

Periodontal ligament (PDL)

The periodontal ligament is a soft, fibrous specialized connective tissue (C.T.) which is present in the periodontal space, which is situated between the **cementum of root** and the **alveolar process**. Because the collagen fibers are attached to the cementum and alveolar bone, the ligament provides soft tissue continuity between the mineralized connective tissues of periodontium.

PDL ranges in thickness between 0.15 and 0.38 mm and is **thinnest** in the *middle portion* of the root and its width *decreases* with age. PDL is the tissue with **high turnover rate**, contains cells and extracellular structures of collagenous fibers and a noncollagenous protein.

Development:-The periodontium develops from dental follicle or sac that surrounds the tooth which in turn derived from ectomesenchymal tissue. The dental follicle gives rise to the **fibroblasts** which will form the collagen fibers and ground substance of PDL, and to cementoblasts which will form cementum, and also gives rise to the osteoblasts which will form alveolar bone.

Structures of pdl:

The pdl consists of three components which are commonly found in other C.T., these are **cells**, **ground substance** and **fibrous matrix**.

Cells of pdl:

The cells of pdl may be divided into three main categories:

1- **Synthetic cells**: They have the ability to produce and secrete protein, include :

a- **Fibroblasts**: Are the **principle cells** of PDL, which found usually running parallel to the collagen fibers of PDL that formed them. The shape of the cell either spindle in shape with long processes or round. They are responsible for formation of ground substance and collagen fibers of PDL. Ligament fibroblasts achieve remodeling of collagen, it is capable of synthesizing and degrading collagen fibers.

b-Osteoblasts: These cells are responsible for bone formation, they are seen along the surface of bone lining the dental socket. The osteoblasts synthesize collagen and ground substance of bone matrix.

c- Cementoblasts: Its found covering the periodontal surface of the cementum. They have the ultrastructural characteristics typical of cell actively synthesizing protein i.e. an abundant endoplasmic reticulum, a well developed Golgi apparatus and several mitochondria.

2- Resorptive cells:

a- Osteoclasts: These cells resorb bone surface, they are regularly seen where bone remodelling occurs. They are large and multinucleated cells with eosinophilic cytoplasm rich in acid phosphatase enzyme. They are usually present in depression in bone known as Howship's lacunae with ruffled borders cell membrane.

b- Cementoclasts'. These cells resemble osteoclasts. However cementum rarely undergoes resorption, but when occur, multinucleated giant cell cementoclasts often located in Howship's lacunae are found on the surface of C. Its origin is unknown, but it may arise in the same manner of osteoclasts and it may be mononucleated.

c- Fibroblasts: Usually fibroblasts are capable of both **synthesis and resorption** of collagen fibers of pdl. It resorbs fibers during remodeling or turnover of pdl.

3- Progenitor cells: The pdl contains undifferentiated progenitor cells that have the capacity to undergo mitotic division. Morphologically it has a small nucleus and very little cytoplasm, and is found close to the blood vessels.

4- Epithelial cell rest of Malassez:

These are the remnants of the Hertwig's epithelial root sheath, found in the pdl close to the cementum. They are found as a network, strands or tubules or in the form of islands. Under certain pathological conditions they can undergo rapid proliferation and produce a variety of cysts and tumors.

5- Defensive cells:

a- Mast cells: They are small, round or oval cells with numerous cytoplasmic granules.

b- Macrophage cells (Histiocytes): They are predominantly present in pdl, and are embedded adjacent to the B.V. Their role in pdl are phagocytosis of dead cells, and secretory of growth factors that regulate the proliferation of adjacent cells.

Ground substance: is an amorphous background material that binds tissue and fluids, the latter serving for the diffusion of gases and metabolic substances. Ground substance is a major constituent of the PDL, It comprises acid mucopolysaccharides and glycoproteins. Both groups comprise protein and polysaccharides. The ground substance fills the spaces between cells, blood vessels and nerves. The PDL ground substance has been estimated to be 70% water and is thought to have a significant effect on the ability of the tooth to withstand stress loads.

Interstitial tissue:

These are areas surrounded by loose connective tissue containing some of blood vessels, lymphatics and nerves . These area are easily recognize by light microscope in the pdl.

