A comparison of the bond strengths of microwave- and water bath–cured denture material

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A comparison was made of the shear bond strengths between microwave-polymerized and conventional water bath–cured polymethyl methacrylate (PMMA) bonded to denture teeth. Four groups of 15 specimens were prepared and shear bond strengths obtained by use of standardized laboratory testing methods. The results showed that microwave-cured PMMA demonstrated significantly (*p* 0.0001) higher bond strengths than conventional PMMA, and priming of the denture tooth surface with monomer liquid yielded significantly higher bond strengths than other surface treatment (*p* 0.0001). (J PROSTHET DENT 1990;70:406-9.)

The use of microwave energy to polymerize denture base resin was first reported by Nishii[1] in 1968. Subsequently the physical properties of microwave-polymerized resin have been evaluated in several studies.[2,3] De Clerck[2] described the development of microwave-polymerized resins and found that microwave-polymerized resin had a lower residual monomer ratio than conventionally cured resin, but similar physical properties. Sanders et al.[3] examined porosity and came to the conclusion that microwave curing with quench cooling was an effective way of processing acrylic resin and demonstrated less porosity than conventional curing with two of five materials studied.

An important criterion for the selection of denture base material is its ability to reproduce the original impression and to ensure accuracy of fit. Although the polymethyl methacrylate (PMMA) resins show a volumetric shrinkage of approximately 8%, the physical properties of this resin make it the most suitable for complete dentures. Several authors have reported that PMMA resin cured by microwave energy showed better adaptation than the conventional water bath–cured material.[4-6]

Takamata et al.[7] compared the dimensional accuracy of acrylic resins and showed that autopolymerizing resin and microwave-polymerized resin were the most stable. Wallace et al.[8] obtained similar results. Although Nelson et al.[9] found the increase in vertical dimension of occlusion was less for the conventional than for the microwave procedure, the difference was considered acceptable. Studies by others demonstrated similar properties of hardness, porosity, and transverse strength between curing by microwave energy and by conventional water bath techniques with the added advantage of reduced curing time, ease, and cleanness of the microwave-polymerized material.[10-12]

Table I. Surface treatment, curing method, and material used for the four groups

Group	No. in group	Surface treatment	Curing	Material
I	15	None	Warm water	GC Acron
II	15	None	Microwave	GC Acron MC
III	15	Monomer	Microwave	GC Acron MC
IV	15	Sandblast	Microwave	GC Acron MC

During trials of a commercially available microwave-polymerized denture material (Acron MC, GC Dental Industrial Corp., Tokyo, Japan), the clinical impression formed was that the bond strength of microwave-polymerized denture material bonded to acrylic denture teeth was inferior to results with conventional heat-polymerized material. This study compared the bond strengths of resin denture teeth bonded to conventional heat-polymerized and microwave-polymerized denture base materials.

MATERIAL AND METHODS

A silicone mold was made that incorporated a channel 3 mm in diameter and fitted accurately on the ridge surface of a denture tooth. Identical denture teeth from the same batch of acrylic resin were supplied by a manufacturer of denture teeth (Premierdent, Cape Town, South Africa). Modeling wax (Kemdent Pink, Swindon, England) was melted in a thermostatically controlled water bath and kept at a constant temperature of 60° C. The wax was poured onto the fitting surfaces of the denture teeth

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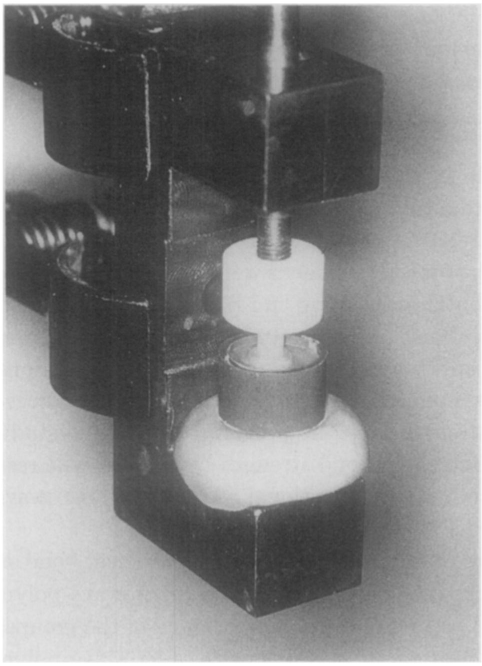

Fig. 1. Embedding of specimen in nylon ring with a jig.

