Periodontal ligament

Definition: PDL is a connective tissue structure that surrounds the root and connects it with the bone .

Structure: the periodontal ligament space has the shape of an hourglass and is narrowest at the mid root level. The width of PDL is approximately 0.25-0.5 mm .

Cellular composition: cells of PDL are categorized as

1-Synthetic cells	***2-Resorpative cells***
a. Osteoblast	a. Osteoclasts
b. Fibroblast	b. Cementoclasts
c. Cementoblasts	c. Fibroblasts
3-Progenitor cells	***4-Epithelial rest of malassez***

5-Connective tissue cells (mast cells and macrophages)

Synthetic cells:

1-Osteoblasts: covers the periodontal surface of the alveolar bone. They are responsible for the formation of alveolar bone.

2-Fibroblasts: the most prominent connective tissue cells (65%). The main function of the fibroblasts is the production of various types of fibers (collagen fibers, Reticulin fibers, Oxytalan fibers and Elastin fibers). Fibroblasts are also instrumental in the synthesis of connective tissue matrix.

3-Cementoblasts: are seen lining the cementum and are responsible for cementum deposition.

Resorpative cells

1-Osteoclasts: these are the cells that resorb the bone and tend to be large and multinucleated.

2-Fibroblasts: they synthesize collagen and also possess the capacity to resorb and degrade the old callogen fibers.

3-Cementoclasts: 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 by cementoclasts.

Progenitor cells: they differentiate into functional type of connective tissue cells.

Epithelial rest of Malassez: they are found close to cementum. When certain pathologic conditions are present, cells of epithelial rest can undergo rapid proliferation and can produce a variety of cysts and tumors of the jaws.

Connective tissue cells

Mast cells: they play a role in inflammatory reaction.

Macrophages: they are capable of phagocytosis.

Extracellular components:

1-Fibers	2-Ground substances
a. Collagen	a. Proteoglycans
b. Oxytalan	b. Glycoproteins

Periodontal fibers: the most important elements of the periodontal ligament are the principal fibers. They are collagenous in nature and are arranged in bundles following a wavy course.

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

The principal fibers of the PDL are arranged in five groups:

1-Alveolar crest fibers: they extend obliquely from the cementum just beneath the junctional epithelium to the alveolar crest.

Function: retain tooth in socket and resist lateral movement.

2-Horizontal group: extends from cementum to the alveolar bone at right angle to the long axis of the tooth.

3-Oblique group: they are the largest group extending coronally in an oblique direction from the cementum to the bone.

Function: they resist axial directed forces.

4-Apical group: they radiate from the cementum of root apex to the bone.

Function: it prevents tooth tipping, resists luxation, and protects blood, lymph and nerve supply of the tooth.

5-Inter-radicular fibers: Extends from cementum of bifurcation areas, splaying from apical into furcal bone.

Function: it resists luxation and also tipping and torqueing.

Ground substance :The ground substance is made up of two major groups of substances

1-Glycosaminoglycans: such as hyaluronic acid, proteoglycans.

2- Glycoproteins: such as fibronectin and laminin

It also has high water content (70%) .

Development of principal fibers of PDL

It will be as follows:

1-Small, fine brush like fibrils are detected arising from the root cementum and projecting into the PDL space.

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

3-The number and thickness of fibers originating from the bone increase and elongate. They radiate towards the loose connective tissue in the mid portion of the periodontal ligament.

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

5-Following tooth eruption, the principal fibers become organized in bundles and run continuously from bone to cementum.

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.

2-Lymphatics: lymphatic vessels follow the path of blood vessels in the periodontal ligament.

3-Nerve intervention: periodontal ligament is mainly supplied by dental branches of the alveolar nerve. The periodontal ligament has mechanoreceptors providing sense of touch, pressure, pain and proprioception during mastication.

4-Cementicles: calcified masses adherent to or detached from the root surface.

Functions of the PDL:

Physical function

1. Provide soft tissue “casing'' to protect the vessels and nerves from injury by mechanical forces.

2. Transmission of occlusal forces to the bone.

3. Attaches the teeth to the bone.

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

5. (shock absorption) Resists the impact of occlusal forces

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.

Nutritive functions

Since PDL has a rich vascular supply, it provides nutrition to the cementum, bone, and gingiva.

