–1. Anterior view of the skull's cranial and facial bones.

Frontal bone

The frontal bone forms the forehead and is the largest cranial bone. It contains the frontal paranasal sinuses that lie just above the sockets of the eyes. These paranasal sinuses (air cavities) are located in the bones surrounding the nasal cavity. The frontal bone attaches to the zygomatic bones that are located on the lateral sides of both eye sockets. The zygomatic processes are the bony projections that extend from the frontal bone to the zygomatic bones.

Parietal bones

The two parietal bones form the larger portion of the top and sides of the skull. Two lines are found on the external surface curving across the middle of each bone—the superior temporal line and the inferior temporal line.

Occipital bone

The occipital bone forms the back of the skull's base. A large hole—foramen magnum—is found in the base of this bone. The spinal cord runs through the foramen magnum and connects to the brain. Two convex, oval bone processes called occipital condyles occupy on each side of the foramen magnum.

Temporal bones

The two temporal bones are located at the sides and base of the skull. The zygomatic process, of the temporal bone, projects from the center of the temporal bone and extends forward connecting to the zygomatic bone. The zygomatic process makes up part of the zygomatic arch. The temporal bone also houses the mastoid process. The mastoid process is a large, heavy bone projection, just below and behind the ear, and serves as an attachment for several muscles responsible for the skull movement. Just in front of the mastoid process is a long, slender, pointed piece of bone called the styloid process.

Sphenoid bone

The sphenoid bone resembles a bat with extended wings. This bone forms the middle base of the skull. You can find paranasal sinuses, called sphenoid air sinuses, with this bone. Two bone projections, known as the *pterygoid processes*, extend downward from the inferior portion of the sphenoid bone. The internal and external pterygoid muscles attach to the pterygoid processes.

Ethmoid bone

The ethmoid bone lies in the anterior portion of the skull base and forms the top part of the nasal septum. This bone also contains paranasal air spaces or sinuses.

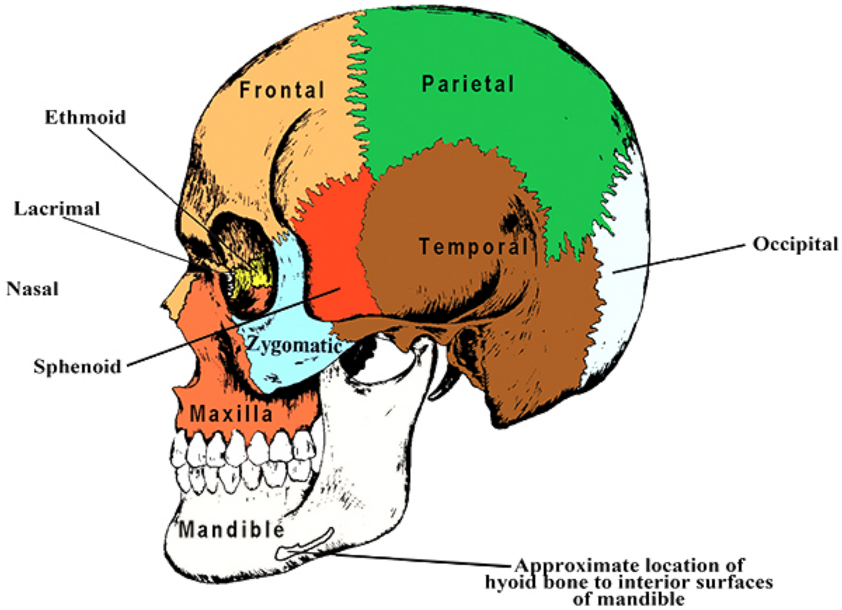
Facial bones

The 14 facial bones (fig. 1–1 and fig. 1–2) are:

1. Zygomatic (paired).
2. Lacrimal (paired).
3. Palatine (paired) (not shown on figure).
4. Inferior concha (paired).
5. Vomer (single).
6. Maxilla (paired).
7. Mandible (single).
8. Nasal (paired).

Zygomatic bones

The two zygomatic bones form a large portion of the sockets of the eyes and the prominence of the cheeks. The temporal process of each bone forms the anterior portion of the zygomatic arch. The frontal process of each bone forms the lower portion of the lateral part of the sockets of each eye. The maxillary process of each bone extends from the prominence of the cheek to the maxilla.



B. LATERAL VIEW

Figure 1–2. Lateral view of the skull's cranial and facial bones.

Lacrimal bones

The two lacrimal bones lie inside the sockets of the eyes. Each bone contains part of the canal through where the tear duct passes. This is the thinnest, most fragile skull bone. The two nasal bones form the bridge of the nose. They connect with the frontal, ethmoid, and maxillary bones.

Palatine bones, inferior conchae, and vomer

The two palatine bones lie in the back part of the nasal cavity. The horizontal process of each bone forms the posterior one-third of the hard palate, floor, and walls of the nasal cavity. The two inferior nasal conchae lie on the outer walls of the nasal cavity. The vomer forms the largest portion of the nasal septum.

Maxillary bones

The two maxillary bones form the upper two-thirds of the face and support the upper teeth. The maxillary consists of four processes (fig. 1–3).

1. Zygomatic—Shapes the cheeks.
2. Frontal—Shapes the nose.
3. Alveolar—Supports the dentition.
4. Palatine—Forms the anterior two-thirds of the palate.

The maxillary sinus is located within the body of each maxilla. The walls of this large, pyramid-shaped cavity are thin, and sometimes the root tips of the posterior maxillary teeth extend into the sinus, which is why extracting posterior teeth can expose the sinus cavity to infection. This is an important point to remember when fabricating or disinfecting a maxillary appliance (e.g., immediate dentures).

The occlusal view of the maxilla (fig. 1–4) shows the median palatine suture created by the juncture of the palatine processes. The mucosa covering the median suture is usually extra firm. Appliances covering this area may require relief. The dentist accomplishes this procedure, if necessary. The incisive foramen is composed of nerves and soft tissue, and usually requires relief.

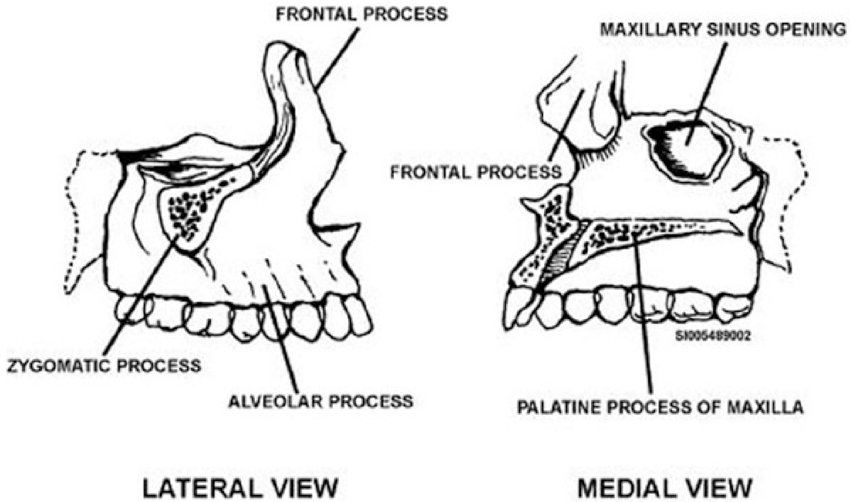


Figure 1–3. Maxillary processes.

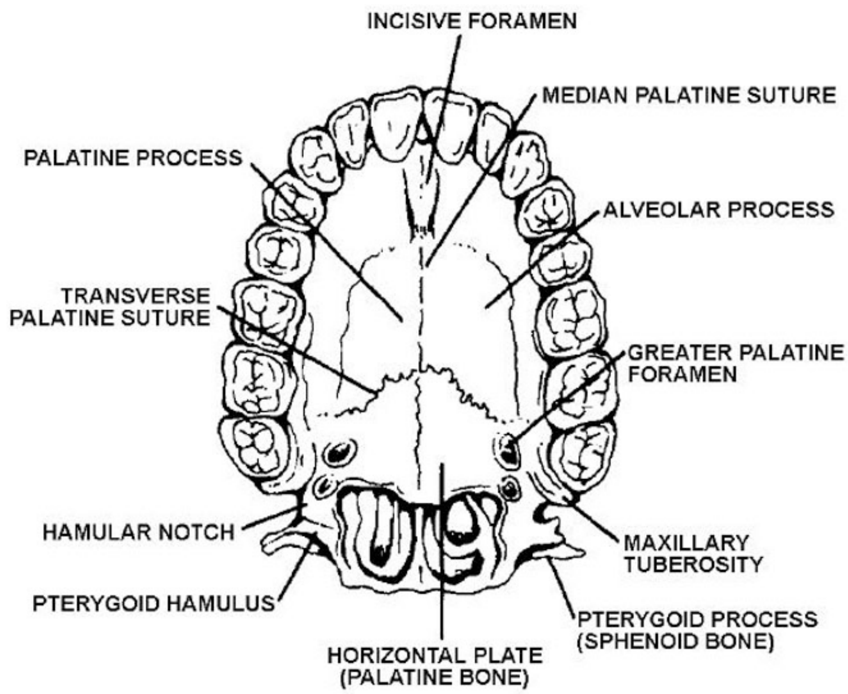


Figure 1–4. Occlusal view of maxilla.

Mandible

For the purposes of this lesson, consider the mandible as one of the facial bones. It is a separate bone articulating with the facial bones. The mandible is the largest and strongest facial bone. The ramus, angle, and body segments comprise the bulk of the mandible. The coronoid, condyloid, and alveolar processes complete the components of this single bone.

The mandible supports the mandibular teeth and provides the framework for the floor of the mouth. Figure 1–5 identifies important landmarks. The perforations on each side of the body's facial surfaces are the mental foramen. A *foramen* is a passage, or opening, in the bone for nerves and blood vessels. Each mental foramen is usually located between the apices of the first and second premolars. Nerves and blood vessels for the cheeks and lower lip emerge through the mental foramen.

An appliance placed over an extremely resorbed residual ridge can press on the mental nerve, causing the patient discomfort in the mandibular ridge area. The mandibular foramen is on the lingual surface of the ramus. This canal contains inferior alveolar nerves, arteries, and veins running from the mandibular foramen to the midline of the mandible.

The mylohyoid ridges are on each side of the lingual surface of the body (fig. 1–6). The mylohyoid muscle attaches to these ridges, forming the floor of the mouth. The ridges extend from just behind the third molars almost to the midline. Below the mandibular central incisors on the lower lingual surface of the body, you can see small bony projections called genial tubercles. The fan-shaped extrinsic tongue muscle attaches to one set of these bony projections.

An integral part of both the mandible and the maxilla are the alveolar processes. These processes, or residual ridges when edentulous, are constantly subject to dynamic stresses. The purpose of the alveolar process is to support teeth. These dentulous alveolar processes react to normal chewing stress by increasing bone density. Abnormal conditions, like malocclusion or tooth loss, reduce bone density and even cause bone resorption. This happens when abnormal lateral force presses against the alveolar process. This stress transmits through either maloccluded natural teeth or incorrectly set artificial teeth.

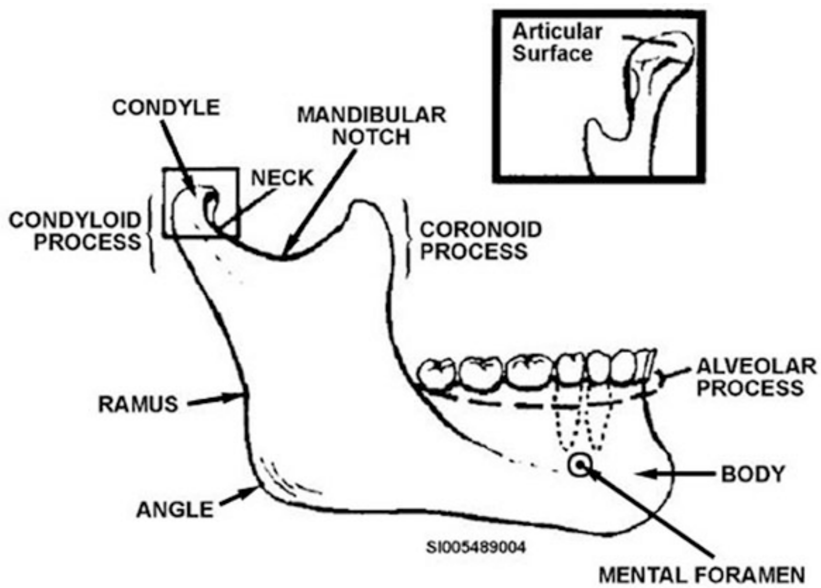


Figure 1–5. Lateral view of the mandible.

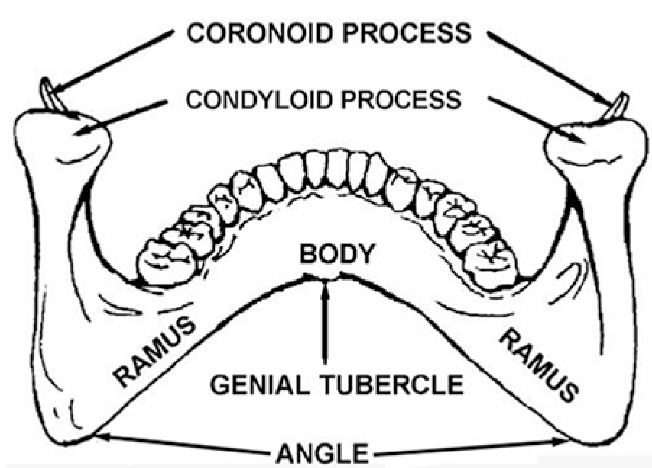


Figure 1–6. Lingual view of the mandible.

Nasal bones

The paired nasal bones are located in the upper-middle portion of the face. The two bones together form the bridge of the nose and differ in size according to the person's facial features. The main function of the nasal bones is to bind the cartilage together, which ends up forming the contours of the nose.

Nerves and blood supply

The maxilla and mandible are composed of living tissue maintained by a network of nerves, arteries, capillaries, and veins. These elements provide the necessary sensation and nutrients to the bone, teeth, and soft tissue. The external pressures of a dental prosthesis must not restrict these nerve and vascular system components. A slight processing error impinging either a nerve or artery could endanger the patient's oral health. The potential increases when the patient has resorbed ridges because they provide less support and protection for the underlying soft tissue and nerves.

202. Temporomandibular joint description

Interpreting how the temporomandibular joint's (TMJ) structure affects mandibular functions requires you to study the joint's components. The TMJ is a union of the temporal and mandibular bones. These bones, coupled by ligaments, encapsulate the cartilage and synovial fluid. Together, these components form the TMJ.

Components

The mandible's mandibular condyle and the temporal bone's glenoid fossa both form the TMJ. The mandibular condyles are convex and wider laterally than anterioposteriorly (fig. 1–7). When viewed from the occlusal, the condylar heads are not at right angles to the rest of the mandible. The condyles twist slightly, adding unique characteristics to lateral mandibular movements.

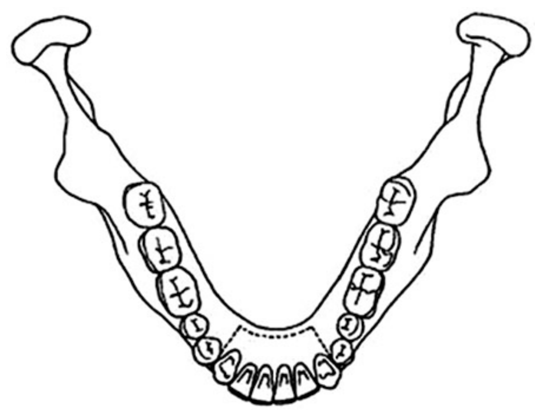


Figure 1–7. Occlusal view of condyles.

A joint is the juncture of two bones; consequently, the TMJ is a joint. The two bones of this joint are the skull's temporal bone and the mandible's condyle bone. The condyle corresponds with the oval depression of the temporal bone called the glenoid fossa (fig. 1–8). The anterior portion of the glenoid fossa forms the articular eminence. The anterior portion of the articular eminence's slope guides forward mandibular movement. Located between the condyles and the glenoid fossae are the articular disc and synovial cavities. The articular disc is made of fibrous cartilage and divides the TMJ into lower and upper compartments. The synovial cavities, located superior (above) and inferior (below) the articular disc, contain fluid that lubricates the TMJ's contact areas.

The lower compartment serves as a socket for rotating the mandibular condyle. This compartment, composed of the mandibular condyle, inferior synovial cavity, and articular disc, is referred to as the condyle-disc complex. This condyle-disc complex is bound by ligaments restricting the lower half of the TMJ to a rotational/hinged movement. This hinged movement rotates around a single axis.

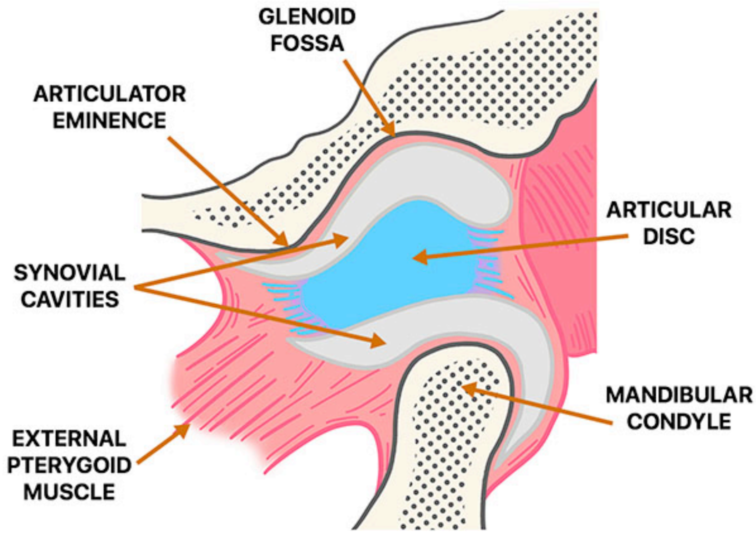


Figure 1–8. Lateral view of the TMJ.

Translatory movement occurs in the upper compartment of the temporomandibular joint, which allows the socket to slide in a forward and backward motion in the glenoid fossa eminence. The upper compartment is the junction of the condyle-disc complex superior surface against the glenoid fossa synovial cavity inferior surface. Ligaments loosely attach the condyle disc complex to the glenoid fossa, allowing a sliding or translatory movement between these surfaces in the superior cavity. A further discussion of hinge and translatory movements continues later in this volume.

Four ligaments stabilize the entire TMJ (fig. 1–9). The table below lists each ligament, their positions, and functions:

TMJ Ligaments, Positions, and Functions		
Ligament	**Position**	**Function**
Capsular (Capsule)	Attaches to the head of the condyle and the temporal bone.	Completely encloses the head of the condyle and the articular disc. This ligament restricts any medial, lateral, or inferior forces that tend to separate or dislodge the articular surfaces
Temporomandibular	Attaches to the neck of the condyle and the zygomatic arch.	Reinforces the capsular ligament lateral aspect.
Sphenomandibular	Originates from the spine of the sphenoid bone and extends downward to the lingual of the mandible's ramus.	It has no significant limiting effect on mandibular movement.
Stylomandibular	Originates from the styloid process and extends downward and forward to the angel and posterior border of the ramus of the mandible.	Limits excessive protrusive movements of the mandible.

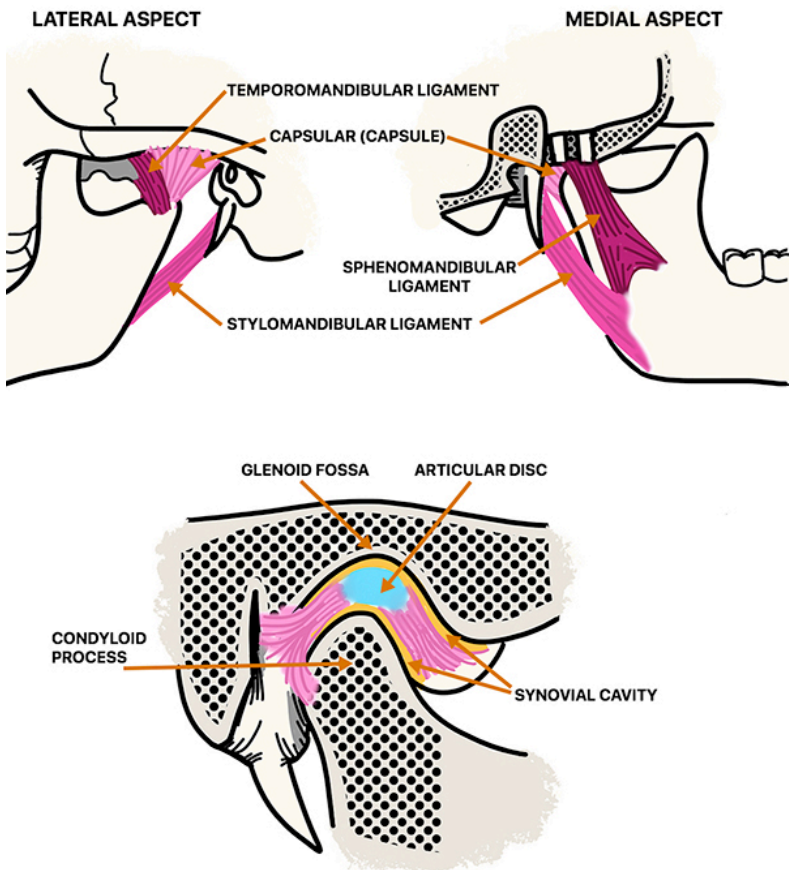


Figure 1–9. TMJ ligaments.

TMJ movement

The TMJ is a very mobile joint that possesses a unique capacity to have nearly simultaneous hinged (rotational) and translatory movements. The glenoid fossa's eminence angle guides each of these movements. The surrounding ligaments stabilize and limit the TMJ movement. A detailed discussion of mandibular movements continues later in this volume.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. How to distinguish the skull bones

1. Match each cranial bone listed in column B with its identifying feature in column A. You may use items from Column B once, more than once, or not at all.

Column A	Column B
____ (1) Lies in the anterior portion of the skull base.	a. Frontal.
____ (2) This is the largest cranial bone.	b. Parietal.
____ (3) Resembles a bat with extended wings.	c. Temporal.
____ (4) This bone has the foramen magnum at its base.	d. Sphenoid.
____ (5) This bone is part of the mastoid process.	e. Ethmoid.
____ (6) This bone is part of the pterygoid process.	f. Occipital.
____ (7) Is a thin projection of this bone and called the styloid process.	

2. List all the paired facial bones.

3. What bones form the upper two-thirds of the face and support the upper teeth?

4. Why can extracting posterior maxillary teeth lead to a sinus infection?

5. What three processes complete the components of the mandible?

6. Where are the genial tubercles located on the mandible?

202. Temporomandibular joint description

1. What parts of the mandible and temporal bones join to form the TMJ?

2. What two bones comprise the TMJ joint?

3. Where are the synovial cavities located?

4. What elements of the TMJ comprise the condyle-disc complex?

5. What four ligaments stabilize the TMJ?

6. Describe the function of the temporomandibular ligament.

1–2. Soft Tissue

The objective of this section is for you to learn where the two types of soft tissue (muscles and mucosa) are located and how they influence both mastication and speech.

203. How to distinguish oral muscles

Efficient mastication (i.e., chewing foods), speech, and facial expression are the result of an interrelationship of muscles that are functionally complex. Each muscle has a unique movement and contributes to the overall mandible action. A properly functioning muscle works best at its particular length. If a bulky prosthesis stretches a muscle or shortens it, due to a lack of support, the patient will have difficulty eating and speaking. Efficient mastication only occurs if all the muscles are working in harmony. A well-made dental prosthesis can restore a patient's ability to eat, speak, and express themselves confidently.

Primary mastication muscles

The four paired primary mastication muscles are located laterally to the midsagittal plane and are listed below:

1. Masseter.
2. Temporalis.
3. Internal (medial) pterygoids.
4. External (lateral) pterygoids.

The masseter, temporalis, and internal pterygoid are elevator muscles. As the name implies, these muscles are responsible for elevating the condyles and holding them against the eminence. The external pterygoid muscles function is to protrude the mandible and move it laterally.

Masseter

The masseter origin is along the zygomatic arch (fig. 1–10). It extends downward to the lower border of the mandibular ramus' lateral aspect. The lower border of the ramus is the masseter's insertion point. Remember, the *origin* of a muscle is the more fixed point of attachment and the *insertion* of a muscle is in either the moving bone or other structure. Contraction of the masseter elevates the mandible. This action provides the necessary force to chew efficiently.

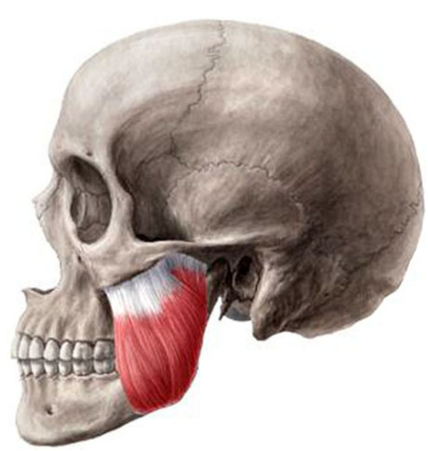


Figure 1–10. Masseter mastication muscle.

Temporalis

The temporalis is a large, fan-shaped muscle originating at the temporal bone, and inserting on the anterior border of the ascending ramus and at the tip of the coronoid process (fig. 1–11). Once the temporalis contracts, its action elevates the mandible.

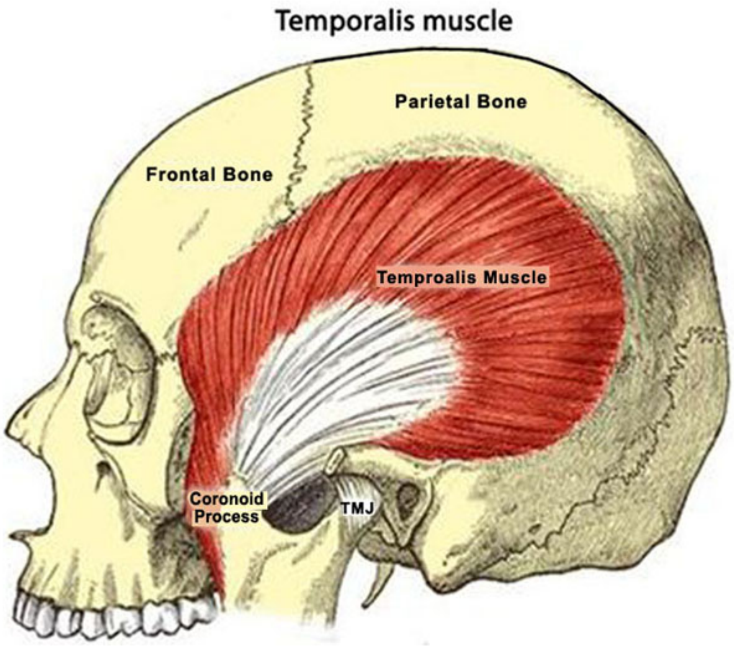


Figure 1–11. Temporalis mastication muscle.

Internal (medial) pterygoid

The internal (medial) pterygoid originates at the sphenoid bone lateral pterygoid process and inserts into the mandibular angle lingual surface (fig. 1–12). The internal pterygoid forms a sling with the masseter that supports the mandible.

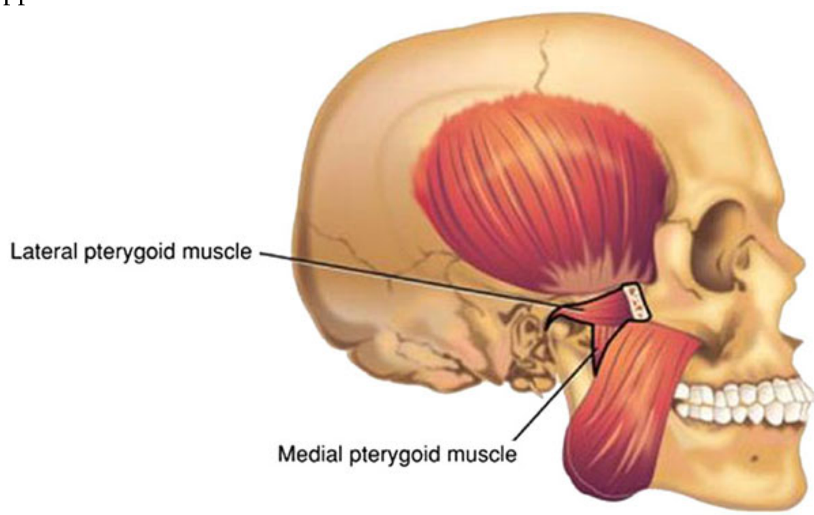


Figure 1–12. Internal (medial) and external (lateral) pterygoid mastication muscles.

External (lateral) pterygoid

This fourth mastication muscle is considered a positioner muscle. It is responsible for the mandible's horizontal position (fig. 1–12). Each external pterygoid muscle is composed of a superior and inferior segment. These segments originate at two points on the sphenoid bone and insert at the neck of the condyle. When both the external pterygoid muscles contract, the mandible will protrude or move forward. If only one external pterygoid muscle contracts, the mandible moves in the opposite direction. This is because the lateral pterygoids originate at the sphenoid bone and insert at the neck of the condyle, posterior to the sphenoid bone. In other words, when the right external pterygoid contracts, the mandible moves in a left lateral direction.

When working in tandem, the lateral pterygoids protrude the mandible. These muscles are responsible for translatory mandible movements. The table summarizes the action of each of the four paired major mastication muscles.

Major Mastication Muscles, Origins, Insertions and Actions			
Muscle	**Origin**	**Insertion**	**Action**
Temporalis	Temporal bone	Coronoid process	Raises the mandible (closes the mouth).
Masseter	Zygomatic process	Facial surface of the mandible angle	Raises the mandible (closes the mouth).
Medial Pterygoid	Sphenoid bone	Lingual surface of the angle of the mandible	Simultaneous action of both medial pterygoids raises the mandible up and against the maxilla.
Lateral Pterygoid	Sphenoid bone	Condyloid process	Simultaneous action of both lateral pterygoids protrudes the mandible. Singular, lateral pterygoid contraction causes the mandible to move forward and to the opposite side of the muscle.

Secondary mastication muscles

The buccinator, orbicularis oris, mylohyoid, and geniohyoid muscles assist the primary mastication muscles (fig. 1–13). The table describes their functions.

Secondary Mastication Muscles and Functions	
Muscles	**Function**
Buccinator	Pulls the angle of the mouth laterally and helps hold food in position during mastication.
Orbicularis oris	Is circular, and closes and protrudes the lips.
Mylohyoid muscles	Help depress the mandible (fig. 1–13), raises and lowers the floor of the mouth, and aid in speech formation.
Geniohyoid muscles	Help depress the mandible (fig. 1–13).

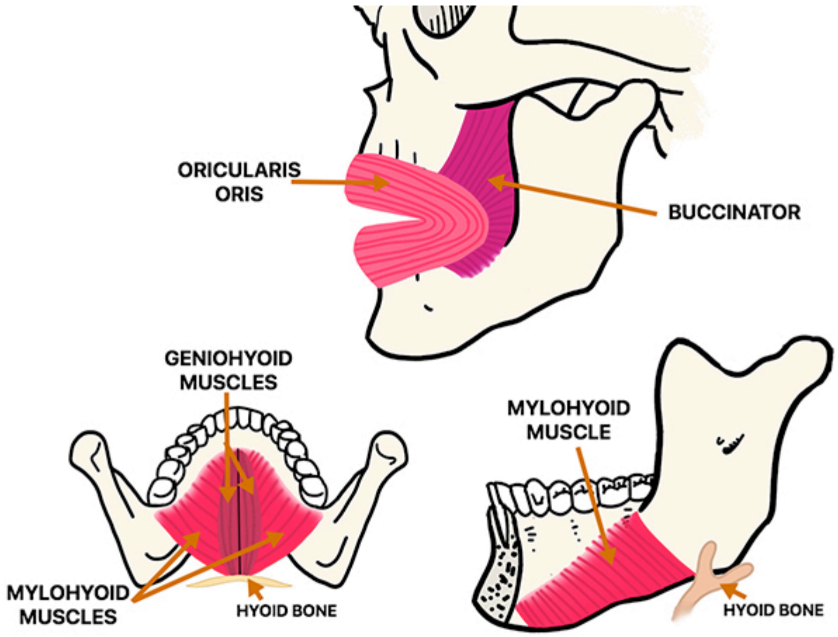


Figure 1–13. Muscles that assist mastication.

Speech

Speech occurs when air emerges from the lungs through the larynx, which determines the desired pitch. The mouth then articulates this sound. This series of events involve a complicated interaction of body structures divided into four categories:

Body Structure Categories and Functions	
Respiration	This process of inhalation and exhalation of the lungs generates the energy for sound creation.
Phonation	The process of converting exerted air from lungs into audible vibrations. The larynx creates these vibrations as air passes through, manipulating the pitch, intensity, and quality of produced sound.
Resonation	The process of amplifying sound produced from phonation. This happens as sound passing through pharynx, oral, and nasal cavities.
Articulation	The process of formulating speech sounds using the lips, tongue, cheeks, teeth, and palate.

Our primary concern lays in the fourth category, articulation. The design, size, and fit of an oral prosthesis can dramatically influence the spatial relationship of the tongue, lips, cheeks, teeth, and palate. This can significantly detract from a patient's ability to speak.

The tongue is the single most important articulator of speech. It shapes sound, regulates airflow, and aids resonance. The lips, controlled by the orbicularis oris, further shape the sounds. Sounds created by the lips are the letters M, B, and P. During these sounds, the lips come together and touch. The tongue and palate are important in forming the D sound. The tongue touches the incisal edges of the maxillary teeth to form the TH sound. A properly made prosthesis must support the lips and cheeks. Additionally, it must not restrict the tongue's function (fig. 1–14).

All dental prostheses affect speech in some way. Normally, a patient adapts his or her speech habits to a well-made appliance. To produce a well-made appliance, you should know the requirements of these muscles. Ensure you maintain proper lip support. A loss of muscle tone can affect a patient's appearance as well as cause difficulty in speaking and eating. The tongue needs room to function. A bulky set of dentures constricts the tongue. The soft palate will dislodge a maxillary appliance, with an overextended posterior area, when the patient speaks and eats. Even worse, the soft palate will ulcerate due to its movement against the denture border.

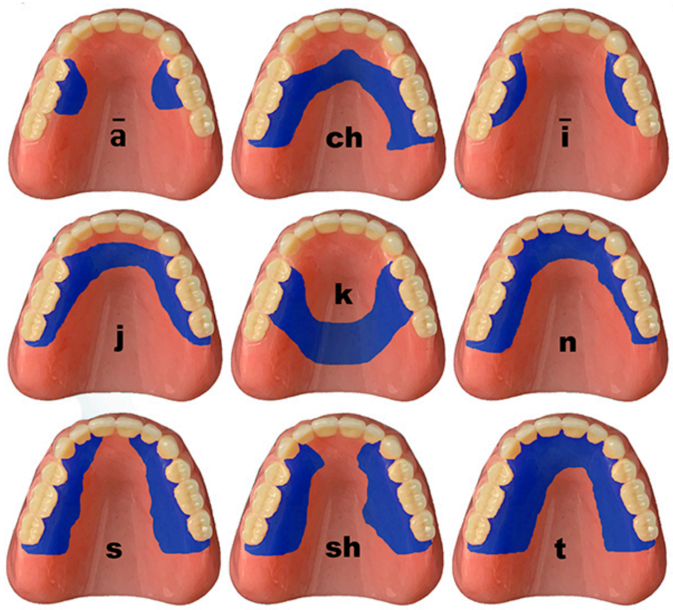


Figure 1–14. Tongue contact area with palate.

Expression

A person's ability to express a smile or frown is dependent on the capability of his or her facial muscles. A poorly designed prosthesis that does not properly support a person's lips and cheeks can reduce that person's ability to convey his or her message. An appliance that closes a patient's vertical dimension of occlusion (VDO) can increase the visibility of existing wrinkles and allow the corners of the patient's mouth to drop. This can cause a patient to look older. Additionally, unsupported facial muscles do not move easily and the patient is unable to smile naturally. To maintain the patient's appearance and optimum muscle function, the prosthesis and any remaining bone and teeth must adequately support the muscles.

204. Oral mucosa examination

Oral mucosa is actually a mucous membrane permeated with mucous glands. Although similar to the skin, mucosa is softer and less resilient. Mucosa is made of two layers:

1. Epithelium.
2. Underlying connective tissue (fig. 1–15).

A loose submucosa contains a series of glands that bathe the mucous membrane with serous or mucus secretions.

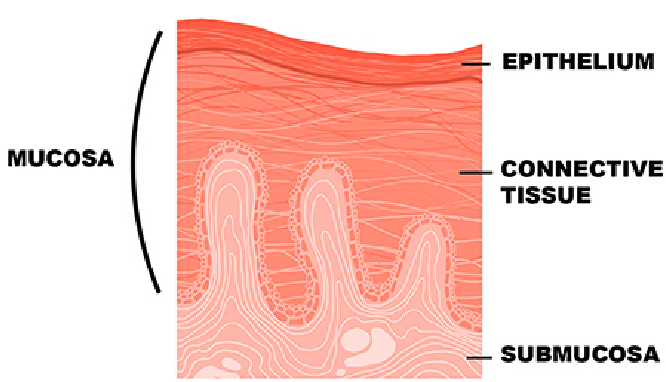


Figure 1–15. Oral mucosa components.

Types of mucosa

The three types of oral mucosa are masticatory, specialized, and lining.

Masticatory

Masticatory mucosa is tightly bound to underlying, surrounding teeth, and residual ridges. It has a thick epithelium with a thin connective tissue. The masticatory mucosa surface is stippled and nonelastic, with a toughened composition. Being nonelastic, this tissue has limited stretch capacity. If the free gingiva (masticatory mucosa) surrounding the cervical third of the crown is stretched beyond its limits, it will recede, resulting in loss of the supporting tissue. By avoiding this type of tissue destruction, you will prevent long-term problems for the patient.

Specialized

Specialized mucosa has nerve endings for sensory reception and taste perception. It covers all sides of the tongue, except the underside (fig. 1–16). Specialized mucosa has four divisions as described in the table below.

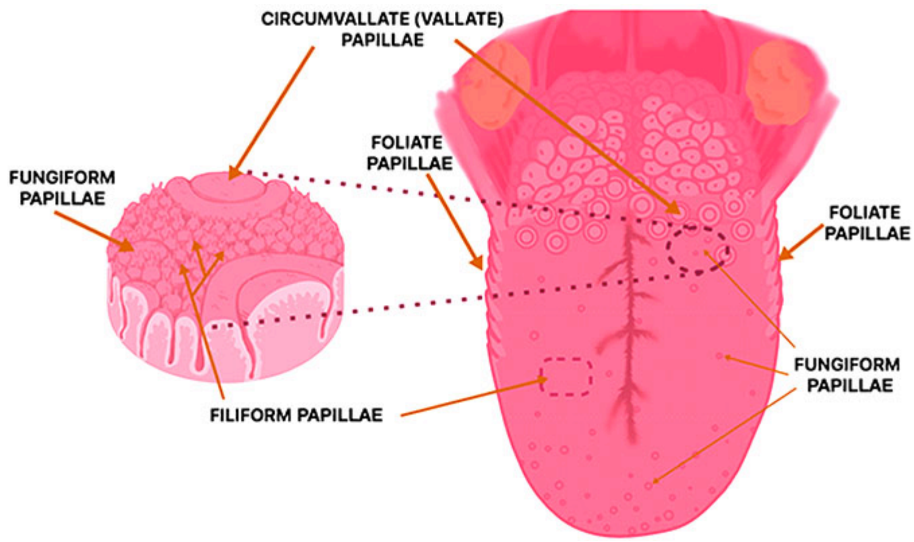


Figure 1–16. Specialized mucosa.

Specialized Mucosa Components, Shapes, and Descriptions		
Division	**Shape/Location**	**Description**
Filiform papillae	Thread-shaped papillae—on the dorsal surface of the tongue.	The smallest and most numerous, it provides the sense of touch. These papillae are sensitive to changes to contact surfaces in the oral cavity (e.g., prosthesis with unnatural texture), which is why mucosa is important to prosthesis design.
Fungiform papillae	Mushroom-shaped papillae—located on the tip, along the sides of the tongue.	Those located on the tip of the tongue are responsible for the sweetness and saltiness sensations.
Foliate papillae	A thin, mucous membrane—runs along the margins of the tongue.	These are partially responsible for detecting the sourness sensation. You can find a variable number of these folds at the posterior part of each margin. These folds are collectively identify as foliate papillae.
Circumvallate (or vallate) papillae	Larger, mushroom-shaped papillae—located on the posterior dorsum of the tongue.	These taste buds are responsible for the bitterness sensation.

Lining

Lining mucosa covers the lips, cheeks, soft palate, and underside of the tongue. It is thin, smooth, loose, and elastic. This mucosa has a thin epithelium and connective tissue with no visible stippling.

Prosthodontic concerns

Oral mucosa changes throughout life due to age, lifestyle, nutrition, and disease. Dental appliances can also affect the condition of mucosa. Complete dentures and removable dental prostheses can distort and injure mucosa. An ill-fitting prosthesis can inflame and damage mucosa, causing the tissue to thicken. As the mucosa thickens, it shifts the appliance support from the alveolar process to less desirable areas. This causes instability resulting in inadequate appliance retention and patient discomfort. Additionally, an appliance that fits improperly can damage the salivary glands.

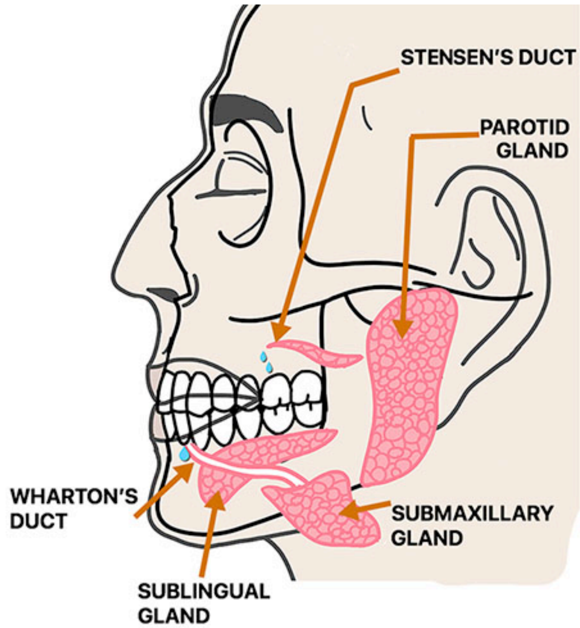


Figure 1–17. Major salivary glands.

Salivary glands

The salivary glands produce a clear, alkaline secretion called saliva. Along with aiding digestion, saliva lubricates dentures, allowing the cheeks and lips to move freely. Saliva also aids denture retention by creating a surface tension between the denture and mucosa.

Embedded in the mucosa are three pairs of salivary glands (fig. 1–17). These glands are the parotid, submaxillary, and sublingual. The table gives the location and description of these pairs.

Salivary Glands, Locations, and Descriptions		
Gland	**Location**	**Description**
Parotid	Lay in the cheeks just in front of the ear.	These are the largest of the salivary glands. They empty their secretions into the oral cavity through the parotid, or Stensen's, ducts. The openings of the ducts are opposite the maxillary second molars.
Submaxillary	Below the mandible, specifically, medial, and inferior to the parotid gland.	Sometimes called submandibular glands, these glands discharge their secretions through the submaxillary or Wharton's ducts. The secretions empty onto the floor of the mouth.
Sublingual	Beneath the tongue.	These are the smallest of the three major saliva glands. Many small, sublingual ducts empty the sublingual gland's secretions onto the floor of the mouth. Other glands empty through the same duct that drains the submaxillary glands.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

203. How to distinguish oral muscles

1. What can a properly fitted dental prosthesis restore?

2. What are the four paired mastication muscles?

3. Where does the masseter muscle extend?

4. Which primary mastication muscle is a positioner muscle?

5. What are the secondary mastication muscles?

6. How can a decreased VDO affect facial appearances?

204. Oral mucosa examination

1. What are the three types of oral mucosa?

2. What occurs if free gingiva is stretched beyond its limits?

3. Mucosa is considered important to prosthesis design. During prosthesis design, why is considering mucosa important?

4. Along with aiding digestion, what other purpose does saliva serve?

5. What salivary gland is located in the cheeks just in front of the ear?

1–3. Tooth Morphology

Morphology is as a branch of biology that deals with the form and structure of an organism or part. Understanding the form of natural dentition is an important prerequisite to creating functional dental restorations.

205. Dental tissue explanations

Before we explain dental tissues, let us look at a tooth's structure. Each tooth has a crown and a root portion. The crown is the part of the tooth seen protruding from the gingiva in a normal healthy mouth. The root is that part of the tooth that is normally present in the gingiva and alveolar bone structures.

If you were to section a tooth in a longitudinal plane, you would see multiple layers of dental tissue (fig. 1–18). The crown and root each consist of two layers of hard substances surrounding the dental pulp. The outer layer of the crown is made of enamel. The dentin is the layer beneath the enamel. A substance called cementum covers the outer layer of the root, and its inner layer is dentin. In the innermost portion of the tooth, there is a chamber (pulp cavity) containing the dental pulp. The dental pulp is composed of nerves, blood vessels, lymph vessels, and connective tissue. The *cervix*, or *cervical line, is the* narrow portion of a tooth, where the crown and root meet.

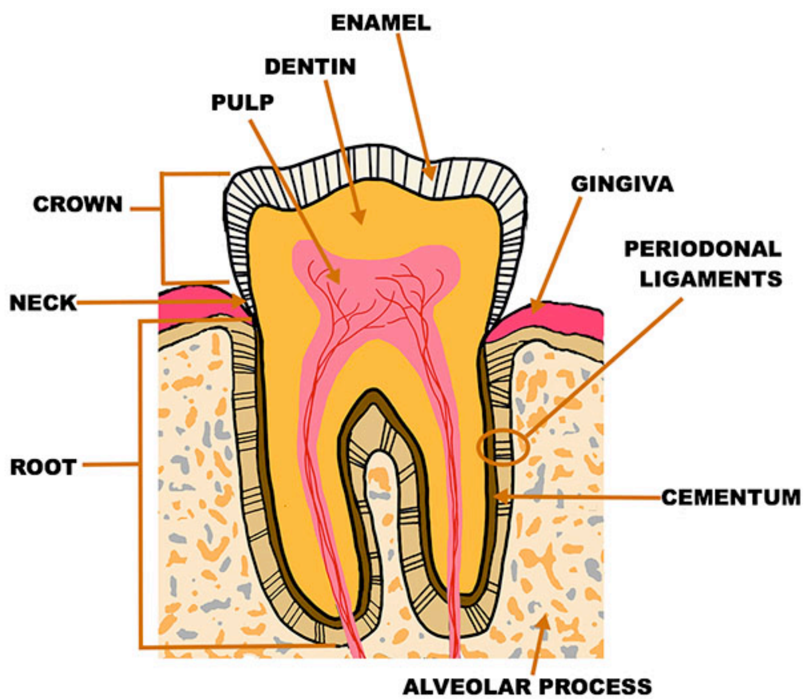


Figure 1–18. Longitudinal cross-section of a tooth.

There are two types of crowns—anatomic and clinical. The anatomic crown extends from the cervix to the incisal edge. The clinical crown is the visible crown above the gingiva.

Although all teeth have roots, the size and number depend on the tooth's form and function. Anterior teeth have a single root, premolars are bifurcated (two roots), and first and second molars are trifurcated (three roots). The tip of the root is the apex, and the opening at the tip for nerve access is the apical foramen. The periodontal ligament connects each tooth to the alveolar bone. This lesson covers these dental tissues: (1) enamel, (2) dentin, (3) dental pulp, (4) cementum, (5) periodontium, (6) alveolar process, and (7) gingiva.

Enamel

Enamel is the hardest calcified tissue in the body. It is thickest at the cusp tip and begins to thin as it approaches the cervix. Approximately 96 to 98 percent of the enamel is inorganic calcium and phosphorous, and the remaining 2 to 4 percent is composed of organic substances, including water. Enamel is made of many rods, or prisms, bound together by an intercementing substance. These prisms are usually six-sided. The prisms bend and scatter light as it hits the enamel. Light is farther scattered by the organic cement and water between the prisms.

The enamel prisms radiate outward from the dentin in straight and wavy lines. This, added to the extremely short length of the prisms and other factors, makes it is easy to understand enamel's translucency. The color of natural teeth originates from dentin and reflects through the enamel.

Dentin

Dentin is the second hardest calcified tissue in the human body and forms the major portion of a tooth. It is composed of approximately 70 to 80 percent inorganic material, and 20 to 30 percent organic material. Dentin is light yellow, porous, and stains easily. As with enamel, the main constituents of the inorganic material are calcium and phosphorus.

Cells called odontoblasts form dentin. During tooth formation, these cells create *primary dentin*. The odontoblasts produce a secondary layer of dentin in an attempt to protect the vital pulp tissues, usually occurring in response to an external irritation (e.g., chemical or thermal stimuli). The production of *secondary dentin* is possible because of the odontoblasts lining the walls of the pulp chamber and canal from the time of the tooth's formation.

Dental pulp

The dental pulp is the vital center of a tooth and is composed of blood vessels, nerves, and cellular elements. The primary functions of dental pulp are dentin formation and nourishment. The nerve tissue in the pulp responds to sensations and irritations exerted on the whole tooth. Pulp irritation causes secondary dentin to form. Irritation also causes the blood vessels to expand and inflame. Since the pulp cavity cannot expand, the inflammation is extremely painful.

Excessive forces placed on a tooth by an orthodontic appliance or heavy proximal contacts on a crown can endanger the tooth's vitality. The ability of the tooth to stabilize itself during and after movement is attributable to the cementum.

Cementum

Cementum is a thin layer of bone-like tissue covering the roots of the teeth. It is composed of approximately 55 percent organic material and 45 percent inorganic material. The organic material is composed primarily of collagen. This collagen is present in all connective tissue.

The cementum and enamel usually meet at the cervix of the tooth, at a point called the cemento-enamel junction. Cementoblasts are biological cells that form the follicular cells around the root of a tooth. This is the formation of cementum. Cementum is the hard tissue that covers over the dentin located in the root portion of the teeth. As cementoblasts produce the cementum, connective tissue extends from the surrounding tissues attaching to the cementum. These extensions are the periodontal ligament fibers.

Periodontium

Periodontium are the tissues surrounding and supporting the teeth, maintaining them in the mandibular and maxillary bones. The periodontal ligament, alveolar process, and gingiva are all components of the periodontium. The periodontal fibers that collectively form the ligaments attach to both the cementum and the alveolar process. The periodontal fibers' function is to hold the teeth in a semi-rigid state.

Periodontal ligament

The periodontal ligament completely surrounds the root of the tooth and attaches to the wall of the bony socket. The functions of the periodontal ligament are support, sensation, nutrition, and formation. In addition to supporting the teeth, the ligament assists in building and maintaining the cementum. As the tooth erupts, fibers of the periodontal ligaments form bundles to support the tooth.

These positioned bundles compensate for functional stresses placed on the tooth. These fibers are somewhat elastic and permit a certain amount of tooth movement. The arranged fibers apply a pulling force on both the cementum and the alveolar process when a force presses against the tooth. The following table shows the primary fiber groups composing periodontal ligaments (fig. 1–19).

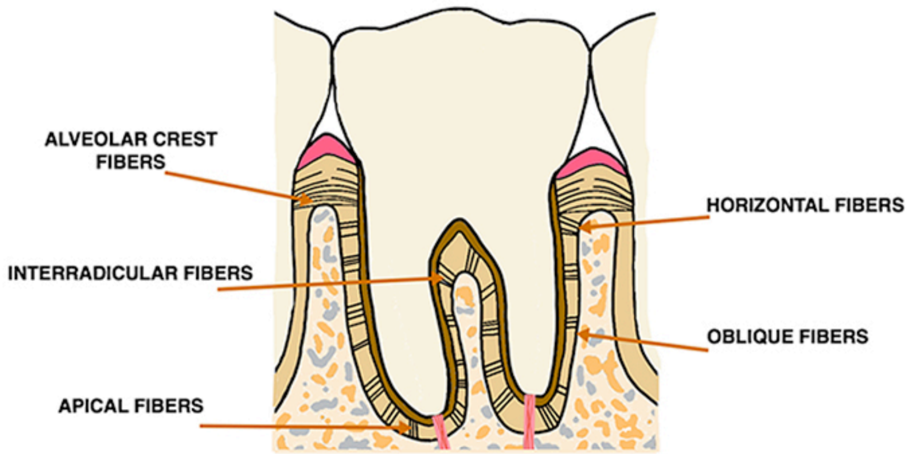


Figure 1–19. Periodontal fibers.

