



Pulp

- It is a specialized structure with unique anatomy, position (inside the tooth) , & functions- considered to be CT.
- Pulp communicates with periodontium via the **apical foramen and lateral canals**.
- **Pulp is dynamic** : very active during tooth development & eruption.
- active during lifetime of the tooth, constantly changes throughout life. (due to the reaction of the cells to different stimuli)
- **Pulp's reaction to cold / hot stimuli is PAIN ALWAYS . (teeth's reaction to hot and cold)**

Q: what is the challenges in pulp treatment ?

A: it's location (since it's inside the tooth)

Proliferation of the pulp fills the cavitation in some cases forming a polep . (mostly in deciduous teeth)

RECALL : pulp provides vitality + color to the tooth .

- Traumatized teeth loose their color gradually → become darker (due to pulp injury) usually one tooth is affected only this is how you differentiate between it and Dentinogenesis imperfecta where all of the teeth are affected .

Q:Why do you need to treat pulp defects or injuries ? because the pulp communicates with the periodontium s the injury can spread easily to the adjacent structures (via apical foramen and lateral canals) .

Odontoblasts are shared between the pulp and the dentin but the body of the pulp is located in the pulp while the processes spread through the dentin.

Functions:

1. Production of dentin (by the odontblast cells)
2. Sensation: detection of stimuli (Pain sensation)
3. Defense: response to foreign antigens
4. Induction (since the dental papilla cells induce the IEE – reciprocal induction)
5. Nutrition
6. Role in forensic dentistry. (they can detect the age from the pulp ,also they can detect the patient's' DNA)

Dentin takes nutrition from the pulp , while the cementum takes nutrition form the PDL

Q : why can't you drill deep in primary teeth ?

A:The primary teeth have larger pulp chambers and higher pulp horns , so higher percentage of pulp exposure



Development of the pulp :

1. At bell stage: cells undergo differentiation into odontoblasts & fibroblasts. Once odontoblasts have begun to lay down dentin, the dental papilla named the developing pulp.
2. As the pulp develops: central cells produce fine collagen fibers & ground substance (high GAGS-**chondroitin sulphates**).
3. Vascularization :starts during early bell stage by small branches from the jaw vessels.
4. Innervation: starts during late bell stage. A large number of nerves enter the pulp, their final pattern is completed with complete root formation.
5. Once the full length of the root is established, the development of the pulp considered completed.

Blood supply to the pulp is achieved before innervation .

Anatomy of the pulp :

- **Coronal pulp & pulp chamber** (has 6 sides)- occupies and resembles the crown of the tooth, contains the pulp horns. Pulp horns diminish with age.
- **Radicular pulp & root canal** - extends from the cervix down to the apex, with age it decreases in volume.
- **Apical foramen**- it is where pulp & PDL meet, main N. & B.V enter & leave the tooth.
- **Accessory canals or lateral canals**- connect between radicular pulp & PDL along the lateral surface of the root, numerous at the apical aspect of the root.

Pulp Histology

Zones:

- 1- **Odontoblastic layer** : composed of odontoblast cells +All other elements are supportive or protective to this layer+ some nerve endings
- 2- **Cell free zone or zone of Weil**:rich in capillaries , nerve axons, & very few cells.

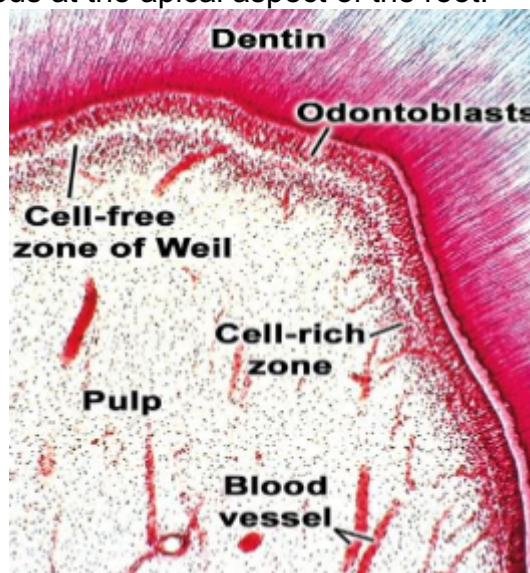
The Raschkow plexus is located here.

By H&E; this region appeared as a space because they lack cells nuclei.

