Anatomy of Periodontium

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12 June 08
Periodontium

The tissue that support the teeth:

- Gingiva
- Periodontal ligament
- Cementum
- Alveolar process
GINGIVA
The Gingiva

The oral mucosa consists of three zones:

- The gingiva and the covering of the hard palate, termed the masticatory mucosa
- The dorsum of the tongue, covered by specialized mucosa
- The oral mucous membrane lining the remainder of the oral cavity.

The gingiva is the part of the oral mucosa that covers the alveolar processes of the jaws and surrounds the necks of the teeth.
Objectives

Student should be able to

- describe the normal macroscopic features of the gingiva: marginal, attached, and interdental gingiva
- describe the normal microscopic features of the gingival epithelium, gingival connective tissue
- discuss the correlation of normal clinical and microscopic features
A COL

B PAPILLA

C JUNCTIONAL EPITHELIUM

D FREE GINGIVA

E ATTACHED GINGIVA

F MUCOGINGIVAL JUNCTION

G ALVEOLAR MUCOSA

H CEMENTUM

I PERIODONTAL LIGAMENT

K LINGUAL PLATE

L ALVEOLAR BONE/CRIBIFORM PLATE

M TRABECULAR/CANCELLOUS BONE
Gingiva

☐ Marginal/margin/free/unattached gingiva
Gingiva: Gingival Sulcus

**Fig. 3**

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Gingival Sulcus

- Is the **shallow** crevice or space around the tooth bounded by the surface of the tooth on one side and the epithelium lining the free margin of the gingiva on the other side.
- It is V shaped, and it permits the entrance of a periodontal probe.
- The clinical determination of the depth of the gingival sulcus is an important diagnostic parameter.
- The histologic depth of a sulcus does not need to be exactly equal to the depth of penetration of the probe. The so-called probing depth of a clinically normal gingival sulcus in humans is less than 3 mm.
Gingiva

- Attached gingiva
Gingiva: Interdental papilla

Fig.4

Fig.5

Fig.6
Objectives

- Describe the normal macroscopic features of the marginal gingiva, attached gingiva, interdental gingiva
- Describe the normal microscopic features of the gingival epithelium, gingival connective tissue
- Discuss the correlation of normal clinical and microscopic features
- Integrate the knowledge of the histology of the gingival and dentogingival junctional tissues with the related pathology that may occur
General Aspects of Gingival Epithelium Biology

- First, it was thought to provide only a physical barrier to infection and the underlying gingival attachment.

- Epithelial cells play an active role in innate host defense by responding to bacteria in signaling further host reactions, and in integrating innate and acquired immune responses.

- For example, by increased proliferation, alteration of cell-signaling events, changes in differentiation and cell death, and ultimately, alteration of tissue homeostasis.
Cell type of the gingival epithelium

- Keratinocytes
- Non keratinocytes cell
  - Melanocytes, these cells produce melanin, which is a pigment found in the skin, eyes, hair, and gingiva
  - Langerhans, Langerhans cells have an important role in the immune reaction as antigen-presenting cells for lymphocytes
  - Merkel cells, They have been identified as tactile perceptors

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Functions and Features of Gingival Epithelium

- **Functions**
  - Mechanical, chemical, water, and microbial barrier
  - Signaling functions

- **Architectural Integrity**
  - Cell-cell attachments
  - Basal lamina
  - Keratin cytoskeleton

- **Major Cell Type**
  - Keratinocyte

- **Other Cell Types**
  - Langerhans cells
  - Melanocytes, Merkel cells

- **Constant Renewal**
  - Replacement of damaged cells

- **Cell-Cell Attachments**
  - Desmosomes, adherens junctions
  - Tight junctions, gap junctions

- **Cell-Basal Lamina**
  - Synthesis of basal lamina components
  - Hemidesmosome

Representative cells from the various layers of stratified squamous epithelium as seen by electron microscopy. (From Weinstock A. In Ham AW: Histology, 7th ed. Philadelphia, JB Lippincott, 1974.)
Figure 4-11 Pigmented gingiva of dog showing melanocytes (M) in the basal epithelial layer and melanophores (C) in the connective tissue (Glucksman technique).
Figure 4-12 Human gingival epithelium, oral aspect. Immunoperoxidase technique showing Langerhans cells. Function: On infection of an area of skin, the local Langerhans' cells will take up and process microbial antigens to become fully-functional antigen-presenting cells.
Figure 4-13 Normal human gingiva stained with the periodic acid-Schiff (PAS) histochemical method. The basement membrane (B) is seen between the epithelium (E) and the underlying connective tissue (C). In the epithelium, glycoprotein material occurs in cells and cell membranes of the superficial hornified (H) and underlying granular layers (G). The connective tissue presents a diffuse, amorphous ground substance and collagen fibers. The blood vessel walls stand out clearly in the papillary projections of the connective tissue (P).
Figure 4-14 Variations in gingival epithelium. A, Keratinized. B, Nonkeratinized. C, Parakeratinized. Horny layer (H), granular layer (G), prickle cell layer (P), basal cell layer (Ba), flattened surface cells (S), parakeratotic layer (Pk).
Gingival Epithelium

- Stratified squamous epithelium:
  - oral or outer epithelium
  - sulcular epithelium, and
  - junctional epithelium/epithelial attachment.
1. GINGIVAL EPITHELium