Periodontal Ligaments Primary Fiber Groups, Locations, and Functions		
Fiber Group	**Location**	**Function**
Alveolar crest	Extends from the cervical cementum to the crest of the alveolar bone.	Helps hold the teeth in the socket and opposes lateral forces.
Horizontal	Extends from the cementum to the alveolar bone at right angles to the tooth root.	Prevents lateral tooth movement.
Interradicular	Passes from cementum to the interradicular bone system in the multirooted teeth.	Anchors and suspends a multirooted tooth in the socket and resists occlusal pressures.
Oblique	Extends obliquely from the cementum of the apical two-thirds of the root upward to the alveolar bone, creating a suspensory or hammock effect.	Anchors and suspends the tooth in the socket and resists occlusal pressures.
Apical	Extends from the cementum surrounding the apex of the root to the alveolar bone.	Prevents the tooth from tipping and extruding.

The long-term absence of functional stresses on the periodontal fibers allows them to loosen and narrow. When function returns to the tooth, as in placement of an opposing partial, pain and even some resorption could result.

Alveolar process

The alveolar process is that bony portion of the maxilla and mandible that supports the teeth. The alveolar process is composed of two parts—cortical bone and cancellous bone. The cortical bone covers the outer portion of both the lingual and facial surfaces of the alveolar process. It is a continuous, dense, compact bone. The cortical bone gives the alveolar process its shape and protects the softer *cancellous* bone and inner tissues. The cancellous bone (fig. 1–20), also known as spongiosa, is a porous and spongy type of bone. The alveolar process undergoes continuous change due to growth, stress, advancing age, and tooth loss. Since the primary function of the alveolar process is to support the teeth, the entire alveolar process undergoes partial atrophy, or decreases in size, when teeth are lost.

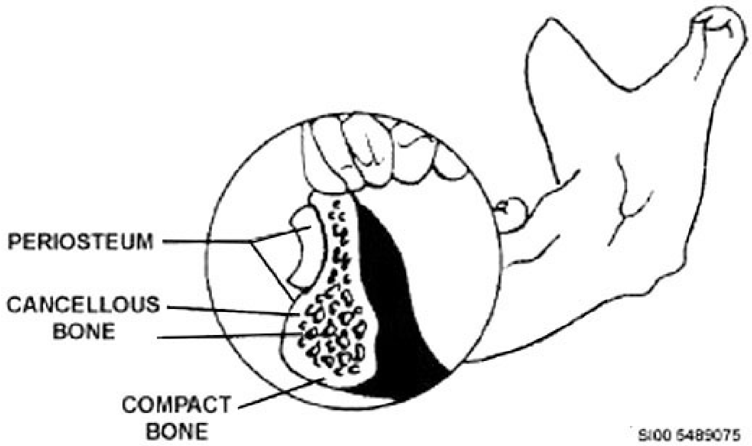


Figure 1–20. Cancellous bone.

Gingiva

The gingival tissue surrounding teeth consists of free and attached gingiva. The entire gingiva contains a very rich nerve and blood vessel supply. When healthy, this tissue has a stippled appearance.

The free gingiva lies relatively close against the crown, just above the cervix. The gingiva margin is the edge of the free gingiva towards the occlusal and incisal teeth surfaces. The gingival sulcus, or gingival cervix, is the space reaching from the free gingival margin to the depth where the gingiva attaches to the tooth. The triangular fold of tissue filling the space between adjacent teeth is the interdental papilla. This tissue is comprised of free and attached gingiva.

The attached gingiva is that portion covering the alveolar bone. It is mainly a connective tissue covered by epithelium. The attached gingiva closely follows the outline of the supporting alveolar bone, rising over root eminences, and developing into valleys between these eminences.

206. Dental anatomy description

Understanding the various levels of secondary or permanent teeth terminology requires knowledge of the following:

- Arch divisions.
- Numbering.
- Tooth divisions.
- Contours.
- Contacts.
- Embrasures.
- Occlusal anatomy.

Arch divisions

Dividing tooth alignment in the dental arches are the three segments listed here:

1. Anterior.
2. Middle.
3. Posterior.

The table below identifies these arches, their segment, and their location.

Dental Arches, Segments, and Locations		
Arch	**Segment**	**Location**
Maxillary	Anterior	A curved line extending to the labial ridge of the cuspids.
	Middle	Extends from the cuspids labial ridge to the facial ridge of the mesiobuccal cusps of the first molars.
	Posterior	A straight line from the facial ridge of the mesiobuccal cusps of the first molar through to the third molar. This line contacts all molar buccal cusps.
Mandibular	Anterior	A curved line extending to the labial ridge of the cuspids.
	Middle	Extends from the cuspids labial ridge to the distobuccal cusp of the lower-first molar.
	Posterior	Begins at the distobuccal cusp of the lower-first molar through to the third molar.

Though segment identification is helpful, you must also be able to identify teeth using the numbering system.

Numbering

Various tooth numbering systems aid in identification. The one used by federal agencies number teeth from 1 to 32. Using this system, the patient's right maxillary third molar is #1, and numbering continues to the patient's left maxillary third molar (#16). The patient's left mandibular third molar is #17, and the numbering ends with the patient's right mandibular third molar, which is #32. The numbering is the same whether the patient has third molars or not. This system speeds communication. Notice that it is easier to write #25 than the patient's right mandibular central incisor.

Tooth divisions

The ability to describe the exact location of a contact point or a unique crown characteristic enhances the communication between the dentist and technician. To simplify this process, we divide teeth into thirds when referring to its surface area. For example, a dentist may submit a work authorization requesting a decalcified area in the mesial incisal third of a ceramic crown on #9. A drawing of the tooth, as shown in figure 1–21, may accompany work authorizations to clarify the dentist's instructions further.

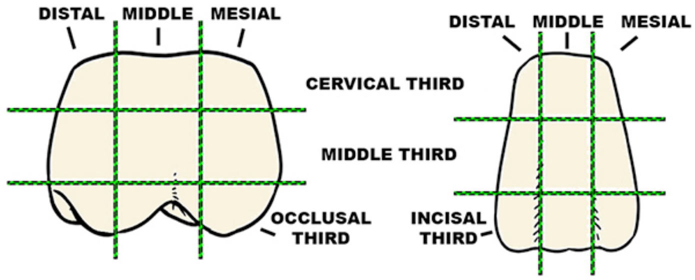


Figure 1–21. Tooth divisions.

Contours

Crown contours are essential to tissue health and the long-term restoration success. Building crown contours that adapt to the surrounding tissues should receive more consideration than the crown esthetics because poor contours can lead to destroying the tooth's supporting tissues.

Facial and lingual surfaces should have flat/convex contours. The gingival third of the tooth should have a straight-line continuance with the root's facial and lingual aspect. This imaginary line, known as the *emergence angle* (fig. 1–22), emerges occlusally from the tissue to the gingival junction and middle third of the tooth. Achieving this angle requires the dentist to reduce the preparation to the proper depth and contour.

The lingual contour of the restoration is as important as the facial (labial) contour. Posterior tooth surfaces should be flat/convex with no obvious bulges. Anterior tooth surfaces should be smooth and sloped to create an open embrasure.

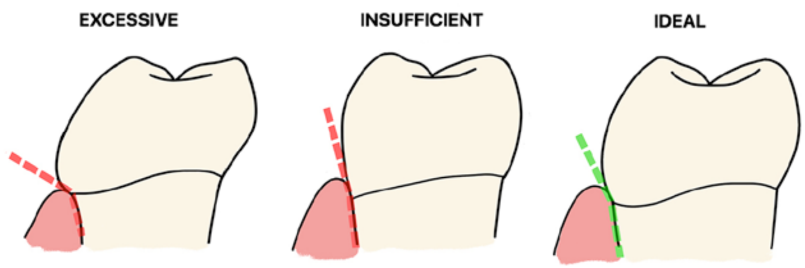


Figure 1–22. Emergence angle.

You must properly contour the interproximal surfaces to avoid impinging the interdental papilla. The proximal surfaces are convex through the contact area; however, below this contact area they become flat to concave occlusogingivally. A restoration with an over contoured (excessive) emergence angle can constrict the surrounding tissue, which can lead to soft tissue damage, tissue resorption, and restoration failure.

When waxing the crown, it is beneficial to know the occlusal and proximal outlines of teeth (fig. 1–23). The two important aspects of tooth outlines include:

1. Location of facial and lingual heights of contour, and the
2. Profile of the emergence angle.

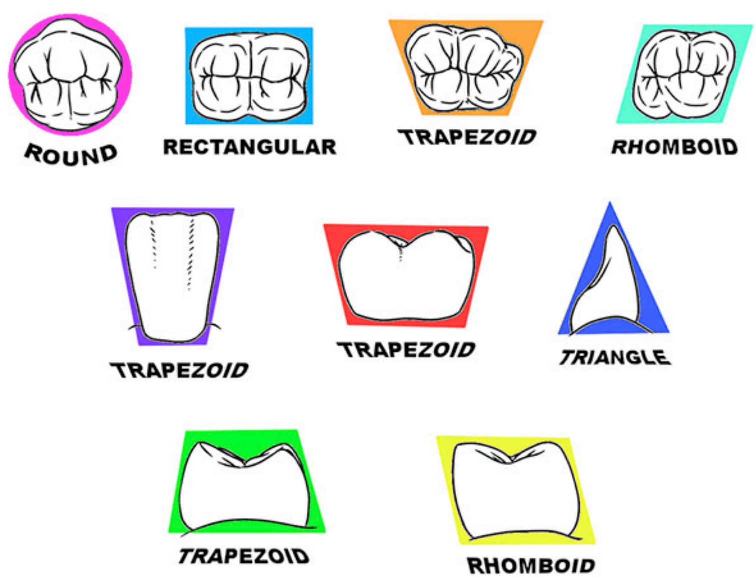


Figure 1–23. Tooth outlines.

The height of contour (fig. 1–24) is the most prominent convexity of a tooth. It is a common mistake when beginning to wax crowns to overemphasize the height of contour. The contour may be too bulky, insufficient, or in the wrong location. An over contoured crown can crowd the gingiva and cause tissue resorption.

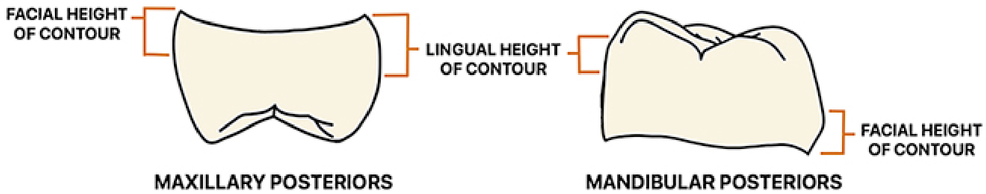


Figure 1–24. Height of contours.

A healthy natural tooth's emergence profile (fig. 1–25) supports the gingiva while allowing the gingiva freedom of movement. However, the gingiva should be free to move, adjacent contact areas should restrict a tooth's anterior and posterior movement. The height of contour and emergence profile must be correct to maintain the patient's oral health.

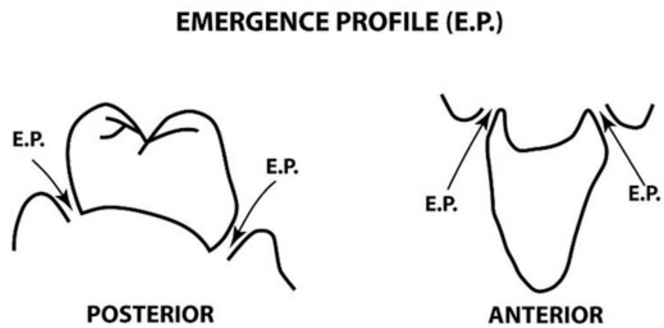


Figure 1–25. Emergence profile.

The height of contour on the facial surface of all posterior teeth is at the cervical third. The height of contour is also at the cervical third on the lingual surface of maxillary posteriors, but it is at the middle third of mandibular posteriors.

Contacts

Proximal tooth contacts stabilize the teeth and prevent food entrapment between the teeth. The correct contact area for the posterior tooth should be at the junction of the occlusal and middle thirds (fig. 1–26). Placing the contact below this point restricts the interdental papilla, which will inflame the papilla and cause tissue resorption. This results in a reduction of tissue support for the tooth. Wide faciolingual contacts can reduce the patient's ability to properly floss and clean interproximal surfaces of the adjacent structures. This limitation can result in a plaque buildup, which, if left untreated, will cause soft tissue resorption.

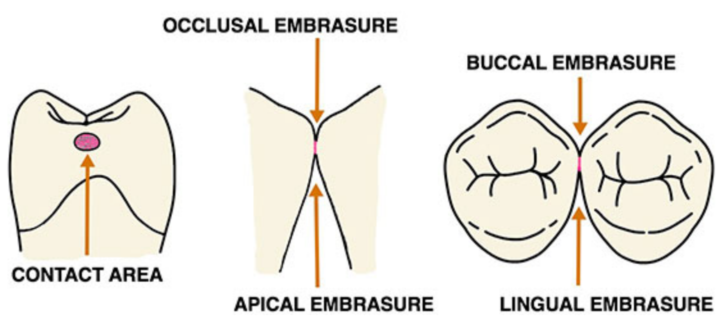


Figure 1–26. Proximal tooth contacts.

Embrasures

There are four embrasures:

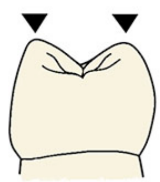
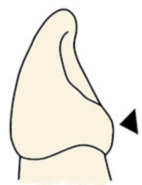
1. Occlusal.
2. Buccal.
3. Gingival (apical).
4. Lingual.

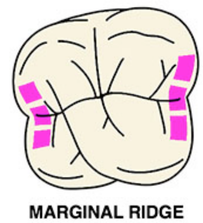
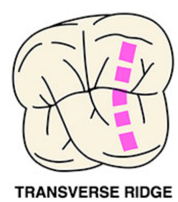
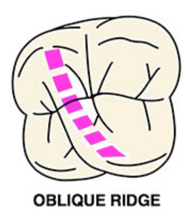
When teeth contact proximally, they create these embrasures (fig. 1–26). The embrasure must have enough room for the interdental papilla. The occlusal, buccal, and lingual embrasures not only mark the separation of teeth, but more importantly, they allow food to escape during mastication. Proper axial contours and contacts are prerequisites to sustain a tooth's functional purpose; however, a tooth's occlusal surface must also meet specific requirements.

Occlusal anatomy

The incisal/occlusal surface of all teeth perform specific functions during mastication. Ridges are positive enamel elevations that form the chewing surfaces of natural dentition. Restorations must have these elevations to function properly. Each incisal/occlusal design must harmonize (intercuspate) with the opposing dentition. If restorations do not harmonize with the existing teeth, the patient can experience both short- and long-term dental problems. These problems can include difficulty in eating, speaking, and even sleeping. The table below is a review of occlusal anatomy.

Occlusal Ridges, Diagrams, Descriptions, and Functions

Ridge	Diagram	Description	Function
Incisal		Cutting edge of all anterior teeth.	Cuts food or incises food.
Cusps	 **Figure 1–27. Positive aspects of tooth anatomy, cusps.**	Located on cuspids and posterior teeth.	Tear food.
Cingulum	 **Figure 1–28. Positive aspects of tooth anatomy, cingulum.**	Located in the lingual cervical third of the cuspids.	Helps tear food by providing a positive slope for opposing canine.

Occlusal Ridges, Diagrams, Descriptions, and Functions			
Ridge	**Diagram**	**Description**	**Function**
Marginal	 **Figure 1–29. Positive aspects of tooth anatomy, marginal ridge.**	The mesial and distal boundaries of posterior teeth.	Provides occlusal boundaries for food during mastication.
Triangular	 **Figure 1–30. Positive aspects of tooth anatomy, triangular ridge.**	Travels from cusp tip to the center of the occlusal surface.	Primary ridge that shears food.
Transverse	 **Figure 1–31. Positive aspects of tooth anatomy, transverse ridge.**	Two triangular ridges.	Shears food.
Oblique	 **Figure 1–32. Positive aspects of tooth anatomy, oblique ridge.**	Continues from the distobuccal cusp to the mesiolingual cusp of maxillary molars.	Shears food.

Each of those raised areas descends into a depressed or negative landmark. These depressions, or fossae, help maintain food (bolus) on the occlusal surface during mastication. When developing restorations, it is important to create fossae that mesh with opposing cusps. However, each depression must also be designed so food does not become trapped, which requires the descending slopes of each depression form a groove or sulcus that is smooth and free of undercuts (food traps). The sulcus, or fissure, is a long, V-shaped depression between ridges and cusps with a developmental groove at the junction of its inclines (fig. 1–33). Supplemental grooves branch off the developmental grooves, and pits are pinpoint depressions found where two or more grooves meet. Fossae are shallow depressions created by converging ridges. Understanding both the location and shape of each tooth is necessary to reproduce its form and function successfully

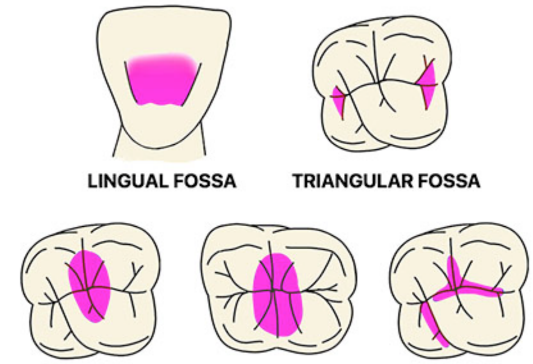


Figure 1–33. Negative aspects of tooth anatomy.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

205. Dental tissue explanations

1. What part of the tooth is protruding from the gingiva in a normal healthy mouth?

2. Match the description in column A with the term in column B. You may use column B items more than once.

Column A	*Column B*
____ (1) This is the junction of a tooth where the crown and root meet.	g. Pulp.
____ (2) This is the hardest calcified tissue in the body.	h. Dentin.
____ (3) This is the second hardest calcified tissue in the body.	i. Enamel.
____ (4) Forms and nourishes dentin.	j. Cervix.
____ (5) Covers the teeth roots and is a thin layer of bone-like tissue.	k. Cementum.

3. What is the primary function of the alveolar process?

4. Describe the difference between free and attached healthy gingiva.

206. Dental anatomy description

1. Describe the emergence angle of a tooth.

2. What must be correct in order to maintain the patient’s oral health?

3. What is the importance of proximal tooth contacts?

4. What happens if restorations do not harmonize with existing teeth?

1–4. Oral Pathology

This final section will familiarize you with some diseases that are treatable by oral prosthesis, as well as discuss conditions created or worsened by poorly made appliances.

207. Diseases related to prosthodontia

Oral pathology is the science specializing in the study of oral diseases. For our purposes, a short discussion of the subject will enhance your appreciation of patient care.

Hard tissue

We often think of caries and tooth loss as the problems needing prosthodontic treatment; however, there are other situations affecting prosthodontic care. We discuss them here.

Genetic factors

One abnormality related to genetic factors is a torus. Torus is a bulging lump of bone. This bony enlargement, or hyperostosis, is usually found in the cuspid-bicuspid region of the mandible and the midline of the maxillary's hard palate. If, and when, the size of the torus interferes with a prosthesis, either surgical removal of tori or appliance relief is necessary.

Supernumerary

Supernumerary, or extra teeth, can cause crowding. To correct crowding, the dentist may extract these teeth and close the space with a fixed-orthodontic appliance. A removable orthodontic appliance can stabilize the remaining teeth. Developmental diseases that deny the complete formation and growth of the tooth "germ" cause a "gapped-tooth" appearance. Many times the treatment plan includes the insertion of fixed prostheses such as porcelain veneers and/or porcelain-fused-to-metal crowns.

Habits

A patient's environment and habits can cause a variety of undesirable oral conditions. Habits like pipe smoking and aggressive tooth brushing can stain and abrade tooth enamel. These habits create unsightly grooves, chips in the enamel, and can sensitize the patient's teeth to both hot and cold substances. Restoring the patient's comfort and appearance can be accomplished using fixed restorations.

A habit that can cause TMJ pain, periodontal instability, tooth wear, and eventual tooth loss is bruxism. Bruxism is the involuntary gnashing, grinding, or clenching of teeth and is usually an unconscious action. Causes include job stress, emotional disturbances, and poor occlusion. Treatment usually includes a hard or soft night guard, also referred to as a *temporal mandibular dysfunction* (TMD) appliance. Bruxing can also be a symptom of a more serious disease known as TMD.

One or more of the following can represent TMJ dysfunction:

1. Joint clicking.
2. Excessive or a lack of joint mobility.
3. Condylar dislocation.
4. Erratic mandibular movement.
5. Extreme tooth wear.
6. Pain.

The treatments for TMD are as numerous as its possible causes. Typically, you will fabricate a TMD appliance to protect the teeth. The TMD appliance also serves as a bite opening prosthesis allowing an increase in the patient's VDO by as much as 10 millimeters. This relaxes both the muscles and ligaments that surround the TMJ. This appliance can help relieve the patient's discomfort, but an improperly made appliance can harm a patient's oral health.

Soft tissue

The lab technician must be aware of the different soft tissue challenges the patients may face. Following the prescribing dentist's fabrication design completely is imperative to the patient's soft tissue health. If there is a question with the design, consult with the prescribing dentist prior to fabricating the appliance. Below are some common soft tissue challenges patients face.

Hyperplasia

Hyperplasia is the inflammation and enlargement of soft tissue. Poor fitting maxillary dentures can cause hyperplasia in the palatal mucosa. If left untreated, hyperplasia can actually displace the maxillary denture base. Inflammatory fibrous hyperplasia is another form of denture-related disease. Inflammatory fibrous hyperplasia is a curtain-like fold of excess tissue that develops in association with improperly designed denture flanges. It is important to remember, a poorly designed prosthesis can degrade the patient's oral health.

Gingivitis

Gingivitis is an inflammation of the gingiva. Causes of gingivitis include poor oral hygiene, hormone disturbances, a bulky crown, or a loose partial denture. If left untreated, gingivitis can deteriorate to become periodontitis.

Periodontitis

Periodontitis is the loss of both gingiva and bone support for teeth.

Ulcers and fibromas

You can find ulcers and fibromas in both dentulous and edentulous patients. Ulcers are sores caused by biting or denture irritation. Fibromas are soft tissue lumps caused by chronic cheek biting. The biting may be due to incorrectly set dentures, a misaligned fixed restoration, or a malocclusion.

Factors related to disease

Some diseases—cancer, diabetes, and alcoholism—require special appliances for treatment. The dentist determines the best treatment plan for these patients. Your responsibility is to fabricate an appliance that meets the patient's unique requirements.

Cancer patients

Special care is required when making appliances for cancer patients. You can create an appliance to replace a segment of the surgically altered alveolus or to carry a radioactive substance to apply continuous localized treatment. Effects of cancer therapy reduce the mucosa's blood supply and saliva production. This condition increases the patient's susceptibility to ulcers and requires a denture base to fit the patient exactly.

Diabetic patients

Diabetes is another disease that requires special attention. Periodontitis and ridge resorption are common problems with a diabetic patient. In addition, the mucous membranes break down causing pain for patients with removable appliances. This "denture sore mouth" prevents eating, which worsens the patient's oral health. The best treatment is to make a well fitting appliance that the patient can tolerate.

Alcoholic patients

Patients with alcoholism encounter similar problems as those with diabetes. Typically, an alcoholic patient's nutrition is poor because they drink more than they eat. This causes periodontitis, ridge resorption, and occasional dry mouth.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

207. Diseases related to prosthodontia

1. Define oral pathology.

2. What must occur when the size of a torus interferes with a prosthesis?

3. What is bruxism?

4. What is the purpose of a TMD appliance?

5. What are causes of gingivitis?

6. What are two effects of cancer therapy treatments?

Answers to Self-Test Questions

201

1. (1) e.
   (2) a.
   (3) d.
   (4) f.
   (5) c.
   (6) d.
   (7) c.
2. Zygomatic, palatine, lacrimal, inferior concha, nasal, and maxilla.
3. The maxillary bones.
4. Because the root tips of maxillary posterior teeth sometimes extend into the sinus cavity and could be exposed after an extraction.
5. (1) Coronoid.
   (2) Condyloid.
   (3) Alveolar processes.
6. Behind and below the mandibular central incisors on the lingual surface of the body.

202

1. The mandibular condyle and the glenoid fossa, respectively.
2. The temporal bone of the skull and the condyle of the mandible.

3. Superior (above) and inferior (below) the articular disc.
4. Mandibular condyle, inferior synovial cavity, and articular disc.
5. Capsular, Temporomandibular, Sphenomandibular, and Stylomandibular.
6. Reinforces the lateral aspect of the capsular ligament.

203

1. A patient’s ability to eat, speak, and express himself or herself confidently.
2. (1) Masseter.
   (2) Temporalis.
   (3) Internal (medial) pterygoids.
   (4) External (lateral) pterygoids.
3. Downward to the lateral aspect of the mandibular ramus’ lower border.
4. The external (lateral) pterygoid.
5. The buccinator, orbicularis oris, mylohyoid, and geniohyoid muscles.
6. It can increase the visibility of existing wrinkles and allow the corners of the patient’s mouth to drop.

204

1. (1) Masticatory.
   (2) Specialized.
   (3) Lining.
2. It will recede, resulting in loss of supporting tissue.
3. It is sensitive to changes to the oral cavity contact surfaces, such as with prosthesis being of unnatural texture.
4. It lubricates dentures, allowing the free movement of cheeks and lips and aids denture retention by creating a surface tension between the denture and mucosa.
5. Parotid gland.

205

1. The crown.
2. (1) d.
   (2) c.
   (3) b.
   (4) a.
   (5) e.
3. To support the teeth, and it can undergo partial atrophy, or decreases in size, when teeth are lost.
4. Free gingiva lies relatively close against the crown of the tooth, just above the cervix; the attached gingiva covers the alveolar bone.

206

1. An imaginary line of continuance that runs from the facial aspect of the root as it emerges occlusally from the tissue to the junction of the gingival and middle thirds of the tooth.
2. The height of contour and emergence profile.
3. They stabilize the teeth and keep food from being trapped between the teeth.
4. The patient can experience both short- and long-term dental problems, which can include difficulty in eating, speaking, and even sleeping.

207

1. The science specializing in the study of oral diseases.
2. Either surgical removal or relief of the appliance is necessary.
3. The involuntary gnashing, grinding, or clenching of teeth that is usually an unconscious action.

4. To protect the teeth and open the patient's vertical dimension of occlusion in the treatment of TMJ dysfunction.
5. Poor oral hygiene, hormone disturbances, a bulky crown, or a loose partial denture.
6. Reduced mucosa blood supply and saliva production.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) Which bone forms the back and base of the skull?
   a. Frontal.
   b. Ethmoid.
   c. Occipital.
   d. Sphenoid.

2. (201) What facial bone is the *largest and strongest*?
   a. Vomer.
   b. Maxilla.
   c. Lacrimal.
   d. Mandible.

3. (201) What surface of the ramus is the mandibular foramen on?
   a. Lingual.
   b. Buccal.
   c. Mesial.
   d. Distal.

4. (202) The lower compartment of the temporomandibular joint (TMJ) is composed of the mandibular condyle, the
   a. inferior synovial cavity, and the articular disc.
   b. inferior synovial cavity, and the glenoid fossa.
   c. super synovial cavity, and the articular disc.
   d. super synovial cavity, and the glenoid fossa.

5. (202) Which movement occurs in the upper compartment of the temporomandibular joint?
   a. Axial.
   b. Hinged.
   c. Rotational.
   d. Translatory.

6. (202) What feature guides the temporomandibular joint's (TMJ) movements?
   a. Eminence angle.
   b. Hinged rotation of the eminence.
   c. Angle of the condyle-disc complex.
   d. Hinged rotation of the condyle-disc complex.

7. (203) What are the four paired primary mastication muscles?
   a. Frontal, parietal, sphenoid, and ethmoid.
   b. Frontal, parietal, occipital, and temporal.
   c. Masseter, temporalis, internal connector, and external connector.
   d. Masseter, temporalis, internal pterygoid, and external pterygoid.

8. (203) What muscle is shaped like a large fan?
   a. Masseter.
   b. Temporalis.
   c. Internal pterygoid.
   d. External pterygoid.

9. (203) Which muscles *assist* in mastication and are known as secondary muscles?
   a. Masseter, temporalis, and buccinator muscles.
   b. Masseter, temporalis, and orbicularis oris muscles.
   c. Buccinator, orbicularis oris, mylohyoid, and geniohyoid muscles.
   d. Buccinator, orbicularis oris, medial pterygoid, and mylohyoid muscles.

10. (203) What body part(s) is/are considered the single *most* important articulator of speech?
    a. Lips.
    b. Tongue.
    c. Larynx.
    d. Cheeks.

11. (204) Musoca is made of underlying connective tissue and
    a. filiform.
    b. fungiform.
    c. epithelium.
    d. membrane.

12. (204) An over contoured crown can stretch free gingiva beyond its limits. If left untreated, this can cause a loss of
    a. enamel.
    b. cementum.
    c. supporting tissue.
    d. periodontal fibers.

13. (204) Which *specialized* mucosa is the smallest, most numerous and provides the sense of touch?
    a. Circumvallate.
    b. Fungiform.
    c. Filiform.
    d. Foliate.

14. (204) What mucosa covers the lips, cheeks, soft palate, and the underside of the tongue?
    a. Specialized.
    b. Masticatory.
    c. Salivary.
    d. Lining.

15. (204) Which type salivary glands lie in the cheeks just in front of the ear?
    a. Circumvallate.
    b. Submaxillary.
    c. Sublingual.
    d. Parotid.

16. (205) Name the two types of crowns.
    a. Anatomic and Clinical.
    b. Anatomic and Cervical.
    c. Clinical and Cervical.
    d. Enamel and Dentin.

17. (205) The natural color of teeth originates from
    a. cementum.
    b. gingiva.
    c. dentin.
    d. pulp.

18. (205) What tissue is the vital center of a tooth and is composed of blood vessels, nerves, and cellular elements?
    a. Dentin.
    b. Enamel.
    c. Cementum.
    d. Dental pulp.

19. (205) The *main* function of periodontal fibers is to semi-rigidly support the
    a. root.
    b. teeth.
    c. maxilla.
    d. mandible.

20. (205) The interdental papilla is a fold of tissue that has which type of general shape?
    a. Ovoid.
    b. Squared.
    c. Circular.
    d. Triangular.

21. (205) The interdental papilla is comprised of which type of gingiva?
    a. Connective and attached.
    b. Free and attached.
    c. Cancellous.
    d. Cortical.

22. (206) In federal agencies, teeth are numbered from 1 to 32. Which central incisor tooth is the prescribing dentist referring to when writing #25?
    a. Right mandibular.
    b. Left mandibular.
    c. Right maxillary.
    d. Left maxillary.

23. (206) Facial and lingual surfaces should have what type of contours?
    a. Flat/concave.
    b. Flat/convex.
    c. Round/concave.
    d. Round/convex.

24. (206) Where is the height of contour on the facial surface of all posterior teeth?
    a. At the cervical third.
    b. At the clinical third.
    c. At the middle third.
    d. At the lingual third.

25. (206) What must have enough room for the interdental papilla?
    a. Cusp.
    b. Teeth.
    c. Fossae.
    d. Embrasure.

26. (206) Which tooth ridge(s) provide(s) occlusal boundaries for food during mastication?
    a. Cusps.
    b. Incisal.
    c. Marginal.
    d. Cingulum.

27. (206) What are shallow depressions created by converging ridges?
    a. Roots.
    b. Fossae.
    c. Margins.
    d. Cingulum.

28. (207) What is defined as a bulging lump of bone?
    a. Torus.
    b. Caries.
    c. Tumor.
    d. Cavity.

29. (207) A temporal mandibular dysfunction (TMD) appliance is intended to open a person's vertical dimension of occlusion (VDO) and to
    a. restrict the muscles and ligaments of the temporal mandibular joint (TMJ).
    b. relax the muscles and ligaments of the TMJ.
    c. restrict the articular disc and ligaments.
    d. relax the articular disc and ligaments.

30. (207) Ulcers, a form of prosthodontia disease, are sores caused by either biting or
    a. misaligned restorations.
    b. denture irritation.
    c. malocclusion.
    d. fibromas.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Oral Physiology

THE MOUTH IS A dynamic, living structure. The appliances made for it must function well without damaging it. To make these appliances, a basic understanding of oral physiology is required. Oral physiology is the science of the normal and abnormal behavior of oral structures during mastication, swallowing, speech, respiration, and head posture. This unit focuses on mandibular movements, occlusion, and articulators.

2–1. Oral Kinesiology

Kinesiology is the study of human motion that attempts to explain how body movements occur. The principles of kinesiology can be used to describe mandibular movement. Constructing a prosthesis that will function in harmony with the other oral structures requires a basic knowledge of oral kinesiology. This section describes mandibular static positions, mandibular movements, and occlusal patterns.

208. Mandibular static positions defined

Although the mandible is capable of various movements, there are several points where you can get precise references of the maxillomandibular relationship. Many of these reference points are transferable. In other words, they provide some of the necessary parameters for fabricating many prostheses.

A few basic terms identifying the mandible’s static positions will improve your ability to understand the complex mandible movements:

1. Maximum intercuspation (MI).
2. Centric relation.
3. Centric occlusion.
4. VDO.
5. Physiologic rest position.

Maximum intercuspation

MI is the complete intercuspation of the opposing teeth independent of condylar position. It is important to understand the value of MI in natural dentition. The MI position is a highly reproducible guide for restoring the shape of badly broken down natural teeth. It is also a guide for aligning and shaping artificial teeth for partially edentulous arches. Technicians routinely make restorations on casts that have been related to each other in MI.

Edentulous patients present a restorative challenge to the dentist. Because the patient is lacking natural dentition, the dentist must determine jaw relationship using other reference points. The restorative process is twofold:

1. Properly orientating the lower jaw vertically.
2. Properly positioning the lower jaw horizontally.

Centric relation

Centric relation is a maxillomandibular relationship where the condyles articulate, in the anteriorsuperior position of the glenoid fossa, against the articular eminences. For most people, MI places the condyles 1.25 millimeter (mm), plus or minus 1 mm, forward of the centric relation. When surfaces of teeth are grossly deteriorated or when all teeth are lost, determining where the condyles fit into the glenoid fossa at MI is difficult.

In these cases, dentists use the highly reproducible centric relation position to orient the lower jaw horizontally for prosthesis construction procedures. Fortunately, most patients function well when the centric relation position is used to orient the lower jaw to the upper horizontally. Your ability to fabricate any restoration or prosthesis in centric relation requires an accurate jaw relation record in centric relation.

Centric occlusion

Centric occlusion is the MI of the opposing teeth. Although it is preferred to coincide with centric relation, this is often not the case in natural dentition.

Vertical dimension of occlusion

Since vertical dimension is any measurement of vertical distance made between the upper and lower jaw, VDO is the vertical distance between the upper and lower jaws when natural teeth or denture teeth are in MI. The presence of teeth (natural or artificial) controls how far the mandible can travel vertically toward the upper jaw. When teeth are badly worn or gone, the natural vertical “stops” (correct VDO) do not exist.

Open vertical dimension of occlusion

Open VDO occurs when the patient’s upper and lower jaws are being held too far apart when natural or artificial teeth meet in MI. Fixed prostheses (e.g., single crowns, multiple crowns, or fixed partial dentures) can be responsible for this problem when natural teeth are present. Improperly made removable prostheses could cause an open VDO in partially or completely edentulous people. An open VDO usually results from an inaccurate VDO estimate (occlusal record) or a prosthesis construction error. Some common symptoms associated with an open VDO are soreness of the mastication muscles, inability to pronounce “s” and “ch” sounds clearly, and tooth contact during speech (clicking noise).

Closed vertical dimension of occlusion

In the case of a closed VDO, the patient’s jaws are too close together when natural or artificial teeth hit in MI. Possible reasons for such over closure are:

- Severe wear of natural or artificial chewing surfaces.
- Marked resorption of the residual ridges in a person who has been wearing the same set of complete dentures for years.
- An erroneous VDO estimate.
- Fabrication error.

Indicators of a closed VDO are reduced biting power and a great deal of space between upper and lower teeth while “s” sounds are spoken; the teeth should barely miss each other.

Estimates of the vertical dimension of occlusion

The principles behind speech or phonetic VDO estimates are simple. In a normal, natural dentition, teeth barely miss contacting when "s" and "ch" sounds are spoken. The vertical dimension a person uses to form these sounds stays about the same throughout adulthood, even though the dental arches might show severe wear or complete tooth loss. The physiologic rest position and phonetic VDO estimates are mandibular positions used by dentists to estimate the patient's original VDO.

Physiologic rest position

The physiologic rest position is the VDO measurement made between the jaws when the muscles controlling the mandible are relaxed. The *physiologic rest measurement* has a larger vertical opening than natural MI dentition. This opening is usually 2 to 4 mm more than the opening in MI. For example, if a patient's VDO in MI is 42 mm, then his or her physiologic rest position could be 44 to 46 mm.

209. Mandibular movements

Mandibular movement occurs as an interrelated series of three-dimensional rotational and translational activities. The mandible is capable of many different and subtle kinds of movements.

Basic movements

The basic mandibular movements consist of the following:

- Hinge.
- Translatory.
- Lateral.

Typical mandibular movement is a smooth blend of two or three of these basic motions.

Hinged (rotational)

In the mandible, rotation occurs when the mouth opens and closes around a fixed point or axis within the condyles (fig. 2–1). This terminally hinged axis of rotation occurs within the inferior cavity of the joint. The junction of this movement is located between the superior surface of the condyle and the inferior surface of the articular disc. This hinged movement is probably the only form of a "pure" rotational movement. This movement is similar in function to a door hinge, where the pin that couples the two hinges is the center of motion.

The mandibular frontal (vertical) axis of rotation occurs when one condyle moves anteriorly out of the hinge position. This occurs with the vertical axis of the opposite condyle remaining in the terminal hinge position (fig. 2–2). The mandibular sagittal axis of rotation occurs when one condyle moves inferiorly while the other remains in the terminal hinge position. Typically, this movement occurs in conjunction with other movements (fig. 2–3).

Translatory

Translation occurs when the mandible moves forward (protrusion). The teeth, condyles, and rami all move in the same direction and degree. TMJ activity occurs within the superior cavity of the joint between the superior surface of the articular disc (disc-condyle complex) and the inferior surface of the fossa synovial cavity. Typically, rotation and translation occur simultaneously (fig. 2–4).

Protrusion and retrusion are both called translatory (sliding) movement. In protrusion, both condyles leave their fossae and move forward on the articular eminences. When the mandible retrudes, both condyles leave the eminences and move back into their respective fossae.

Lateral

The side of the mouth to which the mandible moves is called the *working side*, and the side opposite the working side is called the *nonworking side*. The condyle on the working side is the *working or rotating condyle*. The other condyle is *the nonworking, or orbiting, condyle*. As the mandible moves to the side, the opposing teeth’s cusps and incisal edges must clear one another. The conclusion is that the mandible must open, at least slightly, to make a lateral movement.

During this movement, the working side condyle rotates in its fossa and the nonworking side condyle translates forward and medially down its eminence. This produces a lateral protrusion on the nonworking side. Since the nonworking side follows a limited travel arc around the working condyle, the nonworking condyle is said to be “orbiting the working condyle” (fig. 2–5).

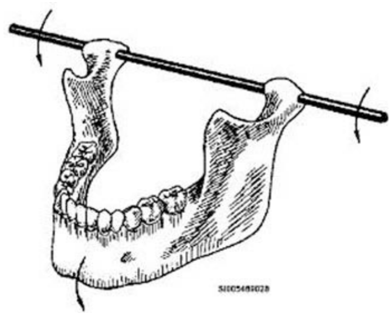


Figure 2–1. Rotational (hinge) movement around a horizontal axis.

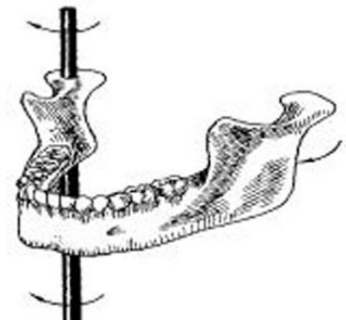


Figure 2–2. Rotational movement around a vertical axis.

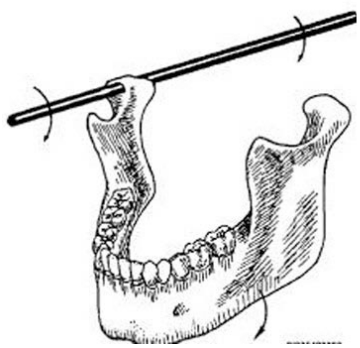


Figure 2–3. Rotational movement around a sagittal axis.

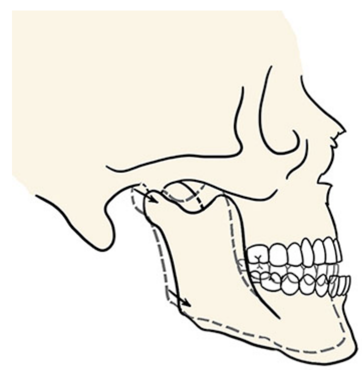


Figure 2–4. Translational mandible movement.

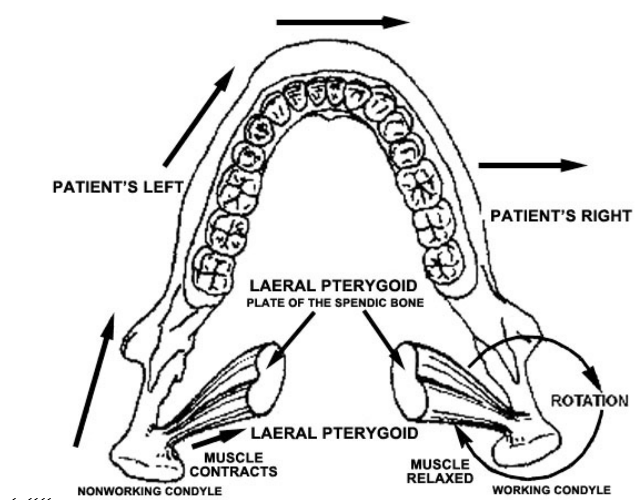


Figure 2–5. Lateral mandibular movement.

Bennett shift

Bennett shift, or Bennett movement, is the mandible and its condyles' total side shift rotating toward the working side. Two fundamental kinds of side shift—progressive and immediate—can occur and they are described in the table below.

Bennett Side Shifts and Descriptions	
Side Shift Types	**Explanation**
Progressive	Is characterized by the working condyle rotating and moving laterally, while the nonworking condyle moves forward and medially.
Immediate	Takes place prior to the working condyle's rotation or the nonworking condyle's translation. It occurs immediately prior to the occurrence of progressive side shift once lateral excursion begins.

Bennett angle

Bennett angle is the angle the orbiting condyle makes with a sagittal plane passing through its fossa, as viewed in the horizontal plane. The orbiting path's angle to the sagittal plane averages 12 to 15 degrees (°). This angle is the combined result of the nonworking condyle advancing medially, plus any side shift that takes place. Do not confuse Bennett angle with Bennett movement (side shift); they are not the same.

Arc of closure

The arc of closure is a combination of mandibular border movements. There are basically two types of arcs:

1. Ideal, as shown in figure 2–6.
2. Adaptive, which is modified by tooth interferences.

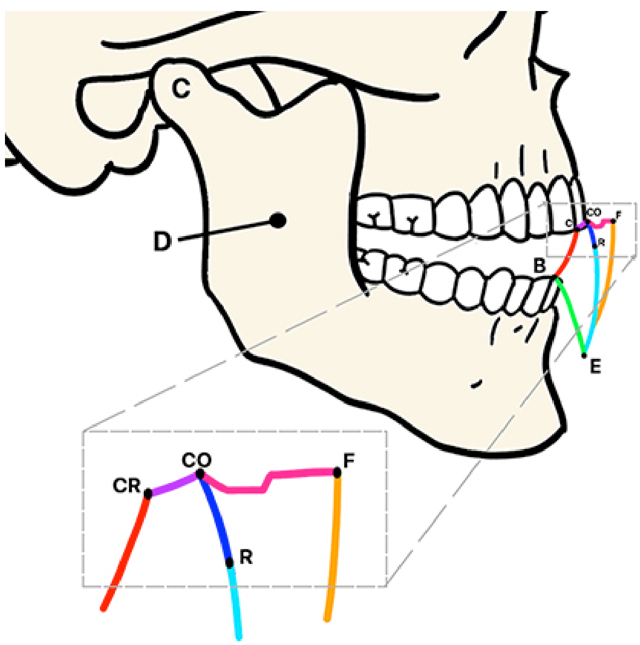


Figure 2–6. Arc of closure.

The arc is a basic hinge motion with two centers of rotation. Referring to figure 2–6, point C is the axis when the condyles remain seated in the glenoid fossae and the mandible opens along path centric occlusion (CO) to B—hinged rotation. Point D becomes the rotational axis when the mandible is opened further to point E, forcing the condyles to leave the glenoid fossae—translation. The following points refer to the incisal edge position at various border movements.

Arc of Closure Descriptions (fig. 2–6)	
Point	**Definition**
CO	Centric occlusion.
F	Maximum mandible protrusive position.
R	Physiologic rest position, when the mandible is in a relaxed position.
CR	Centric relation.
B	The amount of opening when the condyles remain in the glenoid fossae.
E	Maximum amount of opening.

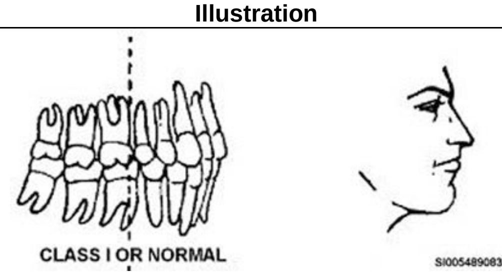
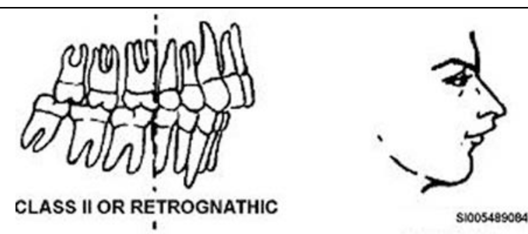
The dentist uses the points indicated in the figure to diagnose and record mandibular position. Complete denture registrations are usually recorded at centric relation and the teeth are arranged in centric relation occlusion. MJ appliances are often recorded in centric relation. When a patient's vertical VDO is closed too far, an appliance is often made to hold the mandible at the physiologic rest position to reduce muscle and ligament strain.

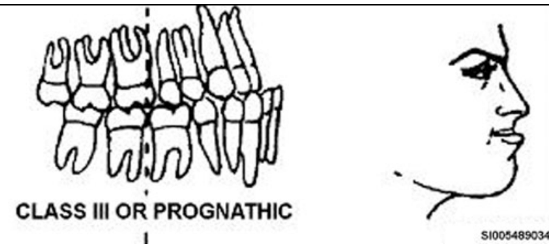
210. Occlusal patterns

Occlusion is the static relationship between the maxillary and mandibular teeth incising or masticating surfaces. This relationship can vary based on the orientation of the mandible to the maxilla. This lesson explores Angle's classification, which defines this relationship and functional occlusion. As you read this lesson, keep in mind the lateral forces involved in these different patterns and think about how these forces could affect a prosthesis and the underlying supporting tissue.

Angle's classification

E. H. Angle developed a classification of normal and abnormal maxillary teeth to mandibular teeth relationships. Angle defined three profile classifications. The classifications are based on a person's profile along with two sets of relationships. First is the mesiobuccal cusp of the upper first molar relative to the buccal developmental groove of the lower first molar position. The second is the upper anterior to lower anterior tooth relationships in terms of vertical and horizontal overlap. The Angle classifications are explained in the table below.

Angle Classifications, Descriptions, and Illustrations		
Class	**Characteristics**	**Illustration**
I	Patient's profile is characterized as normal. The mesiobuccal (MB) cusp of the upper first molar falls in the buccal groove of the lower first molar when the teeth are in MI. In the anterior area, there is a normal range of horizontal overlap (0 to 2 mm); there is an average range of vertical overlap (1 to 5 mm).	 **Figure 2–7. Angle's classification (class I).**
II	The patient's profile is deficient in chin length and characterized as a retruded (retrognathic) profile. The MB cusp of the upper first molar falls anterior to the buccal groove of the lower first molar in MI. In the anterior area, horizontal overlaps in excess of 10 mm are not uncommon. Vertical overlaps where the lower incisors make indentations in the gingiva of the	 **Figure 2–8. Angle's classification (class II).**

Angle Classifications, Descriptions, and Illustrations		
Class	**Characteristics**	**Illustration**
	palate happen occasionally. In any event, the most significant feature about the anterior tooth relationships in Angle's Class II is the marked horizontal overlap.	
III	The patient's profile is excessive in chin length and characterized as a protruded (prognathic) profile. The MB cusp of the upper first molar falls posterior to the buccal groove of the lower first molar in MI. In the anterior area, the upper and lower anteriors are usually edge-to-edge (0 mm of vertical and horizontal overlap). Negative vertical and horizontal overlaps are possible (the lingual surfaces of the lower anteriors are forward to, and extend up, over the incisal edges of the upper anteriors).	 **Figure 2–9. Angle's classification (class III).**

Functional occlusion

Occlusions (relationships between maxillary and mandibular teeth) occurring in natural dentition fall into four types of occlusion:

- Unilateral balanced.
- Mutually protected.
- Delayed anterior guided.
- Asymmetrical.

Unilateral balanced

Another name for this functional occlusion is group function. Its tooth contact characteristics are:

1. In MI, anterior teeth have a horizontal overlap of 1 to 2 mm with a 1 to 2 mm of vertical overlap.
2. During working excursions, the upper and lower anterior teeth on the working side touch. The lingual inclines of maxillary buccal cusps should be in even contact with the mandibular buccal cusps' buccal inclines.
3. There is no contact between any upper and lower teeth on the nonworking side.
4. In the protrusive position, there is edge-to-edge contact between upper and lower anteriors. Posterior contact may or may not be present (varies from person-to-person).

Mutually protected

Mutually protected occlusion (or anterior guided occlusion) is where the anterior teeth are at least partly responsible for causing separation between opposing posterior teeth on the working side and during protrusive excursions. This movement protects the posterior teeth during excursions. The anteriors characteristically show moderate to steep vertical overlap and minimal horizontal overlap.

The posterior teeth take the occlusal load when the teeth are at MI. This protects anterior teeth and completes the mutual protected occlusion. The tooth contact characteristics are:

- In MI, anterior teeth have a horizontal overlap of 0.0 to 0.5 mm and 2 mm or more of vertical overlap.
- The upper and lower anterior teeth on the working side make contact. There is no contact between upper and lower posteriors.
- No contact develops between any upper and lower teeth on the nonworking side.
- In protrusive movement, the anteriors contact edge to edge and there is no posterior tooth contact.

Cuspid guided occlusion is a common variety of anterior guided occlusion where the only teeth making contact on the working side are the upper and lower cuspids. All other anterior guided occlusion features are unchanged.

Delayed anterior guided

This form of occlusion shows group function and anterior guided occlusion in the same working movement. Tooth contact characteristics are:

- In MI, anterior teeth have a horizontal overlap of 1 to 2 mm, and 2 mm or more of vertical overlap.

  NOTE: The delayed anterior guided form of occlusion has horizontal overlap that is characteristic of group function and vertical overlap associated with anterior guided occlusion.
- The working side movement begins with the opposing posterior teeth on one side sliding across one another in group function. The last part of the movement shows anterior guided occlusion where sufficient contact develops between upper and lower anterior teeth to cause separation of opposing posteriors.
- There is no contact between any upper and lower teeth on the nonworking side.
- There is edge-to-edge contact between upper and lower anteriors during protrusion. There is no posterior tooth contact.

