Operative

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Enamel, Dentin, and Pulp; biological consideration

Enamel

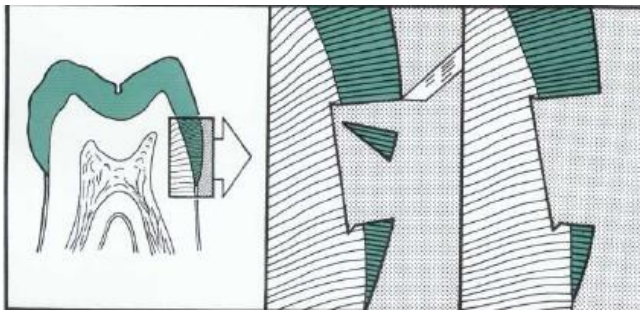
Embryologically, enamel is formed by ameloblasts cells, which originate from the ectoderm embryonic germ layer. Ameloblasts have short extensions toward the dentinoenamel junction and these are termed Toms process.

Chemically, enamel is highly mineralized crystalline structure containing from 95% to 98% inorganic matter by weight. Hydroxyapatite, in the form of a crystalline lattice, is the largest minerals constituent and is present 90% to 92% by volume. Other minerals and trace elements are contained in small amounts. The remaining constituents of tooth enamel are an organic content of about 1% to 2% and a water content of about 4% by weight, and these total approximately 6% by volume.

Structurally, enamel is composed of million of enamel rods or prisms, which are the largest structure components, as well as rod sheaths and a cementing interrod substance in some areas. The structural components of the enamel prism are millions of small elongated apatite crystallites that are variable in size and shape. The crystallites are tightly packed in a distinct pattern of orientation that gives strength and structural identity to the enamel prisms. An organic matrix or prism sheath also surrounds individual crystals, and it appears to be an organically rich interspace rather than a structure entity.

Enamel is the hardest substance of the human body. Hardness may vary over the external tooth surface according to the location of the area; also, it decreases inward, with hardness lowest at the dentinoenamel junction. Enamel is very brittle structure having a high elastic modulus and low tensile strength, which indicates it is

a rigid structure. However, dentin is a highly compressive tissue that acts as a cushion for the enamel. Enamel require abase of dentin to withstand masticatory forces. Enamel rods that fail to possess a dentin base of caries or improper cavity design are easily fractured away from neighboring rods. For maximal strength in cavity preparation all enamel rods should be supported by dentin (Fig.1)



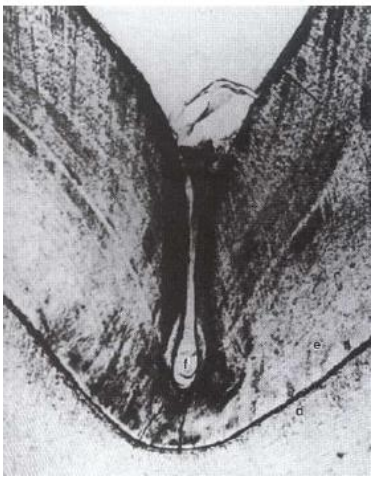
(Fig.1)

Permeability; although enamel is very hard and dense structure, it is permeable to certain ions and molecules, permitting partial and complete penetration. The route of passage appears to occur through structural units that are hypomineralized and rich in organic content such as rod sheaths, enamel cracks, and other defects. It appears that water plays an important role as a transporting medium through small incrystalline spaces. Enamel permeability decreases with age because of the changes in the enamel matrix, although basic permeability is maintained. This decrease is referred to enamel maturation.

Enamel is as hard as steel, however enamel will wear because of attrition or friction 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. Depending on the factors such as bruxism, malocclusion, age and diet; cusps may be completely lost and enamel abraded away so that dentin is exposed. So cavity outline form should be designed so that the margins of restorative materials avoid critical high stress area of occlusal contact.

Enamel is soluble when exposed to acid medium, although the dissolution is not uniform. Solubility of enamel increases from the enamel surface to the dentinoenamel junction. When fluorides are present during enamel formation or are topically applied to the enamel surface, the solubility of surface enamel is decreased. Fluoride concentration decreases toward the dentinoenamel junction. Fluoride additions can affect the chemical and physical properties of the apatite mineral and influence the hardness, chemical reactivity, and stability of enamel while preserving the apatite structures. Trace amounts of fluoride stabilize the enamel by lowering acid solubility, by decreasing the rate of demineralization, and by enhancing the rate of remineralization.

Deep invaginations occurs in pit and fissure areas of occlusal surfaces of premolalrs and molars that decrease enamel thickness in these areas. These fissures act as food and bacterial traps that may predispose the tooth to dental caries (Fig.2). Occlusal grooves, which are sound, serve an important function as an escapeway for the movement of the food to the facial and lingual surfaces during mastication.



(Fig.2)

Because enamel is mostly gray and is semitranslucent, the color of the tooth depends upon the color of the underlying dentin, the thickness of the enamel, and the amount of the stain in the enamel. The amount of translucency of enamel is related to the

variation in the degree of calcification and homogeneity. Abnormal conditions of enamel usually result in aberrant color. Enamel becomes temporary whiter within minutes when the tooth is isolated from the moist oral environment by rubber dam or absorbents. Thus the shade must be determined before isolation and preparation for a tooth - colored restoration. This change in color explained by the temporary lost of loosely bonded (or exchangeable) water (less than 1% by weight).