Bucco-lingual section

- **CT**, gingival connective tissue
- **ES**, enamel space
- **JE**, junctional epithelium
- **OE**, oral epithelium
- **SE**, sulcular epithelium
Structural Characteristics of the Gingival Epithelium: Oral or Outer Epithelium

- The oral or outer epithelium covers the crest and outer surface of the marginal gingiva and the surface of the attached gingiva.
- It is keratinized or parakeratinized. The prevalent surfaces however, is parakeratinized.
- Keratinization of the oral mucosa: palate (most keratinized), gingiva, tongue, and cheek (least keratinized)."
Oral epithelium of the gingiva

- **SC**, stratum corneum (cornified layer)
- **SG**, stratum granulosum (granular layer)
- **SS**, stratum spinosum (spinous layer)
- **SB**, stratum basale (basal layer)
- **CT**, connective tissue
Sulcular Epithelium

- The sulcular epithelium lines the gingival sulcus. It is a thin, nonkeratinized, stratified squamous epithelium without rete pegs and extends from the coronal limit of the junctional epithelium to the crest of the gingival margin.

- The sulcular epithelium is extremely important, because it may act as a semipermeable membrane through which injurious bacterial products pass into the gingiva and through which tissue fluid from the gingiva seeps into the sulcus.
Junctional Epithelium (JE)

- Stratified squamous nonkeratinizing epithelium.
- 3-4 layers thick in early life, but with age to 10-20.
- The length of the JE ranges from 0.25 to 1.35 mm
- PMN are found routinely in the JE
- More permeable than Sulcular epithelium
Junctional epithelium

CT, connective tissue
ES, enamel space
JE, junctional epithelium
Junctional epithelium

Inflamed junctional epithelium

ES, enamel space

PMN, polymorphonuclear leucocytes
Junctional epithelium

Diagram of junctional epithelium
Arrows indicate path taken by cells and fluids between the sulcus and the gingival connective tissue

CT, connective tissue
JE, junctional epithelium
OE, oral epithelium
S, gingival sulcus
SE, sulcular epithelium
Renewal of gingival epithelium

- Daughter cells (B) migrate toward the sulcus. If a JE cell comes into contact with the tooth surface, it will attach to it.
- Dentogingival collagen fiber
Figure 4-18 Junctional epithelium on an erupting tooth. The junctional epithelium (JE) is formed by the joining of the oral epithelium (OE) and the reduced enamel epithelium (REE). AC, Afibrilar cementum, sometimes formed on enamel after degeneration of the REE. The arrows indicate the coronal movement of the regenerating epithelial cells, which multiply more rapidly in the JE than in the OE. E, Enamel; C, root cementum. A similar cell turnover pattern exists in the fully erupted tooth. (Modified from Listgarten MA: J Can Dent Assoc 36:70, 1970.)
Junctional epithelium

- The attachment of the junctional epithelium to the tooth is reinforced by the gingival fibers. For this reason, both are considered a functional unit, dentogingival unit.

- Their functions:
  - junctional epithelium is firmly attached to the tooth surface, forming an epithelial barrier against plaque bacteria.
  - it allows access of gingival fluid, inflammatory cells, and components of the immunologic host defense to the gingival margin.
  - junctional epithelial cells exhibit rapid turnover, which contributes to the host-parasite equilibrium and rapid repair of damaged tissue.

- Turnover times for different areas of the oral epithelium in experimental animals:
  - palate, tongue, and cheek, 5 to 6 days;
  - gingiva, 10 to 12 days,
  - junctional epithelium, 1 to 6 days
Gingival Fluid (Sulcular Fluid)

- It can be represented as either a transudate or an exudate.
- It is potential use as a diagnostic or prognostic biomarker of the biologic state of the periodontium in health and disease.
- It contains components of connective tissue, epithelium, inflammatory cells, serum, and microbial flora inhabiting the gingival margin or the sulcus (pocket).
- In the healthy sulcus the amount of the gingival fluid is very small. During inflammation, however, the gingival fluid flow increases.
- The main route of the gingival fluid diffusion is through the basement membrane, through the relatively wide intracellular spaces of the junctional epithelium, and then into the sulcus.
- The functions are:
  - cleanse material from the sulcus,
  - contain plasma proteins that may improve adhesion of the epithelium to the tooth,
  - possess antimicrobial properties,
  - exert antibody activity to defend the gingival.
Gingival Connective Tissue

- The major components of the gingival connective tissue are collagen fibers (about 60% by volume), fibroblasts (5%), vessels, nerves, and matrix (about 35%).

- It is known as the lamina propria and consists of two layers:
  - a papillary layer subjacent to the epithelium, which consists of papillary projections between the epithelial rete pegs,
  - a reticular layer contiguous with the periosteum of the alveolar bone.

- The ground substance fills the space between fibers and cells, is amorphous, and has a high content of water.
Gingival connective tissue
Gingival Connective Tissue

- The three types of connective tissue fibers are collagen, reticular, and elastic.

- Collagen type I forms the bulk of the lamina propria and provides the tensile strength to the gingival tissue.

- Therefore, densely packed collagen bundles that are anchored into the acellular extrinsic fiber cementum just below the terminal point of the junctional epithelium form the connective tissue attachment.