During active dentinogenesis (early development) , this place is not very prominent . because odontoblasts secrete dentin and go back .

you can only see this layer when all the layers are formed (after complete devp)

- 3- **Cell rich zone**: numerous fibroblasts , stem cells ,sub odontoblastic capillary plexus,& nerve axons.
- 4- **Pulp core**: central zone contains large nerves and blood vessels, in addition to many cells & fibers. (all elements of CT)

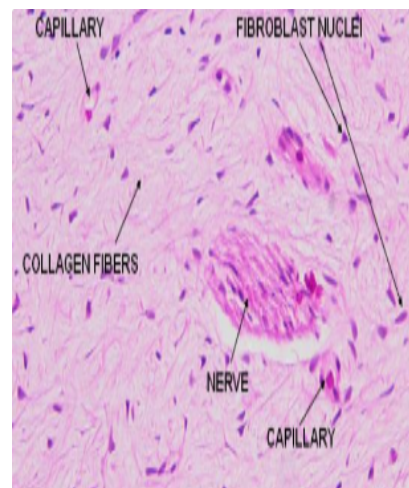




Pulp cells :

1. Fibroblasts:

- are the most numerous cells.
- Produce collagen fibers & ground substance & participate in their degradation.
- They are a major component of the cell rich zone & pulp core.
- spindle to stellate in shape, rich with organelles for protein synthesis.
- Form a loose network, linked by adherens & gap junctions.
- Fibroblasts and undifferentiated mesenchymal cells decrease with age



NOTE :

- During the removal of pulp chamber , you don't remove the floor , you should remove until you see the orifices of the root canals , not until you reach the bi or trifurcation areas.
- Q: why should u preserve as much as possible from the tooth structures during endo tx ? because after RCT the tooth becomes non vital since it loses the pulp , and fractures very easily.
- Empty – pulp chamber an root canals Filled with pulp – radicular pulp and coronal pulp The main communication of the root is the apical foramen which becomes eccentric with time .
- Communication b/w radicular pulp and PDL – they are one of the reasons for the failure of endo TX (at the area of the bi/tri furcation and spread the disease towards the PDL)
- When we start having dentin , the dental papilla cells are called forming pulp
- You can only study pulp in decalcified sections .
- The number of the cells in the pulp are not stable , they undergo apoptosis .
- The most numerous cell is fibroblast



2. Odontoblasts : MOST PROMINENT CELL

- In the mature tooth, odontoblasts form a single layer of cells.
- Coronal odontoblasts are columnar, in the root are more cuboidal.
- With aging appeared as a flatter layer of cells & number of cells declines by apoptosis.

Functions:

- 1- Dentin formation & mineralization.
- 2- Selective barrier : by reducing the speed of toxins to the pulp & allowing tissue fluid to reach D.T.
- 3- Produce pro-inflammatory mediators : cytokines, participate in the recruitment of neutrophils.

Cell junctions between odontoblasts: VIP

The junctions are just between the bodies of the cells not between the processes !

1- Macula adherens junctions (desmosomes) :

responsible for mechanical union.

Junctions that completely encircle the cells -zonula type - are not present.

