

# Effect of Intrinsic Pigmentation on the Flexural Strength of a Microwave-cured Acrylic Resin

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This study investigated the effect of intrinsic pigmentation on the transverse strength of a microwave-cured acrylic resin. Forty transverse strength specimens were fabricated according to ADA specification #12 and divided into 5 groups. No fibers were added to group I (GI, control group); acrylic stain (AS) was added to GII and GIII in concentrations of 0.5 and 1.5% w/w, respectively; acrylic fibers (AF) were added to groups GIV and GV in concentrations of 0.5 and 1.5% w/w, respectively. All specimens were irradiated in a microwave oven with a cycle of 3 min at 360 W, followed by 4 min resting, then 3 min at 810 W. Flasks were bench-cooled for 30 min at room temperature, followed by immersion in cold tap water for 30 min. After storage in distilled water at 37°C for 48 h, all specimens were tested for flexural strength in a testing machine (EMIC-DL 500) at a crosshead speed of 0.5 cm/min. Mean and standard deviation (MPa) for the flexural strength test were: GI=86.0 ± 7.9; GII=86.0 ± 9.8; GIII=86.6 ± 7.7; GIV=84.9 ± 5.3; GV=84.9 ± 5.2. No statistical differences were detected among the groups (ANOVA, p>0.05). The addition of the acrylic fibers or the acrylic stain did not affect the transverse strength of the microwave-cured acrylic resin.

Key Words: denture base staining, microwave-cured acrylic resin, flexural strength.

## INTRODUCTION

Since the introduction of methyl methacrylate as a denture base material (1), the ultimate goal of prosthodontists has been to improve denture naturalism, involving basically the reproduction of the contour, texture and color of the patient's gingival tissue in the denture base (2,3).

Several pigments such as carbon black, zinc oxide, titanium dioxide, cadmium red, iron oxide and pure chalk have been associated with acrylic resins in order to match their color to that of the patient's gingiva, thus avoiding the stereotyped pink denture base (2,4).

Although several studies have proposed different methods and materials for denture pigmentation, none of them attempted to investigate their effects on the mechanical properties of the acrylic resin.

The use of microwave energy to polymerize acrylic resins was first reported by Nishii (5). Subse-

quently, several studies investigated (6-8) the use of microwave energy as a heat source to polymerize PMMA and investigated some properties of denture base resins polymerized by microwave irradiation and conventional heating. They did not find differences for the resin properties between the methods.

The aim of this study was to investigate the effect of an acrylic stain and acrylic fibers on the transverse strength of a microwave-cured acrylic resin. The staining materials were tested in concentrations of 0.5% and 1.5% by weight.

## MATERIALS AND METHODS

Forty transverse strength specimens (65 x 10 x 2.5 mm) were fabricated with Onda Ceryl a microwave-cured acrylic resin (Clássico Artigos Odontológicos Ltda., São Paulo, SP, Brazil) according to the American Dental Association specification #12. Specimens

were packed and processed in dental stone molds replicated from Aquasil, a polyvinyl siloxane impression (Dentsply International Inc., York, PA, USA) of a stainless steel mold. Fiber-reinforced plastic flasks (GC Int'l, Tokyo, Japan) held the stone molds.

The acrylic resin was proportioned and mixed according to manufacturer instructions. Five groups of 8 specimens each were fabricated as follows: GI: control (no staining); GII and GIII: addition of Poli-côr acrylic stain (Clássico Artigos Odontológicos Ltda.) in concentrations of 0.5% and 1.5% by weight, respectively; GIV and GV: addition of Mollet knitting acrylic fibers (Linhas Círculo, Gaspar, SC, Brazil) in concentrations of 0.5% and 1.5% by weight, respectively.

All specimens were processed in a domestic microwave oven (Sharp, Manaus, Brazil) with a microwave cycle of 3 min at 360 W, followed by 4 min resting, then 3 min at 810 W. The flasks were bench-cooled for 30 min at room temperature and immersed in cold tap water for 30 min. All specimens were stored in distilled water at 37°C for 48 h before testing.

