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A REVIEW ON TOXICITY OF DENTAL MATERIALS WITH AN EMPHASIS

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ABSTRACT

In dentistry, different types of materials are used to restore the decayed or to replace the missing teeth. These materials come into direct contact to the hard and soft tissue of oral cavity including dentin, periodontium, oral mucosa and body fluids. Though all these materials with long history of usage are tested for their biocompatibility in the oral cavity. Any adverse reactions due to the leaching of components from these dental materials into the oral environment is a clinical concern. The materials ranging from temporary to permanent or polymers to metals have different applications in dentistry. Besides their important role in restoring, healing or improving the function of oral tissues, the materials may show side effects which may lead to severe lesions or more serious illness. This review provides a comprehensive overview of side effects and toxicity by various materials in Dentistry. The side effects of the materials are discussed here based on clinical and cellular views.

INTRODUCTION:

Ideally the accepted fact is that a biocompatible biomaterial is a substance that does not elicit any adverse effects when it is implanted into the body because it is inert.[1] Preferably, a dental material used in the oral cavity should not interact negatively with or harmful to oral or dental tissue.[2] The dental material should not contain any toxic diffusible ingredients that may enter the circulatory system to cause any systemic or allergic response. It should be free of agents with any carcinogenic properties. [3,4] But a single material may not be biologically acceptable in all applications.

Over the time, the material may show many physical and mechanical changes including leaching out ingredient from restoration, long-term degradation, mechanical strength problems, and failure for secondary caries prevention. [4] Mainly when the oral release of compounds from materials occurs with adverse reactions may lead to contact allergies in allergically vulnerable patients. [5] The literature has documented many studies on the potential allergies from materials including mercury from silver amalgam filling, heavy metals in removable a partial denture, impression materials and irrigation materials used in endodontics. Despite being exposed to potential allergens and toxic substances, the oral mucosa seldom shows inflammatory and allergic reactions. [6] In addition, wounds and lesions heal faster in the oral cavity compared to skin. This is proved to be due to diminished inflammatory response in the oral mucosa. It is therefore strong reasons to believe that the immune system of the oral cavity helps to diminish the degree of reactions to materials. to dental materials are unwanted reactions, either subjective or objective. [7] An adverse reaction can be of allergic, toxic or psychological origin. An unwanted biological reaction can further be local (e.g. contact dermatitis) or general (systemic, for example a hormone-effect).

Contact dermatitis

Contact dermatitis on a cellular level can be divided in mostly two categories: Allergic or toxic (irritative). Allergic Contact Dermatitis is of allergic type IV origin while an irritative contact dermatitis is a non-immunological reaction with direct cell damage followed by an inflammatory reaction Allergic contact dermatitis in dental personnel is predominantly confined to hand dermatitis (Figure 1), while patients with ACD to dental materials tend to experience stomatitis or cheilitis (type IV allergy) or contact urticaria with or without dissemination (Figure 2).[8] The manifestations of Contact dermatitis are itching or burning sensation at site of contact followed by erythema and appearance of the vesicles which may rupture to lead secondary infection. Contact stomatitis or stomatitis venenata are known oral manifestations of contact dermatitis including edematous mucosa along with severe burning sensation. [9]

Clinically it can be impossible to distinguish the different types of reactions without a deeper anamnesis or allergy test. The situation could arise when there is direct contact between body surface with allergen like Monomers of bonding agents, Acrylic component of dental cements, Nickel from orthodontic wires, Resin monomers, Latex gloves and Amalgam etc.[10]

Figure 1: Allergic Contact Dermatitis in Dental Personal

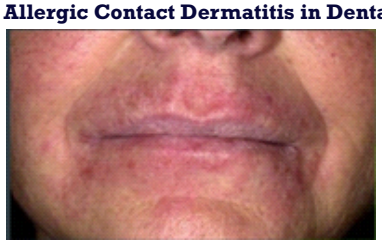

Figure 2: Contact Dermatitis in Patient

Genotoxicity

Genotoxicity is the ability of a material to break down or mutate DNA. Genotoxicity may have triggered by certain types of radiations used in diagnosis and also certain chemical compounds used in Dentistry. A genotoxic material is considered carcinogen because of its abilities to change DNA expression.[11]

Amalgam tattoo: A grey, bluish-grey or blackish patch found on buccal mucosa, gingiva or palate adjacent to an amalgam restoration is known as Amalgam tattoo. This pigmentation is usually painless and benign, can be misdiagnosed as melanoma (figure 3). [12] The main cause of this lesion is the implantation of amalgam into the tissues that may occur while filling the tooth, during the removal of amalgam restoration or while extracting a tooth with amalgam restoration where the bur or instrument containing amalgam particles accidently enters into the adjacent mucosa leaving a blue metal spot.