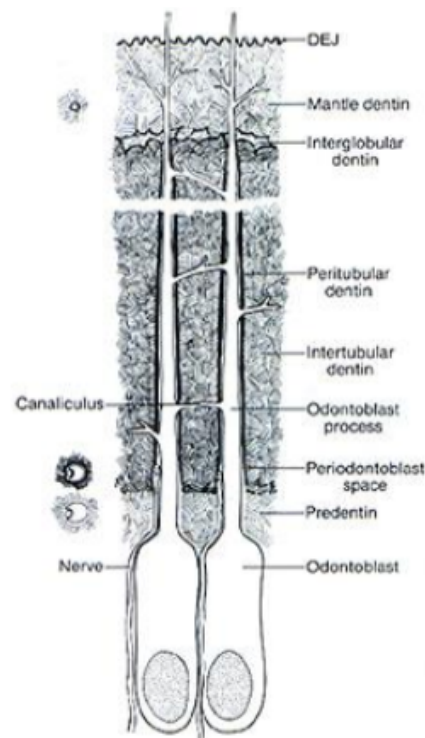
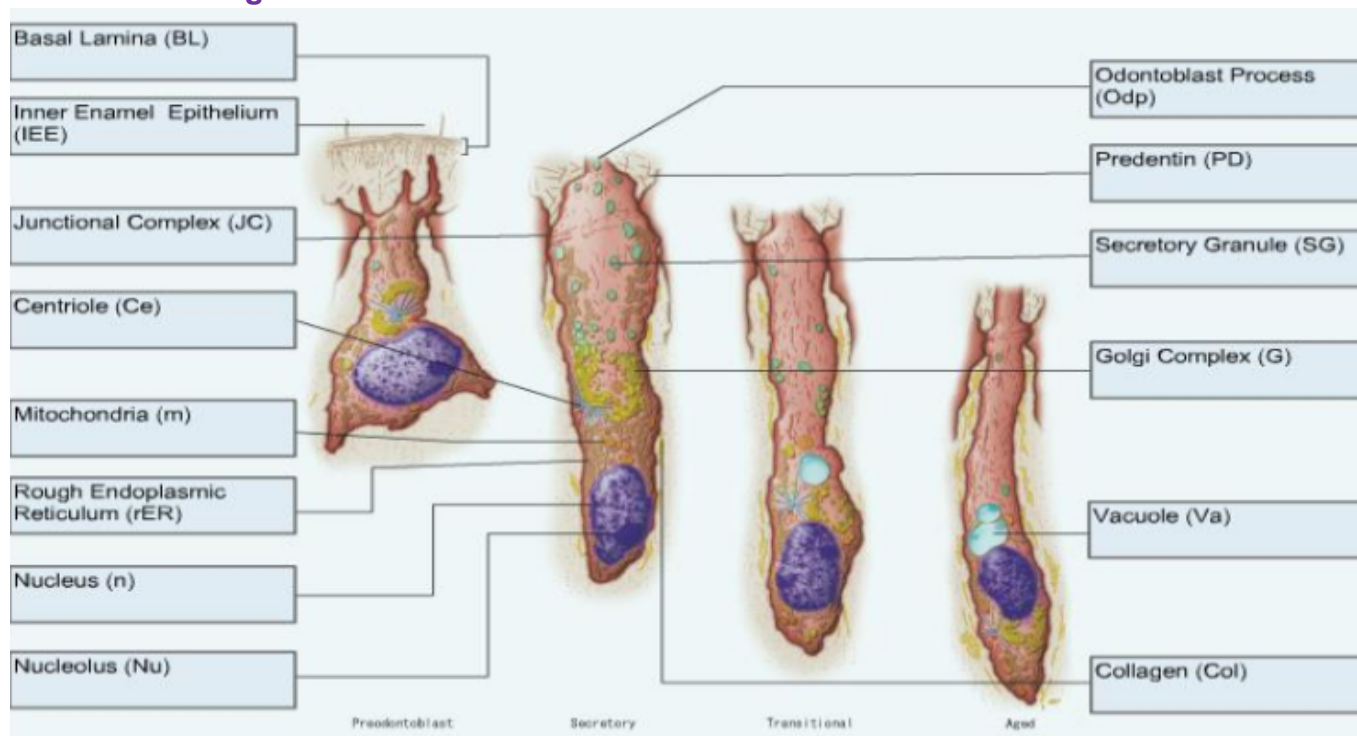
2- Tight junctions :as a near fusion of adjacent

cells membranes, limit the permeability, & help in the mechanical integrity of this layer.

3- Gap junctions: allow movements of small molecules between adjacent cells.

Important in cell to cell communication

Functional stages of odontblast cells:





An active cell : appears elongated, basal nucleus polarized, basophilic cytoplasm, a prominent Golgi, a long process that extends into DT the cell body is 50 μm long & 5-10 μm width.

A resting cell : short, with little cytoplasm, & hematoxyphilic nucleus.

3. Undifferentiated ectomesenchymal cells – stem cells :

- Abundant in the cell-rich zone
- Close to blood vessels.
- Appeared as large, polyhedral cells.

Functions: upon stimulation they divide & differentiate into:

- Fibroblasts
- Odontoblasts

Their number \downarrow with age \rightarrow reparative capability of pulp \downarrow with age

4. Defense cells :

Macrophages:

- Ovoid cells rich with lysosomes-containing enzymes for digestion.
- Engulf, degrade & remove dead cells as normal tissue turnover.
- Engulf, degrade & remove bacteria during infection

Dendritic – antigen presenting cells : they have 3 or more processes, mostly around nerves and Bvs . They act as antigen presenting cells stimulating the division & activity of T lymphocytes.

T-Lymphocytes :

- small numbers in healthy pulp.
- numbers \uparrow in the presence of injury & or inflammation.

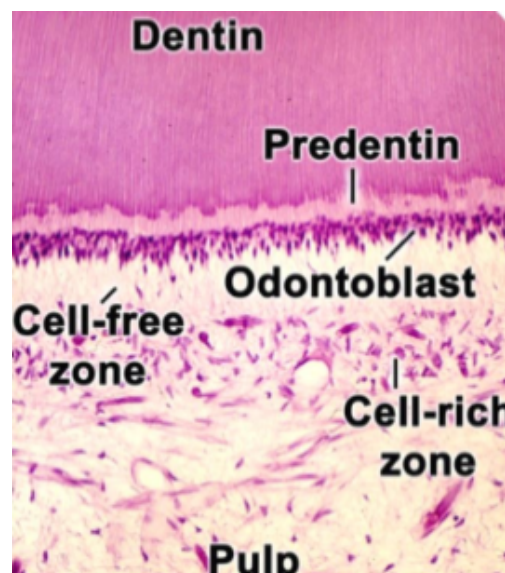
Pulp Fibers : (secreted by fibroblasts)

Collagens form 3-5% of the pulp.

