PERIODONTAL LIGAMENT

The periodontal ligament (PDL) is the specialized fibrous connective tissue structure, with neural and vascular components, that joins the cementum covering the root to the alveolar bone .It is continuous with the connective tissue of gingiva and communicates through vascular channels in the bone with marrow space. At the apical foramen it is continuous with the dental pulp.

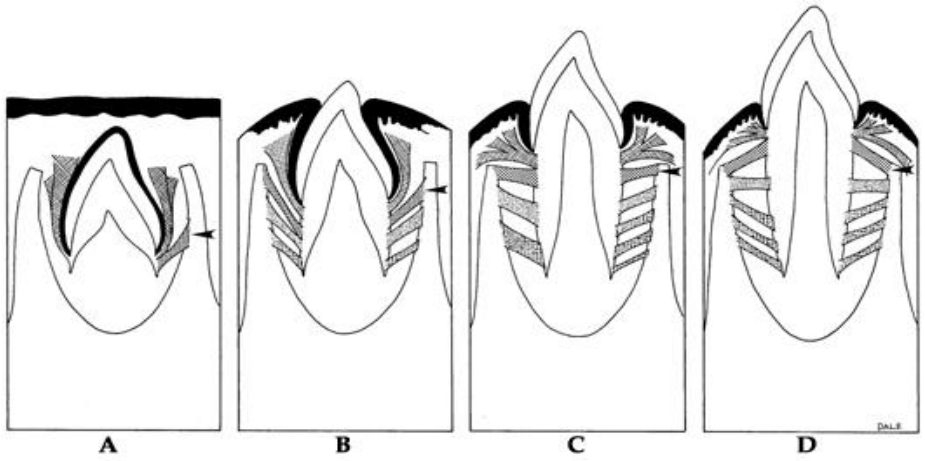
The normal width of PDL in normal functioning tooth is ranging from 0.15-038 mm. Where the region of the alveolar crest is the widest followed by the apical region, and the narrowest width at the fulcrum region(just below mid root).The PDL of primary teeth is wider than those found in permanent teeth.

The ligament is **thicker** in functioning **than** in non-functioning teeth and in areas of tension than in areas of compression

Origin and development:

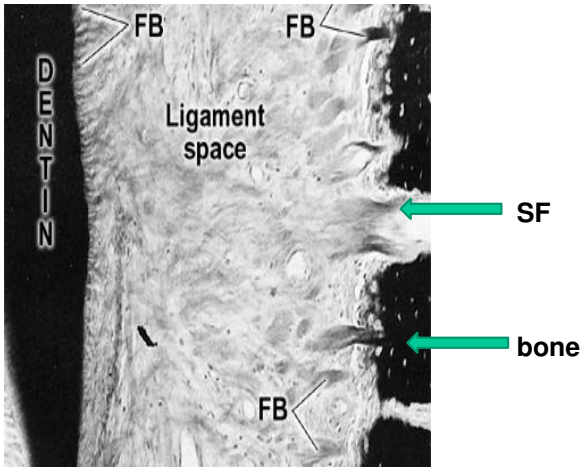
The periodontal ligament is derived embryologically from the ectomesenchymal tissue of the dental follicle that surrounds the developing tooth in its bony crypt. At the time of tooth eruption the cells and collagen fibers in the dental follicle, i.e. the future periodontal ligament, are orientated primarily with their long axis parallel to the root surface. Differentiation of the dental follicle into a periodontal ligament begins at the cemento-enamel junction and proceeds in an apical direction. The ectomesenchymal cells of dental follicle differentiate into fibroblasts which synthesize the fibers and ground substance of periodontal ligament.

The fibers of PDL become embedded in the developed cementum and alveolar bone, as **Sharpey's fibers**. As the tooth erupts the fibers of PDL are oriented in the characteristic fashion.



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Fig;(65)This figure is showing the stage of the development of the PDL fiber. Notice the orientation of the fibers before the eruption and after eruption of the tooth.