- The stability of this attachment is a key factor in limiting the migration of junctional epithelium.\textsuperscript{27}
The gingival fibers

- **Gingivodental Group**
  - The gingivodental fibers are those on the facial, lingual, and interproximal surfaces. They are embedded in the cementum just beneath the epithelium at the base of the gingival sulcus. On the facial and lingual surfaces, they project from the cementum in fanlike conformation toward the crest and outer surface of the marginal gingiva, terminating short of the epithelium. They also extend externally to the periosteum of the facial and lingual alveolar bones, terminating in the attached gingiva or blending with the periosteum of the bone. Interproximally, the gingivodental fibers extend toward the crest of the interdental gingiva.

- **Circular Group**
  - The circular fibers course through the connective tissue of the marginal and interdental gingivae and encircle the tooth in ringlike fashion.

- **Transseptal Group**
  - Located interproximally, the transseptal fibers form horizontal bundles that extend between the cementum of approximating teeth into which they are embedded. They lie in the area between the epithelium at the base of the gingival sulcus and the crest of the interdental bone and are sometimes classified with the principal fibers of the periodontal ligament.
Gingival collagen group

Diagram of the gingivodental fibers extending from the cementum (1) to the crest of the gingiva, (2) to the outer surface, and (3) external to the periosteum of the labial plate. Circular fibers (4) are shown in cross-section.
Gingival Fibers

There are functions:

- To brace the marginal gingiva firmly against the tooth.
- To provide the rigidity necessary to withstand the forces of mastication without being deflected away from the tooth surface.
- To unite the free marginal gingiva with the cementum of the root and the adjacent attached gingiva.
- The gingival fibers are arranged in three groups: gingivodental, circular, and transseptal
Gingival cells

- Fibroblasts
- Macrophages
- mast cells
- Osteoblasts
- Cementoblasts
- Osteoclasts
- Odontoclasts
- polymorphonuclear leucocytes, lymphocytes and plasma cells
- undifferentiated ectomesenchymal cells
Healthy gingiva

Diagrammatic view of the healthy gingiva (Page and Schroeder).

- **AC**, alveolar crest
- **CO**, collagen fibers
- **FI**, fibroblast
- **GS**, gingival sulcus
- **JE**, junctional epithelium
- **L**, lymphocyte
- **N**, neutrophil
- **OE**, oral epithelium
- **P**, plasma cell
- **PDL**, periodontal ligament
- **SE**, sulcular epithelium
- **V**, blood vessel

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Blood supply

- Supraperiosteal arterioles
- Vessels of the periodontal ligament
- Arterioles that emerge from the crest septa
Diagram of arteriole penetrating the interdental alveolar bone to supply the interdental tissues (left) and a supraperiosteal arteriole overlying the facial alveolar bone, sending branches to the surrounding tissue (right).
Repair of Gingival Connective Tissue

- It has high turnover rate, good healing and regenerative capacity, with little evidence of scarring after surgical procedures.

- However, the reparative capacity of gingival connective tissue is not as great as that of the periodontal ligament or the epithelial tissue.
Figure 4-24 Scanning electron microscopic view of gingival tissues of rat molar palatal gingiva after vascular perfusion of plastic and corrosion of soft tissue. A, Oral view of gingival capillaries: t, tooth; interdental papilla (arrowhead) (&#215;180). B, View from the tooth side. Note the vessels of the plexus next to the sulcular and junctional epithelium. The arrowheads point to vessels in sulcus area with mild inflammatory changes. g, Crest of marginal gingiva; s, bottom of gingival sulcus; pl, periodontal ligament vessels. (&#215;150.) (Courtesy NJ Selliseth and K Selvig, University of Bergen, Norway.)
Objectives

- Describe the normal macroscopic features of the marginal gingiva, attached gingiva, interdental gingiva
- Describe the normal microscopic features of the gingival epithelium, gingival connective tissue
- Discuss the correlation of normal clinical and microscopic features
- Integrate the knowledge of the histology of the gingival and dentogingival junctional tissues with the related pathology that may occur
CORRELATION OF CLINICAL AND MICROSCOPIC FEATURES
Color

- The color of the attached and marginal gingiva is generally described as "coral pink" and is produced by
  - the vascular supply,
  - the thickness and degree of keratinization of the epithelium, and
  - the presence of pigment-containing cells.

- The alveolar mucosa is red, smooth, and shiny rather than pink and stippled.

- The epithelium of the alveolar mucosa is thinner, is nonkeratinized, and contains no rete pegs

- The connective tissue of the alveolar mucosa is loosely arranged, and the blood vessels are more numerous.
Size

- The size of the gingiva corresponds with the sum total of the bulk of cellular and intercellular elements and their vascular supply. Alteration in size is a common feature of gingival disease.
Contour

- The contour or shape of the gingiva varies considerably and depends on:
  - the shape of the teeth and
  - their alignment in the arch,
  - the location and
  - size of the area of proximal contact,
  - the dimensions of the facial and lingual gingival embrasures.

- The marginal gingiva envelops the teeth in collarlike fashion and follows a scalloped outline on the facial and lingual surfaces.

- It forms a straight line along teeth with relatively flat surfaces. On teeth with pronounced mesiodistal convexity (e.g., maxillary canines) or teeth in labial version, the normal arcuate contour is accentuated, and the gingiva is located farther apically.
Contour

- The shape of the interdental gingiva is governed by the contour of the proximal tooth surfaces and the location and shape of gingival embrasures.
- The height of the interdental gingiva varies with the location of the proximal contact.
- Thus, in the anterior region of the dentition, the interdental papilla is pyramidal in form, whereas the papilla is more flattened in a buccolingual direction in the molar region.

