

ORIGINAL RESEARCH

The Impact of Polymerization Method on Tensile Bond Strength between Denture Base and Acrylic Teeth

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ABSTRACT

Failure of the bond between acrylic teeth and the denture base resin interface is one of the major concern in prosthodontics. The new generation of denture bases that utilize alternate polymerization methods are being introduced in the market. The aim of the study is to evaluate the influence of polymerization methods on bonding quality between the denture base and artificial teeth. Sixty test specimens were prepared (20 in each group) and were polymerized using heat, microwave and visible light curing. The tensile strength was recorded for each of the samples, and the results were analyzed statistically. The light-activated Eclipse™ System showed the highest tensile strength, followed by heat curing. The microwave-cured samples exhibited the least bonding to the acrylic teeth. Within the limitations of this study, it can be concluded that the new generation of light-cured denture bases showed significantly better bonding to acrylic teeth and can be used as an alternative to the conventional heat-polymerized denture base.

Keywords: Bond strength, Acrylic teeth, Denture base, Visible light curing, Microwave curing.

How to cite this article: Hashem M, Binmgren MA, Alsaleem SO, Vellappally S, Assery MK, Sukumaran A. The Impact of

Polymerization Method on Tensile Bond Strength between Denture Base and Acrylic Teeth. *J Contemp Dent Pract* 2014; 15(3):315-318.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Acrylic resin is the most popular denture base material because of its simple processing technique and relatively low-cost fabrication process.¹ Debonding of acrylic teeth from the denture base remains a major problem in prosthodontic practice.^{2,3} The bond between the teeth and the denture base is influenced by a combination of factors, such as adhesion of the parts to one another, the properties and dimensions of the materials that compose the parts and the mechanical connection of the parts to one another.⁴

Acrylic teeth are often preferred over porcelain teeth because they chemically bond to the denture base material and are easy to adjust in close inter-ridge spacing. With technological advancements, a new generation of denture base materials have been introduced to the market to overcome some of the drawbacks of the existing materials.¹

There have also been developments in the methods of polymerizing the denture base material. Water bath polymerization is the most common and most widely used method for denture processing. Denture base polymerization through microwave processing has become increasingly popular as an alternative to conventional heat polymerization.^{5,6} Microwave curing has several advantages, such as ease of polymerization and low energy consumption compared with the conventional technique. Clinical studies have shown comparable physical and mechanical properties for dentures fabricated by microwave polymerization.^{7,8}

The light-activated diurethane dimethacrylate (UDMA) denture base polymer triad was introduced because of its biocompatibility, low bacterial adherence, ease of fabrication, patient acceptance and ability to bond to other denture base resins.⁹ Due to its brittleness and low impact resistance, its application has been limited.¹⁰

A modified light-cured resin system called Eclipse (Dentsply Trubyte, York, PA) was introduced recently to fabricate denture bases and night guards. Eclipse is a polymethyl methacrylate (PMMA) and benzoyl peroxide-

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free light-cured resin system. The Eclipse system uses the indirect build-up technique to fabricate dentures. Eclipse utilizes three different resins to form the denture base: base plate resin, set-up resin and contour resin. The resins handle like wax and are cured when the shaping is complete. The completed denture base is fabricated on the master mold to record the jaw relationship, which helps to assess and obtain a stable jaw relationship for the denture fitting.

Although the Eclipse system exhibits significantly higher surface hardness, flexural strength and flexural modulus than PMMA denture base polymers, there is little information about its bonding to acrylic teeth compared with heat- and microwave-cured denture base resins. Hence, the aim of this study was to measure the tensile bond strength of heat- and microwave-polymerized resins and to compare with a newly introduced denture base material—Eclipse.