Sensory functions

The PDL is supplied with sensory nerve fibers which transmit sensation of touch, pressure and pain to higher centers.

Clinical consideration:

The width of PDL space varies with age, location of tooth, degree of stress to which the tooth was subjected. In compliance with the physiologic mesial migration of the teeth the PDL is thinner on the mesial root surface than on the distal surface.

A tooth in hyperfunction may have a wider PDL space and a tooth in hypofunction may have a narrow PDL 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 the PDL are its adaptability to rapidly changing applied force and its capacity to maintain its width at constant dimensions throughout its lifetime.

Cementum

It is a thin specialized calcified tissue covering the roots surfaces of the teeth and It has many features similar to the bone tissue but differs from bone in the following aspects.

It is microscopic organization ,Has no innervation ,Has no blood or lymph vessel and doesnot undergo physiological

remodeling(resorption and deposition),but it is characterized by continuous deposition throughout life.

Functions of cementum:

Anchorage of the tooth in the alveolus ,to attach the PDL fibers to the teeth and to contribute to the process of repair after damage to the root surface and following regenerative periodontal surgical procedures.

Cemento-enamel junction (C.E.J)

Three types of relationships involving the cementum may exist at the C.E.J:

Cementum overlaps the enamel (60%-65%).

Edge-to edge (butt joint 30%).

Cementum and enamel fail to meet (5%-10%).

In the last condition,there is a possibility of gingival recession which may result in sensitivity because the dentin is exposed.

There are two types of cementum:

1-Primary (acellular cementum):

Is the first to be formed in conjunction with root formation and tooth eruption , it does not contain cells and sharpey's fibers make up most of its structure . Generally it covers the cervical third of the root.

2-Secondary (cellular cementum):

Which is formed after tooth eruption and in response to functional demands, therefore it grows faster and over a thin layer of acellular cementum at the apical third of the root and furcations of multirooted teeth . This type of cementum contains cells (cementocytes), but sharpey's fibers occupy a smaller portion of this type of cementum. Cellular cementum is less calcified than the acellular type.

Both acellular cementum and cellular cementum are arranged in lamellae separated by incremental lines parallel to the long axis of the root.These lines represent "rest periods" in cementum formation and they are more mineralized than the adjacent cementum.

Structures of cementum:- cementum consist of

1-***Fibrous elements***:-there are two types

a.Extrinsic fibers (sharpey's fibers): which are the embedded portion of the principal fibers of the PDL and are formed by the fibroblast cells . Sharpey's fibers make up most of the structure of acellular cementum and they are inserted at right angles to the root surface and penetrate deep into the cementum.

b.Intrinsic fibers: These fibers are produced by cementoblast cells and are oriented more or less parallel to the long axis of the root and form a cross banding arrangement with sharpey's fibers.

2-***Cellular elements***: The cells associated with cementum are few and generally resides within the PDL.

a.cementoblast cells:responsible for the formation of both cellular and acellular cementum.

b.cementocyte cells:are found only in cellular cementum , they are located within spaces (lacunae) that communicate with each other through canaliculi for transportation of nutrients through the cementum and contribute to the maintenance of the vitality of this tissue.

c.fibroblast cells:these cells belong to the PDL where they are responsible for synthesis of principal fibers but since these fibers become embedded in cementum, fibroblasts indirectly participate in the formation of cementum.

d.cementoclast cells:these cells are responsible for extensive root resorption that lead to primary teeth exfoliation. Permenant teeth do not undergo physiologic resorption but localized cemental resorption may occur which appears as concavities in the root surface and may be caused by local or systemic

causes.local conditions include,trauma from occlusion, orthodontic movement, cyst and occur on mesial surfaces in association with mesial drift. Among systemic conditions are calcium deficiency and hypothyroidism.

Reversal line:The newly formed cementum is demarcated from the root by a deeply staining irregular line which delineates the border of the previous resorption.

Trauma from occlusion:Forces that exceed the adaptive capacity of the periodontium and produce injury.

3-***Interfibrillar matrix***:These are proteoglycans, glycoproteins and phosphoproteins formed by cementoblas cells.Proteoglycans are most likely to play a role in regulating cell-cell and cell-matrix interactions both during normal development and during the regeneration of cementum.

Mineralization of cementum:

occurs by the deposition of hydroxyapatite crystals,first within the collagen fibers,later upon the fiber surface and finally in the interfibrillar matrix.Cellular cementum is less calcified than acellular cementum and cementum mineralizalion is less than that of the bone, enamel and dentin.