Figure 4-27 Thickened shelflike contour of gingiva on tooth in lingual version aggravated by local irritation caused by plaque accumulation.
Consistency

- The gingiva is firm and resilient and, with the exception of the movable free margin, tightly bound to the underlying bone.

- The collagenous nature of the lamina propria and its contiguity with the mucoperiosteum of the alveolar bone determine the firmness of the attached gingiva.

- The gingival fibers contribute to the firmness of the gingival margin.
Consistency

- The gingiva presents a textured surface similar to an orange peel and is referred to as being *stippled*.

- Stippling is best viewed by drying the gingiva. *The attached gingiva is stippled; the marginal gingiva is not.* The central portion of the interdental papillae is usually stippled, but the marginal borders are smooth. The pattern and extent of stippling vary among individuals and different areas of the same mouth.

- Stippling is less prominent on lingual than facial surfaces and may be absent in some persons.

- It is absent in infancy, appears in some children at about 5 years of age, increases until adulthood, and frequently begins to disappear in old age.
Consistency

- Microscopically, stippling is produced by alternate rounded protuberances and depressions in the gingival surface. The papillary layer of the connective tissue projects into the elevations, and the elevated and depressed areas are covered by stratified squamous epithelium. The degree of keratinization and the prominence of stippling appear to be related.

- *Stippling is a form of adaptive specialization or reinforcement for function.* It is a feature of healthy gingiva, and reduction or loss of stippling is a common sign of gingival disease. When the gingiva is restored to health after treatment, the stippled appearance returns.

- The surface texture of the gingiva is also related to the presence and degree of epithelial keratinization.
Figure 4-29 Gingival biopsy of patient shown in Figure 4-7, demonstrating alternate elevations and depressions (arrows) in the attached gingiva responsible for stippled appearance.
1. Healthy gingiva in the person young

2. Healthy lightly pigmented gingiva
   - AG is stippled
   - This pigmentation results from the synthesis of melanin by melanocytes located in the basal layer of the epithelium (brown spots)

3. Healthy, deeply pigmented gingiva
   - Recession in the mandibular anterior area
   - The alveolar crest is located ca. 2mm apical to CEJ
Position

- The position of the gingiva refers to the level at which the gingival margin is attached to the tooth.
- When the tooth erupts into the oral cavity, the margin and sulcus are at the tip of the crown; as eruption progresses, they are seen closer to the root.
- During this eruption process, as described earlier, the junctional epithelium, oral epithelium, and reduced enamel epithelium undergo extensive alterations and remodeling.
- The distance between the apical end of the junctional epithelium and the crest of the alveolus remains constant throughout continuous tooth eruption (1.07 mm).
Position

Initial recession (left), CEJ is marked

Stillman cleft (right), is likely traumatic origin

Palatal recession (left)

McCall’s festoon (right)

Dehiscence (left)

Severe localized recession (right)

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Relationship of the gingival margin with the crown and root surface

A. Normal, B. Wear on the incisal edge and continues eruption with gingival margin remains in the same position as in A., C. Wear on the incisal edge and continues eruption with gingival margin has moved with tooth, D. No wear of the incisal edge is evident. Gingiva has moved apically.

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Objectives

- Describe the normal macroscopic features of the marginal gingiva, attached gingiva, interdental gingiva
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- Discuss the correlation of normal clinical and microscopic features
- Integrate the knowledge of the histology of the gingival and dentogingival junctional tissues with the related pathology that may occur
Periodontal ligament
Objectives

- Describe the structure of the periodontal fibers
- List out the four types of cells in the periodontal ligament
- List out the components of the ground substance
- Discuss the functions of the periodontal ligament
- Integrate the knowledge of the histology of the periodontal ligament with the clinical considerations involved with this dental structure, especially those changes associated with periodontal pathology
Periodontal ligament

- The periodontal ligament is the **connective tissue** that surrounds the root and connects it with the bone. It is continuous with the connective tissue of the gingiva and communicates with the marrow spaces through vascular channels in the bone.

- The average width is about 0.2 mm
Principal fibers of the periodontal ligament

- primarily composed of bundles of type I collagen fibrils.
- classified into several groups on the basis of their anatomic location
  1. Alveolar crest fibers
  2. Horizontal fibers
  3. Oblique fibers
  4. Periapical fibers
  5. Interradicular fibers
- also contains oxytalan fibers
- also contains cell rests of Malassez (M)
The principal fibers of the periodontal ligament

- **Alveolar crest group.** Alveolar crest fibers extend obliquely from the cementum just beneath the junctional epithelium to the alveolar crest. Fibers also run from the cementum over the alveolar crest and to the fibrous layer of the periosteum covering the alveolar bone. The alveolar crest fibers prevent the extrusion of the tooth and resist lateral tooth movements. The incision of these fibers during periodontal surgery does not increase tooth mobility unless significant attachment loss has occurred.

- **Horizontal group.** Horizontal fibers extend at right angles to the long axis of the tooth from the cementum to the alveolar bone.

- **Oblique group.** Oblique fibers, the largest group in the periodontal ligament, extend from the cementum in a coronal direction obliquely to the bone. They bear the brunt of vertical masticatory stresses and transform them into tension on the alveolar bone.

