Biological Influences Of Restorative Procedures & Materials On Vital Tooth Tissues

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Introduction

The objectives of operative dentistry are mainly concerned with: →

- Preservation of the integrity of masticatory apparatus.
- Preservation of tooth vitality.
- Preservation of esthetic.

- The success of any restoration depends on the maintenance of healthy pulp and periodontium.
- To know the biological effects of cutting and restorative procedures on dental tissues, a brief study of these tissues is of great importance.

Tooth structures

Enamel

It is the hardest tissue all over the human body.

Functions:

- Protection of dentin-pulp organ against different irritants.
- Maintenance of esthetic appearance of the tooth.
- Fluid exchange through the inter-prismatic substances.

Composition:

- Mushroom shaped enamel rods directed perpendicular to DEJ and the tangent of enamel surface.
- Cementing inter-prismatic substance binding the rods together $\rightarrow$ this is weaker than the rods and can be easily broken by pressure with sharp cutting instruments

Direction of enamel rods:

- In grooves and pits: → They converge over each other and relatively to the long axis of the tooth making right angle to the tangent of enamel surface
- At cusp tips and marginal ridges: → They diverge from each other in cusp inclination then intermingle together at cusp tips and marginal ridges and known as → Gnarled enamel.
- This gnarled enamel gives more strength to the cusp tips and marginal ridges.
- The cusps and ridges meet at grooves and pits, which are, enamel defects in which caries always starts.
- Cavity preparation is facilitated by starting from these enamel defects

Physical properties:

- It is a very brittle tissue, which gains support from dentin.
- If enamel is undermined→ it will be fractured if it is subjected to stresses.
- Undermined enamel, which is not subjected to stresses, will not fracture → e.g. undermined labial enamel of anterior teeth.

Dentin – pulp organ

- Dentin and pulp are considered as one organ because they are related to each other either:
- Embroylogically: → Both are derived from ecto-mesenchymal dental papilla.
- Anatomically: → Tome's fibers, which constitute 1/3 of the dentin structure, are protoplasmic processes of odontoblastic cells, which are the cells of the pulp.
- Physiologically: → Dentin provides protection to the pulp, while the pulp provides nutrition to dentin

a) <u>Dentin:</u>

- Composition:
- Dentinal tubules originating from the odontoblastic cells and contains the odontoblastic process (Tome's fibers) of these cells.
- Calcified collagen matrix investing the dentinal tubules.
- The dentin meets enamel at a scalloped junction where Tome's fibers anastomose together forming the DEJ, which is very sensitive.

Properties:

- It is less calcified than enamel.
- It is a hydrodynamic or visco-elastic structure as the dentinal tubules contain dentinal pulp fluid.
- Dentinal tubules can permeate bacteria and toxins from restorative materials to the pulp.

b) The pulp tissue proper:

It is a special type of C.T. made of: → Cells
Formative: → e.g. odontoblasts and fibroblasts
Defensive: → e.g. histiocytes and lymphocytes
Reverse cells → e.g. UMCs.
Intercellular substance.
Blood vessels.
Nerves: → Free nerve endings which are the receptors of pain.
Lymphatics.

The odontoblasts are the dentin forming cells throughout life.

- After eruption, odontoblasts lay down *secondary dentin*.
- If the pulp is irritated, the odontoblasts will lay down secondary dentin too, which is called → *Reparative dentin*.
- Pulp tissue, while it is recessing, may leave the pulp tissue under each cusp, which is called pulp horns

Influences of restorative procedures on dento-pulpal organ

- Trauma.
- Thermo genesis.
- Speed.
- Pressure.
- Dissection.
- Vibration.
- Pin drilling and insertion.
- Duration of preparation time.

Trauma

- Actual cutting of dentin irritates the dentin-pulp organ.
- Histopathological pulpal response → Aspiration of odontoblastic nuclei into dentinal tubules.
- Cutting of 1mm of dentin exposes about 30,000 – 45,000 dentinal tubules.

Pulp protection:

→ 1. Use sharp burs with intermittent cutting and coolants.

→ 2. Avoid unnecessary over cutting of dentin.

Thermogenesis

Causes: →

1. Friction.
2. Increased pressure.
3. Increased rotational speed.
4. Increased time of contact.
5. Increased area of contact.
6. Absence of coolants.