Dentin

Dentin forms the largest portion of tooth structure, extending almost the full length of the tooth. Externally dentin is covered by enamel on the anatomical crown and by cementum on the anatomical root.

The most recently formed layer of dentin is always on the pulpal surface. This unmineralized zone of dentin is immediately next to the cell bodies of the odontoblastes and is called *predentin*. Dentin formation begins at areas subadjacent to the cusp tip or incisal ridge and gradually spread to the apex of the root. The dentin forming the initial shape of the tooth is called *primary dentin*, and is usually completed three years after tooth eruption (for permanent teeth). The dentinal tubules are small canals that extend across the entire width of the dentin, from the dentinal enamel or dentinal cemental junction to the pulp. Each tubule contains the sytoplasmic cell process (Tomes fiber) of an adontoblast. Each dentinal tubule is lined with a layer of *peritubular dentin*, which is much more mineralized than the surrounding *intertubular dentin*.

The composition of human dentin is approximately 75% inorganic material, 20% organic material, and 5% water and other materials.

Secondary dentin; it is slowly formed dentin that continues to construct the dimensions of the pulp chamber. In response to 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 wide narrow occlusogingivally. 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.

Sclerotic dentin (Transparent or peritubular dentin); results from aging or mild irritation (such as slow caries) and causes a change in the composition of the primary dentin. The peritubular dentin becomes wider, gradually filling the tubules with calcified materials, progressing from the dentinoenamel junction pulpally. These areas are harder, denser, less sensitive, and more protective of the pulp against subsequent irritation. Sclerosis resulting from aging is physiological dentine sclerosis, and that resulting from a mild irritation is reactive dentin sclerosis.

Reparative dentin (tertiary dentin); is formed in response to moderate – level irritants, such as attrition, abrasion, erosion, trauma, moderate - rate dental caries, and some operative procedures. In about 15 days, mesenchymal cells of the pulp are converted or differentiated to stimulate the activities of original odontoblast(termed secondary odontoblasts), and form irregularly organized tubules. The rate of formation and the thickness and organization of reparative dentin depend on the intensity and duration of the stimulus.

The permeability of dentine is directly related to its protective function. When the external cap of enamel and cementum is lost from the periphery of the dentinal tubules through caries, preparation with burs or abrasion and erosion, the exposed tubules become conduits between the pulp and the external oral environment. Restored teeth are also at risk of toxic seepage through the phenomenon of microleakage between the restorative material and the cavity wall, through capillary action differential thermal expansion, and diffusion, fluids containing various acidic and bacterial products can penetrate the gap between the tooth and restoration and 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 and sensitivity. So restorative techniques with varnishes, liners or dentin bonding resin adhesives are affective to provide reliability sealed margins and sealed dentinal surface.

Sensitivity; the most accepted theory of pain transmission is the hydrodynamic theory. This theory accounts for pain transmission by the small, rapid movements of fluid that occur within the dentinal tubules. Because many tubules contain mechanoreceptor nerve ending near the pulp, small fluid movements in the tubules arising from cutting, drying, pressure changes, osmotic shifts, or changes in temperature account for the majority of pain transmission.

Pulp

The dental pulp occupies the pulp cavity in the tooth. Each pulp organ is circumscribed by the dentin and is lined periphery by a cellular layer of odontoblasts adjacent to the dentin. Anatomically the pulp organ is divided into the coronal pulp located in the pulp chamber in the crown portion of the tooth; and the radicular pulp located in the pulp canals in the root portion of the tooth. The radicular pulp is continuous with the periapical tissues by connecting through the apical foramen of the root. Accessory canals may extend from the pulp canals laterally through the root dentin to the periodontal tissues.

The dental pulp is composed of myelinated and unmyelinated nerves, arteries, veins, lymph channels, connective tissue cells, intercellular substance, odontoblasts, fibroblasts, macrophages, and collagen and fine fibers. The central areas of pulp chamber contains the large blood vessels and nerve trunks. The pulp chamber is circumscribed peripherally by a specialized odontogenic area made up of (1) the odontoblasts, (2) the cell-free zone, and (3) the cell-rich zone.

The pulp is a specialized organ of human body serving four functions: (1) formative or developmental; is the production of primary and secondary dentin by the odontoblasts. (2) nutritive;

supplies nutriments and moisture to the dentine through the blood vascular supply to the odontoblasts and there processes. (3) sensory or protective; provide sensory nerve fibers within the pulp to mediate the sensation of pain. Dentin receptor are unique because various stimuli elicit only pain as a response. The pulp is usually does not differentiate between heat, touch, pressure, or chemicals. Motor fibers initiate reflexes to the muscles of the blood vessel walls for the control of circulation in the pulp. (4) defensive or reparative; is related primarily to its response to irritation by mechanical, thermal, chemical, or bacterial stimuli. Such irritants can cause the degeneration and death of the involved odontoblastic processes and corresponding odontobalsts and the formation by the pulp of replacement odontoblasts (from undifferentiated mesenchymal cells) that lay down irregular or reparative dentin.

A knowledge of the contour and the size of pulp cavity is essential during cavity preparation. In general, the pulp cavity is a miniature contour of the external surface of the tooth. The size varies among various teeth in the same mouth and among individuals, with advancing age; the pulp cavity usually decreases in size. Radiographs are an invaluable aid in determining the size of the pulp cavity and an existing pathological condition. Also with advanced age, the pulp generally becomes more fibrous because of episodes of irritation and may contain pulp stones or denticles. The later are nodular, calcified masses usually appearing in the pulp chamber but also may de in the pulp canal.

End…..2020