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Biohazards Associated with Materials Used in Prosthodontics: A Comprehensive Review

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Abstract
Prosthodontics is a vital branch of dentistry that restores oral function, aesthetics, and health through biocompatible materials. However, these materials can pose biohazards to patients, dental practitioners, and the environment. This review provides an in-depth analysis of the biohazards associated with commonly used prosthodontic materials, including metals, ceramics, polymers, and composite resins. Additionally, it explores risk mitigation strategies, emphasizing biocompatibility, safe handling, and environmentally responsible disposal practices.

Keywords: biohazard, aesthetics, materials.

Introduction

Prosthodontics enhances the quality of life for individuals with missing teeth and oral defects by utilizing a diverse range of materials, including metals, polymers, ceramics, and composite resins. However, these materials present potential risks due to their chemical composition, manufacturing processes, and long-term degradation. This review examines these hazards and proposes measures to minimize their impact.
Various Biohazards are classified as:

1. **Physical Hazards**

a) Physical trauma
b) Fire and burns
c) Acoustic trauma
d) Eye damage

2. **Based on the materials/ Chemical Hazards**

a) Dental Materials (Impression materials, Dental waxes, Dental cements)
b) Metallic materials and their associated Biohazards (Alloys)
c) Polymers and Composite resins and their associated hazards (Methyl methacrylate)
d) Ceramic materials and their associated hazards

e) Latex gloves
f) Lab fumes

3. **Environmental/ Biologic Hazards**
4. **Acoustic Injuries**
5. **Ergonomic Hazards**
6. **Psychosocial Hazards**

1. Physical Hazards:

Physical hazards associated with prosthodontic practice include direct physical trauma, fire and burns, acoustic trauma, eye damage and various problems associated with bad working posture. The direct physical trauma includes accidental skin cuts, abrasion which is mostly due to the misuse of instruments and equipment's. This kind of trauma can act as portal entry for infections or toxic materials.

2. Based on the materials/ Chemical Hazards:

Prosthodontists deals with new materials every day. A wide variety of materials are available used in dentistry today. Most chemicals and materials used in clinical prosthodontic practice and in the laboratory have harmful effects when ingested or inhaled. They may act locally,
systemically having immediate or delayed effect.

a) Dental Materials

- **Irreversible hydrocolloids**: It consist of about 60% of diatomaceous earth. These particles of less than 3 µm in diameter and greater than 20µm in length can be inhaled while manipulation and may prove to be carcinogenic over a long time span. So dust free and lead free alginate materials should be used.
- **Elastomeric impression materials**: Roberta et al. tested polyether and vinyl polysiloxanes for cytotoxicity and showed polyether to be more cytotoxic than vinyl siloxane

Dental wax is one of the most commonly used material for construction of appliances in prosthodontic dentistry. Skin irritation and dermatitis can be induced by prolonged handling of some materials such as paraffin, beeswax, carnauba wax.

In Dental Cements, Eugenol is one of the most cytotoxic and allergic substances known used in dentistry. Clinical reports have indicated high frequency of postulating sensitivity with Glass Ionomer cements. A recent clinical study of pulp sensitivity following cementation with zinc phosphate and glass ionomer cements showed less sensitivity to zinc phosphate than glass ionomer during the first 2 weeks, but after 3 months there are no differences. Modern resin based luting cements are also well tolerated to pulp.

An alkaline solution of potassium cyanide and silver cyanide is commonly used for electroplating of polysulphide and other elastomeric impression materials. Cyanide is known harmful agent to the body and if it comes in contact with acids by any chance will lead to production of hydrogen cyanide gas which is potentially lethal. These solutions should be kept away from all acids and if avoidable silver plating of impressions should be discouraged.

b) Metallic Materials and Their Associated Biohazards

Metals are widely used in prosthodontics for frameworks, crowns, and implants due to their strength and durability. However, they also pose significant risks:

- **Nickel-Based Alloys:** Commonly used for affordability and mechanical properties, nickel is a known allergen that can cause hypersensitivity reactions in susceptible individuals.

- **Chromium-Cobalt Alloys:** While these alloys offer excellent corrosion resistance, chromium ions released during corrosion can be toxic and potentially carcinogenic.
- **Titanium:** Titanium is highly biocompatible but can release particles during machining or wear, leading to inflammatory responses or implant failure.

c) Polymers and Composite Resins

Polymers and composite resins are essential in prosthodontics but may present chemical hazards:

- **Methyl Methacrylate (MMA):** A widely used denture base material, MMA is a potent irritant that can cause allergic reactions and respiratory issues in dental professionals. Methyl methacrylate enters body in vapour form during inhalation or from direct contact through skin. Most common side effect is irritation to eyes, skin, throat, lungs or even our nervous system. Methyl methacrylate vapour in the air at the level of 125 ppm may cause teary eyes, sore throat and coughing. Direct skin contact can cause itching, burning, redness, swelling and cracking of the skin. There are various reports that prolong skin contact with MMA may cause tingling, numbness or whitening of the fingers. Overexposure to MMA can affect our brain and symptoms include headache, drowsiness, nausea, weakness, fatigue, irritability and dizziness.
- **Bisphenol A (BPA):** Found in some composite resins and sealants, BPA is a potential endocrine disruptor with systemic health implications.
- **Residual Monomers:** Incomplete polymerization can lead to the leaching of residual monomers, which may irritate oral tissues and pose systemic risks.

d) Ceramic Materials

Ceramics offer aesthetic and mechanical benefits but are not risk-free:

- **Silica Dust:** Grinding or polishing ceramic restorations generates silica dust, which can cause respiratory issues if inhaled.
- **Fracture Risks:** Fractured ceramic particles can cause irritation or injury to soft tissues.

e) Latex gloves

Latex gloves are more often used in dental practice. They are dusted with cornstarch powder which is often allergenic and give immediate allergic reactions. In vitro evaluation of natural latex, synthetic rubber and polymeric glove material showed various degrees of cytotoxicity. Nitrile gloves or polyvinyl gloves should be used which possess lesser risk.