Permeability of cementum:

In very young animals,acellular cementum and cellular cementum are very permeable and permit the diffusion of dyes from the pulp and external root surface.The canaliculi in cellular cementum is some areas are contagious with the dentinal tubule.The permeability of cementum diminishes with age.

Exposure of cementum to the oral environment:

Cementum becomes exposed to the oral environment in cases of gingival recession and as a result of the loss of attachment in pocket formation.The cementum is sufficiently permeable to be penetrated in these cases by organic substances,organic ions and bacteria.Bacterial invasion of the cementum occurs frequently in

individuals with periodontal disease,and cementum caries can develop.

Development of cementum:

Both cellular and acellular cementum are produced by cementoblast cells.Cementoid is first formed which is a non-calcified tissue containing collagen fibrils distributed in matrix.Cementum is characterized by continuous deposition and increase in thickness throughout life.A thin layer of cementum noted on recently erupted tooth will tend to increase thickness with age.Cementum formation is most rapid in the apical regions to compensates for tooth eruption and attrition. The thickness of cementum is more pronounced in the apical third and in the furcation areas than the cervical portion.Cementum is thicker in distal than in mesial surfaces because of functional stimulation from mesial drift over time.

Cemental defects

1-Hypercementosis:refers to a prominant thickening of the cementum.It is largely an age-related phenomenon and it may be localized to one tooth e.g.tooth without antagonists or with periapical lesion , and sometimes affect the entire dentition that may occur in patients with paget's disease.It could pose a problem if an affected tooth requires extraction.

2-Cemental aplasia or hypoplasia:refers to an absence or paucity of cellular cementum.

3-Ankylosis:Fusion of the cementum and alveolar bone with obliteration of the PDL.It results in resorption of the cementum and its gradual replacement by bone tissue and it may develop after chronic periapical inflammation and occlusal trauma.Clinically,ankylosed teeth lack the physiologic mobility of normal teeth as well as proprioception is lost because pressure receptors in the PDL.are deleted or do not function correctly.Furthermore,the physiologic drifting and eruption of teeth can no longer occur .When implants are placed in the jaw,healing results in bone that is formed in direct apposition to

the implant without intervening CT,this maybe interpreted as a form of ankyloses.

Alveolar process(AP)

Is the portion of the maxilla and mandible that forms and supports the tooth sockets (alveoli).

It develops in conjunction with the formation of and during the eruption of the teeth and is gradually resorbed if the teeth are lost , thus it is tooth dependent structure.

Functions of alveolar process:

1-comprises the attachment apparatus and the supporting tissue of the teeth together with root cementum and PDL fibers.

2-provide the osseous attachment to the PDL fibers.

3-distribute and resorb forces generated by mastication and other tooth contacts.

Alveolus:is the space in the alveolar bone that accommodates the roots of the teeth.

Parts of the alveolar process:

1-Alveolar bone proper: it is a thin layer of compact bone forming the inner socket wall (lines the alveolus), which is seen as the lamina dura in radiographs. A great number of sharpey's fiber bundles are embedded into this layer of bone which is adjacent to the PDL therefore it is called((bundle bone)).

Histologically this bone contains many small holes or openings called ((volkmann's canals)) through which blood vessels , lymphatics and nerves link the PDL with the cancellous bone thus it is called ((cribriform plate)).

2-An external plate of cortical bone

3-Cancellous trabeculae or spongy bone: which is located in the space between the external cortical plate and alveolar bone proper, they meet and fuse to form the alveolar crest.cancellous bone, which act as supporting alveolar bone, with cortical bone surround the alveolar bone proper (ABP).

Basal bone:- is the portion of the jaw located apically but unrelated to the teeth.

Lamina dura:-the layer of ABP appears as white line surrounding the root of the tooth on radiographs.

The alveolar processes are subdivided according to their anatomical relationships to the teeth

1-Interproximal bone (interdental septum):- The bone located between the roots of adjacent teeth.

2-inter radicular bone:- the bone located between the roots of multirooted teeth.

3-radicular bone:- the alveolar process located on the facial, lingual or palatal surfaces of the roots of teeth.

