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Residual Monomer Induced Occupational Dermatitis from Acrylic Denture Base Resin: A Case Report

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KEYWORDS

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ABSTRACT:

Acrylic resins are indispensable materials in prosthodontics, primarily used for denture bases and temporary restorations. Despite their widespread use, exposure to unpolymerized monomers and degradation by-products can provoke allergic reactions among dental professionals. This case report presents a clinically documented episode of allergic contact dermatitis in a prosthodontist following repeated occupational exposure to heat-cured polymethyl methacrylate (PMMA) resin. Characteristic erythematous lesions appeared within 30 minutes of exposure, intensifying over the subsequent two hours. The report emphasizes the need for awareness, early recognition, and preventive strategies among dental professionals frequently handling acrylic-based materials.

1. Introduction

Acrylic polymers have been a cornerstone of dental materials science for many decades, primarily because they combine favourable biological, physical, and mechanical characteristics that meet the demanding requirements of the oral environment. From a biological standpoint, well-processed acrylics are generally biocompatible and exhibit minimal toxicity when properly cured, allowing them to coexist with oral tissues without provoking significant adverse reactions. Physically, they demonstrate excellent chemical stability and dimensional reliability, meaning they resist distortion or degradation when exposed to the temperature fluctuations, moisture, and pH changes of daily mastication. Mechanically, acrylics offer a balance of strength and resilience sufficient to withstand the functional stresses of chewing, while remaining light enough to avoid patient discomfort.

An additional advantage is their straightforward manipulation: acrylic resins can be mixed, molded, and polymerized with ease, enabling precise adaptation to individual anatomical features. Should a prosthesis fracture or lose fit, the material can be repaired or relined chairside or in the laboratory with predictable results. Their comparatively low cost further enhances their appeal, making them accessible for a wide range of patients and helping to afford a quality treatment in manageable expense. These combined benefits explain why, despite the introduction of newer high-tech polymers and ceramics, acrylics remain foremost choice in everyday prosthodontic practice, even though they are not flawless materials and may release small amounts of residual monomer or undergo surface wear over time.

The clinical applications of acrylic resins are remarkably diverse. They form the foundation for complete and partial denture bases, where their ability to mimic the color and translucency of natural gingiva is valuable. Routinely used for relining and repairing existing dentures, for fabricating obturators to close palatal defects, and for constructing maxillofacial prostheses that restore facial form after trauma or surgery. Beyond traditional prosthodontics, acrylics serve in orthopaedic and facial appliances, protective splints, and removable orthodontic devices such as Hawley retainers or functional appliances. In restorative dentistry they appear as veneering materials and in the fabrication of provisional crowns and bridges, providing esthetics and function during the interim between tooth preparation and placement of the final restoration. Acrylic is also the material of choice for individual impression trays and occlusal record bases, which require accurate adaptation and easy customization. Soft, plasticized acrylic formulations are used as tissue conditioners to cushion traumatized mucosa and to assist in the treatment of denture-induced inflammation. Specialized acrylic cements and resins serve as luting agents for the permanent bonding of certain fixed prostheses.

Chemically, most dental acrylics are based on poly methyl methacrylate (PMMA), a polymer formed through addition polymerization of the methyl methacrylate (MMA) monomer. This polymerization can be activated by heat, chemical catalysts, or light, depending on the product and clinical indication. To tailor properties such as flexibility, impact strength, or resistance to crazing, manufacturers may incorporate alternative or additional monomers, including butyl methacrylate (BuMA), ethyl methacrylate (EMA), and urethane dimethacrylate (UDMA). Cross-linking agents like ethylene glycol dimethacrylate (EGDM) are frequently added to improve dimensional stability and reduce water sorption, enhancing the longevity of the final prosthesis. These chemical modifications allow clinicians and technicians to select from a spectrum of acrylic materials optimized for specific applications, balancing esthetics, function, and patient comfort.

This report describes a clinically verified case of allergic contact dermatitis caused by occupational exposure to heat-cured PMMA resin in a prosthodontist, highlighting diagnostic considerations, preventive measures, and the need for safer workplace protocols.

2. Case Report

A 28-year-old female prosthodontic postgraduate student, reported developing erythematous, itchy lesions and burning sensation over the fingertips and palms following repeated laboratory work, involving the packing phase of heat-cured acrylic denture fabrication that is, prior to acrylization, when the material remains in its dough stage.

