OPERATIVE DENTISTRY

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Biological Consideration of Enamel and its clinical significance in practice of restorative dentistry[1]

Enamel provides a hard, durable shape for the function of teeth and a protective cap for the vital tissues of dentine and pulp.

E. is the hardest substance of the human body, E. is very brittle, so it requires a base of dentin to withstand the masticatory force or it fractures easily.

Permeability: Enamel is composed of 90% inorganic hydroxyapatite mineral by volume and 4-12 % water which is contained in the intercrystalline spaces and in a network of micropores opening to the external surface.

Various fluids, ions, and low molecular weight substance can diffuse through the semipermeable enamel. So that the acid demineralization and fluoride uptake are not limited to the surface but are active in three dimensions.

Crystal structure and enamel rods

Enamel is composed of millions of E. rods or prisms. These rods are in the form of small elongated appetite crystal which is densely packed and have a wavy course of orientation that gives strength and durability to the enamel. An organic matrix or sheath surrounds individual crystal. The spacing and orientation of the crystals and the amount of organic matrix make the enamel rod boundary and the center core differentially soluble when exposed for a short time to weak acids.

The acid-treated (etching) E. surface has irregular and pitted surface with numerous microscopic undercut, the etched enamel has a higher surface energy, so resin monomer flows into & adheres to the etched depressions to polymerize & form retentive resin tags. Because there are (30,000) to (40,000) E. rod/mm^2 & acid etch penetration increases the bondable surface area to (10) to (20) folds, micromechanical bonding of resin restorative materials to E. is significant.

Acid-etching modification of E for restoration retention provides a conservative, reliable, alternative to traditional surgical methods of tooth preparation &restoration. (retentive groove, pins, an extension for prevention.)

Starting at 1mm from the CEJ, the rods on the vertical surfaces run occlusaly or incisally at proximately 60-degree inclination and progressively incline to approach the marginal ridge and cusp tips, where the rods are parallel to the long axis of the crown. The rods beneath the occlusal fissures are also parallel to the long axis, but rods on each side of the fissure vary up to 20 degree from the long axis.

Loss of enamel rods that form the cavity wall of cavomargin of dental restorations creates a gap defect, leakage of bacteria and their products that may lead to secondary caries. Therefore, a basic principle of cavity wall preparation is to bevel or parallel the direction of E. rods and avoid undercutting them.

In the cervical region of permanent teeth, enamel rods are oriented outward in a slightly apical direction, therefore a perpendicular cut to the external surface of occlusal walls of preparation on axial surfaces compromised enamel, so an obtuse enamel cavosurface angle is recommended to closely parallel the rod direction and preserve the integrity of enamel margin.

Clinical appearance and diagnosis of pathological conditions

1- Color changes associated with demineralization:

E. is relatively translucent; its color is primarily a function of its thickness and the color of underlying dentin. The thickness is more at the cusp tips and incisal edges and decrease below deep fissures and become thin cervically at the junction with cementum.

Color changes related to E. demineralization and caries are critical diagnostic observation. Subsurface E. porosity from carious demineralization is manifested clinically by a milky white opacity called (white spot lesion) when located on smooth surfaces. In later stages of caries, internal demineralization of E. at the DEJ, subsurface cavitation gives a blue or gray color to the overlying enamel.

2- Cavitation: The dentin is not affected until enamel breaks away to create a cavity, a restoration must then be placed. If untreated the cavitations expand to compromise the structural strength of the crown and microorganisms infiltrate into deep dentin to affect the vitality of the tooth.

3-Wear: E. is hard as steel; however, the enamel will wear because of attrition or frictional contact against opposing enamel or harder restorative materials such as porcelain. Heavy occlusal wear is demonstrated when rounded cuspal contacts are ground to flat facets.

4- Faults and fissures: A deep fissure is formed by the incomplete fusion of lobes of cuspal enamel in the developing tooth. The resulting narrow clefts provide a protected area for acidogenic bacteria. Pits and fissures defects are eight times more vulnerable to caries than are smooth surfaces.

Biological Consideration of Dentin and its clinical significance in practice of restorative dentistry

The function of dentin: The coronal dentin provides both color and elastic foundation for enamel. Together with radicular dentin, dentin forms the bulk of the tooth and protective encasement for the pulp. As a vital tissue without vascular supply or innervations, it is nevertheless able to respond to thermal, chemical or tactile external stimuli.