Asymmetrical pattern of occlusion

This pattern of occlusion is different in that it shows group function going to one working side and anterior guided occlusion to the other working side. The tooth contact characteristics are as follows:

- In MI, the anterior teeth have a horizontal overlap of 0.0 to 0.5 mm on the anterior guided side and 1 to 2 mm of horizontal overlap on the group function side. The anterior teeth in MI have a vertical overlap of 2 mm or more on the anterior guided side, and 1 to 2 mm of vertical overlap on the group function side.
- One working side demonstrates tooth contact patterns characteristic of group function, and the other working side shows tooth contacts found in anterior guided occlusion.
- There is no contact between any upper and lower teeth on either nonworking side.
- No general pattern can be described because protrusive contacts are so variable.

Nonworking contacts involving natural teeth routinely cause pain in the interfering teeth and TMJ pain, and destroy a tooth’s bone support.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

208. Mandibular static positions defined

1. What is MI?

2. What is centric relation?

3. What is the vertical distance between the upper and lower jaws when natural teeth or denture teeth are in MI called?

4. What is measured in the physiologic rest position?

209. Mandibular movements

1. What are the three basic motions that make up all mandibular movements?

2. What is the only "pure" rotational movement?

3. Describe translatory movement.

4. What is the Bennett shift?

5. Describe the difference between a progressive side shift and an immediate side shift; then describe when each shift occurs.

210. Occlusal patterns

1. What factors are considered when classifying a patient's dentition according to Angle's system of classification?

2. Match the description in column A with the term in column B. Column B items are only used once.

Column A	*Column B*
____ (1) The MB cusp of the upper first molar falls anterior to the buccal groove of the lower first molar in MI.	a. Class I.
____ (2) The MB cusp of the upper first molar falls in the buccal grove of the lower first molar when teeth are in MI.	b. Class II.
____ (3) The MB cusp of the upper first molar falls posterior to the buccal groove of the lower first molar in MI.	c. Class III.

3. What are the four types of functional occlusions that occur in natural dentition?

4. What do nonworking contacts involving natural teeth cause?

2–2. Occlusion

Occlusion is the contact between the masticatory surfaces of teeth. The history and study of occlusion are constantly evolving. Occlusion became a topic of interest and discussion following E. H. Angle's description in 1899. The first significant concept, balanced occlusion, advocated bilateral and balancing tooth contacts during all lateral and protrusive movements. This theory, developed primarily for dentures, is not considered an advisable occlusal scheme for fixed prosthodontics. As fixed prosthodontics became more prevalent, the concept of group or unilateral function evolved. This section explores the fundamentals of optimal and pathogenic occlusion and determinates of occlusal morphology.

211. Differences between optimal and pathogenic occlusions

Distinguishing the difference between optimal (nondestructive) and pathogenic (destructive) occlusion is defined by the mandible condyles position. When the condyles are in *centric relation* and the occlusal contacts are in MI, an optimal (nondestructive) relationship exists. Conversely, if the condyles are positioned out of *centric relation* during MI, the potential exists for a pathogenic (destructive) relationship. This section covers the differences between optimal and pathogenic occlusion.

Optimal functional occlusion

The following conditions are considered optimal for the greatest number of patients:

- The condyles are positioned in their most superior-anterior position centric relation (CR) when the mouth closes. In this position, there is an even and simultaneous contact of all posterior teeth.
- All tooth contacts distribute vertical forces along the long axis.
- There is adequate tooth guided contacts on the working side (laterotrusive) to disclude the nonworking (mediotrusive) side contacts when the mandible moves into eccentric positions.
- The cuspids provide the most desirable guidance.

- When the mandible moves into protrusive position, the anterior tooth contacts disclude all posterior teeth.
- The posterior tooth contacts are heavier than anterior tooth contacts during mastication.

Pathogenic occlusion

Pathogenic occlusion causes trauma to the teeth, periodontium, and TMJ due to misaligned occlusal forces. Occlusal schemes that deviate from optimal functional occlusion can traumatize the TMJ, teeth, and periodontium.

Teeth with disproportionate contacts are overloaded and direct occlusal forces away from the long axis. Heavy contacts can be due to premature cusp contact caused by uneven cusp height. Teeth shy of centric contact can erupt into centric occlusion, sometimes causing interferences due to incorrect cusp placement. Incorrect cusp placement causes teeth to slide into centric occlusion. This hit-and-slide effect puts excessive lateral stresses on the teeth (fig. 2–10).

NOTE: Figure 2–10 is representative of nondestructive and destructive occlusion.

Since the periodontium best supports the teeth when occlusal forces are directed vertically along the long axis of the teeth, lateral forces create wider spaces between the root and periodontal structure. If untreated, the periodontium and teeth roots resorb.

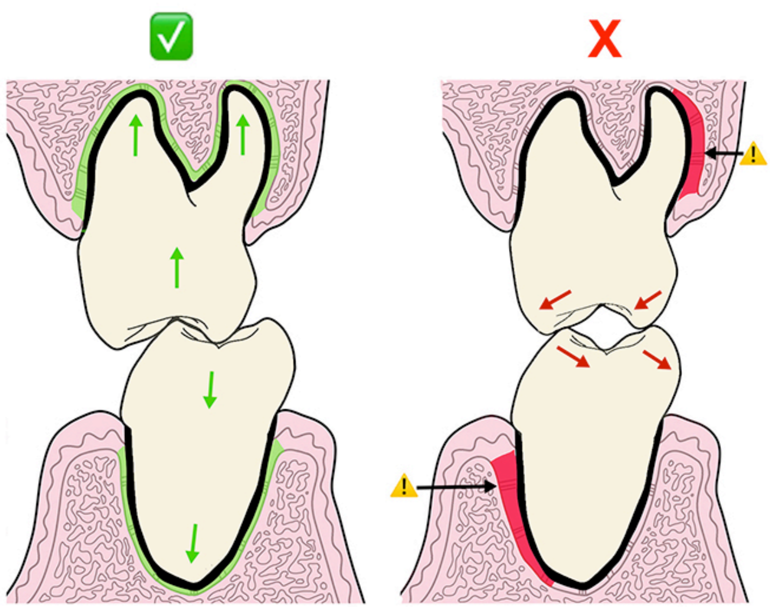


Figure 2–10. Nondestructive lateral stress caused by correct cusp placement. Destructive lateral stress caused by incorrect cusp placement.

Occasionally, a pathogenic occlusion does not affect the teeth as much as the TMJ. Destructive lateral stress conflicts with the TMJ's condylar guidance and endangers the TMJ's function. TMJ involvement causes pain, hypertrophic (overgrown), and hypertonic (rigid) muscles. A patient with extremely pronounced masseter muscles is an example of this condition. Occlusal interferences, along with emotional stress, can cause bruxing, or teeth grinding, resulting in excessive tooth wear.

Occlusal disharmony

Occlusal disharmony is best explained by comparing the TMJ and mandibular movement as a lever system. A lever system consists of a rigid bar in contact with a fulcrum, one point on the bar for the application of force, and another point on the bar for the application of a load.

Classes of lever systems

There are three classes of lever systems as described in the table:

Lever System Classes and Descriptions	
Class	**Description**
I	This system (destructive) consists of a rigid bar across a fulcrum. Force applied to one end of the bar moves a load on the other end. This is a very efficient system because the working force transmitted to the load can be multiplied simply by moving the fulcrum closer to the load and further away from the point of applied force.
II	This system (destructive) consists of a rigid bar with a fulcrum at one end, a load in the middle, and a force applied to the other end. A wheelbarrow is one example of a class II lever system. This system is less efficient than the class I lever system because the load is shared between the fulcrum and the applied force.
III	This system (nondestructive) consists of a rigid bar with a fulcrum placed at one end, a load applied to the other end, and working force applied in the middle. This system is less efficient than the other systems because more force must be applied to do the same amount of work. The normal mandibular jaw is a class III lever system in both the anterioposterior and cross-arch directions.

Nondestructive lever system

To understand the differences between optimal and pathogenic occlusion better, think of the mandible as a lever. The glenoid fossa acts as a fulcrum for the condylar head. The masseter, internal pterygoid, and temporalis muscles exert the lifting force on the mandible, and food (working force) is chewed on the occlusal surfaces of the teeth. Most of the lifting force is in the posterior teeth, and decreases toward the anterior teeth (fig. 2–11).

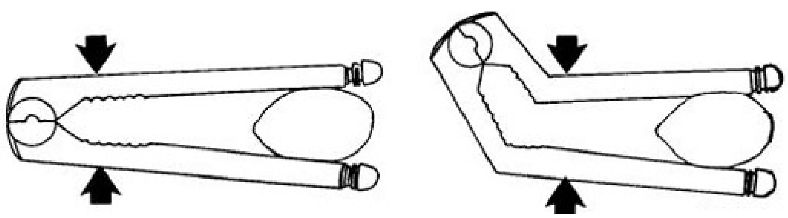


Figure 2–11. Nondestructive lever system.

Healthy posterior teeth are capable of supporting this stress. Their large surface area and multiple root structures stabilize and transfer the functional stresses to the alveolar. This explains why people tend to lose their anterior teeth last, even though they are comparatively weak. This occlusal loading distribution is representative of a class III lever system.

Destructive lever systems

Premature occlusal contacts can change the nondestructive class III lever system to a destructive class I or II lever system by changing the relationship of the fulcrum and working points.

Protrusive biting function

If a posterior contact occurs during a protrusive function, the fulcrum point moves from the TMJ to the point of premature contact (fig. 2–12). This condition is particularly harmful because it results in incisal stress not in line with the long axis of the anterior teeth.

Working side interferences

Working side interferences occur when premature contact exists on the working side (the side where the mandible moves in lateral excursions). Any contact heavy enough to disclude the anterior teeth or interfere with the smooth progress of the nonworking side condyle is a working side interference.

When a cusp is too high, it can cause heavy or premature contact on the working side, moving the fulcrum point from the condyle to the heavy contact. This causes a redirection of the occlusal forces to anterior teeth. Force is no longer directed along the long axis, and the amount of force is increased in the anterior teeth. This condition causes mobility in the anterior teeth.

Nonworking side interference

Even more complications arise from nonworking side interferences. This is because the nonworking (balancing) side contacts reduces the amount of lifting force on the working side and increases the force on the nonworking side. Normally, the muscles on the nonworking side do less work, but a nonworking side contact reverses this situation. The nonworking side muscles are kept in a tense state. The teeth with nonworking contacts receive damaging lateral stresses.

Lateral stresses

Lateral stresses will happen occasionally in all occlusions. The ability to withstand these forces depends partially on the crown-to-root ratio. A healthy tooth will have a 2-to–3 crown-to-root ratio as seen in figure 2–13, tooth A. The dot in tooth A represents the fulcrum for that tooth. Compare the amount of periodontal support for tooth A with the support for tooth B (fig. 2–13) and its lower-fulcrum point. Tooth B's 1-to–1 ratio increases the likelihood of increased mobility and possible tooth loss.

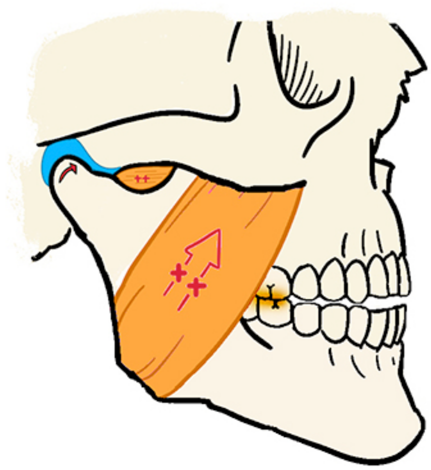


Figure 2–12. Premature occlusal contact shifts fulcrum from condyle to heavy contact.

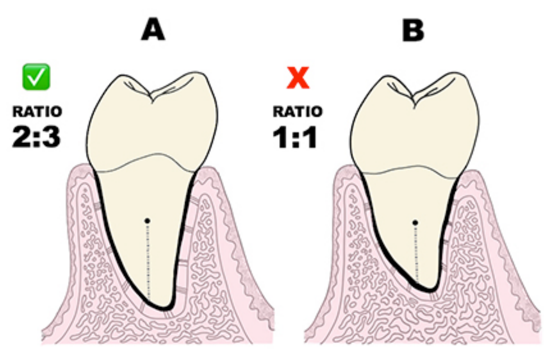


Figure 2–13. Crown-to-root ratio.

212. Occlusal morphology described

Occlusal development (cusp angle, height, and placement) is primarily controlled by the two factors—TMJ and anterior teeth.

TMJ

The TMJs are the posterior controlling factors in occlusal development. It is a nonmodifiable controlling factor because other than surgery, trauma, or pathos (disease), condylar guidance is considered unalterable. Specific nonmodifiable factors that influence occlusal morphology are:

1. The intercondylar distance.
2. The articular eminence angle.
3. The glenoid fossa curvature.
4. The distance of the teeth from the condyles.
5. The amount and type of side shift.

Anterior teeth

Anterior factors governed by natural and artificial dentition are modifiable. Anterior and posterior mandibular movements are guided by the contacts between the mandibular teeth incisal edges and the lingual surfaces of the maxillary teeth. The steepness of these contacting surfaces determines the amount of vertical overlap. A deep vertical overlap can cause significant vertical guidance where a shallow overlap will have little vertical influence.

Determining factors

The dentist determines the relationship between the anterior and posterior controlling factors using jaw relationship records. Once determined, the dentist decides how to fabricate the restoration. The technician then must use this information to make a restoration that matches the controlling factors. These controlling factors directly affect articulator selection, occlusal development of fixed restorations, and selection of artificial teeth for removable appliances.

The patient's immediate and progressive side shift determine cusp height and placement. Parts A and B of figure 2–14 show how an immediate side shift (A) must have shorter cusp height compared to a progressive side shift (B). Part C shows a minimum of vertical anterior overlap with an immediate side shift. If longer cusps are required, the vertical anterior guidance must be increased (D). Pay particular attention to *must*, *may*, and *allow*. If cusps *must* be shorter, it's because lengthening them would create damaging interference. The dentist determines this.

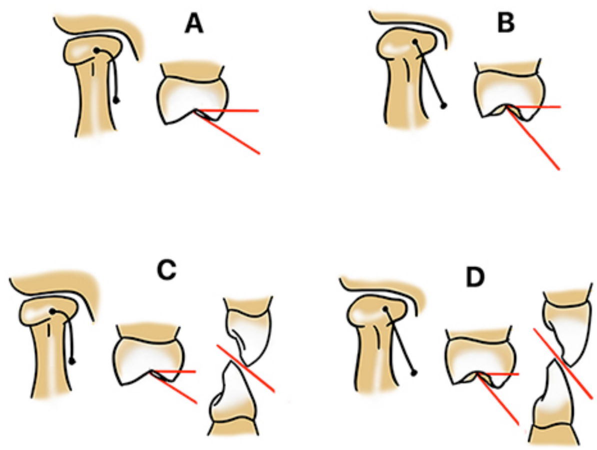


Figure 2–14. The effect of immediate and progressive side shift on cusp height.

An example of lengthening cusps for a patient with a shallow eminence is by lengthening the anterior teeth, and, therefore, the vertical overlap, the cusps may be lengthened. A short summary for cusp heights determinates are shown in the table:

Types of Occlusion and Cusp Height Determinants	
Occlusion	**Cusp Height Requirement**
An immediate side shift	*Requires* short cusps
A progressive side shift	*Allows* longer cusps
Shallow angled articular eminence	*Requires* short cusps
Steep angled articular eminence	*Allows* longer cusps
Limited vertical anterior overlap	*Requires* short cusps
Extreme vertical anterior overlap	*Allows* long cusps
Extreme horizontal anterior overlap	*Requires* short cusps
Limited horizontal anterior overlap	*Allows* long cusps

Gothic arch patterns

The distance of each individual tooth from the condyles, along with the intercondylar distance, determines the path of the mandibular teeth against the maxillary teeth (fig. 2–15). The intersection of a stamp cusp's working excursion and its nonworking excursion produces a *Gothic arch* or "arrow point." Stamp cusp routes are diagramed in figure 2–15. The arrow points generated by maxillary stamp cusps crossing mandibular chewing surfaces are directed *forward*. Arrow points generated by mandibular stamp cusps and incisal edges on maxillary tooth surfaces are directed *backward*. MI is found at the apex of this intersection.

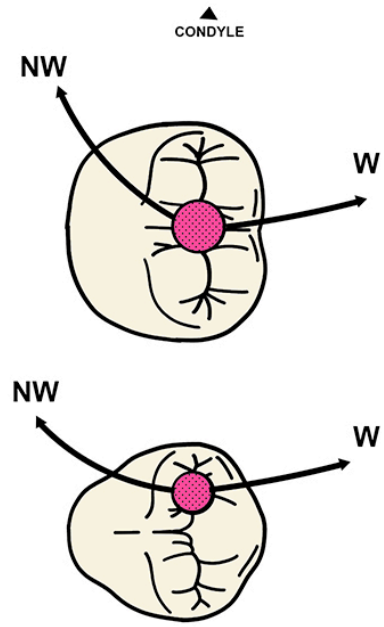


Figure 2–15. Angle between working and nonworking paths increase farther from the condyle.

This path is recorded at different positions in the mouth using a flat plate and stylus or needle. A "gull wing" shaped pattern is formed as the patient moves from the most retruded mandibular position to lateral excursions. This pattern is called a Gothic arch, arrow point tracing, sea-gull tracing, needlepoint tracing, or stylus tracing.

The pattern is used to program any articulator movements. Reproducing a patient's Gothic arch pattern on the articulator reduces eccentric interferences on the restoration. The pattern increases the accuracy of a restoration by indicating ridge and groove direction.

The maxillary lingual grooves and ridges run mesially, and the mandibular buccal grooves and ridges run distally. This relationship correlates to the distance between the condyles. As the distance between the condyles increases, the maxillary cusp develops more mesially and the mandibular cusp develops more distally. Inversely, when there is less distance between the condyles, the maxillary cusp develops more distally, and the mandibular cusp develops more mesially. This relationship is important to remember when fabricating fixed restorations.

If the ridge and groove alignments developed on the articulator conflict with the patient's true lateral movements, undesirable cusp collisions could occur. The following questions should be answered to develop properly aligned ridges and grooves for the prosthesis chewing surfaces:

1. How closely does the articulator simulate the patient's actual side shift?
2. Is the maxillary cast positioned (mounted) in the articulator the same way the maxilla relates to the glenoid fossa?
3. Does the articulator's intercondylar distance match that of the patient's?

Posterior cusp types

Occlusal contacts are made by two types of cusps contacting occlusal fossae—nonfunctional and functional cusps. Nonfunctional cusps shear food and prevent the cheeks and tongue from coming between the teeth. Maxillary buccal cusps and mandibular lingual cusps are nonfunctional cusps.

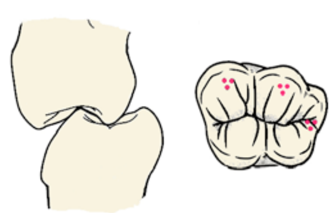


Figure 2–16. Tripodism.

Functional cusps maintain the VDO and grind food. These are the maxillary lingual cusps and the mandibular buccal cusps. The functional cusp should make a three-point contact (tripodism) in the opposing tooth fossa (fig. 2–16). The advantage of a tripod contact is that it maintains tooth stability by distributing occlusal forces and preserving holding cusp height. A tripod contact also allows free excursive movements since the cusp is not locked in place.

A cross-section of two occluding teeth (fig. 2–17) illustrates another form of three-point contact. The A, B, and C contacts contribute to tooth stability in a buccolingual direction. The B contacts between functional cusps must always be present. The A or C contacts may be missing. A missing B contact allows a tooth to tip buccally or lingually, creating an occlusal interference. Occlusal contact points are mostly used in fixed-appliance construction and are discussed in greater detail in a later volume.

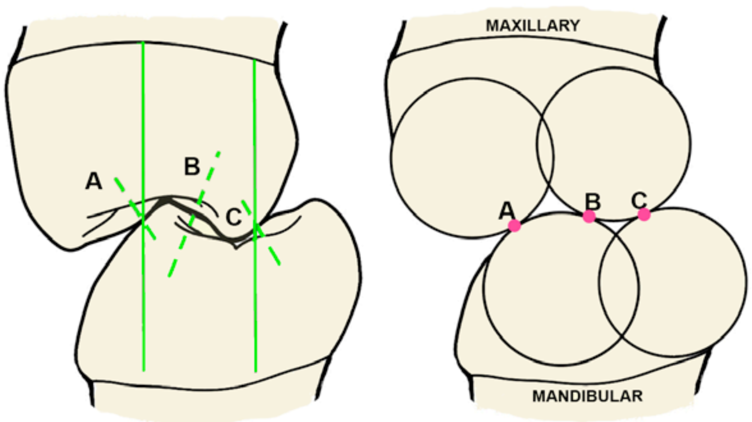


Figure 2–17. A, B, and C contacts.

Occlusal contact points

The following information on cusp-to-embrasure relationships and cusp-to-fossa relationships is adapted from *Principles of Occlusion,* by Richard W. Huffman, DDS, and John W. Regenos, DDS

Cusp-to-embrasure relationships

The cusp-to-embrasure relationship is used in complete denture arrangements (fig. 2–18). It is also the most frequently seen occlusal relationship found in natural dentition. It is a tooth to two teeth relationship. The exceptions occur at the mandibular central incisor and maxillary third molar.

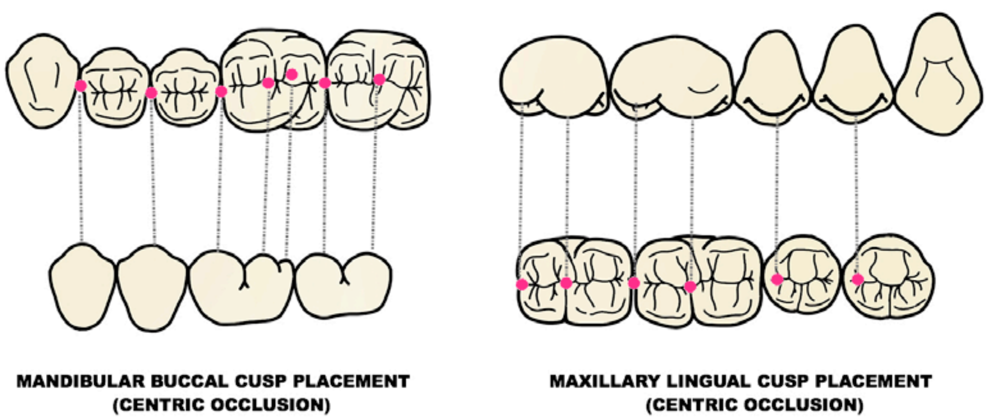


Figure 2–18. Cusp-to-embrasure tooth orientation.

Mandibular buccal cusp

Each maxillary posterior tooth is distal and buccal to its corresponding mandibular tooth. In the tables below, D represents distal, B represents buccal, L represents lingual, and M represents mesial.

Mandibular Cusps and Maxillary Posterior Locations	
Mandibular Buccal Cusp	**Contact Area of Maxillary Teeth in Centric**
1st bicuspid	Embrasure between cuspid and 1st bicuspid
2nd bicuspid	Embrasure between 1st and 2nd bicuspids
1st molar (MB cusp)	Embrasure between 2nd bicuspid and 1st molar
1st molar (DB cusp)	Central fossa of maxillary 1st molar
1st molar (D cusp)	Distal fossa of maxillary 1st molar
2nd molar (MB cusp)	Embrasure between 1st and 2nd molars
2nd molar (DB cusp)	Central fossa of maxillary 2nd molar

All the mandibular buccal cusps are in an embrasure contact relationship with the maxillary teeth, with the below exceptions:

1. The mandibular 1st molar distal buccal (DB) cusp contacts the maxillary 1st molar central fossa.
2. The mandibular 1st molar D cusp contacts the maxillary 1st molar distal fossa.
3. The mandibular 2nd molar DB cusp contacts the maxillary 2nd molar central fossa.

Maxillary lingual cusp

The maxillary lingual cusps also have a unique relationship with mandibular teeth as described in this table:

Maxillary Lingual Cusps and Mandibular Teeth Locations	
Maxillary Lingual Cusp	**Contact Area of the Mandibular Teeth in Centric**
1st bicuspid	Distal fossa of lower 1st bicuspid
2nd bicuspid	Distal fossa of lower 2nd bicuspid
1st molar (ML cusp)	Central fossa of lower 1st molar
1st molar (DL cusp)	Embrasure between 1st and 2nd molar
2nd molar (ML cusp)	Central fossa of lower 2nd molar
2nd molar (DL cusp)	Embrasure distal to 2nd molar

All the maxillary lingual cusps are in a fossa relationship, except as follows:

1. The maxillary 1st molar distal lingual (DL) cusp contacts in the embrasure between the mandibular 1st and 2nd molars.
2. The maxillary 2nd molar DL cusp is not actually in contact, but it is in a relationship to the embrasure that is distal to the mandibular 2nd molar.

Maxillary buccal cusps

The buccal cusps of the maxillary and mandibular teeth interdigitate when in a working position. All of the maxillary buccal cusp tips are in an embrasure relationship, except as follows:

1. The maxillary 1st molar MB cusp tip is in the mandibular 1st molar buccal developmental groove.
2. The maxillary 1st molar DB cusp is in the mandibular first molar DB developmental groove.
3. The maxillary 2nd molar MB cusp is in the mandibular 2nd molar buccal developmental groove.

Mandibular buccal cusps

All of the mandibular buccal cusps are in an embrasure relationship, except as follows:

1. The mandibular 1st molar DB cusp tip is in the maxillary 1st molar buccal developmental groove.
2. The mandibular 1st molar D cusp tip contacts the distal incline of the maxillary 1st molar DB cusp.
3. The mandibular 2nd molar DB cusp tip is in the maxillary 2nd molar buccal developmental groove.

Cusp-to-fossa relationships

This type of cusp placement is a tooth-to-tooth relationship. It locates the mandibular buccal cusps into the fossa of their maxillary counterparts. The maxillary lingual cusps are positioned into the fossa of their mandibular counterparts.

A cusp-to-fossa relationship better directs the forces over the long axis of the teeth. It further tends to stabilize individual tooth positions and maintains the teeth in their respective positions in the dental arches. This arrangement is used in the construction of long-span, fixed restorations, and for patients with higher than average tooth mobility. The use of cusp-to-fossa relationships and fixed restorations are discussed in detail in a later volume. For now, you’ll review cusp placement. Refer to figure 2–19 as you read these tables:

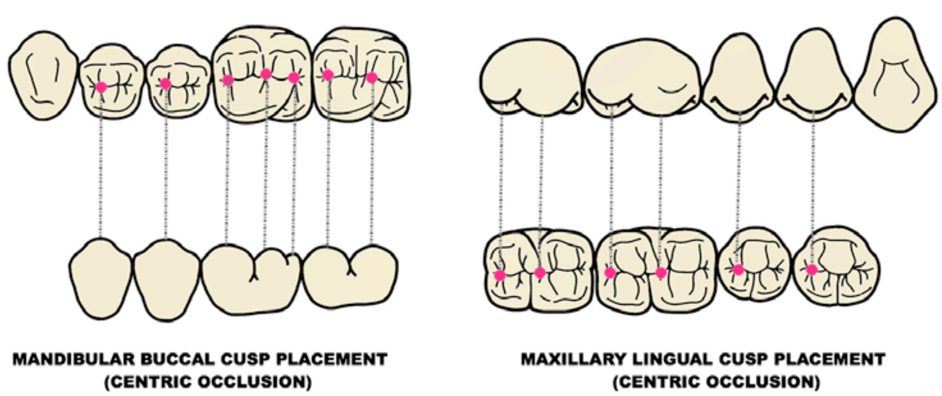


Figure 2–19. Cusp-to-fossa tooth orientation.

Mandibular Buccal Cusps Placement to Maxillary Teeth Locations	
Mandibular Buccal Cusps	**Contact Areas on Maxillary Teeth in Centric**
1st bicuspid	Mesial fossa of maxillary 1st bicuspid
2nd bicuspid	Mesial fossa of maxillary 2nd bicuspid
1st molar (MB cusp)	Mesial fossa of maxillary 1st molar

Mandibular Buccal Cusps Placement to Maxillary Teeth Locations	
Mandibular Buccal Cusps	**Contact Areas on Maxillary Teeth in Centric**
1st molar (DB cusp)	Central fossa of maxillary 1st molar
1st molar (D cusp)	Distal fossa of maxillary 1st molar
2nd molar (MB cusp)	Mesial fossa of maxillary 2nd molar
2nd molar (DB cusp)	Central fossa of maxillary 2nd molar

Maxillary Lingual Cusps Placement to Mandibular Teeth Locations	
Maxillary Lingual Cusps	**Contact Areas on Mandibular Teeth in Centric**
1st bicuspid	Distal fossa of mandibular 1st bicuspid
2nd bicuspid	Distal fossa of mandibular 2nd bicuspid
1st molar (ML cusp)	Central fossa of mandibular 1st molar
1st molar (DL cusp)	Distal fossa of mandibular 1st molar
2nd molar (ML cusp)	Central fossa of mandibular 2nd molar
2nd molar (DL) cusp)	Distal fossa of mandibular 2nd molar

The working position has an intercuspation of the mesial and distal inclines of the buccal cusps; however, they are not in an embrasure relationship. The bicuspids pass through notches known as the *Thomas Notch* (named after Dr. Peter K. Thomas who originated cusp-fossa functional waxing). These bicuspid notches are located on the maxillary buccal cusps mesial inclines and the mandibular buccal cusps distal inclines. The maxillary molar cusp tips glide through the developmental grooves. The mandibular buccal cusps glide through accessory or supplemental grooves on the maxillary molars buccal cusps. The lingual cusps mesial and distal inclines have a similar relationship to the buccal cusps.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

211. Differences between optimal and pathogenic occlusions

1. What conditions exist with optimal occlusion?

2. What conditions exist with pathogenic occlusion?

3. When do working side interferences occur?

4. What helps a tooth withstand lateral stresses in the mouth?

212. Occlusal morphology described

1. What nonmodifiable factors determine influence occlusal morphology?

2. What determines cusp height and placement?

3. What determines the path of the mandibular teeth against the maxillary teeth?

4. What function do posterior, non-functioning cusps serve?

5. Describe the cusp-to-fossa relationship.

2–3. Occlusion, Articulators, and Prosthodontic Applications

The articulator is an instrument that duplicates important diagnostic and mandible border movements; however, without proper handling, the articulator’s usefulness is compromised. You are required to understand its capabilities, advantages, and disadvantages to use this instrument effectively.

213. Anatomic relationships and types of articulators

A dental articulator is used to duplicate certain important diagnostic and mandible border movements. The three categories of articulators (fig. 2–20) include:

1. Nonadjustable.
2. Semi-adjustable.
3. Fully adjustable.

Figure 2–20. Types of articulators.

Nonadjustable articulator

The nonadjustable articulator comes in these two types—hinge and fixed-guide. Both of these articulators are able to maintain centric occlusion (CO) but are either unable to, or inaccurately, reproduce the patient’s true eccentric movements. Reproducing CO is possible with these instruments as long as a bite record is not used. This is because these small articulators have a shorter movement radius (the distance between the teeth and the axis of rotation) than does the patient. Another limitation of the hinge articulator is that it cannot move laterally or protrusively. If used at all, it is for constructing temporary crowns and partial dentures.

The fixed-guide articulator has a predetermined condylar guidance that is unchangeable. You will use the fixed-guide articulator to make appliances that do not need precise lateral and protrusive excursions. Appliances like anterior crowns, monoplane dentures, and removable dental prosthesis replacing anterior teeth are successfully made on this type of articulator. It is important for you to be aware that restorations fabricated on these articulators can increase the chair side adjustment time for the dentist if the articulators' limitations are not recognized.

NOTE: The following information on articulators has been adapted from *Fundamentals of Fixed Prosthodontics*, by Herbert T. Shillingburg, DDS, Sumiya Hobo, DDS, MSD, Lowell D. Whitsett, DDS.

Some of the common limitations associated with this hinge-type, nonadjustable articulator are its arc of closure and Gothic arch patterns. As the mandible moves up and down in the retruded position, a mandibular tooth cusp tip moves along an arc in the sagittal plane, with the center for that rotation located at the hinge axis passing through the condyles. If the location of the axis of rotation, relative to the cusp tip, differs markedly from the patient to the articulator, the radius of the cusp tip arc of closure could be different, producing an error. Drastic differences between the radius of closure on the articulator and in the patient's mouth can affect the placement of morphological features, such as cusps, ridges, and grooves on the occlusal surface.

Casts mounted on a smaller articulator will have a much shorter movement radius, and a tooth will travel a steeper arc during the small articulator closure (fig. 2–21). The teeth will occlude in a different intercuspal position on the articulator than in the mouth if the casts are mounted at an increased occlusion dimension (a thick occlusal registration). A slight positive error could cause a premature occlusal contact between the maxillary posterior teeth mesial incline and the mandibular posterior teeth distal incline.

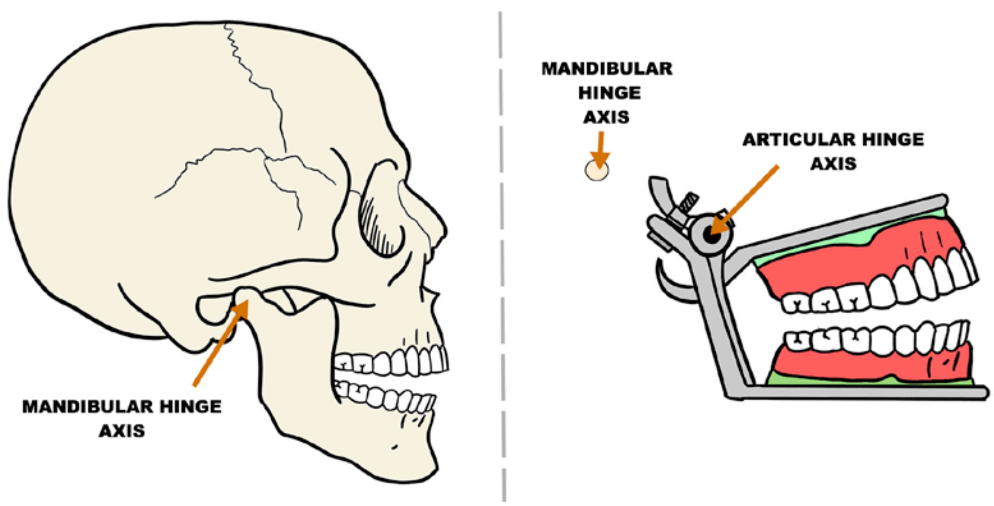


Figure 2–21. The difference between the mandibular hinge axis (MHA) and the articulator hinge axis (AHA).

On a small hinge articulator, the discrepancy between the arcs traveled by a cusp on the instrument and in the mouth can be sizable, particularly on the nonworking side, as shown in figure 2–21. The result is an increased possibility of incorporating a nonworking side occlusal interference into the restoration (fig. 2–22).

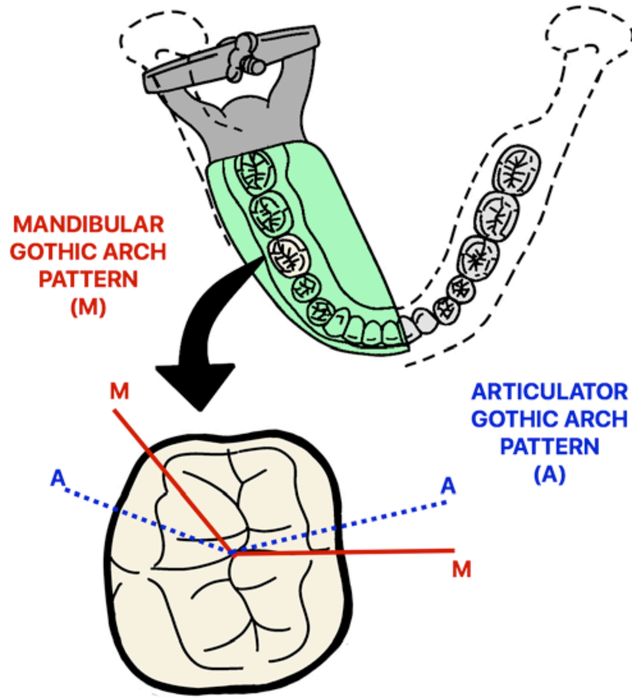


Figure 2–22. The difference between the mandibular Gothic arch pattern and the Gothic arch pattern of a small articulator.

Semi-adjustable articulators

Semi-adjustable articulators have a greater capability of duplicating condylar movement than nonadjustable articulators. The most common adjustments found on semi-adjustable articulators are:

1. Condylar inclination.
2. Bennett shift.
3. Intercondylar distance.

Condylar inclination

Condylar inclination is the angle where the condyle descends forward and down the eminence in the sagittal plane. Properly duplicating this inclination will directly affect the occlusal development of a posterior tooth restoration (specifically, fossa depth and cusp height) (fig. 2–23). The semi-adjustable articulator can duplicate the slope of this movement, but not the pathway. Actual condylar movement has a curved pathway; however, semi-adjustable articulators can only achieve a straight path.

Bennett shift

The Bennett shift (angle) is where the orbiting condyle moves inward, as measured on a horizontal plane, with a slight inferior movement. The semi-adjustable articulator can only duplicate the horizontal direction of the Bennett movement. The flat surfaces of this instrument cannot duplicate the slight inferior movement. This limitation could cause heavy eccentric contacts on the restoration, as the opposing cusp moves out of centric occlusion and into lateral movements.

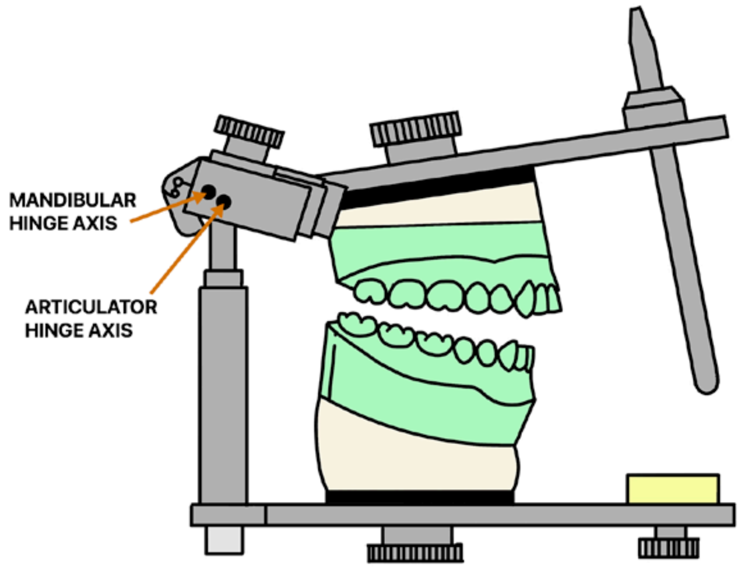


Figure 2–23. The difference between the semi-adjustable articulator mandibular hinge axis (MHA) and the articulator hinge axis (AHA).

Intercondylar distance

The intercondylar distance between the condyles’ rotational centers can have an effect on the working (lateroretrusive) and nonworking (medioretrusive) pathways of posterior cusp over their opposing occlusal surfaces—in a horizontal plane. A deviation between articulator and mandibular intercondylar widths can cause the ridge and groove placement of posterior restoration to be slightly off track from the patient’s actual Gothic arch angles. This can result in slight eccentric contacts chair side where none existed on the articulator.

The semi-adjustable articulator can closely approximate the condylar distances of most patients. Typically, this is achieved by using a face-bow transfer. If used correctly, a facebow can also provide a maxillary-to-mandibular orientation and place the casts at the appropriate distance from the condyles. This distance is important because placing the casts closer to or farther from the condyles, based on an approximate hinge axis, will produce slight errors during lateral excursions (fig. 2–24).

The semi-adjustable articulator reproduces the direction and endpoint, but not the intermediate track of some condylar movements. As an example, the inclination of the condylar path is reproduced as a straight line in the articulator when, in fact, it usually traverses a curved path along the articular eminence. On many instruments, the Bennett movement is reproduced as a gradually deviating straight line, although several recently introduced semi-adjustable articulators do accommodate the immediate side shift.

Intercondylar distance on a semi-adjustable articulator does not have total adjustability. These can be adjusted to small, medium, and large configurations, if at all. Restorations made on this type of articulator will require some intraoral adjustment, but it should be inconsequential if the restoration was fabricated carefully. The semi-adjustable articulator can be used to fabricate most single units and bridges.

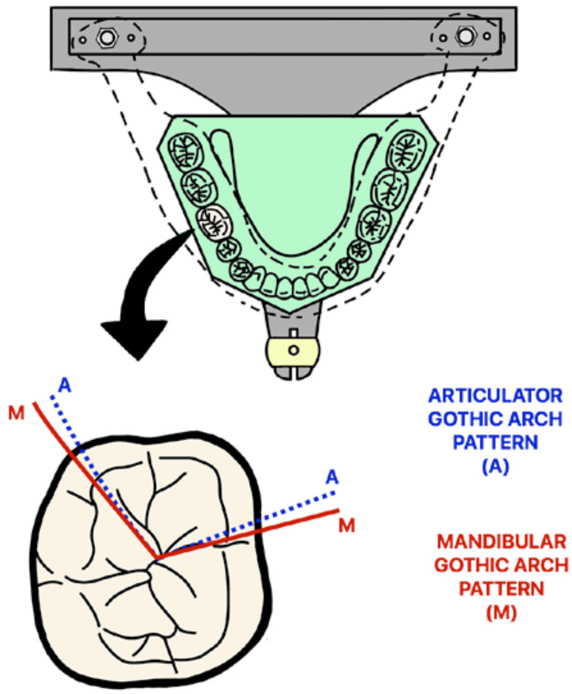


Figure 2–24. Slight lateral excursion errors due to placing the casts closer to or farther from the condyles based on an approximate hinge axis.

Arcon and nonarcon articulators

The capability to adjust intercondylar distance is not the only difference between semi-adjustable articulators. Arcon and nonarcon articulators constitute another factor in classifying articulators. The arcon instrument has the condyle guidances on the upper member and the condyles on the lower member. This is the same relationship as in the skull.

The nonarcon instrument has the opposite arrangement; the condylar guidances are on the lower member, and the condyles are on the upper member. This means the arcon articulator will maintain the same condylar inclination to the occlusal plane in the open and closed positions (fig. 2–25, views A and B). The nonarcon articulator open and closed positions change the condylar inclination (fig. 2–25, views C and D).

The arcon articulator will have an arc of closure that simulates the patient's closure more accurately than a nonarcon articulator. Also, the use of thick occlusal registrations on an arcon articulator will not change the arc of closure, as they would on a nonarcon articulator. This becomes very important when you fabricate TMD appliances. These appliances will be fabricated several millimeters out of MI, creating an open VDO. For this reason, you must reproduce the patient's arc of closure as accurately as possible.

Improving the accuracy of the semi-adjustable articulator requires the use of a facebow transfer, interocclusal record, and eccentric occlusal checkbites.

A simple facebow greatly increases the usefulness of the semi-adjustable articulator. A facebow transfer relates the maxillary cast to the articulator's condylar guidance in the same manner as the maxilla relates to the TMJ's condylar axis. When the lower cast is correctly related to the upper cast, the opening and closing arc will follow the same pathway on the articulator as it does on the patient.

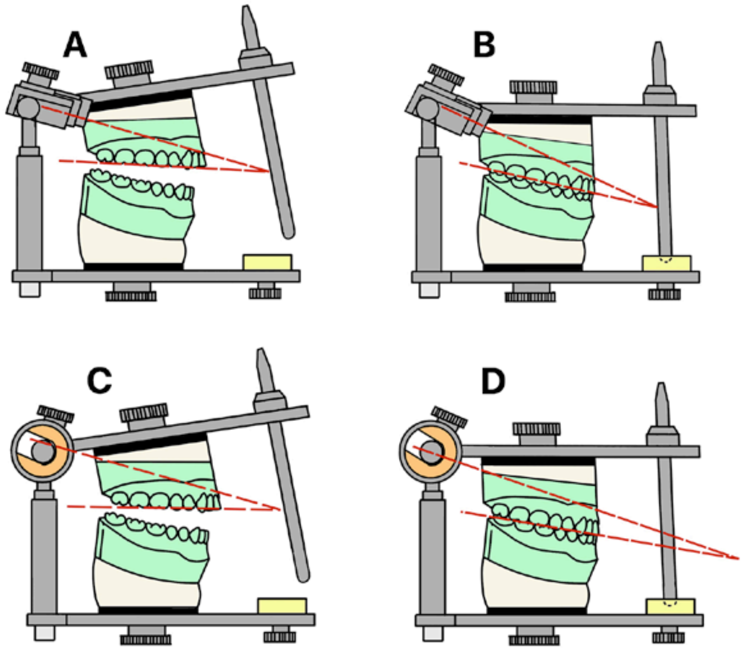


Figure 2–25. Comparison of the condylar inclination angle and the occlusal plane on an arcon and nonarcon articulator.

Changing the height of the casts (fig. 2–26, views A and B) does not change the accuracy of the mounting. This is true because when the upper cast is seated in the facebow fork, any elevation change rotates around the condyle balls in an arcon articulator. This rotation point maintains a correct relationship with the horizontal axis. Figure 2–26 shows the anatomic and articulator relationship. Achieving an accurate maxillary to mandibular relationship requires using interocclusal records.

Interocclusal records are intended to orient the mandibular cast to the maxillary cast properly. Typically, the dentist identifies and captures the patient's CO position. Eccentric occlusal checkbites are used to adjust the articulator to match the patient's condylar movement.

Fully adjustable articulators

The fully adjustable articulator is the most intricate instrument in dentistry for duplicating mandibular movement. This instrument is capable of repeating condylar inclination, Bennett angle or shift, rotating condylar movement (working condyle), and intercondylar distance. It is used for full-mouth rehabilitations and other procedures requiring mandibular movements to be precisely reproduced.

The fully adjustable articulator is capable of duplicating the angle and curvature of a patient's orbiting condylar movement. When the exact characteristics of the orbiting condyle are duplicated, the correct fossa width in posterior restorations can be achieved. This minimizes the need to adjust undesirable eccentric contacts.

During lateral movements, the rotating (working) condyle does not purely rotate around a fixed point, but can move slightly laterally; also, superior, inferior, forward, or backward. The fully adjustable articulator can mirror these movements.

The intercondylar distance between the condyles rotational centers can be precisely duplicated using a fully adjustable articulator. This capability minimizes errors in eccentric pathways.

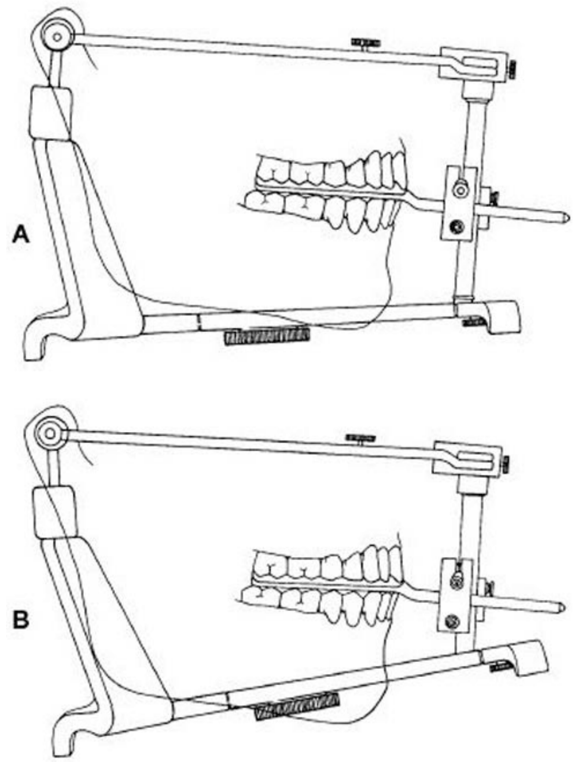


Figure 2–26. Facebow transfer.

Articulator maintenance

Keeping your articulators clean extends the life of the instruments. Plaster dust is an abrasive. Look at the stone room and see if there is dust covering the cabinets and surfaces. Every moving articulator part can be subject to wear during function if there is plaster dust between the parts. This can flatten the condylar balls and wear the inserts of the condyle itself. When this happens, the movement of the upper and lower parts of the instrument cannot accurately reproduce the anatomical movement of the patient.

Plaster and stone can get lodged into the springs and mounting plates. It is important to wipe away the excess with a soft towel before the initial set to avoid scraping off the instrument's finish.

Wax can be another source of malfunction if you are not careful. It can drip or if carved it can cause improper instrument operation. It can hang onto dirt and particles and become in essence an abrasive paste.

Be careful not to drop your articulators. It bends the parts and knocks the calibration out of whack. If you do drop it, contact your equipment custodian to decide if it needs to be sent to the company to check calibration and misaligned parts.

214. Prosthodontic applications

Each type of prosthesis fabrication (fixed or removable) requires the dentist to diagnose and treat each patient independently. Because each patient's needs are unique, certain factors must be considered before a dental prosthesis is fabricated. In this lesson, you will study the two common prosthodontic applications.

Fixed prosthodontics

When combining artificial replacement teeth with remaining natural teeth, the rule is to provide the occlusal arrangement that will best protect the occlusal well-being of the patient. Two common occlusal arrangements are anterior guidance and unilateral or group function. Use of the anterior guidance requires the patient to have healthy periodontium, well-supported anterior teeth with cuspids, class I occlusion, and no crossbite. When these conditions are not met, the dentist will normally ask that more posterior teeth be involved (1st and 2nd bicuspids) possibly to the point that the entire restoration bears the occlusal load of group function.

In unilateral balance, or group function, the teeth on the working side distribute the occlusal load. The absence of contact on the nonworking side prevents those teeth from being subjected to destruction by constructing balancing interferences. Under ideal conditions, this technique is done using a fully adjustable articulator, but you will most often use a semi-adjustable articulator for all but the most difficult cases.

Removable prosthodontics

Balanced occlusion is based on two anatomic curves found in natural dentition—curve of Spee and curve of Wilson.

The curve of Spee is an anteroposterior curvature. The curve of Wilson is a mediolateral curve. When combined, they form the curve of occlusion (fig. 2–27). Each of these curvatures is theoretical components to the plane of occlusion concept. The *plane of occlusion* refers to an imaginary surface that touches the incisal edges of the incisors and the tips of the posterior teeth occluding surfaces.

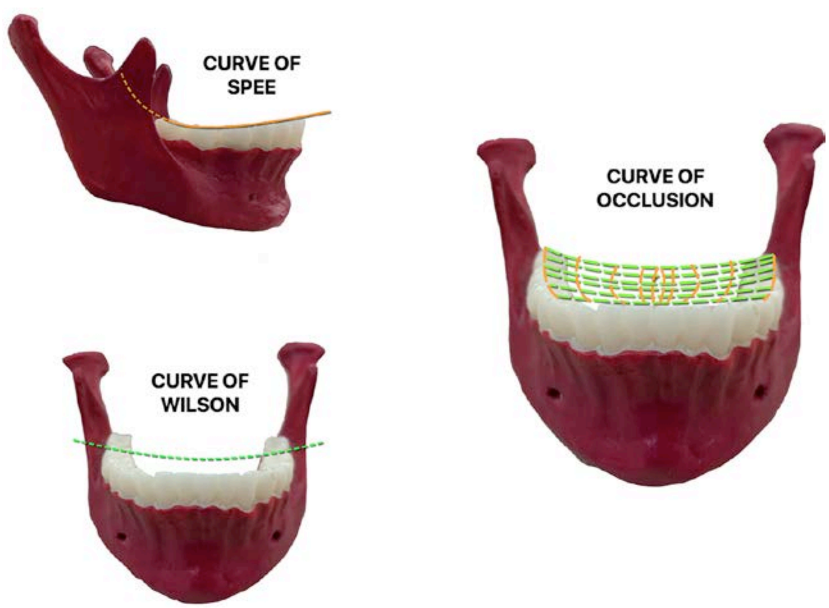


Figure 2–27. The curve of Spee, curve of Wilson, and curve of Occlusion.

What is significant to understand about the curve of Spee is that the long axis of each posterior tooth is positioned to align nearly perpendicular to its occlusal curvature. That is why the distal mandibular molar has the greatest forward tilt and the most anterior tooth has the least tilt. If complete dentures are not fabricated with this concept in mind, the patient can have a severe anterior tipping problem.

