Tooth-supporting structures

Periodontal ligaments

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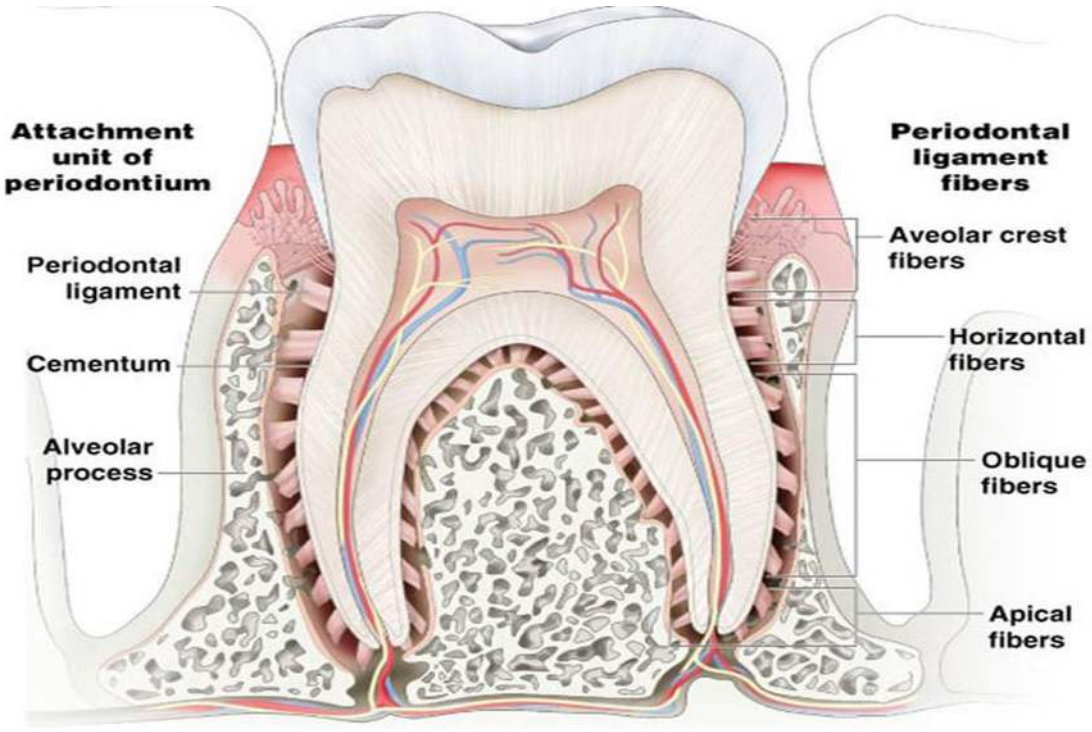
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Tooth-supporting structures

Tooth-supporting structures include the periodontal ligaments, cementum, and alveolar bone (Newman *et al.*, 2011).

