**Oral Histology**

**Lect 7 The Pulp Dr. Enas Fadhil Kadhim**

The dental pulp occupies the center of each tooth and consists

of soft connective tissue. The pulp is housed in the pulp chamber

of the crown and in the root canal of the root. The pulp present

in the crown is called coronal pulp and the pulp present in the

root is called radicular pulp. The shape of the pulp therefore

resembles the shape of the tooth in which it is housed.

**Coronal pulp**

The coronal pulp in young individuals resembles the shape of

the outer surface of the crown dentin. The coronal pulp has six surfaces: the roof or occlusal, the mesial, the distal, the buccal,

the lingual, and the floor. It has pulp horns, which are protrusions

that extend into the cusps of each crown. The number of

these horns thus depends on the cuspal number. The cervical

region of the pulp organs constricts as does the contour of the

crown, and at this zone the coronal pulp joins the radicular

pulp. Because of continuous deposition of dentin, the pulp

becomes smaller with age. This is not uniform through the

coronal pulp but progresses faster on the floor than on the roof

or side walls.

**Radicular pulp**

The radicular or root pulp is that pulp extending from the cervical

region of the crown to the root apex. In the anterior teeth

the radicular pulps are single and in posterior ones multiple.

They are not always straight and vary in size, shape, and number.

The radicular portions of the pulp are continuous with the

periapical connective tissues through the apical foramen or

foramina. The dentinal walls taper, and the shape of the radicular

pulp is tubular. During root formation the apical root end is

a wide opening limited by an epithelial diaphragm .

As growth proceeds, more dentin is formed, so that when the

root of the tooth has matured the radicular pulp is narrower.

The apical pulp canal becomes smaller also because of apical

cementum deposition.

**Apical foramen**

The location and shape of the apical foramen may undergo

changes as a result of functional influences on the teeth.

A tooth may be tipped from horizontal pressure, or it may

migrate mesially, causing the apex to tilt in the opposite direction.

Under these conditions the tissues entering the pulp

through the apical foramen may exert pressure on one wall of

the foramen, causing resorption. At the same time, cementum

is laid down on the opposite side of the apical root canal,

resulting in a relocation of the original foramen .

Sometimes the apical opening is found on the lateral side of

the apex, although the root itself is not curved.

Frequently, there are two or more foramina separated by a portion

of dentin and cementum or by cementum only.

**Accessory canals**

Accessory canals leading from the radicular pulp laterally

through the root dentin to the periodontal tissue may be seen

anywhere along the root but are most numerous in the apical

third of the root. They are clinically significant in

spread of infection, either from the pulp to the periodontal

ligament or vice versa. The mechanism by which they are

formed is not known, but it is likely that they occur in areas

where there is premature loss of root sheath cells because these

cells induce the formation of the odontoblasts which form the

dentin. Accessory canals may also occur where the developing

root encounters a blood vessel. If the vessel is located in the area

where the dentin is forming, the hard tissue may develop

around it, making a lateral canal from the radicular pulp.

**STRUCTURAL FEATURES**

The central region of both the coronal and the radicular pulp

contains large nerve trunks and blood vessels. Peripherally, the

pulp is circumscribed by the specialized odontogenic region composed

of

 (1) the odontoblasts (the dentin-forming cells).

(2) thecell-free zone (Weil’s zone).

(3) the cell-rich zone .

The cell-free zone is a space in which the odontoblast may move

pulpward during tooth development and later to a limited extent

in functioning teeth. This may be why the zone is inconspicuous

during early stages of rapid dentinogenesis since odontoblast

migration would be greatest at that time. The cell-rich layer

composed principally of fibroblasts and undifferentiated mesenchymal

cells is restricted to the coronal regions, as it is formed

during the pre-eruptive phase of the tooth. During early dentinogenesis

there are also many young collagen fibers in this zone.

(4) pulp core which is characterized by the major vessels and nerves of the pulp.

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**Intercellular substance**

The intercellular substance is dense and gel like in nature, varies

in appearance from finely granular to fibrillar, and appears more dense in some areas, with clear spaces left between various

aggregates. It is composed of both acid mucopolysaccharides

and protein polysaccharide compounds (glycosaminoglycans

and proteoglycans).

**The cells of Pulp**

**1**-**Fibroblasts**

The pulp organ is said to consist of specialized connective tissue

because it lacks elastic fibers. Fibroblasts are the most numerous

cell type in the pulp. As their name implies, they function

in collagen fiber formation throughout the pulp during the life

of the tooth. They have the typical stellate shape and extensive

processes that contact and are joined by intercellular junctions to

the processes of other fibroblasts.

**2-Odontoblasts**

the second most prominent cell in the pulp,

reside adjacent to the predentin with cell bodies in the pulp

and cell processes in the dentinal tubules. The number of odontoblasts

corresponds to the number of dentinal tubules.