Blood Vessels of PDL:

The blood supply is derived from the inferior and the superior alveolar arteries to the mandible and maxilla respectively and reach the PDL from three sources:

- 1- Branches from the **apical vessels**, that supply the dental pulp.
- 2- Branches from the ***intra-alveolar vessels***, these numerous branches run horizontally penetrate the alveolar bone to enter the pdl and here they're called perforated arteries .
- 3- Branches from gingival vessels these enter the pdl from coronal direction.
- 4- The arterioles and capillaries forming arch network that more evedent in the half of the pdl space adjacent to the cementum. There is rich vascular plexus at the apex and in the cervical part of the ligament.
- 5- The venous vessels run axially to drain the apex.

Lymphatics:

Anetwork of lymphatic vesseles following the path of B.V., provides the lymph draining of pdl, the flow from the ligament towards and into the adjacent alveolar bone.

Nerves:

Usually associated with B.V., pass through foramina in the alveolar bone, including apical foramen to enter the pdl. The N. Supply of pdl comes from either the inferior or superior dental N. and they are:

- 1- Bundles of N.fibers run from the apical region of the root towards the gingival margin.
- 2- Nerves enter the ligament horizontally through multiple foramina in the bone. These intra-alveolar nerves as they enter the ligament, the nerve fibers are either of *large diameter* and *myelinated* or of *small diameter*, in which case they may or may not be myelinated, the *unmyelinated small diameter* fibers are associated with blood vessels.

The fibers of PDL:

The fibers present in PDL are made up of 1-**collagen fibers** (type I and type III)

2-**oxytalan fibers** (type of elastic fibers).

The **collagen fibers** form the major element within the pdl. They are arranged in two types:

A-Principle fibers of PDL :

Collagen fibers are embedded into cementum on one side of the periodontal space and into alveolar bone on the other called **Sharpy's fibers**. The principle f. Can be divided into groups according to the direction in which they run in the pdl as follows:

1- Alveolar crest fibers group:

These fibers are attached to the cervical part of the cementum just below the C.E.J. and running down ward and outside to insert into the crest of the alveolar bone. The function of this f. resists the intrusive force during mastication.

2- Horizontal fibers group:

These fibers extend in a horizontal direction, from the midroot cementum to the adjacent alveolar bone. These fibers resist tipping of the teeth during mastication.

3- Oblique fibers group:

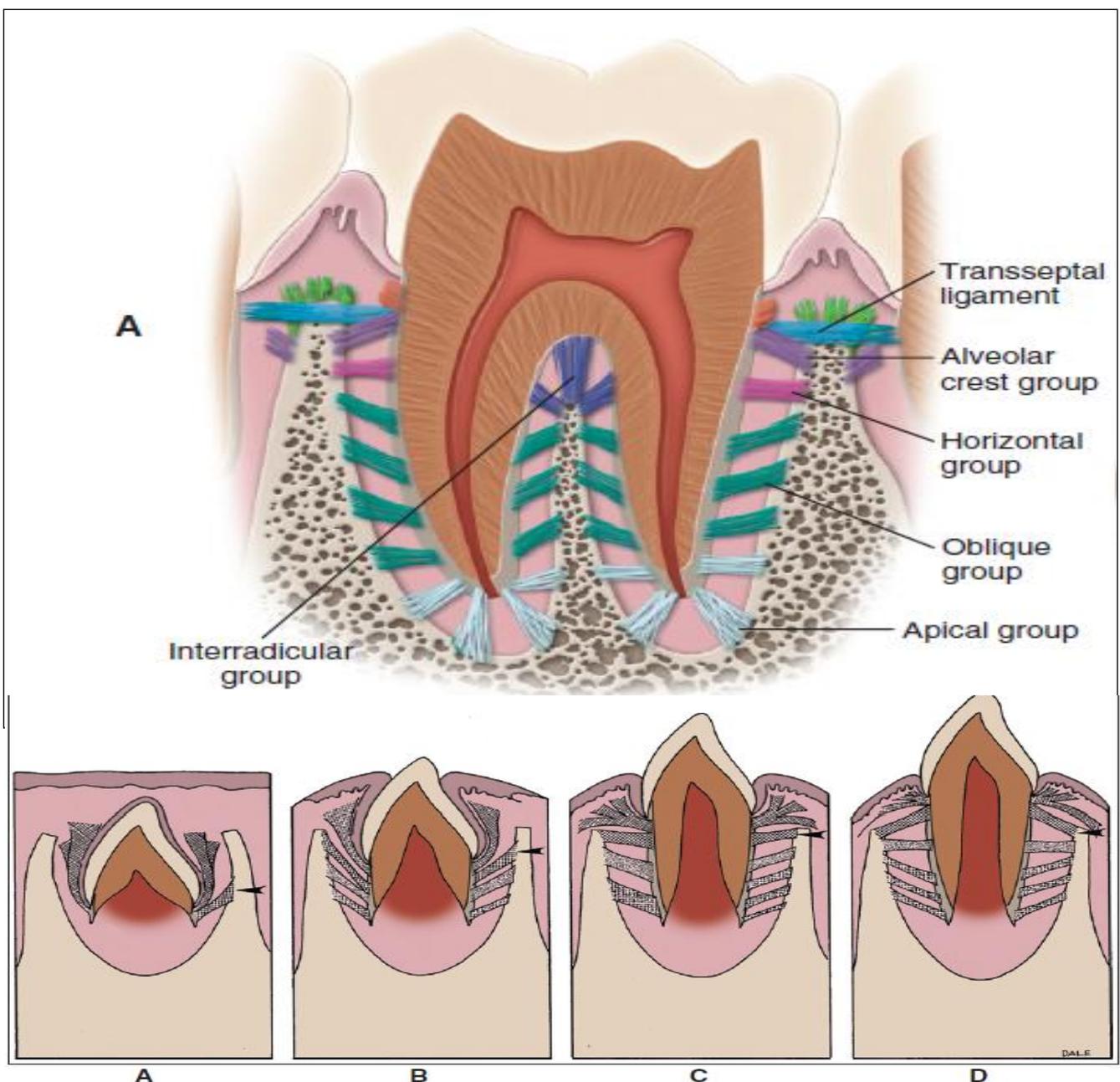
These fibers represent the most numerous type in the pdl. They are running from the cementum in an oblique direction to insert in the alveolar bone coronally. These fibers resist vertical or intrusive masticatory forces.

