Biologic consideration of dentin and its clinical significance in operative dentistry

Dr. Ahmed Al-Jobory
Dentine V.S. Enamel

Dentine

Enamel

Dentine

Enamel

Organic 25%
Water 25%
Mineral 50%

90% inorganic

Dentine:

Enamel:

Dentine enamel junction
Enamel rods

Enamel rod unit
Function:

• The **coronal dentin** (crown) provides both color & elastic foundation for enamel. Together with **radicular dentin** (root), dentin forms the bulk of the tooth & protective (cover) for the pulp.

• As a vital tissue without vascular supply or innervation, it is nevertheless able to respond to thermal, chemical or external stimuli
Support

• Tooth strength & rigidity are provide by intact dentinal substrate.
• Resistance of tooth to fracture significantly lowered with increasing depth & width of cavity preparation. Therefore, a conservative initial approach that combines localized removal of carious tooth structure placement of a bonded restoration, & placement of sealant recommended.
• If large preparations are required, the dentist should consider placement of onlay or crown.
Morphology

![Pie chart showing the composition of Dentin: Mineral 50%, Water 25%, Organic 25%]
Morphology

- Dentin is composed of small apatite crystals embedded in cross-linked organic matrix of collagen fibrils.
- The extended cytoplasmic processes of the formative cells (the odontoblasts) form channels or tubules traversing the full thickness of the tissue Dentin contains 45% to 50% inorganic apatite crystals, about 30% organic matrix, & about 25% water.
During tooth preparation, dentin distinguished from enamel by:

1- **Color:** dentin is normally **yellow-white** and slightly darker than enamel, in older patients dentin is darker and become brown or black in cases if dentin exposed to oral fluids, old restorative materials or slowly advancing caries.

2- **Reflectance:** dentin surfaces are more **opaque** and **dull**, being less reflective to light than enamel surfaces, which appear shiny.

3- **Hardness:** dentin is **softer** than enamel, sharp explorer tends to catch and hold in dentin.

4- **Sound:** when moving an explorer tip over the tooth, **enamel surfaces provide a sharper, higher pitched sound** than dentin surfaces.
Two main types of Dentine are present

1. **Intertubular dentin**: the primary structural component of the hydroxyapatite-embedded collagen matrix between tubules.

2. **Peritubular dentin**: the hyper-mineralized tubular walls. These component ratios vary according to depth of dentin, age & traumatic history of the tooth.
FIGURE 2- Cross-sectioned tubules showing intense exposed peripheral intertubular collagen fibers (arrow) and outer peritubular collagen fibrils (arrowhead) (20 years old) (Bar = 1 μm / 10,000 X)
Depth of dentin

**Outer dentin**
- The dentin near the DEJ.
- The tubules of the outer dentin are relatively far apart. The Intertubular dentin makes up 96% of the surface area.

**Inner dentin**
- The dentin near the pulp.
- The dentin near the pulp differs from that near DEJ. These differences affect the permeability and bonding characteristics of inner dentin.
- In the inner dentin, the tubules' diameters are larger, and the distance between tubule centers is half that of tubules at DEJ. Thus, the Intertubular matrix area is only 12% of the surface area, and the permeability of inner dentin is about eight times more permeable than the dentin near DEJ.
Permeability of dentin

- The permeability of dentin directly related to its protective function. When the external cap of enamel & cementum is lost from the periphery of the dentinal tubules through caries, preparation with burs or abrasion & erosion, the exposed tubules become canals between the pulp & the external oral environment.
• Restored teeth are also at risk of toxic seepage through the phenomenon of microleakage between the restorative material & the cavity wall, through capillary action differential thermal expansion, & diffusion, fluids containing various acidic & bacterial products can penetrate the gap between the tooth & restoration & initiate secondary caries of the internal cavity walls. Bacterial substances can continue diffusion through permeable dentinal tubules to reach the pulp... putting the tooth at risk for pulpal inflammation & sensitivity. So restorative techniques with varnishes, liners or dentin bonding resin adhesives are effective to provide reliably sealed margins & sealed dentinal surface.

