



BIOCOMPATIBILITY OF DENTAL MATERIALS: A REVIEW

Dentistry

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ABSTRACT

Biocompatibility is the ability of a material to elicit a biological response, when applied to the body, without causing a chronic inflammatory reaction, foreign body reaction or toxicity, is related to the interaction of the cell or any biomaterial. There are several biological responses that can occur when a material is placed in contact with living tissue, this response may be inflammatory in nature, allergic, toxic and mutagenic. The use of a non biocompatible material of the dental element can cause an increase in the inflammatory response, leading to cell death and tissue necrosis.

KEYWORDS

Biocompatibility, Immunotoxicity, Irritation, Restorative Dental materials, Sensitization, Toxicity

INTRODUCTION

Biocompatibility aids in ensuring the health of patients and practitioners. Issues related to it can be linked to the legal liability of dentists. A knowledge regarding biocompatibility of commonly used dental materials is important so to critically judge advertising claims by the manufacturers.

DEFINITION

Biocompatibility is "the ability of a material to elicit an appropriate biological response in a given application"^{1,2}. If examined closely, this definition implies an interaction among a host, a material and an expected function of the material. All three factors must be in harmony before the material can be considered biocompatible.

Tests For Evaluation :

Group I tests – consist of cytotoxic evaluation in which dental material in a fresh or cured state are placed directly on tissue culture cells or on membranes that leach through the barriers.

Eg. Genotoxicity test : Mammalian and non mammalian cells. Bacteria, yeast, fungi cells are used to determine whether change in chromosome structure, gene mutation are caused by test materials.

Group II : Secondary tests : The product is evaluated for its potential to create systemic toxicity.

Eg. Oral median lethal dose, irritation, implantation tests. Dermal toxicity.

Group III : Preclinical usage tests : Approval of the product after it has successfully pass the primary and secondary tests on the basis that the product would not be harmful to humans.

Allergic Responses to Dental Materials:

a) Allergic contact dermatitis :

Seen commonly first by primary physicians. It is a skin condition caused by simple chemical insult to the skin. An allergic contact dermatitis associated with monomers of bonding agent frequently involves the distal parts of the fingers and palmar aspects of finger tips.

Allergy to Latex Products :

Hypersensitivity to latex containing products may represent a true latex allergy or a reaction to accelerators and antioxidants used in latex processing. Thiuram is a chemical used in the fabrication of latex articles that has also been reported to cause allergic reactions.

Polyether component: Allergy, Localized rashes, Wheezing, Anaphylaxis.

Allergic Contact Stomatitis :

It is the most common adverse reaction to dental material.

It may be local or at distant site.

Dental material contain many components known to be common allergens, such as chromium cobalt, mercury, eugenol, components of resin based materials, formaldehyde. People who are sensitive to formaldehyde may develop enhanced tissue responses under this condition.

Free residual methyl methacrylate monomer in autopolymerized acrylic dentures can cause allergic reactions (to avoid it, dentures are immersed in water for 24 hours)

Allergic reaction is associated with resin based materials. The polymerization of composite materials is never complete, there is a percentage of reactive groups do not participate in polymerization. The incomplete polymerization of a resin restorative material may predispose to material degradation. Degradation and wear of the materials release components of the resin based materials and these may cause reaction both locally and systemically.

Adverse Reaction:

- Gingival reactions.
- Lichenoid reactions.

Dental Iatrogenesis :

Creation of side effects, problems or complications resulting from treatment by a physician or dentist.

A favourable situation requires that the intensity of a pulp response, if any, should be higher initially and decrease with increasing postoperative time intervals.

In most instances, 2 mm of dentin thickness provides an adequate insulating barrier against traumatic thermal operative techniques and irritating components of most restorative materials.

At low speed handpiece 6000-20,000 rpm air water sprays a cavity preparation 2 mm from pulp elicit minimal pulp lesion. At high speed > 50,000 rpm, with adequate low pressure air H₂O spray, the pulp response is greatly reduced.

Pulpal Reactions To Restorations And Various Restorative Materials:

Some of the properties of materials that might be capable of producing

injury mainly includes ;

- a) Acidity
- b) Absorption of water during setting
- c) Heat evolved during setting
- d) Poor marginal adaptation resulting in bacterial contamination.

Zinc Phosphate Cement:

Acts as a luting agent. Commonly used to retain crowns, inlays, onlays, bridges, orthodontic bands, used as base and temporary restorative material.

ZnPO₄ is considered to be the most irritating of all the intermediary base materials.

- a) Acidity during setting : pH of ZnPO₄ liquid is approximately 2. As soon as powder and liquid are combined, the pH level begins to rise 3 minutes after start of mixing, the pH is approximately 3.5 – 4. The pH then increases rapidly, but still is only 5.5 at 24 hours, it may take 24 hours before neutrality (7) is attained. The pH is lower and remains lower for a longer period when thin mix is employed.

Acidity can be reduced by increasing P:L ratio, increasing surface area of contact with dentin to take full advantage of buffering capacity of dentin.

The others are microleakage, exothermic heat, depletion underlying dentin from part of its calcium content.

Studies have shown that in young teeth in wide open dentinal tubules, the acid from cement can penetrate a dentin thickness as great as 1.5 mm and result in an intense inflammatory response.

Polycarboxylate Cement :

Uses:

Permanent cementation of crowns and bridges, orthodontic bands, stainless steel crowns and for root canal fillings, cement base.