Beside this, there are several side effects of amalgam fillings attributed to Mercury as its main ingredient. Mercury

poisoning also known as hydrargyria or mercurialism, is a disease caused by exposure to mercury or its compounds with resulting side effects include damage to the brain, kidney, and lungs and several diseases, including acrodynia (pink disease), Hunter-Russell syndrome, Minamata disease etc.[13]

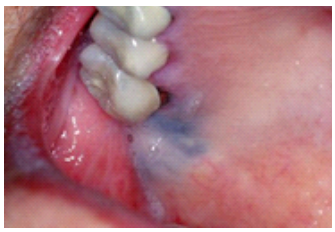

Figure 3: Amalgam Tattoo

Lichenoid reaction: Lichenoid lesion is a skin reaction associated with any systemic disease, use of a food flavouring agent, administration of a drug or by contact with a metal. In figure 4, oral lichenoid reactions/lesions involving buccal mucosa with direct contact with amalgam restorations has been shown.[14]

Figure 4: Lichenoid reaction due to Drug reaction

Contact stomatitis: Stomatitis means a sore mouth whereas contact stomatitis presents as inflammation or pain of oral mucosa due to allergic substances and irritants such as heat, frictional trauma, or chemicals. Even oral flavouring agents like cinnamon or peppermint, preservatives, and dental materials may act as allergens.[15] Dental materials with documented history of contact stomatitis includes:

- Mercury in amalgam restorations
- Metals like nickel, palladium, gold, mercury, zinc in crowns and bridges
- Formaldehyde, acrylate monomer or free monomer in acrylic in Dental prostheses
- Eugenol in packs or dressings and temporary restoration
- Latex in gloves and rubber dams
- Nickel in orthodontic wires.

Contact stomatitis occur as a complication of delayed hypersensitivity reaction when low molecular weight antigens penetrates into the mucosa to combine with epithelial-derived proteins and form haptens that bind to Langerhan's cells migrate to the regional lymph nodes. This help to expose the already sensitized antigen to T lymphocytes for clonal expansion.[16] The oral mucosa is with good vascularity and has less keratin than skin so it provides rapid removal of potential antigens penetrated into mucosa even before occurring any allergic reaction and presents with decreased the possibilities of haptens formation.[17]

Geographic lesions: Geographic tongue is an inflammatory disorder, also called as erythema migrans, benign migratory glossitis, erythema areata migrans or stomatitis areata migrans. It is a common benign condition with a typical appearance of affected tongues with a bald, red area of varying sizes surrounded by an irregular white border mainly affecting the dorsal surface of the tongue. The conditions are usually asymptomatic, but patients may experience burning in the mouth. Several factors have been proposed to causes such as emotional stress, psychological factors, habits, diabetes and hormonal disturbances. However, allergies reactions by metal material as amalgam, gold or orthodontic wires has been documented causing geographic tongue.[20]

Recurrent aphthous stomatitis (RAS): Recurrent aphthous stomatitis is a disorder formed by combination of term "aphthous" that is a Greek word means ulceration. It is one of the most common painful oral mucosal conditions seen among 20-30% of adult patients. The ulcer is recurrent, may be present as multiple or single, large or small, round or ovoid ulcers with circumscribed margins. There is a numerous factor responsible for occurrence such as stress, vitamin and mineral deficiencies, trauma, Crohn's disease and allergies may cause recurrent ulcers. The current concept is that this clinical syndrome may include heredity, hematologic deficiencies, and immunologic abnormalities. A restoration with rough surface or sharp edges, sonium hypochlorite used during root canal treatment and sodium lauryl sulfate in toothpaste are also responsible etiologic factors in RAS development.[21]

Dental materials and related Toxicity:

Dental materials have been classified in many ways depending upon the usage. Dental materials also may be classified as provisional and permanent dental materials based upon the time of their application (Table 1). The provisional or temporary dental materials are used for a short period of time during treatment usually to heal the tissue or to improve the function.[22] Whereas, the permanent dental materials are often used to replace a tissue or restore its function on permanent basis.

Table 1: Classification of Materials used in Dentistry with potential Toxicity

PERMANENT DENTAL MATERIALS
Restorative material: Amalgam, composite, resin cements
Reconstructive material: Denture Base, Implants
Appliances: Denture with metal base, Metal or Metal Ceramic Crowns, Removable Partial Dentures
PROVISIONAL DENTAL MATERIALS
Therapeutic material: Medicines, Mouth washes, Toothpaste, Chewing Gums, Food Additives, Dentifrices
Devices: Brackets, Orthodontic Plaque, Wires, Space maintainor
Impression Materials, Gloves

Amalgam restoration with mercury toxicity: Amalgam filling or silver filling are considered be the oldest and most commonly used type of restoration for restoring a decayed tooth. Fleischmann in 1928 had reported the first case of dental metal allergy associated with amalgam restorations in the oral cavity that resulted in stomatitis and dermatitis around the anus of the patient. Till date, a numerous study has investigated the mercury toxicity in amalgam restorations and still under process. The amalgam restoration consists of 50% mercury along with a combination of silver, tin, and copper. Studies have found that the amount of mercury vapor in amalgams may varies from 1- 3 ug/day (micrograms/day), on an average up to 27 ug/day.[23] Mercury is a powerful neurotoxin which may cause neurological disturbances, autoimmune disease, chronic illnesses or mental disorders.[24]