MATERIALS AND METHODS

The *in vitro* experiment was performed using acrylic teeth (Trilux, Dental VIPI Ltd, Pirassununga, SP, Brazil) attached to three types of denture base. The acrylic block to determine the dimensions was first made out of wax, and then a heavy-body silicone impression mold was made to fabricate the other wax patterns off the acrylic block to hold the teeth (Fig. 1). Next, the 5 mm ends of the wax patterns were carefully placed on the ridge lap surface of the acrylic tooth. The specimens were machined to a 6.5 mm diameter so that a butt joint existed at the interface of the resin and the tooth. The specimens were loaded with tension until fracture occurred. A total of 60 samples were prepared with 20 specimens for each polymerization method (Table 1).

Group 1: The combination of the acrylic tooth and the wax pattern were placed in a denture flask to substitute the wax with acrylic and allowed curing to occur. Liquid and powder forms of PMMA were mixed according to the manufacturer’s instruction to obtain a pourable consistency. Polymerization was performed at 55°C. Subsequently, the surface was finished using rotary instruments and polished.

Group 2: For the microwave polymerization (Acron MC, GC Dental, Tokyo, Japan), the polymerization was performed as per the manufacturer’s instructions, and the specimens were cured in a microwave oven.

Group 3: The light-curing resin Eclipse was prepared according to the manufacturer’s instructions, with the resin packed directly into the silicone mold. The acrylic teeth were embedded, and the polymerization was achieved with light. To finish the specimens, conventional rotary instruments and polishing brushes were used until a glossy surface was achieved.

The specimens were loaded with tension at a crosshead speed of 5 mm/min until fracture occurred. The maximum tensile stress before failure was recorded for each specimen (Fig. 2). The bond strength (in MPa) was recorded for each specimen.

STATISTICAL ANALYSIS

The statistical analysis was performed with GraphPad® InStat 3.05 software (GraphPad Software Inc, San Diego, CA, USA) using analysis of variance (ANOVA). The Tukey-Kramer multiple comparison test was used to compare

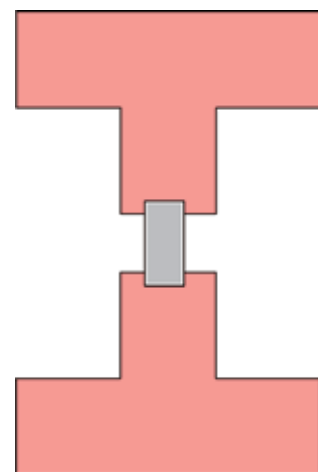


Fig. 1: The method used to mount the teeth to the denture base for testing in the Instron machine

Table 1: The type and details of the denture base materials used in the study

Acrylic resin	Processing method	Chemical composition	Manufacturer
Lucitone 550	Hot water bath for 9 hours at 74°C	<i>Powder:</i> Methylmethacrylate (methyl-n-butyl) copolymer, benzoyl peroxide and mineral pigments. <i>Liquid:</i> Methyl methacrylate, ethylene glycol dimethacrylate (EGDMA) as a cross-linking agent and hydroquinone	Dentsply International Inc., Chicago, IL, USA
Acron MC	Microwave energy for 3 mins at 500 W	<i>Powder:</i> Polymethyl methacrylate-ethyl acrylate copolymer. <i>Liquid:</i> Methyl methacrylate and N-dimethyl-p-toluidine	GC Dental, Tokyo, Japan
Eclipse™ Denture base system	Visible light curing	Acrylated urethane oligomer (TBDMA), urethane dimethacrylate (HDIDMA), octadecyl acrylate, hexanediol dimethacrylate, photo initiators and accessories, pigments and red fibers	Dentsply International Inc., Chicago, IL, USA



the tensile strength of the three types of polymerization method used. A p-value <0.05 was considered statistically significant.

