

# Allergic effects of the residual monomer used in denture base acrylic resins

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## ABSTRACT

Denture base resins are extensively used in dentistry for a variety of purposes. These materials 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, and for fabrication of orthodontic removable appliances. There have been increased concerns regarding the safe clinical application of these materials as their biodegradation in the oral environment leads to harmful effects. Along with local side effects, the materials have certain occupational hazards, and numerous studies can be found in the literature mentioning those. The purpose of this article is to outline the cytotoxic consequences of denture base acrylic resins and clinical recommendations for their use.

**Key words:** Denture base allergy, denture base resins, residual monomer

## INTRODUCTION

The use of acrylic based resins in dentistry has become very frequent, and these materials offer properties and characteristics due to which they can be used for many purposes. Common uses of these materials include the fabrication of denture bases, orthodontic removable appliances, temporary crowns, and denture relining.<sup>[1-4]</sup> The acrylic resin bases are used for removable partial or complete dentures and also for implant supported removable dentures.<sup>[5]</sup> Orthodontic appliances made up of acrylic resin serve many purposes including space maintenance and arch expansion.<sup>[6]</sup> The use of acrylic temporary crowns is important during crown and bridge fabrication processes, and these provisional restorations are usually placed after tooth preparation using temporary luting cement.<sup>[7]</sup> Acrylic based soft and the hard relining process is very useful in removable prosthodontics which helps in improving denture's retention, stability, and support.<sup>[8]</sup> Soft liners are also useful for recording neutral zone impressions of completely edentulous arches.<sup>[9,10]</sup> The use of acrylic resins for copings in restorative dentistry has also been described,

however, this use in modern dentistry is not widely documented.<sup>[11]</sup>

Undesirable effects caused by denture base resins have been widely documented in the literature.<sup>[12-16]</sup> 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.<sup>[17,18]</sup> Allergic tests carried on the skin of patients has also confirmed that the denture base acrylic resin is responsible for allergic reactions.<sup>[19-21]</sup> Thus, whenever a denture wearer presents with signs and symptoms outlined above, a possibility

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of allergic reaction must always be considered, and thorough investigation carried out to achieve an accurate diagnosis. For the immediate and delayed type of hypersensitivity reactions, patch testing, blood tests, or allergen specific IgE tests can be carried out.<sup>[22,23]</sup>

The cytotoxic effects caused by denture base acrylic resins are mainly caused by the substances leaching out from these resins. The main substance which is leached out by the process of diffusion from these materials is the unreacted residual monomer.<sup>[24-26]</sup> 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.<sup>[3,27,28]</sup>

It is worth emphasizing that steps must be undertaken to ensure that dental practitioners and students are aware of these adverse effects. The purpose of the current article is to outline the cytotoxic consequences of denture base acrylic resin, clinical recommendations for their use and to review previous similar published literature.

## CLASSIFICATION OF DENTURE BASE RESINS

Acrylic denture base polymers are mainly used for the construction of denture bases in partially or completely edentulous arches. A denture base is that portion of a denture which rests over the soft tissues in the oral cavity. McCabe and Walls<sup>[29]</sup> classified denture base polymers into five types. Table 1 outlines the classification of denture base polymers. Table 2 outlines the main constituents of powder and liquid of denture base polymers where activator (N N'-dimethyl-p-toluidine) being only present in self-cure/auto-polymerized denture base resins.

It has been reported that self-cured/auto-polymerized acrylic resins leach out higher quantities of residual monomer than heat-cured denture base resins.<sup>[29-32]</sup> Baker *et al.*,<sup>[33]</sup> during their investigation found greater quantities of methyl methacrylate (MMA) in saliva of the individuals who were wearing dentures made up of self-cured/auto-polymerized denture base resins. Kedjarune *et al.*,<sup>[34]</sup> stated that the quantity of the residual monomer was actually dependent

**Table 1: Classification of denture base polymers<sup>[30]</sup>**

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)
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

**Table 2: Composition of acrylic denture base materials<sup>[29]</sup>**

Component	Constituents
Powder	
Polymer	Polymethylmethacrylate beads
Initiator	A peroxide such as a 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

upon the method of polymerization and the powder liquid (P/L) ratio used during mixing of the material. They recommended that it must be ensured that the amount of residual monomer is reduced before insertion of the dentures and suggested that the practitioners recommend to their patients that newly made dentures are not to be worn overnight so as to avoid mucosal irritation caused due to leachable residual monomer molecules.

