

# *Oral Histology*

Lec-5

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## *Dentin*

**Dentin** (American English) or **dentine** (UK English) is a calcified tissue of the body, and along with enamel, cementum, and pulp is one of the four major components of teeth. It is usually covered by enamel on the crown and cementum on the root and surrounds the entire pulp. By weight, 70% of dentin consists of the mineral hydroxylapatite, 20% is organic material, and 10% is water. Yellow in appearance, it greatly affects the color of a tooth due to the translucency of enamel. Dentin, which is less mineralized and less brittle than enamel, is necessary for the support of enamel. Unlike enamel, dentin continues to form throughout life and can be initiated in response to stimuli, such as tooth decay or attrition.

### **Dentin structural units**

#### **1- Dentinal tubules(D.T.) and its odontoblastic process:**

Dentin consists of microscopic channels, called dentinal tubules, which radiate outward through the dentin from the pulp to the exterior cementum or enamel border. The dentinal tubules extend from the dentinoenamel junction (DEJ) in the crown area, or dentinocemental junction (DCJ) in the root area, to the outer wall of the pulp. These tubules contain fluid and cellular structures. As a result, dentin has a degree of permeability, which can increase the sensation of pain and the rate of tooth decay. The strongest held theory of dentinal hypersensitivity suggests that it is due to changes in the dentinal fluid associated with the processes, a type of *hydrodynamic mechanism* or theory.

The course of D.T. is somewhat curved, resembling an *S shape* known as primary curvature. Starting at right angles from pulpal surface, the first convexity of this doubly curved course directed toward the apex of the root ending perpendicular to D.E.J, this configuration indicate the course taken by odontoblasts during dentinogenesis. Secondary curvature also can be distinguished over the entire length of D.T., they probably reflect the minor changes in the direction of movement of odontoblasts. In the root and in the area of incisal edge or cusps, the tubules are almost straight.

The ratio between surface areas at the outside and inside of the D. is about 5:1, so the tubules are farther apart in the peripheral layers and are more closely packed near the pulp. In addition they are larger in diameter near the pulpal cavity (3-4 $\mu$ m) and smaller at their outer ends( 1 $\mu$ m).

The terminal part of D.T. branched into 2-3 branches near D.E.J resulting in the increase number of tubules in this area. Also there are lateral branches of D.T. which called canaliculi .

## **2-Peritubular D.:**

It's the D. that surrounds the D.T. and form 1 $\mu$ m thick sheath around each tubule(about 0.75  $\mu$ m near DEJ and 0.4  $\mu$ m near the pulp). Peritubular D. is missing in D.T. in interglobular D. indicating that this is a defect of mineralization in this area. Peritubular D. is highly calcified and its about 40% more calcified than adjacent intertubular D.

## **3-Intertubular D.:**

It's the D. located between the D.T., and its formed the most of the body of D. Its less mineralized than the peritubular D., and it consist of network course of collagen fibers in which apatite crystals deposited on it.

## **Incremental lines in D.**

### **1- Imbrication or von Ebner lines:**

It appear as fine lines, which in cross section run at right angles to the D.T. The course of the lines indicates the growth pattern of the D. The distance between the lines corresponds to the daily rate of apposition, which in crown varies from 4-8 $\mu$ m and becomes decreasingly less as root formation progress.

### **2- Counter lines of Owens:**

Its hypocalcified line, it distinguish in longitudinal ground section as accentuated few lines. These lines arises due to disturbances in D. matrix and mineralizing process.

### **3- Neonatal lines:**

This line separating between prenatal and postnatal D., and mostly found in deciduous and first permanent molar. This line is the result of incomplete calcification, due to metabolic disturbances at the time of birth to the abrupt changes in environment and nutrition.

### **Interglobular D.:**

Mineralization of the D. sometimes beings in small globular areas that normally fused to form a uniformly calcified D. layer. If fusion does not take place, hypomineralized regions (only primary mineralization phase occur) remain between the globules, which termed *interglobular D.* This type of D.is found in the crown in both sections (decalcified and ground sections) near the D.E.J. and in the root near C.D.J. In ground sections is sometimes lost and replaced by air ,so it appear black.

### **Tomes' granular layer:**

In the ground sections a thin layer of D. adjacent to the cementum almost appears granular and only found in the root, this is known as Tomes' granular layer. Its thought to represent an interference with mineralization of the entire surface layer of the root D. prior to the beginning of cementum formation.