RESULTS

The mean tensile strength values and standard deviations of the three groups tested are presented in Figure 3 and Table 2. The visible light-polymerized denture base showed the highest tensile strength (33.35 ± 2.13 MPa) compared with the heat- or microwave-polymerized denture base



Fig. 2: The sample in position in the Instron testing machine

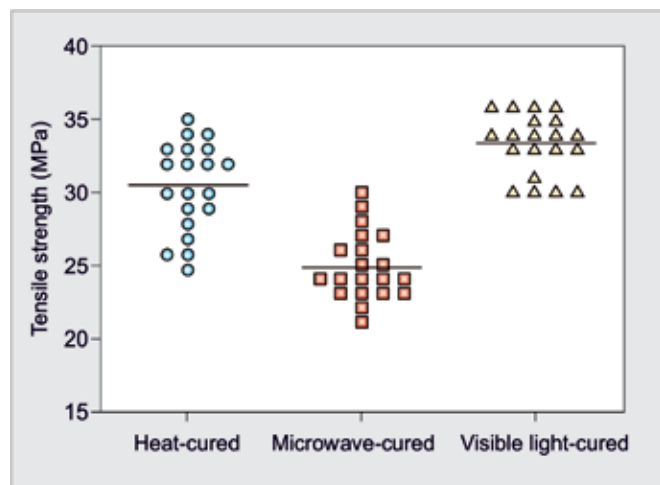


Fig. 3: The tensile strength (mean and SD) of the three systems (heat-cured, microwave-cured and visible light-cured) used in the study

Table 2: The tensile strength (mean and standard deviation) of the 3 denture base materials used in the study

Method of polymerization	Mean (MPa)	SD
Heat-cured	30.50	2.96
Microwave-cured	24.90	2.36
Visible light-cured	33.35	2.13

($p < 0.001$). The heat-polymerized denture base showed significantly higher tensile strength than the microwave-cured denture base ($p < 0.001$). The microwave-cured denture base showed the least bonding to acrylic teeth compared with other methods of polymerization.

DISCUSSION

The most common cause of complete denture failure is poor adhesion between the artificial teeth and the acrylic resin denture base.^{3,11,12} One of the primary advantages of acrylic teeth is their ability to adhesively bond to denture base resins. The adhesion is influenced by the type of resin base material and its physical and chemical properties, contamination of the bond interfaces during laboratory procedures, and the presence of impurities on the surface of the tooth in close contact with the denture base.^{12,13}

Debonding of denture teeth from the denture base can occur in three ways: adhesive, cohesive or mixed. Adhesive failure is considered to have occurred when there is no trace of acrylic resin on the tooth surface after the fracture. Cohesive failure occurs when the fracture is either in the base material or the tooth. Mixed failure occurs when there is a combination of adhesive and cohesive failure at the bonded interface.¹⁴

Different processing techniques have been used to improve and simplify polymerization techniques and to reduce denture production time. The use of microwaves to polymerize PMMA was one of these techniques, and it reduced the processing time with a uniform and rapid heating of the denture base.¹⁵ The visible light-curing denture base resin is a novel method, and the material is composed of a matrix of UDMA, microfine silica and high-molecular weight acrylic resin monomers.

Several factors can contribute to the failure of the acrylic tooth-denture base resin interface including the type of processing methods used.^{13,16} Studies comparing the bonding of acrylic teeth to microwave-polymerized and heat-polymerized denture base resins have shown increased bonding with heat-polymerized denture base resins.^{12,17,18} However, other studies have found that microwave-polymerized resin shows better bond strengths with acrylic teeth than heat-polymerized resin.^{19,20}

Earlier studies have shown that Eclipse exhibits significantly higher surface hardness, flexural strength and flexural modulus than PMMA denture base polymers. In the present study, we found that the light-activated denture base showed significantly higher bond strength compared with microwave- and heat-polymerized PMMA.

CONCLUSION

In the present study, a significantly higher bond strength was observed between the denture base and acrylic teeth with the light-cured Eclipse system compared with the heat- or microwave-cured denture bases. Within the limitations of this study, it can be concluded that the new generation of light-cured denture base materials can be an improved alternative to the conventional heat-polymerized denture base.

ACKNOWLEDGMENT

The authors would like to extend their appreciation to the Research Center, College of Applied Medical Sciences and Deanship of Scientific Research at King Saud University, for funding this research project.

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