- **Apical group.** The apical fibers radiate in a rather irregular manner from the cementum to the bone at the apical region of the socket. They do not occur on incompletely formed roots.

- **Interradicular group.** The interradicular fibers fan out from the cementum to the tooth in the furcation areas of multirrooted teeth.
The location of some of the principal fibers of the periodontal ligament.

- **AC**: alveolar crest fibers
- **H**: horizontal fibers
- **OBL**: oblique fibers
- **PA**: periapical fibers
- **IR**: interradicular fibers
Objectives

- Describe the structure of the periodontal fibers
- List out the four types of cells in the periodontal ligament
- List out the components of the ground substance
- Discuss the functions of the periodontal ligament
- Integrate the knowledge of the histology of the periodontal ligament with the clinical considerations involved with this dental structure, especially those changes associated with periodontal pathology
Figure 5-1 Principal fibers of the periodontal ligament follow a wavy course when sectioned longitudinally. The formative function of the periodontal ligament is illustrated by the newly formed osteoid and osteoblasts along a previously resorbed bone surface (left) and the cementoid and cementoblasts (right). Note the fibers embedded in the forming calcified tissues (arrows). V, Vascular channels.
Figure 5-2 Collagen fibers embedded in the cementum (left) and bone (right) (silver stain). Note Sharpey's fibers within the bundle bone (BB) overlying lamellar bone.
Figure 5-3 Collagen microfibrils, fibrils, fibers, and bundles.
Figure 5-4 Diagram of principal fiber groups.
Figure 5-5 Transseptal fibers (F) at the crest of the interdental bone.
Figure 5-6 Rat molar section showing alveolar crest fibers radiating coronally.
Figure 5-7 Epithelial rests of Malassez. A, Erupting tooth in a cat. Fragmentation of Hertwig's epithelial root sheath giving rise to epithelial rests located along, and close to, the root surface. B, Human periodontal ligament with rosette-shaped epithelial rests (arrows) lying close to the cementum (C).
Figure 5-8 Cementicles in the periodontal ligament, one lying free and the other adherent to the tooth surface.
Figure 5-9 Foramina perforating the lamina dura (dog jaw).
Cellular Elements

- Four types of cells have been identified in the PL:
  - connective tissue cells
  - epithelial rest cells
  - defense cells
  - cells associated with neurovascular elements.

- Connective tissue cells include fibroblasts, cementoblasts, osteoblasts, osteoclasts, and odontoclasts

- These cells synthesize collagen and have also been shown to possess the capacity to phagocytose "old" collagen fibers and degrade them by enzyme hydrolysis.
Cellular Elements

- The epithelial rests of Malassez form a latticework in the periodontal ligament and appear as either isolated clusters of cells.
- Epithelial rests proliferate when stimulated, and participate in the formation of periapical cysts and lateral root cysts.
- The defense cells include macrophages, mast cells, and eosinophils.
Cellular Elements

- Histological cross-section through a periodontal ligament
- A, arteriole; BB, bundle bone; C, cementum; CC, cementocytes; D, dentin; F, fibroblasts; M, cell rests of Malassez; NV, neurovascular channel; OB, osteoblasts; OC, osteocytes; SF, Sharpeys fibers; V, thin-walled venules.

* = fiber insertions are wider on the bone than cementum side.
Objectives

- Describe the structure of the periodontal fibers
- List out the four types of cells in the periodontal ligament
- List out the components of the ground substance
- Discuss the functions of the periodontal ligament
- Integrate the knowledge of the histology of the periodontal ligament with the clinical considerations involved with this dental structure, especially those changes associated with periodontal pathology
Ground Substance

- It consists of two main components:
  - glycosaminoglycans such as hyaluronic acid and proteoglycans, and
  - glycoproteins such as fibronectin and laminin
  - It also has a high water content (70%).

- The periodontal ligament may also contain calcified masses called cementicles, which are adherent to or detached from the root surfaces
Objectives

- Describe the structure of the periodontal fibers
- List out the four types of cells in the periodontal ligament
- List out the components of the ground substance
- Discuss the functions of the periodontal ligament
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Functions of the Periodontal Ligament

- Physical Function
- Formative and Remodeling Function
- Nutritional and Sensory Functions
Physical Functions

- Provision of a soft tissue "casing" to protect the vessels and nerves from injury by mechanical forces.
- Transmission of occlusal forces to the bone.
- Attachment of the teeth to the bone.
- Maintenance of the gingival tissues in their proper relationship to the teeth.
- Resistance to the impact of occlusal forces (shock absorption)
  - Light forces are absorbed by intravascular fluid that is forced out of the blood vessels
  - Moderate forces are also absorbed by extravascular tissue fluid that is forced out of the periodontal ligament space into the adjacent marrow spaces
  - The heavier forces are taken up by the principal fibers
Formative and Remodeling Function

- Cells of the periodontal ligament participate in the **formation** and **resorption** of cementum and bone which occur:
  - in physiologic tooth movement;
  - in the accommodation of the periodontium to occlusal forces; and
  - in the repair of injuries.
- The periodontal ligament is constantly undergoing remodeling.
  - Old cells and fibers are broken down and replaced by new ones, and mitotic activity can be observed in the fibroblasts and endothelial cells.
  - Fibroblasts form the collagen fibers and may also develop into osteoblasts and cementoblasts.
Nutritional and Sensory Functions

- Supplies nutrients to the cementum, bone, and gingiva by way of the blood vessels and provides lymphatic drainage.