Table II. Mean bond strength in MPa per group, median, and standard deviation

Group	n	Mean	Median	SD
I	15	0.129	0.124	0.044
II	15	0.380	0.390	0.054
III	15	0.517	0.528	0.061
IV	15	0.334	0.304	0.092

through the 3 mm channel. The wax was allowed to cool for 5 minutes before the denture tooth with attached wax cylinder was removed and stored at room temperature. Sixty specimens were prepared in this manner. The ridge area of 15 teeth had been sandblasted with 50 μm aluminium oxide powder at a controlled distance of 52 mm for 30 seconds before the wax sprues were attached. Table I lists the surface treatment, curing method, and material used for each group.

Fifteen specimens were invested in a conventional flask (Hanau, Varsity, Ejector Type, Buffalo, N.Y.) to ensure that the teeth and bodies of the wax cylinders were submerged at the tooth-PMMA interface. The remaining 45 specimens were invested in microwave flasks (H. K. Type, GC FRP Flask, Tokyo, Japan). After the plaster had set, the flasks were opened and the wax was eliminated by heat-soaking for 5 minutes in 90° C water followed by flushing with fresh water at 100° C. A separating medium was carefully applied to stone surfaces (Kafir D, British Gypsum, Loughborough, United Kingdom) with a fine brush and allowed to dry. Group 1 specimens were in the

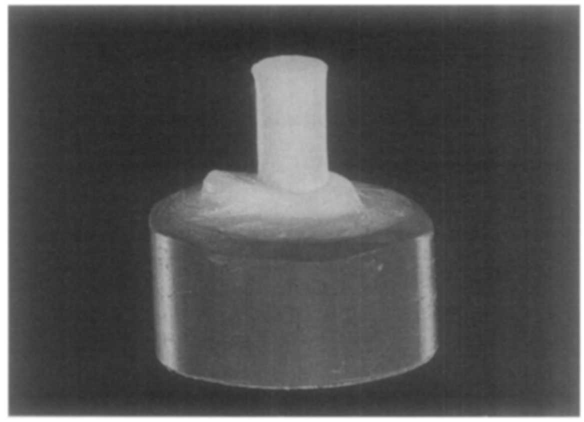

Fig. 2. Specimen embedded in nylon ring.

Table III. Specimens grouped according to type of fracture

Group	Total No. of specimen	%	Group I	Group II	Group III	Group IV
A: 100% Adhesive (clean interface)	28	47	12	4	0	12
B: Adhesive and cohesive (interface and PMMA)	6	10	3	—	—	3
C: Adhesive and cohesive (interfase, PMMA and tooth)	15	25	—	5	10	—
D: Adhesive and cohesive (tooth and interface)	10	17	—	6	4	—
E: 100% cohesive (PMMA and tooth—no interface)	1	1	—	—	1	—

brass flask packed with conventional acrylic resin (G. C. Acron, GC Dental Industrial Corp.) according to the manufacturer's instructions and cured at the recommended cycle (slow speed) in a thermostatically controlled water bath. The flask was left to cool overnight. Group 2 consisted of teeth packed and processed with microwave acrylic resin (G. C. Acron). The specimens of group 3 were primed with the appropriate monomer before processing, and group 4 was composed of the sandblasted tooth surfaces. The latter 45 samples were cured in a microwave oven (Model SA 2010 B, Tedelex Litton, Memphis, Tenn.) with an output