The curve of Wilson is a mediolateral curve that shows the mandibular posterior teeth buccal-lingual inclination. This buccal-lingual inclination improves the prosthesis's ability to resist occlusal loading. Additionally, this mediolateral curvature is important to maintaining cross-arch contacts. This is extremely important in denture fabrication. Dentures that do not have this cross-arch contact are prone to tipping, which is why bilateral balanced dentures are constructed to mirror the patients plane (curve) of occlusion.

The curve of occlusion is sometimes called the compensating curve. The compensating curve compensates for the maxillary and mandibular teeth separating as the condyles travel down the articular eminence. In natural dentition, the separation is not a problem because the teeth are firmly in the alveolar. This is not the case with dentures, which makes a stable denture setup a requirement.

A bilateral balance arrangement works well until the patient masticates. Once the patient begins chewing, the food unbalances the dentures. The patient maintains denture stability by chewing on both sides of the arch and using other tricks. So, why go through all of the trouble of arranging a bilateral balanced occlusion when a patient will only chew approximately one hour each day. The other 15 hours of denture wear will be devoted to nonfunctional tooth contacts. Patient satisfaction increases because the dentures do not tip during this nonfunctional activity.

Normally, patients needing monoplane dentures do not have a compensating curve unless requested by the dentist. To incorporate a curve in a monoplane denture, you must tilt the second molar or build balancing ramps into the dentures.

Removable dental prostheses and complete dentures opposing natural dentition are usually arranged in centric occlusion only. The question of whether to provide working side contacts, balancing side contacts, or even balancing protrusive contacts is determined according to the extensiveness and position of the edentulous area.

Occlusion for toothborne removable dental prostheses may be arranged in a similar manner to the occlusion seen in a harmonious natural dentition. Stability of the partial is assured by clasps at both ends of the denture base.

Occlusion for extension removable dental prostheses must be given individual consideration, depending on the type of defect present, because the denture base stability is more critical than for toothborne removable partial dentures. The following situations should also be noted:

1. Contact of opposing anterior teeth, in centric occlusion, is desirable to prevent a continuous eruption of opposing natural incisors in an anterior extension removable dental prosthesis (RDP). Contact of the opposing anterior teeth in eccentric positions should not be developed. Such contact will be detrimental to the ridge and in no way enhances the stability of the partial.
2. Unilateral distal extension RDPs should only have working side contacts, since it is entirely tooth supported by the framework on the balancing side. Also, these contacts should occur simultaneously with the working side contacts of the natural teeth to distribute the stress over the largest possible area.
3. Maxillary bilateral distal extension RDPs should have simultaneous working and balancing contacts to prevent the maxillary partial from lateral tipping. However, this desirable relationship must often be compromised when the patient’s anterior teeth have an excessively steep vertical overlap with little or no horizontal overlap.
4. Strive for balanced occlusion to help stabilize the maxillary denture when a mandibular bilateral distal extension RDP opposes a maxillary complete denture. However, the mandibular anterior teeth could prevent you from providing a posterior balancing contact in a protrusive relationship.
5. Contact between opposing posterior teeth in a straightforward protrusive relation is not desirable in any situation other than the one just mentioned for an opposing complete denture.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

213. Anatomic relationships and types of articulators

1. What are the three categories of articulators?

2. What type of appliances can be fabricated with the fixed-guide articulator?

3. Name the most common adjustments found on a semi-adjustable articulator.

4. What is condylar inclination?

5. What can a facebow transfer provide if it is used correctly?

6. What is the most intricate instrument in dentistry for duplicating mandibular movement?

214. Prosthodontic applications

1. What are the two common occlusal arrangements used when combining artificial restorations with natural teeth?

2. When should a lab technician use anterior guidance?

3. What is a mediolateral curve that shows the buccal-lingual inclination of mandibular posterior teeth?

4. Removable dental prosthesis and complete dentures opposing natural dentition, usually arranged in what type of occlusion?

Answers to Self-Test Questions

208

1. It is the complete intercuspation of the opposing teeth independent of condylar position.

2. The maxillomandibular relationship where the condyles articulate in the anteriorsuperior position of the glenoid fossa against the articular eminences.
3. VDO.
4. The VDO made between the jaws when the muscles controlling the mandible are relaxed.

209

1. (1) Hinge.
   (2) Translatory.
   (3) Lateral motions.
2. Hinged movement.
3. Translation occurs when the mandible moves forward (protrusion) and the teeth, condyles, and rami all move in the same direction and degree.
4. It is the total side shift movement of the mandible and its condyles toward the working side.
5. Progressive side shift is characterized by the working condyle rotating and moving laterally, while the nonworking condyle moves forward and medially. Immediate side shift takes place prior to the working condyle's rotation or the nonworking condyle's translation, which occurs immediately prior to the progressive side shift occurrence once lateral excursion begins.

210

1. The person's profile, the position of the mesiobuccal cusp of the upper-first molar in relation to the buccal developmental grooves of the lower-first molar, and the amount of vertical and horizontal overlap of anterior teeth.
2. (1) b.
   (2) a.
   (3) c.
3. (1) Unilateral balanced.
   (2) Mutually protected.
   (3) Delayed anterior guided.
   (4) Asymmetrical.
4. Pain in the interfering teeth, TMJ pain, and it destroys a tooth's bone support.

211

1. When the mouth closes, the condyles are positioned in their most superior-anterior position where there is an even and simultaneous contact of all posterior teeth. All tooth contacts distribute vertical forces along the long axis. When the mandible moves into eccentric positions, there is adequate tooth guided contacts on the working side (laterotrusive) to disclude the nonworking (mediotrusive) side contacts. Cuspids provide the most desirable guidance. When the mandible moves into protrusive position, the anterior tooth contacts disclude all posterior teeth. During mastication, posterior tooth contacts are heavier than anterior tooth contacts.
2. Teeth with disproportionate contacts are overloaded and direct occlusal forces away from the long axis. Heavy contacts can be due to premature cusp contact caused by uneven cusp height. Teeth shy of centric contact can erupt into centric occlusion, sometimes causing interferences due to incorrect cusp placement. Incorrect cusp placement causes teeth to slide into centric occlusion. This hit-and-slide effect puts excessive lateral stresses on the teeth.
3. When premature contact exists on the working side, which is the side where the mandible moves in lateral excursions.
4. The crown-to-root ratio.

212

1. The intercondylar distance, articular eminence angle, glenoid fossa curvature, distance of the teeth from the condyles, and the amount and type of side shift.
2. The patient's immediate and progressive side shift.

3. The distance of each individual tooth from the condyles along with the intercondylar distance.
4. Nonfunctional cusps shear food and prevent the cheeks and tongue from coming between the teeth.
5. This type of cusp placement is a tooth-to-tooth relationship. It locates the mandibular buccal cusps into the fossa of their maxillary counterparts. The maxillary lingual cusps are positioned into the fossa of their mandibular counterparts.

213

1. (1) Nonadjustable.
   (2) Semi-adjustable.
   (3) Fully adjustable.
2. Those such as anterior crowns, monoplane dentures, and removable dental prostheses replacing anterior teeth.
3. Condylar inclination, Bennett shift, and intercondylar distance.
4. The angle at which the condyle descends forward and down the eminence in the sagittal plane.
5. A maxillary-to-mandibular orientation and place the casts at the appropriate distance from the condyles.
6. The fully adjustable articulator.

214

1. Anterior guidance and unilateral (group) function.
2. When the patient has healthy periodontium, well-supported anterior teeth with cuspids, class I occlusion, and no cross bite.
3. Curve of Wilson.
4. Centric occlusion only.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

31. (208) Symptoms commonly associated with open vertical dimension of occlusion (VDO) are muscle soreness and the
    a. ability to pronounce “v” and “ch” sounds clearly.
    b. inability to pronounce “v” and “ch” sounds clearly.
    c. ability to pronounce “s” and “ch” sounds clearly.
    d. inability to pronounce “s” and “ch” sounds clearly.

32. (208) What measurement, in millimeters (mm), is the difference in the vertical opening, compared to natural dentition, during physiologic rest?
    a. 2 to 4 mm more than the opening in maximum intercuspation.
    b. 2 to 4 mm less than the opening in maximum intercuspation.
    c. 4 to 6 mm more than the opening in maximum intercuspation.
    d. 4 to 6 mm less than the opening in maximum intercuspation.

33. (209) Typical mandibular movement is a smooth blend of how many basic motions?
    a. One or two.
    b. Two or three.
    c. Three or four.
    d. Four or five.

34. (209) Which mandibular action describes how the teeth, condyles, and rami all move in the same direction and degree?
    a. Hinged.
    b. Lateral.
    c. Rotational.
    d. Translational.

35. (209) This is the *side* of the mouth to which the mandible moves.
    a. Sagittal side.
    b. Orbiting side.
    c. Working side.
    d. Nonworking side.

36. (210) Which angle’s classification describes the patient’s profile as having deficient chin length that is characterized as retruded or retrognathic?
    a. I.
    b. II.
    c. III.
    d. IV.

37. (210) If a patient’s anterior teeth have between 1 and 2 millimeters horizontal and vertical overlap in maximum intercuspation (MI), what is the patient’s type of occlusion?
    a. Cuspid guided.
    b. Unilateral balanced.
    c. Mutually protected.
    d. Delayed anterior guided.

38. (210) With an asymmetrical pattern of occlusion, nonworking contacts involving natural teeth routinely cause
   a. bruxism.
   b. protrusion.
   c. fractured dentition.
   d. destruction of a tooth's bone support.

39. (211) What mandible *position* distinguishes the difference between *optimal* and *pathogenic* occlusion?
   a. Rotation.
   b. Condyles.
   c. Retrusion.
   d. Movements.

40. (211) A nondestructive lever system places *most* of the lifting force on the
   a. anterior teeth.
   b. posterior teeth.
   c. articulating condyles.
   d. articulating glenoid fossa.

41. (211) Which crown-to-root ratio increases the likelihood of mobility and tooth loss?
   a. 0.5 to 1.0.
   b. 1.0 to 1.0.
   c. 1.0 to 1.5.
   d. 1.5 to 2.0.

42. (212) The temporomandibular joints (TMJ) are the posterior controlling factors in
   a. occlusal development.
   b. buccual development.
   c. lingual development.
   d. mesial development.

43. (212) The patient's immediate and progressive side shift determines placement and
   a. cusp height.
   b. cusp width.
   c. ridge height.
   d. ridge width.

44. (212) Which contact *must* always be present between functional cusps to avoid buccal or lingual tipping?
   a. A.
   b. B.
   c. C.
   d. D.

45. (212) Which type of relationship better directs the forces over the long axis of the teeth?
   a. Curved.
   b. Gothic arch.
   c. Cusp-to-fossa.
   d. Cusp-to-embrasure.

46. (213) Nonadjustable articulators can maintain centric occlusion but are either unable to, or inaccurately, reproduce the patient's true
    a. centric movements.
    b. eccentric movements.
    c. progressive side shift.
    d. immediate side shift.

47. (213) Which types of precise excursions are *not* needed when using the fixed-guide articulator to make appliances?
    a. Vertical and protrusive.
    b. Vertical and sagittal.
    c. Lateral and sagittal.
    d. Lateral and protrusive.

48. (213) Which type of articulator has the condyle guidances on the upper member and the condyles on the lower member?
    a. Arcon.
    b. Nonarcon.
    c. Condylar.
    d. Noncondylar.

49. (214) When creating an anterior guided occlusal arrangement, the patient *must* have healthy periodontium, no cross bite, well supported
    a. posterior teeth, and class I occlusion.
    b. anterior teeth, and class I occlusion.
    c. posterior teeth, and class II occlusion.
    d. anterior teeth, and class II occlusion.

50. (214) The curve of Wilson is important to maintain what type of contacts?
    a. Centric.
    b. Eccentric.
    c. Excursive.
    d. Cross-arch.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Dental Materials Science

THE SUCCESS OF A prosthesis depends on many things, such as your skill, and the materials and equipment you'll use to fabricate a prosthesis. Understanding the principles and characteristics of dental materials are as important as construction techniques. In addition to understanding and using existing materials, you should continue to research new materials as they become available. This unit gives you a brief summary of the basic physical sciences and color.

NOTE: Parts of the material in this unit were adapted from the *Science of Dental Materials,* by Ralph W. Phillips, D.S C.

3–1. Basic Materials Science

The science of dental materials includes basic physical sciences and various applied sciences. Among the two physical sciences are the fields of chemistry and physics. Some of the applied sciences are metallurgy, ceramics, and mechanics. You will study the basics of these sciences to help you understand the physical properties of matter.

215. The nature of matter

Within this learning objective, you'll examine the nature of matter that is pertinent to your field, including the following:

- Basic properties of matter.
- Physical states of matter.
- Equilibrium.
- Changes of state.
- Identity of matter.
- Types of matter.

Basic properties of matter

What is matter? Can matter be seen or felt? Look around you. The books on your desk, the desk itself, the walls, and you are all composed of matter!

Simply defined, *matter is anything that occupies space and has weight or mass*. All of the items mentioned in the preceding paragraph are, of course, examples of matter. Since matter must occupy space, two bodies of matter cannot occupy the same space. The possession of mass provides each body of matter with gravitational attraction and, thereby, gives it weight. The books, desk, and walls we mentioned previously are obviously also matter but what about air and other gases. It is true that a colorless and odorless gas, such as air, is not readily apparent to our senses. Such gases occupy space, have weight, and are therefore matter.

However, do not jump to conclusions and think that everything is matter. Many things that you are aware of are not matter. For example, electricity, rays of light, and sound are NOT matter, but they DO exist. What are they then? Such things are examples of *energy*, which is defined as *the capacity* *for doing work*. We know now that matter can be converted into energy, and energy is converted into matter under certain controlled conditions.

So matter can be transformed from one form to another. Think, for instance, of an iron post. If it is left exposed to moist air, it will soon exhibit signs of rust. Likewise, fruit juices exposed to air will ferment, and when wood or paper is burned, the original material seems to disappear.

Under normal circumstances, matter can neither be created nor destroyed; it is merely passed from one form to another. For example, consider the iron "taken" from the post. It was not lost; instead, it entered into a combination with the water vapor and oxygen in the air to form a new substance called *iron oxide* (rust). Similarly, the alcohol in the fruit juice did not develop out of nothing; rather, it was formed from the sugar, which in turn disappeared as the alcohol was formed. Likewise, the burned wood produced ashes and gave off gases, the combined weights of which equaled the original substance.

Physical states of matter

All matter exists in one of these three states—solids, liquids, and gases.

To understand why matter exists in a particular physical state, you must first realize that all matter is composed of very tiny particles (atoms and molecules). The degree to which the particles are packed together determines whether the matter takes the form of a gas, liquid, or a solid (fig. 3–1).

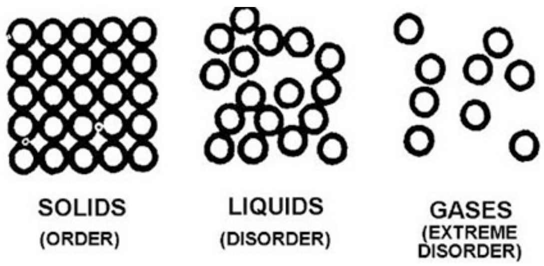


Figure 3–1. States of matter.

Solids

Wood, glass, salt, sand, and iron are all common examples of solids. In the solid state of matter, the particles are packed closely together, so they remain in fixed positions. Solids have specific shapes and boundaries. They may expand or contract slightly when heated or cooled normally, but they remain hard and in fixed shapes.

There are two types of solids—crystal and noncrystalline structures. The difference between them depends on the atomic arrangement. Dental materials are made up of many millions of atoms. How are the atoms arranged in a solid? How are they bound together? As early as 1665, Robert Hook simulated the characteristic shapes of crystals by stacking musket balls in piles. It was 250 years later before anyone knew he had exactly modeled the crystal structure of many familiar metals, with each ball representing an atom.

Crystal structure

In the solid state, atoms are attracted to each other and form a space lattice or crystal. The crystal arrangement is maintained with the minimal amount of energy possible. A space lattice is defined as any arrangement of atoms in space, so that every atom is situated similar to every other atom. In other words, the atoms have a regularly spaced configuration. Most metal crystals are cube-shaped, with an atom at each corner; consequently, metals have a specific melting temperature.

Noncrystalline structure

Noncrystalline structure is the other form that can occur in the solid state. The structural arrangements of the noncrystalline solids do not have a definite melting temperature, but rather, they gradually soften as the temperature is raised and gradually harden as they cool. The temperature at which they first form a rigid mass upon cooling, or lose hardness or brittleness upon heating, is called the *transition temperature*. Dental synthetic resins and waxes are also examples of materials that exhibit a noncrystalline structure.

Some dental waxes solidify as *amorphous materials*, meaning that the *molecules* (combinations of atoms) are distributed at random. Even in this case, there is a tendency for the arrangement to be regular. It is a law of nature that any substance should approach the equilibrium position so that there is minimal internal energy. Such a condition implies that molecules should approach as closely together as possible in a regular pattern in the solid or liquid states. Regularity of unit arrangement is most conducive to minimal energy in any given environment.

For example, glass is considered a noncrystalline solid; its atoms tend to form a short-range order lattice, instead of the long-range order lattice characteristic of crystalline solids. In other words, the ordered arrangement of the glass is localized with a considerable number of disordered units. This is like pulling apart a pile of balls to create two piles. The balls left between the two piles are the random units. Since such an arrangement is typical of liquid structures, such solids are sometimes called *supercooled liquids*.

Liquids

Alcohol and water are common examples of liquids. Although liquids have a definite volume at a given temperature, they do not have a fixed shape. Their particles are packed closer together than are those of gases; however, they are still somewhat free to move about. As a result, liquids take the shape of the containers they are placed into.

Gases

Oxygen and hydrogen are common examples of gases. Air is a combination of several gases. In gases, the particles are far apart. As a result, there are vacant spaces between the particles; therefore, the particles are able to move in almost complete independence of each other. Since the particles are free to move about, gases do not have shapes or boundaries. The volume of a gas can be changed to a great degree because of a change in temperature or pressure because the particles can be easily pushed farther apart or drawn closer together.

Equilibrium

Regardless of the type of solid-state structure, a limiting factor prevents the atoms or molecules from approaching each other too closely. If the atoms approach too closely, they are repelled from each other by their electron charges. On the other hand, the forces of attraction tend to draw the atoms together. The position where these repulsion and attraction forces become equal in magnitude (but opposite in direction) is the normal, or equilibrium, position of the atoms.

As an external force causes the atoms to move closer together or further apart, the mutual repulsion or attraction of the atoms increase. As the interatomic space increases, so does the mutual attraction. The atoms try to maintain a distance requiring a minimal amount of energy. Unless measures are taken to maintain a new interatomic distance, the atoms will try to return to as close an equilibrium state as possible, which could cause distortion.

Changes of state

If temperature and pressure are altered sufficiently, many substances can pass from one physical state to another without changing their chemical nature. We classify a substance as a solid, liquid, or gas according to the form in which it is *normally* found. For example, we classify water as a liquid, although at a lowered temperature it becomes a solid (ice), and at an elevated temperature a gas (steam). Therefore, matter not only occupies space and has weight, but it also occurs in various physical states, such as solids, liquids, and gases. In this paragraph, we have used a substance (water) as an example of a form of matter that can change from one state to another.

Identity of matter

Any specific form of matter in which all specimens have the same properties, they will have a specific identity, such as salt, water, and wood. These properties are the physical and chemical characteristics that distinguish one substance from another.

When a substance possesses a characteristic that we can see, feel, or smell (e.g., odor, color, shape, freezing point, boiling point, or solubility), we call it the physical characteristic of that substance. For example, two of water's physical characteristics are that it freezes at 0° centigrade (C) and boils at 100 degrees Celsius (°C). Polysulfide rubber base has a distinctive odor, color, shape, and solubility, so we list these as its physical characteristics.

However, a substance's chemical characteristics are more difficult to see than its physical characteristics. Characteristics such as energy content, reaction with other substances, and reactions with light, heat, and electricity are chemical characteristics. Below are examples of chemical characteristics:

1. Salt remains unchanged when heated, but sugar will char and burn.
2. Iron will rust if exposed to moist air, while gold does not.
3. Hydrogen peroxide will decompose chemically if you do not store it in a tight, light-resistant container in a cool place.

Types of matter

As you look at the different objects around you, you may be impressed by the endless variety of matter. All matter is made up of either pure substances or mixtures of pure substances. The four types of matter are list in the table.

Types of Matter Substances and their Explanations

Type	Explanation
Elements	These are the simplest form of matter. They are the basic constituents of all matter. Some elements exist free in nature; others are found only in combination. Free or combined, they are the building blocks that make up every variety in the universe.
Compounds	This is pure substance made up of elements that are combined chemically. It is perfectly homogeneous (uniform) and has a definite composition regardless of origin, location, size, or shape. A compound can be decomposed into its elements by some type of chemical change; however, the elements cannot be separated into a compound or compounds by any physical means.
Mixtures	This is non-uniform from point-to-point, and composed of two or more compounds that have been mixed physically. No chemical reaction takes place between the parts of a typical mixture. Each element or compound keeps its original chemical properties in a mixture. Generally, mixtures can be separated into individual compounds by physical means. For example, adding a little water to a salt-sand mixture dissolves the salt; then filtering the mixture removes the sand, and finally, heating the mixture evaporates the water, leaving the salt.
Solutions	Some compounds, when placed in water or a similar substance, will form a solution. Solutions resemble mixtures consisting of two or more different substances, but they differ in that, they are homogeneous (uniformly mixed). For example, a solution of sugar in water consists of individual sugar molecules that have separated and scattered randomly among the water molecules. Most materials of interest in dentistry are mixtures or solutions, and their uses are often associated with changes of state.

216. Physical properties of dental materials

In order to understand how to properly manipulate dental materials fully, and be able to predict how these materials will react under the conditions of actual use, it's necessary to understand some of the basic physical and chemical properties. You should know how these properties are compared and be aware of how they affect the potential value of the material in relation to the many factors that make demands on dental materials.

When delving into the physical properties of dental materials, there is the great temptation to span the field; however, we must restrict ourselves to the following factors of:

1. Force
2. Stress
3. Strain
4. Elasticity
5. Ultimate strength
6. Ductility and malleability
7. Flow
8. Hardness
9. Distortion
10. Thermal properties
11. Adhesion
12. Wetting

Force

Force is any push or pull upon matter. The table below examines the types and functions, as well as indicates locations and provides examples.

Types of Force, Functions, Locations, and Illustrations			
Force	**Function**	**Location**	**Illustration**
Tensile	Pulls and stretches a material	Top and/or bottom	**Figure 3–2. Types of forces and the resultant stresses and strains.**
Compressive	Pushes material together	Top and/or bottom	**Figure 3–3. Types of forces and the resultant stresses and strains.**
Shearing	Tries to slice material apart	At the sides where the supports oppose the compressive force.	**Figure 3–4. Types of forces and the resultant stresses and strains.**
Bending	Bending stress and strain is a combination of the three forces. The effect of force upon an object can be seen in figure 3–5.	Top, bottom, and sides.	**Figure 3–5. Types of forces and the resultant stresses and strains.**

Stress

This is the internal reaction or resistance within a body to any externally applied force. Stress is what occurs within a material when a force is applied from the outside. For stress to occur within a material, there must be an applied outside force. The greater the applied force, the greater the stress within the material. The movement of the atoms causes stress from the equilibrium position. When an applied force tends to stretch a material, tensile stress occurs.

When a weight is suspended from a metal wire, tensile stress is created in the wire, and its length is increased. If the weight is placed on top of a material, a compressive force is established, which in turn, creates a compressive stress. The length of the specimen tends to decrease. When an applied force tends to slide one layer of a material past an adjacent layer, shearing stress is produced in the material. Scissors are also referred to as "shears" because they create a shearing stress in the material as one layer of the material is forced to shear past the adjacent layer.

Strain

Strain is the external distortion or change produced in a body as the result of an externally applied force. The type of strain (distortion) depends on the type of stress involved. Stress is the internal reaction to an external force, and strain is the change resulting from that stress. The greater the stress, the greater the resulting strain. Each type of stress creates an accompanying type of strain. Tensile stress is always accompanied by tensile strain, compressive stress is always accompanied by compressive strain, and shearing stress is always accompanied by shearing strain.

Elasticity

Elasticity is defined as the ability of a body that has been changed or deformed under stress to assume its original shape again when the stress is removed. An object that regains its original shape when stress is removed is said to be elastic. A rubber band is also called an *elastic band* because it can be stretched (tensile stress) and will return to its original shape when the stress is removed. An object that remains permanently changed is said to be *plastic*. After compressive stress has been placed on a piece of modeling clay, it will not return to its original form; therefore, it is considered plastic.

Ultimate strength

The greatest stress a structure or material can withstand without fracture or rupture is known as its *ultimate strength* or, for the sake of brevity, its strength. If the stress and strains are tensile in type, the stress at fracture is termed the ultimate tensile strength. If the stresses are compressive in character, then maximum stress is called *ultimate compressive strength*, or *crushing strength*. The maximum shearing is called *shearing* or *shear strength*.

As a wire is stretched, it lengthens and narrows in cross-section as seen in fig. 3–6. The proportional limit (PL) on the graph indicates an equal amount of stress and strain. Any force beyond this point will result in an external deformity. Yield point (YP) on the graph is the point when permanent deformation occurs. Finally, the ultimate strength (UTS) is the breaking point of the wire. These points on the graph occur whether the force is compressive, tensile, or shearing.

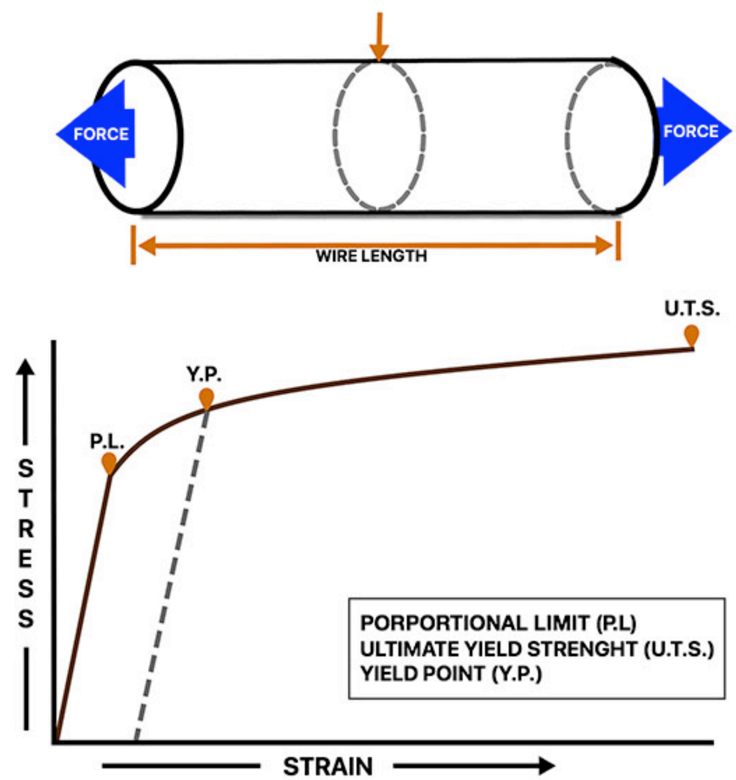


Figure 3–6. Stress-strain curve for a wire under tension.

Ductility and malleability

Ductility and malleability are indicative of the ability of metal to be bent, contoured, or otherwise permanently deformed (reshaped). More precisely, *ductility* is the ability of a material to withstand permanent deformation under tensile stress without fracturing. If a metal or alloy can be formed into a wire, that is, shaped under tensile strain, it is said to be ductile. In contrast, *malleability* is the ability of a material to withstand permanent deformation under compressive stress without rupturing. If a metal can be hammered or rolled into a sheet, that is, shaped under compressive strain, it is said to be malleable. These characteristics are measured as a *percent of elongation*. The higher the percent of elongation, the more likely you will be able to burnish the metal.

Flow

Some materials continue to deform permanently under a load, even though the load (stress) is held constant. The slow bending of a glass rod under its own weight when it is supported at its two ends is an example of this. This change is called *flow*. It may also be referred to as *creep* or *slump*. In dental materials, flow is generally measured under compressive stress and has been used to evaluate the tendency of dental waxes or gold alloys to deform (flow) under a constant load.

Hardness

Surface hardness, for dental purposes, is generally measured in terms of its resistance to scratching or indentation. The three tests used to measure surface hardness are listed in the table.

Surface Hardness Tests and Explanations

Test	Explanation
Brinell	In performing the Brinell test, a small steel ball is pressed against the material to be tested and a predetermined compressive force is applied. After the load is released, the size of the indentation in the material is measured, and the results are expressed in terms of the Brinell hardness number (BHN). The softer the material, the larger the indentation and the smaller the BHN number. The stronger the material, the smaller the indentation and the higher the BHN.
Rockwell	This differs from the Brinell test in that it uses a diamond shape instead of a steel ball. It is often used to measure the hardness of the chrome alloys. Material hardness is designated by a Rockwell hardness number (RHN).
Vickers	This employs the same principle of hardness testing as the Brinell test uses. However, the Vickers test uses a diamond in the shape of a square-based pyramid, rather than a steel ball. This test is quite suitable for determining the hardness of quite brittle materials; therefore, it has been used for measuring the hardness of tooth structure. Recently, this test has replaced the Brinell hardness test because it is better suited for measuring a wide range of hardness values and materials. The value for this test is expressed as a Vickers hardness number (VHN).

Distortion

Whenever a substance is permanently deformed, there are stresses and strains present. Compressing or stretching these stresses causes internal rearrangement of the atomic structure of the material, which leaves it in a state of tension. With the passage of time, particularly in the presence of heat, the materials tend to relax and the tension is eased. Relaxation is the atoms' attempt to return to their original equilibrium positions. The resulting change in shape or dimension is known as *distortion*.

Because dimensional changes can result in the misfit of a precise dental restoration or prosthesis, the phenomenon of relaxation and the resulting distortion is very important in dentistry. For example, dental waxes tend to relax at room temperature after being bent or molded. The resulting distortion can be very important to the technician if that wax has been used to create a very precise crown pattern.

Thermal properties

The ability of a material to conduct heat is known as *thermal conductivity*. It is measured by determining the rate that heat can be transmitted through a given cross-sectional area of a specimen of the material and the higher the value, the greater the thermal conductivity.

Metals are excellent conductors of heat and have high thermal conductivity. Acrylic resin is a heat insulator and has a low thermal conductivity. In constructing a complete denture, a high rate of thermal conductivity is desirable so the patient may have a more normal sense of hot and cold while eating. This is one of the advantages of a cast metal base denture over an entire acrylic denture. A disadvantage is the amount of heat conducted by a metal crown to the pulp. Because metal is a good conductor, and the enamel and dentin (both good thermal insulators) are reduced, heat is readily transmitted to the pulp, causing sensitivity or discomfort. This is alleviated by the insulating properties of cement.

Thermal expansion is *the rate that a material expands or contracts with temperature changes*. It is usually measured in terms of the linear coefficient of thermal expansion, which is the increase in length of a material per unit length when the temperature is increased by 1°C. If two different materials expand exactly the same amount every time their temperature changes, there would be little reason to consider thermal expansion. However, this is not always the case in the dental laboratory environment. It is because of the different values of thermal expansion that casts separate from their mountings. Thermal expansion also distorts inlay wax.

Adhesion

Adhesion is the force that causes unlike molecules to attach to each other. The retention of artificial dentures is probably dependent, to some extent, on adhesion between the denture and saliva, and between the saliva and soft tissue. In order for adhesion to take place, the materials being joined must be in intimate contact. The adhesive action of liquids involves the interplay of wetting and surface tension.

Wetting

Wetting is the characteristic of a liquid flowing easily over the surface and coming into contact with all of the small irregularities that may be present. The wetting characteristics of a solution are generally determined by measuring the angle formed by the solution when a drop of it is placed on the surface. This measurement is called the *contact angle*, and it is depicted in figure 3–7.

Figure 3–7. Contact angle.

Water placed on a clean surface will flow freely and have a low-contact angle and good wetting qualities. When placed on a waxed surface, water will form drops. Each drop has a high-contact angle and poor wetting qualities. When a liquid has a low-contact angle on a solid, the liquid is said to “wet” the solid well. A solution with ideal wetting qualities will spread out into such a thin film that the contact angle will be zero.

When a liquid resists wetting another material, it’s because the surface atoms have a greater attraction for each other than for the opposite material. A *debubblizer* (surface tension reducer) is used to reduce the surface tension of a material to enhance the liquid’s flow characteristics. The debubblizer may be applied to wax or with special solutions, mixed with the gypsum product.

217. Biological limitations

What do we mean by “recognizing biological limitations” as they apply within our specialty? Here you’ll learn the physical properties of teeth, the stresses of mastication, and the factors affecting dental materials.

Physical properties of teeth

Many of the mechanical properties of the human tooth structure have been measured, but the reported values vary markedly from one investigation to another. Undoubtedly, the differences are due to the technical problems associated with preparing and testing such minute specimens, in some instances less than 1 millimeter in length.

The properties of enamel vary somewhat with its position on the tooth (e.g., enamel on the cusp is stronger than that on the side of the tooth). Also, the properties vary according to the histological structure. It turns out that the enamel is stronger under compression in a direction parallel to the enamel rods than it is in a direction perpendicular to the rods. On the other hand, the properties of the dentin appear to be quite independent of structure, regardless of the direction of compressive stress. For example, the average compressive strength of enamel reported is in the range of 3,850 kilograms per square centimeter (55,000 pounds per square inch).

Tensile properties of tooth structure have also been measured. For example, dentin is considerably stronger in tension than enamel, 525 kilograms per square centimeter (7,500 pounds per square inch) and 105 kilograms per square centimeter (1,500 pounds per square inch), respectively.

Although the compressive strengths of the enamel and dentin are comparable, the proportional limit and modulus of elasticity of enamel are higher than the similar properties of dentin. The higher *modulus of elasticity* (less flexibility) results in a lower *modulus of resilience* for enamel in comparison with dentin.

Stresses during mastication

As discussed previously, the actual biting stresses during mastication are difficult to measure because of their dynamic nature. A number of studies have been conducted to determine the biting force. One average value reported was 77 kilograms (170 pounds). However, it varies markedly from one area of the mouth to another and from one individual to another. Although there is considerable overlapping, biting force generally is higher for males than for females, and is greater in young adults than in children. The table shown here gives the areas of the mouth with the average kilograms and pounds of pressure.

Biting Force Tooth Areas and Pressure Weights		
Area	**Kilograms of Pressure**	**Pounds of Pressure**
Molar	41 to 91	90 to 200
Premolar	23 to 46	50 to 100
Canines	14 to 34	30 to 75
Incisors	9 to 25	20 to 55

If a force of 77 kilograms (170 pounds) is applied to the cusp apex over an area equivalent to .039 square centimeters (0.006 square inch), the compressive stress is 1,969 kilograms per square centimeter (28,000 pounds per square inch [psi]). If the area were smaller, then the stress would be proportionately greater.

Clearly, the nearly instantaneous forces incurred during mastication are much higher than those measured in these studies. The reader may have had the painful experience of suddenly biting on a small, hard object in food, such as a slug when eating wild game. The slug may be dented, and in some cases, a tooth may be injured. On the other hand, the slug cannot be dented when a conscious effort is made to apply a static force with the jaws.

Normally, the energy of the bite is absorbed by the food bolus during mastication, as well as by the teeth themselves. Nevertheless, the design of the teeth is somewhat of an engineering marvel in that they are generally able to absorb such impact energies. For example, the modulus of resilience of dentin is greater than that of enamel; thus, it is better able to absorb impact energy. Enamel is a brittle substance with a comparatively high elasticity modulus, a low proportional limit, and a low modulus of resilience. However, supported by the dentin, with its ability to deform elastically, teeth seldom fracture under normal occlusion. The principle of backing a brittle substance with a plastic material in order to increase the flexibility of the former under load is well known by the structural engineer.

The compressive properties of the more popular restorative materials used in operative dentistry are usually less than those of natural teeth. Only the metallic materials (e.g., amalgam and gold alloy) approach the properties of your natural teeth. Although the gold alloy modulus of resilience is the lowest of the materials considered, it effectively resists forces of mastication because of its considerable toughness. It has a relatively high proportional limit and high ductility, both of which contribute to its toughness. When the gold alloy is subjected to high stress, it tends to deform rather than fracture. Amalgam has a higher modulus of resilience than gold does, but it is a brittle material. Thus, in instances of extreme stress, it fractures rather than deforms.

Criteria of selection

Since most of the physical properties we have described have been obtained on specimen shapes and sizes, and under types of stress that are dissimilar to oral conditions, in some cases, the question that immediately arises is how dental materials can be selected by the dentist on the basis of these properties. The engineer employs similar criteria for the selecting construction materials, such as for a bridge. The engineer has an advantage over the dentist because he or she knows beforehand, at least approximately, what the expected stresses on the structure will be. Furthermore, the expected stress values are multiplied by a safety factor so that the structure will be able to withstand a certain amount of overstress.

Unfortunately, the magnitude of the mastication forces is not known to the extent that the dentist can predict the stresses to which the restorative prosthesis will be subjected. However, general ideas of the physical properties necessary for the materials used can be obtained with experience. For example, if a certain gold alloy has given service in a certain type of dental restoration over a considerable period, it is reasonably certain that the alloy is satisfactory. The physical properties (e.g., proportional limit, modulus of elasticity, and tensile strength) of the alloy can be determined and these values can serve as criteria for selecting other materials for similar use.

The physical properties can also be used as criteria for improving restorative prostheses. For example, a dentist discovers that a certain patient has permanently deformed a dental prosthesis in service. Seemingly, this patient exerted great stresses in the prosthesis during mastication. If this happens, the logical procedure is to remake the prosthesis with material possessing a higher-proportional limit and the BHN.

The use of such criteria has also been valuable to the manufacturer in developing new and improved materials. With such criteria, the success or failure of the material can largely be predicted, and the patient saved much discomfort and ill health. The various American Dental Association specifications are also determined using this criteria as a basis. The most valuable selection criterion for the dentist is whether the particular material meets the requirements of such specifications. If it *does* meet these requirements, the dentist can be sure that the material will be satisfactory when it is used properly.

Factors affecting dental materials

The mouth is a harsh environment—one ideally suited for destroying food. Materials being used in the mouth are subject to great forces and are exposed to abrasive and corrosive conditions continuously. In addition to having the ability to resist these conditions, the material must also be as follows:

- Biologically compatible with the physiological needs of the patient.
- Dimensionally stable.
- Esthetically pleasing.
- Corrosion resistant.
- Nonconductive.

Biological characteristics

The biological characteristics of dental materials are closely related to their physical properties. Materials that possess ideal physical and chemical properties may be unsuitable as dental material if they do not also perform within the biological limitations imposed by the oral cavity. To meet the biological limitations, the material must be harmless to people and preserve or restore the health of their teeth and oral tissues. A substance that is potentially poisonous to people is obviously not suitable as a dental material, despite the desirability of its other characteristics. Few dental materials are totally inert or completely harmless to people and their dental tissues; therefore, all materials must be used properly, with appropriate precautions followed. Materials used in the mouth must be nonirritating to the soft tissues. They must be neither mechanically nor chemically damaging, nor cause an allergic or sensitizing effect.

Dimensional stability

The mouth temperature fluctuations can be as great as 100 to 150 degrees Fahrenheit (°F) within a matter of seconds when an individual is drinking hot coffee or eating ice cream. Restorative materials must be able to withstand such radical changes. They must have, as nearly as possible, the same rates of thermal conduction, expansion, and contraction as those of natural dental tissues.

Esthetically pleasing

Restorations must resemble the natural dentition as closely as possible. This demands color matching and color stability, plus materials that can be shaped to resemble the dentition, or be designed not to be highly visible. Color stability is important. The restoration may be subjected to many substances such as tea and coffee that will tend to stain it. Chemical action within the oral environment may cause changes within the material itself that result in discoloration.

Corrosion resistant

Acidity in the mouth varies greatly. Some foods like citrus fruits are very acidic, while others are quite alkaline. In addition, acid is liberated when bacteria act on food debris present in the mouth. So, the surfaces of the teeth and the dental restorations are constantly in contact with the corrosive effects of substances that are acidity or contain alkaline. In such an environment, some materials tend to discolor, corrode, and deteriorate.

This deterioration is a critical point because some materials used as restorations will develop a minute space at the marginal seal. If left untreated, fluids, microorganisms, and debris from the mouth will penetrate the outer margins of the restoration (microleakage) and progress down the walls of the preparation, through the dentin, and into the pulp. If the leakage is severe, the pulp will be continually irritated. This could cause the tooth to remain sensitive following placement of the restoration.

Nonconductive

Metals should be nonconductive. Conductive metals can create a galvanic shock. Small electrical currents, created whenever two dissimilar metals contact in the oral cavity, cause galvanic shock.

Because both metals are wet with saliva, an action similar to that in a battery is created. When the two metals touch, an electrical current is formed, creating a small shock. A similar effect could occur when the edge of a silver fork touches a restoration.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

215. The nature of matter

1. How is matter defined?

2. Name the physical states of matter.

3. What is equilibrium?

4. What is the simplest form of matter?

5. What is nonuniform from point-to-point, and composed of two or more compounds that have been mixed physically?

216. Physical properties of dental materials

1. What is stress?

2. What is an object said to be when it regains its original shape when stress is removed?

3. What is the breaking point of a wire?

4. Define malleability.

5. What are the three tests used to measure surface hardness?

6. What is the main difference with the Vickers test when compared to the Brinell test?

7. How is thermal conductivity measured?

8. What is wetting?

217. Biological limitations

1. When is enamel stronger?

2. Describe biting force.

3. What factors affecting dental materials must the prescribing dentist take into consideration?

4. What must restorative materials possess to withstand radical changes in the mouth?

5. Why must metals that are placed in the mouth be nonconductive?

3–2. Color

Color plays a major role in your duties as a dental laboratory technician. Whether assisting during a shade selection or characterizing a prosthesis, you will deal with color on a sophisticated level. A patient will notice an incorrect shade immediately. Thus, to ensure patient satisfaction, you should understand:

- What is color.
- How color is seen.
- What influences color perception.

218. The elements of color theory

As you study the elements of color theory, you will look, in sequence, at color terminology and color mixing with regard to their applicability within our field.

Color terminology

Understanding a few common terms makes learning easier, as with any subject. The definition and nature of light is an essential part of color.

Light

Think of light as energy radiating away from its source as a wave-particle. Wave-particles have specific lengths that are referred to as wavelengths. The light wavelengths you are able to see range from between 380 and 760 nanometers (nm). A nanometer is one ten-millionth of a centimeter. This range is called the *visible spectrum*. It is the only part of the electromagnetic spectrum visible to the human eye. Figure 3–8 is a simplified version of the visible spectrum that indicates the colors and their lengths.

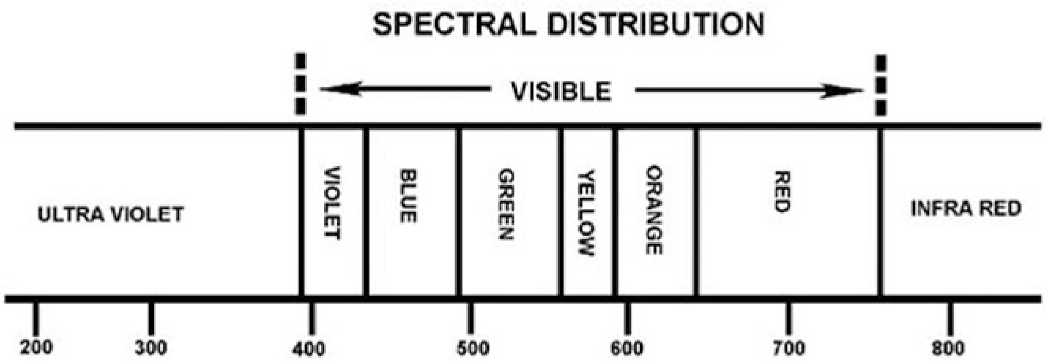


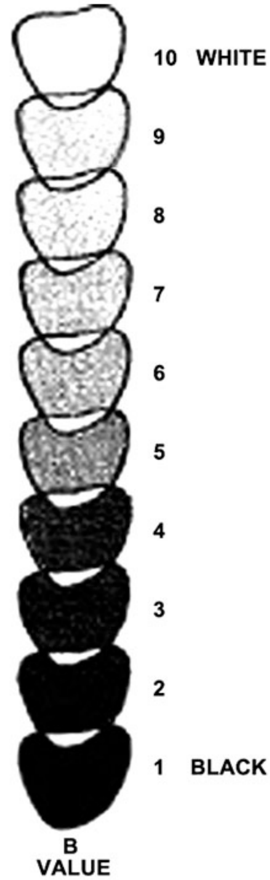
Figure 3–8. The visible electromagnetic spectrum.

Color variables

Hue, chroma, and value are the three variables used to describe color and are explained in the table.

Color Variables, Explanations, and Examples		
Variable	**Explanation**	**Illustration**
Hue	The name of a color. It is a label for that part of the spectrum you see as violet, blue, green, and so forth.	
Chroma	The strength of the hue. Texts describe chroma as saturation, intensity, or concentration of a hue. Based on the scale in fig. 3–9, you can describe a hue as having a high or low chroma; thus, red has high chroma, and pink has low chroma.	

Color Variables, Explanations, and Examples		
Variable	**Explanation**	**Illustration**
		 **Figure 3–9. Chroma scale.**
Value	The amount of reflection a hue has. Like chroma, value is often referred to by different terms—brightness, darkness, or lightness. According to the scale in fig. 3–10, you would describe a tooth with a 3 rating as low value, or less reflective. A tooth with a high-value rating is a more reflective, brighter tooth.	

Color Variables, Explanations, and Examples		
Variable	**Explanation**	**Illustration**
		 **Figure 3–10. Value scale.**

Color-mixing System Types and Descriptions	
System	**Description**
Additive	The additive color-mixing system concerns light and the resulting colors created by adding two or more wavelengths of light. Combining all of the colors in the visible spectrum produces white light.
Subtractive	The subtractive color-mixing system creates colors with pigments, not light. The pigments absorb all other hues except the one reflected back to the viewer. Black is produced by mixing all the colors of pigments in the subtractive system.
Partitive	The partitive color-mixing system is a fusion of the additive and the subtractive color-mixing systems.

Color mixing

Now that you're familiar with the basics of light and color terminology, you can enter the gray area of color-mixing. Patients require natural appearing restorations. How well you accomplish this requirement depends on your technical ability and knowledge of light and color. Part of this knowledge includes the three color-mixing systems.

You should be most concerned with the subtractive color-mixing system in the dental field, so that is what the following information will include.

Subtractive color-mixing

In the subtractive color-mixing system, color is produced with pigments that absorb all other hues except the one reflected back to the viewer. A red ball reflects red light because all of the other colors in the light striking the ball are absorbed by the ball's pigment. Only the color red is reflected away from the ball and is visible to the viewer.

Color characteristics

The primary colors are red, yellow, and blue. The secondary colors are orange, green, and violet. Figure 3–11 shows their arrangements. One primary opposes one secondary color, and they are called c*omplements*. The complementary pairs are red and green, yellow and violet, blue and orange. You can produce gray by mixing a pair of complements.

Take a look at another example using the red ball to explain why this happens. If the red ball is absorbing all visible light wavelengths except red, and then green is applied over the red, the green will absorb all of the visible light wavelengths except green. In other words, the red has absorbed the green and the green has absorbed the red. Now, no wavelengths are being reflected (visible) and you see gray. Gray contains a proportion of black and black is the absence of visible light.

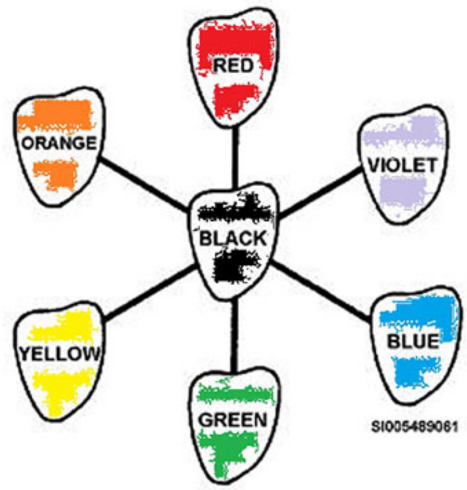


Figure 3–11. The subtractive color wheel.

Color pigments

If an object has color, it contains pigment. Figure 3–12 has white light, or daylight, striking a leaf. The pigment within the leaf absorbs the red, yellow, orange, blue, and violet. Green is not absorbed and is reflected away from the leaf by the pigment.

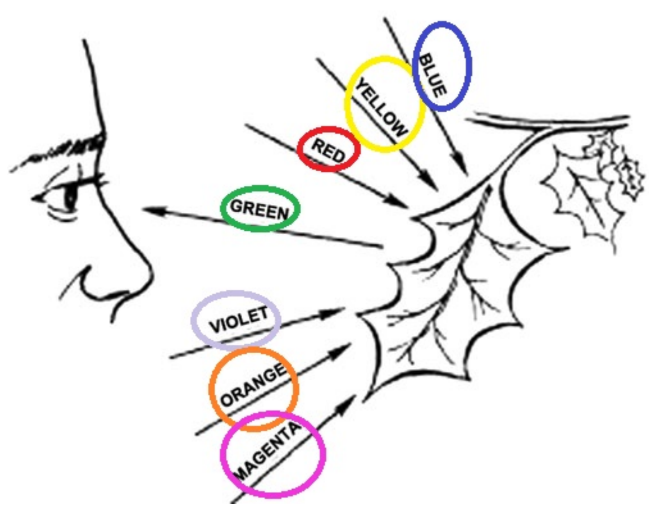


Figure 3–12. Color reflection.

Pigment acts like a filter. A pigmented object must have a full spectrum of light striking it to reflect the correct color. A filter placed between the pigmented object and the light source affects the object's reflected color. Figure 3–13 shows a red filter subtracting all color, except red, from the light.

The remaining red light strikes a normally yellow tooth and is reflected as red. In white light, the tooth is a high-value yellow; in red light, it is a high-value, low-chroma red. The tooth is unable to absorb all of the red light and reflects the remainder, resulting in a lower chroma.

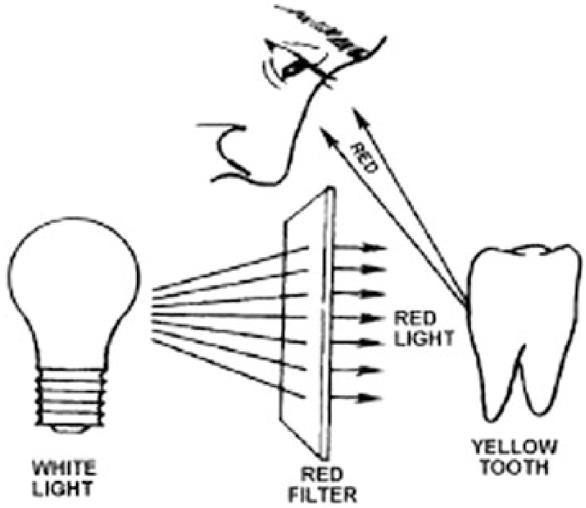


Figure 3–13. The effect of an unbalanced light source on an object.

You will notice a couple of characteristics of color, particularly when you begin working with porcelain stains. For example, the chroma and value of each hue will vary from hue to hue. An example is mixing yellow and pink to make orange. Due to pink's higher chroma, you will most likely use less pink than yellow to make orange. You must adjust the amount of hues according to their values and chroma. The second thing you'll notice is value reduction. Whenever you mix pigment, the value of the resulting hue is reduced. That happens because the amount of reflected light is reduced as more of the direct light is absorbed.

219. Factors influencing color perception

As you look at the factors influencing color perception, you need to comprehend the nature of receptor cells and the effect the environment has on how you perceiver color.

Receptor cells

A discussion of color requires some information on how the human eye receives color. We begin the discussion by focusing on two types of receptor cells—rods and cones.

Figure 3–14 shows the cell's location at the back of the eye.

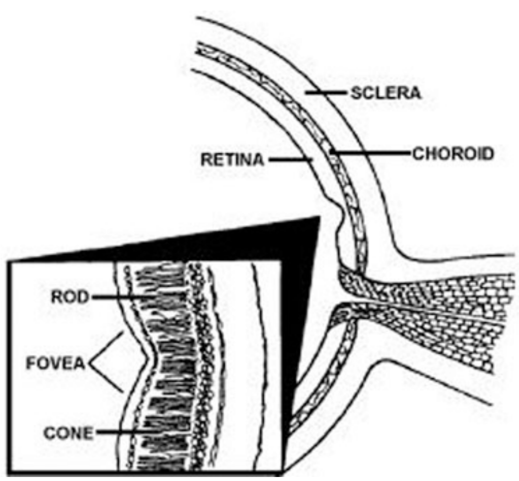


Figure 3–14. Rod and cone cell location.

