Periodontal Ligament

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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.

At the root apex, the PDL merges with the dental pulp.
Together with cementum, alveolar bone and lamina propria of the gingiva, the PDL forms the tissue which supports the teeth in jaw.

These supporting tissues are often referred to collectively as the *periodontium.*
The average width of PDL -- 0.2 mm
(range 0.15 to 0.38 mm)

<table>
<thead>
<tr>
<th>Width of PDL</th>
<th>Heavy loaded teeth</th>
<th>Normally loaded teeth</th>
<th>Functionless teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near crest of alveolus</td>
<td>0.35mm</td>
<td>0.14mm</td>
<td>0.10mm</td>
</tr>
<tr>
<td>Middle of alveolus</td>
<td>0.28mm</td>
<td>0.10mm</td>
<td>0.06mm</td>
</tr>
<tr>
<td>Near fundus of alveolus</td>
<td>0.30mm</td>
<td>0.12mm</td>
<td>0.06mm</td>
</tr>
</tbody>
</table>
• The ligament appears as the *periodontal space* on radiographs

• 0.4-1.5mm

• Radiolucent area between the lamina dura of alveolar bone proper and radiopaque cementum

• Narrower in permanent teeth than deciduous teeth
Synonyms of PDL:

- Desmodont
- Gomphosis (Type of fibrous joint)
- Pericementum
- Alveolar periosteum
- Dental periosteum
- Cemental ligament
- Alveolodental ligament
- Periodontal membrane

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• Space where PDL is present - PDL space
  – Normal width- 0.2mm (decreases with age)
  – Reduced in non functional conditions

• Width varies
  – More in apical and cervical 3rd
  – Narrow in the middle 3rd
  – Hour Glass appearance
Development

- HERS sends inductive signal to ectomesenchymal pulp cells to secrete predentin by differentiating into odontoblasts.

- HERS becomes interrupted and forms strands called as *Epithelial rests of Malassez*.

- This separation permits the cells of the dental follicle / dental sac to migrate to the external surface of the newly formed root dentin and differentiate into:

  - **Cementoblasts** - Cementum
  - **Fibroblasts** - Fibers of PDL & ground substance
  - **Osteoblasts** - Alveolar Bone

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Structural elements

• Cells
  – Formative, Resorptive, Progenitor, Epithelial, defense

• Fibers
  – Collagen, Elastic and Reticulin fibres

• Ground substance
  – Glycoprotein's, Proteoglycans

• Blood vessels, Nerves, Lymphatics
## Principle Cells In PDL

### Synthetic Cells
- Osteoblasts
- Fibroblasts
- Cementoblasts

### Resorptive Cells
- Osteoclasts
- Fibroblasts
- Cementoclasts

### Epithelial cells in ligament
- Epithelial rests of Malassez

### Other connective tissue cells
- Mast cells
- Macrophages
- Eosinophilis

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<table>
<thead>
<tr>
<th>Synthesizing Cell/ Active Cell</th>
<th>Resting / Inactive Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Euchromatin present with open or uncoil chromatin</td>
<td>➢ Hetrochromatin or coiled chromatin which is condensed</td>
</tr>
<tr>
<td>➢ Nuclear outline is indistinct</td>
<td>➢ Nuclear outline is distinct</td>
</tr>
<tr>
<td>➢ More no. of organelles is present</td>
<td>➢ No. of organelles is less</td>
</tr>
<tr>
<td>➢ Increased in cytoplasmic content</td>
<td>➢ Cytoplasmic content is less</td>
</tr>
<tr>
<td>➢ Nuclear and overall size of cell is increased</td>
<td>➢ Nuclear and cell size comparatively less</td>
</tr>
<tr>
<td>➢ Metabolically active</td>
<td>➢ Metabolically inactive</td>
</tr>
</tbody>
</table>

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**Synthetic Cells - Osteoblasts**

- The osteoblasts covering the periodontal surface of the alveolar bone constitute the a **modified endosteum and not a periosteum**.

- The surface of the bone is covered largely by osteoblasts in various stages of differentiation by progenitor cells as well as occasional osteoclasts.

