Comparison of the Transverse Strength of Six Acrylic Denture Resins

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Abstract

Aim: The aim of this study was to evaluate the transverse strength of three kinds of heat-cured acrylic resin (Meliodent HC, Acron HC, Lucitone 199); one kind of microwave-cured acrylic resin (Acron MC); one kind of visible light-cured resin (Triad VLC); and one kind of self-cured acrylic resin (Meliodent SC). ***Method:*** A total of 60 specimens (65 mm x 10 mm x 3 mm) were fabricated, ten from each material. The specimens were loaded until failure on a three-point bending test machine. For statistical analysis, Kruskal-Wallis test followed by Dunn's multiple comparison test were used. ***Results:*** The transverse strength values showed statistically significant differences among experimental groups (P=0.0001). The mean transverse strength (MPa) was as follows in decreasing order: Acron MC, Meliodent HC, Acron HC, Lucitone 199, Meliodent SC, Triad VLC. ***Conclusion:*** Within the limitations of this study, Acron MC showed the highest mean transverse strength value among the materials tested.

Key Words: Transverse Strength, Acrylic Resin, Heat Curing, Microwave Curing, Visible Light Curing

Introduction

Acrylic resin removable dentures are susceptible to fracture after periods of clinical use [1]. There are many predisposing clinical factors for denture fractures [2-5]. Biting and mastication forces have a deforming effect during function; any factor that increases the deformation of the base and changes the stress distribution may lead to denture fracture [2]. Midline fracture as a result of bending of complete dentures in the mouth is a frequently encountered problem [2,6].

The material most commonly used for fabricating removable partial and complete dentures is heat-cured polymethylmethacrylate (PMMA). Its low cost, ease of application and polishing, and reliance on simple processing equipment have made PMMA a preferred base material; however, this material presents limitations, particularly in terms of transverse and impact strength [7,8]. In order to develop stronger denture base materials resistant to fracture, different approaches have been proposed such as the production of high-impact strength resins and reinforcement of denture base materials [9-16]. High-impact strength acrylics employ a PMMA polymer modified by adding a rubber compound to improve strength properties [7].

Many different processing techniques have been proposed to improve and simplify the polymerisation technique and to reduce denture production time. The use of microwave energy to polymerise PMMA was one of these techniques. It is possible to process acrylic dentures in a very short time, because the surface and the deeper parts of the resin are uniformly and rapidly heated [17]. Light-curing of a denture is a novel method compared with other processing methods [18]. A visible light-curing denture base resin has been described as a composite having a matrix of urethane dimethacrylate, microfine silica, and high molecular weight acrylic resin monomers [19].

Information about the mechanical properties of acrylic materials could help with the understanding and improvement of denture fractures. Therefore, the purpose of this *in vitro* study was to evaluate and compare the transverse strength of six denture acrylic materials. Three of these were heat-cured acrylic resins (conventional heat-cured acrylic

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resin, rapid heat-cured acrylic resin, high-impact strength acrylic resin), and the others were light-cured denture base resin, microwave-cured resin and self-cured acrylic resin.

Materials and Methods

Fabrication of specimens

In this study, specimens were fabricated from three heat-cured denture base resins: Meliodent HC (A) (Heraus Kulzer Ltd, Newbury, UK), Acron HC (B) (Howmedica Austenal Dental Products) and Lucitone 199 (C) (Dentsply York Division, USA); one microwave denture base acrylic: Acron MC (D) (GC-Dental Ind Corp, Tokyo-Japan); one self-cured resin: Meliodent SC (E) (Heraus Kulzer Ltd, Newbury, UK); and one light-cured denture base resin: Triad VLC (F) (Dentsply York Division, USA). The trade names, descriptions and polymerisation regimes of the acrylic resins presented in *Table 1.*

A total of 60 specimens were fabricated using moulds made by investing brass blocks of dimensions 65 mm in length, 10 mm in width, and x 3 mm in thick, in dental stone (Moldano, Heraeus Kulzer GmbH, Hanau, Germany). The specimens were divided into six groups; ten each, according to the material tested.

Heat-cured acrylic resin specimens were processed by placing denture resin under compression in the water bath (Kavo EWL 5501, Kavo Elektrotechnisches, Germany) in metal flasks. Microwave-cured acrylic resin specimens (AMC) were polymerised in a microwave oven (2450-Hz, 550 W maximum potency; Vestel Goldstar ER, 535, Manisa, Turkey). Self-cured acrylic resin specimens were prepared according to the manufacturer's directions. Light-cured denture resin specimens were polymerised in the Triad Visible Light-Curing Unit (Triad 2000, Dentsply International Inc., York, USA).

The specimens were ground with 600-grit silicon carbide paper to remove excess materials to obtain a smoother surface. All of the specimens were stored in distilled water in a thermostatically controlled water bath (Elektromag-M96K water bath, Turkey) at 37°C for 48 hours prior to testing.

Transverse strength test

Transverse strength testing was performed using a three-point bending test machine (AVK-Budapest, 1980). A three-point testing design was used whereby the simple specimen beam was centrally loaded at a cross-head speed of 5 mm/min over a two-point support span set at 50 mm. The specimens were deflected until rupture occurred. The force required for rupture was recorded and the stress was calculated by means of the following equation [20]:

$$S= 3.P.L/ 2.b.d^2$$

where S is the stress in the outer fibres at midspan, expressed in MPa; P: load at a given point on the load-deflection curve, expressed in N; L: support span length, expressed in mm; b: width of beam tested, expressed in mm; and d: depth of beam tested, expressed in mm.