4- Apical fibers group:

These fibers extend perpendicular from the surface of the root apices to the adjacent alveolar bone which surrounds the apex of the tooth root. This group resists vertical and extrusive forces when applied to the tooth.

5- Inter radicular fibers group:

These fibers are located between the roots of the multirooted teeth, and extend perpendicular to the cementum and into the crest of interradicular septa in multirooted teeth.



B- Gingival fiber groups :

These are collagen f. which are not really from pdl, but are located coronally to the pdl. They arise from the lamina propria of gingiva. Their function is to attach the gingiva to the tooth. These are arranged in 5 groups as follow:

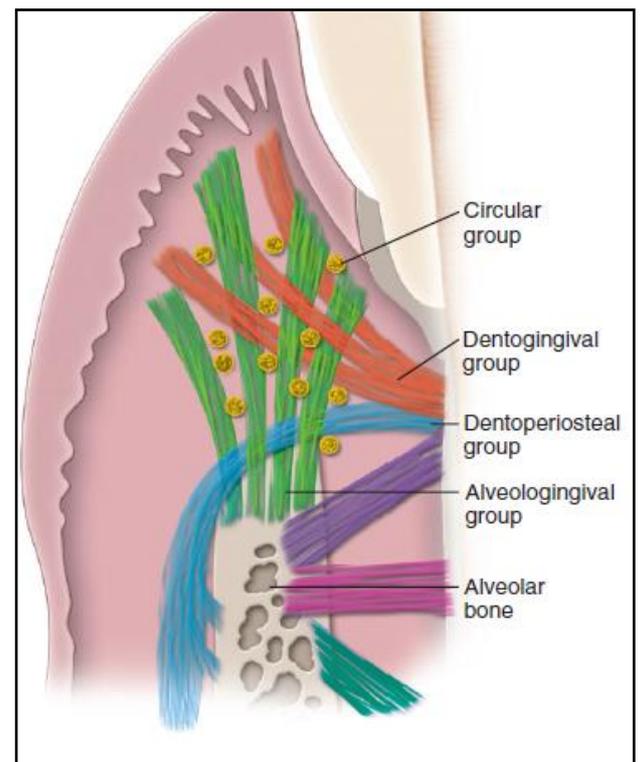
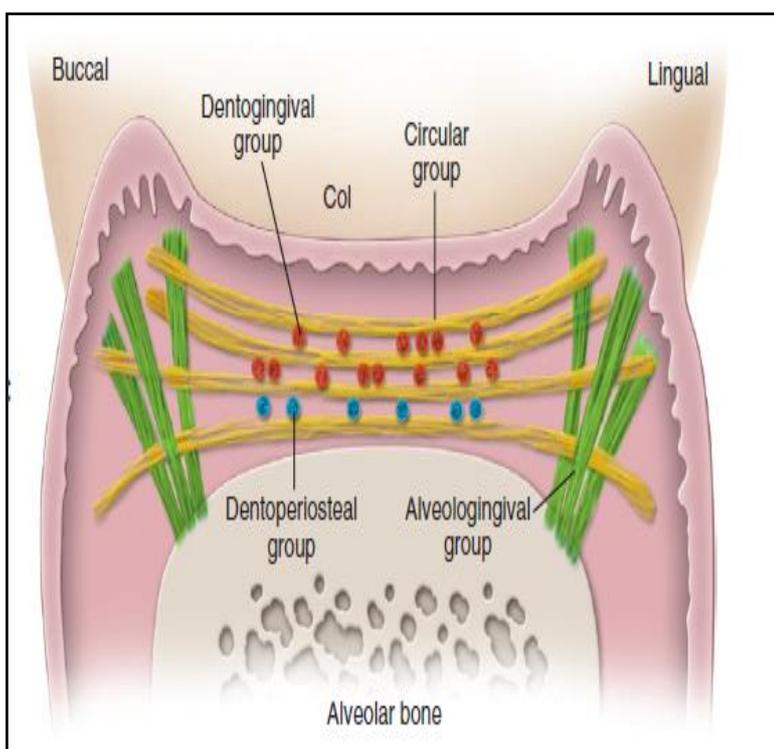
1- Dentogingival group: These fibers are the most numerous, extending from the cervical cementum to the lamina propria of both free and attached gingiva.

