

Flexural properties of a light-cure and a self-cure denture base materials compared to conventional alternatives

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PURPOSE. A new light curing urethane dimethacrylate and a cold curing resin with simpler and faster laboratory procedures may have even improved flexural properties. This study investigated the 3-point flexural strengths and flexural moduli of two alternate base materials. **MATERIALS AND METHODS.** A cold curing resin (Weropress) and a light curing urethane dimethacrylate base material (Eclipse). Along with Eclipse and Weropress, a high impact resin (Lucitone199) and three conventional base materials (QC 20, Meliodent and Paladent 20) were tested. A 3-point bending test was used to determine the flexural strengths and flexural moduli. The mean displacement, maximum load, flexural modulus and flexural strength values and standard deviations for each group were analyzed by means of one-way analysis of variance (ANOVA) (with mean difference significant at the 0.05 level). Post hoc analyses (Scheffe test) were carried out to determine the differences between the groups at a confidence level of 95%. **RESULTS.** Flexural strength, displacement and force maximum load values of Eclipse were significantly different from other base materials. Displacement values of QC 20 were significantly different from Lucitone 199 and Weropress. **CONCLUSION.** The flexural properties and simpler processing technique of Eclipse system presents an advantageous alternative to conventional base resins and Weropress offers another simple laboratory technique. [J Adv Prosthodont 2011;3:136-9]

KEY WORDS: Denture polymers; Flexural strength; Flexural modulus; Eclipse; Weropress

INTRODUCTION

Polymethyl methacrylate (PMMA) polymers have been referred as conventional base materials and there is an ongoing effort to improve the properties of denture base materials. The goal is to have longer lasting and more biocompatible denture bases with better mechanical properties and simpler processing techniques that require less time to construct denture.¹ Mechanical properties of denture base resins are crucial for the clinical success of removable prosthesis. Fractures and cracks are the most common types of failures related to base material.^{2,3}

High impact acrylics were developed by the insertion of a rubber compound into the resin to improve impact resistance and strength properties of PMMA materials.^{4,5} On the other hand, the long and rather difficult laboratory procedures of both conventional and high impact resins led to studies about self-cure and light-cure resins.⁶ Self-cure resins offered shorter laboratory

procedures but the residual monomer caused an increased risk of tissue reactions and decreased fracture resistance.⁷ On the other hand, light-curing systems offered simpler laboratory procedures and less risk of allergic reactions as they do not contain methyl methacrylate monomers.⁸ Furthermore, poor fracture resistance of early light-cure systems was improved by the entrance of a new material on the market.⁹ However, to our knowledge these new self- and light-cure materials have not been comparatively evaluated yet.

Therefore, the aim of this study was to investigate the 3-point flexural strengths and flexural moduli of these two alternate base materials (Eclipse and Weropress) and compare them to three conventional heat-cure acrylic resins QC 20, Meliodent and Paladent and one high impact heat-cure acrylic Lucitone 199.

MATERIALS AND METHODS

All materials used in this study are listed in Table 1.

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Table 1. Denture base materials used in the study

	Polymer/monomer ratio V/Wt	Manufacturer
Lucitone 199	10 ml/21 g	Dentsply Weybridge, UK
High impact		lot 080319
QC 20	10 ml/23 g	Dentsply International, Inc., Milford, DE
PMMA		lot 087501
Meliodent	10 ml/23.4 g	Heraeus Kulzer Ltd., Berkshire, UK
PMMA		lot 012174
Paladent 20	10 ml/25 g	Heraeus Kulzer Hanau, Germany
PMMA		lot A148B-1
Weropress	21 ml/30 g	Merz Dental Lütjenburg, Germany
PMMA		lot 24608
Eclipse		Dentsply Trubyte, York, PA. USA
Urethane dimethacrylate		lot 070821