- Supplied with sensory nerve fibers capable of transmitting tactile, pressure, and pain sensations by the trigeminal pathways.

- Nerve bundles pass into the periodontal ligament from the periapical area and through channels from the alveolar bone that follow the course of the blood vessels.
Figure 5-10 Left, Diagram of tooth (mandibular premolar) in a resting state. Right, When a force is exerted on the tooth, in this case in faciolingual direction (arrow) the tooth rotates around the fulcrum or axis of rotation (black circle on root). The periodontal ligament is compressed in areas of pressure and distended in areas of tension.
Figure 5-11 Microscopic view of rat molar subjected to occlusohorizontal forces. Note the alternating widened and narrowed areas of the periodontal ligament as the tooth rotates around its axis of rotation. The axis of rotation is in the interradicular space.
Thickness of Periodontal Ligament

- Age, location of the tooth, and degree of stress to which the tooth was subjected
- The mesial side is thinner than distal side
- A tooth that is not in function has a thin periodontal ligament
- A tooth in functional occlusion has a periodontal ligament space of approximately 0.25 mm, plus or minus 0.10 mm
- A tooth subjected to abnormal stress has a considerably thicker periodontal space.
Table 5-1. Thickness of Periodontal Ligament of 172 Teeth from 15 Human Subjects

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<th>Average of Alveolar Crest (mm)</th>
<th>Average of Midroot (mm)</th>
<th>Average of Apex (mm)</th>
<th>Average of Tooth (mm)</th>
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<td>0.23</td>
<td>0.17</td>
<td>0.24</td>
<td>0.21</td>
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<td>83 teeth from 4 jaws</td>
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<tr>
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<td>0.14</td>
<td>0.19</td>
<td>0.18</td>
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<tr>
<td>36 teeth from 5 jaws</td>
<td></td>
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<tr>
<td>Ages 51-67</td>
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<td>0.12</td>
<td>0.16</td>
<td>0.15</td>
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<tr>
<td>35 teeth from 5 jaws</td>
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<tr>
<td>Age 24 (1 case) 18 teeth from 1 jaw</td>
<td>0.16</td>
<td>0.09</td>
<td>0.15</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Cementum
Objectives

- Describe the types of cementum
- List out the types of the cementum relationships at the cemento-enamel junction (CEJ)
- Define the thickness of the cementum
- Discuss the cementum resorption and repair
- Discuss the hypercementosis and ankylosis
- Integrate the knowledge of the histology of the cementum with the clinical considerations involved with this dental structure, especially those changes associated with periodontal pathology
Cementum

- Cementum is the calcified mesenchymal tissue that forms the outer covering of the anatomic root.
- There are two main types of root cementum: acellular (primary) and cellular (secondary).
- Both consist of a calcified interfibrillar matrix and collagen fibrils.
Distribution of cementum on the tooth surface

- **ACEL**, acellular cementum
- **CEL**, cellular cementum
- **CVX**, cervix
Figure 5-12 Acellular cementum (AC) showing incremental lines running parallel to the long axis of the tooth. These lines represent the appositional growth of cementum. Note the thin, light lines running into the cementum perpendicular to the surface; these represent Sharpey's fibers of the periodontal ligament (PL). D, Dentin. (&#215;300.)
Figure 5-13 Cellular cementum (CC) showing cementocytes lying within lacunae. Cellular cementum is thicker than acellular cementum (see Figure 5-15). Evidence of incremental lines also exists, but they are less distinct than in acellular cementum. The cells adjacent to the surface of the cementum in the periodontal ligament (PL) space are cementoblasts. D, Dentin. (×300.)
collagen fibers in cementum

- There are two sources:
  - Sharpey's (extrinsic) fibers and are formed by the fibroblasts
  - (intrinsic) and are produced by the cementoblasts

- The inorganic content of cementum (hydroxyapatite; Ca$_{10}$[PO$_4$]$_6$[OH]$_2$) is 45% to 50%, which is less than that of bone (65%), enamel (97%), or dentin (70%).
Objectives

- Describe the types of cementum
- List out the types of the cementum relationships at the cemento-enamel junction (CEJ)
- Define the thickness of the cementum
- Discuss the cementum resorption and repair
- Discuss the hypercementosis and ankylosis
- Integrate the knowledge of the histology of the cementum with the clinical considerations involved with this dental structure, especially those changes associated with periodontal pathology
Cemento-enamel Junction

Fig. 1-10

Overlap (60%-65%)
Butt (30%)
Exposed Dentin (5%-10%)

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Thickness of Cementum

- Cementum deposition is a continuous process, most rapid in the apical
- the thickness of a hair
- thicker in distal
- Hypercementosis is a prominent thickening
Cementum Resorption and Repair

- Cementum resorption may be due to local or systemic causes
  - trauma from occlusion; orthodontic movement; cysts, and tumors; replanted and transplanted teeth
  - calcium deficiency, hypothyroidism, Paget's disease