2- Alveologingival group: These fibers radiate from the bone of the alveolar crest and extending into lamina propria of both free and attached gingiva.

3- Circular group: this small group of fibers forms a band around the neck of the teeth, interlacing with other groups of fibers in the free gingiva and helping to bind the free gingiva to the tooth.

4- Dentoperiosteal group: Running from the cementum over the periosteum of the outer cortical plates of the alveolar process, these fibers insert into the alveola process .

5- Transseptal fiber system: These fibers are connect two adjacent teeth, i.e. The fiber run from the cementum of one tooth over the crest of alveolar bone to the cementum of the adjacent tooth. Together these fibers forming an interdental ligament connecting all the teeth of the arch.



2- **ELASTIC FIBERS**: The three types of elastic fibers are elastin, oxytalan, and elaunin . Only oxytalan fibers are present within the PDL; however, elaunin fibers may be found within fibers of the gingival ligament.

Oxytalan fibers:

Oxytalan fibers are type of immature elastic fibers present in pdl. The fibers run vertically from the cementum of the root apically forming a three- dimensional branching meshwork that surround the root and terminates in the apical complex of arteries, veins, and lymphatic vessels. Oxytalan fibers are numerous and dense in the **cervical region of the ligament , where they run parallel to the gingival group of collagen fibers**. Their function is thought to **regulate vascular flow** in relation to tooth function. Because they are elastic, they can expand in response to tensional variations, with such variations then registered on the walls of the vascular structures.

Cementicles:

These are calcified bodies found in the pdl, seen in older individual as the cementum increase thickness with age. Seen in the pdl either free, or embedded in cementum or attached to it, in this case its called excementosis. Its origin not fully established, but it may be due to epithelial rest of Malassez that form nidus for their calcification.

Functions of the PDL:

1- Supportive: PDL forms a functional system which provides **an attachment** for the tooth to the bone of the jaw, while at the same time permitting the teeth to withstand the force of mastication by the wavy course of collagen fibers.

2-Sensory: Pdl having the mechanoreceptor contributes to the pressur and touch on the teeth. So the proprioceptive reflex protects the tooth in case of sudden overload.

3-Nutritive: The B.V. In the pdl provides nutrient supply required by the cells of the pdl and to the cementocytes in cementum and most superficial osteocytes in alveolar bone.

4-Formative: The fibroblasts are responsible for the formation of new collagen fibers. Another formative function is by the cementoblasts and osteoblasts which are essential in bulding up cementum and alveolar bone respectively.

Age changes of PDL

- 1 - Decreased cellularity.
- 2-Increased collagen fibrosis and the fiber bundles were thicker; also the fiber groups were broader and more highly organized.
- 3-The periodontal -alveolar bone surface was smooth and regular in young adults but in older adults became jagged and uneven and an irregular insertion of the fibers was seen.
- 4-Cementum was thicker with age and the periodontal- cementum surface also became irregular with time
- 5-Increase the size of interstitial spaces.