Histopathological pulpal response

1. Aspiration of odontoblastic nuclei into the dentinal tubules.
2. Irreversible pulpal damage.
3. Necrosis of the cell rich zone.
4. Dentin burns.
5. Dentin charring.

Pulp protection:

1. Avoid using pressure.
2. Avoid using increasing high speed without coolants.
3. Avoid using dull cutting burs.
4. Avoid over cutting of dentin in any dire
5. Use small size burs.

6. Avoid prolonged contact of the bur with the tooth structure.
7. Avoid using rotary instruments in deep cavities, hand instruments are preferable.
8. Carbide burs are better than diamond stones.
9. Avoid cutting across recessional lines of the pulp horns.
10. Use air/water coolants.

Speed

With high speed without coolants → irreversible pulp damage will occur.

With low speed more is needed and more heat generation will result.

The pulpal response will vary according to: →

1.The operative load used.

2. Revolutions per minutes.

3.Diameter of the cutting bur.

4.Temperature rises.

5.Type of coolants used.

Histopathological pulpal response :→

Aspiration of odontoblastic nuclei into the dentinal tubules.

Pulp protection:

1. Never cut dry cavities.
2. Coolants are necessary

Pressure

- Pressure is inversely proportional to speed.
- At conventional speed, pressure of 1.5 pounds is needed, while with high speed, pressure of 1.5 – 2.5 ounces is needed.
- Histo-pathological pulpal response → Aspiration of odontoblastic nuclei into the dentinal tubules.
- Pulp protection: → The use of coolants is necessary with high and low speeds as pressure will generate heat.
- Pulpal irritation starts at 8 ounces.

Desiccation

It means dryness of dentin.

Causes: → :

1. Over heating of dentine
2. Use of chemicals.
3. Air dryness technique.

- Histopathological pulpal responses:

Aspiration of the odontoblastic nuclei into the dentinal tubules.

Pulp protection :

Effective air water spray coolant is to be used to avoid heat generation and subsequent desiccation.

Vibration or eccentricity

It will lead to:

1. Uncontrolled cutting.
2. Heat generation.

Histo-pathological reactions:

- Rebound response → Limited area of pulp necrosis at area remote of the cut dentinal tubules.

- Calcio-traumatic response → Areas of hypocalcified and hypercalcified dentin appears as dark blue dentin near the pulpal surface of the cut dentin.
- Edema, fibrosis and reduction in the pre-dentin layer.

Pulp protection:

Avoid using eccentric rotary tools.

Pin drilling and insertion

Dentin pins seems to stretch the dentin while they are being inserted.

If the pin insertion exceeds the elastic limits of dentin due to: →

a) Using oversized pin.

b) Dull pin.

c) Clogged flutes of the pin.

This will lead to :

a) internal trauma with minute fracture lines.

b) improper pin insertion may lead to pulp exposure.

Cemented types of pins will lead to pulpal irritation due to the cementing media used.

The greater the pin diameter the greater will be the heat transfer from the pin metal to the underlying dentin and pulp.

Duration of the preparation time

The longer the preparation time, the more the irritation to the pulp.

Influences of restorative materials on dento-pulpal organ

1) Cavity varnish:

- The principle function of the cavity varnish is to reduce the microleakage as it provides better adaptation at the restoration / tooth interface.
- So, it provides indirect protection.
- It retards or prevents the corrosive products or metallic ions from amalgam to pass into the dentinal tubules as these ions may retard the reparative power of the pulp.
- It prevents acid penetration from the restoratives as zinc phosphate cement, to pass into the dentinal tubules to the pulp leading to its irritation.

2) Calcium hydroxide:

- It has minimal irritational quality to the pulp at any remaining dentin thickness.
- It has alkaline pH (12), so it has the ability to neutralize the acids of dental cements.
- It induces reparative dentin formation when applied on deep cavities or on cavities with vital pulp exposure.
- It acts as a chemical barrier against the penetration of metallic ions of amalgam restoration into the dentinal tubules.
- It has an antibacterial action.

