Lecture 15

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Restorative Dentistry and Pulpal Health

Teeth are vital organs; they should be treated with consideration when subjected to operative procedures. The pulp responds very quickly to external stimuli, and the response depends on the severity of the stimuli. The effects of the different operative procedure on the pulp can be subdivided into:

A-Effect of Local Anesthetic on the Pulp

Vasoconstrictors of LA potentiate and prolong anesthetic effect by reducing blood flow in the area. Reduction in blood flow during a restorative procedure could lead to an increase in the concentration of irritants accumulating within the pulp.

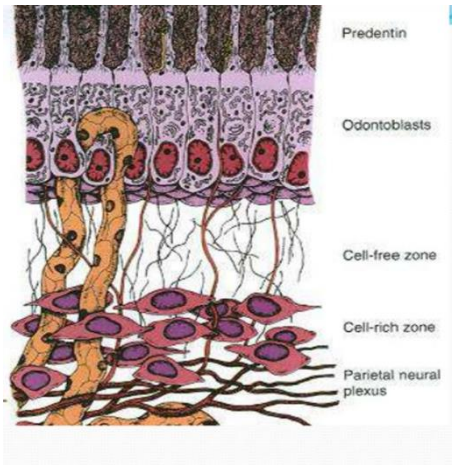
B-Effect during cavity and crown preparation (cutting procedures)

Effects of cutting procedure on the pulp can be divided into:

1- Thermal injury (frictional heat)

Despite low thermal conductivity of dentin, the heat generated by grinding procedures of tooth structure has often been considered as being the greatest single cause of damage, if high temperatures are produced in the deep cavity by continuous cutting without proper cooling, the underlying pulp may be severely damage. Excessive heat generation lead to change in dentin color due to vascular stasis and hemorrhage in sub-odontoblastic vascular plexus present in the pulp.

If the damage is extensive and the cell-rich zone of the pulp is destroyed, reparative dentin may not be formed resulting in generalized cellular degeneration and localized abscess may develop.



Basic factors in rotary instrumentation that cause a temperature rise in the pulp:

a. Force applied by the operator is directly proportional to heat generation.

b. Revolutions per minute (speed of rotation):

The development of ultra-speed (300,000 RPM) and more found to be more traumatic to the pulp than low- speed (6000 RPM) because of increase of frictional heat, but this occur in case if inadequate air water coolant is used. So, it is essential that the development of these high-speed hand pieces should be accompanied by adequate cooling mechanisms to dissipate the heat generated by grinding. Water cooling system is better than air-cooling.

The advantages of a water-cooling system are

(1) reduction of temperature rise

(2) removal of debris

(3) clean vision

c. Size, shape and the condition of cutting tools:

Tungsten carbide much harder than stainless -steel, once the bur dull, there is a decrease in cutting efficiencies and an increase in heat and vibration.

Diamond bur has a full surface contact with the tooth surface so is more heat generation. Bur with longitudinal serration or with a crosscut its better because water can get to the cutting blades easily and this will reduce the heat generation.

d. Duration of actual cutting time:

Intermittent cutting at intervals of a few seconds can reduce the heat generation compared to continuous cutting.

The heat of polishing: the pulp damage caused by polishing the restorations must be considered, especially if we use dry powder. Polishing burs made of rubber created higher temperatures than cup brushes. Continuous polishing using high speed of rotation is associated with greater heat production than intermittent polishing with low speed. This procedure can be considered as a source of thermal irritation during restorative procedures.

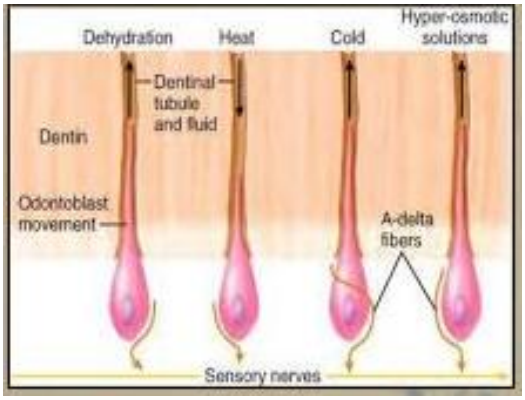
2- Amputation of the odontoblastic processes