Transverse strength was measured using a three-point transverse test in a testing machine (EMIC-DL 500, EMIC Equipamentos e Sistemas de Ensaio Ltda., (São José dos Pinhais, PR, Brazil) with a 100-kg load cell and a crosshead speed of 5 mm/min. The transverse strength (S) was calculated employing the formula  $S=3PL/2bt^2$ , where P is the fracture load, L the distance between supports (50 mm), b the specimen width and t the specimen thickness. Stress values were expressed in MPa and tested for differences by using a two-way analysis of variance ( $p=0.05$ ).

## RESULTS

Flexural strength results are presented in Table 1. Analysis of variance demonstrated no statistical differences between groups ( $p>0.05$ ).

Table 1. Means and standard deviation of transverse strength (MPa).

	GI	II	III	GIV	GV
Mean	86.1	86.0	86.6	84.9	85.0
SD	7.9	9.8	7.7	5.3	5.2

GI = control; II = 0.5% acrylic stain; III = 1.5% acrylic stain; GIV = 0.5% acrylic fibers; GV = 1.5% acrylic fibers.

## DISCUSSION

In this study, acrylic resins polymerized by conventional water bath methods were not tested. However, several investigations have demonstrated no significant differences in mechanical properties between acrylic resins polymerized by microwave or conventional water bath methods (6-8). The final transverse strength of the control group was 86 MPa. Del Bel Cury et al. (9) found a transverse strength value of 92 MPa for the same brand of resin tested in this study. Another brand of a microwave-cured acrylic resin was shown to have similar (85.4 MPa) (10) or superior (92 Mpa) (11), 98.7 MPa (12), 105.1 MPa (9) and 108.2 MPa (13) values of transverse strength.

Several studies have used different methods to obtain denture naturalism (14-16) and Plack et al. (14) described a method of mixing carbon soot to the acrylic resin to characterize the denture of a dark-skinned patient. However, these extrinsic techniques show poor results due to the difficulty in harmonizing the colors, the short time change of the hue and wear from abrasion (1).

Fibers have been associated with acrylic resins for denture staining and red nylon thread has been used to imitate the appearance of blood vessels. Zimmerman (2) and Gomes et al. (15) added acrylic fibers in shades of red and violet to simulate blood vessels. Silva et al. (16) presented an intrinsic technique of layering acrylic fibers inside a prepared flask for denture base pigmentation.

The inclusion of acrylic stain and acrylic fibers in the concentrations of 0.5 and 1.5% by weight did not affect the transverse strength of the Onda Cryl resin. Williamson et al. (10) found that polyethylene fibers significantly decreased the transverse strength of Acron MC resin and slightly increased the transverse strength of Lucitone 199 resin when added at concentrations of 0.5% by weight and polymerized by microwave irradiation. Gutteridge (17) and Dixon & Breeding (18) found no significant changes in the strength of resins after the addition of fibers. However, polyethylene fibers have been shown to increase the impact strength and Young's modulus (19,20).

It can be concluded that, the addition of the acrylic fibers or the acrylic stain to the microwave-cured acrylic resin did not affect its transverse strength; and that both methods of intrinsic pigmentation showed

to be esthetically and mechanically acceptable for clinical use. Further studies should be carried out in order to determine the chemical interactions between the acrylic fibers and the acrylic denture base used in this study.

## RESUMO

Silva FAP, Silva TBP, Rached RN, Del Bel Cury AA. Efeito da pigmentação intrínseca na resistência à flexão de resina acrílica polimerizada por microondas. *Braz Dent J* 2002;13(3):205-207.

Esse estudo avaliou o efeito da pigmentação intrínseca na resistência à flexão de uma resina acrílica polimerizada por microondas. Quarenta corpos de prova foram confeccionados (especificação no. 12 da ADA) e divididos em cinco grupos. O grupo I (GI) serviu como controle sem receber pigmentação. Pigmento acrílico foi adicionado aos grupos II (GII) e III (GIII) nas concentrações de 0,5 e 1,5%, respectivamente. Fibras acrílicas (FA) foram adicionadas à resina acrílica dos grupos IV (GIV) e V (GV) nas concentrações de 0,5 e 1,5% p/p, respectivamente. Todos os espécimes foram polimerizados em forno de microondas em um ciclo que consistia de 3 minutos a 360W, seguido por 4 minutos de pausa, e 3 minutos a 810W. As mufas foram resfriadas por 30 minutos em temperatura ambiente e imersas em água fria por 30 minutos. Após a armazenagem em água destilada por 48 h a 37°C, todos os espécimes foram avaliados quanto à resistência a flexão (MPa), exibindo os seguintes valores (médias e desvios-padrão): GI=86,0 ± 7,9; GII=86,0 ± 9,8; GIII=86,6 ± 7,7; GIV=84,9 ± 5,3; GV=84,9 ± 5,2. Não foram detectadas diferenças estatísticas significantes entre os grupos (ANOVA, p>0,05). A adição de fibras acrílicas ou pigmento acrílico não afetou a resistência à flexão da resina acrílica polimerizada por microondas.