• The remaining dentin thickness is the key determinant of the diffusion of gradient
Sensitivity of dentin

- Although dentin is sensitive to thermal, tactile and osmotic stimuli across its (3-3.5 mm) thickness.
- Dentin is neither vascularized nor innervated; accept for about 20% of tubules that have nerve fibers penetrating inner dentin by few microns. Therefore, odontoblast & its process is the possible stimulus receptor.
Theories of thermal sensitivity

1. Theory of thermal shock

• This states that sensitivity is the result of **direct thermal shock** to the pulp via temperature changes **transferred from** the **oral cavity through the restorative material**, especially when the **remaining dentin is thin**. Protection from this insult would be then provide by an adequate thickness of an insulating material.
2. Theory of hydrodynamic

- This theory is based on the capillary flow dynamics of the fluid-filled dentinal tubule. In a vital tooth with exposed dentin, there is a constant slow movement of fluid outward through the dentinal tubules. The hydrodynamic theory proposes that when a stimulus such as air evaporation, cold or heat (i.e. generated from dental bur) or tactile pressure these stimuli causes the slow fluid movement to become more rapid causing displacement of odontoblast bodies & the nerve endings in the pulp are deformed, a response that is interpreted as pain.
As the dentin near the pulp, tubule density & diameter increase also the permeability increase, thus increasing both the volume & flow of fluid. This explains why deeper restorations are associated with more problems of sensitivity.

According to this theory, if the tubules could occluded, fluid flow is prevent & temperatures do not induce pain. So the operative factor in reducing sensitivity to thermal changes is by effective sealing of the dentinal tubules rather than placement of an insulating materials.

This theory has gained general acceptance in recent years & has changed the direction of restorative procedures away from thermal insulation & toward dentinal sealing. Thus, there is increasing emphasis on the integrity of the interface between restorative material & cavity preparation.
Dentin is made of many tiny fluid-filled tubules through which sensation is transmitted to the dental pulp.
3. Transduction theory:

- Which presumes that the odontoblast process is the primary structure excited by the stimulus and that the impulse is transmitted to the nerve ending in the inner dentine through the membrane of the odontoblast process, this is not a popular theory since there are no neurotransmitter vesicles in the odontoblast process to facilitate the synapse.
4. Direct conduction theory:
   - In which the fluid stimulates directly affect the nerve endings in the dentinal tubules.
Dentine hypersensitivity
Physiologic and tertiary dentin
Physiologic dentin

• 1. **Primary dentin**: formed relatively quickly until root formation completed by odontoblasts.

• 2. **Secondary dentin**: This slowly formed dentin continues to constrict the dimensions of the pulp chamber. In response to mild occlusal stimulus, secondary dentin mainly deposited in the pulp horns & on the roof & floor of the pulp chamber so after many decades the chamber becomes quite narrow occluso-gingivally. The dentist must pay attention for the size & location of the pulp chamber to decide the design of the preparation & placement of retentive features such as pins.
Sclerotic dentin (transparent or peritubular dentin)

• Results from aging or mild irritation (such as slow caries) and cause a change in the composition of the primary dentin. The tubular content appears to replace by calcified material that obliterates the tubules, progressing from the DEJ pulpaly. These areas are harder, denser, less sensitive & more protective of the pulp against subsequent irritation.

• Sclerosis resulting from aging is (physiological dentin sclerosis) and that resulting from mild irritation called (reactive dentine sclerosis).
Reparative dentin (tertiary dentin)

• Intense traumatic insult (injury) to the tooth, whether caused by bacterial penetration associated with caries, or heat & trauma from a dental bur, may be severe enough to destroy the supporting odontoblasts in the affected location. Within 3 weeks, fibroblasts or mesenchymal cells of the pulp are converted or differentiated to stimulate the activities of original odontoblast, & form irregularly organized tubules.

• The rate of formation & the thickness & organization of reparative dentin depend on the intensity & duration of the stimulus.
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