Periodontal ligaments

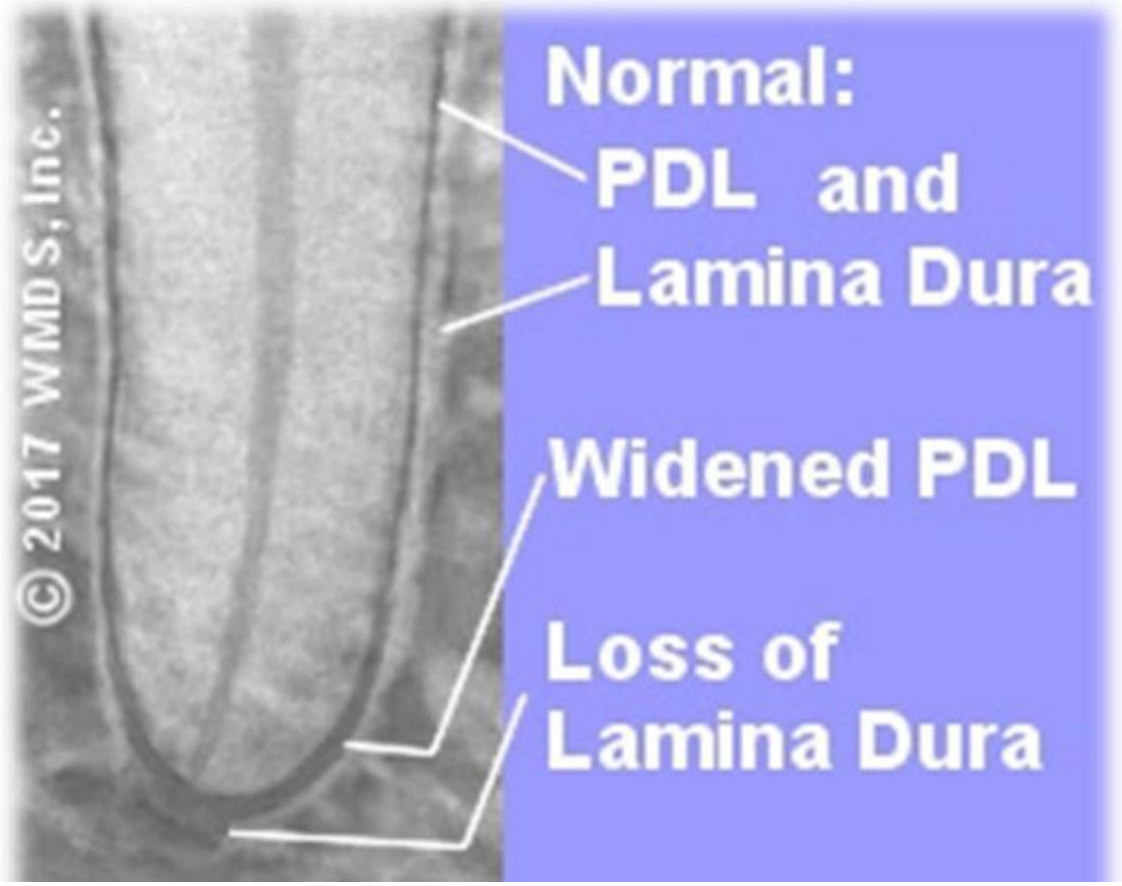
• Definition

The periodontal ligament is a highly cellular connective tissue that surrounds the tooth root and connects it to the inner wall of the alveolar bone.

• Structure

The shape of the periodontal ligament space of an hourglass is narrowest at the mid-root level. The width of the periodontal ligament is approximately 0.25 mm ± 50 percent.

The ligament appears as a radiolucent area of 0.4 to1.5mm between the radiopaque lamina dura of the alveolar bone and cementum.



➢ Cellular Composition

Cells of periodontal ligaments are categorized as:

1. Synthetic cells:

a. Osteoblast

b. Fibroblast

c. Cementoblast

2. Resorptive cells

a. Osteoclast

b. Fibroblast

c. Cementoclast

3. Progenitor cells

4. Other epithelial cells

Epithelial rest of Malassez

5. Connective tissue cells

a. Mast cells

b. Macrophage

1. Synthetic cells

a. Osteoblasts: Covers the periodontal surface of the alveolar bone. Osteoblast function is the formation of alveolar bone.

b. Fibroblasts: The fibroblast is a stellate or spindle-shaped cell. Fibroblast is the most prominent connective tissue cell (65% of the total cell population). The main function of fibroblasts is the production of various types of fibers (collagen, oxytalan, reticulin, and elastin fibers. Fibroblast also forms the connective tissue matrix.

c. Cementoblast: is lining the cementum and responsible for cementum deposition

2. Resorptive Cells

a. Osteoclasts: These are the cells that resorb the bone and tend to be large and multinucleated. The precursor cells of the osteoclasts are circulating monocytes.

b. Fibroblast: The fibroblasts responsible for resorption contain fragments of collagen that appear to be undergoing digestion. The presence of these cells indicates the resorption of fibers occurring during either disease or physiological turnover or remodeling of the periodontal ligament.

c. Cementoclasts: The main observation in this is that cementum is not remodeled in the fashion of alveolar bone and periodontal ligament, but that it undergoes continual deposition during life. However, resorption of cementum occurs in certain circumstances.

3. Progenitor cells:

They differentiate into the functional type of connective tissue cells.

4. Epithelial cell rests of Malassez:

They are found close to the cementum. These cells are remnants of the epithelium of Hertwig's epithelial root sheath. The epithelial cell rests persist as a network, strands, islands, or tubule-like structures near and parallel to the surface of the root. When certain pathologic conditions are present, cells of the epithelial rests can undergo rapid proliferation and can produce a variety of cysts and tumors of the jaws.