- Cementum resorption is not continuous, may alternate with periods of repair
Figure 5-15 Cemental resorption associated with excessive occlusal forces. A, Low-power histologic section of mandibular anterior teeth. B, High-power micrograph of apex of left central incisor shortened by resorption of cementum and dentin. Note partial repair of the eroded areas (arrows) and cementicle at upper right.
Figure 5-16 Scanning electron micrograph of root exposed by periodontal disease showing large resorption bay (R). Remnants of the periodontal ligament (P) and calculus (C) are visible. Cracking of the tooth surface occurs as a result of the preparation technique. (©2007 Elsevier Inc.) (Courtesy Dr. John Sottosanti, La Jolla, Calif.)
Figure 5-17 Resorption of cementum and dentin. A multinuclear osteoclast in seen at X. The direction of resorption is indicated by the arrow. Note the scalloped resorption front in the dentin (D). The cementum is the darkly stained band at the upper and lower right. P, Periodontal ligament.
Ankylosis

- Fusion of the cementum and alveolar bone
- Resorption of the root and its gradual replacement by bone tissue
- Implants
ALVEOLAR PROCESS
Objectives

- Describe the cells and intercellular matrix
- Discuss the structure of the socket wall, periosteum and endosteum, interdental septum
- Define the contour of alveolar process
- Describe the Fenestrations and Dehiscences
- Discuss of the development of the tooth supporting tissue
- Define the physiologic migration of the teeth
- Describe the occlusal forces and the periodontium
- Discuss the vascularization and innervation of the Supporting Structures
- Integrate the knowledge of the histology of the alveolar bone with the clinical considerations involved with this dental structure, especially those changes associated with periodontal pathology
ALVEOLAR PROCESS

- The alveolar process is the portion of the maxilla and mandible that forms and supports the tooth sockets

- Consists of
  - Compact bone
  - Cortical bone
  - Alveolar bone proper (also known as the cribriform plate or lamina dura) and
  - Cancellous bone
Alveolar process

1 Alveolar bone, or
   - Cribiform plate
   - Alveolar wall
   - Lamina dura

2 Trabecular bone

3 Compact bone
Figure 5-18 Mesiodistal section through mandibular molars of a 17-year-old female, obtained at autopsy. Note the interdental bony septa between first and second molar. The dense cortical bony plates represent the alveolar bone proper (cribriform plates) and are supported by cancellous bony trabeculae. The third molar is still in early stages of root formation and eruption.
Figure 5-19 Section through human jaw with tooth in situ. The dotted line indicates the separation between basal bone and alveolar bone. (Redrawn from Ten Cate AR: Oral histology: development, structure, and function, ed 4, St Louis, 1994, Mosby.)
Cells and intercellular matrix

- Osteocyte, Osteoblasts, Osteoclasts
- Bone consist of 65% hydroxyapatite (cementum?)
- Organic matrix consists mainly (90%) of collagen type 1 with small amounts of osteocalcin, osteonectin, bone morphogenetic protein, phosphoproteins, and proteoglycans
Figure 5-22 Rat alveolar bone. Histologic view of two multinucleated osteoclasts in Howship's lacuna.
Figure 5-23 Deep penetration of Sharpey's fibers into bundle bone (rat molar).
Alveolar process: socket wall

In this transilluminated bone preparation it becomes clear that the alveolar bone is perforated by numerous small holes, as in a sieve (cribriform plate)
Figure 5-20 Relative proportions of cancellous bone and compact bone in a longitudinal faciolingual section of A, mandibular molars; B, lateral incisors; C, canines; D, first premolars; E, second premolars; F, first molars; G, second molars; and H, third molars.
Figure 5-21 Shape of roots and surrounding bone distribution in a transverse section of maxilla and mandible at midroot level.
Periosteum and Endosteum

- All bone surfaces are covered by connective tissue.
- outer surface → periosteum
- internal → endosteum.
- The periosteum consists of
  - an inner layer composed of cells that have the potential to differentiate into osteoblasts
  - an outer layer that is rich in blood vessels and nerves and is composed of collagen fibers and fibroblasts. Bundles of periosteal collagen fibers penetrate the bone, binding the periosteum to the bone
- The endosteum is composed of a single layer of osteoprogenitor cells and a small amount of connective tissue
Interdental Septum

- The interdental septum consists of cancellous bone and cortical plates.
- If the interdental space is narrow, the septum may consist of only lamina dura (between mandibular 2nd premolars and 1st molars consists of only lamina dura in 15% cases).
- If roots are too close together, an irregular "window" can appear in the bone between adjacent roots.
- The mesiodistal angulation of the crest of the interdental septum usually parallels a line drawn between the cemento-enamel junctions of the approximating teeth.
- The distance between the crest of the alveolar bone and the CEJ in young adults varies between 0.75 and 1.49 mm (average, 1.08 mm). This distance increases with age to an average of 2.81 mm.
Figure 5-25 Interdental septa. A, Radiograph of mandibular incisor area. Note the prominent lamina dura. B, Interdental septa between the mandibular anterior teeth shown in A. There is a slight reduction in bone height with widening of the periodontal ligament in the coronal areas. The central cancellous portion is bordered by the dense bony cribriform plates of the socket, which form the lamina dura around the teeth in the radiograph. Attachments for the mentalis muscle are seen between the canine and lateral incisors. (From Glickman I, Smulow J: Periodontal disease: clinical, radiographic, and histopathologic features, Philadelphia, 1974, Saunders.)
Figure 5-26 Boneless "window" between adjoining close roots of molars.