Symptoms consistently developed within 15 minutes of direct contact with the acrylic dough mixture. Initial presentation included mild edema, localized to the exposed skin areas (Figure 1). Within two hours, the lesions progressed to increased erythema, vesiculation, and burning sensation (Figure 2).

No systemic symptoms such as respiratory difficulty or generalized urticaria were noted. The reaction subsided within 24-48 hours following discontinuation of contact.

Notably, subsequent exposure to the fully polymerized heat-cured acrylic resin or polished dentures did not trigger any reaction, confirming hypersensitivity specifically to the unpolymerized methyl methacrylate monomer used during mixing and packing.

Implementation of preventive measures, including the use of double nitrile gloves, local exhaust ventilation, and avoiding direct handling of the dough mix, significantly reduced recurrence. The subject was advised to minimize contact with

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monomeric acrylic and utilize mechanical mixing or barrier protection wherever feasible.

Figure 1- 20 minutes post-exposure

Figure 2- 2 hours post-exposure

Classification of Denture Base Resins

Type	Class	Description
1	1	Heat-cured/self-processing polymers (powder and liquid form)
1	2	Heat-cured/self-processing polymers (plastic cake form)
2	1	Self-cured/auto-polymerized polymers (powder and liquid form)
3	–	Thermoplastic type resins
4	–	Light-activated type resins
5	–	Microwave-cured type resins

According to the classification proposed by McCabe and Walls, denture base polymers are divided into five main types based on their mode of polymerization and processing characteristics (Table 1). These include heat-cured polymers, self-cured (auto-polymerized) polymers, thermoplastic resins, light-activated resins, and microwave-cured resins. Each category exhibits distinct chemical and mechanical behaviors, which influence the degree of polymerization and the amount of residual monomer left in the final product.

Table 2 summarizes the basic constituents of acrylic denture base materials. The polymer powder primarily consists of polymethyl methacrylate (PMMA) beads containing an initiator, typically benzoyl peroxide and color pigments. The monomer liquid is predominantly methyl methacrylate (MMA), which includes additives such as ethylene glycol dimethacrylate (EGDM) as a cross-linking agent, hydroquinone as an inhibitor to prevent premature polymerization, and an activator such as N,N′-dimethyl-p-toluidine. The latter is present only in self-cured or auto-polymerizing resins, initiating polymerization at room temperature without external heat.

Component	Constituents
Powder	
Polymer	Polymethylmethacrylate beads
Initiator	A peroxide such as benzoyl peroxide
Pigments	Salts of cadmium or iron or organic dyes
Liquid	
Monomer	Methyl methacrylate
Cross-linking agent	Ethylene glycol dimethacrylate
Inhibitor	Hydroquinone
Activator	N,N′-dimethyl-p-toluidine

It has been widely reported that self-cured acrylic resins tend to release a higher quantity of residual monomer compared to heat-cured resins. Baker et al. detected increased concentrations of methyl methacrylate (MMA) in the saliva of individuals wearing dentures fabricated from self-cured materials. Similarly, Kedjarune et al. observed that the residual monomer content depends significantly on the method of polymerization and the powder-to-liquid (P/L) ratio used during mixing. They recommended that every effort should be made to minimize unreacted monomer before delivering the prosthesis to the patient. Patients should also be advised not to wear newly fabricated dentures overnight, to prevent mucosal irritation caused by leaching residual monomer.

Acrylics as Biomaterials

Acrylics are considered biomaterials because they replace or compensate for lost oral tissues and must function harmoniously in the mouth. Their success depends on biocompatibility, defined as the ability

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of a material to perform in a specific environment without harmful effects. No dental material is completely inert, so biocompatibility is always a matter of degree and can change over time due to mechanical, chemical, or thermal stresses.

Biocompatibility is evaluated in terms of local or systemic toxicity, irritation, allergy, mutagenicity, or carcinogenic potential. Dental materials must meet international quality standards such as ISO-TR 7405 to ensure safety.

Polymerization Reaction and Monomer Content

Polymerization of denture base resins is an addition reaction initiated through various methods, such as heat-curing, auto-polymerization, or light activation. During this reaction, the liquid monomer methyl methacrylate is converted into the solid polymer poly methyl methacrylate. However, complete conversion rarely occurs; some portion of the monomer remains unreacted within the cured resin. These unpolymerized monomers can subsequently leach into saliva and oral tissues, where they are responsible for local cytotoxic and allergic reactions. The higher the concentration of residual monomer, the greater the potential for biological irritation and adverse effects.