- Collagen fibrils mainly Type I & III in a ratio of 60%-40%.
- Small amounts of Type V & VI present as meshwork of **microfibrils**.
- Type IV is found in basement membrane of B.V.

No proved for the presence of free elastic fibers in the pulp. (specially in the walls of the arterioles)

Fibroblasts cells are responsible for all types of collagen formation.





Ground Substance: (secreted by fibroblasts)

- Appear as amorphous & semi-fluid gel.
- FUNCTION : It acts as medium for transport of nutrients from B.V. to the cells as well as for transports of metabolites from cells to B.V.
- Compose of:
 1. **Water**
 2. **Proteoglycans & Glycosaminoglycans GAGs**: In mature pulp 60% **hyaluronic acid**, while in developing pulp mainly **chondroitin sulphate**
 3. **Glycoprotein**: as **Fibronectin, Cadherins, & Integrin** : act mainly in cell to cell adhesion, as well as help in cells to fibers adhesion.

Vascular supply :

- Arterioles & venules enter the pulp via **apical foramen & lateral canals**.
- A network of vessels is seen beneath odontoblasts as **subodontoblastic capillary plexus**.
- **Also capillaries are present within odontoblast layer, but they do not enter D.T.**
- Pulp blood flow under nervous control-sympathetic nerves.
- Pulp has a high tissue fluid pressure, this allow dentinal fluid to move outwards & inwards.
- **Lymphatics**:It is difficult to differentiate, they show immunohistochemically properties.

Pulp Nerves :

- Pulp is heavily innervated. Nerve bundles run from the root toward the coronal pulp, & most of their ends locate close to odontoblast or underneath them.
- The only type of nerve ending is the free nerve ending ,which is a specific receptor for pain regardless of the source of stimulation (heat, cold, pressure).
- Note: Proprioceptors nerve fibers are **NOT** found in the pulp.
- **Types of nerve fibers:**

A-delta fibers

- forms plexus beneath cell rich zone , they lose myelin sheath and proceed to cell free zone forming Raschkow plexus. Free nerve endings pass into the odontoblastic layer, predentin, & end in D.T.
- A-delta fiber pain is a quick, sharp, momentary pain that subsides quickly on removal of the stimulus.

They respond mainly to cold & pressure stimuli.

C -fibers

- either sensory or autonomic control B.V.
- They are associated with burning , aching, throbbing types of pain.
- They are true pain conducting fibers that respond to stimuli.
- **stimulated by hot liquids or foods.**
- When C fibers pain dominate ,it signifies irreversible local tissue damage.



Pulp stones or (Denticles):

Pulp stones are small calcified bodies (appear as radiopaque regions) - classified according to:

1. Location:

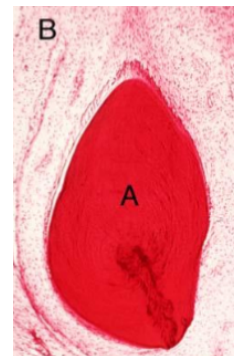
- Free
- Attached
- Embedded.

Free is found loose within the pulp but may eventually grow large enough to invade on adjacent D. and become attached. Once it is attached, it will become gradually inside D. and turned to embedded type.

2. Structure:

a) True :

- contain dentinal tubules surrounded by odontoblasts
- Found mainly in coronal area.
- Theory: that pieces of HERS get inside the pulp during devp



b) False :

- contain concentric layers of mineralization
- more in the root canal. 2 types:

1. Calcify Degenerations:

calcification of pulp components may induce pulp cells to produce concentric layers of mineralization.

2. Diffuse Calcification:

calcified deposits along the collagen bundles or B.V.