The figure is showing how the Sharpey's fibers(SF) are inserting into the bone

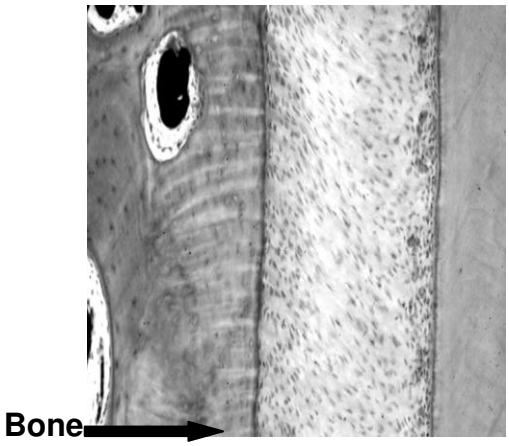


Fig. (66)Sharpey's fibers appear as white bands within the bundle bone of alveolar process.

Histological structure:

The periodontal ligament is formed of cells and extracellular substances.

The Extracellular substances comprise of fibers, ground substances, in addition to the blood vessels, nerves and lymphatics.

The major cell types of the healthy functioning periodontal ligament include the following:

i. Synthetic cells: They are the fibroblasts, osteoblasts and cementoblasts.
ii. Resorpetive cells: They are the cementoclasts, osteoclasts and fibroclasts.
iii. Progenitor cells: They are undifferentiated stem cells of the ligament. They are the remnants of the ectomesenchymal cells of the dental follicle.
iv. Defensive cells: Macrophage, lymphocytes and mast cells
v. Epithelial cells (epithelial rest cells of Malassez): they are the remnants of the epithelial root sheath of Hertwig.

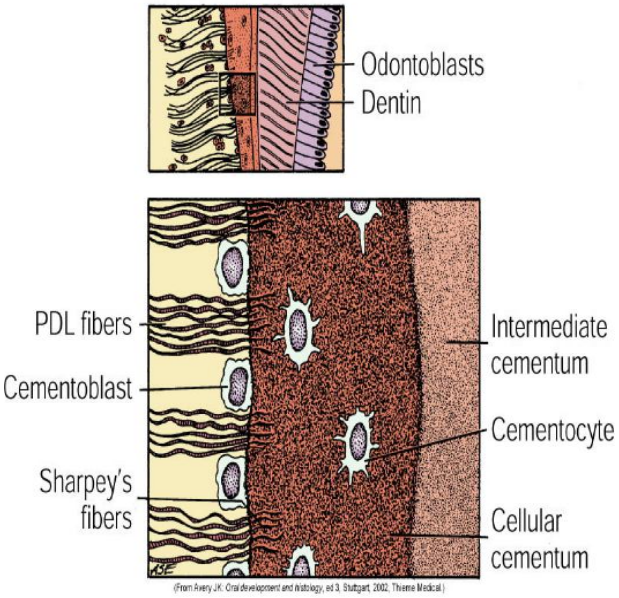
I. Cells

Synthetic cells:

a. Fibroblasts: The fibroblasts are the fiber forming cells; they are predominant cell types in the PDL. They are responsible for the synthesis of fibers and ground substance of the PDL. The fibroblasts are constantly being renewed through fibroblast division.

b.Osteoblasts: Bone forming cells, they are present on the bone surface. The collagen fibers of the PDL that penetrate the bone intervene between the cells.

c. Cementoblasts : cement forming cells



Resorptive cells:

a. Osteoclasts: The function of these cells is to resorb bone, thus they are seen on the bone surface. They are regularly seen in functioning PDL, where bone remodeling occurs.

b. Fibroclasts: Usually fibroblasts are capable of both synthesis and resorption of fibers. The synthesis and resorption of collagen fibers is called **remodeling**. **Remodeling** of collagen fibers does not cause changes in the shape of PDL because the rate of collagen removal and formation is in constant equilibrium.