One critical factor influencing polymerization efficiency is the powder-to-liquid (P/L) ratio. Jorge et al. demonstrated that increasing the proportion of polymer powder in the mix (for example, a 5:3 ratio) reduces the amount of residual monomer after curing. Consequently, a higher polymer content during mixing correlates with lower cytotoxic potential.

Polymerization temperature and duration also play a vital role. Elevated temperatures and extended curing times enhance monomer conversion and minimize unreacted content. It has been suggested that polymerization protocols incorporating 7 hours of incubation in water at 70°C followed by 1 hour at 100°C yield the highest degree of monomer conversion. Additionally, boiling during the polymerization phase for at least 30 minutes and storing heat-cured dentures in water for 24-48 hours before delivery can further reduce monomer leaching and related mucosal irritation.

Self-cured denture base materials, when subjected to supplementary polymerization in water at 60°C and subsequently stored in water at room temperature for 24 hours, exhibit significantly reduced levels of residual monomer compared to untreated samples.

Among various laboratory polymerization techniques, heat-cured acrylic resins consistently demonstrate the lowest cytotoxic effects. In contrast, self-cured acrylics are associated with the highest levels of residual monomer and thus the most pronounced adverse biological responses. Interestingly, microwave-cured acrylic resins have been shown to achieve superior polymerization efficiency within shorter durations. Studies report that approximately 20 minutes of polymerization using microwave irradiation significantly decreases residual monomer content compared with conventional curing methods. This improved conversion efficiency contributes to a corresponding reduction in the potential hazardous effects associated with the material.

Therefore, it is essential to identify optimum polymerization conditions to minimize the cytotoxic and allergic potential of acrylic resins. Extended polymerization cycles, appropriate P/L ratios, and post-curing water storage are recommended best practices. Clinicians should avoid using self-cured acrylics for definitive dentures whenever possible and advise patients to soak new dentures in water prior to use. Nevertheless, it must be acknowledged that, irrespective of polymerization method, a certain level of unreacted residual monomer is inevitable, posing a continuing concern for both dental professionals and patients.

Potentially Toxic Substances

Acrylic polymerization is never 100 % complete, so residual components and by-products can leach out, enter saliva, and be absorbed through the oral mucosa, gastrointestinal tract, skin, or respiratory system.

Residual monomers
Unpolymerized MMA is a proven allergen and irritant. Residual monomer content decreases with high-temperature polymerization near the glass-transition temperature of PMMA (about 115 °C), producing a denser structure. Cold-cured acrylics, polymerized at room temperature without pressure, are more porous and contain higher monomer levels. Standards (ISO 1567:1999) limit residual MMA to 2.2 % for heat-cured and 4.5 % for cold-cured materials. Post-polymerization heat or microwave treatments and soaking in water for several days can reduce monomer levels by up to 25 %.

Formaldehyde
Formaldehyde can form through oxidation or degradation of methacrylic groups, especially in cold-cured resins. It can bind to proteins and trigger allergic reactions.

Other additives

- Benzoyl peroxide, used as an initiator, may remain unreacted and release free radicals, showing cytotoxic and possibly carcinogenic activity.
- Phthalate plasticizers in soft liners are known toxins and estrogenic agents.
- N,N-dimethyl-p-toluidine (activator) and hydroquinone (stabilizer) have documented tissue toxicity.
- Trace metals such as cobalt, nickel, beryllium, or cadmium can leach under acidic conditions and provoke allergies.

Clinical Manifestations

Most adverse effects are local and reversible. Common reactions include:

- Prosthetic stomatitis and cheilitis – burning, soreness, or candidiasis beneath dentures.
- Contact stomatitis in children wearing removable orthodontic appliances.
- Chronic irritation leading to fibrous hyperplasia, and rarely oral cancer.

Systemic effects are less common but can involve respiratory or gastrointestinal symptoms and generalized skin reactions such as urticaria.

Allergic hypersensitivity arises from immune responses to monomers or cross-linkers. Studies show MMA sensitivity in about 1 % of the general population but up to 17 % of denture wearers. Dental staff are at particular risk: 20–40 % of technicians show immune reactions, typically presenting as contact dermatitis or hand eczema, with symptoms such as dryness, cracking, and itching. Rarely, respiratory problems, headaches, and neurologic issues have been reported from inhalation of monomer vapors.