The distance between the crest of the alveolar bone and the cementoenamel junction increases with age to an (average of 2.81mm).The thickness of alveolar process varies from one region to another depends on the position of the teeth in the arch and their relationship to one another, e.g. teeth that are labially positioned in the arch will have thin labial radicular bone and thicker lingual radicular bone.

Bone marrow:- The cavities of all bones of new-born are occupied by red marrow while in the adult jaw occupied by fatty or yellow type of marrow , however foci of red bone marrow are seen in the jaw which may be visible radiographically as zones of radiolucency.

Common locations are the maxillary and mandibular molar and premolar areas.

Periosteum and Endosteum:

Periosteum:-it is a layer of tissue covering the outer surface of bone,it contains collagen fibers and cells (osteoblasts) with blood vessels, nerves and fibroblasts

Endosteum:- the marrow spaces inside the bone are lined by endosteum, this tissue contains cells (osteoblasts)

Anatomical defects of bone

1-**Fenestration**(window):-This bony defect include isolated areas in which the root is not covered with bone but covered only by periosteum and overlying gingiva and it does not extend to the marginal bone.

2-**Dehiscence**:-This bony defect include the denuded areas which extend to the bone margin,exposing the root surface.The defects may extend to the middle of the root or farther.

Such defects occur on approximately 20% of the teeth,they occur more often on the facial bone than on the lingual bone are more common on anterior than on posterior teeth.

The cause of these defects is not clear, but may be related to some factors such as, prominent root, malposition or labial protrusion of the root with thin bony plate.

Haversian system or Osteon:

It is an internal mechanism that bring a vascular supply to bones, consists of central canal called (Haversian canal)which in their center contains the blood vessel. These blood vessels surrounded by bone lamellae which arranged in concentric layers constitute the center of an osteon.The blood vessels in haversian canal are connected with each other by anastomoses running in the Volkmann's canals,so the nutrition of bone is secured by the incorporation of blood vessels in the bone tissue.

Bone cells

1-Osteoblast cells(bone forming cells):is responsible for the production of an organic matrix of bone which is consisting primarily of collagen fibers called (osteoid), this bone matrix undergoes mineralization by the deposition of minerals such as calcium and phosphate,which are subsequently transformed to hydroxyl apatite.

2-Osteoclast cells:-These are large multinucleated cells found in concavities on the bone surface called (howship's lacunae) these cells responsible for bone resorption.

3-Osteocyte cells:- osteoblast cells that become trapped in the bone matrix and later on in the mineralized bone tissue , we call them osteocyte cells, they are located in the lacunae and are connected with the one another by extending processes into canaliculi through which they get nutrients and removes metabolic waste products.

Resorption of bone

The sequence of events in the resorptive process as follows:

1-attachment of osteoclasts to the mineralized surface of bone

2-creation of a sealed acidic environment,which demineralizes bone and exposes the organic matrix

3-degradation of the exposed organic matrix to its constituent amino acids via the action of released enzymes(e.g.,acid phosphates, cathepsin).

4-Sequestering of mineral ions and amino acids within the osteoclast

Composition of the bone:

Bone consists of 2/3 inorganic matter and 1/3 organic matrix

The inorganic matter is composed principally of the minerals calcium and phosphate,along with hydroxyl,carbonate,citrate,and lactate trace amounts of other ions such as sodium,magnesium and fluorine. The mineral salts are in the form of hydroxy apatite crystals.

The organic matrix consists mainly of collagen type I fibers (90%),with small amounts of non collagenous proteins such as osteocalcin and osteonectin.

Bone contains 99% of the body's calcium ions and therefore is the major source for calcium release when the calcium blood levels decrease,this is monitored by the parathyroid gland.

Remodeling of alveolar bone:

Alveolar bone undergoes constant physiologic remodeling (resorption and formation)in response to external forces specially occlusal forces.

Teeth erupts and tend to move mesially throughout life to compensate for wearing in the proximal contact areas with age which become flat , this referred to as physiologic mesial migration , thus osteoclast cells and bone resorption occur in areas of pressure on the mesial surface and osteoblast cells with new bone formed in areas of tension on the distal surface.This process of resorption and formation of bone is called bone remodeling and it is important in the orthodontic treatment.

Remodeling of alveolar bone is regulated by local influences include functional requirements on the tooth and age related changes in bone cells while,systemic influences are probably hormonal(e.g.,parathyroid hormone,or vitamin D3).