They have a constant location adjacent to the predentin, in what

is termed the “odontogenic zone of the pulp” . The cell

bodies of the odontoblasts are columnar in appearance with large

oval nuclei, which fill the basal part of the cell . Immediately

adjacent to the nucleus basally is rough-surfaced endoplasmic

reticulum and the Golgi apparatus. The cells in the odontoblastic

row lie very close to each other. Between odontoblasts gap, tight

and desmosomal junctions exist. Further toward the

apex of the cell appears an abundance of rough-surfaced endoplasmic

reticulum. Near the pupal-predentin junction the cell cytoplasm

is devoid of organelles. Focal junctional complexes are

present where the odontoblast cell body gives rise to the process.

Actin filaments are inserted into this region. The clear terminal

part of the cell body and the adjacent intercellular junction is

described by some as the terminal bar apparatus of the odontoblast.

 During the early period of active dentinogenesis it does

contain occasional mitochondria and vesicles. During the later

stages of dentinogenesis these are less frequently seen.

**3-Undifferentiated mesenchymal cells**

Undifferentiated mesenchymal cells are the primary cells in the

very young pulp, but a few are seen in the pulps after root completion.

They appear larger than fibroblasts and are polyhedral in

shape with peripheral processes and large oval staining nuclei. The

latter are distinctive because they lack a ribosome-studded endoplasmic

reticulum and have mitochondria with readily discernible

cisternae. They are found along pulp vessels, in the cell-rich zone

and scattered throughout the central pulp.

They appear spindle shaped. They are believed to be a

totipotent cell and when need arises they may become odontoblasts,

fibroblasts, or macrophages. They decrease in number in old age.

4-**Defense cells**

These are histiocytes or macrophages, dendritic cells, mast cells, and plasma cells.

In addition, there are the blood vascular elements such as the

neutrophils, eosinophils, basophils, lymphocytes, and

monocytes. These latter cells emigrate from the pulpal blood

vessels and develop characteristics in response to inflammation.

**5-Pulpal stem cells**

Among the numerous stem cells that have been identified from

dental tissues and characterized, those from the pulpal tissues

include dental pulp stem cells (DPSCs) and stem cells from

human exfoliated deciduous teeth (SHED). The stem cells were

shown to undergo proliferation and migrate to the site of

injured odontoblasts and produce dentin.

**Blood vessels**

The pulp organ is extensively vascularized. It is known that the

blood vessels of both the pulp and the periodontium arise from

the inferior or superior alveolar artery and also drain by the

same veins in both the mandibular and maxillary regions. The

communication of the vessels of the pulp with the periodontium,

in addition to the apical connections, is further enhanced by

connections through the accessory canals. These relationships

are of considerable clinical significance in the event of a potential

pathologic condition in either the periodontium or the

pulp, because the infection has a potential to spread through

the accessory and apical canals. Although branches of the alveolar

arteries supply both the tooth and its supporting tissues, those

periodontal vessels entering the pulp change their structure from the branches to the periodontium and become considerably

thinner walled than those surrounding the tooth.

Small arteries and arterioles enter the apical canal and pursue

a direct route to the coronal pulp . Along their

course they give off numerous branches in the radicular pulp

that pass peripherally to form a plexus in the odontogenic

region

**Nerves**

The abundant nerve supply in the pulp follows the distribution of the blood vessels. The majority of the nerves that enter the pulp are nonmyelinated. Many of these gain a myelin sheath

later in life. The nonmyelinated nerves are found in close association

with the blood vessels of the pulp and many are sympathetic

in nature. They have terminals on the muscle cells of the

larger vessels and function in vasoconstriction .

Thick nerve bundles enter the apical foramen and pass along

the radicular pulp to the coronal pulp where their fibers separate

and radiate peripherally to the parietal layer of nerves.The large myelinated fibers mediate the sensation of pain that may be caused by external stimuli. The peripheral axons form a network of nerves located adjacent to the cell-rich zone. This is termed the parietal layer of nerves, also known as the plexus of Raschkow.

**FUNCTION OF PULP**

**1-Inductive**

The primary role of the pulp anlage is to interact with the oral

epithelial cells, which leads to differentiation of the dental lamina

and enamel organ formation. The pulp anlage also interacts

with the developing enamel organ as it determines a particular

type of tooth.

**2-Formative**

The pulp organ cells produce the dentin that surrounds and

protects the pulp. The pulpal odontoblasts develop the organic

matrix and function in its calcification. Through the development

of the odontoblast processes, dentin is formed along the

tubule wall as well as at the pulp–predentin front.

**3-Nutritive**

The pulp nourishes the dentin through the odontoblasts and their

processes and by means of the blood vascular system of the pulp.

**4-Protective**

The sensory nerves in the tooth respond with pain to all stimuli

such as heat, cold, pressure, operative cutting procedures, and

chemical agents. The nerves also initiate reflexes that control

circulation in the pulp. This sympathetic function is a reflex,

providing stimulation to visceral motor fibers terminating on

the muscles of the blood vessels.