3. Discussion

Acrylic resin continues to be one of the most extensively used materials in prosthodontics for denture bases, relining, and provisional restorations. However, concerns regarding the biological safety of methyl methacrylate (MMA) and its residual monomer content remain significant, affecting both patients and dental personnel. The release of residual monomer from denture base resins is well documented, and its extent varies with polymerization method, curing process, and water storage conditions.[1,2] Post-polymerization water-bath treatment has been shown to reduce unreacted monomers and improve mechanical properties by promoting a higher degree of conversion.[3] Nevertheless, even with optimal curing, trace amounts of monomer persist and may contribute to adverse tissue responses.

Historically, the introduction of acrylic resin revolutionized prosthodontics by replacing vulcanite and other materials, offering improved esthetics and handling properties.[4] Despite its advantages, numerous reports have highlighted its potential to cause irritation, allergic reactions, and cytotoxic effects. The nature and degree of these effects depend on the polymerization type and the duration of contact with oral or dermal tissues.[6,7] Incomplete polymerization or undercuring leads to higher residual monomer release, which can leach into saliva and soft tissues, resulting in local or systemic effects.

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Bond strength and interfacial adaptation between denture base materials and reline resins are also influenced by polymerization factors, which may indirectly affect biocompatibility through leaching of residual components.[8] Moreover, the manipulation of acrylic resin in clinical and laboratory environments exposes dental professionals to volatile MMA vapors and direct skin contact. Chronic exposure to MMA has been associated with mucosal irritation, respiratory discomfort, and neurotoxicity due to its ability to permeate the skin and interfere with myelinated nerve function.[9–11] These occupational risks emphasize the importance of ventilation, protective measures, and awareness among prosthodontists and technicians.

Allergic contact stomatitis and burning mouth sensations have been described in denture wearers sensitive to acrylic resin components.[12–14] Such reactions often present as erythema, soreness, or ulceration of the oral mucosa. In rare cases, immediate hypersensitivity reactions can also occur, particularly in patients with a history of atopy or previous sensitization to acrylates.[15,16] It is important to distinguish these manifestations from other causes such as ill-fitting dentures, microbial colonization, or xerostomia, which may present with similar symptoms.[17,18] The defensive role of saliva, combined with the high vascularity of the oral mucosa, helps mitigate antigen penetration, but the severity of the reaction is largely determined by the concentration and duration of monomer exposure.

From a prosthodontist's perspective, acrylic allergy presents unique occupational challenges. Handling auto-polymerizing resins during chairside relining, polishing, or repair procedures often induces localized dermatitis, itching, or erythematous patches on the fingers and forearms. In my own clinical experience, even brief exposure to self-cured acrylic resin without protective barriers results in skin irritation, burning, and dryness. These symptoms are consistent with contact-type hypersensitivity reactions described in dental personnel exposed to MMA and related compounds.[19] Despite wearing gloves, the permeability of latex and vinyl materials allows diffusion of MMA monomer, underscoring the need for nitrile or specialized impermeable gloves and improved laboratory ventilation. Awareness and early identification of symptoms are critical to prevent progression to chronic dermatitis or respiratory complications.

The toxic potential of MMA extends beyond localized effects. Systemic exposure whether through inhalation or accidental ingestion has been associated with central nervous system manifestations, including dizziness, headaches, and visual disturbances.[20] Therefore, stringent adherence to polymerization protocols, adequate post-curing, and safe handling practices are essential to minimize both patient and operator risk. The use of vacuum mixing and sealed storage containers can further reduce vaporization and improve material safety.

Overall, while acrylic resins remain indispensable to prosthodontic practice, their biological implications must not be overlooked. An integrated approach that combines material optimization, protective measures, and clinician awareness is necessary to ensure biocompatibility and occupational safety.

4. Conclusion

Acrylic denture base resins provide excellent esthetics, adaptability, and cost-effectiveness, yet their residual monomer content and potential allergenicity continue to pose clinical and occupational challenges. The presence of unreacted MMA, even in minimal amounts, can result in local irritation, allergic stomatitis, and systemic reactions in sensitive individuals. Among dental professionals, repeated exposure during laboratory and chairside procedures can induce contact dermatitis and respiratory discomfort.

Preventive measures including the use of impermeable gloves, adequate ventilation, proper polymerization techniques, and post-polymerization treatments are essential to reduce exposure risks. From a clinician's standpoint, it is imperative to recognize the possibility of acrylic allergy both in patients and in oneself, ensuring that

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safety protocols are strictly followed. Future research should aim to develop alternative biocompatible polymers with minimal residual monomer content, thereby enhancing both patient safety and operator well-being.

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