It has excellent biocompatibility, potential adhesion to tooth structure.

Although polycarboxylate cement liquid, is more acidic than ZnPO₄ liquid (1.7), it is neutralized more rapidly during setting process. Polyacrylic acid has relatively high molecular weight, it is restricted from diffusing through the dentinal tubules.

Histological studies reveal that the polycarboxylate cements cause a pulpal response similar to that caused by ZnO eugenol, with a slight to moderate response after 3 days and only mild, chronic inflammation after 5 weeks, regenerative dentin formation is minimal, they are recommended in cavities with intact dentin in the floors of the cavity preparation.

Zinc Oxide Eugenol :

Used as temporary and permanent luting agent, root canal sealer, thermal insulating base, temporary restorative material, periodontal pack.

The reason that ZnO eugenol is a good temporary cement and causes only a mild reaction in pulp is that ;

- a) pH is approximately 7 at the time, they are inserted into the tooth.
- b) It adapts very close to dentin, thus providing a good marginal seal.
- c) Its antibacterial properties inhibits bacterial growth on cavity walls.

When ZnO eugenol comes in direct contact with the pulp tissues, following reaction takes place.

- 1) Chronic inflammation may remain limited, the area will be walled off by fibrous tissues followed by matrix formation, mineralization and bridging of the exposure.
- 2) Chronic inflammation may propagate to involve all pulp and root canal tissues with slow, symptomless necrosis.
- 3) Chronic inflammation may lead to complete fibrosis of pulp and root canal tissues leaving pulp dentin organ susceptible to any irritation and with little or no defense.
- 4) Chronic inflammation may change to acute inflammation leading to necrosis of pulp and root canal tissues.

Eugenol is slightly acidic and produces palliative or obtundant actions on the pulp in low concentration. Since eugenol injures cells, one must use Ca(OH)₂ cavity liner in very deep cavity preparation where there is risk of pulp exposure.

Glass Ionomer Cements :

Used both as luting agent and as a restorative material. They elicit greater pulp reaction than ZnO eugenol but less than ZnPO₄. It contains polyacrylic acids which are weaker than phosphoric acid and possess higher molecular weight that may limit their diffusion through the dentinal tubules.

However the luting agents pose a greater hazard because of lower powder : liquid ratio 1.25 – 1.5 g/ml of liquid and a slower setting reaction. Post operative sensitivity has been associated with cementation of full cast crowns. It has been suggested that the hydraulic pressure generated during seating may force some of liquid into the dentinal tubules.

At the time of initial mixing, the cement is highly acidic and have the potential to produce post operative sensitivity and pulpal irritation. The final pH value reaches 6-7. Pulpal studies indicate that glass ionomer cements cause a mild, inflammatory response which is normally resolved in 30 days.

Silicate Cements :

The pH of the liquid is less than 2 and may be as low as 1. After the liquid and powder are mixed and material is ready for insertion, the pH is less than 3 and remains below 7 even after 1 month.

Silicate cement is highly irritating to pulp. The pulps of younger persons are more likely to react severely to these cements than the pulp of older persons.

A non-irritating base, such as ZnO eugenol should be used under silicates.

When Ca(OH)₂ comes in contact with the pulp tissues, the layer of tissue that it contacts directly will undergo chemical necrosis (Coagulation). To anticipate a favourable pulpal reaction, the following criteria must be met ;

- a) the pulpal tissue must exhibit no signs of degeneration and have sufficient vascularity, cellularity.
- b) Ca(OH)₂ must not be pushed inside the pulp chambers and root canal space, thereby increase the area to be bridged by reparative dentin.
- c) The microbial status at exposure site cannot be controlled.

If these criteria are fulfilled, the pulp tissue next to coagulated surface area in contact with Ca(OH)₂ will deposit an organic matrix which will mineralize within 4-6 weeks.

Filled and Unfilled Resin :

Irritating agents

- 1) Residual monomer
- 2) Exothermic heat of polymerization
- 3) Leakage, especially when accompanied by marginal percolation
- 4) High coefficient of thermal expansion
- 5) Enamel etching acids acidulating applied on dentin.

Although, they produce a less severe inflammatory reaction of the pulp, they require use of Ca(OH)₂ or GI cavity liner as resins are irritants.

The acid etchant appears to open dentinal tubules and permits greater penetration of low viscosity bonding agent with potentially irritating low molecular weight monomer.

Amalgam :

Residual mercury can diffuse from the restoration to the surrounding dentin. Use of radioactive mercury in silver amalgam has also revealed that some mercury might even reach pulp. Such mercury has been reported to poison odontoblasts, subsequently reducing predentin and secondary dentin formation.

Endodontic Procedures :

Percolation of periradicular exudates into incompletely filled canals is the greatest cause of endodontic failure. It is presently speculated that the transudate constantly leaking from partially filled canals arises indirectly from blood serum. The serum is trapped in cul de-sac of poorly filled canal, away from influence of blood stream in which it undergoes degradation. Later when the degraded serum slowly diffuses into periradicular tissue, it acts as an irritant to produce

periapical inflammation.

CONCLUSION:

As dental materials remain in intimate contact with living tissues for long periods the knowledge regarding the biocompatibility of the used dental material is of utmost importance to the dentist. Ultimately, each dentist must determine whether the benefits outweigh the risks for the patient under consideration.

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