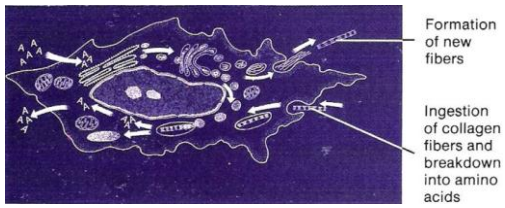
The rate of collagen remodeling in the PDL is faster than all other connective tissue.

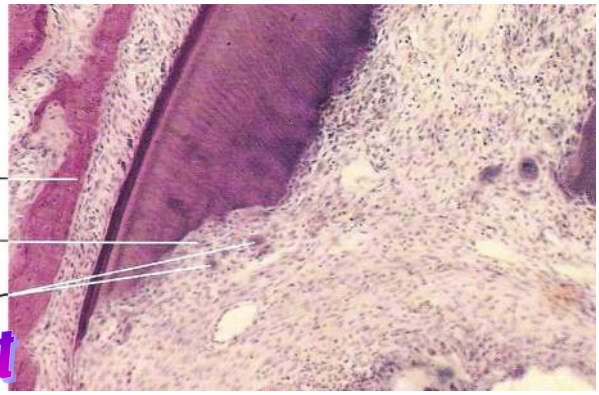
c. Cementoclasts: These resemble osteoclasts. As the cementum rarely undergoes resorption. However, resorption of the cementum can occur under certain circumstances. Cementoclasts often found in Howship's lacunae on the surface of cementum.

The presence of the osteoblasts and osteoclast (bone cells) as well as bone progenitor cells in the PDL is the reason behind considering the PDL as **modified periosteum.**

Cells of periodontal ligament

Fibroblast





Osteoclast

Defensive cells:

Macrophage and leukocytes wandering cells including the lymphocytes are also present in the PDL.

Epithelial cells
These are the remnants of epithelial root sheath. They are found as network, strands or in the form of Islands. Under certain pathologic conditions they undergo rapid proliferation and produce a variety of cysts and tumours.

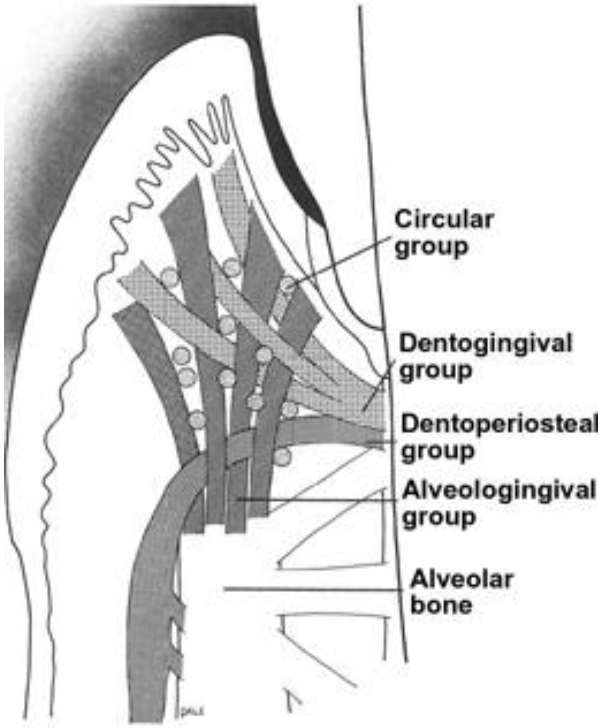
II. Fibers:

The periodontal fibers of the periodontal ligament are **primarily composed of collagen fibers type I**. In addition to the collagen fibers, the periodontal ligament also contains **oxytalan fibers**. Elastic fibers are restricted almost entirely to the wall of the blood vessels. The collagen fibers are inserted into the bone and cementum as Sharpey's fibers
The **collagen** fibers have been classified into several groups on the basis of their anatomic location.