Composite and resin restorative Materials: Even though resin-based restorative materials are considered safe but their constituents may leach out to cause allergic contact stomatitis specifically in patients with mild gingival or mucosal erythema. With composite resin material the development of lichenoid reactions in the oral mucosa has been reported most commonly. This could be attributed to formaldehyde formation in resin composite restorations causing more than one third allergic reactions in Dentistry.[25]

Resin Cements: Even though dental resin composites have improved their physico-chemical properties, the concern for its intrinsic toxicity remains high. Some components of

restorative composite resins are released in the oral environment initially during polymerization reaction and later due to degradation of the material. During exposure to oral environment, biodegradation of resin composite materials can also be induced by fatigue, washing effect of saliva, thermal changes and microbial interactions.[26]

Denture base Resins: Denture base resins are extensively used in dentistry that can be classified as chemical, heat, light, and microwave polymerization materials depending upon the factor which starts the polymerization reaction. Their applications include use during denture base construction, relining existing dentures, temporary crowns and for fabrication of orthodontic removable appliances. Constant contact of saliva with the material cause's expansion of the openings present between the polymer chains causing the unreacted monomer to diffuse out. Thus, the substances which are leached out from the denture bases into the saliva are transferred to the oral structures causing adverse allergic reactions. [27] The most common and frequently reported a problem with the patients having allergic reactions to denture base acrylic resin is mouth soreness and burning sensation. Areas presenting with burning sensation include the palate, tongue, oral mucosa, and the oropharynx.[28]

Dental implants: Dental implants are considered as future of Dentistry including Titanium, Vanadium or metal implants with heavy metals such as beryllium (Be), cobalt (Co), chromium (Cr). These metals can lead to acute and chronic toxic effects by causing cytotoxicity to macrophages and fibroblasts that can be bound by iron proteins (ferritin and transferrin) affecting its distribution and accumulation in the body. This may lead to local and systemic reactions inhibiting the cellular proliferation with kidney lesions. [29]

Rubber Latex: Nutter in 1979, first reported the case of latex allergy. The most common risk of population for latex allergy has been documented highest among children with spina bifida followed by healthcare workers wearing latex gloves and then in patients who have underwent surgery before one year of age and with latex-fruit syndrome.[30] The allergic reactions to latex vary from stomatitis to airway compromise and may be immediate or may take hours to develop and, if severe, may last up to 10 days. Even the use of dental rubber dam has been reported to cause angioneurotic and delayed hypersensitivity.[31]

Eugenol containing restorative and impression Materials: Eugenol is derived from clove oil and a well-known irritant to induce type IV hypersensitivity reactions and anaphylactic reaction. Eugenol is used in dentistry in many forms including temporary restorative material in combination with zinc oxide, as a cement for coating obturation material, as toothache drops, periodontal pack after surgeries and impression material for denture production. Eugenol being highly soluble which is continuously released from zinc oxide eugenol paste lead to oral environment saturated with eugenol to cause cytotoxicity. Thus, eugenol containing periodontal packs used to be applied on open mucosal surgical site is unpopular these days.[32]

Impression Materials: The cytotoxicity has been commonly documented with polyether and vinyl poly siloxanes impression dental materials. Allergic reactions documented with polyether impression materials manifests as itching, swelling and redness. Alginate and polysulfide rubbers impression materials containing lead peroxide has found to be producing severe toxic reactions than hydrocolloid and polysulfide without lead whereas silicone and newly formed polyether are producing mild skin reactions. An impression material needs to be mixed thoroughly to give a homogenous mix to minimize the contact of aromatic sulfuric ester catalyst paste with the skin or mucosa that is found to elicit adverse tissue reactions and contact allergies. [33]

Local Anaesthetic agents:
Earlier the ester group in local anaesthetic agents included tetracaine, benzocaine and procaine which were well known for their sensitizing potential. However, since 1983, tetracaine has been proven as most common contact allergen. Thus, currently newer amide local anaesthetic agents like lignocaine, prilocaine, mepivicaine, and bupivicaine are used by the dentists which causes minimal allergic reactions.[34]

Local anaesthetics may lead to psychogenic reactions, allergic reactions, toxicity and even paresthesia to administrated patient. The most common psychogenic Reactions by Local anaesthesia includes anxiety induced reactions and syncope. In addition, it may cause various symptoms like hyperventilation, nausea, vomiting and alterations in heart rate or blood pressure with signs such as edema, urticaria and bronchospasm.[35]

Toxicity to local anaesthetics are because of its systemic absorption in body which initiates with neurological signs such as sedation, light-headedness, mood alteration, muscle twitching, slurred speech, diplopia and sensory disturbances which later may progress to tremors, respiratory depression, tonic–clonic seizures and may end up with coma, respiratory or cardiac arrest.[35]

CONCLUSION:

A single material may not be biologically acceptable in all Dental applications. The side effects may include a small lesion in oral cavity to a life-threatening situation ranging far from the application place of the materials or near. Dental materials may be categorized in provisional or permanent materials with their related side effects depending upon the quality and quantity of ingredients.

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