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Synthetic Cells - Fibroblasts

- In longitudinal sections fibroblasts appear to be *oriented parallel* to the oriented bundles of *collagen fibers.*
- Predominately seen
  - Spindle, fusiform, with long and ovoid nucleus and eosinophilic cytoplasm

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– Dual function
  • **Synthetic** (RER, GC, Mitochondria)
  • **Resorptive** (Vacuoles- proteolytic enzymes: acid phosphatase, collagenase)
  • Secretes MMP

– Protein synthesis– collagen –type I, elastin, as well as proteoglycans, glycoproteins, GAGs

– Interconnected- desmosomes, gap junctions- Adaptive responses to mechanical loading

– Actin and myosin filaments-c/as Myofibroblast-Help in eruption of teeth

– Ciliated- control of cell cycle

– Produce growth factors- IGF-I, BMPs, PDGF, TGF-beta and IL-I

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• Rapid turn over
• Remodelling of pdl fibers and ground substance
Synthetic Cells - Cementoblasts

- The distribution on the tooth surface of variously differentiated cementoblasts and their progenitors is similar to the distribution of osteoblasts on the bone surface.
Resorptive Cells - Osteoclasts

- Osteoclasts are cells that resorb bone and tend to be large and multinucleated but can also be small and mononuclear.

- Multinucleated osteoclasts are formed by fusion of precursor cells similar to circulating monocytes.

- In the light microscope cells appear to occupy bay in the bone (Howship’s Lacunae)

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Resorptive Cells - Osteoclasts

• In electron microscope, the part of plasma membrane lying adjacent to bone that is being resorbed is raised in characteristic folds called as Ruffled or Striated Border.

• The bone related to the ruffled border can be seen undergoing resorption.

• Osteoclasts are rich in acid phosphates, which is contained in lysosomes.

• Cells contain proteolytic enzymes.

Resorption occurs in two stages:

  - Demineralization of minerals
  - Disintegration of organic matrix

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Resorptive Cells - Fibroblasts

- Collagen fibrils in PDL can be resorbed under physiologic condition by mononuclear fibroblasts

- It produces collagen fiber and extracellular matrix during the life as well as having ingesting and degrading this same matrix
Resorptive Cells - Cementoclasts

• Cementoclasts resembles osteoclasts

• Resorption of cementum occurs under certain circumstances, and carried out by mononucleated cementoclasts or multinucleated giant cells, often located in Howship’s lacunae found on the surface of the cementum.

• The origin of cementoclasts is unknown but it is conceivable that they arise in the same manner as osteoclasts.
Progenitor cells

- PDL contain progenitor for synthetic cells that have the capacity to undergo mitotic division.

- After cell division, one of the daughter cells differentiated into a functional type of connective tissue cell, while the other remains an undifferentiated progenitor cell retaining the capacity to divide when stimulated appropriately.
• Small closed face nucleus, little cytoplasm
• Highest concentration - blood vessels
Epithelial Rests of Malassez

- The PDL contains epithelial cells that are found close to the cementum called as epithelial rests of malassez.

- They are the remnants of epithelium of Hertwig’s epithelial root sheath.

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DEFENCE CELLS

Histocytes or Macrophages

- Irregularly shaped cell with short blunt process
- Light microscopic features – Nucleus smaller, rounded darker staining than fibroblast, granular cytoplasm
- It contains aggregates of vesicles, dense irregular bodies
- Horse shoe shaped/ kidney shaped nucleus
• MACROPHAGES- Near blood vessel
• Phagocytosis
• Derived from monocytes
• Dual role- phagocytosis of dead cells
• Secrete growth factors- regulate proliferation of fibroblasts
Mast Cell

- Small, round or oval cell having 12 to 15 μm and contain numerous cytoplasmic granules metachromatically stains

- It contain enzymes – heparin & histamine

- The physiologic role of heparin – inflammatory reaction
Eosinophils

- Occasionally seen in normal PDL
- Characteristic granules (peroxisomes)
- Capable of phagocytosis
EXTRACELLULAR SUBSTANCE

• Extra cellular substance comprises the following:

1. Fibers
   a) Collagen     b) Oxytalan etc

2. Ground Substance
   a) Proteoglycans b) Glycoproteins etc

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PDL fibers

- Collagen fibers: I, III, IV, V, VI, VII and XII. Groups of fibers that are continually remodeled. (Principal fiber bundles of the PDL). The average diameter of individual fibers are smaller than other areas of the body, due to the shorter half-life of PDL fibers (so they have less time for fibrillar assembly).