3) Zinc oxide eugenol cement:

- It has minimal irritational quality due to its eugenol content and good initial sealing.
- The eugenol has bacteriostatic, obtundant, palliative and sedative effect on the pulp → So, it is applied as a dressing to relief pain and discomfort after instrumentation.
- It provides chemical protection for the pulp through its blocking to penetration of irritant constituents liberated from the restorative materials.
- Provides thermal insulation to the pulp but does not induce reparative dentin formation.
- When applied directly on the pulp it can elicit a low-grade chronic inflammatory reaction.

4) Zinc phosphate cement:

- ZPC has an initial low pH on setting (4.2 at 3 minutes) and approximate neutrality only 48 hours later.
- At 3 days moderate to severe localized pulpal damage is developed specially if the cement is applied in deep cavities.
- After 5 – 6 weeks, repair of the pulp takes place.
- Application of ZPC on direct contact with the pulp causes severe pulpal inflammation followed by pulp necrosis.
- The use of protective underlying ZnO/E, cavity varnish or calcium hydroxide is recommended.
- It has good thermal insulation capacity and good chemical protection against metallic ions penetration.

5) Zinc poly-carboxylate cement:

- It causes slight to moderate pulp response at 3 days, and a decreased response at 5 weeks.
- Minimal reparative dentin formation in response to poly-acrylate is noted after 5 – 8 weeks.
- When it is placed on exposed pulp a varying degree of severity has been noted.

The low tissue irritational potential may be due to:

- The rapid rise of pH after setting.
- The large molecular size of poly-acrylate molecule plus its ability to complex with proteins results in limitation of diffusion through the dentinal tubules.
- Poly-acrylic acid has a low toxicity.

6) Glass ionomer cement:

- It is a biologically compatible material due to the mentioned properties of the poly-acrylic acid.
- Mild pulpal reactions may be observed when glass ionomer cement is applied on either hemorrhagic or non-hemorrhagic pulp exposures.
- The reactions will be severe by time intervals.

7) Composite resin:

- It is a highly irritating material to the pulp tissue specially when applied over pulp exposures or in very deep cavities.
- Severe inflammatory reactions associated with abscess formation are observed.
- This high irritational quality may be due to: →
- Chemical make up of the material.
- Micro-leakage due to polymerization shrinkage and the difference in coefficient of thermal expansion between it and the tooth structure.
- The heat generated of visible light curing system
- It is advisable to protect the pulp with calcium hydroxide liner especially in deep cavities before application of composite.

8) Amalgam restoration:

- It has a fair biological compatibility in conventional depth cavities.
- In deep cavities it will show slight irritation due to:

a) Its thermal conductivity.

b) Penetration of Hg ions and corrosive products through the dentinal tubules.

In such cavities, the use of bases and liners are indicated.

- In presence of other metallic restoration, galvanism will also irritate the pulp.

9) ***Cast gold restoration:***

- The gold itself is biologically compatible, but its irritating quality is referred to the cementing medium used to stabilize it inside the cavity.

Factors influencing the pulp response to restorative procedures and materials

1) *The depth of the cavity:*

a) Actual cavity depth: → Depth of the cavity in enamel and dentin → i.e. the distance traveled from CSA to pulpal floor.

b) Clinical cavity depth: → The thickness of dentin bridge overlying and protecting the pulp.

c) Effective cavity depth: → The thickness of dentin bridge following the wavy coarse of D.Ts. from the pulpal floor up to the roof of the pulp.

The deeper the cavity: →

1. The more severe will be the pulpal reaction

2. The more need for hand instruments rather than rotary.

3. The more need for application of liners and bases.

2) The previous condition of the pulp:

- Whether it is inflamed due to caries or not.
- Any type of irritation response will be normal or exaggerated according to the previous condition of the pulp.
- When the pulp is inflamed → rest treatment for the pulp is necessary to give a chance for the pulp to return to its normal healthy condition before starting any restorative procedure.
- Sealing the cavity with ZnO/E as temporary restoration is indicated till pulpal response return to normal

3) ***Condition of the pulpal floor:***

- Whether there is a frank exposure or the depth of the cavity threading pulp exposure

- As a general rule, every deep cavity must be treated as an exposed cavity that requires capping to the pulp with calcium hydroxide liner.

4) The irritational quality of the restorative material:

- The restorative materials vary in their irritational properties.

- So, Proper protection of the pulp is necessary to keep these materials away from near approximation to the pulp