## POLYMERIZATION REACTION AND THE MONOMER CONTENT

The polymerization reaction in denture base resins is an addition reaction that involves the activation of the initiator. It is usually through heat polymerization (heat-curing), auto-polymerization (self-curing), and light polymerization.<sup>[34-38]</sup> The polymerization reaction (the curing process) results in the conversion of MMA into poly-MMA during which the monomer molecules are converted into polymers. During this process, not all the monomer molecules are converted and thus, some unreacted residual monomers remain unpolymerized.<sup>[29]</sup> The unreacted monomer may leach out into the saliva which actually causes the cytotoxic effects in the oral cavity.<sup>[39,40]</sup> The greater the quantity of the unreacted monomer, higher will be the deleterious effects.

One of the important factors that must be considered during manipulation of denture base resins is the P/L ratio of the materials. When Jorge *et al.*,<sup>[41]</sup> carried out a study investigating the P/L ratios of these resins during manipulation, they found out that when resins were prepared in the laboratory using higher levels of the polymer (contained in the powder) content that is, to a ratio of 5:3, lower quantities of the residual monomer were found. Lesser the amount of residual monomer, lesser would be the cytotoxic effects.<sup>[34]</sup>

The polymerization temperature is another factor that plays a vital role and is responsible for different degrees of cytotoxic effects. When polymerization time is extended, the amount of residual unreacted monomer is reduced significantly and thus, the chances of cytotoxic effects are reduced. It has been recommended that a 7 h incubation in water at 70°C followed by a 1-h incubation in water at 100°C causes the maximum conversion of the monomer.<sup>[42]</sup> It has been recommended that boiling during polymerization stage should be carried out for at least 30 min at maximum temperatures and that the heat-cured denture bases should be stored in water for 1–2 days before being delivered to the patients. This is expected to reduce the cytotoxic effects caused due to residual monomer to a significant extent.<sup>[40]</sup> Self-cured denture bases which are additionally polymerized in water at 60°C and are kept in water at room temperature for a period of 1-day show significantly decreased amounts of residual monomer content.<sup>[2]</sup>

Among various laboratory methods used to carry out polymerization of denture base acrylic resins, it is well understood that heat-cured acrylic resins have shown to produce less cytotoxic effects,<sup>[43]</sup> while the greatest deleterious effects have been shown to be produced by self-cured acrylics.<sup>[44]</sup> When cytotoxic effects of microwave cured acrylic resins were tested, it was shown that 20 min of polymerization carried out using microwave irradiation resulted in residual monomer content which was significantly reduced as compared to the monomer content found using other polymerization methods.<sup>[45,46]</sup> This reduction in the monomer content after using the microwave method of polymerization could play a vital role in the reduction of the hazardous effects of the material.<sup>[47]</sup>

Optimum polymerization conditions must be identified and extended time for polymerization must be used to reduce the cytotoxic effects. Dentures fabricated

using self-cured acrylic resins should be avoided, and immersion of newly made dentures in water should be recommended. However, regardless of the curing conditions, the unreacted residual monomer in denture base acrylic resins is inevitable and could be a source of the problem for both clinicians and the patients.<sup>[48,49]</sup>

## THE HARMFUL EFFECTS

Reports of allergic effects caused among professionals due to the use of dental materials are becoming increasingly common and patch testing has proven to be a reliable and easy way to detect these potential reactions.<sup>[19]</sup> Clinical practice in prosthodontics involves the fabrication of implant-supported dentures, conventional fixed and removable partial dentures. Since the acrylic resin is the main constituent of these prostheses, allergic reactions may also be encountered in patients. As mentioned previously, unreacted MMA monomer may leach out into the oral cavity, and results in toxic effects and allergic reactions, especially, if the prosthesis is undercured. Significant damage at the cellular level involving cell membrane, mitochondria, and lymphocytes has previously been reported in the literature.<sup>[50,51]</sup>