- Elastic fibers
- Oxytalan fibers: variant of elastic fibers (immature), parallel to teeth, adjacent to capillaries. Regulate vascular flow in relation to tooth function.
- May have role in tooth support.
- Eluanin: variant of elastic fibers

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-Reticular fibers
  -Fine immature collagen
  -Related to BM of blood vessels and epithelial cells
  -Argyrophilic

-Secondary
  -Located b/n & among principle fibers
  -Nondirectional, randomly oriented
  -Newly formed collagenous elements that have not been incorporated in principle fiber bundles

-Indifferent fiber plexus
  -Small collagen fibers
  -Run in all directions
  -Artifact
The main types of collagen in the periodontal ligament are types I and III, and these are categorised as fibrous collagens. (>90%)

>70 % is type I collagen. This is the major protein component of most connective tissues including bone and skin.

Ligament is relatively rich in type III Collagen-- about 20% of total.
Principle fibers of PDL

5 groups of fibers run from tooth to alveolar bone (alveodental ligament)-

• **The Alveolar crestal Group**-
  – Attached just apical to CEJ & runs downward & inwards to insert into the rim of the alveolus.
  – Resist tilting, intrusive, extrusive and rotational forces (lateral tooth movements).
  – The incision of these fibers during periodontal surgery does not increase tooth mobility unless significant attachment loss has occurred.
• **The Horizontal Group**
  – Just apical to the alveolar crest gp & running at right angles to the long axis of the tooth from cementum to bone just below alv. crest.
  – Coronal 1/4\(^{th}\) of pdl space
  – Resist horizontal and tipping forces

• **The Oblique Group**
  – Most numerous & run from cementum in oblique direction to insert in bone coronally.
  – They bear the brunt of vertical masticatory stresses and transfer them into tension on the alveolar bone.
  – Resist vertical and intrusive forces

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• **The Apical Group**-
  – Radiates from cementum around the apex of the root to the bone forming base of the socket.
  – Resist forces of luxation, may prevent tooth tipping and probably protect delicate blood and lymph vessel & nerves near the root apex
  – *They do not occur on incompletely formed roots.*

• **The Interradicular Group**-
  – It is found only between roots of multirotted teeth & running from the cementum into the bone, forming the crest of interradicular septum.
  – Resist tooth tipping, torquing & luxation
  – Lost in recession, furcation involvement
• The principal fibres of the periodontal ligament that are embedded into cementum and the bone lining the tooth socket are termed 'Sharpey's fibers'.

• The principal fibres are more numerous but smaller at the attachments into cementum than at the alveolar bone.
• Few Sharpey’s fibers pass uninterruptedly through the bone of the alveolar process to continue as principle fibers of adjacent pdl-termed as **transalveolar fibers**

• May serve as a mechanism to connect adjacent teeth
Intermediate plexus

• Controversy exists concerning the extent of individual fibers across the width of the periodontal ligament.

• One view holds that there are distinct tooth-related and bone-related fibers, and that these intercalate near the middle of the ligament at an intermediate plexus.
• Earlier considered to be an area of high metabolic activity, in which splicing and unsplicing of fibers might occur (highest activity near the terminals)

• Seen only in longitudinal sections of continuously growing incisors
• 2 theories for plexus formation

– Occurs because fibers are actively remodelling to accommodate small tooth movements (zone of shear)

– Sectioning artifact

– Recent view- these fibers do not meet but travel the entire thickness of PDL and give branches in between which gives appearance of plexus
Crimping

- Specific type of waviness
- Seen under polarizing microscope
- The crimp is gradually pulled out when the ligament is subjected to mechanical tension, until it disappears

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GROUND SUBSTANCE OF PDL

- Collagen fiber bundles - 60% by volume.
- Ground substance - 70% water
- Tissue fluid pressure is high in the pdl, about 10 mm Hg above atmospheric pressure.
- The tissue fluid has been implicated in the tooth support & eruptive mechanisms
Functions

• Exchange of metabolites

• Ion and water binding and exchange

• Control of collagen fibrillogenesis

• Fiber orientation

• Binding of growth factors

• Tooth support and eruptive mechanisms
• The ground substance of the pdl consists mainly of

— GLYCOSAMINOGLYCANS
  • Hyaluronan
  • Dermatan
  • Chondroitin sulfate
  • Heparin sulfate