a. The principle fibers.
b. The accessory fibers
c. The Oxytalan fibers.

a. The principle fibers: are primarily composed of bundles of type I collagen fibrils. They have been classified into several groups on the basis of their anatomic location:

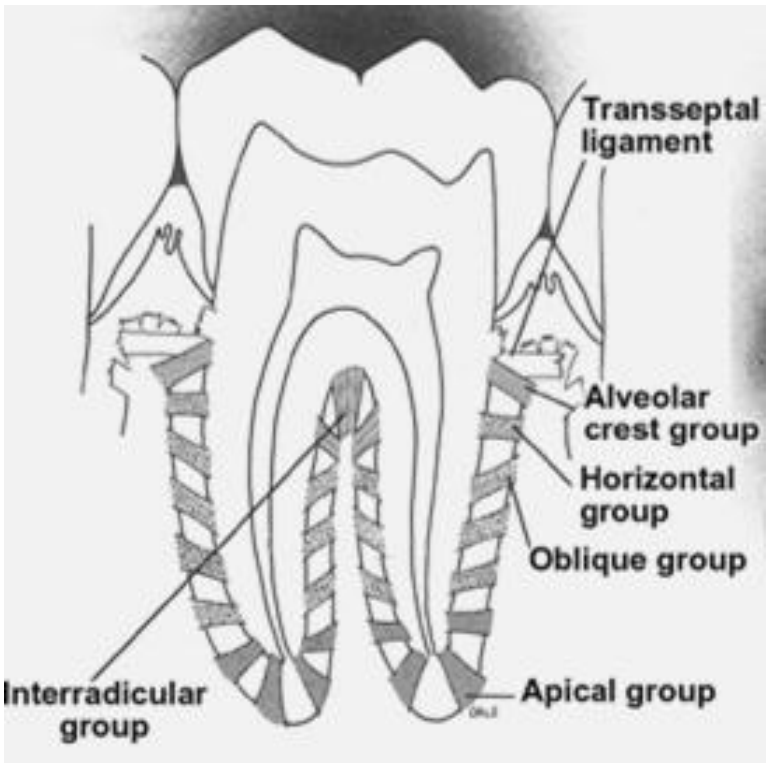
i. Gingival fibers: Attaching the gingiva to the cementum and bone, fixing the gingiva in its position and preventing its separation during the process of mastication.



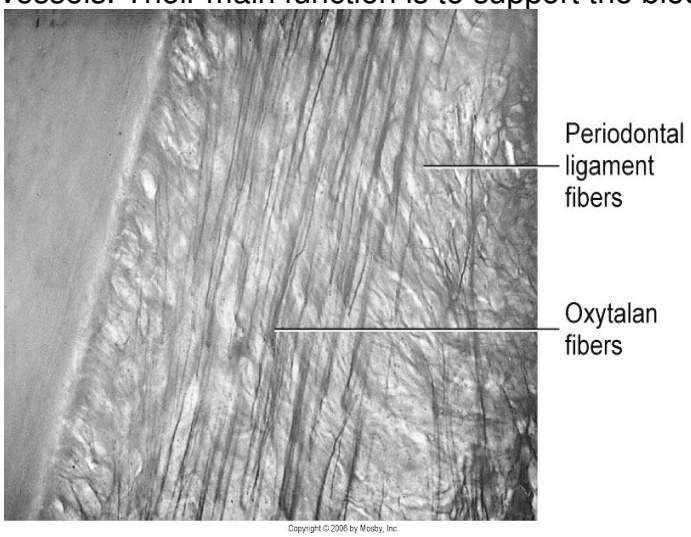
ii. The transseptal ligament: It connects two adjacent teeth. The ligament runs from cementum of one tooth to the cementum of adjacent tooth, without attaching to the alveolar crest.