Specimen Preparation

A total of 48 specimens were prepared according to ISO 1567 standard with 6 different resins. Dimensions of the master patterns were $65 \times 10 \times 3$ mm according to specified standards. These patterns were covered with high viscosity polyvinylsiloxane (Silagum Putty, DMG, Hamburg, Germany) before being invested in conventional flasks with Type 3 dental stone (Moldano; Heraeus Kulzer, Hanau, Germany). Acrylic resins were mixed and packed in accordance with the manufacturers' instructions. Conventional acrylics (Meliodent, QC-20, Paladent 20) and high impact Lucitone 199 were polymerized at 74°C for 9 hours in an automated polymerization unit (Kavo EWL 5501, Kavo Electrotechnisches Werk GmbH, Germany). Weropress specimens were polymerized in a pressure pot heat cure unit (Ivomat IP3, Ivoclar Vivadent AG, Schaan, Lichtenstein) under 2 bars of pressure at 45°C for 12 minutes. A teflon mold with a transparent plexyglass lid was designed to prepare the Eclipse specimens. The Eclipse dough was sandwiched in this mold and cured in its specific unit (Enterra VLC Curing Unit; DeguDent GmbH, Hanau, Germany) using the recommended 15 minute polymerization cycle. After polymerization the excess materials were removed by trimming with tungsten carbide burs using a handpiece at low speed. Both sides of the specimens were polished under running water with #320-, 400-, and 600-grit silicon carbide papers respectively. Before transverse strength test the specimens were immersed in distilled water at room temperature ($20 \pm 2^\circ\text{C}$) for 15 days.

Transverse Strength Testing

A 3-point bending test device (MTS Mini-Bionics, model 858, MTS Corporation, Eden Prairie, MN, USA) was used to determine the flexural strengths and flexural moduli. The device consisted of a loading wedge and a pair of adjustable supporting wedges placed 50 mm apart. The specimens were

centered on the supporting wedges and the loading wedge was set to travel at a crosshead speed of 5 mm/min engaged at the center of the upper surface of the specimens. Specimens were loaded until fracture occurred. Transverse strengths were calculated using the following equation;

$$S = 3PI / 2bd^2$$

Where: S = transverse strength (N/mm²), P = load at fracture (N), I = distance between the supporting wedges (mm), b = width of the specimen (mm), and d = thickness of the specimen (mm).

The mean displacement, maximum load, flexural modulus and flexural strength values and standard deviations were calculated for each group, and the data were analyzed by means of one way analysis of variance (ANOVA) (with mean difference significant at the 0.05 level). Post hoc analyses (Scheffé test) were carried out to determine the differences between the groups by using SPSS statistical software version 11.5 (SPSS Inc., Chicago, IL, USA) for Windows at a 95% confidence level.

RESULTS

The mean flexural strength, flexural modulus, force maximum load and displacement values of Eclipse, Meliodent, Lucitone 199, Weropress, QC 20 and Paladent 20 are given in Table 2. One-way ANOVA indicated that there were statistically significant differences in the flexural strengths ($P < .001$), flexural moduli ($P < .05$), force maximum load ($P < .001$) and displacement values ($P < .001$) among the six denture base materials (Table 3). Post hoc Scheffé test indicated that for flexural strength, displacement and force maximum load, the values of Eclipse are significantly different from other base materials. Only for displacement, the values of QC 20 are significantly different from Lucitone 199 and Weropress. Besides, there were no significant differences between the values of six denture base materials for flexural modulus (Table 2).

Table 2. Scheffé multiple comparison test results expressed in mean values and standard deviations

	<i>n</i>	Displacement	Max. load	Flexural strength	Flexural modulus
P	8	5.80 (0.44) ^{a,b}	111.75 (12.90) ^a	76.97 (8.88) ^a	2120.34 (211.72) ^a
Q	8	5.04 (0.71) ^a	107.75 (16.93) ^a	74.21 (11.65) ^a	2285.84 (531.17) ^a
L	8	8.11 (1.52) ^b	104.52 (7.29) ^a	71.98 (5.02) ^a	1629.31 (248.80) ^a
M	8	5.81 (1.18) ^{a,b}	117.69 (25.34) ^a	81.06 (17.45) ^a	2134.77 (632.74) ^a
W	8	7.83 (2.59) ^b	101.34 (17.18) ^a	69.79 (11.83) ^a	1928.06 (616.30) ^a
E	8	11.20 (1.36) ^c	165.64 (15.47) ^b	114.07 (10.65) ^b	2419.46 (437.46) ^a

Values having same superscript letter are not significantly different ($P < .05$)

P: Paladent, Q: QC 20, L: Lucitone 199, M: Meliodent, W: Weropress, E: Eclipse

Table 3. One-Way ANOVA test results for various parameters between and within groups of six different materials