Rods

The rods transmit black, white, and gray images to the optic nerve. A black and white television produces similar images. These images are achromatic, or colorless. Rods are responsible for value perception since they do not transmit color.

Approximately 100 million rod cells are in the retina, or inner eye layer. You can find most rod cells concentrated outside the periphery of the macula lutea that surrounds the fovea centralis. The macula lutea and fovea centralis are the focal point for images received in the eye. Rods are stimulated by very low-light levels, such as moonlight. The rods are used for your night vision, which is highly sensitive to value. You can use your rods when judging value by squinting.

Although a good judge of value, your rods do not produce a sharp image as your cones do. The haziness of night vision is caused by rod cells connected to the optic nerve in bunches (fig. 3–15).

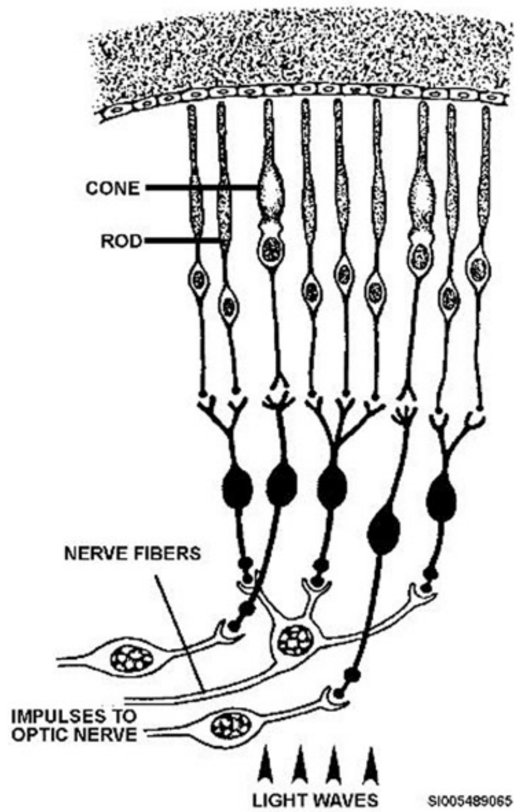


Figure 3–15. Receptor cell connection to the optic nerve.

Cones

The cone cells transmit color, or chromatic, images. There are 6 million cone cells in each eye, many fewer than rod cells. There are 50 thousand cone cells in the fovea centralis (fig. 3–14). This is important because the fovea is in direct line with the pupil. This means that the image being viewed is focused directly on the fovea. Combine this with each cone cell's direct connection to the optic nerve and you have a very well defined color image.

As you recall, the rod cells' locations and connections reduce the quality of night vision. You do not notice this poorer value perception during the day because your day vision is dominated by color. To transmit color images to the optic nerve, cone cells need more light stimulation than do rod cells. Because cone cells are not stimulated by extreme low levels of light, you are unable to see color at night. Figure 3–15 shows receptor cell stimulation and connection to the optic nerve.

An interesting phenomenon occurs when cone cells are overstimulated. This overstimulation is caused by staring at a colored object for a long period. This results in what is known as *cone cell fatigue*. When cone cells are fatigued, they produce a "negative after-image" which is the cone cells' way of compensating for overstimulation. When overstimulated, cone cells transmit the image in its complementary colors. This image will last until the cone cells recover. You can prove this by staring at a high-value yellow object for one minute. Then, switch your gaze to a white paper. You should see a faintly blue-violet image.

Obviously, seeing blue when you are trying to match a yellow tooth is going to affect the color of the restoration. As your cone cells fatigue, it will be increasingly difficult to choose between two similar hues. You can use cone fatigue to enhance shade matching. The hues of teeth range between yellow and yellow-orange. The complement color is blue.

Before matching shades, stare at a blue card. This sensitizes your cone cells to the yellow hue of teeth. Refer to the card frequently during the procedure to maintain sensitivity. Additional shade-matching techniques are discussed in a later unit.

Environment

Your surroundings and light affect the color you perceive. The colors emitted by overhead lighting affect the perceived color of an object. Walls, floors, ceilings, and clothing also have an impact on the color around you.

Light source

Can light affect perceived color? Yes, it can, and the process of selecting a service dress uniform provides a good example.

When selecting your jacket, pants, or skirt, it is important to compare them for a color match; however, you should not compare them inside. Most office and retail lighting sources are either incandescent or fluorescent. Either of these light sources projects a dominant light wave that can affect how you see a given color. That is why you should always use natural lighting to compare colors. This phenomenon that occurs when two objects match in one lighting condition but do not match in other lighting conditions is called metamerism (fig. 3–12).

Metamerism must be considered when matching restorations with natural teeth because you are faced with two very different materials (i.e., materials that reflect two different spectrums of light). This is represented in fig. 3–16, line B, which depicts the results of an analysis of the light reflection of a Vita Lumin B–3 shade tab. The reflected light is mostly yellow-red, or orange. Figure 3–16, line A, is an analysis of a bioform B–51 shade tab, which has a large amount of yellow in its reflection.

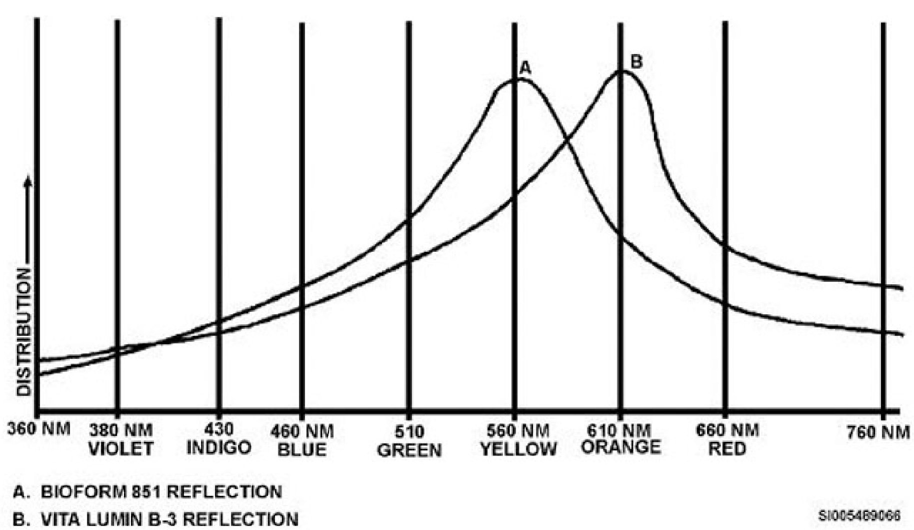


Figure 3–16. Light reflection of two different shade tabs.

In both of these cases, violet, blue, and green were absorbed to a greater degree than the yellow, orange, and red since a higher amount of reflection occurs. These were reflected in varying amounts from the two shade tabs. It is impossible to have the same spectral distribution between two materials, even though they appear to be an exact match. Placed under different light sources at different times, the color match will differ.

Figure 3–17 shows an estimate of the spectral distribution of fluorescent, incandescent, and natural daylight. Most fluorescent lights emit more blue than any other color in their spectrum. In contrast, incandescent lights emit in the yellow-to-red range of the spectrum. So, when a shade guide is viewed in each of these lights, the perceived shades are altered. For example, an orange shade tab in incandescent light appears blue-white in fluorescent light.

If artificial light were the problem, you would think that going outside in *balanced* natural light to view the shade guide would solve the problem. Unfortunately, daylight's spectrum is *never* truly balanced. Line C in figure 3–17 indicates the best spectral balance you can expect. This will last for a short time, around noon on a slightly overcast day. Yellow, orange, and red dominates the spectrum for the rest of the day.

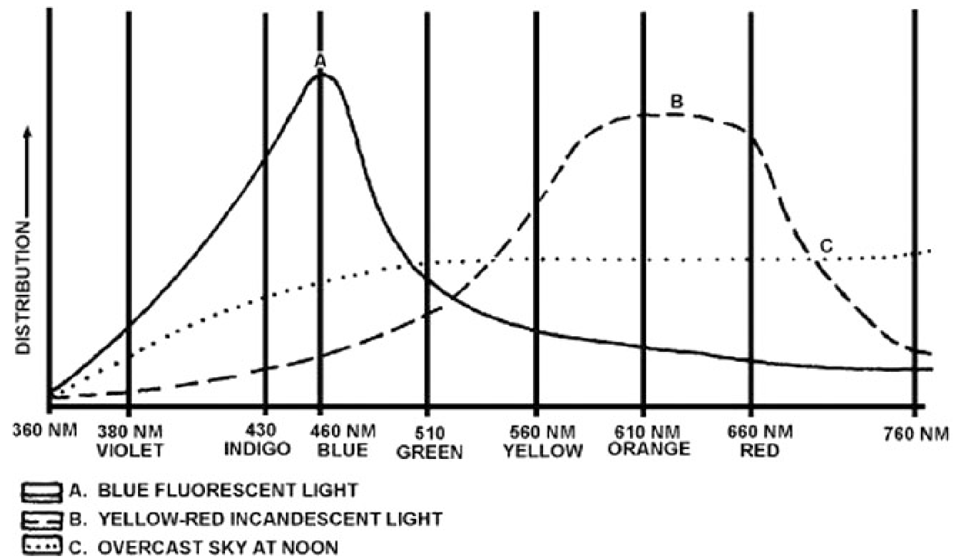


Figure 3–17. Fluorescent, incandescent, and natural light spectral distribution.

The problem seems insurmountable, but there is hope! Color-corrected fluorescent lights are available. These lights have a color–rendering index between 90 and 100, with 100 representing the best spectrum balance. So, a tube with a 90 or better rating is excellent for shade matching. Therefore, the problem is solved.

Light source quantity

One way to measure light is by foot-candles (fc). One fc equals the illumination of an area 1 foot around a candle. According to *Criteria for Design and Construction of Air Force Health Facilities*, a laboratory should have a *minimum* illumination of 70 fc in general areas and ceramics. The minimum required for fine-detail work is 200 fc. This immediate 130 fc difference in work areas could overstimulate your cone cells. Cone fatigue and accompanying negative after-image can be produced by a more than 100-fc difference in work areas. To avoid this, illuminate your shade matching and general areas to a minimum of 100 fc.

Surroundings

Reciprocity and contrast are the major factors involved in how your surroundings influence color perception. Imagine a ball of light traveling through a pinball machine. As the ball travels downward to the flippers (the viewed object), it strikes bumpers (other objects). The bumpers struck by the ball of light then reflect light. The colors these bumpers emit are reflected off other bumpers, the board, and you; in fact, anything they are close enough to illuminates. If these colored lights are complementary and too far apart to mix, they contrast and intensify each other's hues.

Reciprocity

Reciprocity is how the hue of one object is affected by the reflected hue of the nearest object. Refer to fig. 3–18 as you read the following. The red lip and yellow tooth, on the left, reflect their true hues. As the lip descends, the tooth appears to turn orange and then red-orange. This change in the tooth's appearance is due to how the reflected red light enters and reflects off the yellow tooth where it mixes with the reflected yellow light. Less direct yellow light reaches the tooth as the lip descends. This causes the increasing amount of red light to mix with the decreasing amount of yellow light, creating orange.

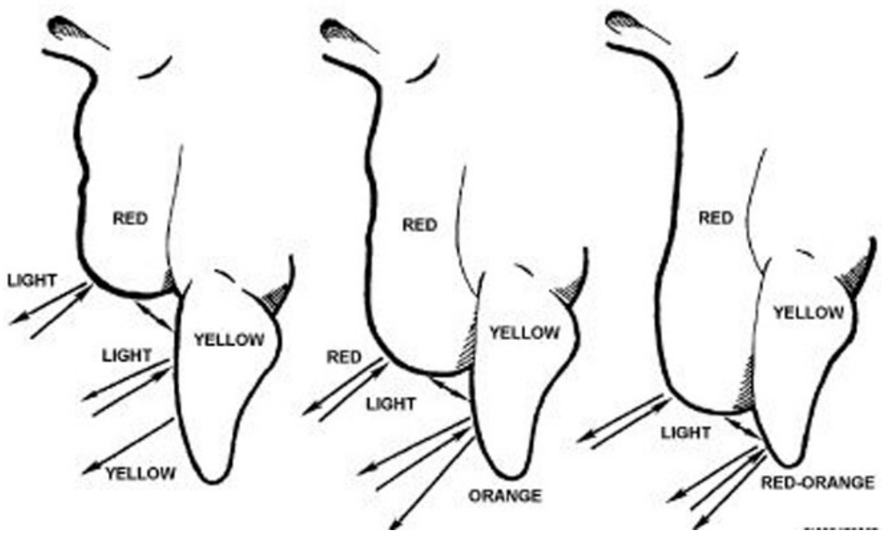


Figure 3–18. The reciprocal effects of objects on one another.

Of course, this example is exaggerated to explain reciprocity and its effect on teeth. The actual change is much more subtle and sometimes hard to notice. How greatly the hue of one object is affected by the reflected color of the nearest other object depends on these factors:

1. Hues and chroma of the objects involved.
2. Amount of transparency of the object.
3. Surface texture of the object.
4. Quantity and quality of light.
5. Proximity of the objects.

Figure 3–19. Value contrast.

Contrast

Hue, chroma, and value of teeth can be affected in another way—value contrast (fig. 3–19). A low-value tooth on a white background looks dark because the background reflects more light than the tooth does. The same value tooth looks lighter on a black background for the opposite reason.

Chroma contrasts occur when complementary colors are placed next to each other. The farther apart on the color wheel, the more they raise each other's chroma. You can see this by placing a red and then a green object of similar chroma on a white surface. Then, place the red and green objects next to each other. Their colors will be more intense than when they are viewed separately because the complements increase each other's chroma. There can be an apparent hue change along with the value and chroma changes. Surrounding colors, as well as the viewed object, cause cone fatigue and accompanying negative after-image.

Teeth are surrounded by red tissue. As your cones fatigue, they transmit a green image to your optic nerve. The tooth will appear slightly green and lower in value. A lower-value selection will invalidate the shade match.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

218. The elements of color theory

1. What wavelengths of light can the human eye see?

2. Match the terms in column A with the color variable they best describe in column B. Items in column B will be used more than once.

Column A	Column B
____ (1) Brightness.	a. Hue.
____ (2) Saturation.	b. Chroma.
____ (3) Color name.	c. Value.
____ (4) Strength.	
____ (5) Darkness.	
____ (6) Concentration.	
____ (7) Lightness.	

3. Describe the additive color-mixing system.

4. What results from mixing all of the additive colors?

5. What results from mixing all of the subtractive colors?

6. What color-mixing system is the most important in the dental field?

7. What are the primary and secondary colors?

8. How is the color gray produced?

9. Briefly describe value reduction.

219. Factors influencing color perception

1. What are rods responsible for and why?

2. What causes night vision haziness?

3. What do the cones cells transmit?

4. Describe negative after-image.

5. What lighting should be used when comparing colors and why?

6. What is metamerism?

7. What light is best for shade matching?

8. How can an excess difference of 130 fc between rooms affect your vision?

9. Explain the reciprocal affect objects have on each other.

10. How can you increase the chroma of two complementary colors?

Answers to Self-Test Questions

215

1. Anything that occupies space and has weight or mass.
2. Solids, liquids, or gases.
3. The position at which the forces of repulsion and attraction become equal in magnitude (but opposite in direction) is the normal, or equilibrium, position of the atoms.
4. Elements.
5. Mixtures.

216

1. This is the internal reaction or resistance within a body to any externally applied force. It is what occurs within a material when a force is applied from the outside.
2. Elastic.
3. Ultimate strength.
4. It is the ability of a material to withstand permanent deformation under compressive stress without rupturing.
5. (1) Brinell.
   (2) Rockwell.
   (3) Vickers.
6. It uses a diamond in the shape of a square-based pyramid, rather than a steel ball.
7. By determining the rate that heat can be transmitted through a given cross-sectional area of a specimen of the material and the higher the value, the greater the thermal conductivity.
8. The characteristic of a liquid flowing easily over the surface and it coming into contact with all of the small irregularities that may be present.

217

1. Under compression in a direction parallel to the enamel rods than it is in a direction perpendicular to the rods.
2. It varies markedly from one area of the mouth to another, and from one individual to another. Although there is considerable overlapping, biting force generally is higher for males than for females, and is greater in young adults than in children.
3. Biologically compatible with the physiological needs of the patient, dimensionally stable, esthetically pleasing, corrosion resistant, and nonconductive.
4. As nearly as possible, the same rates of thermal conduction, expansion, and contraction as those of natural dental tissues.
5. Conductive metals can create a galvanic shock; small electrical currents, created whenever two dissimilar metals contact in the oral cavity, cause galvanic shock.

218

1. Those that range between 380 and 760 nm.
2. (1) c.
   (2) b.
   (3) a.
   (4) b.
   (5) c.
   (6) b.
   (7) c.
3. It concerns light and the resulting colors created by adding two or more wavelengths of light.
4. White.

5. Black.
6. Subtractive.
7. The primary colors are red, yellow, and blue; secondary colors are orange, green, and violet.
8. By mixing a pair of complements.
9. Whenever you mix pigment, the value of the resulting hue is reduced. That happens because the amount of reflected light is reduced, as more of the direct light is absorbed.

219

1. For value perception because they do not transmit color.
2. Rod cells connected to the optic nerve in bunches.
3. Color, or chromatic, images.
4. It is the cone cells' way of compensating for overstimulation. When overstimulated, cone cells transmit the image in its complementary colors, and this image lasts until the cone cells recover.
5. Natural lighting because incandescent or fluorescent lighting affect how you see color.
6. The phenomenon of two objects matching in one lighting condition but not in others.
7. Color-corrected fluorescent lights with a color–rendering index of 90 and over.
8. It could overstimulate your cone cells causing cone fatigue.
9. The hue of one object is affected by the reflected hue of the nearest object.
10. By placing the objects next to each other because they complement each other's chroma.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

51. (215) In crystalline solids, the atoms form regular, long-range lattices; however, noncrystalline solids form localized, short-range lattices with a/an
    a. definite melting point.
    b. structure similar to metal.
    c. absence of any atoms between lattices.
    d. number of disordered units between lattices.

52. (215) The equilibrium of atoms is determined by the position where
    a. repulsion and attraction of the atoms become equal.
    b. repulsion and attraction of the atoms become unequal.
    c. attraction of the atoms is stronger than the repulsion.
    d. repulsion of the atoms is stronger than the attraction.

53. (215) Which type of matter is non-uniform from point-to-point?
    a. Mixture.
    b. Element.
    c. Solution.
    d. Compound.

54. (216) What is any push or pull upon matter?
    a. Stress.
    b. Strain.
    c. Force.
    d. Hardness.

55. (216) The *internal* reaction or resistance within a body to *any* externally applied force is called
    a. strain.
    b. stress.
    c. elasticity.
    d. ultimate strength.

56. (216) What term is used to describe the body’s ability to assume its original shape again after being changed or deformed under stress?
    a. Flow.
    b. Ductility.
    c. Elasticity.
    d. Malleability.

57. (216) A high rate of thermal conductivity is desirable with a complete denture because
    a. the acrylic resin is a thermal conductor.
    b. a metal denture base is a thermal insulator.
    c. the heat is transmitted to the dental pulp quickly.
    d. the patient has a more normal sense of hot and cold.

58. (217) A tooth’s enamel resists fracture under normal occlusion because
    a. it is the hardest substance in the body.
    b. the modulus of elasticity allows for flex.
    c. it is supported by the more elastic dentin.
    d. it’s periodontal ligaments hold the tooth firmly in place.

59. (217) The condition where small electrical currents are created when two *dissimilar* metals contact in the mouth is known as
    a. flow.
    b. microleakage.
    c. galvanic shock.
    d. temperature effects.

60. (218) Which are the three variables used to describe color?
    a. Hue, chroma, and value.
    b. Pigment, hue, and value.
    c. Value, pigment, and hue.
    d. Chroma, value, and pigment.

61. (218) Which color-mixing system is a fusion of the additive and the subtractive?
    a. Partitive.
    b. Parietal.
    c. Passive.
    d. Partial.

62. (218) When you mix two color pigments, the value of the resulting hue is
    a. terminated.
    b. reduced.
    c. absorbed.
    d. increased.

63. (219) When you stare at a colored image too long, the eye’s cone cells become overstimulated. This results in the image being transmitted in
    a. white.
    b. black.
    c. primary colors.
    d. complementary colors.

64. (219) What must be considered when matching restorations with natural teeth?
    a. Metamerism.
    b. Light refraction.
    c. Value reduction.
    d. Spectral reflectivity.

65. (219) When complementary colors are placed side-by-side, they affect each other by
    a. neutralizing each other.
    b. decreasing each other’s value.
    c. decreasing each other’s chroma.
    d. increasing each other’s chroma.

Please read the unit menu for unit 4 and continue ➔

Unit 4. Dental Materials

THE SCIENCE OF DENTAL MATERIALS is a complex subject. On the basic level, knowing how to manipulate a material correctly usually ensures a successful appliance. But, to perform at the journeyman level, you must know the characteristics of the materials as well as how the materials react with their environment. A working knowledge of these principles will help prevent mistakes. Also, if things do go wrong, you will have a better chance of determining the cause of the failure and the corrective action.

NOTE: Parts of the material in this unit were adapted from the *Science of Dental Materials*, by Ralph W. Phillips, D.S C.

4–1. Impression Materials

Impression materials are used to register or reproduce the form of teeth and oral tissues. There are three types of materials—rigid, plastic, and elastic.

Increasingly, elastic materials are taking the place of rigid and plastic materials. Most dentists primarily use hydrocolloids and elastomeric impression materials.

220. Differentiating hydrocolloid impression materials

When colloid (a gelatinous substance) is dissolved in water, the particles attract water molecules and swell in size, forming a *hydrocolloid*. Since hydrocolloids are solids suspended in liquids, they are considered *lyophilic* or liquid attracting. The primary advantage of hydrocolloids over other impression materials is their elasticity and ability to be removed from tooth undercuts.

There are two types of hydrocolloids:

1. Reversible hydrocolloid.
2. Irreversible alginate (hydrocolloids).

Reversible hydrocolloid

Reversible hydrocolloid is reusable, highly accurate, and elastic; it is a very reliable impression material. It is used as a duplicating material when making removable dental prosthesis frameworks. The reversible hydrocolloid impression materials are compounded from thermally reversible hydrocolloid gels. The solid state of colloids is known as a *gel*.

Upon heating, the gel breaks down to form a viscous liquid called a *sol*. When cooled to room temperature, the sol returns to gel. This gives the material its reusable quality. Approximately 80 percent of reversible hydrocolloid is water, 17 percent is agar (a seaweed extract), and the remainder is comprised of modifiers and other material. The large amount of water in reversible hydrocolloid has a great impact on the dimensional stability of the material.

Properties

When removed from the cast, reversible hydrocolloid begins exuding water immediately. The water evaporates causing the gel to shrink. Some dentists immerse the impression in a water bath of 2 percent potassium sulfate to stop water loss and act as a gypsum hardener. The problem with immersion is that as the material absorbs water, a dimensional change results. Therefore, you need to store the impression in a container with 100 percent humidity when the impression cannot be poured immediately. This storage method is the most effective way to prevent dimensional change.

A problem common to all types of impression materials is the stresses and strains created in the materials when impressions are removed from the mouth or cast. It is estimated that a 10 percent distortion (deformation) occurs when the impression is removed from the mouth or cast (fig. 4–1). Relaxation then takes place to return the material to a state of equilibrium. However, there is never a 100 percent return to the original state.

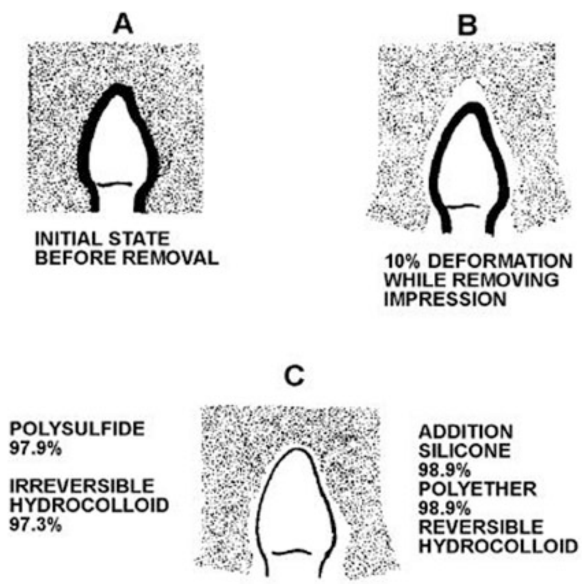


Figure 4–1. Relaxation amounts of different impression materials.

Borax, a chemical modifier, is added to hydrocolloid impression materials to resist tearing during the removal of the impression. Borax retards the set of gypsum. Combined with the large amount of water in the impression, borax can cause a soft surface on a cast. This can be overcome by soaking a reversible hydrocolloid impression in a hardening solution like two percent potassium sulfate. The incorporation of an accelerator, or commercial hardener, in the gypsum will also harden the cast. If the materials are handled properly, there should be no need for hardeners or accelerators. Most laboratory-caused problems are the result of excess water in the impression, delay in pouring the impression, and the cast being removed from the impression too soon.

Manipulation

Reversible hydrocolloid is a very accurate and sensitive material. The success of the impression depends on handling the material properly. The material must be handled exactly according to each manufacturer's directions.

The dimensional stability of reversible hydrocolloid is poor. Impressions of this material must be poured immediately and placed in a humidor with 100 percent relative humidity. If this is not possible, then wrap the impression in a moist paper towel, being careful not to distort the impression. Attention to proper handling procedures is worthwhile as casts poured from agar materials exhibit the most bubble-free surfaces. These procedures are as follows:

1. Boil the material to its sol state.
2. Allow the impression to set completely in a water-cooled tray.
3. Remove the master cast from the mold with a snapping action, always, to prevent distortion.
4. Pour the mold immediately.
5. Wash the gel after each use to remove gypsum particles before reusing.
6. Store the material in a plastic bag, after it has been washed, to prevent water from evaporating.
7. Be sure to follow the manufacturer's directions and replace the material when it becomes unfit for further use.
8. Never store the material in water because this reduces its strength.

Irreversible alginate

The second kind of hydrocolloid material is irreversible, which means it can only be used once. This colloid is typically referred to as alginate. Alginate's elastic capability is necessary to duplicate the natural contours found in dentition accurately. Alginate is used primarily for making impressions to include both teeth and soft tissue. Since alginate was developed for a technique of impression-making that is rapid and simple, the accuracy is not as precise as those obtainable with reversible hydrocolloid or rubber-based materials. Its main use is for study casts and master casts for removable dental prosthesis.

Properties

Although not as accurate as reversible hydrocolloid, alginate does have an advantage in mechanical strength due to its large quantities of inert fillers. Thicker mixes result in increased strength with some loss in the ability to reproduce surface detail. An alginate impression, like reversible hydrocolloid impressions, is subject to dimensional change and water loss or gain. Because of this, it must also be poured immediately to prevent water loss and distortion. If this is not possible, temporarily store the impression in a humid atmosphere. An alginate impression will shrink continuously if stored in air, and expand if stored in water.

Another important characteristic of alginate is its ability to flow into undercuts. The easy flow of alginate must be kept in mind with maxillary impressions. A patient with a high palate needs a tray that extends into this high vault. Without that type tray, the excessive alginate thickness will slump. This produces a cast with a lower palate than the patient actually has. This problem usually occurs when a stock tray is used to take an impression for a treatment partial or a Hawley appliance. The appliance fits the cast but rocks in the mouth. Filling the palate of the tray with utility wax, just short of palatal contact, produces adequate support for the alginate.

Manipulation

Alginate is prepared by mixing a measure of powder into a precise volume of water, determined by the manufacturer's directions. It is then mixed 45 to 60 seconds by rapidly pressing the material against the sides of the bowl. The next step is loading the tray. The tray must allow 3 mm of space for both reversible and irreversible hydrocolloids to ensure adequate strength and surface detail reproduction. This is important to remember when a spacer material is being adapted to a cast for custom tray fabrication. Custom trays for alginate are usually perforated to lock the material in place.

Either leave the impression in place, in the mouth or on a cast, for the recommended time after the alginate loses its stickiness (i.e., reaches the gel state). The ultimate alginate strength is reached at four minutes. However, waiting that long could prevent a snapping removal of the impression and cause distortion. The alginate could break teeth off the cast, or even dislodge a patient's teeth when removed.

When the impression arrives at the laboratory, treat it with care. Do not place the impression unsupported on the bench top, or allow the surface to be exposed to air, for any period. As is true of both hydrocolloid materials, you must prepare the impression according to infection control guidelines and store it in a humid atmosphere if you're unable to pour the impression immediately.

221. Distinguishing synthetic impression materials

There are four synthetic impression materials commonly used in the Air Force. Rubber-based impression materials are made of three varieties—polysulfide, addition (vinyl) silicone, and polyether materials. These synthetics differ in their chemical composition and reaction, but are similar in most other characteristics. The elastic property of these materials allows them to be used in impressions for fixed dental prosthesis, removable dental prosthesis, and complete dentures. The fourth synthetic material is impression compound. However, compound is rarely used in undercut areas because of its plastic nature.

Rubber-based materials

Rubber impression materials are supplied as pastes in collapsible metal tubes. One tube contains the *base* while the other contains an *accelerator* or *catalyst*. When mixed in appropriate amounts, the mixture hardens to form a synthetic rubber.

Properties

These rubber-based materials have three advantages over other elastic impression materials. They are:

1. The strength of these materials is very high in comparison to the hydrocolloids.
2. They are not affected by variations in storage conditions (e.g., time and temperature).
3. Their ability to reproduce fine details and transfer them to cast or die (accuracy).

Three of these rubber-based materials and their characteristics are in the table below:

Rubber-based Materials, Descriptions, and Operational Characteristics		
Material	**Description**	**Working Characteristics**
Polysulfides	Are identified by their usually dark color of one of the two pastes and the opaque mix. This material has a sulfur-type odor. If mixed incorrectly, the impression will have streaks in it that affect dimensional stability.	Mixing time is 45 to 60 seconds, with a 5-minute working time. The impression must not begin setting before placement in the mouth. If the 5-minute working time is exceeded, the resulting impression will have inadequate expansion, producing a smaller cast. The impression must set completely before being removed from the mouth and poured no later than 1 hour after removal.
Addition (vinyl) Silicones	Are generally lighter in color, translucent when set, and have a much more subdued odor.	The dimensional stability of the addition-type silicone is superior to all other rubber-based materials.
Polyethers	Have lighter colors than polysulfides, but are somewhat darker than the silicones.	The working time and setting time are much shorter than for the other two rubber-based materials. Polyether is comparable to polysulfide for long-term

Rubber-based Materials, Descriptions, and Operational Characteristics		
Material	**Description**	**Working Characteristics**
		dimensional stability. Unlike polysulfide; however, polyether will absorb water. **NOTE:** Most Air Force clinics stock polysulfides, rather than silicone or polyether materials, due to its success rate and extremely low cost compared to other comparable materials.

Manipulation
Several technical considerations should be examined when working with these materials. When constructing custom trays, you should provide a uniform thickness of two mm for the material. A slightly roughened tray surface will increase the adhesion between the impression material and the butyl rubber cement. If you need to remove the impression material from a custom tray, use an eyedropper of monomer to dissolve the cement, and then peel away the impression material.

Impression compounds
Today, compounds have a limited use in the Air Force as an impression material. Usually, they are used for molding the border of acrylic custom trays (an improvised custom tray for complete dentures), securing broken pieces of a denture, cast mountings, and so on.

Properties
Following are the properties of impression compounds:

1. They are classified as a plastic impression material, not elastic material, because they will not release from an undercut area without permanent deformation.
2. They are thermoplastic materials that soften to working consistency by placing them in a hot water bath or by heating them over a flame.
3. They have a high thermal expansion coefficient; consequently, a high amount of contraction when cooling.
4. They are supplied in stick and cake forms.

Manipulation
The thermal properties of impression compounds have a great influence on the technique for their use. Because of the low-thermal conductivity of these materials, they are difficult to heat and cool. If a large quantity is needed, it’s suggested that a water bath be used. A water bath has a controlled temperature and it uniformly heats the compound. An open flame could burn the compound and affect its working properties.

The impression should be poured immediately since the compound is noncrystalline and easily warped by internal stresses. To remove the master cast from a compound impression, soak the impression in warm water for several minutes. This will soften the compound and aid in removing the impression without damaging the cast.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

220. Differentiating hydrocolloid impression materials

1. What is the major advantage of hydrocolloids over impression compounds?

2. Why is reversible hydrocolloid a reliable impression (duplicating) material?

3. If reversible hydrocolloid cannot be poured immediately, what must you do to ensure the impression will not distort?

4. Why would a patient with a high palate need a tray that extends into a high vault?

5. What is a drawback in waiting for alginate to reach its ultimate strength?

221. Distinguishing synthetic impression materials

1. What are the four types of synthetic impression materials commonly used in AF dental clinics?

2. What three advantages do rubber-based materials have over other elastic impression materials?

3. What happens if polysulfides are mixed incorrectly?

4. Which rubber-based material has a dimensional stability that is superior to all other rubber-based materials?

5. Describe the properties of impression compounds.

6. If a large quantity of impression compound is needed, what material should the lab technician use?

4–2. Gypsum Products and Investments

Gypsum products serve a wide variety of uses in dentistry, such as those listed here:

- As stone for pouring impressions.
- To flask complete dentures.
- To mount casts.
- As a binder in soldering and low-heat casting investments.

NOTE: High-heat investments use phosphate as a binder.

The raw mineral gypsum is known chemically as *calcium sulfate dihydrate*. When this mineral is heated, the water evaporates and the calcium sulfate dihydrate becomes a calcium sulfate hemihydrate. If water is added to the gypsum powder, the process is reversed, and the hemihydrate resumes the dihydrate form again.

As you know, when this reaction takes place, heat is generated. A chemical reaction of this type is known as an *exothermic reaction*. The heat that is generated during the setting of the gypsum is equal to the heat required to make the gypsum powder. All of the gypsum dentistry products are chemically hemihydrated; however, they differ in the way their method of manufacture controls the crystal size and arrangement.

222. Examining gypsum products

To examine gypsum products properly, as they relate to your specialty, you need to look at:

- Their manufacturer.
- Basic physical properties.
- Manipulation.
- Some common problems at the impression pouring bench.

Manufacture

Gypsum is converted into model plaster by grinding it into small particles and then heating it slowly in open vats to drive off the water from hydration. Under a microscope, the plaster appears as rough, irregular crystals. Each crystal contains a definite proportion of water. This is called *water of crystallization*. The amount of water eliminated by heating has a bearing on the behavior of the plaster when it is again mixed with water in the laboratory. Three different types of gypsum are used in the laboratory and they are described in the table below:

Types of Gypsum and their Descriptions

Type	Description
II, dental stone (plaster).	Is produced by heating in an open kettle and yields crystals that are porous and relatively weak.
III, dental stone (cast stone).	Is produced in a closed container under an elevated steam pressure, and yields denser, prism-shaped crystals. The result is a stronger, less porous dental stone that requires less water when mixing. An idea of the particle size and amount of water needed to make a cast can be gained by weighing the same amounts of type II and III dental stones. Although they weigh the same, there will be a larger volume of type II stone compared to type III stone due to the larger size type II stone particles.
IV, dental stone (die stone).	Is produced by boiling in a kettle of 30 percent calcium chloride solution. These improved stones have crystals that are smaller and more random-shaped. Less water is needed because of their lower surface area. Also, the smaller particles form crystals closer together than the other dental stones. Using less water results in a product with a higher compressive strength. Other chemicals are added to control the setting expansion during the hardening process.

NOTE: We do not discuss type I (also a dental plaster) because of its limited use in the laboratory.

Physical properties

The three physical properties of a gypsum-based product are setting expansion, setting time, and strength.

Setting expansion

The first property, setting expansion, affects the dimension of all gypsum products whether it’s a cast, investment mold, or mounting. The expansion must be controlled and compensated for since it will ultimately affect the final restoration. An excessive amount of water can decrease expansion. Inversely, less water actually increases expansion. This is because decreasing the amount of water to powder ratio causes the forming crystals to push against each other.

Normal setting

A gypsum product expands predictably when it is allowed to solidify unconfined in a normal room temperature environment. A setting expansion that takes place under these conditions is called normal setting expansion. A gypsum material sets up in air or in contact with water. The setting expansion varies depending on the conditions to which the material is exposed. For example, the expansion can be increased by immersing the setting gypsum in water. Since the supply of water is never depleted, the crystal formation is limited only by its chemical composition.

Hygroscopic setting

Hygroscopic setting expansion occurs when a gypsum material is allowed to solidify under water. A hygroscopic expansion is expected to exceed a normal setting expansion more than doubly. In some dental procedures, a gypsum product solidifies in limited contact with water (e.g., an investment is sometimes made to set against a wet ring liner). The expansion is greater than the normal setting expansion, but it is not as great as a hygroscopic expansion.

Thermal

This kind of expansion occurs as a result of a gypsum product being heated. The amount of thermal expansion is proportional to the temperature.

Setting time

There are two setting points for gypsum. The initial set occurs when the crystal lattice is formed and some of the water is absorbed to create the crystals. The liquid mix changes to a fragile solid within minutes of mixing. The initial set can be recognized by the loss of gloss from the stone. The final set occurs within 24 hours. There are several factors you should consider that affect the setting time and they are listed below:

1. Preformed gypsum particles in a dirty bowl accelerate the set.
2. Unless a retarder is added by the manufacturer, a fine particle-size gypsum, like type IV, will set quicker.
3. The setting time is lengthened by increasing the amount of water-to-powder ratio lengthens because it delays the gypsum crystals from interlocking.
4. Prolonged mixing breaks down formed crystals, which reform quicker than new crystals; thereby accelerating the mix.
5. The effect of water temperature varies from one brand of stone to another. However, universally, a water temperature exceeding 120 degrees Fahrenheit (°F) retards the set.

Strength

The strength of the dental stone increases rapidly as the material hardens after the initial set. However, the free-water content of the cast definitely affects its strength. That is why we recognize two strengths of gypsum—wet and dry. The wet strength is the strength when excess water is left in the cast after the gypsum reaches the initial set. Dry strength is reached in 24 hours as the cast dries. Although the dry strength is two or more times that of the wet strength when completely dry, porosity and micro porosity conspire to weaken the cast. A micro porosity caused by a water pocket is shown in figure 4–2.

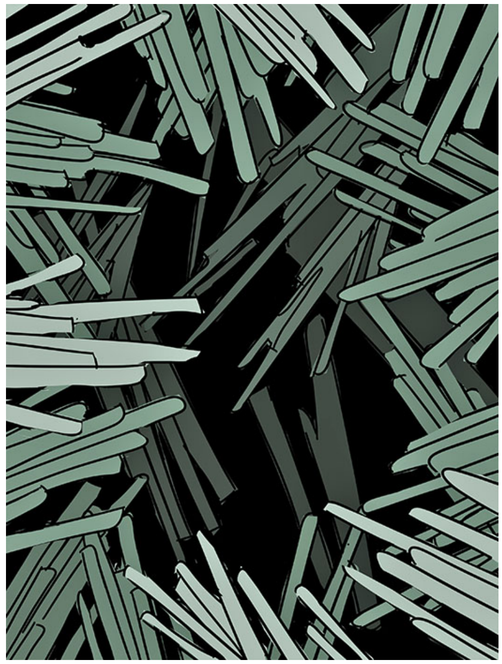


Figure 4–2. Fracture surface of stone.

Strength can be increased by using less water in the mix. Conversely, increasing the amount of water-to-powder ratio reduces the stone's compressive and tensile strengths due to the interlocking of the crystals being lessened. The increased space left by the greater amount of water inhibits the connection of the crystals. Another risky thing to do is to add water to a thick mix. This disrupts the crystal structure, causing a weaker cast. The same is true of adding powder to a thin mix. Over mixing also disrupts crystal formation and weakens the cast.

Manipulation

Like all dental materials, dental stone is formulated to compensate for other dental materials. The cast removed from an impression is not an exact representation of the patient's mouth. Dimensional changes in both the impression and stone have subtly altered the cast. These changes are minor if the manufacturer's directions are followed and proper technique is used. But, as you have already read, varying the amount of water can alter dental stone. Changes that are even more drastic take place when accelerators and retarders are added.

An *accelerator* is a chemical substance that reduces the setting time of the gypsum, while a *retarder* will lengthen the setting time. Besides affecting the setting time, they reduce both setting expansion and crushing strength. For this reason, avoid their use if at all possible. If you decide to use an accelerator, use slurry water because it is easier to control its effect. Refer to the following table for a brief overview of the physical properties affecting gypsum materials.

Gypsum Materials and their Physical Properties					
Material	**Setting Time**	**Heat Resistance**	**Normal Setting Expansion**	**Hygroscopic Setting Expansion**	**Thermal Expansion**
Plaster	Initial: 7-13 min. Final: 45 min	(Does not apply)	Highest	(Does not apply)	(Does not apply)
Stone (hydrocal)	Initial: 8-15 min. Final: 45 min.	(Does not apply)	Medium	(Does not apply)	(Does not apply)

Gypsum Materials and their Physical Properties

Material	Setting Time	Heat Resistance	Normal Setting Expansion	Hygroscopic Setting Expansion	Thermal Expansion
Die Stone	Initial: 15 min. Final: 25-30 min.	(Does not apply)	Low	(Does not apply)	(Does not apply)
Soldering investments	Initial: 8-12 min. Final: 20 min.	Matched to melting temperature of the solder	Lowest	(Does not apply)	Matched to the expansion of the metals being soldered
Gold Casting Investments	Initial: 15 min. Final: 25-60 min.	Matched to the burnout and casting temperature of the metal being cast	Thermal Expansion Technique: semi hygroscopic and thermal expansion must compensate for gold shrinkage (1.4 percent) Hygroscopic Expansion Technique: hygroscopic expansion, pattern wax expansion, and thermal expansion must total about 1.4 percent		
Chrome Nickel system investment	Initial: 12 min. Final: 35-45 min.	Special, gypsum bound investment for Ticonium system	Combine semi hygroscopic and thermal expansion must compensate for shrinkage of chrome nickel (about 1.7 percent)		

Some simple *do's* and *do not's* for handling stone are as follows:

Do's and Don'ts for Handling Stone

Do's	Don'ts
1. Use the proper ratio of water-to-powder recommended by the manufacturer; always weigh the powder and measure the water.	1. Store gypsum products in unsealed containers for prolonged periods.
2. Use only uncontaminated powder, and avoid any that have crystallized lumps.	2. Whip or fold the powder mix with water. To do so increases the chance of incorporating air.
3. First, place water in a mixing bowl, and slowly sift powder into the water to avoid the induction of air bubbles.	3. Repeatedly remove the spatula from the mix; this causes air entrapment.
4. Use good equipment; scarred or cracked mixing bowls sometimes contain particles that can spoil the mix.	4. Pour an impression contaminated with blood or other debris. Blood and other organic materials retard the set. Use the casts within 45 to 60 minutes after pouring.
5. Vacuum mix to eliminate air bubbles and increase the crushing strength.	5. Forget to read the manufacturers'

Do's and Don'ts for Handling Stone	
Do's	**Don'ts**
6. Pour immediately after mixing.	instructions.
7. Use a saturated calcium sulfate dihydrate solution (SDS) when soaking casts for duplication; this prevents loss of surface detail on the casts.	6. Use casts to make calcium SDS.
8. Wait approximately 2 hours before trimming. Allow the cast to dry 24 hours to develop the full strength before working with the cast. Dry strengths are much higher than wet strengths.	
9. Use older stock before using newer stock.	
10. The spatula should be rounded to match the bowl's contour so that the spatula can wipe the surface of the bowl readily.	
11. Mix dental stone with a stiff blade spatula; flexible blades "drag," causing a less thorough mix.	
12. Gently vibrate the mix to remove bubbles; vibrating for long periods or at a high setting will induce air bubble in the mix.	

Once the cast is set and trimmed, you will occasionally need to soak it for flasking, duplicating, or performing other procedures. Anytime a cast requires soaking, place it in a saturated *calcium* SDS. This is a clear, true solution of water with a maximum amount of dissolved, dihydrate (set) gypsum product. Cast surfaces exposed to SDS do not erode nearly as much as when exposed to tap water. Saturated calcium SDS is made by placing fragments of set gypsum casts in water for about 5 days. After the solution has settled, pour off the clear portion so that you can use it later to soak casts.

Prior to weighing the stone for the mix, ensure that the powdered stone has been stored properly. Gypsum products are somewhat sensitive to changes in the relative humidity of their environment. Even the surface hardness of casts could change slightly with the relative humidity of the atmosphere. Casts made from thinner mixes appear to be affected more than casts made with thicker mixes. Setting time for the mix is decreased if stored in 70 percent or greater humidity level in an open container. The higher humidity begins crystalizing the gypsum powder. If this continues, the crystallization continues so that, ultimately, the setting time is increased because the water cannot form new crystals.

Common problems at impression pouring bench

Before addressing some commonplace errors encountered at the impression-pouring bench, review a few basic concepts about gypsum. The phrase "less is more" is an appropriate summary of these ideas as you review the following:

1. If more water is used, the crushing strength will be reduced and the setting time will be longer.
2. If less water is used, the crushing strength will be increased and the setting time, shortened.
3. The longer or faster the mixture is spatulated, the greater the crushing strength and the shorter the setting time.
4. Be careful not to over mix because it breaks down the last crystals forming and reduces the strength of the final product.
5. Poor mixing technique, over vibrating, and releasing the mechanical spatulator vacuum all incorporate air into the mix.

Bubbles, or porosity, in a cast is a major problem. Not only can they ruin the accuracy of an otherwise perfectly good cast, but they also weaken the cast. From a material's perspective, the causes just cited and the characteristics of the materials can cause bubbles. A surface tension reducer may be needed if your pouring technique is not the problem.

Carelessness or the dental stone can cause breaking teeth off a cast when separating it from an impression. Even though die stone has the greatest compressive strength, it has the least tensile strength, making it the most brittle of all dental stones. This is an important point to remember when separating a full mouth rehabilitation cast with long, skinny preparations.

A soft cast surface is caused by too much water in a mix, or pouring an impression with residual water left in the impression. Too much water in a mix causes another problem—weak casts. The weakness is demonstrated when a cast fractures when it is soaked in water. Fractures of this nature will occur in any temperature water.

223. Differentiating types of investments

A study of the types of investments must lead us into identifying and differentiating the composition of those that are gypsum-bonded and phosphate-bonded.

Gypsum-bonded investments

Gypsum-bonded investments are commonly used for investing patterns of fixed restorations to be cast in conventional golds.

Composition

The composition of gypsum-bonded investments can be divided into three main components, as described in the table below.

Gypsum-bonded Investment Materials, Functions, and Explanations		
Material	**Function**	**Explanation**
Binder	Holds the particles together.	Consists of some form of calcium sulfate hemihydrate and accounts for approximately one third of the total weight. This type of gypsum is similar to that used in type III dental stone.
Refractory	Provides the temperature resistance and most of the thermal expansion.	Its material is a form of silica, which is usually quartz or cristobalite. It provides expansion during heating. The refractory content of most gold alloy casting investments ranges from 60 to 65 percent.
Chemical modifiers	Control the strength, setting expansion, and thermal expansion.	They are added to investment materials to provide certain physical and mechanical properties. These modifiers usually include graphite or copper powder, boric acid, sodium chloride, and coloring agents. They are added in small quantities to provide a reducing atmosphere for the gold, strength, setting expansion, and thermal expansion properties.

Properties

Since this investment is gypsum-based, it has characteristics similar to dental stone. Changes in the water/powder ratio of investments cause the same changes they would cause in dental stone. However, there are a few characteristics unique to gypsum-bonded investments. The setting expansion is greater than dental stone to compensate for gold shrinkage. Gold shrinkage is compensated for in other ways. The exothermic reaction causes an expansion of the wax pattern that enlarges the mold cavity. The hygroscopic setting of the investment also compensates for gold shrinkage as it increases setting expansion to nearly six times the expansion that occurs in air (bench setting). The amount of expansion in either technique is reduced by any of the following:

- Too much water in a mix.
- Shortened mixing time.
- Old investment being used beyond its shelf life.

Water also affects the investment's thermal expansion in the following ways:

- Investment set in open air has greater thermal expansion than hygroscopically set investment.
- Thermal expansion is reduced by lessening the water in the mix.

Manipulation

Gypsum-bonded investments are generally used for casting type III golds and should not be heated to temperatures greater than 1300°F. Doing so liberates sulfur gas, causing porosity and a rough surface in the casting. There are three type of casting investments, and each uses a different manipulation technique that is listed below:

1. One type is used with the thermal investing and burnout technique.
2. Another type is primarily used with the hygroscopic technique.
3. The third type is used in the Ticonium technique for removable dental prosthesis construction. **NOTE:** This type contains only quartz as a refractory material.

Certain procedures used to construct or repair fixed dental prosthesis require the use of a soldering investment. These materials are similar in composition to casting investments, except they lack the casting investment thermal and setting expansion properties. Expansion is the key to remember here because undue expansion would alter the relationship of the soldered units. Never use solder investment for investing wax patterns or gypsum-bonded inlay investment for soldering.

The following shows what should be *done* and what should be *avoided* or *prevented* while handling gypsum-bonded investments:

Do's and Don'ts for Handling Gypsum-Bonded Investments	
Do's	**Don'ts**
1. Keep Investment well mixed by turning containers over and up repeatedly before use, then let them settle for a few minutes.	1. Store investment at elevated temperatures.
	2. Heat gypsum-bonded investments to burnout temperatures higher than 1300°F, as the binder will decompose, leaving a rough casting.

Phosphate-bonded investments

Phosphate-bonded investments are commonly used to cast investing patterns in pressable ceramics and metals with a high melting range, such as e.max and metal-ceramic alloys.

Composition

Phosphate-bonded investments, like gypsum-bonded investments, contain a binder, refractory material, and chemical modifiers. The difference is the binder, which consists of magnesium phosphate. Phosphate-bonded investments are capable of resisting temperatures up to 1,740°F and are much stronger than gypsum-bonded investments. Therefore, phosphate-bonded investments are also more difficult to recover.

Properties

Mix phosphate-bonded investments with water or with a special liquid composed of a silica sol liquid. This special liquid regulates the amount of setting expansion and, to a small extent, thermal expansion because it increases the amount of silica contained in the mixture. This liquid is normally pre-mixed with distilled water to obtain the desired amount of expansion. It is the ratio of special liquid to distilled water that determines the total amount of expansion. For instance, 7 milliliter (ml) of special liquid, increasing concentration, to 2 ml of distilled water results in more expansion than a ratio of 6 to 3 ml.

Manipulation

Phosphate-bonded investments are used to cast high-melting gold alloys and base-metal alloys that melt above 2,370°F. These alloys are used to construct metal-ceramic restorations and removable dental prosthesis. When using base-metal alloys for fixed restorations, it may be necessary for you to experiment with using a 100 percent special liquid to obtain the desired expansion. Phosphate-bonded investments used in removable dental prosthesis have only quartz as a refractory material.

Phosphate-bonded soldering investments are easier to recover and lack the thermal expansion of the phosphate-bonded casting investments. These special-purpose investments are used in soldering high melting alloys. However, phosphate-bonded casting investment mixed with distilled water may be used for soldering purposes.

Use the following lists of *dos* and *don'ts* while handling phosphate-bonded investments:

Do's and Don'ts for Handling Phosphate-bonded Investments	
Do's	**Don'ts**
1. Allow ammonia gases to escape from the investment mix prior to investing to prevent bubbles on the casting.	1. Allow the spatulated mix to heat up before investing, to avoid distortion of the wax pattern.
2. Increase the special liquid concentration in the premixed solution to increase compensation for casting shrinkage.	
3. Allow the investment to bench set the recommended time after investing prior to burnout.	
4. Keep investment liquids refrigerated, but do not freeze; discard if silica precipitate forms at the bottom of the container.	