5. Connective tissue cells

a. *Mast cells*: These are relatively small, round, or oval cells having a diameter of almost 12 to 15 μm. The cells contain numerous cytoplasmic granules with small or round nucleus. The granules have been shown to contain heparin and histamine. Mast cell histamine plays a role in the inflammatory reaction.

b. *Macrophages:* They are capable of phagocytosis.

➢ ***Extracellular Components***

1. Fibers:

• Collagen

• Oxytalan

2. Ground substance:

• Proteoglycans

• Glycoproteins

Periodontal fibers

The most important elements of the periodontal ligament are the principal fibers. These fibers are collagenous in nature and are arranged in bundles, they follow a wavy course.

The terminal portion of these principal fibers that insert into the cementum and bone are termed Sharpey's fibers.

Collagen is a specific, high molecular weight protein, the most important of which are glycine, proline, and hydroxyproline. Collagen is synthesized by fibroblasts, chondroblasts, osteoblasts, odontoblasts, and other cells. The principal fibers are composed primarily of Type I collagen, whereas reticular fibers are made up of Type III collagen. Type IV collagen is seen in the basal lamina.

The principal fibers of the periodontal ligament are arranged in five groups that develop sequentially in the developing root. They are:

I. ***Alveolocrestal group***: They extend obliquely from the cementum just beneath the junctional epithelium to the alveolar crest. Their function is to retain the tooth in socket, resist lateral tooth movement and protect deeper periodontal ligament structure.

II. ***Horizontal group*****:** Extend from the cementum to the alveolar bone at right angles to the long axis of the tooth.

III. ***Oblique group***: They are the largest group in the periodontal ligament; extend coronally in an oblique direction from the cementum to the bone. They resist axially directed forces.

IV. ***Apical group***: They originate from the cementum of the root apex, bending apically and laterally into the bone of the alveolar fundus. Their main function is it prevents tooth tipping; resist luxation, and protect blood, lymph, and nerve supply to the tooth.

V. ***Inter-radicular fibers:*** Extends from the cementum of bifurcation areas, bending from apical into furcal bone. It resists luxation and tipping.

Oxytalan fibers are defined as Immature elastic fibers that Run in an axial or oblique direction. One end is embedded in cementum or bone and the other end is in the wall of blood vessels. The Oxytalan fibers play a part in supporting the blood vessel of periodontal ligaments during mastication (i.e., they prevent the sudden closure of the blood vessel under masticatory forces.