Parameter	Variation	Sum of squares	df	Mean square	F	<i>P</i>
Displacement	Between groups	220.532	5	44.106	20.385	<.0001
	Within groups	93.039	43	2.164		
	Total	313.571	48			
Max. Load	Between groups	25189.299	5	5037.86	18.018	<.0001
	Within groups	12023.067	43	279.606		
	Total	37212.366	48			
Flexural strength	Between groups	11947.660	5	2389.532	18.018	<.0001
	Within groups	5702.720	43	132.621		
	Total	17650.380	48			
Flexural modulus	Between groups	3214410	5	642882.036	2.846	<.05
	Within groups	9714320	43	225914.416		
	Total	12928730	48			

One-Way ANOVA test and set the level of significance at $P < .05$

DISCUSSION

Flexural strength of a material is accepted to determine the fracture resistance. The loading characteristics of fracture strength tests imitate clinical situations which a denture base undergoes in the oral environment, we preferred to stick to ISO 1567:1999 standard for transverse strength testing.⁵ Even though fatigue fracture is clinically more relevant, as it simulates the clinical failure mechanism more closely, the assessment of flexural strength is easier and thus has been used by other researchers.¹⁰⁻¹² However, the lack of a thermo-cycling process and loading phase without immersing in artificial saliva could be stated as limitations of this study.

It is well known that self-cure systems offer simpler laboratory procedures. However, besides the other mechanical and chemical properties, these materials should have sufficient fracture resistance. To our knowledge, Weropress has not been investigated on the basis of flexural properties yet. According to the results of present study, Weropress specimens exhibited the lowest transverse strength among all groups but this finding was not statistically significant except for the Eclipse group. This finding indicates that flexural properties of Weropress may be considered as acceptable.

The use of light-polymerized denture base resins has been supported by several authors, not only for exhibiting acceptable strength and dimensional stability, but also for their relatively complete polymerization without free monomer in addition to their ease of manipulation and elimination of the usual denture processing armamentarium.¹³⁻¹⁷ Earlier studies have investigated the mechanical properties of Triad (light-cured resin) comparing to conventional and high impact resins. The overall results of these studies indicate that the transverse strength of Triad is higher than conventional polymethylmethacrylate but lower than high impact resins.¹⁸ However, one of the two different base resins we examined, the light-activated urethane dimethacrylate (UDMA) (Eclipse), revealed significantly higher flexural strength values where the cold-curing Weropress remained within the range of other materials.

High impact resins were developed to overcome the need for higher impact resistance. Uzun and Hersek¹⁹ investigated conventional, hi-impact and strengthened injection mold resins and reported that the transverse strength of six different base materials did not exhibit significant differences which are supported by the findings of similar materials in this study.

Our results, supporting previous studies, revealed that Lucitone 199 has better flexural properties and higher dis-

placement values when compared to conventional resins. However, Weropress showed similar displacement and flexural strength values where Eclipse specimens exhibited even improved values. Therefore, both materials must also be evaluated on the basis of their impact resistance.

Newly introduced Eclipse has been reported to have superior flexural strength and higher flexural modulus when compared to high impact (Lucitone 199), conventional base (Meliodent) resins and triad resin.^{6,18} The results of this study are in good agreement with the findings of previous studies. Machado *et al.*¹⁸ reported that Eclipse exhibited less porosity after polymerization when compared to early UDMA system (Triad). Diaz-Arnold *et al.*²⁰ reported that Eclipse specimens showed the highest standard deviations in mean flexural strength values (± 15.83) in comparison to "so called" high-impact resin groups (Lucitone 199, Diamond D, HI-I, Nature-Cryl Hi-Plus other groups). They suggested that the high standard deviation indicated variations in specimen fabrication. According to their comment, as the specimens were not flaked and packed they were not dense enough and this led to the high standard deviation in eclipse group. The Eclipse system, as presented by the manufacturer, is not designed for polymerization under pressure. However in the present study the corresponding standard deviation is approximately 35% lower. This might be due to the use of semi-transparent white teflon mold instead of the aluminum mold for Eclipse group. A possible higher quality of polymerization might have taken place.

As the results indicate Eclipse resin to have better and Weropress to have acceptable flexural properties when compared to well known alternatives, these materials deserve further investigation over their physical properties like impact and fatigue strength, water sorption and solubility and surface characteristics like hardness and staining, to clear out any possible advantages for clinical use.

CONCLUSION

Within the limitations of this study following conclusions can be drawn;

1. Regarding the flexural strength properties and simpler processing technique, Eclipse system owns a potential as an advantageous alternative to conventional base resins.
2. Weropress system may have similar advantages of easy processing when compared to conventional resins.

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