— PROTEOGLYCANS AND GLYCOPROTEINS.
  • Fibronectin- Sticky protein; promotes attachment of cells to collagen fibrils, involved in cell migration and orientation
  • Tenascin
  • Vitronectin, osteonectin etc
STRUCTURES PRESENT IN THE CONNECTIVE TISSUE (interstitial tissue)

- BLOOD VESSELS
- LYMPHATICS
- NERVES
- CEMENTICLES
- LESS REGULARLY ARRANGED COLLAGEN FIBERS
Blood supply of PDL

- **RICH VASCULATURE** - High metabolic requirements

- **Sup and Inf. Alveolar artery**
  - Br from Apical vessels that supply dental pulp
  - Br from Intraalveolar vessels
    - Perforate the alveolar bone and enter the PDL
    - More in mandibular posterior teeth
  - Br from Gingival vessels - enter from coronal direction

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• Specialized features
  – cervical plexus of capillary loops
  – fenestrations – increases diffusion & filtration

  ▪ Blood - Functional variation at different sites
  ▪ Venous drainage- accompany arterial counterparts
Lymphatic drainage

• Lymphatic vessels follow the path of blood vessels
• Mandibular anteriors- submental LN
• Mand premolar, molar- submandibular LN
• Mand 3rd molar- jugulodigastric LN
• Maxillary- deep cervical & submandibular cervical LN
Nerve supply

• Functionally, 2 types of nerve fibers
  – Sensory:
    • pain & pressure (nociception & mechanoception) and proprioception
    • Myelinated nerve fiber- 5-15 um
  – Autonomic:
    • related to blood supply
    • Non- myelinated nerve fiber-0.5 um
• The nerve supply originates from the inferior or the superior alveolar nerves.

• The fibers enter from the apical region and lateral socket walls.
• Types of Nerve endings are seen
  
  – Free nerve endings (most frequent)
    • Pain & pressure
  
  – Spindle shaped (lowest frequency) with many vesicles
  
  – Ruffini nerve endings- located in the apical area
    • Mechano receptors for pressure sensation
    • Knob like ending.
  
  – Meissener’s corpuscles are also mechanoreceptors located primarily in mid-root region.
Cementicles

• Cementum like areas in PDL
• Presents as globular, round or spherical basophilic masses of structures seen in PDL
• Concentric acellular mass
• When attached to cementum c/as Excementosis or free in PDL
• Seen in apical & middle portion of root
• Calcified deposits surrounding the degenerating epithelial cell or thrombosed vessel

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Functions of pdl

• Provision of soft tissue ‘casing” in order to protect the vessels and nerves from injury due to mechanical forces.
• Attachment and support-Attaches the teeth to the bone, resisting displacing forces and for protecting dental tissues from damage caused by excessive occlusal loads
• Responsible for the mechanism whereby a tooth attains, then maintains its functional position. This includes mechanism of tooth eruption, tooth support and drift
• Nutrition
• Synthesis (Its cells form, maintain and repair alveolar bone and cementum-Formation and resorption of cementum and bone)
• Resorption
• Sensory- (Proprioception)-Its mechanoreceptors are involved in the neurological control of mastication
• Homeostatic
Why unmineralized??

• Various molecules – play a role in maintaining the unmineralised pdl
  – Pdl cells can inhibit mineralised bone nodule formation by bone stroma cells
  – Msx2 – prevents osteogenic differentiation of pdl fibroblasts, by repressing Runx2 transcriptional activity
  – Balance b/n bone sialoprotein & osteopontin
  – Matrix Gla protein - inhibitor of mineralization - preserves pdl width
  – RGD-Cementum attachment protein - GAG
Age changes

• Decrease in cells
• Increase in fibrous tissue
• Decrease in vascularity, mitotic activity
• Narrowing of width of PDL
• Scalloping seen on calcified tissues (bone, cementum)- pdl attached to the peaks of these scallops

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Clinical considerations

• Tooth out of function- poor adaptability for load- heavy restoration
• Orthodontic tooth movement- the compression of PDL is compensated by bone resorption, whereas on tension side, apposition takes place.
• Acute trauma- pdl width increased
• Infection via pulp reach PDL- dental granuloma( replace fibers with granulation tissue) which then progresses into apical cyst.
• Infection via gingiva- gingivitis progressing to periodontitis
• Epithelial cell rests- cysts & tumors
• Tooth was avulsed- clean the root surface –ankylosis/ preserve all soft tissue
• Guided tissue regeneration
Thank You

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