iii. Dentoalveolar ligaments: They are connecting between the alveolar bone and the cementum. They are divided into the following groups:

1. **Alveolar crest group:** The bundles of this group radiate from the crest of the alveolar bone and attached to the cervical part of the cementum. This group resists intrusive force of mastication.
2. **Horizontal group:** The fiber bundles run from the cementum to the bone at right angle to the long axis of the tooth. These fibers resist tipping of the tooth.
3. **Oblique group:** The fiber bundles, their attachment in the bone is somewhat higher than the attachment in the cementum. This group is considered to be the main support of the tooth against masticatory force. This group of fibers resists vertical masticatory force.
4. **Apical group:** The bundles radiate from the apical region of the root to the surrounding bone. This group resists vertical force applied to the tooth.
5. **Interradicular group:** The bundles radiate from the crest of interradicular septum to the furacation of multirooted tooth. This group resists vertical and lateral force.



b. **Accessory fibers:** They are collagenous in nature and run from bone to cementum in different directions to prevent rotation of the tooth. They are found in the region of the horizontal group.
c. **Oxytalan fibers:** These are immature elastic fibers. They run in an axial direction, one end being embedded in the cementum and the other end is in the wall of the blood vessels. Their main function is to support the blood vessels during mastication.

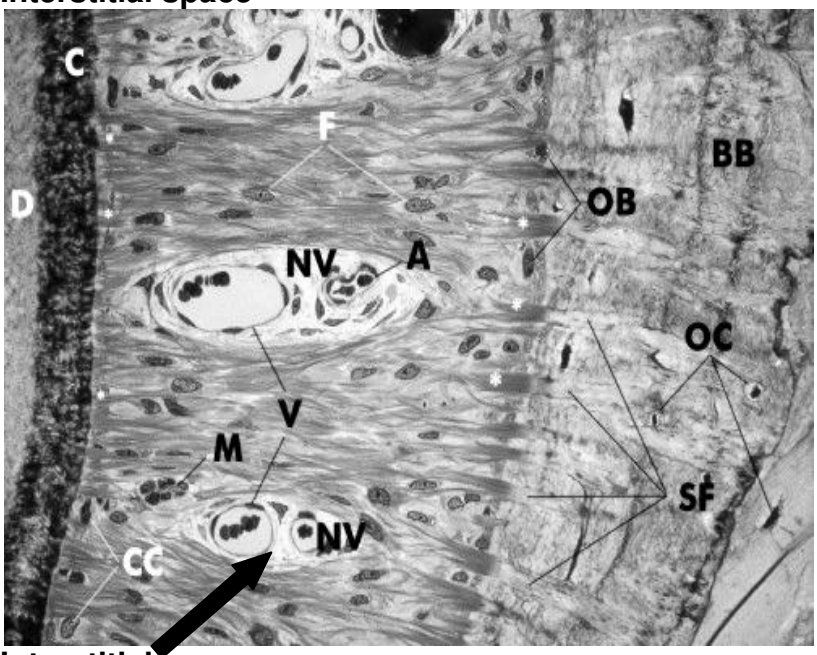


III: Ground substance:

They comprise proteoglycans and glycoprotein. Both groups comprise proteins and polysaccharides, but of different types. The ground substance fills the spaces between cells, blood vessels and nerves. They help attracting water (70%).

Interstitial tissue or spaces: Found between the fibers of the periodontal ligament they are areas containing some of the blood vessels, lymphatics and nerves, surrounded by loose connective tissue. These interstitial spaces are designed to withstand the impact of masticatory forces.