Table 1. *Trade Names, Processing and Polymerisation Regimes of Materials Tested*

Trade name (description)	Powder/ liquid ratio	Mixing time (second)	Doughing time (minute)	Polymerisation procedure
Meliodent HC (A) (rapid heat polymerised acrylic resin)	23.4 g/10 ml	30	6	20 min in 70°C and 23 min in boiling water
Acron HC (B) (heat polymerised acrylic resin)	3.5/1 (by volume)	30	30	60 min in 70° and 60 min in boiling water
Lucitone 199 (C) (heat polymerised, high-impact acrylic resin)	21 g/10 ml	20	9	90 min at 73°C and 30 min in boiling water
Acron MC (D) (microwave-polymerised acrylic resin)	100 g/43 ml	30	20	3 min at 500 watt in microwave oven
Meliodent SC (E) (autopolymerised acrylic resin)	5/3.5 (by volume)	30	-	14 min at room temperature (23±1°C)
Triad VLC (F) (visible light-cured resin)	Prefabricated	-	-	10 min in visible light-curing unit

The mean transverse strength values and standard deviations were calculated for each group, and the data were analysed by means of Kruskal-Wallis test, followed by *post hoc* Dunn's multiple comparison test. Statistical significance level was set at $P<0.05$.

Results

The mean transverse strength values and standard deviations of all groups tested are presented in *Table 2.* Although microwave-polymerised acrylic resin showed the highest mean transverse strength (124.30±9.91 MPa), the lowest mean transverse strength value belonged to the visible light-cured resin (80.22±9.99 MPa). The Kruskal-Wallis test indicated that there were significant differences in the transverse strength among groups ($P< 0.0001$). Then the comparisons between the groups were carried out with *post hoc* Dunn's multiple comparison test.

Table 2. *The mean ±standard deviation of transverse strength of all groups tested*

Material	Transverse strength (MPa)
A	120.00 ± 9.13 ^{a}
B	113.30 ± 10.88 ^{a}
C	103.40 ± 11.96 $^{a, b}$
D	124.30 ± 9.91 ^{a}
E	84.64 ± 12.93 ^{b}
F	80.22 ± 9.99 ^{b}

Note: Groups with the same superscript letters were not significantly different ($P>0.05$) by *post hoc* Dunn's multiple comparison test.

Discussion

Many studies have reported desirable properties of polymer denture resins such as adequate strength, satisfactory thermal properties, dimensional stability, insolubility in oral fluids, acceptable aesthetics, ease of handling, and moderate cost [18,21-23]. In order to compare the performance of different denture resins, various mechanical tests can be performed. However, previous investigations have not been in agreement regarding the mechanical properties of these resins [17,24].

The transverse strength test, one of the mechanical strength tests, is especially useful in comparing denture base materials in which a stress of this type is applied to the denture during mastication [18]. The transverse (flexural) strength is a combination of compressive, tensile and shear strengths, all of which directly reflect the stiffness and resistance of a material to fracture [8,19].

The present *in vitro* investigation was designed to compare the transverse strength of five denture base resins and one self-cured resin. Visible light-cured resin showed the lowest mean transverse strength value (80.22±9.99 MPa) followed by self-cured acrylic resin (84.64±12.93 MPa). However, a previous study, carried out in 1987 [25], reported that visible light-cured (VLC) denture base material exhibited superior transverse strength properties (125.23±14.71 MPa) compared to conventional acrylic resins (97.67±8.83 MPa). This finding was not in agreement with the present study, where it was found that microwave-cured acrylic resin showed a higher transverse strength than visible light-cured resin. The findings of the present study were consistent with those of two other studies [26,27], one of which [26] was performed in 2007.

The reason for the lower transverse strength values of visible light-cured resin and self-cured resin compared with the other materials might be due to the presence of the large number porosities in this material [26,28]. It was concluded that these materials could not be kept under pressure during the polymerisation process; common defects and internal voids often result [28]. It has been proposed that internal porosities concentrated stresses in the matrix and contributed to the formation of microcracks under loading. It should also be noted that, consistent with manufacturer's recommendations, the urethane dimethacrylate material was polymerised on one side only. Because the material was not packed and flasked under pressure, it was difficult to attain consistently dense specimens. Increased degree of conversion may serve to increase the bulk flexural and fatigue strength of light-cured resin [29].

The transverse strength of the microwave- and heat-polymerised PMMA-based polymers did not differ in the present study, which is inconsistent with some previous studies [17,30,31]. Finally, a recent study [32] reported that when compared with the specimens cured in a microwave oven, water-bath-cured resin is considered to have markedly less porosity.

Conclusion

This investigation evaluated the transverse strength of six different denture resin materials, Meliodent HC, Acron HC, Lucitone 199, Acron MC, Triad VLC and Meliodent CC. Within the limitations of this study, the following conclusions were drawn:

- Microwave-cured acrylic resin showed the highest mean transverse strength value, whereas visible light-cured acrylic resin showed the lowest.

- Heat-cured resins had slightly lower transverse strength values than microwave-cured resin. There was no statistically significant difference among them ($P>0.05$).
- There was no statistically significant difference between the mean transverse strength values of visible light-cured resin and self-cured resin ($P>0.05$).

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