Amputation of the distal segment of odontoblast processes is a consequence of cavity preparation, but this quickly followed by repair of the cell membrane. While if the

amputation of the odontoblast process occurs close to the cell body, this will lead to irreversible injury. Also, during cutting procedure there is a disturbs of tight junction between adjacent odontoblasts, thus increasing the permeability of the odontoblast layer and could increase the potential for entry of toxic substances into the subjacent pulp tissue. It has been confirmed that after cavity preparation in rat molars, Apoptosis (the death of cells) of odontoblast occurs, this may indicate a greater impact of surgical phase on the pulpal damage during a restoration in comparison to that of the restorative materials. In humans, postoperatively, the main reparative response of odontoblast to a cavity is the secretion of reactionary dentine.

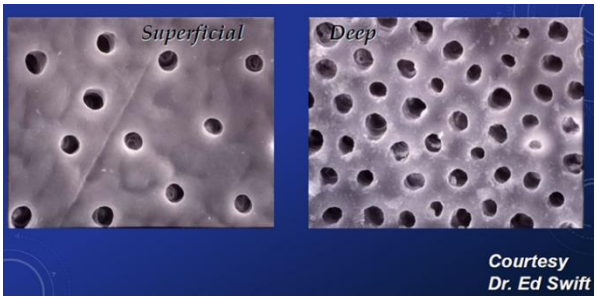
3-Dehydration

When the surface of freshly cut dentin is dried with a jet of air there is a rapid outward movement of fluid through the dentinal tubules. According to the theory of dentin sensitivity, this movement results in stimulation of the sensory nerve of the pulp and drawing odontoblasts up into tubules, these displaced odontoblasts soon die and disappear as they undergo autolysis and result in an inflammatory response. The destroyed odontoblasts replaced by new odontoblast like cells arise from the cell rich zone of the pulp and within 1-3 months reparative dentin formed.



4-Remaining dentin thickness (RDT)

Dentin permeability increases with increasing cavity depth due to the differences in size and number of dentinal tubules. The permeability of dentin is of great importance in determining the degree of pulp injury resulting from the restorative procedures and materials. The distance between the floor of the cavity preparation and the pulp greatly influences the pulpal response to operative procedures and materials. Conservation of the remaining tooth structure is more important to pulpal health than is the replacement of lost tooth structure with cavity liner and base. Also, it has been noted that there is an inverse relationship between the remaining dentine thickness and pulp injury and repair.



5-Pulpal exposure

Exposure of the pulp during cavity preparation occurs in the process of removing carious dentin. Accidental mechanical exposure may result during the placement of pins or retention points in dentin (large pulp chamber, extensive pulp horn even with a shallow cavity). Injury to the pulp appears to be due to the bacterial contamination, so carious exposure results in much more bacterial contamination than does accidental exposure, therefore treatment prognosis is poor with carious exposure. Occasionally a pulp exposure is made unknown to the dentist because there is no bleeding. The first indication of a problem is the patient complaint of pulpal pain when the anesthesia wears off. Treatment of pulpal exposed teeth compared to non-exposed teeth is more challenging in terms of hemorrhage control, identifying and removing infected tissue and loss of dentine barrier, which can maximize adverse effects of pulp capping materials on the pulp.

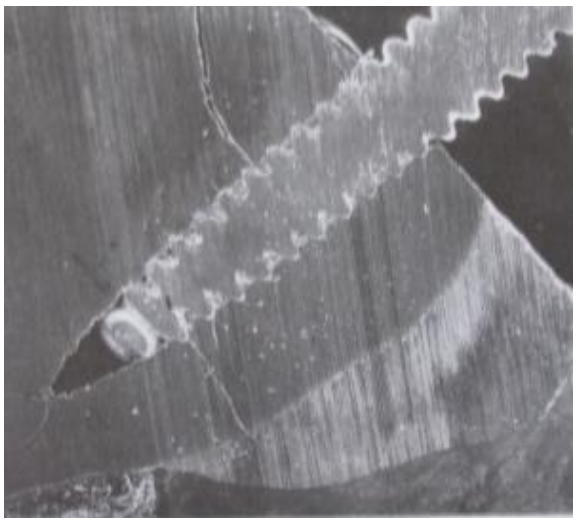
6-Pin insertion

Since the advantages of pin placement into dentin is to support amalgam and composite restoration or as a framework for building up vital badly broken teeth for full crown construction, increase in pulp inflammation and death has been noted. Pin insertion result in

-Heat generation and this will increase the incidence of pulp damage.