Interstitial space

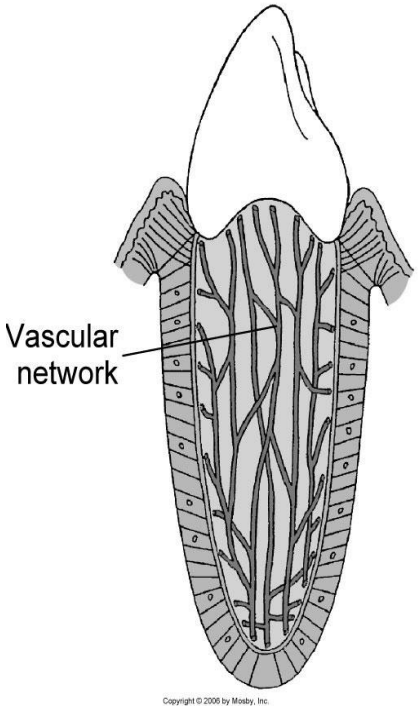


Interstitial space

Blood supply:

PDL has rich blood supply compared with other connective tissues. The blood vessels are forming a vascular network around the root of the tooth. The arterial blood supply is derived from 3 sources:

1. Branches from the apical vessels that supply the dental pulp.
2. Branches from the intra-alveolar vessels which run horizontally penetrating the alveolar bone to enter the periodontal ligament and these constitute the main blood supply.
3. Branches from the gingival vessels which enter the periodontal ligament from the coronal direction, the venous vessels run coronal to the arteries.
   Arteriovenous anastomoses and shunts have been demonstrated in the PDL.



Lymphatics

A network of lymphatic vessels follow the path of blood vessels, usually the flow is from the ligament towards and to the adjacent alveolar bone, and gingival tissue. Lymph vessels form a network around the root.

Nerve supply

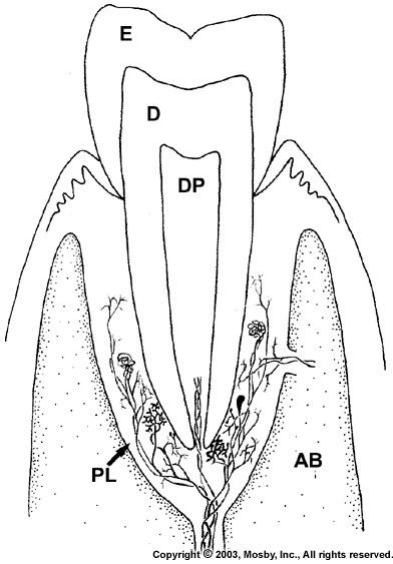
The PDL is innervated by two groups of nerve fibers:

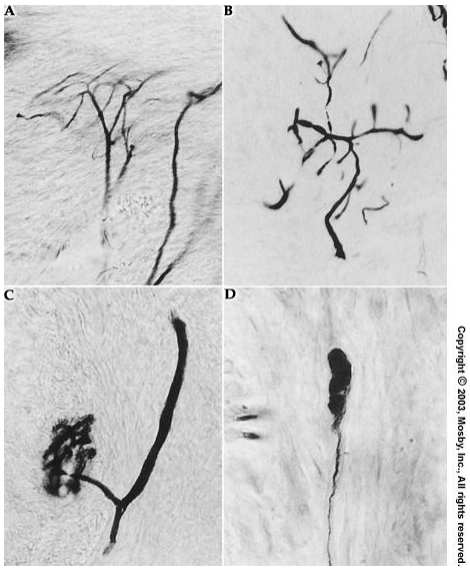
1. Sensory fibers
2. Autonomic for blood vessels.

The nerve supply of the periodontal ligament comes from either the inferior or superior dental nerves.

Bundles of nerve fibers run from the apical region of the root towards the gingival margin.
Nerves enter the ligaments horizontally through multiple foramina in the bone. These intra- alveolar nerves, as they enter the ligament, one branch running apically and the other toward the gingiva.
Nerve fibers in the periodontal ligaments are either large fibers being myelinated or the small fibers being either myelinated or non-myelinated. The small fibers appear to end in fine branches throughout the ligament and the large in variety of endings such as knob like, spindle like and Meissener like.