**5-Defensive or reparative**

The pulp is an organ with remarkable reparative abilities.

It responds to irritation, whether mechanical, thermal, chemical,

or bacterial, by producing reparative dentin and mineralizing

any affected dentinal tubules. The changes in the odontoblast,

subodontoblastic layer and type of tertiary dentin formation

varies with the extent of caries exposing the dentin (open/closed

lesion), its progression (active/slowly progressive lesion). The

reparative dentin was found to be more atubular in closed/active

lesions and more tubular in open/slowly progressive lesions.

**REGRESSIVE CHANGES (AGING)**

**1-Cell changes**

In addition to the appearance of fewer cells in the aging pulp,

the cells are characterized by a decrease in size and number of

cytoplasmic organelles.

 The fibroblasts in the aging pulp exhibit less

perinuclear cytoplasm and possess long, thin cytoplasmic processes.

**2-Fibrosis**

In the aging pulp accumulations of both diffuse fibrillar components

as well as bundles of collagen fibers usually appear.

Fiber bundles may appear arranged longitudinally in bundles

in the radicular pulp, and in a random more diffuse arrangement

in the coronal area. This condition is variable, with some

older pulps showing surprisingly small amounts of collagen

accumulation, whereas others display considerable amounts. The increase in fibers in the pulp organ is gradual

and is generalized throughout the organ. Any external trauma

such as dental caries or deep restorations usually causes a localized

fibrosis or scarring effect. Collagen increase is noted in the

medial and adventitial layers of blood vessels as well. The

increase in collagen fibers may be more apparent than actual,

being attributable to the decrease in the size of the pulp, which

makes the fibers present occupy less space, and hence they

become more concentrated without increasing in total volume.

**3-Vascular changes**

Vascular changes occur in the aging pulp organ as they do in any

organ. Atherosclerotic plaques may appear in pulpal vessels.

In other cases the outer diameter of vessel walls becomes greater

as collagen fibers increase in the medial and adventitial layers.

Also calcifications are found that surround vessels .

Calcification in the walls of blood vessels is found most often in

the region near the apical foramen. The capillary endothelium

shows changes due to age. The endothelium in the elderly shows

numerous pinocytic vesicles, microvesicles and microfilaments.

In addition lipid like vacuoles, glycogen granules and many

Golgi complexes are present. Blood flow decreases with age.

**Pulp stones (denticles)**

Pulp stones, or denticles, are nodular, calcified masses appearing

in either or both the coronal and root portions of the pulp

organ. They often develop in teeth that appear to be quite normal

in other respects. They usually are asymptomatic unless

they impinge on nerves or blood vessels. They have been seen in

functional as well as embedded unerupted teeth.

**Pulp stones are classified, according to their structure as**

**true denticles** or **false denticles**.

**True denticles** are similar in structure to dentin in that they have dental tubules and contain the processes of the odontoblasts that formed them andthat exist on their surface . True denticles are

comparatively rare and are usually located close to the apical

foramen. A theory has been advanced that the development of

the true denticle is caused by the inclusion of remnants of the

epithelial root sheath within the pulp. These epithelial remnants

induce the cells of the pulp to differentiate into odontoblasts,

which then form the dentin masses called true pulp stones.

**False denticles** do not exhibit dentinal tubules but appear

instead as concentric layers of calcified tissue. In

some cases these calcification sites appear within a bundle of

collagen fibers . Other times they appear in a location

in the pulp free of collagen accumulations . In the center of these concentric layers of calcified tissue there may be remnants of necrotic and calcified cells. Calcification of thrombi in blood vessels, called

phleboliths, may also serve as nidi for false denticles. All denticles

begin as small nodules but increase in size by incremental

growth on their surface. The surrounding pulp tissue may

appear quite normal. Pulp stones may eventually fill substantial

parts of the pulp chamber.

**3-Diffuse calcifications**

Diffuse calcifications appear as irregular calcific deposits in the

pulp tissue, usually following collagenous fiber bundles or

blood vessels . Sometimes they develop into larger

masses but usually persist as fine calcified spicules. The pulp

organ may appear quite normal in its coronal portion without

signs of inflammation or other pathologic changes but may

exhibit these calcifications in the roots. Diffuse calcifications

are usually found in the root canal and less often in the coronal

area, whereas denticles are seen more frequently in the coronal

pulp. Diffuse calcification surrounds blood vessels.



True Denticles

False Dentricles

Diffuse Calcification

Pulp stones may also be classified according to their location as **free**, **attached**, or

**embedded**, depending on their relation to the dentin of the

tooth.

**1-The free denticles** are entirely surrounded by

pulp tissue,

**2-attached denticles** are partly fused with the dentin**,**

**3-embedded denticles** are entirely surrounded by dentin.

**Free Denticles**

**Attached Dentricles**

**Embbedd Denticles**