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

222. Examining gypsum products

1. What three types of gypsum are used in the dental laboratory?

2. Why is setting expansion critical in all gypsum products?

3. How can the setting expansion of gypsum be increased?

4. Describe the effect of different setting points for gypsum.

5. Why does increasing the water-to-powder ratio lengthen setting time?

6. What are some common problems caused by separating a cast from the impression? Why?

223. Differentiating types of investments

1. What three categories can gypsum-bonded investments be divided in to?

2. What component controls the strength, setting expansion, and thermal expansion?

3. How does water effect thermal expansion?

4. Why should you mix phosphate-bonded investments with a special liquid composed of silica sol?

5. When using phosphate-bonded investments why should the ammonia gases be allowed to escape from the investment?

4–3. Waxes

Waxes play an important role in each prosthesis you make. Their most important uses are as patterns for the resin molds and cast metal restorations. You will also use them to hold the pieces of a broken denture together, or to box an impression. The way you handle waxes determines whether they are a help or a hindrance.

The types of wax that are most commonly used in dentistry include the following:

- Inlay.
- Baseplate.
- Casting.
- Sticky.
- Utility.
- Boxing.

In this section, you'll study the significant properties of these waxes and their applications. You will also study the use of undercut wax, disclosing wax, and low-fusing impression wax.

224. Wax characteristics

While seeking to determine the characteristics of wax, your attention will be focused on its composition, melting range, thermal expansion, and distortion. You will study these in the order named.

Composition

The way wax reacts to the environment depends on its composition. The various types of waxes and their interaction with the environment is listed in the table below:

Types of Waxes and their Composition		
Type	**Description**	**Melting Range**
Beeswax	A major portion of baseplate wax and other waxes; it is yellow, brittle, and flows well.	Between 145 to 158°F
Paraffin	A petroleum by-product: is white and soft and is used in all dental waxes.	Between 122 to 158°F
Carnauba	A hard, tough wax used to raise the melting range of paraffin, as well as increase its toughness.	Between 176 to 185°F
Dammar resin	Is added to dental waxes to increase their toughness and smoothness.	Normally liquid at room temperature

In addition to the above waxes, synthetic waxes are now being used to a greater extent than in the past. The improved uniformity of the wax makes it ideal for inlay wax. Synthetic waxes improve the flow characteristics and cohesiveness of inlay waxes, making it ideal for the wax additive technique.

Melting range

Combining natural and synthetic components creates a wax with a melting range that varies by several degrees. This is due to the crystalline and noncrystalline structures of the components. Since wax does not melt at a specific temperature, softening a wax to its molten state requires using an optimal temperature. Manufacturers recommend one temperature to ensure that all components of the wax are molten.

Exceeding the working temperature of some of the wax components causes evaporation, which alters the wax properties. Leaving a wax pot too close to a flame or plunging an overheated instrument into the wax will burn out or evaporate some wax components. White vapors coming from molten wax indicate an excessive working temperature. Another problem is under heating the wax. Since the components melt at different temperatures, under heating causes a nonhomogeneous wax without the desired working properties.

Thermal expansion

Wax has a high coefficient of thermal expansion. Since wax expands a great deal when heated, it also contracts the same amount as it cools. Dimensional changes of this magnitude are frequently responsible for distorted patterns, teeth shift in denture wax-ups, and other problems in the lab. Dipping a die short of the margins and letting it cool will demonstrate the amount of possible shrinkage. Partial denture wax-ups are also vulnerable to shrinkage. Overheating a partial wax-up lingual plate causes it to lift away from the cast as it cools.

Distortion

Overheating, under heating, internal stresses, and relaxation of the wax all contribute to distortion. Distortion is a change in the normal shape or position of an object. Improper heating or frequent reheating of wax causes internal stresses in a wax-up. The wax will relax as its molecules try to return to a state of equilibrium. Relaxation of stressed wax has the potential to cause distortion. Stress is released and distortion could occur when removing a wax-up from the die or cast. Also, stress relief occurs during the initial setting of the investment as the pattern is warmed by the investment's exothermic reaction. Ideally, the pattern will be in a state of equilibrium when it accurately fits the die.

Wax relaxation is directly affected by the wax memory. If the wax is under heated and deformed, the wax will attempt to return to its original shape, as seen in figure 4–3. The bottom part of the figure shows the wax shape after cooling for 24 hours. A wax's memory can be overcome by uniformly heating the entire wax to the correct temperature.

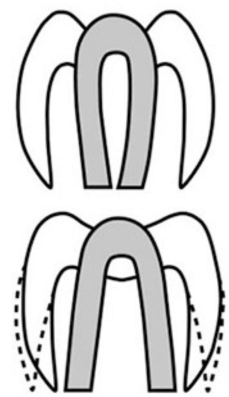


Figure 4–3. Memory potential of wax.

225. Types of dental waxes

Any adequate indication of the types of dental waxes would have to include:

1. Inlay wax.
2. Baseplate wax.
3. Casting wax.
4. Sticky wax.
5. Utility wax.
6. Boxing wax.
7. Other waxes.

Inlay wax

Inlay wax is composed of the waxes listed in the table. The table also describes their purpose or use.

Inlay Wax Composition and Uses	
Type	**Purpose**
Paraffin	Makes up the bulk.
Gum dammar	Improves the smoothness in molding and renders it more resistant to flaking and cracking.
Carnauba	Controls the softening point and hardness of the wax.

There are three types of inlay wax and their usages are listed in this table:

Inlay Wax Types and Uses	
Type	**Uses**
A	A hard, low-flow wax used occasionally in the indirect technique.
B	For the direct technique or for intraoral use.
C	For the indirect technique or for laboratory use.

Inlay wax is used in pattern making for fabricating fixed and removable restorations. Ivory wax is inlay wax without the dye coloring that contrasts the color of the wax with the stone die. Because it does not discolor, the acrylic, ivory wax was once used to make acrylic jacket crowns. Presently, ivory wax is used to cover the exposed porcelain surfaces during a postsolder procedure and for diagnostic wax-ups.

Properties

Inlay wax must be capable of accurately reproducing every small detail of a crown preparation. You must be able to carve the wax, without chipping or fracturing the pattern, and handle the finished pattern without undue risk of fracture. Finally, it must burn out cleanly without leaving a residue.

Manipulation

The best technique is one that limits the amount of stress produced and then limits the distortion that follows. Use the following lists of *dos* and *don'ts* while handling inlay wax.

Do's and Don'ts of Inlay Wax Handling	
Do's	**Don'ts**
1. Keep the wax temperature as uniform as possible throughout the entire pattern-making process.	1. Plunge a heated metal sprue into a wax pattern.
2. Add fresh wax to molten wax to replace ingredients that may have vaporized.	2. Repeatedly remove and then replace a wax pattern on its die, because the margins are likely to distort.
3. Maintain positive pressure on the wax during the cooling of the wax pattern.	3. Store for an extended period at room temperature.
4. Add wax to the die in small amounts to minimize distortion.	
5. Use warm instruments for carving, but not hot enough to cause melting.	
6. Use a combination of waxes—softer waxes in the occlusal and internal areas and harder waxes in the proximal areas—to minimize distortion when the hygroscopic investment technique is used.	
7. Invest a wax pattern immediately.	
8. Readapt the margins if the pattern cannot be invested immediately.	

Baseplate wax

Basically, these materials have the same composition as inlay waxes. However, they do have reduced amounts of hard waxes and increased proportions of waxes such as beeswax. Baseplate wax is supplied in medium and hard composition.

NOTE: The hard grades are used in hot environments to eliminate difficulties that result from stress release. Hard waxes will not flow at high-room temperatures.

Properties

When baseplate wax is used as a pattern for a denture, it is exposed to repeat local heating as the individual teeth are positioned in their proper relationship. The wax is also subjected to a variety of distorting forces as the teeth and the wax are pushed in the desired position. The final wax-up will have a large quantity of residual stresses trapped in it. These waxes are subject to the nature of stress release in the same manner as inlay patterns. As a result, observe the same precautions as with the finished pattern.

Manipulation

When working with baseplate wax, manipulate the wax at or above its softening temperature to avoid creating residual stresses. Also, flask the completed wax-up as soon as possible to capture the greatest degree of accuracy in the setup. There are two things you should avoid doing and they are:

1. Heating with a hot spatula, which causes the wax to pool.

2. Overheating wax with an alcohol torch during flaming.

Casting wax

In addition to inlay wax and baseplate wax, there are a number of other waxes that are used to prepare patterns. Of these, the materials known as *casting wax* are provided in several different forms for pattern fabrication.

Sheet

Sheet waxes are the most common type of casting waxes. They are sold standard square sheets of 24- through 30-gauge thicknesses. They are most often used for the framework with complete and partial dentures. These waxes resemble baseplate wax but are softer and have a greater tendency to adhere when pressed together.

Shape

Shape waxes are waxes sold in long, thin strips that are partially preshaped to aid in constructing uniform patterns for cast removable dental prosthesis frameworks. These pieces are most commonly half-round or round in cross-section and come in a variety of sizes.

Preformed patterns

Preformed patterns of wax are also available. These preformed patterns are used mostly to prepare cast removable dental prosthesis patterns and are sold with a number of preshaped forms in varying sizes mounted on a card. Preformed wax patterns simulating rugae are also available for dentures. Their advantages are that they reduce production time and lessen the chance of incorporating internal stresses in the pattern.

Sticky wax

This is a hard, brittle wax that adheres well to most materials when melted. Sticky waxes consist of a mixture of wax and resins that are not only adhesive, but also have little flow at room temperature. This wax tends to break before distorting. Sticky wax is often used to hold together denture pieces in a specific position. This can be very important in acrylic repairs where a minor shift in the position of two pieces could ruin the outcome.

Utility wax

This soft adhesive wax has many purposes. It is sometimes used to build up areas of impression trays before taking an impression. It is also used to attach boxing wax to an impression before pouring.

Boxing wax

Boxing wax strips are used to wrap around the periphery of an impression tray to form a mold into which dental stone can be poured. When applying boxing wax around hydrocolloid or rubber-based impression materials, take care to prevent distorting the impressions during the boxing procedure.

Other waxes

The other waxes of interest are undercut wax, disclosing wax, and low-fusing wax.

Undercut

Undercut wax is used to block out the area between survey lines on a cast designed for the framework of removable dental prosthesis construction. Another use would be to block out undercuts on a stone die prior to pattern making.

Disclosing

A dentist uses disclosing wax to detect points of unequal pressure when inserting fixed and removable dental prosthesis. This wax will flow away from the pressure points, disclosing them for corrections.

Disclosing wax can be removed easily by scrubbing with wax solvent followed by soapy water in an ultrasonic cleaner.

Low-fusing

Low-fusing wax is similar to disclosing wax in that it flows under pressure in the mouth. It is used as a corrective liner in complete denture and removable dental prosthesis final impressions. As a technician, take care not to touch or distort the tissue side of the impression. Use room-temperature water to rinse the impression.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

224. Wax characteristics

1. What is the melting range of beeswax?

2. Why is the thermal expansion of wax so critical?

3. What are some of the causes of wax distortion?

4. How do you overcome wax’s memory?

225. Types of dental waxes

1. What is inlay wax composed of?

2. Why is hard baseplate wax used in hot environments?

3. What are preformed wax patterns used for in the dental laboratory?

4. How is disclosing wax removed?

4–4. Acrylic Resins

Over the years, many materials have been used as the denture base for a complete or removable dental prosthesis appliance. Today, the most common resin used to construct denture bases is methyl methacrylate, or acrylic resin. Some acrylic resins are manufactured to fill a particular need or purpose. A few of these special-purpose resins are repair resins, crown and bridge resins, denture base stains, tray acrylic, and clear acrylic. While treatment liners and mouth protector materials are not acrylic resins, you will also study them in this section.

226. Denture base acrylic resins

Synthetic resins are normally sold in fine powder (polymer) and liquid (monomer) form. They are mixed together to form a gel, or dough, and then processed into a rigid solid. The polymer is composed of small spherical particles, which are usually colored by adding small amounts of metal oxides, pigments, opacifiers, and short, red rayon or nylon fibers to simulate small blood vessels.

The monomer is composed of individual small molecules capable of joining together to form larger polymer molecules. Because of this, an inhibitor is added to prevent polymerization during storage.

There are two types of acrylic denture-base resins and they are as follows:

1. Heat-cured resins.
2. Cold-cured resins.

Heat-cured resins

The polymer-monomer ratio for most heat-cured resins is 3 to 1 by volume. Mixing the material properly ensures maximum strength, minimum porosity, and good color. The acrylic dough forming time depends on how rapid the monomer diffuses into the polymer. This process can be hurried by placing the mixing jar in warm water, or, if more working time is needed, place the jar in cool water. Be careful not to allow the water to make contact with the acrylic because this contamination will weaken the acrylic.

The curing cycle for heat-cured denture resins requires the flasked denture to be immersed in a water bath with a steadily increasing temperature. This starts the polymerization process. Polymerization occurs at approximately 158°F. As this chemical reaction takes place, heat is given off (exothermic heat), and very high temperatures are reached within the mold. If the denture is short-cured, that is, heated for 1.5 hours at 160°F and then boiled for 30 minutes, these internal temperatures rise much higher than the boiling point of monomer (approximately 212°F). Long curing the denture maintains the mold temperature below the boiling point.

The slower run-up allows the monomer to evaporate before the mold temperature rises near the boiling point. Regardless of how carefully processed, some residual monomer remains in a heat-cured resin. This weakens the denture somewhat, but rarely causes toxicity problems for the patient. Longer curing times increase the strength of the acrylic.

When the temperature is raised too quickly, the free monomer still present in the mold causes the liquid to boil from the mixture, resulting in internal porosity. Internal porosity is mostly tiny bubbles below the denture surface. The thicker sections of a denture, such as the lingual flange of a lower denture, are especially prone to internal porosity. Porosity is also caused by mixing the monomer and polymer improperly, and insufficient packing pressure, which is caused by an insufficient amount of dough or careless packing technique.

During the curing cycle, the acrylic shrinks towards its greatest bulk, usually the ridge areas. This creates internal tensile stresses in thinner areas. This is demonstrated by readily lifting the palate away from the cast in a maxillary denture. Internal stresses cause other problems. Deflasking the denture releases some of the stresses causing distortion. Heat produced from over finishing acrylic also releases stress and causes distortion. However, following proper procedures will effectively minimize distortion.

Crazing is another problem related to internal stress. Craze lines are small cracks running at right angles to tensile stresses in a denture. They are usually found around teeth and weaken the entire denture as well as ruin its appearance. Solvents also cause crazing where tensile stresses are present. Excess monomer contacting a denture during a repair could cause craze lines.

Storage

Acrylic resin expands as it absorbs water. When in water, it can absorb 0.5 percent in weight in 1 week. Because of this trait, proper storage is critical. If acrylic resin is allowed to dry out, it will shrink and warp. Store completed acrylic appliances in a sealed bag with approximately 1 teaspoon of water to provide a humid atmosphere. Total immersion is unnecessary and promotes water absorption.

Manipulation

When you're handling the heat-cured resins, you must meet certain requirements. Follow these two lists of rules for heat-cured acrylic resins.

Do's and Don'ts for Heat-cured Acrylic Resins	
Do's	**Don'ts**
1. Pack dough in a mold that is clean and dry.	1. Pack dough in a warm mold, as the dough may become stiff.
2. Pack dough in room-temperature molds.	2. Do not pack dough when it is stringy or sandy in appearance.
3. Follow the manufacturer's directions for mixing; usually the ratio is three parts of powder to one part of liquid by volume.	3. Allow the flask press to contact the bottom of the curing unit directly.
4. Mix the powder and liquid thoroughly.	4. Place additional material in the mold for the final closure.
5. Pack dough when it no longer sticks to the jar.	5. Allow the curing temperature to rise too high or too quickly.
6. Use plastic sheets or gloves while handling dough.	6. Cool the flask too quickly; this could cause warpage.
7. Trial-pack at least three times until the halves of the flask meets in metal-to-metal contact.	7. Use a dry brush or buffing wheel to generate heat during polishing procedure.
8. Fill the curing unit with enough water to dissipate excess heat.	8. Allow the denture to dry out after processing.
9. Allow flask to bench cool 1 hour and then cool for 15 minutes in cold water if flask is warm after curing.	
10. Deflask the denture carefully to avoid breakage.	
11. Place finished appliance in water.	

Cold-cured resins

These resins are also known as *auto polymers*, or chemically activated acrylic resins. They have a chemical activator, so polymerization occurs at room temperature. Because the polymerization is not as complete as the heat-cured resins, it is important that you keep the resin under pressure until the reaction is completed to prevent warpage. Porosity does not occur as frequently with cold-curing resins because the exothermic heat will not cause the monomer to boil.

In comparison to the heat-cured acrylics, the cold-cured materials have less curing shrinkage and lower strength and hardness. The cold-cured acrylics also require less processing time and equipment than heat-cured acrylics. Some self-curing resin brands have difficulty with color stability. The dimensional stability of the denture is better if the flask is held under pressure for at least 2 to 3 hours; however, overnight curing is preferred to improve the properties of the cured resin.

227. Special-purpose resins

In addition to the denture base resins, a variety of other resins with different characteristics are found in the dental laboratory. In most cases, the properties of these resins are similar to materials you've already studied.

Cold-cure repair resins

Similar in composition to cold-cure denture resins, these resins are used for rapid repair of any acrylic-based appliance and fabrication of stabilized acrylic baseplates. Cold-cure acrylic resins are specially formulated so that when mixed, they produce a viscous, semifluid mix. They cure in a very short period, usually 6 to 8 minutes. It is best to place the denture to be repaired in a pressure pot of warm water (115°F and 20 pounds psi air pressure) for 30 minutes. Like most self-curing resins, these materials have relatively poor mechanical properties and poor color stability in comparison to denture-based materials.

Nevertheless, the cold-curing repair resins are the materials of choice for acrylic repairs and relines because heat-curing releases strains in the original denture and causes it to warp. The following lists of *do's* and *don'ts* pertain to using cold-cured acrylic resins:

Do's and Don'ts for Using Cold-cured Acrylic Resins	
Do's	**Don'ts**
1. Determine the cause of the fracture. Does it require strengthening? A bulk of acrylic is better than mechanical reinforcement.	1. Repair dentures that have failed from fatigue caused by poor fit or design and construction errors.
2. Position and reassemble the broken pieces accurately prior to pouring the matrix.	2. Heat the denture excessively during curing or finishing.
3. Clean all parts thoroughly prior to repairing.	
4. Apply separator to all exposed areas of the matrix.	
5. Secure pieces to matrix with sticky wax.	
6. Apply monomer.	
7. Cure the repair in a pressure pot.	

Crown and bridge resins

Crown and fixed dental prosthesis resins are primarily used as interim treatment during the construction of a permanent prosthesis. They are similar to the cold-cure repair resins, except the powder is colored to produce a resin with a reasonable color match to the patient's teeth. This resin can be easily molded using a vacuum or pressure-formed matrix.

There are several different types of resins available for permanently veneering crowns and fixed dental prosthesis. These resins are cured by either dry heat, visible light, or immersion in a heated water bath. Some resins can be veneered to the teeth without a metal framework. The newer resins are microfilmed composites that have superior advantages over the dry heat-cured resins. Compared to dry heat-cured resins, micro filled resins have better color match, can be used at the chair, have better abrasion resistance, and polish to a more natural appearance. Some dentists prefer micro filled composites to porcelain because composites can be bonded to type III dental alloys. This allows the dentist to burnish the margins. These resins can also be used on full coverage crowns and inlays because of their natural appearance and abrasive characteristics that are closer to enamel.

Light cured resins

Light cured resins, although commonly used in the clinical environment, also play a useful role in the dental laboratory. These dimethacrylate materials are prepacked in light-tight packages to prevent premature polymerization. You may use light cured resin when fabricating custom trays, denture repairs, or even denture relines. Small light curing ovens are used to polymerize the material once it has been adapted to the desired form.

Denture base stains

Stains are used to alter the basic coloring of the denture base. The purpose of the pigment is to simulate more closely the colors of the patient's mucosa in the finished denture.

A kit for denture stains containing colored polymer powders is used in a specific area of the mold cavity as listed in the table for denture stain colors and usages.

Denture Stain Colors and Usages	
Stain	**Uses**
Light red	Light foundation color.
Brown	Dark foundation color.
Medium red	Interdental papillae and sulci.
Near white	Neck and eminence color (thin gingival tissue).
Dark red	Frenums and sulci adjacent to them.

The powder is saturated using the standard monomer for that acrylic. If too much monomer is used, the separating medium could dissolve, causing dental stone to adhere to the denture base. This is best removed using a sodium citrate solution because shell blasting might burn the acrylic.

Tray acrylic
This self-curing resin is used to fabricate custom impression trays. The properties desired in these materials are ease of adaptation to the cast, little distortion upon curing, and ease of trimming in the hardened state. You can lengthen the working time of this material by submersing the mixing jar in a bowl of cold water.

Clear acrylic
Surgical templates are made of clear, heat-cured acrylic resin. After extracting the remaining teeth, the template is used to disclose possible interferences between the alveolar bone and the immediate denture. Processing against tin foil is preferred over an alginate-separating medium because the processed acrylic is clearer.

Treatment liners
Treatment liners allow oral tissues to recover, which improves tone and health, before making a new prosthesis or relining an existing denture. The tissue side of the denture is relieved at least 0.5 millimeters to allow room for the liner. Because the liners stiffen rapidly, the dentist changes the tissue conditioners at 3- to 4-day intervals. These materials are also used as functional impression materials. Do not touch the tissue surface of the liner or you’ll end up with a finger print on the patient’s cast. Also, be sure to pour the impression immediately upon receiving it in the laboratory.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

226. Denture base acrylic resins

1. When fabricating a denture base, how are polymers colored to simulate small blood vessels?

2. When processing the denture base, what are three causes of porosity in the acrylic?

3. When choosing which resin to use, how do cold-cured resins compare with heat-cured resins?

4. When using a cold-cure resin, how long should it remain under pressure? Why?

227. Special-purpose resins

1. What is the *best* method for curing cold-cure repair resins?

2. What is the *preferred* method of processing a reline? Why?

3. How can the working time be lengthened while handling tray acrylic?

4. What is the purpose of a surgical template?

5. What is the purpose of a treatment liner?

4–5. Dental Metallurgy

Dental alloys form the most important single group of restorative materials used in dentistry. A basic knowledge of metallurgical principles can help you select and handle various alloys. Metallurgy is defined as the science of the chemical, physical, and mechanical behavior of materials.

228. Dental casting alloys

The identification of dental casting alloys must involve the following:

- Specifications.
- Physical properties.
- Noble casting alloys.
- Metal-ceramic alloys.
- Removable dental prosthesis alloys.

Specifications

One method metallurgists use to determine the mechanical properties of metal is tensile testing. Although most materials are not subjected to tensile loads under clinical conditions, tensile testing is by far the most convenient testing method. However, there is a relationship between the tensile values and the alloy's performance in the mouth. The properties of greatest practical importance are yield strength, tensile strength, elongation, modulus of elasticity, hardness, and melting range.

Yield strength

The yield strength of a metal is the *maximum* amount of stress that a material can withstand without obvious deformation. Since any permanent distortion results in a clinical failure, the yield strength can be compared to the functional stress that the alloy can bear. For example, a hard alloy with high-yield strength can withstand more occlusal stress than a softer alloy of low-yield strength.

Tensile strength

Tensile strength refers to the amount of force or stress a wire or other alloy can withstand before it fails and ultimately breaks.

Elongation

Elongation is the amount an alloy increases in length (similar to ductility) when drawn from zero stress to the breaking point. This property is of importance as a measure of the burnishability or adjustability of a casting's margins. As you may have already guessed, an alloy of high-yield strength will have low elongation values. So, an alloy with a high gold content will be more burnishable than a nonprecious alloy with higher yield strength.

Modulus of elasticity

The elastic modulus, which is simply defined as the ratio of stress-to-strain (fig. 4–4), is a measurement of the metal's resistance to temporary deformation. Because it is a ratio of stress-to-strain, modulus of elasticity is usually expressed as pounds per square inch. Among the precious metal casting alloys, the modulus is fairly constant. It becomes of considerable importance in choices between precious and nonprecious alloys. Semiprecious and nonprecious alloys have a higher modulus of elasticity because they are more resistant to stress. This is why the clasp tip of a removable dental prosthesis can engage the undercut on a tooth time and time again without losing its strength and resiliency (elasticity).

$$\text{elastic modulus} = \frac{\text{stress}}{\text{strain}}$$

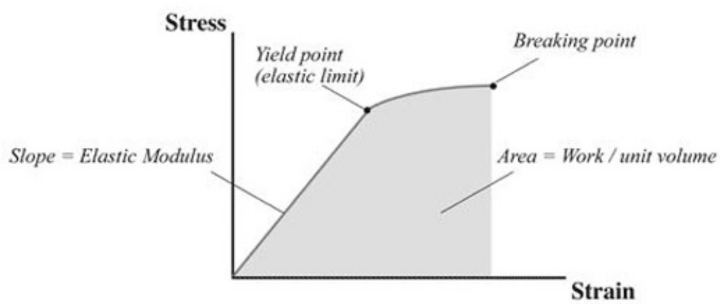


Figure 4–4. Modulus of elasticity.

Hardness

As stated earlier, hardness is defined as resistance to scratching or indentation. The hardness of an alloy should be considered when selecting an alloy for a restoration that will be exposed to heavy occlusal forces. The relationship between yield strength and indentation hardness is very close. Brinell and Vickers hardness tests are used to measure resistance to indentation. Recently, the Vickers test replaced the Brinell test, and a VHN now designates hardness value and the higher the number, the harder the alloy. The Vickers number will also help you classify noble alloys as soft, medium, hard, and extra hard.

Melting range

The alloy range of temperature, which it is partly solid and partly liquid, is known as the alloy's *melting range*. The alloy begins to melt at the lower limit (fig. 4–5, point A), and continues to melt until it is completely molten at the upper limit (fig. 4–5, point B). The upper limit serves as a guide in judging the ease with which the alloy can be melted for casting, and the lower limit is useful in selecting a suitable solder. The danger of using an alloy that has a narrow melting range is that solidification happens too quickly. This is the case of the porcelain alloys that require higher casting pressure (more turns on the casting arm) and higher casting temperatures. Figure 4–5 also illustrates that a pure metal has a melting point instead of a melting range.

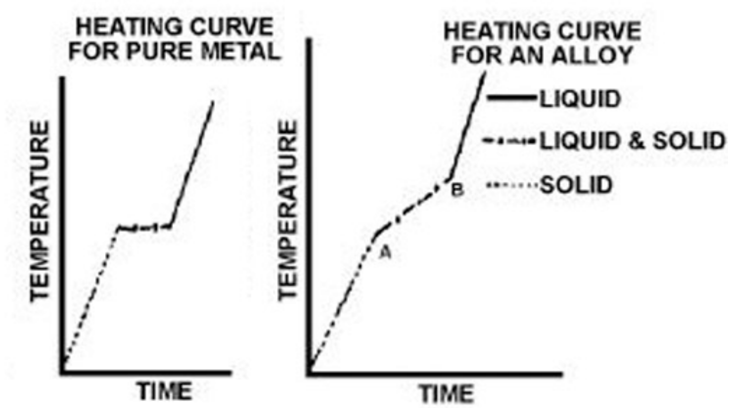


Figure 4–5. Melting range.

It is important to know the melting range of a dental alloy for casting. The alloy must be completely liquid at the casting temperature so that it can be forced into the mold. Consequently, the alloy should be heated well above its liquid temperature. The alloy's manufacturer should supply the fusion temperature, as well as the casting temperature. Generally, the casting temperature is approximately 150°F above the liquidus temperature.

The fusion temperature indicates neither the alloy's liquidus nor solidus, but rather the temperature between them. It is very important when estimating the maximum soldering temperature of an alloy. The metal distorts and partially melts at the fusion temperature.

Physical properties

Many of the physical properties (e.g., hardness, ductility, malleability, and elasticity) were already discussed in a previous unit and require only a short review. In addition to the other physical properties, you should become familiar with specific gravity, grain size, and the color of heated metals.

Specific gravity

The specific gravity is the density of mass of a unit of metal compared with an equal volume of water at room temperature. The specific gravity of water is one, which is the standard for comparison. For example, since the specific gravity of silver is 10.5, 1 cubic centimeter would weigh 10.5 times as much as 1 cubic centimeter of water. Chrome-nickel alloys have a lower specific gravity with the advantage of being lighter than noble alloys. Specific gravity also has an effect on how a pattern is sprued and cast. Heavier alloys require an unrestricted flow of metal with an average amount of casting pressure. In contrast, the lighter, nonprecious alloys use the "fire hose" spruing technique of spraying molten metal into the mold and require greater casting pressure.

Grain size

The normal grain size is of considerable importance. As a general rule, a smaller grain size provides superior physical and mechanical properties. Some of the properties enhanced by reducing normal grain size include ductility, tensile strength, toughness, and ease in polishing. There are two ways that grain size is affected and they are:

1. The rate of cooling.
2. Prolonged heating below an alloy melting range.

Grain growth is the merging of several smaller grains into larger new grains at the expense of the smaller grain structure. If a metal is heated for prolonged periods, the smaller grains form into larger grains, causing grain growth. This could be a danger in soldering a fixed dental prosthesis. Prolonged heating will leave the alloy hard and brittle. You must not heat stainless steel wires, used in orthodontic appliances, for prolonged periods below their melting range. The grain structure of these alloys differs from cast alloys, because they are drawn into long, thin wires by a cold-working process—bending, drawing, and hammering. As a result, these metals show an increased hardness and tensile strength, and they become more resistant to bending without breaking.

Cooling

When an alloy is heated and allowed to cool, the grain size is affected by the rate of cooling. As the alloy is cooled below the upper limit of its melting range, small, isolated, solid metal crystals appear. If the alloy is heated below its melting range for an extended period, these isolated crystals begin to grow, forming larger crystals; but if the alloy is cooled rapidly, as in quenching, the crystals remain small. The quicker the alloy cools, the smaller and finer the grains will be. Higher yield strength is the result of a smaller grain structure with significant grain boundaries that resist the dislocations within the metal.

The disordered solid alloy and the ordered solid alloy are a result of heat treatment. An alloy that is cooled rapidly is in the disordered state and characterized by a fine-grain structure, which has increased strength and less ductility. A long annealing time, or higher annealing temperature, results in larger grain sizes, reduced strength, but increased ductility.

Heat treatment

Cold working is the severe metal alloy deformation at ambient temperature. As a result, a dense array of dislocations and disorders (i.e., strain energy) in the grain structure results in increased yield strength and hardness, with an associated decreased ductility. There is also an increase in the alloy brittleness. This can be overcome by annealing. Annealing causes a reduced strain energy and a possible increase in grain growth; thereby, reducing the alloy strength and increasing its ductility (i.e., softens).

In the annealing process, the metal is heated and the grain structure grows. Larger grains soften the alloy. A rapid cool (quench) maintains smaller grain size and associated properties. Controlling the time and temperature during the annea and quench, or cool periods, is the key to optimizing the physical properties. This reduces the alloy’s strength and hardness but improves ductility, malleability, and elasticity.

Some manufacturers recommend that fixed dental prosthesis be softened for finishing and hardened/tempered prior to delivery to the dentist. Using the manufacturer’s recommendations, the alloy is first annealed to relieve any strain caused by cold working. Then, it is heated to a specific temperature and reduced at a fixed rate to a lower temperature. This causes a controlled grain growth and optimizes the alloy physical properties for improved clinical performance (i.e., strength, hardness, brittleness, ductility, elasticity, etc.).

Color of heated metals

The color of heated metals indicates the approximate metal temperature. See Howe’s color scale indicated in this table of heated metals’ approximate temperatures.

Howe’s Color Scale and Temperature Ranges	
Color	**Approximate Temperature Range**
Dull red	1022°–1148°F (550°– 620 degrees Celsius {°C})
Cherry red	1300°F (750°C)
Light red	1562°F (950°C)
Orange	1742°–1922°F (950°– 1050°C)
Yellow	1652°F (900°C)

Howe's Color Scale and Temperature Ranges	
Color	**Approximate Temperature Range**
White	2102°F

This color-temperature relation can be very important when soldering because the metal's color indicates the temperature. Remember, the environment can alter the perceived metal temperature. Bright sunlight can cause the metal to look too cool; in a darkened room, the metal may look too hot.

Noble casting alloys

Noble metals resist oxidation and corrosion. The four noble metals primarily used in dentistry are as follows:

1. Silver.
2. Platinum.
3. Palladium.
4. Gold.

Gold is very useful for dental purposes. Although too soft for using alone, it can be combined with other metals in varying proportions to produce alloys of almost any desired properties. Until recently, gold was the dominant metal in alloys. But, due to cost, other noble metals are gaining popularity. The following are advantages of using gold:

- Does not tarnish in the mouth because it does not react chemically with mouth fluids.
- Its margins are easy to burnish due to gold's extreme malleability and ductility.
- Can be hardened to withstand occlusal wear, or softened to wear at about the same rate as tooth enamel.
- Can be cast into a mold, providing a dense, nonporous casting that is easily soldered.

Gold alloys are rated according to the percentage of pure gold present. This rating is listed as either carat or fineness. A carat is based on 24 parts, that is to say, 24-carat gold is pure gold and 18-carat gold contains 18 parts of pure gold and 6 parts of other metals. Fineness is based on 1,000 parts, that is to say, 1,000-fine gold is pure gold. 750-fine gold contains 750 parts of pure gold to 250 parts of other metals. You can convert carat to fineness by dividing the carat number by 24 and multiply by 1000. For example, 18/24 = .75 carat, and .75 X 1,000 = 750 fineness. Convert fineness to carat by dividing the fineness number by 1000, and multiply that number by 24. For example, 750/1000 = .750 fineness, and .750 X 24 = 18 carat.

Types and uses

Casting alloys are classified by their values for hardness; remember that hardness is also a good indicator of strength. That is why different types of noble alloys have different physical properties. One type of alloy might be fine for an occlusal inlay, while it would be too soft for use as a fixed, dental prosthesis. The reverse is also true; a hard alloy could not be as malleable as an alloy used for occlusal inlays. Therefore, the casting alloys are classified into four types. See the following table for a description of these alloys.

Types of Alloys and their Descriptions				
Type	**Use**	**Description**	**Melting Point**	**VHN value**
I (soft)	Restorations not subjected to much occlusal stress (e.g., the buccal surface of molars).	Soft, malleable, and easily burnished.	1740 to 1920°F	60–90
II (medium)	Restorations, inlays or some crowns	Referred to as "inlay alloy," is burnishable,	1650 to 1780°F	90–120

Types of Alloys and their Descriptions				
Type	**Use**	**Description**	**Melting Point**	**VHN value**
	subject to moderate stress.	but not to the same degree Type I alloy.		
III (hard)	Heated metal.	Harder, and not as easily burnished as Type I or II alloys. Will withstand more wear and is not as likely to deform under the forces of mastication.	1650 to 1760°F	120–150
IV (extra hard)	Removable dental prosthesis frameworks and clasp assemblies.	Extremely hard and not easily burnished.	1600 to 1800°F	Quenched –150 or greater Hardened –220 or greater

Composition

Elements most commonly found in noble alloys are gold, silver, copper, platinum, palladium, zinc, and indium. There is a progressive increase in the hardening elements for types I through IV. The increased use of silver in types II and III is intended to lighten the color of the alloy, not to affect the hardness. As the copper content of gold is increased, the alloy becomes darker, unless it is offset by silver. Most people consider this darker color less attractive. The zinc in these alloys is present to prevent losing copper by oxidation of the molten metal.

As a result, as the copper content is increased, the zinc content also increases. Zinc lowers the melting point of the alloy, making it more fluid and easier to cast. The following table identifies the major attributes of each of the elements.

Alloy Attributes and Elements							
Attributes	***Gold (Au)***	***Silver (Ag)***	***Copper (Cu)***	***Platinum (Pt)***	***Palladium (Pd)***	***Zinc (Zn)***	***Indium (In)***
Melting Point	1945°F 1060°C	1761°F 960°C	1981°F 1083°C	3224°F 1774°C	2829°F 1554°C	787°F 420°C	313°F 156°C
Specific gravity	19.32	10.49	8.96	21.45	12.0	7.31	7.31
Metal Color	Yellow	White	Red	White	White	White	White
Chemical Activity	Inert	Active	Active	Inert	Active	Active	Active
Alloy Density	Raises	Lowers	Lowers	Raises	Lowers	Lowers	Lowers
Alloy Melting	Raises	Lowers	Lowers	Raises	Raises	Lowers	Lowers
Tarnish Resistance	Raises	Lowers	Lowers	Raises	Raises	Lowers	Lowers
Alloy Hardness		Raises	Raises	Raises	Raises		
Alloy Color	Yellows	Whitens	Reddens	Whitens	Whitens		
Alloy Ductility	Raises	Raises	Lowers	Raises	Raises		
Alloy	Raises	Raises	Raises	Raises	Raises		

Alloy Attributes and Elements							
Attributes	***Gold (Au)***	***Silver (Ag)***	***Copper (Cu)***	***Platinum (Pt)***	***Palladium (Pd)***	***Zinc (Zn)***	***Indium (In)***
Malleability							

Manipulation

Certain precautions must be observed when using alloys to maintain its physical properties. Any time casting alloys are melted, take care to prevent burning out trace elements or contaminating the alloy by an outside ingredient. Use the following lists of *dos* and *don'ts* while handling noble casting alloys:

Do's and Don'ts when Handling Noble Casting Alloys	
Do's	**Don'ts**
1. Use the correct casting technique and equipment.	1. Clean used gold alloys by melting on a charcoal block before reusing.
2. Clean used gold alloys by melting on a charcoal block before reusing.	2. Overheat alloys.
3. Clean used gold alloys by melting on a charcoal block before reusing.	
4. Clean used gold alloys by melting on a charcoal block before reusing.	

Metal-ceramic alloys

The alloys you use to make the metal-ceramic substructures must meet these three special requirements:

1. They need to be strong to withstand the compressive forces and higher temperatures during porcelain-firing procedures.
2. They must provide a strong bond between the porcelain and the metal.
3. The alloy coefficient of thermal expansion of and the porcelain must be compatible. This eliminates any stress in the cooling porcelain.

A perfect match of the coefficient of thermal expansion between metal and porcelain should not exist. It is recommended that when matching metal-porcelain alloys with porcelain, you select an alloy with a higher coefficient of thermal expansion than the porcelain. Thus, the metal will expand more upon heating, and shrink more upon cooling than the porcelain. As the metal shrinks during cooling, the porcelain is pulled toward the metal into a state of compression. This greatly improves the mechanical strength of the bond.

An alloy that has a lesser coefficient of thermal expansion than porcelain will cause the porcelain to crack. The cracking is caused by the porcelain's continuing shrinkage after the metal has stopped shrinking.

The alloys you'll use most often in the metal-ceramic techniques are the gold-platinum-palladium alloys or gold-platinum-silver alloys. Of course, you'll sometimes use nonprecious alloys for cases of extreme strength due to limited space.

Porcelain-metal bonds

A strong bond between metal and porcelain is required for the success of the metal-ceramic restoration. There are two types of porcelain-metals bonds:

1. Mechanical.
2. Chemical.

A mechanical bond results from the porcelain gripping action that has solidified in the metal surface microscopic grooves and undercuts. The roughened metal surface increases the wettability of the porcelain and increases the chemical bond surface area.

The chemical bond is the greatest contributor to bond strength. Chemical bonding occurs when oxides, primarily tin oxide, on the metal surface fuse with the porcelain during firing, creating a tenacious bond. These oxides form when the metal is heated in the oven according to the manufacturer’s recommendation.

The combination of mechanical and chemical bonding enables porcelain surrounding a cooling metal substructure to be drawn together, placing the veneer in a state of compression. This adds considerable strength to the restoration. Nonetheless, bond failure takes several forms and has several possible causes that are listed here.

- Porcelain breaks from the metal, leaving a clean metal surface; it is due to a lack of oxide formation.
- Porcelain separating from the oxide indicates a problem with the alloy.
- Metal oxide separating from the metal and metal oxide separating from metal oxide are caused by the overproduction of oxide.
- Porcelain separating from porcelain is caused by tensile stresses created by metal substructure’s flexing.
- The last, and least likely, bond failure is metal breaking from metal.

Noble alloys

The noble alloys you use in the metal-ceramic technique differ only slightly from those previously described. These alloys are hardened by adding platinum and palladium. Their color is relatively light and there is a high-melting range. Small amounts of tin and indium are added to the alloy to produce an oxide film on the metal during the oxidation procedure. This oxide film provides the bond for the porcelain to fuse to the metals surface. The higher melting range of these alloys requires the use of phosphate-bonded investment and a 1,300°F burnout temperature. The two more commonly used alloys are gold-platinum-palladium and gold-palladium-silver.

Gold-platinum-palladium

These alloys contain mostly gold. Platinum and palladium are added to raise the melting temperature, reduce the coefficient of thermal expansion, and strengthen the alloy. Small portions of base metals (e.g., indium, zinc, and tin) are included to produce a thin oxide film on the surface of the noble alloy. This film provides the chemical means for bonding between the metal and porcelain. A typical composition for these alloys is 84 percent gold, 7.9 percent platinum, 4.6 percent palladium, 1.3 percent silver, and approximately 2 percent indium and tin.

These high-gold content alloys offer many advantages over other alloys with few disadvantages. The bond strength of gold-platinum-palladium alloys is excellent. They also cast easily, finish and polish well, and produce easily burnished margins. However, gold-platinum alloys are expensive and have lower mechanical strength when compared to other alloys. Connectors must be thick to maintain the mechanical strength. Long span, fixed dental prosthesis subject to increased occlusal forces should use a stronger alloy.

Gold-palladium-silver

Known as white gold or semiprecious alloys, these alloys are less expensive and have increased hardness and mechanical strength. Because these alloys are higher in yield strength than gold-platinum-palladium alloys, they are useful for long-span restorations. They are cast, finished, and polished easily. A typical composition for these alloys is 50 percent gold, 30 percent palladium, 12 percent silver, and 8 percent indium and tin.

However, there are some disadvantages with using silver and palladium. The silver that is present in the alloy could cause “greening” of the fired porcelain. It could also contaminate a porcelain furnace’s muffles, and the high palladium content can increase the risk of hydrogen gas absorption during casting. The release of hydrogen gas from the metal might be a problem during the porcelain firing sequence, creating gas bubbles in the porcelain. The porcelain bond is also not as good as the gold-platinum-palladium alloy, but it is adequate for the metal-ceramic bond. Manufacturers’ technical representatives can provide you with additional information about specific alloy characteristics.

Manipulation

Most of the rules that you should follow for conventional gold alloys also apply here. In particular, adhere to the list in the table for conventional gold alloys.

Do’s and Don’ts for Conventional Gold Alloys	
Do’s	**Don’ts**
1. Use phosphate-bonded investment for the casting of noble high-fusing alloys.	1. Use contaminated crucibles or lined crucibles for casting.
2. Employ electric induction casting equipment or a properly adjusted propane-oxygen multi-orifice torch for melting.	2. Use casting flux.
3. Sandblast alloys to remove investment debris.	3. Use dirty wheel and points to prepare porcelain-bearing areas.
4. Rough grind all porcelain bearing surfaces with clean, ceramic-bonded points and wheels.	4. Use rubber wheel casting prior to porcelain application.
5. Follow the manufacturer’s instructions for proper handling and porcelain application.	

The table identifies the major attributes of each of the alloy elements.

Alloy Elements and their Major Attributes			
Attributes	**Nickel(Ni)**	**Chromium(Cr)**	**Cobalt(Co)**
Melting Point	2647°F 1453°C	3434°F 1890°C	2723°F 1495°C
Specific Gravity	8.9	7.2	8.9
Metal Color	Silver white	Silver gray	Gray
Alloy Density		Lowers	
Alloy Melting	Lowers	Raises	Raises
Corrosion Resistance	Raises	Raises	Raises
Alloy Hardness	Raises		
Alloy Color	Whitens	Grays	Grays
Alloy Ductility	Raises		
Alloy Malleability	Raises		

Base alloys

Base alloys are similar in composition to the nonprecious alloys used in removable dental prosthesis. A typical composition for these alloys is 60 to 80 percent nickel, 12 to 20 percent chromium, and additions of other alloys to refine the alloy's chemical and physical properties. The affect nickel, chromium, and cobalt has on an alloy is seen above.

Since base alloys do not contain noble metals, they readily oxidize when heated. The alloys could overdevelop the oxide layer, causing the bond between the porcelain and metal to fail. Because of this high-oxidizing tendency, the techniques for metal preparation and porcelain additions are different from those used with precious alloys.

Properties

The physical properties of these nonprecious alloys are considerably different from the precious alloys. In general, the alloys are much stiffer and harder, requiring high-speed equipment to finish and polish them. Nonprecious alloys are useful where long span, thin frameworks are necessary.

Manipulation

Because base-metal alloys are technique sensitive, be sure the manufacturer's directions are followed explicitly. Also, always finish alloys with nickel and beryllium following prescribed safety standards to avoid undue health risks.

Platinum foil

Platinum foil is supplied in thin sheets (approximately 0.001 of an inch). Pure platinum has a strong attraction for molten gold and this property makes it a very useful metal in the dental laboratory. Platinum is used for gold repair procedures, such as mending holes in castings, and as a matrix for veneers. Because of the metal's high melting point (3,190°F) and its low thermal expansion, it is not affected very much by high firing temperatures.

When making a matrix, annealing the foil is recommended to relieve cold working stresses. Anneal platinum foil by heating it to a cherry red color with a Bunsen burner. This changes the malleability of the platinum foil, making it easier to burnish.

Removable dental prosthesis alloys

The base-metal alloys used in an appliance are either cast or wrought metal. In their finished form, they are strong, hard, bright metals that resemble stainless steel or chrome plate. Cast base-metal alloys are used most often for removable dental prosthesis frameworks. The wrought alloy's main application is in the form of wires or bands used in making orthodontic appliances.

Casting alloys

Base-metal alloys contain 85 percent by weight of chromium, cobalt, and nickel. Chromium contributes tarnish, corrosion resistance, rigidity, and strength. Nickel is commonly used as a minor alloy addition in base-metal alloys to increase ductility. Recently, manufactured alloys have greater amounts of nickel. In fact, in some alloys, nickel is a major ingredient. For example, Ticonium 100 metal contains about 25 percent chrome, 60 percent nickel, and no cobalt.

Because all metals shrink as they solidify, you must compensate by expanding the investment mold. The casting shrinkage of Ticonium is 1.7 percent. You must use a high-heat investment with a silicate or phosphate binder when working with cobalt-chromium alloys, but you use a gypsum-bonded investment with chrome-nickel alloys. Another advantage of nickel-chrome alloys is that they can be easily soldered without softening the alloys.

A variety of other elements is often found in chrome alloys. Molybdenum, tungsten, beryllium, iron, manganese, and aluminum are added in varying amounts to control the mechanical properties of the alloy. Chrome alloys are much harder and have higher melting ranges than the gold alloys. The specific gravity is only one half that of the gold alloys. As a result, a removable dental prosthesis constructed from this alloy will be lighter than one made from a gold alloy. Due to the increased hardness of chrome alloys, they must be finished on a high-speed lathe (over 20,000 revolutions per minute). Because of the high-melting range of chrome alloys, the alloy must be cast using an induction-casting machine.

Wrought alloys

The wrought base-metal alloys are available in the form of wires and band materials. Three main types of wrought alloys are used at present and they are:

1. Stainless steel.
2. Nickel-chromium.
3. Cobalt chromium alloys.

The wrought alloys differ from the base-metal casting alloys in how they are manufactured. Wrought base-metal alloys are made through a process of rolling, annealing, and drawing into the various forms. This processing gives the alloys certain mechanical properties that are of interest to dentists. Of particular importance is the alloy's elastic and flexible nature. This property allows a wrought wire clasp to spring into and out of an undercut area. The alloys do not distort easily due to their increased tensile and yield strength.

Certain procedures, as listed below, must be followed if the desired properties of wrought alloys are to be maintained:

1. Avoid making bends too quickly and bends that are too large or too sharp when working with wrought wires.
2. Do not nick or dent wires because this will cause them to break when stress is applied.
3. Anneal the wire to relieve the stress effects of cold working if repeated bending and shaping become necessary.
4. Follow the manufacturer's annealing instructions for best results.
5. Take special care to prevent overheating the wire when you are soldering stainless steel wires.
6. Avoid prolonged exposures to temperature in excess of 1300°F because it softens the wire and reduces corrosion resistance.

229. Solders, fluxes, and antifluxes

Soldering is joining two pieces of metal into a single, solid structure. This is done by heating the parts to be joined, as well as adding a lower-fusing alloy (solder) that will create the solder joint. In addition to the solder, flux and sometimes antiflux, are required for successful soldering. All three of these materials and their effect on each other are discussed in this lesson.

Types of solders

Solders are used to join units of fixed dental prosthesis. They are also used to make repairs of everything from mending holes in castings to adding proximal contacts. Solders come in many forms; the most common being wires and strips. They also differ in their composition, depending on its usage.

Gold solders

The amount of pure gold in solder is indicated by its fineness. You know an alloy with a fineness of 650 has 650 parts of gold and 350 parts of other metals. The same is true for gold solders. With some solders, you will find that manufacturers give a carat rating. The carat rating indicates the alloy gold content for which the solder is to be used; therefore, an 18-carat solder is intended for soldering an 18-carat alloy, but the solder itself may be less than 18 carat. Several items, which are listed below, are added to solder to improve its usefulness:

1. Copper is added to the solder to improve its strength, make it react to heat treatment procedures, and lower the fusion temperature.

NOTE: Fusion temperature refers to the highest temperature to which the castings can safely be exposed in the soldering process. It is usually close to the lower limit of the melting range of that particular gold casting alloy.

2. Tin and zinc are added to lower the fusion temperature.
3. Silver is added in greater proportion than copper to whiten and improve the wetting (spreading) of gold solders.

Presolder

The term *presolder* designates a high-fusing solder that is used to solder a metal-ceramic alloy prior to a porcelain application. These solders must be capable of withstanding the porcelain high-firing temperatures; therefore, they contain more precious metals and less tin and zinc. Copper and silver are not used because they produce a green discoloration.

Silver solder

Silver solders are normally silver-copper-zinc alloys, although cadmium may be substituted for some or all of the zinc. They usually contain more than 50 percent silver and enough copper to lower the melting range of the silver-copper alloy. Zinc and cadmium further lower the melting range. Silver solders are useful in joining stainless steel orthodontic wires-brackets due to their light color and low fusing temperatures.

Fluxes

These substances are applied to an alloy to prevent the formation of an oxide film or to remove an already formed oxide film. Borax, combined with charcoal and silica, are the main ingredients of most fluxes. These ingredients dissolve metal oxides rapidly and allow the solder to flow more easily. The flux can be applied as a powder (casting flux), liquid (flux mixed with alcohol), or paste. A paste flux is easier to control and apply.

Fluoride fluxes are similar in composition to borax fluxes, except that they contain fluoride salts. Fluorides dissolve chromium oxide and are excellent fluxes for soldering base-metal alloys. They are usually supplied as a fine white powder that is used as a liquid in alcohol or a paste in petrolatum.

Antiflux

An antiflux prevents the flow of solder and is used to confine the solder to the desired area. Graphite from a pencil is a convenient antiflux; however, it is removed by oxidation at higher temperatures. An effective antiflux for prolonged heating or higher temperature can be made from a solution of rouge or chalk in alcohol.

Solder selection

Selection is made based on the solder’s tarnish resistance, strength, fusion temperature, and color.

Tarnish resistance

The 650-fine solder is widely used for soldering fixed prosthetic restorations made out of conventional casting golds. As fineness increases above 650, tarnish resistance increases, but strength decreases. Below 650-fine, the solder gets stronger, but the tarnish resistance could drop below acceptable limits.

Strength

As the fineness of a solder increases, its strength decreases. Solders with fineness ratings above 650 should not be used to unite fixed dental prosthesis subject to much stress due to the solder’s flexibility.

Fusion temperature

Dental gold solders are supposed to melt and flow without overheating and possibly melting the parts to be joined. A solder should melt at a temperature 100°F below that of the parts to be joined. This temperature is known as the fusion temperature. The fusion temperature is the highest temperature to which an alloy can safely be exposed in the soldering process.

Color

Match the color to the parent metal as closely as possible so that the solder joint is not easily noticed.