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Contours

- Normally conforms to the prominence of the roots,

- The height and thickness of the facial and lingual bony plates are affected by the alignment of the teeth, by the angulation of the root to the bone, and by occlusal forces.
Figure 5-27 Normal bone contour conforms to the prominence of the roots.
Figure 5-28 Variation in the cervical portion of the buccal alveolar plate. A, Shelflike conformation. B, Comparatively thin buccal plate.
Fenestrations and Dehiscences

- Isolated areas in which the root is denuded of bone and the root surface is covered only by periosteum and overlying gingiva are termed fenestrations. In these instances the marginal bone is intact.

- When the denuded areas extend through the marginal bone, the defect is called a dehiscence.

- Fenestration and dehiscence are important, because they may complicate the outcome of periodontal surgery.
Figure 5-29 Dehiscence on the canine and fenestration of the first premolar.
Remodeling of Alveolar Bone

- Internal remodeling (resorption and formation), which are regulated by local and systemic influences.

- Local influences include functional requirements on the tooth as well as age-related changes in bone cells.

- Systemic influences are probably hormonal (parathyroid hormone, calcitonin, and others).

- Remodeling of alveolar bone affects its height, contour, and density.
Physiologic Migration of the Teeth

- Tooth movement does not end when active eruption is completed and the tooth is in functional occlusion.
- With time and wear, the proximal contact areas of the teeth are flattened and the teeth tend to move mesially. This is referred to as physiologic mesial migration. By age 40, it results in a reduction of about 0.5 cm in the length of the dental arch from the midline to the third molars. Alveolar bone is reconstructed in compliance with the physiologic mesial migration of the teeth.
- Bone resorption is increased in areas of pressure along the mesial surfaces of the teeth, and new layers of bundle bone are formed in areas of tension on the distal surface.
Figure 5-24 Bundle bone associated with physiologic mesial migration of the teeth. A, Horizontal section through molar roots in the process of mesial migration (left, mesial; right, distal). B, Mesial root surface showing osteoclasia of bone (arrows). C, Distal root surface showing bundle bone that has been partially replaced with dense bone on the marrow side. PL, Periodontal ligament.
Occlusal Forces and the Periodontium

- The periodontium exists for the purpose of supporting teeth during function and depends on the stimulation it receives from function for the preservation of its structure. Therefore, there is a constant and sensitive balance between occlusal forces and the periodontal structures.
Occlusal Forces and the Periodontium

- Alveolar bone undergoes constant physiologic remodeling in response to occlusal forces.
- When occlusal forces are increased, the cancellous bony trabeculae increase in number and thickness, and bone may be added to the external surface of the labial and lingual plates.
- The periodontal ligament can accommodate increased function with an increase in width, a thickening of its fiber bundles, and an increase in diameter and number of Sharpey's fibers. Forces that exceed the adaptive capacity of the periodontium produce injury called trauma from occlusion.
- When occlusal forces are reduced, the number and thickness of the trabeculae are reduced. The periodontal ligament also atrophies, appearing thinned, and the fibers are reduced in number and density, disoriented and ultimately arranged parallel to the root surface.
Table 5-2. Comparison of Periodontal Width of Functioning and Functionless Teeth in a 38-Year-Old Man

<table>
<thead>
<tr>
<th></th>
<th>Entrance of Alveolus</th>
<th>Middle of Alveolus</th>
<th>Fundus of Alveolus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy function:</strong> Left</td>
<td>0.35</td>
<td>0.28</td>
<td>0.30</td>
</tr>
<tr>
<td>upper second bicuspid</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Light function:</strong> Left</td>
<td>0.14</td>
<td>0.10</td>
<td>0.12</td>
</tr>
<tr>
<td>lower first bicuspid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Functionless:</strong> Left</td>
<td>0.10</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>upper third molar</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Modified from Kronfeld R: J Am Dent Assoc 18:1242, 1931.
Figure 5-31 Atrophic periodontal ligament (P) of a tooth devoid of function. Note the scalloped edge of the alveolar bone (B), indicating that resorption has occurred. C, Cementum.
VASCULARIZATION OF THE SUPPORTING STRUCTURES

- The blood supply to the supporting structures of the tooth is derived from the inferior and superior alveolar arteries to the mandible and maxilla, and it reaches the periodontal ligament from three sources:
  - apical vessels,
  - penetrating vessels from the alveolar bone, and
  - anastomosing vessels from the gingiva.
Figure 5-32 Vascular supply of monkey periodontium (perfused with India ink). Note the longitudinal vessels in the periodontal ligament and alveolar arteries passing through channels between the bone marrow (M) and periodontal ligament. D, Dentin. (Courtesy Dr. Sol Bernick, Los Angeles.)
Figure 5-33 Vascular supply to the periodontal ligament in rat molar, as viewed by scanning electron microscopy after perfusion with plastic and tissue corrosion. Middle and apical areas of the periodontal ligament are shown with longitudinal blood vessels from apex (below) to gingiva (above), perforating vessels entering the bone (b), and many transverse connections (arrowheads). Apical vessels (a) form a cap that connects with the pulpal vessels. (Courtesy NJ Selliseth and K Selvig, University of Bergen, Norway.)
REFERENCES/SUGGESTED READING

- Carranza FA: Clinical Periodontology, 9th ed, WB Saunders