Unitermos: pigmentação de bases de prótese, resina acrílica para microondas, resistência à flexão.

## REFERENCES

1. Quinlivan JT. Characterization of denture bases. *Dent Clin N Am* 1975;19:321-332.
2. Zimmerman DE. Denture esthetics III: Denture base color. *Quintessence Int* 1982;13:747-758.
3. Kotwal KR. Color matching denture bases for non-white patients. *J Prosthet Dent* 1980;44:673-674.
4. Gerhard R, Sawyer N. Dentures to harmonize with heavily pigmented tissues. *J Am Dent Assoc* 1966;73:94-95.
5. Nishii M. Studies on the curing of denture base resins with microwave irradiation with particular reference to heat-curing resins. *J Osaka Dent Univ* 1968;2:23-40.
6. De Clerk JP. Microwave polymerization of acrylic resins used in dental prostheses. *J Prosthet Dent* 1987;57:650-658.
7. Reitz PV, Sanders JL, Levin B. The curing of denture acrylic resins by microwave energy - physical properties. *Quintessence Int* 1985;16:547-551.
8. Takamata T, Setcos JC, Phillips RW, Boone ME. Adaptation of acrylic resin dentures as influenced by the activation mode of polymerization. *J Am Dent Assoc* 1989;119:271-276.
9. Del Bel Cury AA, Rached RN, Ganzarolli SM. Microwave-cured acrylic resins and silicone-gypsum molding technique. *J Oral Rehab* 2001;28:433-438.
10. Williamson DL, Boyer DB, Aquilino SA, Leary JM. Effect of polyethylene fiber reinforcement on the strength of denture base resins polymerized by microwave energy. *J Prosthet Dent* 1994;72:635-638.
11. Smith LT, Powers JM, Ladd D. Mechanical properties of new denture resins polymerized by visible light, heat, and microwave energy. *Int J Prosthodont* 1992;4:315-320.
12. Alkhatib MB, Goodacre CJ, Swartz ML, Munoz-Viveros CA, Andres CJ. Comparison of polymerized denture base resins. *Int J Prosthodont* 1990;3:249-255.
13. Rached RN, Del Bel Cury AA. Heat-cured acrylic resin repaired with microwave-cured resin: bond strength and surface texture. *J Oral Rehab* 2001;28:433-438.
14. Plack WF, Todd RA, Woody RD. A technique for the simulation of melanin in denture bases. *J Am Dent Assoc* 1981;103:53-54.
15. Gomes T, Adolphi D, Mori M, Corrêa GA, Braunwarth J. Zahnfleischcharakterisierung von totalprothesen mittels kunststoff-farb-skala nach Tomaz Gomes. *Quintessenz Zahntech* 1994;20:665-674.
16. Silva FAP, Andrade CAS, Silva TB, Silva WAB. Técnica de caracterização de bases de prótese utilizando fibras de lã acrílica. *Rev Ass Paul Cirurg Dent* 2000;54:115-118.
17. Gutteridge DL. Reinforcement of poly (methyl methacrylate) with ultra-high-modulus polyethylene fiber. *J Dent* 1992;20:50-54.
18. Dixon DL, Breeding LC. The transverse strengths of three denture base resins reinforced with polyethylene fibers. *J Prosthet Dent* 1992;67:417-419.
19. Braden M, Davy KW, Parker S. Denture base poly (methyl methacrylate) reinforced with ultra-high modulus polyethylene fibers. *Br Dent J* 1988;164:109-113.
20. Gutteridge DL. The effect of including ultra-high modulus polyethylene fiber on the impact strength of acrylic resin. *Br Dent J* 1988;164:177-180.

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