-Pins may have been inadvertently inserted directly into the pulp or so close to it that they acted as a severe irritant.

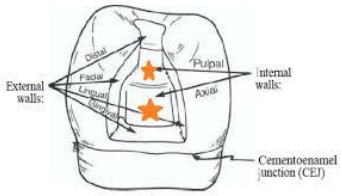
-Craze and stress in dentin during insertion.



C-Effect of lining materials and procedure

- Zinc phosphate cement: the initial cement mixture is highly acidic because of phosphoric acid, although the PH approaches neutrality in a short period of time, newly mixed phosphate cement is highly irritant to the pulp and produce irreversible pulpal damage. (acidity will decrease the blood flow and cause pulpal death).
- Zinc Polycarboxylate cement is less irritant than Zinc phosphate cement, the lower level of irritation may be due to the large molecular size of polyacrylic acid molecules which restricts penetration through dentin and adapted well to dentin and has a bacteriocidal effect.

- Zinc Oxide Eugenol has a palliative effect, PH (7), bacteriostatic and bactericidal, has a good marginal seal. Eugenol, a phenol derivative, is known to be toxic, its capable of producing thrombosis of blood vessels when applied directly to pulp tissue. Because eugenol injures cells, there is a question whether should be used in very deep cavity preparation where there is a risk of pulp exposure.
- Glass ionomer cement: it has been found that GIC has no irritating effect upon living pulp.



-Lining materials should not place on the wall and margins because it dissolves in oral fluid leaving a wide gap between the restoration and tooth and this consider as a source of an irritant.

-The thickness of base materials should be (1-2mm) is an effective barrier against both hot and cold stimuli in a deep cavity.

-Force of cementation: the patient complains of pulp pain when an inlay or crown is finally cemented with ZPC due to chemical irritation of the cement liquid as a factor. But on the other hand, the hydraulic pressure exerted during cementation could not help but drive the fluid toward the pulp that results in separation of the odontoblast layer from the dentin and cause irritation to the pulp.

D-Effect of filling materials and procedure

In resin restoration, the initial toxic shock is so severe, that extensive use of mouth curing plastic as filling and temporary crown might be related to a great number of pulp death.

Composite resins and bonding agents: Resin composites and bonding resin can also cause marked inflammation, damage to the pulp and dilatation and congestion of blood vessels when placed in deep dentin. In fact, compounds such as triethylene glycol dimethacrylate (TEGDMA) and camphoroquinone, 2-hydroxyethyl methacrylate (HEMA) components, which diffuse from bonding resins and resin composites through dentine into the pulpal tissue in small quantities (micrograms) within hours and days after placement, can cause adverse cytotoxic effects on the pulp. The release of unreacted monomer (1.5-5% of the methacrylic group remain unreacted) is because of mechanical, thermal and chemical factors that inhibit complete polymerization, which is enough to initiate a cytotoxic effect.

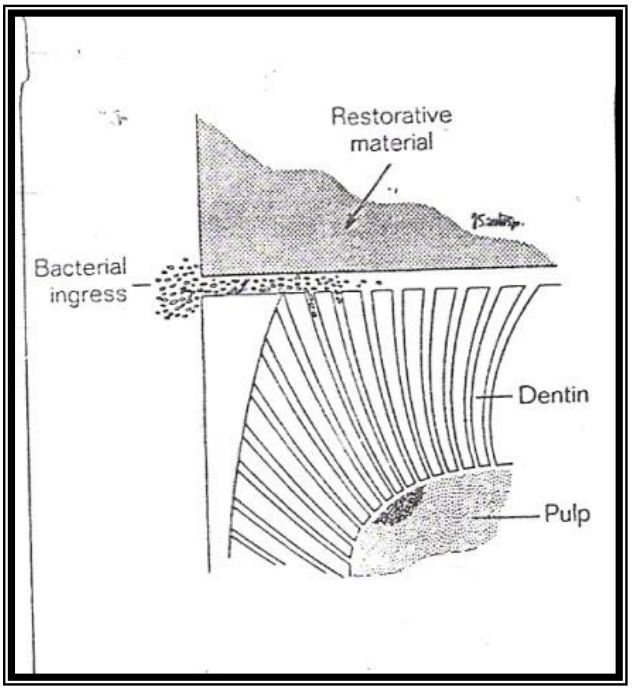
Acid etching: there is no significant effect of the acid on the pulpal microvascular vessels. But the acid etching widens the opening of dentinal tubules that increase the dentin permeability, and enhance bacterial penetration of dentin.