In human the small fibers are responsible for **pain sensation, while** the larger diameter fibers terminated in specialized ending known as **mechanoreceptors,** responsible for localization of touch and pressure on the teeth





The sensing of pressure is important in PDL to detect any slight displacement of the teeth, especially during biting soft food containing small hard object. Thus the PDL is protecting the teeth from vigorous masticatory force.

Functions of PDL:

1. **Supportive:**
   The periodontal ligament serves primarily a **supportive** function by attaching the tooth to the surrounding alveolar bone proper. This function is mediated primarily by the principal fibers of the periodontal ligament that form a strong fibrous union between the root cementum and the bone.
   As the force of mastication is applied on the teeth, the wavy course of the collagen fibers gradually straighten out and then acting as inelastic strings or tie, transmitting tension to the wall of the socket. Also the periodontal fibers being non elastic prevent the tooth from being moved too far. The pressure of blood in the numerous vessels also provides a hydraulic mechanism for the support of the teeth.
2. **Sensory:** The PDL is having **mechanoreceptor** contributes to the sensation of touch and pressure on the teeth. The mechanoreceptor protects the teeth in cases of sudden overload. It causes inhibition of the activity of masticatory muscles. Opening the mouth at once relieve the pressure.

3. **Nutritive: The** blood vessels in the PDL provide nutrient supply required by the cells of the ligament and to the cementocytes and the most superficial osteocytes.
4. **Formative:** The synthetic cells, as the fibroblasts, present in the PDL are responsible for the formation of new periodontal ligament fibers. Another formative function is provided by the cementoblasts and osteoblasts which are essential for the building up of the cementum and bone respectively.
5. **Protective function:** The protective function of the PDL is achieved by:

i. **Principle fibers**: The fibers are having different groups of different direction making them well adapted to fulfill the function of the PDL. The Dentoalveolar ligaments **convert** the masticatory **pressure** exerted on the tooth **into tension** or traction on the cementum and bone. If the exerted force on a tooth is transmitted as pressure this will lead to differentiation of osteoclasts in the pressure area and resorption of bone.
ii. **The blood vessels**: The capillaries form a rich network; they are arranged in a form of coil and attached to the cementum and bone through the oxytalan fibers. This arrangement makes it possible when pressure is exerted on the tooth, the blood does not escape immediately from the capillaries and thus avoiding or buffering the pressure action before it reaches the bone. The behavior of the blood in the capillaries may be simulated to a hydraulic brake.
iii. **The third protective function** of PDL is attained by its mechanoreceptors nerves.

Age changes of periodontal ligament

The PDL shows:

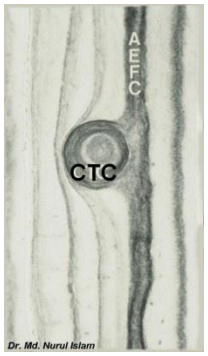
i. Decreases in vascularity and decreases in the number of its cells.
ii. Decreases I the rate of remodeling of collagen fibers with age.
iii. Decreases in the width.
iv. Appearance of calcified bodies called cementicles near the surface of cementum. The cementicles may be attached or free.

Cementicles

Cementicles are small-mineralized bodies, which may be found in the periodontal ligament.

They may be attached to the cementum or the alveolar bone, or occur free in the periodontal ligament. When present, cementicles are generally found about all or most of the teeth.

Cementicles may be formed by mineralization of degenerating epithelial rests or thrombosed vessels.



Clinical consideration

1. Vitamin C deficiency affects collagen synthesis. In scurvy PDL fibers almost completely disappear within few months.
2. Masticatory forces on teeth act as stimulating factor for physiological remodeling. Partial or total loss of function caused by extraction of the opposing teeth brings atrophy of the entire tooth supporting apparatus (bone and PDL).
3. Remodeling of fibers is important for orthodontic tooth movement and tooth drift (mesial migration and occlusal drift).
4. Chronic inflammatory diseases of the PDL lead to loss of PDL attachment and eventual tooth loss.