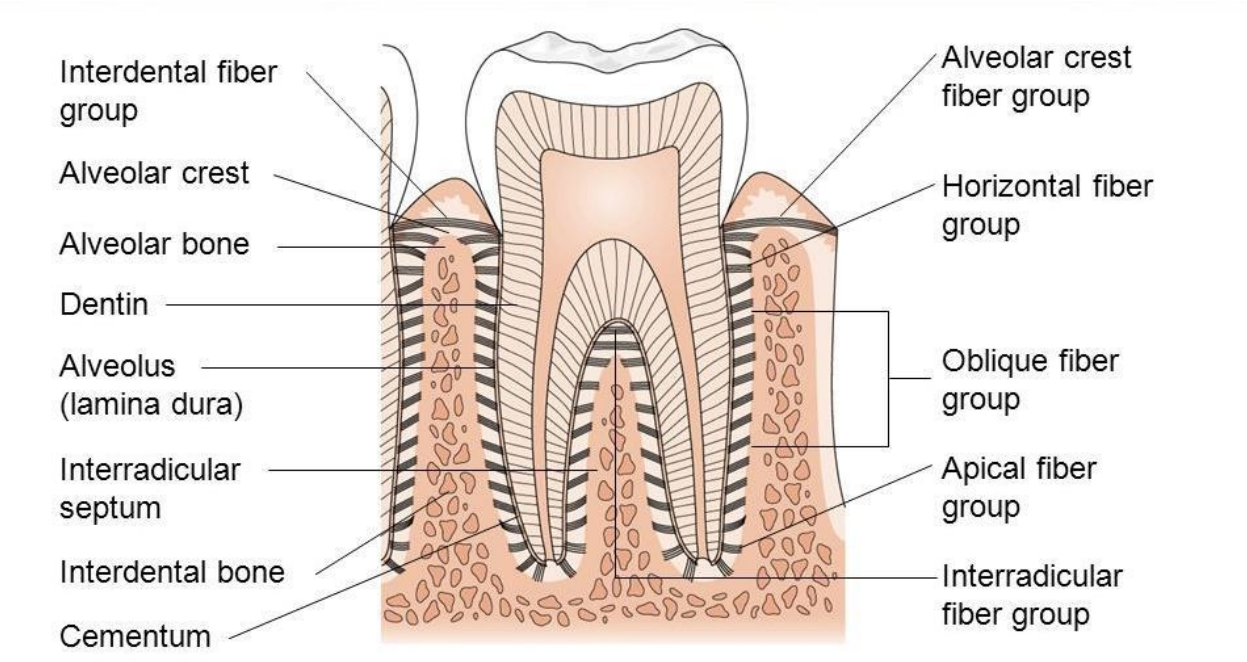
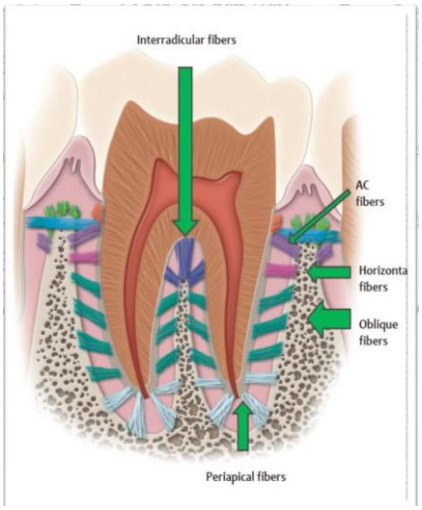


Figure 1. Principle periodontal fibers



Ground substance

The space between cells, fibers, blood vessels, and nerves in the periodontal space is occupied by ground substance. The ground substance is made up of two major groups of substances. Glycosaminoglycans such as hyaluronic acid, proteoglycans, and glycoproteins such as fibronectin and laminin. It also has high water content (70%)

Development of Principal Fibers of Periodontal Ligament

The principal fibers develop in conjunction with the eruption of the tooth. The fibroblasts surrounding the developing root produce collagen fibers. These fibers are seen in the periodontal space without a specific orientation.

1. First small, fine brush-like fibrils are noticed arising from the root cementum and projecting into the periodontal ligament space.

2. Similar fibers are seen on the surface of the bone but only in thin, small numbers.

3. Later, the number and thickness of fibers originating from the bone increase and elongate. They radiate towards the loose connective tissue in the midportion of the periodontal ligament.

4. The fibers originating from the cementum also increase in length and thickness and fuse with the fibers originating from the alveolar bone in the periodontal ligament space.

5. They mature progressively towards the root apex as the eruption progresses. When the tooth, following eruption, reaches contact in occlusion and starts to function, the principal fibers become organized in bundles and run continuously from bone to cementum.

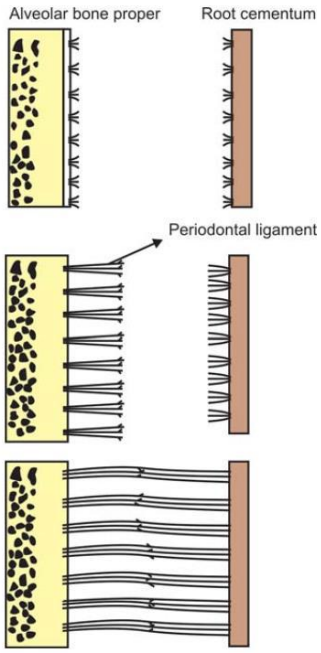


Figure 2. Development of periodontal fibers (principles)