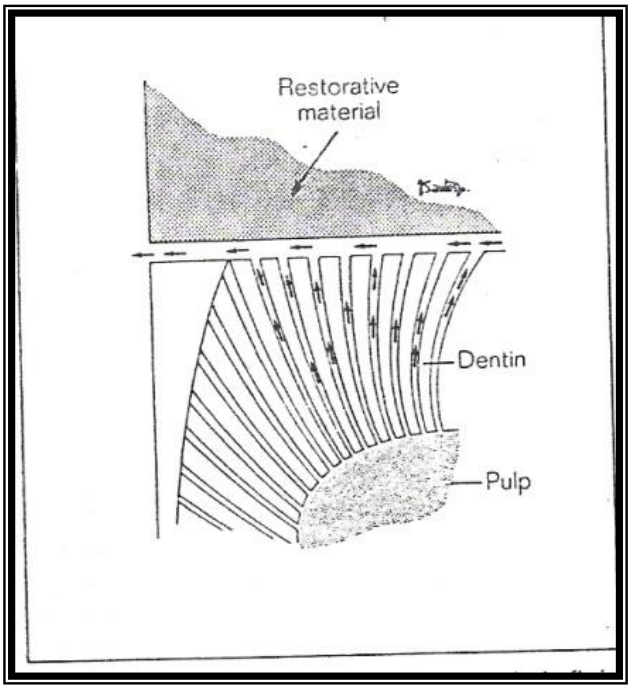
Dental amalgam: Ions such as silver, copper, and mercury, which are released from amalgam, may have an adverse effect on the pulpal tissue by diffusion through dentinal tubules beneath restorations. Because of the unreacted mercury, freshly mixed amalgam is more cytotoxic than set amalgam. Mercury compounds exhibited higher cytotoxicity compared to the resin composite constituents because of the ability of the mercury compounds to interfere with the cellular metabolism and function leading to cell swelling and finally cell death.

Patient, sometime report hypersensitivity following insertion of dental amalgam and this may be related to 1-force of insertion 2-possibility to the expansion of amalgam after insertion.

The pulp may be injured from severe temperature changes induced by thermal energy passing through the metallic restoration. Thus, wherever the cavity preparation is deep and inadequate thickness of dentin is present for thermal isolation, protection by a cement base must be provided.

No permanent filling material has been shown to provide a perfect marginal seal. So, leakage and bacterial contamination are always a threat to the integrity of the pulp.





Bacteria growing beneath restoration will produce toxic products that diffuse through the dentinal tubules and cause inflammatory reactions. adequate liner or cement base should be employed to seal the dentinal tubules before inserting restorative materials, and it's better that these cements have the ability to inhibit bacterial growth (e.g. ZOE, GIC).

Two important factors affecting marginal adaptation: 1-temperature changes, 2-masticatory forces. If a material has a different coefficient of thermal expansion than tooth structure, the temperature change is likely to produce gaps between the material and the cavity. In composite filling, the marginal seal has been improved by acid etching of beveled enamel and the use of the bonding agent or primer. But it has been shown that the initial marginal seal tends to decrease as the etched composite restoration ages.

E-Accumulative effect is the whole irritation that the tooth is subjected to during all this time (carious process, cavity preparation, lining and filling procedure, secondary caries) so the pulp in a continuous process of irritation and inflammation. If there is a small inflammatory process it may be getting worse till the whole pulp involved and become necrotic. This may occur very fast or slowly depending on the severity of irritation, and this may occur without any discomfort to the patient.
Many operative insults can be minimized considerably during routine operative procedures:

- Depth, width and extension of the cavity preparation
- Heat and desiccation damage during cavity preparation
- Chemical injury through use of medicaments (e.g. acid etchants, …etc.)
- Toxicity of liners, bases and filling materials
- Prevention of microleakage