### **Types of dentin:**

There are three types of dentin, primary, secondary and tertiary. Primary dentin is the outermost layer of dentin and borders the enamel. Secondary dentin is a layer of dentin produced after the root of the tooth is completely formed. Tertiary dentin is created in response to a stimulus, such as a carious attack.

#### **Primary dentin**

Primary dentin, the most prominent dentin in the tooth, lies between the enamel and the pulp chamber. The outer layer closest to enamel is known as mantle dentin. This layer is unique to the rest of primary dentin. Mantle dentin is formed by newly differentiated odontoblasts and forms a layer approximately 150 micrometers wide. Unlike primary dentin, mantle dentin lacks phosphorylation, has loosely packed collagen fibrils and is less mineralized. Below it lies the circumpulpal dentin, a more mineralized dentin which makes up most of the dentin layer and is secreted after the mantle dentin by the odontoblasts. Circumpulpal dentin is formed before the root formation is completed.

Newly secreted dentin is unmineralised and is called predentin. It is easily identified in haematoxylin and eosin stained sections since it stains less intensely than dentin. It is usually 10-47 micrometer and lines the innermost region of the dentin. It is unmineralized and consists of collagen, glycoproteins and

proteoglycans. It is similar to osteoid in bone and is thickest when dentinogenesis is occurring.

### **Secondary dentin**

Secondary dentin is formed after root formation is complete, normally after the tooth has erupted and is functional. It grows much more slowly than primary dentin, but maintains its incremental aspect of growth. It has a similar structure to primary dentin, although its deposition is not always even around the pulp chamber. It is the growth of this dentin that causes the decrease in the size of the pulp chamber with age. This is clinically known as pulp recession; cavity preparation in young patients therefore carries a greater risk of exposing the pulp. If this occurs, the pulp can be treated by different therapies such as direct pulp capping.

### **Tertiary dentin**

Tertiary dentin is deposited at specific sites in response to injury by odontoblasts or replacement odontoblasts from the pulp depending on the severity of the injury. Tertiary dentin can be divided into reactionary or reparative dentin.

Tertiary dentin secreted by odontoblasts is often due to chemical attack, either by chemicals diffusing through the dentin and insulting the odontoblasts, or by diffusion of toxic bacterial metabolites down the dentinal tubules in the instance of a carious attack with dental decay. This tertiary dentin is called *reactionary dentin*. This is an attempt to slow down the progress of the caries so that it does not reach the pulp.

In the case of an infection breaching the dentin to or very near the pulp, or in the instance of odontoblast death due to other attack (e.g. chemical or physical), undifferentiated mesenchymal cells can differentiate into odontoblast-like cells which then secrete another type, *reparative dentin*, underneath the site of attack. This is not only to slow the progress of the attack, but also prevents the diffusion of

bacteria and their metabolites into the pulp, reducing the probability of partial pulp necrosis.

The distinction of the two kinds of tertiary dentin is important, because they are secreted by different cells for different reasons. Reactionary dentin is secreted at varying speeds, dependant on the speed of progression of caries in the outer dentin surface. Histologically, it is easily distinguishable by its disordered tube structure, its the location of the secretion (its protrudes into the pulpal cavity) and its slightly lower degree of mineralization than normal. The tooth is often able to be saved by a simple restoration. In contrast, reparative dentin is secreted when the tooth has a poor prognosis.

Tertiary dentin is deposited rapidly, with a sparse and irregular tubular pattern and some cellular inclusions; in this case it is referred to as "*osteodentin*".

However, if the stimulus is less active, it is laid down less rapidly with a more regular tubular pattern and hardly any cellular inclusions.

Stimuli of different nature not only induce additional formation of reparative D. but also lead to changes in the D. itself, calcium salts may be deposited in or around degenerated odontoblastic processes and may obliterate the tubules. This type of D. called *transparent or sclerotic D.*, and can be demonstrated only in ground sections. It appear light in transmitted light and dark in reflected light, because the light passes through the transparent D. but reflected from the normal D.

In ground section of D., the odontoblastic process disintegrated as a result of sever stimuli to the pulp like caries, attrition or abrasion, and the empty tubules are filled with air. They appear dark in transmitted light and white in reflected light, this type of D. called *dead tracts* and its area of decreased sensitivity. Reparative D. seals these dead tracts at their pulpal end.

**Clinical consideration:**

- The rapid penetration & spread of caries in the dentin is the result of the tubule system in the dentin.
- The dentinal tubules form a passage for invading bacteria that may thus reach the pulp through a thick dentinal layer.
- Air driven cutting instruments cause dislodgement of the odontoblasts from the periphery of the pulp & their aspiration within the dentinal tubule.