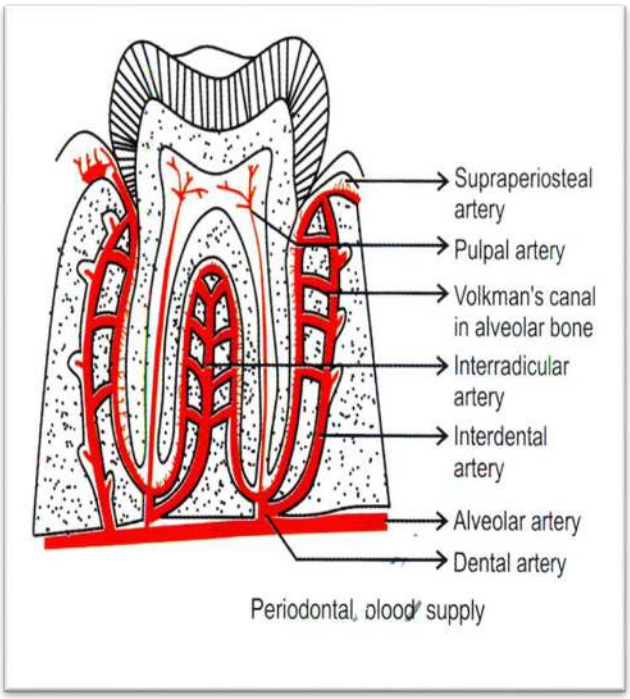
Structures Present in The Connective Tissue

1. *Blood vessels*: periodontal ligament is supplied by branches derived from three sources dental, inter-radicular, and interdental arteries:
   a. Dental artery: before it enters apical foramen gives off branches to the periodontal ligament which also supplies the pulp.
2. b. The inter-radicular artery gives off branches in the alveolar process that supplies the periodontal ligament through the cribriform plate.
3. c. The interdental artery emerges from the crest of the alveolar bone and supplies the coronal part of the periodontal ligament

2. *Lymphatics vessels* follow the path of blood vessels in the periodontal ligament

3. *Nerve innervation* Periodontal ligament is mainly supplied by the dental branches of the alveolar nerve through the apical perforations of the tooth socket. The periodontal ligament is richly supplied by mechanoreceptors whose cell bodies are in the trigeminal ganglion. These receptors provide a sense of touch, pressure, pain, and proprioception during mastication

4. *Cementicles*: are calcified masses adherent to or detached from the root surface. They may be developed from calcified epithelial rests, calcified Sharpey's fibers, and calcified vessels within the periodontal ligament.



Functions Of Periodontal Ligaments

The following functions of the periodontal ligament:

1. Physical Function

The physical functions of the periodontal ligament are:

a. Provides soft tissue "casing" to protect the vessels and nerves from injury due to mechanical forces.

b. Transmit the occlusal forces to the bone.

c. Attaches the teeth to the bone

d. Maintains the gingival tissues in their proper relationship to the teeth.

e. Shock absorption resists the impact of occlusal forces.

2. Formative and Remodeling Function

Cells of the periodontal ligament have the capacity to control the synthesis and resorption of the cementum, ligament, and alveolar bone. Periodontal ligament undergoes constant remodeling; old cells and fibers are broken down and replaced by new ones.

3. Nutritional and Sensory Function

Since the periodontal ligament has a rich vascular supply it provides nutrition to the cementum, bone, and gingiva. The periodontal ligament is supplied by nerve fibers that can transmit the sensation of touch, pressure, and pain to higher centers. The nerve bundle follows the course of the blood vessel and enters the periodontal ligament from the periapical area through channels from the alveolar bone. These bundles divide into single myelinated fibers, which later lose their myelin sheath and end in one of the four types of neural termination.

• Free endings, carry pain sensations

• Ruffini-like mechanoreceptors located in the apical area

• Meissner's corpuscles are also mechanoreceptors located primarily in the mid-root region.

• Spindle-like pressure and vibration endings, located mainly in the apex. Pain sensation is transmitted by small-diameter nerves, temperature by intermediate type, and pressure by large, myelinated fibers.

Clinical Considerations

The width of periodontal ligaments' space varies with age, location of the tooth, and degree of stress to which the tooth was subjected. In compliance with the physiological mesial migration of the tooth, the periodontal ligaments are thinner on the mesial root surface than on the distal surface.

A tooth with hyperfunction may have a wider periodontal ligament space and a tooth in hypofunction may have a narrow space.

The width of PDL space is about 0.25mm in normal functions. It is widest at the cervical and apical portions of the root and narrowest at the middle.

The most interesting features of PDL are its adaptability to rapidly changing applied force and its capacity to maintain its width at constant dimensions throughout its lifetime.

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