Manipulation

A solder joint must be clean; otherwise, contaminants can weaken the solder joint. The following lists of *do's* and *don'ts* will be helpful while handling solders and fluxes:

Do's and Don'ts for Handling Solders and Fluxes	
Do's	**Don'ts**
1. Use only solder and corresponding flux designated for that specific alloy.	1. Substitute either the recommended solder or flux as they are designed to work together.
2. Clean surfaces completely of oxides, dirt, and oils to produce good sound joints.	2. Rely on flux to clean surfaces that should be cleaned by other techniques.
3. Coat the surfaces to be soldered with a liberal, uniform application of flux.	3. Apply flux so thickly that it is difficult to keep it from flowing to areas, which should not be in contact.
4. Use a gap of 0.125 to 0.250 mm as a guide; many use the thickness of a calling card.	4. Use a flame so large it is impossible to control the application of heat to desired areas.
	5. Keep flux away from porcelain-veneered surfaces. Coating porcelain with ivory wax is recommended before investing and applying flux.
	6. Use correctly sized torch tip so that the flame is large enough and hot enough to raise the piece to the soldering temperature as well as supply enough heat so that the solder will melt and flow.
	7. Use a fine, needle-like flame for soldering orthodontic appliances; heat quickly, solder, and then cool.
	8. Set the temperature of the furnace at the temperature recommended for the solder and flux, for oven soldering, or 50°F above the temperature of the solder.
	9. Use solder that melts at a higher temperature for the first solder operation, then solder to be used in later soldering or porcelain applications.
	10. Cool the appliance to room temperature slowly to prevent distortion.
	11. Remove all traces of flux.
	12. Remove all traces of flux.
	13. Force cooling by quenching the appliance in water.

Allow any flux to remain after soldering. Fluxes are toxic and corrosive materials.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

228. Dental casting alloys

1. What must be included with the identification of dental casting alloys?

2. How does yield strength of a metal compare with functional stress?

3. Describe elongation.

4. Why can the clasp tip of a removable dental prosthesis engage the undercut on a tooth repeatedly without losing its strength and resiliency?

5. What is specific gravity?

6. What is a general rule in regards to grain size of an alloy?

7. What is grain growth?

8. What type of quench maintains smaller grain size and associated properties. Controlling the time and temperature during the annea and quench, or cool periods, and is the key to optimizing the physical properties?

9. What type of gold should be used on an inlay?

10. Name the three requirements of a metal-ceramic alloy.

11. How is a mechanical bond formed?

12. What mechanical properties of wrought wire are of interest to dentists? Why?

229. Solders, fluxes, and antifluxes

1. Why would you use solders?

2. Why is copper added to solder?

3. What property is reduced by increasing a solder's fineness above 650?

4. When should a solder melt? What is this known as?

4–6. Dental Porcelains

The objective of this section is to help you gain an understanding of porcelain. We will do this by discussing its physical properties. In the dental lab, porcelain is used as follows:

1. As a restorative material that is bonded to a metal substructure.
2. As a restorative material that is bonded to existing prepared dentition.

230. Physical properties of dental porcelain

Dental porcelain is the most esthetic, biologically harmonious, restorative material available today. A basic knowledge of its properties will aid you, the technician, in two ways:

1. Selecting compatible materials.
2. Troubleshooting failed cases.

Understanding why a case failed should keep you from repeating the mistake. Knowledge of the material's composition is key to this understanding.

Manufacturing

Basically, porcelain is glass, but it is glass that has been modified and carefully compounded. The composition of dental porcelain is controlled carefully to modify the physical properties of the glass, both in the molten and solid forms. These properties include viscosity, melting temperature, chemical durability, thermal expansion, and resistance to devitrification. Without going into a lengthy discussion about "the nature of glasses," we will examine some of the physical properties of porcelain.

To get the needed properties, the minerals are mixed together in powdered form. Then, they are heated in a refractory crucible to a temperature well above the firing temperatures used in the laboratory. The minerals melt together, forming a molten glass. The molten glass is quenched in water, causing it to crack and fracture. The process of blending, melting, and quenching the glass components is called *fritting*.

It is from this frit that porcelain powders are made. Each time this is done, more of the undissolved particles are converted to glass. The process is repeated until the particles become so small that they merely fuse together when heated. By pre-firing in this manner, the manufacturer controls the maturing temperature of the porcelain as well as its composition.

Composition

Porcelain is made of three materials, as indicated by this table:

Porcelain Materials and their Functions	
Material	**Function**
Quartz (silica)	Acts as a refractory, keeping the porcelain from slumping when fired. It also strengthens the fired porcelain.
Kaolin	An opaque binder that holds the unfired porcelain particles together, allowing it to be carved to shape.
Feldspar	As the primary glass-former, it lowers the viscosity and fusion temperature of porcelain as it is fired.

When combined in the correct proportions, these minerals form a very durable crown. This durability is necessary because the porcelain must withstand a variety of chewing forces. The first of these forces is compressive. The restoration must have great compressive strength. When porcelain is adequately supported, it can resist this compressive stress. In addition, porcelain must have adequate tensile (pulling) strength.

Unfortunately, the tensile strength of a restoration is immediately lessened by its own processing errors. Under firing and over firing, varied cooling rates, and porosity all contribute to a weakened structure. The final strength is shearing (rotation). Porcelain is very weak in this area since it lacks the orderly molecular structure found in metal. As a solid, porcelain's molecular structure resembles a liquid because its atoms are arranged in a shortened order.

Although porcelain is composed of quartz, kaolin, and feldspar, the primary constituent is silica (SiO2—quartz), which exists in a crystalline form. This crystalline silica melts at extremely high temperatures. In its unaltered state, this silica is undesirable for dental porcelains. Changing these characteristics requires using glass modifiers.

Glass modifiers

These glass modifiers (typically sodium, potassium, or calcium) effectively lower the fusion temperatures of silica. This lower fusion allows desirable materials to be included in the dental porcelain. The actual fusion temperature for dental porcelains is dependent on the mix of modifiers. Dental porcelains currently fall into one of four categories based upon their fusion temperature:

Dental Porcelain Categories and Temperatures	
Category	**Fusion Temperature**
High-fusing	2372°F (1300°C)
Medium-fusing	2013–2072°F (1101–1300°C)
Low-fusing	1562–2012°F (850°C)
Ultra-low fusing	1562°F (<850°C)

Medium- and high-fusing porcelains are used to produce denture teeth. Low- and ultra-low fusing porcelains are used for crown and bridge construction.

Translucence

Translucency, or the ability of light to penetrate a surface, is vital to a natural-appearing porcelain crown. Without it, you have something that resembles a solid white tooth. Air bubbles between the particles usually cause this lack of depth. However, no matter how hard you try, you'll *never* match the amount of translucency of natural enamel. This is due to both *what* and *how* the two are made. Natural enamel, as you know, is constructed of rods, which are all going in one direction.

They are cemented together with an organic material. When light hits these rods, it refracts (bends) deep into the tooth. The cement aids the transmission of light. Porcelain, on the other hand, is made up of layers of irregularly shaped blobs. Although fused at the boundaries, air pockets remain between the particles. Air does not aid light transmission, but rather this composition resists light penetration. Some manufacturers sell a transparent porcelain that is placed over the buildup of shaded porcelain.

This is effective, but requires the skill of an experienced ceramist. The temperature at which the porcelain is fired also affects translucency.

Bisque bake

Bisque bake is referred to as maturity and has three recognizable stages as listed in this table:

Bisque Maturity Levels and Descriptions	
Bisque Level	**Description**
Low	The lowest of the firing range point. Particles have begun to soften but have not fused at their boundaries. Consequently, the porcelain is very porous and weak and little shrinkage has occurred.
Medium	Recognized by definite shrinkage and its slight porosity because the particles have fused. Any air that has not escaped at this point will remain as spheroid-shaped pockets.
High	The porcelain has a completely sealed, grainy-appearing surface. *Maximum* shrinkage has occurred, and the porcelain has a slight shine.

Porcelain should be fired to its high bisque, and any additions should be fired at a lower temperature. This maintains the grain boundaries. If firing from low to high, there is a possibility the particles will fuse into larger particles, reducing the number of grain boundaries and translucency.

Glazing

To get an autogenous (natural) glaze, it must have all surface particles fused. Fluxes fuse on the surface, sealing the porcelain and creating the glaze. Now, if vacuum is lost during the firing, or an attempt is made to glaze at a low bisque, the fluxes will not rise to the surface. Instead, they will fill the porosity in the porcelain. Surface fluxes are the key to a successful autogenous glaze. An over glaze (very fine, low-fusing, air-fired porcelain) could be used, but over glazes are not as wear resistant.

Vitrification

Vitrification is a desired quality of your porcelain restoration. *Vitrification* simply means *to change into a glass by heat and fusion*. To obtain porcelain's amorphous crystal structure, you must fire (or sinter) to the correct temperatures and for the full firing sequence. The goal is to fuse the separate grains at their boundaries. To do this, you must condense the wet porcelain before you fire it under vacuum.

Condensation packs the particles closer together, drawing off the liquid used to model the porcelain. The better you condense the porcelain, the closer the grain boundaries. This is important for the proper fusion of grain boundaries, resulting in properly vitrified porcelain. Vitrified porcelain will have maximum shrinkage and a completely sealed surface with slightly rounded details.

Devitrification

Carrying vitrification to extremes results in devitrification. This is the result of repeated firings at or above the high-bisque temperature, causing the grains to fuse together into one solid grain. This is an undesirable quality that leaves the devitrified porcelain with a milky appearance. As a result, some components responsible for glazing have crystallized, requiring extreme temperatures to melt them. Surface detail and sharp corners are lost due to low-fusing oxides rising to the surface.

Coalescence

Coalescence is almost indistinguishable from devitrification. The crown still looks like a lifeless marble, but the cause is different. Coalescence is the result of firing at one extremely high temperature. This is usually an act of desperation, such as when a ceramist, scrambling to meet a deadline, cannot get a crown to glaze naturally (autogenous glaze).

Unwilling to admit that it is probably devitrified, the ceramist raises the glaze temperature 30°C. On completion of the firing cycle, the masterpiece is removed and the ceramist finds a coalesced, devitrified marble. The only remedy is—remake. As you can see, porcelain is a very technique-sensitive material. The best results are obtained by consistent techniques and practice.

231. Types of dental porcelain and additives

Historically, dental porcelains have been divided into the two types:

1. Feldspathic.
2. Aluminous.

Though still widely used, new dental porcelains have been developed.

Types of dental porcelain

In this discussion, we begin with the common feldspathic and aluminous porcelains, and include some more recent developments in dental porcelains. They will include, but are not limited to:

1. Injection-molded porcelains.
2. Glass infiltrated alumina core porcelains.
3. Computer-aided design/computer-aided manufacturing (CAD/CAM) porcelains.
4. Low-fusing leucite reinforced porcelains.

Feldspathic porcelain

Natural feldspar is any group of minerals, principally alumina silicates of potassium, sodium, and calcium. Natural feldspar contains most of the elements needed for glass making. Another important property of feldspar is its tendency to form the crystalline mineral leucite. Leucite is a potassium aluminum-silicate mineral that has a large coefficient of thermal expansion. A coefficient of thermal expansion is a number that indicates the relative amount of expansion of a material caused by each degree of temperature change.

This coefficient of thermal expansion is important when matching a porcelain-fused-to-metal (PFM) substructure with the proper porcelain. A mismatch can cause a premature failure of the bond between the substructure and the porcelain. Glass fluxes, such as boric oxide, are added to lower the softening temperature of the glass. This mixture can then be fritted at specific temperatures to obtain the desired porcelain frit.

Aluminous porcelain

An alternative to the metal-ceramic crown is the porcelain jacket crown (PJC). The PJC is more esthetic than the metal-ceramic crown. Not until the development of aluminous porcelain did the PJC gain in popularity. The addition of pure alumina to the feldspar-flux mass greatly strengthens the porcelain. However, as the amount of alumina increases, the translucency of the porcelain decreases. Consequently, the greatest percentage of alumina crystals (as much as 50 percent) is contained in the core material. The core powders, in effect, strengthen the PJC in much the same manner as a metal substructure does.

The percentage of alumina crystals decreases in the dentin and enamel porcelain powders. They overlay the high-strength core and give color and translucency to the jacket crown. The result is a restoration of superior esthetics, as compared to a PFM, that also meets the demands for strength in anterior restorations. However, this material does shrink, which causes the margins to be less than ideal.

Injection-molded porcelains

Injection-molded or pressable porcelain systems use the lost-wax technique to form a porcelain core, inlay, veneer, or crown. Heat pressing is accomplished by compressing a heated porcelain ingot into a mold under pressure. This technique is the system used by the IPS Empress® system. This porcelain is highly desirable for anterior restorations; however, use in the posterior segments is limited.

Glass-infiltrated alumina core porcelains

This type of porcelain is an improvement of existing alumina-based porcelains. Typically, this porcelain has replaced the PJCs. In-Ceram® is a porcelain for single anterior and posterior crowns and anterior, three-unit bridges. This all-porcelain material has a high flexural strength and gives an excellent fit. Material modifications to the core material provide increased translucency and esthetics.

CAD/CAM porcelains

These porcelains use a computer to design and machine an aluminous oxide core. Typically, an image of the prepared abutment is scanned into the computer where a modeling program configures the dimensions and guides a milling machine in grinding the substructure to specifications. The external (occlusal) surfaces are typically milled by hand. Inlays are a common type of restoration produced using these porcelains.

CAD/CAM technology has been used to improve the design and fabrication of crowns, veneers, bridges, inlays, and onlays. You determine CAD/CAM porcelains by the type of material that is to be milled out. Some of the different types of materials used in the dental lab career field include the following:

Type Systems and Materials Used

System	Type of Material
IPS e.max®	Lithium disilicate.
IPS Empress® system	Leucite-reinforced ceramic and zirconia based.

The e.max® and EMPRESS materials are normally milled to full contour, adjusted, and glazed. Zirconia based products allow the lab technician the ability to stack porcelain on top of the substructure with a feldspathic porcelain. A good example of a feldspathic porcelain used on top of the substructure is Vident VM9 or VM13 porcelains.

Low-fusing leucite reinforced porcelains

This porcelain can be fired in conventional porcelain furnaces and combines some features from both feldspathic and aluminous porcelains. Leucite-reinforced porcelains have improved strength and are used in combination with injected molded systems. Porcelains like IPS Empress® are examples of this material. Although they possess greater strength and fracture resistance than conventional porcelains, they also tend to cause more abrasion wear to any opposing tooth structures.

Coloring and opacifying agents

Although porcelain is a remarkable material, it is not capable of totally reproducing the qualities of natural enamel. Porcelain lacks the color, translucence, and vitality to simulate the dentin and enamel shades of teeth.

Color pigments

Pigments are metallic oxides fritted with the basic glass and added during the manufacturing process. The highly pigmented glass is ground into a fine powder and used to modify the uncolored porcelain powder. The following table shows the various metallic oxides used to color dental porcelain along with their function:

Metallic Oxides Hues and Functions

Hue	Metallic Oxide	Function
Pink	Chromium-tin or chrome alumina	Useful in eliminating the greenish hue in the glass and add a warm tone to the porcelain.
Yellow	Indium or praseodymium	It is the most stable for producing an ivory shade.
Blue	Cobalt salts	Used to produce a bluish hue. It is especially useful for producing some of the enamel shades.
Green	Chromium oxide	This color should be avoided because green is the characteristic color of glass.
Gray	Iron oxide (black) or platinum gray	Useful in making enamels, or for dentins in the gray section of the shade guide and they can also give a translucent effect.

Once the needed color is added, the porcelain's high translucency must be modified. This is accomplished by adding opacifying metallic oxides to the porcelain.

Opacifying agents

Opacifying agents are primarily metallic oxides ground to a very fine particle size. The oxides usually used are cerium, titanium, and zirconium. Very little opacifier is used in the enamel porcelains because enamel porcelain requires more translucency. Body, or dentin, porcelains have more opacifying agents because they add to the basic color of the restoration. The manufacturer supplies the porcelain powder in these three forms:

Porcelain Powders and Descriptions	
Form	**Description**
Opaque porcelain	Very opaque—its purpose is to mask out the color of the underlying metal.
Body porcelain	Matches the gingival shade of the tooth.
Incisal porcelain	Very translucent and overlays the dentin porcelain. It must match the incisal shade of the tooth.

Each manufacturer supplies a wide range of shades. Even so, it is extremely difficult to make a complete match without characterizing the restoration with stains or color modifiers.

Color modifiers and stains

Color modifiers and stains are made the same way as the concentrated color frits (used for coloring basic dental porcelain powders) are made. A color modifier is used intrinsically (internally) to create gingival effects or highlight body colors. A stain is more concentrated than a color modifier and is used most often for extrinsic (external) coloration. Stains are applied to the surface of the porcelain, they are usually mixed with low-fusing, air-fired porcelain. This allows the stain to fuse to the porcelain at a lower temperature. Stains are used to color correct (alter shades) and characterize porcelain restorations. Some examples of characterizations are enamel check lines, enamel cracks, mottled enamel, decalcification, and other dental restorations.

Glazes and add-on porcelains

Occasionally, you will have a problem constructing a porcelain restoration. Manufacturers supply special porcelains to correct specific problems.

Glazes

Dental glazes are clear, low-fusing porcelains that can be applied to the surface of a fired crown to produce a glossy surface. Glaze powders are difficult to apply evenly and are often used to seal off a poorly *baked* restoration. An autogenous (self-produced glaze) is preferred over the glaze powders.

Add-on porcelains

Add-on porcelains are similar to glaze porcelains, except for the addition of opacifiers and coloring pigments. They are sometimes marketed as *correction powders*, which are normally air-fired porcelains. Add-on porcelains sinter at a low temperature to avoid over firing a restoration. These porcelains enable you, the technician, to make minor corrections without the risk of high temperatures and the vacuum cycle.

Manipulation

Usually, porcelains are fused to a metal framework; therefore, any number of problems might arise without a clear solution. A problem with internal porosity in the fired porcelain could be a result of improper casting or improper finishing. The degree of success will be dependent on how well you follow the manufacturer's instructions. Use the below lists for handling dental porcelains.

Do's and Don'ts for Handling Porcelains	
Do's	**Don'ts**
Mix opaque porcelain to a creamy consistency	Touch casting or fired opaque and body porcelain prior to any porcelain addition.
Keep treated casting and porcelain covered when not in use.	Use abrasives to grind porcelain previously used for metal.
Condense porcelain by vibration, spatulation, brushing, and blotting adequately.	Expose porcelain powders to airborne dust and grindings.
Allow the porcelain buildup to completely dry before firing it.	Touch hot porcelain with metal tools or expose it to thermal shock from rapid cooling.
Clean fired porcelain surfaces thoroughly in an ultrasonic cleaner with distilled water.	Over vibrate raw porcelain mass during buildup.
Use only abrasives that you designate "for porcelain only."	Thin porcelain to a featheredge, or it may fracture.
Ensure porcelain furnace pulls a vacuum of 26 to 29 inches of mercury within 30 seconds.	
Keep porcelain moist, not wet, during buildup.	
Use manufacturer's recommended liquids, stains, and over glaze (matching coefficient of thermal expansion).	
Always air-fire the final glaze bake.	

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

230. Physical properties of dental porcelain

1. When fabricating a porcelain crown, why is the tensile strength of the restoration immediately lessened?

2. Explain what glass modifiers do. What is the result?

3. What is the desired quality of porcelain restoration? Explain how to generate a high quality restoration.

4. When firing a porcelain crown or bridge, what happens when the crown is devitrified?

231. Types of dental porcelain and additives

1. Match each definition in column A with the correct term in column B. The items in column B are used once.

Column A	*Column B*
____ (1) Used to provide a bluish hue.	a. Glass-infiltrated alumina
____ (2) Combines pure alumina to the feldspar-flux mass.	b. Injection molded porcelains
____ (3) Has most of the elements needed for glass making.	c. CAD/CAM porcelains.
____ (4) Uses lost-wax technique.	d. Feldspathic porcelain.
____ (5) Used for anterior three-unit bridges.	e. Aluminous porcelain.
____ (6) Uses a computer to design core.	f. Cobalt salts.
____ (7) It is an opacifying agent.	g. Zirconium oxide.

4–7. Other Dental Materials

So far, all of the materials discussed have required special handling—mixing, measuring, heating, and shaping. This last section deals with other dental materials that, although they do not require special care, are used in the laboratory daily.

232. Other commonly used materials

This is a sort of “catch all” learning objective. In this lesson, you will study:

1. Abrasives.
2. Reagents.
3. Separating media.
4. Wetting agents.

Abrasives

The basic technique behind smoothing and polishing any appliance is to use progressively finer particles until there is a reflective surface. Reducing abrasive size produces smaller and smaller scratches until they are no longer visible. This polished surface is one that reflects light evenly and one that contains no obvious scratches. This use of abrasives usually involves three steps as listed here:

1. Rough finishing.
2. Rubbering.
3. Polishing.

The difference between rough finishing and polishing is the type of abrasive used and the effect it produces on the surface.

The abrasives you will study include carbide and diamond burrs, powders, pastes, and anything that abrades a material. Several factors affect the rate of abrasion. Particle size, shape, pressure, hardness, and rotational speed all affect the way an abrasive is used.

The following table gives these factors and their effect:

Abrasive Factors and Effects	
Factor	**Effect**
Large particles (coarse burs)	Produce deep scratches and require less working pressure.
Irregularly shaped particles (e.g., as on diamond burs)	Produce deep scratches when compared to double cut burs.
Increased pressure	Abrades quickly, causing deep scratches.
Rotational speed	The faster speed, the faster the abrasion.
Particle hardness	Determines the degree of abrasion.

Smaller burrs generally operate best at higher revolutions, whereas larger burrs operate best at lower revolutions.

Probably the single, most considered factor affecting abrasion is the hardness of the abrasive. There should be a large difference between the hardness of the abrasive and the surface to be finished. A scale known as the Mohs scale classifies abrasives. The Mohs scale is only comparative, but it's a good indicator of the relative abrasive power of several materials used to smooth and polish in the dental laboratory. A comparison of several commonly used abrasives is given in the following table. The abrasives are listed from top to bottom in order of their hardness. Note that chalk is the softest and that diamond is the hardest.

Abrasives, Mohs, Uses, and Forms			
Material	**Mohs number**	**Use**	**Form**
Chalk	Unknown	Imparts a high luster to acrylic resin.	Powder combined with binder in a stick form.
Rouge	Unknown	Gives metal a high luster.	Powder combined with binder in a stick form.
Tripoli	5	Smoothes metal and acrylic resins.	Powder combined with binder in a stick form.
Pumice	5.5	Smoothes metal and acrylic resins.	Three grits: flour, medium, and course.
Quartz	7	It's primary material for crucible, binder for finishing stones and finishing metal.	Mandrel mounted disc.
Garnet	6–5 – 7.5	Smoothes metal.	Mandrel mounted disc.
Emery	Unknown	Trim acrylic resin and various baseplate materials.	Arbor band.
Carborundum	9.5	Smoothes metal.	Points, stones, and disc.
Diamond	10	Prepares natural teeth, contours and polishes porcelain.	Points, stones, disc, and paste.

Reagents

These are substances that cause chemical reactions. Reagents include acids, solvents, investment solutions, monomer, and the list continues. Luckily, we don't discuss every item. Keep safety in mind with these items since most of these materials are potentially harmful. Acids, once a mainstay of the laboratory, have been replaced by commercially prepared pickling and etching solutions. These solutions are safer, but they still require special precautions when handling.

Separating media

Separators work by preventing one material from bonding to another material. This is accomplished by filling a material's surface porosity with a nonbonding material. Commercially prepared materials are available to prevent bonding.

Gypsum to gypsum

Several commercial products are available to prevent gypsum from bonding with gypsum without leaving a space between the gypsum. Petrolatum and liquid floor wax work, but they create space. Liquid soap is also somewhat effective.

Gypsum to acrylic resin

Commercial alginate-based separators work well when handled correctly to prevent gypsum from bonding to acrylic resin. Disadvantages include discoloring clear acrylic, peeling away from the gypsum, and deteriorating easily. Tinfoil is an excellent separator for clear resin since it does not discolor the resin. Its main disadvantages are difficulty adapting to the cast and the amount of time required to adapt it.

Gypsum to wax

Commercial die lubricants work well in preventing gypsum from bonding to wax because they do not create a lot of space. Alginate-based separators are a good separator between gypsum and baseplate wax.

Wetting agents

Water and liquid investments exhibit a high-surface tension when contacting wax and certain impression materials. This tension can lead to nodules on a cast or crown. Wetting agents reduce the surface tension of liquids and allow them to spread out over the surface evenly. You must select a compatible wetting agent and follow the manufacturer's directions.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

232. Other commonly used materials

1. When finishing and polishing restorations, what are the three steps in using abrasives?

2. When using abrasives to finish, what type of abrasive produces deep scratches?

3. When using gypsum-to-acrylic separating medium, some disadvantages are created. What are those disadvantages?

4. When using a wetting agent on a wax-up or other material, what purpose does the wetting agent serve?

Answers to Self-Test Questions

220

1. Their elasticity and ability to be removed from tooth undercuts.
2. Because it is reusable, highly accurate, and elastic.
3. You must wrap the impression in a moist paper towel.
4. Because the excessive thickness of alginate will slump, producing a cast with a lower palate than the patient actually has.
5. It could prevent a snapping removal of the impression and cause distortion. The alginate could also break teeth off the cast, or even dislodge a patient's teeth when removed.

221

1. Polysulfide rubber, silicone rubber, polyether rubber materials, and impression compound.
2. (1) The strength is very high in comparison to the hydrocolloids.
   (2) They are not affected by variations in storage conditions such as time and temperature.
   (3) Their ability to reproduce fine details and transfer them to cast or die.
3. The impression will have streaks in it that affect dimensional stability.
4. Addition vinyl silicone.
5. They are classified as a plastic impression material, not elastic material, because they will not release from an undercut area without permanent deformation. They are thermoplastic materials that soften to working consistency by placing them in a hot water bath or by heating over a flame. They have a high thermal coefficient of expansion; therefore, a high amount of contraction when cooling. They are supplied in stick and cake forms.
6. A water bath.

222

1. (1) II dental stone (plaster).
   (2) III dental stone (cast stone).
   (3) IV dental stone (die stone).
2. Because it affects the dimensional accuracy of the final restoration.
3. By immersing the setting gypsum in water. Since the supply of water is never depleted, the crystal formation is limited only by its chemical composition.
4. The initial set occurs when the crystal lattice is formed and some of the water is absorbed to create the crystals; the liquid mix changes to a fragile solid within minutes of mixing; and the initial set can be recognized by the loss of gloss from the stone. The final set occurs within 24 hours.
5. Because the interlocking of the gypsum crystals are delayed.
6. Breaking teeth off a cast when separating it from an impression can be caused by carelessness or the dental stone. Even though die stone has the greatest compressive strength, it has the least tensile strength, making it the most brittle of all dental stones. This is an important point to remember when separating a full mouth rehabilitation cast with long, skinny preparations.

223

1. (1) Binder.
   (2) Refractory.
   (3) Chemical modifiers.
2. Chemical modifiers.
3. Investment set in open air has greater thermal expansion than hygroscopically set investment and thermal expansion is reduced by lessening the water in the mix.
4. It regulates the amount of setting expansion and some thermal expansion because it increases the amount of silica contained in the mixture.
5. To prevent bubbles on the casting.

224

1. Between 145 to 158°F.
2. Because wax has a high coefficient of thermal expansion causing it to expand a great deal when heated and contract the same amount as it cools.
3. Overheating, under heating, internal stresses, and the relaxation of the wax.
4. By uniformly heating the entire wax to the correct temperature.

225

1. Paraffin, gum dammar, and carnauba.
2. To eliminate difficulties that result from stress release because they do not flow at high room temperatures.
3. Mostly for preparing cast removable dental prosthesis patterns and are sold with a number of preshaped forms in varying sizes mounted on a card. Preformed wax patterns simulating rugae to reduce production time and lessen the chance of internal stresses in the pattern.
4. By scrubbing with wax solvent followed by soapy water in an ultrasonic cleaner.

226

1. By adding small amounts of metal oxides, pigments, opacifiers, and short, red rayon or nylon fibers to simulate small blood vessels.
2. By raising the temperature too quickly, by improper mixing of the monomer and polymer, and by insufficient packing pressure.
3. Cold-cured resins have less curing shrinkage and lower strength and hardness values. Cold acrylics require less processing time and equipment than heat-cured. Some are not as color stable as the heat-cured resins.
4. At least 2 to 3 hours, however, overnight curing is preferred to improve the properties of the cured resin because the dimensional stability of the denture is better for the flask.

227

1. Place the denture to be repaired in a pressure pot of warm water for 30 minutes.
2. Using the cold-cured repair resin, and it prevents denture warpage of the denture base from heat processing.
3. By submersing the mixing jar in a bowl of cold water.
4. After extraction of the remaining teeth, the template is used to disclose possible interferences between the alveolar bone and the immediate denture.
5. To allow oral tissues to recover, this improves tone and health, before making a new prosthesis or relining an existing denture.

228

1. Specifications, physical properties, noble casting alloys, metal-ceramic alloys, and removable dental prosthesis alloys.
2. An alloy with a high-yield strength will withstand more occlusal stress than a softer alloy of low-yield strength.
3. Elongation is the amount an alloy increases in length (similar to ductility) when drawn from zero stress to the breaking point.
4. Because semiprecious and nonprecious alloys have a higher modulus of elasticity because they are more resistant to stress.
5. The density or mass of a unit of metal compared with an equal volume of water at room temperature.
6. A smaller grain size provides superior physical and mechanical properties.
7. Grain growth is the merging of several smaller grains into large new grains at the expense of the smaller grain structure.
8. The alloy is in the ordered state and characterized by grain structure that is harder and stronger, and the alloy that is quenched is in the disordered state and characterized by a finer grain structure that is softer and more ductile.
9. Type II casting alloy.

10. (1) Need strength to withstand the higher temperatures and compressive forces during porcelain-firing procedures.
    (2) Provide a strong bond between the porcelain and the metal.
    (3) The coefficient of thermal expansion of the alloy and the porcelain must be compatible.
11. By the gripping action of the porcelain that has solidified in the microscopic grooves and undercuts of the metal surface.
12. The alloy's elastic and flexible nature. This property allows a wrought wire clasp to spring into and out of an undercut area, and the alloys do not distort easily due to their increased tensile and yield strength.

229

1. To join units of fixed dental prosthesis and to make repairs of everything from mending holes in castings to adding proximal contacts.
2. To improve its strength, make it react to heat treatment procedures, and lower the fusion temperature.
3. The solder's strength.
4. A solder should melt at a temperature 100°F below that of the parts to be joined. This temperature is known as the fusion temperature.

230

1. Because of under firing and over firing, varied cooling rates, and porosity all contribute to a weakened structure.
2. They effectively lower the fusion temperatures of silica, which allows desirable materials to be included in the dental porcelain.
3. Vitrification. Vitrification simply means to change into a glass by heat and fusion by firing to the correct temperature, in the full sequence to fuse the grains at their boundaries.
4. Results of repeated firings at or above the high-bisque temperature causes the grains to fuse together into one solid grain, which is an undesirable quality that leaves the devitrified porcelain with a milky appearance.

231

1. (1) f.
   (2) e.
   (3) d.
   (4) b.
   (5) a.
   (6) c.
   (7) g.

232

1. Rough finishing, rubbering, and polishing.
2. Large particles (coarse burs)
3. Discoloring clear acrylic, peeling away from the gypsum, and deteriorating easily.
4. Wetting agents reduce the surface tension of liquids and allow them to spread out over the surface evenly.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

66. (220) Which impression material is very accurate and sensitive?
    a. Reversible alginate.
    b. Irreversible alginate.
    c. Irreversible hydrocolloid.
    d. Reversible hydrocolloid.

67. (220) If you are unable to pour an alginate impression immediately, you must store it in a humid atmosphere to prevent water
    a. loss and distortion.
    b. gain and distortion.
    c. loss and increased strength.
    d. gain and increased strength.

68. (221) Besides strength, what two factors are additional *advantages* of rubber-based materials over hydrocolloid (or elastic)?
    a. Cost and speed.
    b. Accuracy and cost.
    c. Cost and ability to reproduce fine detail.
    d. Accuracy and unaffected by varying storage conditions (e.g., time and temperature).

69. (221) An impression that is made of polysulfide that exhibits streaks indicates
    a. incorrect mixing.
    b. material that is too old to use.
    c. two different color catalysts were used.
    d. two different color accelerators were used.

70. (222) Adding more water or powder to a mix weakens the cast of a gypsum-based product because it
    a. decreases setting time.
    b. increases setting expansion.
    c. develops stress between unions.
    d. disrupts crystal formation and weakens the cast.

71. (222) Die stone is the *most* brittle of all dental stones because it has
    a. the least tensile strength.
    b. an irregular crystal structure.
    c. the least compressive strength.
    d. an irregular volume of crystals.

72. (223) Which type of gas is produced if gypsum-bonded investments are heated higher than 1300°F?
    a. Sulfur.
    b. Nitrogen.
    c. Ammonia.
    d. Hydrogen.

73. (223) The *setting* expansion of phosphate-bonded investment can be increased by
    a. burning out at a lower temperature.
    b. increasing the special liquid concentration.
    c. decreasing the special liquid concentration.
    d. discharging ammonia gases from the investment.

74. (223) What type of casting investment, mixed with distilled water, may be used for soldering purposes?
    a. Gypsum-bonded.
    b. Refractory-bonded.
    c. Phosphate-bonded.
    d. Hydroscopic-bonded.

75. (224) Since wax expands a great deal when it is heated, what happens once it cools?
    a. It resists distortion.
    b. It contracts the same amount.
    c. It has a low expansion coefficient.
    d. It requires overbuilding to restore compensation.

76. (225) While handling inlay wax, use softer waxes in the occlusal and internal areas, and harder waxes in the proximal areas of fixed dental prostheses to
    a. minimize distortion.
    b. allow the waxes’ memory effect to occur.
    c. differentiate the anatomy of the wax pattern.
    d. allow the margins to expand and contract as needed.

77. (225) When working with baseplate wax, manipulating the wax at or above its softening temperature will
    a. press out any air pockets.
    b. make wax placement easier.
    c. reproduce the root eminences.
    d. avoid creating residual stresses.

78. (225) What type of wax is used to wrap around the periphery of an impression tray to form a mold to pour into a dental stone?
    a. Utility.
    b. Boxing.
    c. Baseplate.
    d. Low-fusing.

79. (226) Polymerization of heat-cured acrylic occurs at what temperature in degrees Fahrenheit (°F).
    a. 154°F.
    b. 156°F.
    c. 158°F.
    d. 160°F.

80. (226) In comparison to the heat-cured acrylics, the cold-cured materials have lower strength and hardness and
    a. more porosity.
    b. less monomer.
    c. less curing shrinkage.
    d. more processing time.

81. (227) To make cold-cured resin repairs, place the denture in a pressure pot of warm water at
    a. 115 degree Fahrenheit (°F), 20 pounds per square inch (psi), for 20 minutes.
    b. 115°F, 20 psi, for 30 minutes.
    c. 119°F, 30 psi, for 20 minutes.
    d. 119°F, 30 psi, for 30 minutes.

82. (227) Treatment liners allow oral tissues to recover, which
    a. avoids relining a denture.
    b. improves tone and health.
    c. improves the dentures aesthetics.
    d. avoids fabricating a new appliance.

83. (228) The *maximum* amount of stress a metal can withstand without obvious deformation is known as
    a. yield strength.
    b. modulus of elasticity.
    c. percent of elongation.
    d. ultimate tensile strength.

84. (228) Which term is used to describe the amount an alloy increases in length when drawn from zero stress to the breaking point?
    a. Hardness.
    b. Elongation.
    c. Yield strength.
    d. Modulus of elasticity.

85. (228) S*pecific gravity* is the density of mass of a unit of metal compared with an equal volume of water
    a. below sea level.
    b. at zero degrees.
    c. at sea level.
    d. at room temperature.

86. (228) When matching metal-porcelain alloys with porcelain, select an alloy with a
    a. higher coefficient of expansion than the porcelain.
    b. lower coefficient of expansion than the porcelain.
    c. higher coefficient of elasticity.
    d. lower coefficient of elasticity.

87. (229) Which type of solder is useful when joining stainless steel orthodontic wires-brackets?
    a. Presolder.
    b. Postsolder.
    c. Silver solder.
    d. Gold solder.

88. (229) What substance prevents the flow of solder and is used to confine the solder to the desired area?
    a. Salt.
    b. Flux.
    c. Borax.
    d. Antiflux.

89. (229) In addition to the solder's tarnish resistance and strength, you also select solder based on its
    a. solidus temperature.
    b. fusion temperature and color.
    c. solidus temperature and color.
    d. enhancement, and color.

90. (229) A solder should melt at which temperature *below* that of the parts you are joining?
    a. 70°F.
    b. 80°F.
    c. 90°F.
    d. 100°F.

91. (230) When constructing a crown, air pockets trapped between porcelain particles *adversely* affect
    a. glazing.
    b. bisque level.
    c. translucency.
    d. devitrification.

92. (230) What bisque level should porcelain be fired at for maximum shrinkage?
    a. Initial.
    b. Low.
    c. Medium.
    d. High.

93. (230) A *devitrified* restoration is *unable* to glaze naturally because
    a. it contains contaminated porcelain.
    b. it has reached the high bisque stage.
    c. it contains well defined grain boundaries.
    d. its glazing components have crystallized.

94. (231) When fabricating a computer-aided design/computer-aided manufacturing (CAD/CAM) unit, what tooth surfaces are typically milled by hand?
    a. Occlusal.
    b. Lingual.
    c. Buccal.
    d. Incisal.

95. (231) Some of the drawbacks of dental porcelain are its lack of vitality, natural color, and
    a. coalescence.
    b. translucence.
    c. compressive strength.
    d. high sintering temperature.

96. (231) How are color modifiers *usually* used in dental restorations?
    a. To subdue body colors.
    b. Extrinsically to create marginal effects.
    c. Intrinsically to create gingival effects.
    d. In combination with an applied glaze.

97. (231) How much vacuum should a porcelain furnace pull within 30 seconds?
    a. 20 to 23 inches of mercury.
    b. 23 to 26 inches of mercury.
    c. 26 to 29 inches of mercury.
    d. 29 to 32 inches of mercury.

98. (232) In addition to pressure, which factors affect the effectiveness of an abrasive?
    a. Particle size and hardness.
    b. Particle size, shape, and rotational speed.
    c. Particle shape, hardness, and rotational speed.
    d. Particle size, shape, hardness, and rotational speed.

99. (232) Separators work by preventing one material from bonding to another material by
    a. interfering with dendrite formation.
    b. creating negatively charged ions in one material.
    c. creating negatively charged ions in both materials.
    d. filling a material’s surface porosity with a nonbonding material.

100. (232) To prevent wax from bonding to gypsum, use a commercial die lubricant or
    a. soften the wax thoroughly.
    b. an alginate-based separator.
    c. apply petrolatum to the gypsum.
    d. coat the gypsum with floor wax.

Student Notes

Glossary

Terms

Abrasive—A range of coarse to fine granules with sharp edges used for smoothing, grinding, or polishing.

Abrasive paste—An abrasive suspended in a paste commonly used to smooth off small irregularities on denture teeth after gross grinding.

Absorption—Taking up a substance into the mass of another.

Abutment—(1) On removable partial dentures, it is the tooth on which a clasp is placed to support and retain the removable partial denture. (2) On fixed partial dentures, it is the tooth to which the retainer is cemented. (3) On implants, it is the part that supports and/or retains the prosthesis.

Accelerator—A substance that speeds up a chemical reaction.

Acid—Any one of a group of corrosive chemicals used to clean oxide layers or surface contaminants from gold castings.

Acid etching—(1) In clinical dentistry, treating the enamel, generally with phosphoric acid, by removing approximately 40 microns of rod cross-section for resin retention. (2) As a laboratory procedure, using electrolysis or chemicals to remove a microscopic layer of metal to produce mechanical retention for resin bonding. (Do not confuse *with electropolishing,* which occurs to a much greater degree.)

Acrylic resin—A plastic widely used in dentistry for making denture bases, provisional crowns, custom trays, etc.

Acrylic resin impression tray—See *custom tray*.

Acrylic resin veneer—A tooth-colored layer of plastic placed over the facial surface of a metal crown to improve the crown's appearance.

ADA specification—A detailed description of the qualities and properties required of a dental Material as set forward by the American Dental Association (ADA).

Adhesion—The sticking together of unlike substances.

Adjustment—A modification to a dental prosthesis to enhance fit, function or appearance.

Agar—A gelatin-like substance obtained from certain seaweeds (algae) and used in compounding reversible hydrocolloid impression materials.

Aker's clasp—See *circumferential clasp.*

Alginate—An irreversible type of hydrocolloid made from a salt of alginic acid.

Align—To properly position in relation to another object or objects.

Alloy—A metal consisting of a mixture of two or more pure metals.

Alveolar process—Part of the mandible and maxilla that surrounds and supports the roots of natural teeth.

Alveolus—The bony socket holding the root of a tooth by the periodontal ligament.

Amalgam—An alloy of mercury, silver, and other metals used as a restorative material.

Amorphous—Not having a definite crystalline structure.

Anatomic crown—The part of a tooth covered with enamel.

Anatomic teeth—Denture teeth with cusp angles of 30 degrees or more.

Anneal—To heat a metal, followed by a controlled cooling to remove internal stresses and create a desired degree of toughness, temper, or softness to the metal.

Anode—The positive pole of an electric source.

Anterior guidance—See mutually protected articulation.

Anterior guide pin—The pin fitting into the upper member of the articulator, resting on the anterior guide table; maintains a selected amount of vertical separation. Also called incisal guide pin.

Anterior guide table—Component of the articulator upon which the anterior guide pin rests to maintain occlusal vertical dimension and influence articulator movements. Also called incisal guide table.

Anterior teeth—The central and lateral incisors and the cuspids of either arch.

Anterior tilt—A term used in surveying the master cast; when the cast is tipped on the surveyor table so the anterior part of the cast is lower than the posterior.

Anteroposterior—Extending from the front, backward.

Anteroposterior curve—The anatomic curve established by the occlusal alignment of the teeth, from the cuspid through the buccal cusps of the posterior teeth, when viewed from the side. Also called the curve of Spee.

Antiseptic—Chemical agent applied to tissue to inhibit growth of microorganisms.

Apical—Pertaining to the apex or root tip.

Apical foramen—The opening at the end of a root of a tooth through which the tooth receives its nerve and blood supply.

Approach arm—The part of a bar clasp connecting the retentive portion to a removable partial denture framework.

Aqua regia—A mixture of three parts hydrochloric acid and one part nitric acid. Used for removing a layer of gold.

Arch—See *dental arch.*

Arch form—The general contour or shape of the arch. Patients' arches are sometimes classified as square, tapering, or ovoid, according to their general shape.

Arcon articulator—An articulator having the condyle elements attached to the lower member in the same way condyles are an anatomic feature of the mandible in a human skull.

Arrangement—See *tooth arrangement.*

Arrow point (gothic arch angle)—On an articulator, the pointed pattern made by the intersecting working and balancing paths of a stamp cusp as it travels out of maximum intercuspation. The maximum intercuspation position is the apex of the arrow.

Articular disc—The circular-shaped, flat piece of fibrocartilage lying between the condyle of the mandible and the glenoid fossa of the temporal bone.

Articulating paper—Colored paper or film, usually supplied in strips, used intraorally and in the laboratory to detect contact between the maxillary and mandibular teeth.

Articulation—(1) In the anatomic sense, the place of union or junction of two or more bones of the skeleton. (2) In dentistry, the contact relationship between the occlusal surfaces of the teeth during function.

Articulator—A mechanical device representing the temporomandibular joints and jaws to which maxillary and mandibular casts can be attached for performing prosthodontic procedures.

Artificial stone—See *dental stone.*

Asbestos substitute—A strip used to line a casting ring used to invest fixed prosthodontic units; replaced asbestos strips.

Asepsis—A pathogen-free condition.

Attrition—The wearing away of the biting surfaces of the teeth.

Autogenous glaze—A natural glaze.

Autopolymerizing resin—Resin whose polymerization is initiated by a chemical activator.

Auxiliary lingual bar—An extension from the lingual bar of a mandibular removable partial denture framework used to stabilize loose, periodontally involved anterior teeth. Also called a supplemental Kennedy bar.

Axial—Lines, walls, or surfaces parallel with the long axis of a tooth.

Axis—An imaginary line passing through a body, around which the body may rotate, for example, transverse horizontal axis.

Axis orbital plane—The horizontal plane established by the transverse horizontal axis of the mandible with a point on the inferior border of the right or left bony orbit (orbital); can be used as a horizontal reference point; corresponds to the Frankfort plane.

Backing—The metal plate constructed to fit the slot or pins of the porcelain facing. May be manufactured or may be cast in the laboratory.

Balanced articulation—The bilateral, simultaneous, anterior and posterior occlusal contact of teeth in centric and eccentric positions. Also called balanced occlusion.

Balanced occlusion—See *balanced articulation.*

Balancing side—See *nonworking side.*

Balancing side occlusal contacts—See *nonworking side occlusal contacts.*

Bar—A major connector used in removable partial denture construction to connect the right and left sides of the framework.

Bar clasp—A type of clasp in which the retentive tip approaches the undercut from below the survey line. Also called infrabulge clasp.

Basal seat area—See *denture foundation area.*

Base—The part of a removable prosthesis that retains artificial teeth and replaces the alveolar process and gingival tissues. The base of a removable prosthesis is made of metal or denture resin.

Base metal—Any metal element that doesn't resist tarnish and corrosion. Any metal which is not noble.

Baseplate—See *record base.*

Baseplate wax—A hard, pink wax used for making occlusion rims, waxing dentures, and many other dental procedures.

Beading—(1) As in "beading a cast:" to score a cast in any desired area to provide a seal between the finished prosthesis and the soft tissue. (2) As in "beading an impression": to rim an impression with a wax strip before pouring so that all critical impression landmarks show up in the cast.

Beadline—The indentation resulting from beading the cast.

Beeswax—The wax derived from the bee's honeycomb used in many dental waxes.

Bennett movement—See *laterotrusion.*

Bicuspid or premolar—A tooth having two cusps.

Bifurcated—Having two roots (forked).

Bilateral—Having two sides. Any removable partial denture having a major connector is called a bilateral appliance.

Biocidal—Destructive to living organisms.

Biteplane—See *occlusal plane.*

Blind vent—See *chill set.*

Block out—The process of eliminating undesirable undercut areas of a cast or denture. This procedure is most frequently used in preparing a cast for removable partial denture construction. The undercut areas below the survey line on the teeth are blocked out with wax.

Block out tool—A rod used in the surveyor spindle to remove excess wax between the height of contour and the gingival border of abutment teeth on master casts.

Blow torch—A device designed to mix gas and air so it can be ignited. The flame is directed on an object to heat or melt the object.

Body of a clasp—Connects rest and clasp arm(s) to the minor connector.

Boiling point—The temperature at which a vapor pressure of a liquid is equal to the external pressure.

Boley gauge—A caliper-like instrument calibrated in millimeters and used for fine measurements in the laboratory.

Bolus—The chewed up mass of food and saliva.

Borax or sodium tetraborate—A white crystalline substance used as a flux in soldering and casting procedures.

Boxing an impression—Wax wrapped around the impression for confining the dental stone as the cast is poured.

Boxing wax—A pliable wax in strip form, used to box an impression.

Bracing—The resistance to displacement in a lateral direction from masticatory forces.

Bracing arm—See *reciprocal arm.*

Brass—An alloy of about 60 to 70 percent copper and the remainder is zinc.

Bridge—See *fixed partial denture.*

Brinell hardness—An index number denoting the relative surface hardness of a material, usually abbreviated Bhn. Used in testing softer metals, and nonbrittle materials such as gold, copper, and silver.

Broken stress fixed partial denture—See *interlock fixed partial denture.*

Bruxism—A clenching of the teeth accompanied by lateral motion in other than chewing movements of the mandible. Grinding or gritting of the teeth usually during sleep or nervous tension. Causes excessive wear of occlusal surfaces.

Buccal—Pertaining to the cheek. The surface of the tooth toward the cheek.

Buccal frenum—A connecting fold of membrane attaching the cheeks to the alveolar ridge in the bicuspid region of each arch. (plural: buccal frena)

Buccal groove—Landmark on the buccal surfaces of mandibular molars, extending vertically from the occlusal surface down toward the cemento-enamel junction.

Buccal notch—The V-shaped notch in the impression or denture formed by or for the buccal frenum.

Buccinator muscle—The cheek muscle.

Buff—To polish by rubbing or by holding the object against a revolving felt wheel impregnated with a polishing agent.

Bur—A small rotating instrument used in the dental hand piece for cutting acrylic resin or metal. Also used by the dentist to cut enamel or dentin.

Burlew discs—The rubber wheels impregnated with pumice, used for polishing dental restorations.

Burn out—See *wax elimination.*

Burn out temperature—The temperature that must be reached to properly eliminate a wax pattern **properly** from the mold and expand the mold.

Burnish—The drawing or flattening out of a malleable metal through pressure. If a rounded instrument is repeatedly rubbed across the margin of a soft gold casting and the tooth, the gold will be thinned and spread over onto the enamel of the tooth.

Butt joint—A type of joint in which the two pieces to be joined touch each other but do not overlap.

Calculus—The hard calcium-like deposit, which forms on teeth and on artificial dentures.

Cameo surface—The viewable portion of the denture. The part of the denture base normally polished, and includes the facial and lingual surfaces of the teeth.

Camper's line—An imaginary line on a patient's face running from the anterior border of the ala of the nose to the superior border of the tragus of the ear. The dentist uses this line to check the orientation of the occlusal plane of a complete denture.

Canine—A tooth having one cusp or point; the third tooth from the midline. So named because they correspond to the long teeth of a dog. Also called *cuspid.*

Canine or cuspid eminence—The prominence of labial bone, which overlies the root of the upper canine

Canine guided articulation—A form of mutually protected articulation in which the canines disengage the posterior teeth during an excursive mandibular movement. Also called cuspid guidance.

Cantilever fixed partial denture—A fixed partial denture supported on only one end with one or more abutments.

Cap—A term used for the top of a denture flask.

Capillary attraction—The characteristic by which, because of surface tension, a liquid in contact with a solid is elevated or depressed as in a capillary tube.

Carbon marker—A graphite stick that fits into the surveyor spindle, used to make a line or mark on the master cast when surveying.

Carborundum—A trade name for silicon carbide. Extremely hard blue crystals used as an abrasive in many dental stones and points.

Caries—Tooth decay.

Carnauba wax—A type of wax obtained from the South American palm tree used in some dental materials.

Cartilage—Translucent elastic tissue.

Cast—(1) The positive reproduction of the mouth in stone or similar material upon which a prosthetic appliance can be constructed; (2) To produce a shape by thrusting a molten liquid into a mold possessing the desired shape.

Cast base—The portion of the removable prosthesis covering the edentulous ridges and supporting artificial teeth made of metal. Also called metal base denture.

Casting—(1) An object formed in a mold; (2) The process of forming a casting in a mold.

Casting machine—A device designed to hold the investment mold and melted metal which has the capability of forcing the melted metal into the mold by either centrifugal force, air pressure, or vacuum.

Catalyst—A substance that accelerates a chemical reaction without affecting the physical properties of the material involved.

Cathode—The negative pole of a source of electric current.

Cement—Dental luting agents that have the dual purpose of holding the casting on a tooth and protecting the pulp against thermal shock.

Cementum—A soft, bone-like structure covering the root surface of the tooth.

Centigrade—A heat measuring scale calibrated so the freezing temperature of water is 0 degrees Celsius and the boiling temperature of water is 100 degrees Celsius.

Centimeter—A hundredth of a meter; 2.54 centimeters equals 1 inch.

Central fossa—The rounded, relatively shallow depression found in molars in the approximate middle of the occlusal surface.

Centric occlusion (CO)—The occlusion of teeth when the mandible is in centric relation, may or may not coincide with maximum intercuspation.

Centric relation—A maxillomandibular relationship in which the condyles articulate with their respective discs in the anterior-superior position of the glenoid fossa against the articular eminences.

Centrifugal—A force in a direction from the center outward.

Centripetal—A force in a direction from the periphery toward the center; the opposite of centrifugal.

Ceramic—Having to do with the use of porcelain.

Ceramic crown—A ceramic restoration restoring a clinical crown without a supporting metal substructure.

Ceramo-metal—See *metal ceramic restoration.*

Ceresin—A mineral wax often used as a substitute for beeswax.

Cervical—Pertaining to the neck of a tooth.

Cervical line—The line where the cementum and enamel join. Also known as the cementoenamel junction.