During manipulation of acrylic resins, vaporization of the MMA monomer occurs, and this may cause harmful effects due to inhalation which can potentially irritate the lung tissues and can also affect the central nervous system (CNS).<sup>[52]</sup> A study which involved exposing rats to MMA vapors showed that there were histological manifestations clearly present such as edema, emphysema, and even collapse of the lungs.<sup>[53]</sup> Therefore, it must be stressed that the dental technicians who manipulate acrylic resin must work in an environment which is thoroughly ventilated so that harmful effects including dyspnea, cough, and triggering of asthma could be minimized and ideally avoided.<sup>[54,55]</sup> MMA can also penetrate the skin and it is also recommended that the resin during mixing is not held with bare hands since direct neurotoxic effects may be caused. Myelinated nerve functions have shown to be affected if MMA is absorbed directly via the skin and may lead to neuropathy.<sup>[56]</sup>

Contact allergy is a condition seen in the denture wearers which is a result of delayed hypersensitivity reaction. As mentioned previously, the effects of self-cured acrylic resins is more as compared to

the heat-cured ones, however, it must be stressed that the symptoms of burning mouth and/or soreness could be occurring due to a variety of other factors including ill-fitting dentures and poor oral hygiene.<sup>[57-59]</sup> The presence of saliva in the oral cavity provides the essential defensive barrier by diluting the potential harmful antigens before their penetration into the oral mucosa. The effect of the penetrated irritants is also reduced due to the high vascular nature of the oral mucosa. However, this will largely depend on the concentration of the residual monomer.<sup>[33,34,60,61]</sup> The chairside relining procedure involves the application of resin based relining materials. They are usually hard and soft liners and care should be exercised during their use as the residual monomer is readily leached out immediately and could be a source of irritation to the oral mucosa. The immersion of auto-polymerized resins in water before insertion into the patient's mouth is particularly important.<sup>[43,44]</sup>

The monomer used during manipulation of acrylic resins may cause direct effects on the skin of dental technicians and students in the laboratories. These effects are usually dependent on the time of exposure and are mostly occupational.<sup>[62]</sup> It must be mentioned that the gloves worn for cross infection control have no effect over contamination by the monomers. The monomer penetrates vinyl and latex gloves and could become a source of irritation to the skin of clinicians and the technicians.<sup>[63]</sup> Ingestion of MMA (by mistake or deliberately) may also lead to systemic side effects affecting the gastrointestinal tract and may cause CNS effects that is, sleepiness, dizziness, headaches, and blurred vision.<sup>[64,65]</sup>

## RECOMMENDATIONS FOR USE

Users must be made aware that denture base resins and other materials used in dentistry not only effect the environment but may also cause local and systemic side effects. The authors would like to recommend the following measures so that the deleterious effects of denture base resins can be minimized:

- a) It is highly recommended that the areas where denture base resin materials are being used are thoroughly ventilated so that effects caused due to vaporization of the residual monomer could be reduced
- b) The use of impermeable gloves is recommended along with the use of aprons and protective eyewear

- c) The material must be stored in tightly sealed containers
- d) In case of exposure, the site must be thoroughly washed with water especially if the contact has been made with the eye. Contact lenses should be removed immediately and washed thoroughly
- e) Move to an area with fresh air and loosen up tight clothing to facilitate breathing in case contact was made, and ventilation was not appropriate. If there is a spill, clean the area thoroughly using appropriate cleaning agents
- f) Proper curing techniques must be applied, and the use of vacuum mixing is recommended
- g) In case of any symptom appearing and if they persist, immediately seek medical advice.

## CONCLUSION

Whenever, a patient wearing an acrylic prosthesis complains for allergic reaction or chemical irritation, the possibility of these symptoms caused by denture base materials must be considered. These materials have good properties and offer reasonable esthetics, however; they may cause toxic side effects in some individuals. Regardless of the curing technique used, the presence of unreacted residual monomer in denture base acrylic resins is inevitable and could be a source of problem for both clinicians and the patients and techniques must be applied in laboratory and clinical settings to reduce the exposure as much as possible. In addition, emphasis must be given to raise awareness among the dental students and technicians about the possible hazardous side effects caused by these materials.

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