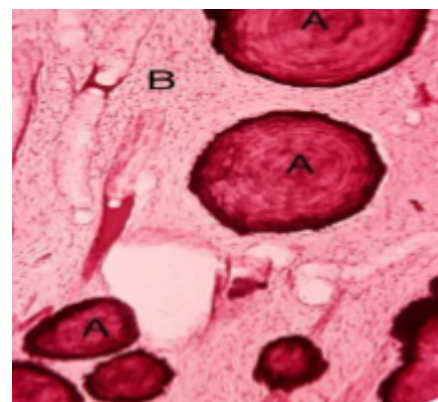
Age Changes :

1. Decreases as pulp ages:

- Intercellular substance, water, and cells.
- Size of the pulp cavity due to secondary or tertiary dentin.
- Innervation (less pain sensation)

2. Increases as pulp ages:

- Number of collagen fibers & bundles.
- Calcifications-pulp stones appeared as snow storm calcifications, or single stones.
- Sclerosis of B.V.



Clinical considerations :

- Pulp is the sense organ that needs the use of anesthesia during dental procedures.
- It defends in response to dental caries, attrition, & trauma.
- Pulp inflammation is painful to patient & its treatment as a challenge to dentist.
- Pain of pulp is difficult to localize, & commonly referred to other regions ,needs good steps to diagnose the affected tooth.



5. Due to periodontal diseases , exposed lateral root canal may lead to spread of infection to the pulp.
6. Pulp exposure may healed by newly differentiated odontoblast cells.
7. Necrotic pulp may lead to periapical diseases+ lateral lesions or cysts
8. Tooth with necrotic pulp –causes discoloration of crown (single tooth discoloration)
9. Pulp stones; if it is large-interfere endodontic treatment.

Responses of the dentin-pulp include:

- Dentin sclerosis in the areas of injury
- Tertiary dentin formation in the area of injury
- Decreased cellularity
- Fibrosis
- Dystrophic calcifications (is the deposition of calcium salts in dead tissue)
- Pulp stone formation
- Chronic inflammation

Chronic injuries :

- caries
- attrition
- erosion
- abrasion
- chemical injuries from filling materials
- heat from cavity cutting
- deep cavity preparations

NOTES :

Apical foramen becomes eccentric with time .
Failure of Endo Tx is due to the presence of the lateral canals.

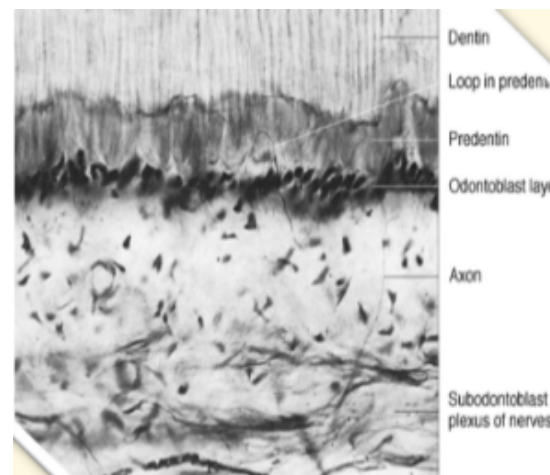
Q: How are lateral canals formed ?

1-During tooth development the epithelial root sheath gives induction to the dental papilla cells to be odontoblast & form radicular dentin . then HERS breaks down. If you have Bvs in the area , the dentin will form around the Bvs and thus forms lateral canals

2- early degeneration of HERS , no induction by the IEE and the odontoblasts won't be induced to form dentin in this area , the dentin forms above and below the area where HERS broke down leading to formation of the lateral canal.

3-If the epithelial diaphragm extensions that form to divide the AF into 2 or 3,fails to fuse then this will lead to formation of lateral canals .

(this is why lateral canals form at the area of bi and trifurcations)





Lateral canals at bi- furcation are formed by :

- A- Blood Vessels
- B- Epithelial root sheath
- C- Epithelial diaphragm
- D- None of the above

Cysts → periapical : within the pulp anatomy because there is main communication through the apical foramen so the disease coming from the pulp can pass through the AF and form a periapical cyst .

Laterally → another communication between pulp and PDL by lateral canals .

Q: what structures participate in the pain sensation ?

A:Hydrodynamic theory → tissue fluid + nerve endings + main nerves

Q:Explain why the pulp reacts to heat or cold by pain only ? (it can't recognize the type of stimuli) or that the patient can't recognize which tooth hurts .

A: Because there is only free nerve endings not proprioceptors while in the gingiva the patient can identify he type of stimuli and the exact location because of the presence of proprioceptors.

- Sharp , quick pain that subsides quickly → caused by A -delta fibers → reversible (can be treated)
- Burning , etching pain , longer duration →caused by C fibers → irreversible (can't be treated)

Q:If a patient comes over with pulpitis saying that the entire right quadrant (maxillary + mandibular) hurts how can you differentiate and say which tooth exactly hurts ?

A:You anaesthetize the mandibular jaw so if there is still pain then it is in the maxillary jaw .



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