Cervix—The neck of a tooth.

Chalk—Calcium carbonate. A powder used for final polishing.

Characterization—(1) (of dentures): Anything done to a denture to make it look natural, including staining the denture base, making special tooth arrangements, staining the denture teeth, etc.; (2) (of metal ceramic restorations): Staining and/or modifying the surface texture and shape to make the restoration look natural.

Checked tooth—A tooth with a hairline crack.

Chewing cycle—See *masticatory cycle.*

Chill set—A riser or vent which does not extend outside the mold.

Christensen's phenomenon—The space occurring between opposing occlusal surfaces during mandibular protrusion. Occurring because of disclusion of posterior teeth in protrusion due to condylar guidance.

Chroma—Saturation of a hue.

Chuck—The lathe attachment that grips the various burs, abrasive wheels, or buffing wheels.

Circumferential clasp—Clasps that approach the undercut portion of a tooth from above the survey line.

Clasp—The part of a removable partial denture that partly encircles the abutment tooth and helps to retain, support, and stabilize the appliance.

Clasp arms—The shoulders and tips of a clasp; the part of the clasp that extends from the body out to the tip.

Clasp shoulder—The part of the clasp arm that connects the body to the retentive terminal; the portion of the clasp arm closest to the body.

Cleft palate—An opening in the palate. It may be in the hard or soft palate, or both. An acquired cleft palate is caused by surgery, disease, or accident. A congenital cleft palate is present at birth.

Clinical crown—That part of a crown visible in the mouth above the gum line.

Closed bite—Slang for *decreased occlusal vertical dimension.*

Coalescence—The result of firing porcelain at one extremely high temperature.

Cohesion—The molecular attraction by which the particles of a body are united throughout their mass.

Cold cure—The polymerization of acrylic resins at room temperature. See *autopolymerizing resin.*

Cold flow—A change in shape or dimension at a temperature lower than the normal softening point of the material.

Collar—The neck of an artificial tooth below the cervical line, used to embed and retain the tooth in a denture base.

Combination clasp—A circumferential clasp assembly having one cast arm and one wrought wire arm.

Compensating curve—The combination of the two curves made when the denture teeth are set on anteroposterior and lateral curves for purposes of achieving a balanced articulation.

Complete denture—A dental prosthesis replacing all natural dentition and the associated structures of the maxilla or the mandible.

Compression molding—The method of denture molding employing a two-piece split mold. Acrylic resin dough is placed between the two halves of the mold and cured under pressure.

Concave—Curving inward; dished in.

Condensation—The process of making a substance more compact.

Conductivity—The property of conducting heat or electricity. Silver and copper are two of the best conductors.

Condylar guidance—A device on an articulator which is intended to produce guidance in the articulator's movements similar to that produced by the paths of the condyles in the temporomandibular joints.

Condylar guide inclination—The angle formed by the inclination of a condylar guide control surface of an articulator to a specified reference plane. For example, horizontal condylar guide inclination.

Condylar indication—The scale on the articulator measuring the amount of condylar inclination.

Condylar path—The path of the mandibular condyle in the temporomandibular joint during mandibular movement.

Condyle—The rounded articular surface at the articular end of a bone. In the temporomandibular joint, it is football shaped and found on the end of the condyloid process of the mandible.

Condyle head—See *condyle.*

Congenital—Condition occurring in the offspring before birth.

Connective tissues—The tissues that bind together and support the various structures of the body.

Connector—(1) In removable partial dentures, a part of the framework, which serves to connect two parts with another. Connectors are divided into major and minor. (2) In fixed prosthodontics, the portion of a fixed partial denture connecting the retainers and the pontics.

Contact surface—The area on a tooth touching an adjacent tooth. Normally, found on both mesial and distal surfaces of all teeth except the third molars. Also called *contact area.*

Continuous bar connector—A type of lower removable partial denture that employs a second or auxiliary bar with a lingual bar. Also called a *continuous bar retainer and double lingual bar*.

Contour—(1) (noun): The shape of a surface; (2) (verb): To shape into a desired form.

Convex—A surface curved outward toward the viewer.

Cope—A term used for the upper half of a denture flask.

Coping—A thin covering or crown.

Copper band—The hollow cylinders of thin copper in various diameters used to make impressions for crowns and inlays.

Coronal—Pertaining to the crown portion of a tooth.

Creep—To change shape permanently due to prolonged stress or exposure to high temperatures.

Crest of the ridge—The high point of the alveolar ridge.

Crossbite—See *reverse articulation.*

Cross-section—A cut section of an object, made so the cut is perpendicular to the object's long axis.

Crown—(1) In anatomy, the part of the tooth covered by enamel; (2) In the laboratory, an artificial replacement that restores missing tooth structure with a metal or ceramic restoration.

Crucible—The heat resistant container used to hold the metal while it is melted in preparation for casting.

Crucible former—The device used to hold the sprued wax pattern upright in the casting ring when it is invested. It is shaped to form a funnel for the gold as it enters the mold. Sometimes erroneously called a sprue former.

Crushing strength—The amount of pressure required to crumble or crush a material.

Crystallization—The solidification of a gaseous or liquid substance.

Cure of denture—See *polymerization.*

Curve of Spee—See *anteroposterior curve.*

Cusp—A cone-shaped elevation on the occlusal surface of a molar or bicuspid and on the incisal edge of the cuspid.

Cuspid—See *canine.*

Cuspid line—The vertical line the dentist scribes on the record rims to indicate the position the cuspid is to occupy in the setup.

Custom tray—An impression tray made on a preliminary cast used to make the final impression.

Cyanoacrylate—A quick setting adhesive. Also called super glue.

Dappen dish—A glass medicine dish.

Debubblizer—A wetting agent used to lower surface tension of the water in an investment so it flows more easily over the wax pattern.

Decalcification—The loss or removal of calcium salts from calcified tissues. Characterized by areas of white, splotchy opacity on the surfaces of teeth.

Deciduous tooth—A tooth that will be replaced by a permanent tooth.

Decreased occlusal vertical dimension—A reduction in the distance between two points when the teeth are in occlusal contact. Also called closed bite.

Deflask—The removal of the denture from the mold in the flask.

Dehydrate—To remove the moisture from a substance.

Density—The mass of a substance per unit volume.

Dental arch—A term given to the horseshoe-like arrangement of either the upper or lower teeth or the residual ridge.

Dental implant—A prosthetic device implanted within the bone to provide retention and support for a fixed or removable appliance.

Dental plaster—A gypsum that is refined by grinding and heating.

Dental stone—A specially calcined gypsum physically different from dental plaster in that the grains are nonporous and the product is stronger.

Dental wax—Any of the various waxes used in dentistry.

Dental wrought wire—An alloy in wire form manufactured by drawing it through die plates of varying diameters.

Dentin—The tissue of the tooth underlying the enamel of the crown which makes up the bulk of the substance of the tooth.

Dentition—The natural teeth as a unit.

Dentulous—With teeth; as opposed to edentulous (without teeth). Also called *dentate.*

Denture—See *complete denture.*

Denture base material—The material of which the denture is made; exclusive of the teeth.

Denture border—(1) The margin of the denture base at the junction of the polished surface and the impression surface; (2) The peripheral border of a denture base at the facial, lingual, and posterior limits. Also called peripheral roll.

Denture foundation area—The surfaces of the oral structures available to support a denture.

Denture staining—The process of adding pigments to the facial flange of the denture to more closely simulate natural mouth tissue.

Deoxidizing—To remove oxides from the surface of a gold alloy by heating the alloy in an acid or other proprietary agent. Also called *pickling.*

Deoxidizing investment—See *reducing investment.*

Desiccate—To make dry; to remove all moisture.

Desirable undercut—The part of an abutment tooth below the survey line, which can be engaged by the clasp tip to retain the removable partial denture.

Developmental groove—A groove formed by the union of two lobes during the development of the crown of a tooth.

Devitrification—To eliminate vitreous (glass) characteristics partly or wholly; to recrystallize.

Diagnosis—The determination of the nature of the disease condition present in a patient.

Diagnostic cast—A reproduction of the mouth for the purpose of study and treatment planning.

Diamond point—Small mounted points impregnated with diamond particles, used in the dental handpiece.

Diastema—A space between the teeth.

Diatoric—A channel placed in the denture tooth as a mechanical means of retaining it in the denture base.

Die—The positive reproduction of a prepared tooth in any suitable substance.

Dimensional stability—The ability of a material to retain its size and form.

Direct current—The current in which the electricity flows along a conductor in one direction.

Direct inlay technique—The method of inlay construction in which the wax pattern is made on the tooth in the mouth by the dentist.

Direct retainer—The part of a removable partial denture appliance designed to resist dislodgement directly; for example, the clasp.

Disc—A flat circular plate usually impregnated with an abrasive agent, used in the laboratory to smooth and polish. The abrasive agent may be silica, garnet, emery, or some other agent.

Disclude—Separation of the maxillary and mandibular teeth.

Disinfectant—An agent that kills infecting agents, for example, phenol.

Distal—A surface facing away from the midline of the mouth; the distal surface of a tooth.

Distortion—Changed from a normal shape or position

Double lingual bar—See *continuous bar connector.*

Dough—The moldable mixture formed by combining acrylic resin powder and liquid.

Dovetail—A widened portion of a prepared cavity used to increase retention.

Dowel—A post, usually made of metal, fitted into the prepared root canal of a natural tooth. Also called post and core.

Drag—A term for the lower half of a denture flask.

Dry heat—The heat of a flame as opposed to moist heat from a water bath.

Ductility—The property of a metal, which permits it to be drawn into a wire without breaking.

Duplicate cast—A cast produced from an impression of another cast.

Duplicating a cast—The process of producing a duplicate cast.

Duplicating material—A substance such as hydrocolloid used to make an impression so an accurate copy of the cast can be produced.

Eccentric—Any position of the mandible other than its normal position.

Edentulous—Without teeth; may be an area, an arch, or an entire mouth.

Elastic—Susceptible to being stretched, compressed, or distorted and then tending to resume the original shape.

Elastic limit—The extent to which a material may be deformed and still returned to its original form after removal of the force.

Electric current—The flow of electrons from one point to another.

Electrode—Either pole of an electric mechanism.

Electrolyte—The liquid used in electroplating.

Electroplating—The process of covering the surface of an object with a thin coating of metal by means of electrolysis.

Electropolishing—The removal of a minute layer of metal by electrolysis to produce a bright surface.

Elongation—The amount a metal will stretch before breaking.

Embrasure—The space defined by surfaces of two adjacent teeth. The space is divided into occlusal/incisal, facial, lingual, and gingival areas.

Emergence profile—The contour of a tooth or restoration, such as a crown on a natural tooth or dental implant abutment, as it relates to the adjacent tissues.

Emery—An abrasive substance used as a coating on paper discs which are used to smooth and polish.

Eminence—A prominence or projection, especially upon the surface of a bone.

Enamel—The white, compact, very hard substance covering and protecting the dentin of the crown of teeth.

Enamel rod—The microscopic prisms, held together by an intercementing substance, forming the bulk of the enamel.

Endodontia—The branch of dentistry dealing with diagnosing and treating nonvital teeth.

Envelope of motion—The three dimensional space made by the mandibular border movements within which all unstrained mandibular movement occurs.

Equilibration of occlusion—See *occlusal equilibration.*

Erosion—The superficial wearing away of tooth substance due to chemical agents, most often seen on labial and buccal surfaces.

Esthetics—Harmony of form, color, and arrangement. The quality of a pleasing appearance.

Etiology—The causative factors, which produce a disease.

Eugenol—(1) An aromatic oil derived from clove oil to relieve pulpal pain; (2) May also be combined with zinc oxide to make a temporary sedative cement; (3) A principal ingredient in zinc oxide eugenol impression pastes.

Excursion—The movement occurring when the mandible moves away from maximum intercuspation.

External or lateral—Surfaces farther from the medial plane.

Extracoronal—Outside of the crown portion of a natural tooth.

Extraoral—Outside of the mouth.

Extrinsic—Outside, as opposed to intrinsic or inside.

Extrinsic coloring—Coloring from without; applying color to the external surface of a prosthesis.

Extrusion—The movement of teeth beyond the natural occlusal plane; may be accompanied by a similar movement of their supporting tissues and/or bone.

Face form—The outline of the face from an anterior view.

Face profile—The outline of the face from the side or lateral view.

Facebow—A device used to record the relationship between the maxillae and the temporomandibular joints and to transfer this relationship to the articulator.

Facebow fork—A device used to attach the facebow to an occlusion rim, or to index the maxillary teeth, for a facebow transfer.

Facial—(1) Pertaining to the face; (2) The surface of the tooth or appliance nearest the lips or cheeks. used synonymously for the words *buccal* and *labial.*

Facing—The thin veneer of porcelain or resin which closely fits a metal backing, used in fixed and removable partial dentures.

Facial moulage—A negative reproduction of the face made out of artificial stone, plaster of paris, or other similar materials.

Female attachment—See *matrix.*

Festooning—Shaping and contouring a denture wax up or the cured denture base to simulate natural tissue.

Fin—A flash of excess metal, which results from a fracture in the investment mold.

Fineness—The proportion of pure gold in a gold alloy; the parts per 1000 of gold.

Finish line—(1) On an artificial tooth: the raised line in the cervical region used as a guide to trim the wax on the denture base material; (2) In removable partial dentures; the special preparation placed in the metal to form a definite sharp junction between the metal and acrylic resin.

Finishing—(1) The process of smoothing and trimming a prosthesis before its final polish; (2) The entire procedure of smoothing and polishing.

First molar—The 6-year molar. The sixth tooth from the midline.

Fissure, dental—A fault in the surface of a tooth caused by the imperfect joining of the enamel of the different lobes.

Fistula—An abnormal passage resulting from incomplete healing.

Fixed bridge—See *fixed partial denture.*

Fixed partial denture—A fixed dental prosthesis, cemented to the prepared teeth or attached to implants, restoring one or more, but fewer than all of the missing natural teeth.

Fixture—(1) Something fixed or attached. 2: The intraosseous portion of a dental implant.

Flange—The part of the denture base which extends on the facial or lingual surface from the finish lines of the teeth to the periphery.

Flash—(1) The overflow of denture base material, which results from over-packing a denture mold; (2) The thin metal fins which sometimes occur on castings.

Flash point—The temperature at which a vapor ignites.

Flask—(1) A metal case or tube used in investing procedures. Holds the casts and the investment during the packing and curing phases of denture construction; or the metal ring used to invest a wax pattern; (2) To flask or surround; to invest.

Flasking—The process of investing a waxed pattern to create a mold.

Flat plane tooth—See *nonanatomic teeth.*

Flexible—Capable of being bent without breaking.

Flexure line—See *vibrating line.*

Flow—Deformation of a material under loading.

Flow on wax—To melt and apply the wax in liquid form.

Flux—(1) A substance used to increase fluidity and to prevent or reduce oxidization of a molten metal; (2) Any substance applied to the surfaces to be joined by soldering to clean and free them from oxides and promote union.

Foil—An extremely thin, pliable sheet of metal, usually of variable thickness.

Foramen—An opening in a bone or tooth allowing for the entrance or exit of blood vessels and nerves. For example, the apical foramen in the tooth.

Fossa—An anatomical pit, groove, or depression.

Fovea palatine—Two small pits or depressions in the posterior aspect of the palate, one on each side of the midline, at or near the attachment of the soft palate to the hard palate.

Fox plate—A device occasionally used by dentists to establish the occlusal plane on occlusion rims. used to compare with arbitrary lines or planes on the head, for example, Camper's line.

Framework—The metal skeleton of a removable partial denture or metal-ceramic fixed partial denture.

Frankfort horizontal plane—A horizontal plane represented in profile by a line between the lowest point on the margin of the orbit to the highest point on the margin of the auditory meatus. It nearly parallels the upper member of an articulator; making it a useful plane of orientation for setting denture teeth.

Freehand waxing—A method of waxing in which the wax is flowed from an instrument directly onto the refractory cast to form the removable partial denture framework.

Freeway space—See *interocclusal rest space.*

Frenum—See *frenulum.* Plural: frenums or frena.

Frenulum—The small band or fold of connective tissue covered with mucous membrane which attaches the tongue, lips, and cheeks to adjacent structures.

Friable—Capable of being easily crumbled into small pieces; brittle.

Frontal bone—The bone that forms the front part of the cranium.

Fulcrum—The support upon which a lever rests when a force is applied. In removable partial dentures an abutment tooth may act as a fulcrum for the appliance.

Fulcrum line—An imaginary line through the abutment teeth around which a removable partial denture would rock if not prevented from doing so.

Functional mandibular movements—All natural, proper, or characteristic movements of the mandible made during speaking, chewing, yawning, swallowing, etc.

Furnace 1: burn out—The gas or electric oven used to eliminate the wax from a mold.

Furnace 2: porcelain—A specially constructed oven used to fuse dental porcelain.

Fusible—Able to be melted.

Fusion temperature—The highest temperature to which an alloy can safely be exposed in the soldering process; usually close to the lower limit of the melting range.

Gauge—A measure of the thickness or diameter of an object.

Galvanic current—A current of electricity produced by chemical action between two metals suspended in liquid.

Garnet—An abrasive, glass-like coating on paper discs used for smoothing and polishing.

Gelatin—The solidification of a liquid substance in which a gel forms and acts as a matrix between the undissolved particles. Alginate gels as it sets.

Gingiva—The gum tissue.

Gingival crevice—The shallow fissure formed by the attachment of the gingiva to the crown of the tooth.

Gingivectomy—The removal of the gingival tissue from around the necks of the teeth.

Gingivitis—An inflammation of the gingiva.

Glaze—The final firing of porcelain in which the surface is vitrified and a high gloss is imparted to the material.

Gold—A noble metal used extensively in dentistry, most commonly, in the form of an alloy.

Gold alloy—An alloy consisting of gold mixed with other metals, such as, silver, platinum, copper, and palladium.

Grain—The basic unit for the apothecaries' avoirdupois, and troy systems of weight. A troy grain is 1/24 of a pennyweight.

Grain growth—The merging of smaller grains into larger grains of metal during prolonged heating of the appliance at excessively high heat. This process produces a brittle metal.

Gram—A unit of weight in the metric system, equal to approximately 15 grains in the apothecaries' system of weight.

Groove—A long narrow depression on the surface of a tooth, such as the indentation between two cusps.

Group function—Multiple contact relations between the maxillary and mandibular teeth in lateral movements on the working side; simultaneous contact of several teeth act as a group to distribute occlusal forces. Also called unilateral balance.

Gypsum—The natural hydrated form of calcium sulfonate.

Half flasking—The process of investing the denture in the lower or first half of the denture flask.

Hamular notch—See *pterygomaxillary notch.*

Handpiece or straight handpiece—The instrument used to hold and spin burs and mounted points in dental operations.

Hard palate—The anterior two-thirds of the roof of the mouth composed of relatively hard, unyielding tissue.

Hardening heat treatment—See *tempering.*

Heat soaking—The process of allowing the invested inlay or removable partial denture to remain in the oven at the burn out temperature for a prescribed length of time to remove all carbon and properly expand the mold.

Heat treatment—In its broadest sense, the annealing or tempering of an alloy (Sometimes the term *heat treatment* is confined solely to the tempering.)

Heel of a denture—The posterior extremities of a denture. The heels correspond with the retromolar pad area of the lower denture and the tuberosity area of the upper denture.

Height of contour—The greatest circumference of the crown of a tooth.

High lip line—The horizontal line the dental officer marks on the occlusion rim to indicate the approximate level of the upper lip when the patient smiles. Used to help select the length of the anterior teeth.

Highly adjustable articulator—An articulator that allows replication of three-dimensional movement of recorded mandibular motion.

Hinge axis—See *transverse horizontal axis.*

Hinge joint—A joint that moves in only two directions, such as the knee joint.

Horizontal overlap—The projection of teeth beyond their antagonists in a horizontal direction. Also called overjet.

Hue—The basic color; white, black and grays possess no hue.

Humidor—Container used to maintain a humid atmosphere.

Hydration—The addition of water to a substance. Plaster that has absorbed water from the air is said to be hydrated.

Hydrocal—A form of gypsum that is harder and more durable than ordinary dental plaster.

Hydrocolloid—An impression material used extensively in dentistry. It may be reversible agar type or irreversible alginate type.

Hydrocolloid, irreversible, alginate type—An impression material supplied as a powder to be mixed with water. It can only be used once, hence, the name irreversible.

Hygienic pontic—A pontic that is easier to clean because it has a domed or rounded cervical form and does not have contact with the ridge. Generally used in the posterior where esthetics are of no concern.

Hyperplasia—The abnormal overgrowth of a part. Increase in size and number of cells.

Hyperplastic tissue—Excessive tissue proliferation, usually as a response to chronic irritation.

Immediate denture—A complete denture or removable partial denture fabricated for placement immediately following the removal of natural teeth.

Implant—See *dental implant.*

Impression—A negative reproduction of a given area.

Impression paste—A material usually supplied as a base and a hardener to be mixed together and used as a corrective impression material.

Impression plaster—Plaster of paris made expressly for impressions of the mouth. It contains accelerators, and usually coloring and flavoring agents. It may also contain starch.

Impression tray or stock tray—See *stock impression tray*.

Impression tray, individual—See *custom tray.*

Impression, final—An impression used to form the master cast.

Impression, functional—An impression that captures supporting structures in the form they will assume during mastication.

Impression, pickup—An impression in which an object is lifted off the teeth by the impression material. When the cast is poured, the object will be seated in its proper place on the cast.

Impression, two-piece—An impression taken in two separate steps with (usually) two separate types of impression materials.

Incisal—Pertains to the cutting edge of the anterior teeth.

Incisal edge—The biting edge of an anterior tooth.

Incisal pin—See *anterior guide pin.*

Incisal table—See *anterior guide table.*

Incisive foramen—An exit hole for blood vessels and nerves found behind the maxillary central incisors in the midline. The foramen is covered by the incisive papilla.

Incisive papilla—A small pad of tissue located at the midline just behind the crest of the maxillary ridge, which protects the vessels and nerves as they exit from the incisive foramen.

Incisor—A tooth with a cutting edge; the centrals and laterals.

Inclination—Deviation of the long axis of a tooth with respect to a vertical line of reference. Four basic directions of inclination are described as facial, lingual, distal, and mesial.

Inclined plane—A surface that slopes at an angle from the horizontal plane.

Index—A guide, usually of a rigid material, used to reposition teeth or other parts in some original position.

Indirect inlay technique—A method of waxing the pattern on a die outside of the mouth.

Indirect retainers—A part of a removable partial denture framework located on the opposite side of the fulcrum line from tipping forces, and designed to counteract those forces.

Induction casting machine—A specially constructed casting machine which melts metal using an electric current of extremely high frequency.

Induction current—The process of generating an electric current in a conductor using a magnetic field.

Inferior—Below.

Infrabulge—The area on a tooth below the survey line.

Infrabulge clasp—See *bar clasp.*

Ingot—Gold supplied in the form of one or two pennyweight (1.55 or 3.1 grams) pieces. Some of the base metal alloys are supplied in small cylinders and are also called ingots.

Initial set—The first hardening of a gypsum product.

Injection flask—A denture flask designed to permit compression molding of an acrylic resin denture with a sprue leading into the mold.

Inlay—A restoration made to fit inside a prepared tooth cavity, and cemented into place.

Insertion—(1) The attachment point for a muscle in the bone or other structure to be moved; (2) See *placement.*

Intaglio surface—The portion of the denture or other restoration having its contour determined by the impression; the internal or reversal surface of an object. Also called internal surface or tissue surface.

Interact distance—The interring distance; the vertical distance between the maxillary and mandibular edentulous arches under specified conditions. Also called intermaxillary space.

Intercondylar distance—The distance between the rotational centers of two condyles.

Interdigitation—See *maximum intercuspation.*

Interim prosthesis—A fixed or removable prosthesis, designed to enhance esthetics, stabilization and /or function for a limited period of time, after which it is replaced by a permanent prosthesis.

Interlock—A device connecting a fixed unit or a removable prosthesis to another fixed unit.

Interlock fixed partial denture—A fixed partial denture constructed in two pieces containing a matrix and patrix. Also called broken stress fixed partial denture.

Intermaxillary space—See *interarch distance.*

Intermediate abutment—A natural tooth located between terminal abutments serving to support a fixed or removable prosthesis.

Internal or medial—Surfaces closer to the medial plane.

Interocclusal rest space—The difference between the vertical dimension at rest and the vertical dimension while in occlusion. Also called freeway space.

Interproximal—Between adjoining tooth surfaces.

Interproximal space—The space between two adjacent teeth.

Intraoral—Within the mouth.

Intraoral tracing—A tracing made within the mouth.

Intrinsic coloring—Coloring from within; the incorporation of a colorant within the material of a prosthesis or restoration.

Inverted spruing—A method of spruing a cast removable partial denture in which a hole is made in the investment model so the sprue approaches the wax pattern from underneath.

Invest—To envelop or embed an object in an investment material.

Investment—(1) The gypsum material used to enclose a denture wax pattern in the flask, forming a mold; (2) In fixed or removable prosthetics, a heat resistant material used to enclose a wax pattern before wax elimination.

Investment cast—See *refractory cast.*

Jacket crown—See *ceramic crown or resin crown.*

Jaw—A common name for the maxillae or mandible.

Jaw relation—See *maxillomandibular relationship.*

Knoop hardness—A surface hardness test using a diamond stylus.

Labial—Pertaining to the lips. The surface of an anterior tooth opposite the lips.

Labial bar—The metal piece or major connector connecting the right and the left sides of a lower removable partial denture. It is contoured to the labial tissue anterior to the lower teeth.

Labial frenum—The connective tissue attaching the upper or the lower lip to the alveolar ridge at or near the midline.

Labial notch—The V-shaped indentation in an impression or denture; formed by, or for the labial frenum.

Lamina dura—The layer of compact bone forming the wall of a tooth socket.

Lateral condylar path—The path of the condyle in the temporomandibular fossa when the mandible moves laterally.

Lateral incisor—An anterior tooth located just distal to the central incisor. The second tooth from the midline.

Lateral interocclusal record—A jaw relationship record of the teeth with the mandible in a functional position.

Laterotrusion—Condylar movement on the working side in the horizontal plane. This term may be used in combination with terms describing condylar movements in other planes; for example, laterodetrusion, lateroprotrusion, lateroretrusion, and laterosurtrusion.

Lesion—Any hurt, wound, or local degeneration.

Leverage—A mechanical principle in which force is multiplied by extending the lifting force farther from and on the opposite side of the fulcrum from the object to be moved.

Ligament—A tough band of tissue connecting the articular extremities of bone.

Line angle—The angle formed by the union of two surfaces of a tooth. The junction of the mesial surface with the labial surface of an incisor is called the mesiolabial line angle.

Lingual—Pertaining to the tongue. The surface of a tooth or prosthesis next to the tongue is the lingual surface.

Lingual flange—The part of a denture or impression extending from about the crest of the ridge to the periphery on the lingual surface.

Lingual frenum—The band of tissue attaching the tongue to the floor of the mouth.

Lingual notch—(1) The indentation on the lingual periphery of a lower impression made by the lingual frenum; (2) An indentation provided in the same area of the denture to allow free movement of the lingual frenum.

Long axis—An imaginary line passing lengthwise through the center of a tooth.

Low fusing alloy Any one of the alloys, which melt at very low temperatures.

Major connector—A part of a removable partial denture framework connecting one side of the appliance with the other. A lingual bar is an example.

Male attachment—See *patrix.*

Malleability—The property of a metal, which permits it to be extended in all directions without breaking.

Malocclusion—Defective occlusion or deviation from normal occlusion.

Malposition—Incorrect positioning of teeth.

Mamelons—Small elevations of enamel present on incisors as they erupt; quickly worn down during mastication.

Mandible—The lower jaw.

Mandibular—To refer to the mandible or lower jaw.

Mandibular translation—The translatory (medio-lateral) movement of the mandible when viewed in the frontal plane.

Margin—(1) The border or boundary, as between a tooth and a restoration; (2) The outer edge of a crown, inlay, or onlay.

Marginal ridge—The elevations of enamel forming the mesial and distal boundaries of the occlusal surfaces of the posterior teeth and the mesial and distal boundaries of the lingual surfaces of the anterior teeth.

Masking—The process of applying an opaque covering to camouflage the metal component of a prosthesis. Also called opaqueing.

Masseter muscle—A muscle of mastication, extending from the external surface of the angle of the mandible to the zygomatic process.

Master cast—The positive reproduction in stone made from the final impression.

Master impression—The negative impression from which the master cast is made.

Mastication—The chewing of food.

Masticatory cycle—A three dimensional representation of mandibular movement produced during the chewing of food. Also called chewing cycle.

Matrix—(1) The mold in which something is formed to use as a relationship record. See *index*. (2) The portion of a dental attachment system that receives the patrix. Also called female attachment.

Maxilla—The upper jaw.

Maxillary—To refer to the maxilla or upper jaw.

Maxillary orthopedic appliance (biteguard)—See *maxillary orthotic appliance.*

Maxillary orthotic appliance—An acrylic resin appliance designed to cover the occlusal and incisal surfaces of the maxillary teeth of a dental arch to stabilize the teeth and/or provide a flat platform for unobstructed excursion glides of the mandible.

Maxillary tuberosity—An area in the form of a bulge, at the posterior end of the maxillary alveolar ridge.

Maxillofacial prosthetics—A subspecialty of prosthodontics where prostheses are fabricated to replace missing or damaged head and neck structures, for example, artificial eyes, ears, noses, or obturator dentures.

Maxillomandibular relationship—Any spatial relationship of the maxilla to the mandible. Also called jaw relation.

Maxillomandibular relationship record or registration—A record of the relationship of the mandible to the maxillae.

Maximum intercuspation (MI)—The complete intercuspation of the opposing teeth independent of condylar position.

Medial raphe—The fibrous tissue extending along the middle of the hard palate.

Median line—(1) An imaginary line extending through the middle of the face; (2) The midline of a cast.

Median (medial)—Toward the middle.

Median plane—The plane dividing the body in equal left and right halves.

Melting point—The point at which a pure metal becomes molten, or changes from a solid to a liquid.

Melting range of an alloy—The interval between the temperature at which the alloy begins to melt, solidus, and the temperature at which it is completely molten, liquidus.

Mental foramen—A foramen on the facial surface of the mandible near the roots of the premolar, through which pass the mental vessels and nerves.

Mesial—The surface of a tooth nearest the midline in a normal occlusion.

Metal—A substance which is to some degree malleable and ductile and which conducts heat and electricity.

Metal base denture—See *cast base.*

Metal ceramic restoration—A fixed restoration consisting of a metal alloy substructure covered with a veneer of porcelain. Also known as *porcelain-fused-to-metal and ceramo-metal* *restorations*.

Metamerism—The phenomenon occurring when the color of two objects match in one lighting condition but do not match in others.

Methyl-methacrylate—The chemical name for synthetic acrylic resin. One of its most common uses is as a denture base material for complete and removable partial dentures.

Metric system—A decimal system of weights and measures. The basic units are the meter for length and grams for weight or mass.

Midline—The imaginary line through the middle of an object, dividing the object into equal parts.

Millimeter—A unit of length in the metric system equal to 1000 microns or the one thousandth part of a meter.

Mill in—(1) The procedure of refining occluding surfaces through the use of abrasive materials; (2) The machining of boxes or other forms in cast restorations to be used as retainers for fixed or removable prostheses.

Minor connector—The part of a removable partial denture frame uniting clasps and rests to the remainder of the framework.

Modeling plastic impression compound—A thermoplastic dental impression material.

Modulus of elasticity—A complex measure of the elasticity; a ratio of stress to strain; as the modulus of elasticity rises, the material becomes more rigid.

Modulus of resilience—A measure of the amount of energy stored in a material when stressed to its proportional limit.

Molars—The teeth situated in the posterior region of the mouth. The teeth behind the premolars.

Monomer—A chemical compound that can undergo polymerization. Most common is *methyl methacrylate liquid*.

Morphology, tooth—The study of the form and structure of a tooth.

Mucolabial fold—The junction between the cheek and the alveolar mucosa of the upper or lower jaw.

Mucosa (mucous membrane)—The soft tissue lining the oral cavity.

Mutually protected articulation—An occlusal scheme in which the posterior teeth prevent excessive contact of the anterior teeth in maximum intercuspation, and the anterior teeth disengage the posterior teeth in all mandibular excursive movements.

Mutually protected occlusion—See *mutually protected articulation.*

Mylohyoid ridge—An oblique ridge on the lingual surface of the mandible extends from the level of the roots of the last molar teeth and that serves as a bony attachment for the mylohyoid muscles forming the floor of the mouth.

Nasal bone—The two small bones forming the arch of the nose.

Nasolabial fold—The crease between the nose and the upper lip.

Noble metal—A metal not readily oxidized at ordinary temperatures or by heating, for example, gold or platinum.

Nonnoble—A metal that is expected to form oxides or sulfides (e.g., silver or tin).

Nonanatomic teeth—Artificial teeth that do not conform to the anatomy of natural teeth. Also called flat plane or zero degree teeth.

Nonprecious—A term used to describe metals or alloys that are not scarce, and do not possess a *high* intrinsic value. Examples are nickel and chromium. The term nonprecious is regarded by many as less technically correct than the preferred term *base metal.*

Nonworking side—The side of the mandible that moves toward the median line in a lateral excursion. The side opposite the side toward which the mandible moves. Also called balancing side.

Nonworking side occlusal contacts—contacts of the teeth on the side opposite the side toward which the mandible moves in articulation. Also called balancing side occlusal contacts.

Oblique ridge—The transverse ridge of enamel crossing the occlusal surface of the upper molars from mesiolingual to distofacial.

Obturator—A prosthesis used to close an abnormal opening between the oral and nasal cavities.

Occipital bone—The bone forming the posterior portion and base of the skull.

Occlude—To bring together; to bring the upper and lower teeth together.

Occlusal equilibration—(1) To equalize; (2) To remove high spots and areas of interference. To adjust the contact areas between the upper and lower teeth so each tooth carries an equal share of the occlusal load.

Occlusal plane—The plane established by the occlusal surfaces of the premolar and molars of both the upper and lower jaws in opposition. May also refer to the same plane established in the occlusion rims.

Occlusal surface—The biting, grinding, or chewing surfaces of molars and premolar.

Occlusal vertical dimension—The distance measured between two points when the occluding members are in contact. Also called vertical dimension of occlusion (VDO).

Occlusion—(1) The act or process of closure or of being closed or shut off; (2) The static relationship between the incising or masticating surfaces of the maxillary or mandibular teeth.

Occlusion rim—See *record rim.*

Opaqueing—See *masking.*

Open bite—Slang for *open occlusal relationship.*

Open occlusal relationship—The lack of tooth contact in an occluding position. Also called open bite.

Orbitale—The lowest point in the margin of the orbit (directly below the pupil when the eye is open and the patient is looking straight ahead) that may readily be felt under the skin. Can be used as a reference point for making a facebow record.

Orientation of occlusal plane—The position which the occlusal plane is to occupy between the upper and lower ridges.

Origin—The fixed point of attachment of a muscle.

Oxidation—The process of heating a metal substructure in a porcelain furnace to cleanse the porcelain-bearing surfaces of contaminants and produce an oxide layer for porcelain bonding. Also called degassing.

Oxidize—To combine with oxygen, for example, iron rust or brass tarnish.

Palate—The roof of the mouth; classified into both hard and soft palate areas.

Palatine bone—The paired bones forming the posterior one-third of the hard palate.

Pantograph—In dentistry, an instrument used to graphically record in one or more planes paths of mandibular movement and to provide information for the adjustment of an articulator.

Papillary hyperplasia—Abnormal tissue growth found on the hard palate.

Paraffin—A white, waxy hydrocarbon distilled from coal or petroleum and used to compound several dental waxes.

Parafunctional mandibular movement—Disordered movement of the mandible, for example, movements associated with tension, emotion, or aggression.

Parietal bone—The two quadrilateral bones forming the sides of the skull.

Pathogen—Any disease producing agent (e.g., a virus, bacterium or microorganism).

Pathogenic—Capable of producing disease.

Path of insertion—See *path of placement.*

Path of placement—The specific direction in which a prosthesis is placed on the abutment teeth.

Periapical—The area around the apex or root tip of a tooth.

Periodontics—The branch of dentistry dealing with the science and treatment of the tissues and bone surrounding the teeth.

Periodontium—Collectively**,** the tissues which surround and support the tooth.

Petrolatum—A lubricant; used as a separator in many dental laboratory procedures.

Phonation—Action constituting a source of vocal sound.

Phonetics—(1) The science or study of speech sounds and their production, transmission and reception; (2) The symbols representing the speech sounds of a language. In a denture wearer, it refers to the patient’s ability to say “S” and “CH” clearly with the appliance in place.

Physiology—The branch of biology dealing with the functions and activities of living organisms and their parts, including all physical and chemical processes.

Physiologic rest position—The position of the mandible in which all the masticatory muscles are in a relaxed state.

Pigment—A finely ground powder used to impart color to a material.

Placement—The process of directing a prosthesis to a desired location; the introduction of prosthesis into the patient’s mouth. Also called insertion.

Plaster of paris—A white, powdery, slightly hydrated calcium sulfate, used in dentistry, for making casts and molds when combined with water to form a quick setting paste.

Plastic—(1) Capable of being shaped or formed; (2) Pertaining to the alteration of living tissues. 3: Any of numerous organic synthetic or processed materials that generally are thermoplastic or thermosetting polymers. They can be cast, extruded, molded, drawn, or laminated into films, filaments, and objects.

Pit—In dentistry, a depression usually found where several developmental lines intersect.

Point angle—The angle made on a tooth by the convergence of three planes or surfaces.

Polishing agent—Any material used to impart a luster to a surface.

Polymer—Compound (powder) composed of smaller organic units. Most common in dentistry is methyl methacrylate powder.

Polymerization—The reaction, which takes place between the powder and liquid during the curing of acrylic resin. It is characterized by the joining together of molecules of small molecular weights to a compound of large molecular weight.

Porcelain—A ceramic material. In dentistry, most porcelains are glasses and are used in the fabrication of teeth for dentures, pontics and facings, metal ceramic restorations, and other restorations.

Porcelain-fused-to-metal restoration—See *metal ceramic restoration.*

Porous—Pitted; not dense; containing voids and bubbles.

Porosity—The presence of voids or pores within a structure.

Posterior—Situated in back of or behind.

Posterior palatal seal—See *postpalatal seal.*

Postpalatal seal—An elevation of acrylic resin on the tissue side of the posterior border of a maxillary appliance for the purpose of sealing it against the resilient soft tissue in the palate.

Posterior tooth—All premolar and molars.

Precious metal—A metal containing primarily elements of the platinum group, gold, and silver.

Precious metal alloy—An alloy predominantly composed of elements considered precious.

Preliminary impression—A negative reproduction made for the purpose of forming a preliminary cast.

Process—(1) In anatomy, a prominence or projection of bone; (2) In dentistry, any technical procedure that incorporates a number of steps; the procedure of polymerization of dental resins for prostheses or bases

Prognosis—A forecast of the probable outcome of an illness.

Propane—A flammable gas found in petroleum and natural gas.

Prophylaxis—In dentistry, the removal of calculus and stains from the teeth.

Proportional limit—The amount of stress a metal will stand before it is permanently stretched or bent; a measure of the strength and toughness of an alloy.

Prosthesis—An artificial replacement for a lost part of the body. In dentistry, it is used in the more limited sense of a strictly dental replacement. Plural is *prostheses.*

Prosthodontics—The branch of dentistry pertaining to the restoration and maintenance of oral function, comfort, appearance, and health of the patient by the restoration of natural teeth and/or the replacement of missing teeth and contiguous oral and maxillofacial tissues with artificial substitutes.

Protrude—To project forward.

Protrusion—(1) The act of protruding something forward; (2) In dentistry, a position of the mandible anterior to centric relation.

Protrusive interocclusal record—A registration of the mandible in relation to the maxillae when both condyles are advanced in the temporal fossa.

Protrusive articulation—Occlusal contact relationships between maxillary and mandibular teeth when the mandible moves into a forward position.

Protruberance—A projecting part; bulge.

Proximal—(1) Situated close to; (2) Next to or nearest the point of attachment or origin, a central point.

Proximal tooth surface—The surface of a tooth, which lies next to another tooth.

Pterygomaxillary notch—The notch formed by the junction of pterygoid hamulus of the sphenoid bone and the maxilla. Also called hamular notch. It is located just posterior to the maxillary tuberosity.

Pulp—The connective tissue found in the pulp chamber and canals, made up of arteries, veins, nerves, and lymph tissue.

Pumice—A type of volcanic glass used as an abrasive agent in many polishing procedures.

Quadrant—In dentistry, one of the four sections of the dental arches, divided at the midline.

Quick cure resin—See *autopolymerizing resin*.

Ramus—The ascending part of the mandible.

Rational posterior teeth—See *nonanatomic teeth.*

Reciprocity—The state of being inversely related or proportioned; opposite.

Record base—An interim denture base used to support the record rim material for recording maxillomandibular records.

Record rim—The occlusal surfaces fabricated on a record base for the purpose of making maxillomandibular relationship records and/or arranging teeth. Also called occlusion rim.

Reducing zone of a flame—The zone of a flame least apt to cause oxidation of the metal when melting or soldering.

Reducing investment—A specially made investment which contains fine graphite or copper particles to prevent oxidization of the casting. Also called deoxidizing investment.

Relief—(1) The reduction or elimination of undesirable pressure or force from a specific region e.g., the scraping of a working cast to better fit a facing to the ridge; (2) Material added to a cast to relieve the pressure over specific areas in the mouth. Also added to the master cast before duplicating it to create a raised area on the refractory cast.

Reline—The replacement of the tissue surface of the denture to make it fit more accurately.

Removable partial denture—A dental prosthesis that artificially replaces teeth and associated structures in a partially edentulous dental arch and can be removed and replaced by the patient.

Resin—(1) A gummy substance obtained from various trees. It is used to make many dental materials; (2) A broad term used to describe natural or synthetic materials that form plastic materials after polymerization.

Resorption—The loss of tissue substance by physiologic or pathologic processes. The roots of the primary teeth are resorbed naturally.

Rest position—See *physiologic rest position.*

Retromolar pad—The soft tissue pad at the posterior extremity of the mandibular ridge.

Retrusion of the mandible—A backward movement of the mandible.

Reverse curve—A curve of occlusion defined by the cusp tips and incisal edges, which, when viewed in the sagittal plane, is curved upward or superiorly.

Reverse articulation—An occlusal relationship in which the mandibular teeth are located facial to the opposing maxillary teeth; the maxillary buccal cusps are positioned in the central fossa of the mandibular teeth. Also called crossbite.

Reversible hydrocolloid—An impression material containing agar which can be softened to a jellylike consistency and cooled to a solid to make an impression or duplicate a cast. This procedure can be repeated by reheating, hence, the name *reversible.*

Rhomboidal—In the shape of an oblique-angled parallelogram with only the opposite sides equal. The occlusal outline of the maxillary molars are rhomboidal.

Ridge—(1) An elevated body part; a long, narrow, raised crest; (2) A linear elevation of enamel on the surface of a tooth, for example, a marginal ridge; (3) The alveolar ridge: the area of the upper and lower jaws formerly occupied by the natural teeth.

Ridge contour—The shape of the alveolar ridge, with reference to its height, width, and degree of slope.

Ridge lap—The area of an artificial tooth, which normally overlaps the alveolar ridge. It corresponds on the inner surface of the denture tooth, approximately to the location of the collar on the facial surface.

Ridge relationship—The position of the upper and lower ridges relative to each other.

Ridge resorption—The resorption of the alveolar bone, once teeth are no longer present, resulting in a progressively flatter ridge.

Rockwell hardness—A method of measuring the hardness of metals which are too hard for the Brinell needle.

Root—The portion of the tooth covered with cementum.

Root canal—The small channel running through the tooth's root, connecting the pulp chamber and the root-end opening.

Rouge, jeweler's—A red powder usually in cake form used on a buff or chamois wheel to impart a high luster to metal.

Rugae—The elevated folds or wrinkles of soft tissue situated in the anterior part of the palate.

Sagittal plane (mid)—The plane dividing the body vertically into two equal halves.

Sanitization—A process, which removes gross debris and reduces the number of microorganisms on nonliving material.

Saturated calcium sulfate dihydrate solution (SDS)—A clear, true solution of water and a maximum amount of dissolved, dihydrate (set) gypsum product.

Separating medium—An agent used between two surfaces to prevent them from sticking together.

Setting expansion—The dimensional increase that occurs concurrent with the hardening of various materials, such as plaster of paris, dental stone, die stone, and dental casting investment.

Setting time—The time necessary to harden or solidify.

Setup—See *tooth arrangement.*

Shade—A term used to describe a particular hue, or variation of a primary hue, such as a greenish shade of yellow.

Shelf life—The period of time for which a material can be stored without losing its useful properties.

Sideshift—Articulator simulation of mandibular translation.

Slurry—Suspension of gypsum particles in water.

Soft palate—The movable part of the palatal anatomy posterior to the hard palate.

Solder—(1) A fusible metal alloy used to unite the edges or surfaces of two pieces of metal; (2) The act of uniting two pieces of metal by the proper alloy of metals.

Soluble—Capable of being dissolved.

Solute—In a solution, the dissolved solution is called the solute. In salt water, the water is the solvent, and the salt is the solute. See *solvent*.

Solvent—A substance that is capable of dissolving another substance, for example, water is the solvent of salt. See *solute*.

Specific gravity—The weight of a substance as compared to the weight of exactly the same volume of water. The standard formula used is: 1 cm^3 of water at 4 °C = 1.

Sphenoid bone—The irregular wedge-shaped bone at the base of the skull.

Stability—The property of resistance to tipping and rocking of a prosthesis.

Stabilized record base—A record base lined with an impression material to increase its stability.

Strain—The deformation of a material caused by an external force.

Stress—The forces within a substance opposing an external force.

Sublingual—The area under the tongue.

Sulcus—(1) A furrow, fissure, or groove; (2) In dentistry, a linear depression in the surface of a tooth, the surfaces meet at an angle. A sulcus is always found along the surface of a developmental line.

Sulfuric acid—An acid made up of hydrogen, sulfur, and oxygen. Mixed with water in equal parts, it is used as a deoxidizing solution for gold.

Superior—Above**.**

Supernumerary tooth—An extra tooth, one in excess of the normal number.

Support—(1) To hold up or serve as a foundation or prop for; (2) The foundation area on which a dental prosthesis rests.

Supraerupted tooth—A tooth that has emerged past the occlusal plane.

Surgical guide—Any prosthesis prepared for insertion during a surgical procedure and intended for short use. Also called surgical template and surgical prosthesis.

Suture line—A junction line where the bones of the cranium unite.

Symphysis, mandibular—The immovable dense midline junction of the right and left halves of the adult mandible.

Tempering—The procedure of imparting to a metal a desired degree of hardness. Also called heat hardening treatment.

Temporal bone—The irregular-shaped bone at the side and base of the skull.

Temporomandibular joint (TMJ)—The joint formed by the condyle of the mandible, the temporal bone and associated soft tissues.

Tendons—The heavy fibrous bundles attaching a muscle to bone.

Tensile strength—A measure of resistance to breakage from a stretching or pulling force.

Thermal expansion—The increase in size of a material when it is heated.

Thermoplastic—A material that softens under heat and solidifies when it is cooled without chemical change.

Thirty degree tooth—An anatomical type of artificial posterior tooth. The manufacturer claims the cusp incline forms a 30 degree angle with a horizontal plane.

Tooth arrangement—The placement of teeth on a denture with definite objectives in mind.

Tissue-borne—A partial denture where all the masticatory stresses are borne by the soft tissues of the mouth.

Tooth-borne—A partial denture is where all the masticatory forces are carried by the abutment teeth.

Torque—A twisting force.

Torus—(1) A smooth, rounded anatomical proturberance; (2) Torus mandibularis found midline on the hard palate. Found on the lingual surface of the body of the mandible. There may be several tori (plural); usually in the area of the midline backward to about the premolar; (3) Torus palatinus.

Translatory (sliding) motion—That motion of a rigid body in which a straight line passing through any two points always remains parallel to its initial position. The motion may be described as a sliding or gliding motion.

Transverse horizontal axis—An imaginary line around which the mandible may rotate within The sagittal plane. Also called hinge axis.

Transverse plane—The plane that divides the top horizontally from the bottom.

Transverse ridge—The ridge of enamel formed at the junction of the buccal and lingual ridges on the occlusal surface of a molar or bicuspid.

Trapezoid—A four-sided plane figure with two parallel sides. The occlusal surface of the lower first molar is trapezoidal in outline.

Trauma—A wound or injury, whether physical or psychic.

Treatment partial—See *interim prosthesis*.

Treatment plan—An outline of the various clinical steps in proper sequence to be followed in restoring a mouth to health and function.

Triangular ridge—The ridge of enamel which extends from the tip of the cusp down onto the occlusal surface of the premolar and molars.

Trifurcated—Having three roots.

Tubercule—A nodule or small eminence.

Tuberosity—See *maxillary tuberosity*.

Twenty degree (20°) teeth—A trade name denoting artificial posterior teeth with cusp angles of 20°.

Unilateral balanced occlusion—See *group function*.

Vacuum fired—To bake porcelain in a vacuum.

Value—The dimension of a color denoting relative blackness or whiteness.

Vault—The palate or roof of the mouth.

Veneer—A thin layer.

Vertical dimension of occlusion (VDO)—See *occlusal vertical dimension*.

Vertical overlap—(1) The distance teeth lap over their antagonists as measured vertically. It may also be used to describe the vertical relations of opposing cusps; (2) The vertical relationship of the incisal edges of the maxillary incisors to the mandibular incisors when the teeth are in maximum intercuspation.

Vibrating line—An imaginary line in the soft palate marking the junction between the movable and immovable tissues. Also called flexure line.

Vickers hardness—A range of hardness measured by the indentation made by a square-based, pyramidal diamond point under various loads.

Viscosity—A measure of a liquid's resistance to flow or its relative fluidity.

Vitrification—The process of making a homogenous, glassy substance by heat and fusion.

Volatile—To evaporate quickly.

Volatility—The ability to become gaseous or to vaporize into gas.

Vomer—The bone forming the lower and posterior portions of the septum of the nose.

Warpage—The loss of an original shape or contour.

Wax—There are many different types of waxes used in dentistry, each is compounded to produce certain physical properties for a specific purpose. They are manufactured in various forms, such as, baseplate, boxing, inlay and sticky.

Wax pattern—Wax that has been formed into the size and shape desired in the finished prosthesis and used to form the mold in the investment.

Wax up (noun) —The finished wax pattern for any dental prosthesis. (verb) (1) To smooth and finish the wax on a complete denture. (2) To flow and carve a wax pattern for a fixed restoration. (3) To contour the wax for any dental prosthesis.

Weld—A process for joining metals using heat and pressure, or pressure alone.

Working articulation—Occlusal contacts of teeth on the side toward which the mandible has moved. Also called working occlusion.

Working side—The side toward which the mandible moves in a lateral excursion.

Yield strength—The amount of stress required to produce a particular offset that is chosen. A value of 0.2 percent plastic strain is often used (called 2 percent offset).

Zero degree teeth—See *nonanatomic teeth.*

Zinc oxide—A powder incorporated with eugenol or a similar oil to form a mild antiseptic and analgesic paste; a constituent of most impression pastes.

Zygomatic processes, temporal and maxillary—The bony extensions of the temporal and maxillary bones, which unite with the zygomatic bone to form the zygomatic arch.

Abbreviations and Acronyms

°	degree
°C	degrees Celsius
°F	degrees Fahrenheit
AHA	articulator hinge axis
BHN	Brinell hardness number
CAD/CAM	computer-aided design/computer-aided manufacturing
CO	centric occlusion
CR	centric relation
DB	distal buccal
DL	distal lingual
fc	foot-candle
L	lingual
M	mesial
MB	mesiobuccal
MHA	mandibular hinge axis
MI	maximum intercuspation
ml	milliliter
mm	millimeter
nm	nanometer
PL	proportional limit
PFM	porcelain-fused-to-metal
PJC	porcelain jacket crown
psi	pounds per square inch
RDP	removable dental prosthesis
RHN	Rockwell hardness number
SDS	sulfate dihydrate solution

TMD	temporomandibular disorder
TMJ	temporomandibular joint
UTS	ultimate strength
VDO	vertical dimension of occlusion
VHN	Vickers hardness number
YP	yield point

Student Notes

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