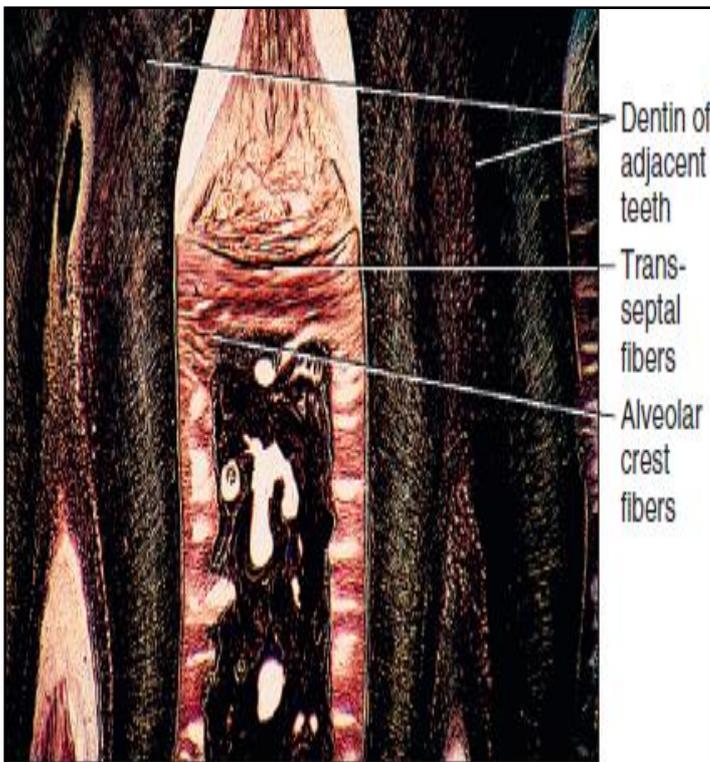


FIGURE 9-30 Histology of alveolar crest fibers extending from the cementum of the cervical region to the alveolar bone. Periodon-

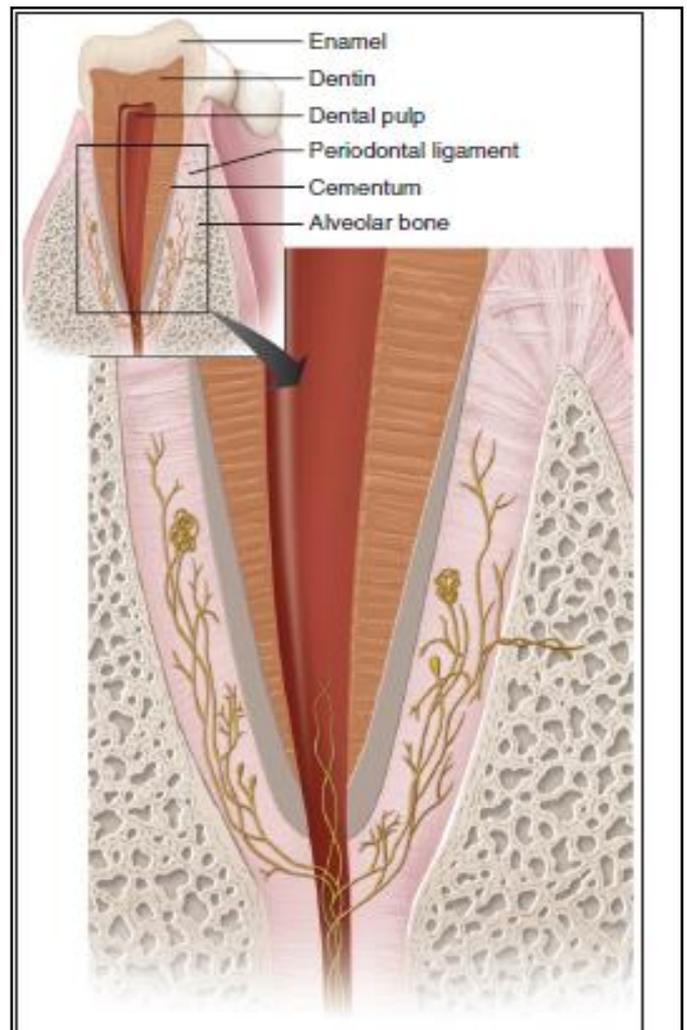


FIGURE 9-33 Nerve terminals in a human periodontal ligament.