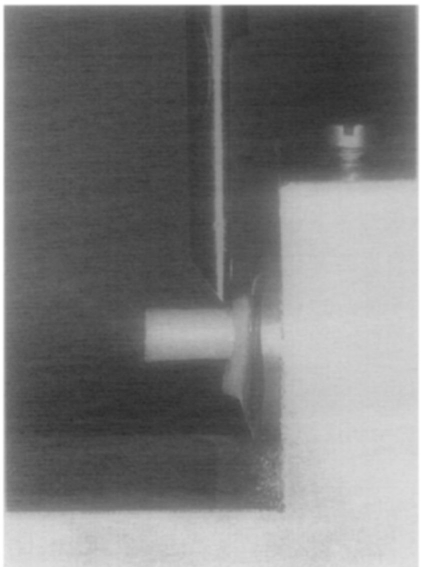

Fig. 3. Application of shear load with knife-edged rod at base of bonded PMMA cylinder.

of 700 watts for 3 minutes at high temperature. The flask was left to bench cool overnight.

All of the specimens were carefully deflasked and cleansed in an ultrasonic bath with plaster remover and stored in saline solution at 37° C for 7 days. After storage, the specimens were mounted in a jig and embedded in nylon rings by use of autopolymerizing acrylic resin to ensure that denture tooth position remained constant (Figs. 1 and 2). Shear bond strengths were randomly tested in an Instron testing machine (Table model 1026, Southampton, England) with the use of a 5 kg load cell and a crosshead speed of 5 mm/minute according to the method described by Retief.[13] The shear load was applied with a knife-edged rod positioned at the base of the bonded PMMA cylinder (Fig. 3). The use of a knife-edged rod resulted in a wedge-opening load. The recordings on the chart paper were measured with a digital vernier gauge (Mitutoyo, Tokyo, Japan) by two operators and the average was accepted.

RESULTS

Table II shows mean and median values and standard deviation for each group. Group 3, which represents monomer-primed denture teeth bonded to microwave-polymerized PMMA, achieved the highest shear bond strength of all four groups, with a mean value of 0.517 MPa. The weakest shear bond strength was found in group 1, which represents untreated denture teeth bonded to conventional hot water bath–polymerized PMMA ($\bar{x}$ 0.129 MPa).

The Kruskal-Wallis one-way analysis of variance by ranks indicated a statistically significant difference between groups 1 and 2 (p 0.0001). The same applied for groups 2 and 3 (p 0.0001), as well as for groups 3 and 4. However, no statistically significant difference existed between groups 2 and 4 ($p > 0.05$). The fracture site on the specimens was observed with a stereomicroscope with ×20 enlargement. Different types of fractures were noticed and the specimens were grouped accordingly. (Table III).

DISCUSSION

Little has been published on bond strength between acrylic denture teeth and PMMA base material. Two articles of relevance are by Morrow et al.[14] and Huggett et al.[15] In both studies, specimens were tested according to American Dental Association and British Standards Institution specifications. In these studies, the specimens were prepared and loaded to simulate clinical conditions. This study eliminated mechanical retention and measured shear bond strength only. No previously published studies that compared shear bond strength between acrylic resin denture teeth with conventional PMMA and microwave-polymerized PMMA were found.

There was a significant difference in shear bond strength between the conventional and microwave-polymerized PMMA resin, the latter greater in all of the groups. Priming of the tooth surfaces with microwave-polymerized monomer increased the bond strength significantly. However, there was no difference between the sandblasted and nontreated microwave-polymerized resin bond strengths to denture teeth. Table III indicates that 47% of specimens represented complete adhesive fracture, of which 24 belonged to groups 1 and 4 and had the lowest shear bond strengths. Of the specimens, 52% showed mixed cohesive-adhesive bond failures and only one specimen of group 3 displayed complete cohesive fracture.

SUMMARY

Bond strength of microwave-polymerized PMMA to denture teeth was superior to that of conventional heat-polymerized PMMA. Surface treatment by roughening did not enhance bond strength, whereas priming with monomer significantly improved the bond strength of microwaved PMMA. Adhesive bond failure was demonstrated in the groups that displayed weaker bonds versus mixed adhesive-cohesive fractures in the groups with higher bond strengths. Identical denture teeth (Premierdent, Capetown, South Africa) from the same batch of acrylic resin were used. The use of denture teeth and PMMA resins from other manufacturers may alter the results.

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