4. Environmental Biohazards

Improper disposal of prosthodontic materials contributes to environmental pollution:

- **Metal Waste:** Non-biodegradable metal waste can accumulate in landfills.
- **Acrylic Resins:** Resistant to degradation, acrylic resins contribute to long-term environmental impacts.
- **Chemical Waste:** Improper disposal of adhesives and polishing agents can contaminate water sources and harm aquatic life.

Bacterial contamination from spatter and aerosol dissemination generated at high speed instrumentation remains as a significant risk to dental personnels. Apart from the microorganism contamination, the composition of the aerosol produced is also great concern. The size of particles ranges between 2 to 30 µm and can lead to many respiratory ailments as they can reach to alveoli.

Other possible sources of infectious contamination are dental unit waterlines, hand pieces, saliva ejectors,

suction tubes, aerotors and hand pieces and radiological instruments. Dental unit waterlines pose as a threat as it may harbour opportunistic and respiratory pathogens
such as Legionella species, mycobacterium species and Pseudomonas species.

4. Acoustic Injuries:

Dentist had always been an occupational interest in the subject of of Noise Induced Hearing Loss (NIHL). This is due to use of high speed turbine dental drills used during surgeries, Ultrasonic instruments, high velocity suctions, cleaners, model trimmers etc. They emit
sound ranging from 66 db. to 91 db.
Loss of hearing and tinnitus are the common side effect of noise beyond the permissible levels in a setup. Risk depends upon the susceptibility of a particular individual, total daily exposure and type of instruments used. Ear protection should be worn during the
procedures and hearing test at least once a year should be recommended.

5. Ergonomic Hazards:

Ergonomic hazards constitute a physical factor within the environment that harms the musculoskeletal system. Dental professionals are commonly affected with musculoskeletal disorders in their career. Common symptoms of MSD's are presence of discomfort, disability or persistent pain in joints, muscles, tendons and other soft tissues.
Prosthodontists are at high risk of neck and back problems due to limited work ared associated with oral cavity. These working restrictions cause them to assume stressful body positions to achieve good access and period of time which in turn lead to symptoms like low back pain, stiffness, tingling sensation and paraesthesia and muscle weakness. Repetitive and forceful use of vibrating tools increases the fluid accumulation and inflammation. This can be minimized by at least 6 minute of rest from work every hour, proper ergonomic dental unit design, Personalized rehabilitation exercises, regular stretching and aerobic activities.

6. Psychosocial Hazards:

Dentist encounter numerous sources of professional stress, beginning in the dental clinic. Important risk factors contributing to stress among dentists are coping with difficult or uncooperative patients, over workload, constant drive for technical perfection, underuse of skills, challenging environment and low self-esteem. Various physical and emotional demands result in physical and mental burnout. Stress management workshops, deep breathing exercises, relaxation, hypnosis and desensitization techniques help to manage
these psychosocial hazards

Strategies for Risk Mitigation

To minimize risks associated with prosthodontic materials, the following strategies should be adopted:

- **Material Selection:** Prioritize biocompatible and hypoallergenic materials with validated safety profiles.
- **Safe Handling Practices:** Implement protective equipment use and proper ventilation during material processing to reduce exposure.
- **Patient Education:** Inform patients about potential material risks and involve them in treatment decisions.

- **Disposal Protocols:** Adhere to local regulations for material disposal and implement recycling programs.
- **Advancements in Material Science:** Support research into biocompatible, sustainable materials with minimal environmental impact.
- **Digital Dentistry:** Utilize CAD/CAM workflows to minimize material waste and improve efficiency.
- **Collaboration with Industry:** Partner with manufacturers to develop eco-friendly packaging and materials.

Future Directions

Ongoing advancements in prosthodontic materials and practices aim to enhance safety and sustainability:

- **Biodegradable Materials:** Research into biodegradable polymers and resins seeks to replace traditional non-biodegradable options.
- **Smart Materials:** Materials that respond to environmental stimuli, such as self-healing composites, can improve durability and safety.
- **Regulatory Frameworks:** Strengthening international safety and sustainability regulations is essential for ensuring best practices.
- **AI in Material Design:** Machine learning can accelerate the discovery of safer and more sustainable materials.
- **Education and Awareness:** Integrating environmental and safety considerations into dental education fosters a new generation of sustainable practitioners.

Conclusion

While prosthodontic materials have revolutionized oral rehabilitation, their potential biohazards must be acknowledged. Awareness of these risks and adherence to best practices can safeguard patients, dental practitioners, and the environment. Continuous research and innovation in material science promise a safer and more sustainable future for prosthodontics.

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