Morphology: Dentin is composed of small apatite crystals embedded in a cross-linked organic matrix of collagen fibrils. The extended cytoplasmic processes of the formative cells (the odontoblasts) form channels or tubules transferring the full thickness of the tissue. Dentin contains 45% to 50% inorganic apatite crystals, about 30% organic matrix, and about 25% water. Dentin is pale yellow.

Support: Tooth strength and rigidity are provided by the intact dentinal substrate. The resistance of tooth to fracture is significantly lowered with increasing depth and width of cavity preparation. Therefore a conservative initial approach that combines localized removal of carious tooth structure, placement of a bonded restoration, and the placement of sealant is recommended.

The permeability of dentin: It is directly proportional to the dentin depth. When the external cap of enamel and cementum is lost from the periphery of the dentinal tubules by caries, preparation with burs, abrasion or erosion, the exposed tubules become a communicative pathway between the pulp and the external oral environment.

The sensitivity of dentin: Although dentin is sensitive to thermal, tactile and osmotic stimuli across its (3-3.5mm) thickness. Dentin is neither vascularized nor innervated.

Theories of thermal sensitivity

1- **Theory of thermal shock:** This states that sensitivity is the result of a 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 the insult would then be provided by an adequate thickness of an insulating material.

2- **Hydrodynamic theory:** It is based on the capillary flow 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. This theory proposes that when a stimulus such as air evaporation, cold or heat stimuli causes slow fluid movement to become more rapid causing displacement of odontoblast bodies and the nerve endings in the pulp are deformed, a response that is interpreted as pain.

As dentin near the pulp, tubule density and diameter increase also the permeability increase, thus increasing both the volume and flow of fluid. This explains why deeper restorations are associated with more problems of sensitivity.

According to the theory, if the tubules can be occluded, fluid flow is prevented and temperature does not induce pain.

Two main types of dentin according to its morphology which are:

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

2- **Peritubular dentin:** The hypermineralized tubular walls.

These components ratio vary according to a depth of dentin, age and traumatic history of the tooth.

Depth of dentin: dentin is classified according to the depth from pulp

1- Outer dentin: It is the dentin near the DEJ, the tubules of the outer dentin are relatively far apart and the intertubular dentin makes up 96% of the surface area.

2- Inner dentin: 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 is only 12% of the surface area, and the permeability of inner dentin is about eight times more permeable than the dentin near the DEJ.

Physiology of dentin: dentin is classified according to the physiological need into:

1- **Primary dentin:** Which is formed relatively quickly until root formation is completed by odontoblast.

2- **Secondary dentin:** A slowly formed dentin that continues to constrict the dimension of the pulp chamber in response to a mild occlusal stimulus, secondary dentin is mainly deposited in the pulp horns and on the roof and floor of the pulp chamber so after many decades the chamber becomes quite narrow occluso-gingivally. The dentist must pay attention for the size and location of the pulp chamber to decide the design of the preparation and placement of retentive features such as pins.

3- **Sclerotic dentin (transparent or peritubular dentin):** Results from aging or mild irritants such as slow caries and causes changes in the composition of the primary dentin. The tubular content appears to be replaced by calcified material that obliterates the tubules, progressing from the DEJ pulpally. These areas are harder, denser, less sensitive and more protective of the pulp against subsequent irritation.

Sclerosis resulting from aging is called **(physiological dentin sclerosis)** and that resulting from mild irritant called **(reactive dentin sclerosis)**

4- **Reparative dentine (tertiary dentin):** An Intense traumatic insult to the tooth, whether caused by bacterial penetration associated with caries, heat or trauma from bur that 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 odontoblasts and form irregularly organized tubules. The tooth will be able to compensate for the traumatic or carious loss of peripheral dentin with deposition of new dentin substrate and reduction of pulpal irritation from tubule permeability. Unless the lesion is either arrested or removed and a restoration placed, the diffusion of bacterial toxins will reach the pulp and initiate strong inflammatory response and result in pulpal necrosis.

1. Ritter, A.V., *Sturdevant's art & science of operative dentistry-e-book*. 2017: Elsevier Health Sciences.