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Evaluation of Flexural Resistance of a Denture Base Acrylic Resin Reinforced with Glass Fiber and With Composite Resin.

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Abstract - *The objective of this study was to evaluate the flexural strength of denture base resin reinforced with glass fibers and with a laboratorial composite resin. Group G1 was formed with specimens made of acrylic resin. Group G2 was formed with the same acrylic resin but reinforced with a glass-fiber system, and G3 was reinforced with the composite resin. A flexural strength test was performed in all groups (n=10). The mean value for the G1 was 86.70 MPa ± 6.48, for G2 it was 86.60 MPa ± 15.01 and for G3 it was 108.90 +11.03. The addition of glass fiber did not increase the flexural strength however the use of a resin-based composite produced significant reinforcement.*

KEY WORDS: Acrylic resin, Denture bases, Composite resin.

INTRODUCTION

Acrylic resin, for several decades, has been a widely used material in prosthodontics. Bastos[1] has emphasized the need of this material to fulfill biological, mechanical, aesthetic and phonetic requirements. The mechanical property of flexural resistance should be focused on the acrylic resin, which is related to the fracture resistance of the material, which is also an event of difficult solution[2].

The quality and technique used in the polymerization process of acrylic resin for complete dentures are also a factor that could worsen or improve its flexural resistance property, which is directly related to the amount of residual monomer, as studied by Paes-Junior *et al.*[3] . It is believed that placing a reinforcement material in the acrylic resin would increase its mechanical properties; literature has shown reinforcements with several types of fibers: carbon, glass and metal wires[4,5,6,7]. Vallittu et. al.[6,8,9,10] observed that polymethyl methacrylate had considerably improved its mechanical properties with the use of glass fibre. As cited in the literature above, those glass fibre reinforcements have shown a possible improvement in acrylic resin resistance used for complete dentures, although new studies must be established in perspective of looking for better evidence.

The objective of this study was to comparatively evaluate the flexural resistance of a thermally activated acrylic resin reinforced with a laboratorial composite resin, also thermally activated, and with glass fibre.

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MATERIALS AND METHODS

Using a 67 mm x 12.6 mm x 2.55 mm stainless steel pattern, we prepared ten metal flasks, with 3 stainless steel patterns inside, spaced 10 mm from each other, which were previously filled with gypsum type III (Polident®) in the proportion specified by the manufacturer's instructions. We placed the stainless steel patterns, leaving the largest area side in close contact with the gypsum, and waited about 30 minutes to the final crystallization, then we applied a thin layer of separating agent (Cel-Lak®) for acrylic resin.

After the separating agent dried, we used a laboratorial silicone (VIPI-SIL®) suitable for flask preparation, which is often used to replace the gypsum to minimize dental movement during the flask procedure, according to Muench et. al.[11] and others[12]. Silicone was used to facilitate removing the patterns and to prevent edges of the mould from being damaged; it was deposited around the patterns in their initial polymerization phase with the help of a 20 ml Luer syringe, which ensured good flow, providing a faithful copy, leaving only one side of the patterns without covering. After 30 minutes, the silicone polymerization time, the counter part of the flask was positioned and filled with gypsum type III in small portions, using a vibrator. After the flasks were properly prepared, they were pressed for 1 hour. The flasks were opened, the stainless steel patterns were removed and a thin layer of the separating agent across the gypsum surface was applied again.

A total of 33 specimens were formed, with the thermally activated acrylic resin (SR Triplex Hot®). It was manipulated as recommended by the manufacturer, waiting for the saturation time in a closed glass pot for 10 minutes and with a working time of 20 minutes. Of these specimens, 11 received glass fibre reinforcement (Fibrante®), which consists of unidirectional filaments of glass fibre impregnated with a cross-link agent, cut 60 mm in length and weighing an equivalent of 20% of the specimen without reinforcement, measured on an analytical scale amounting 0.34g. Other 11 specimens received a thermally activated composite resin (Cromasit®) reinforcement, which was prepared through a Centrix syringe on 3 parallel applications of 60 mm in length, weighing 20% of the specimens without reinforcement (0.34g) and polymerized along with the acrylic resin during the polymerization cycle. The group divisions are found in Table 1.

To place the glass fibre and the composite resin reinforcement inside the acrylic resin specimens (Illustration 1), we used a stamp shaped device with half the thickness of a specimen, 1.3 mm, where the acrylic resin was pressed by this device interposed by a cellophane sheet, leaving only half thickness inside the cavities previously made in the flask by the patterns, and then we placed the glass fibre and/or the composite resin, which subsequently was covered with a new layer of acrylic resin[13,14,15]. The G1 group (control group) did not receive reinforcement.

The flasks were slowly and gradually pressed in a hydraulic press until establishing 1000 Kgf, and then they were maintained for 30 minutes. After the pressing time, the flasks were transferred to an individual press and brought to the polymerization process. The polymerization process was undertaken using a short cycle, as recommended by the manufacturer; the flasks were positioned in cool water and brought to 100ºC, waiting the period of 45 minutes with the water boiling. The manufacturer recommends using this method to maintain the residual monomer rate at low levels, ensuring that in this process the levels are less than 2.2%. Once the process finished, a period of two hours was waited for cooling the flasks at room temperature.

The specimens were finished to the final dimensions of 65 mm (length), 10 mm (width) and 2.5 mm (thickness), according to Standard #12 of the American Dental Association (ADA) for flexural resistance tests[16], using two stainless steel devices that serve as guides to match the length, width and thickness of the specimens. The specimens were wet ground to the final dimensions using sandpaper in respective granulation of 180, 320 and 600. After finishing the specimens, they were stored in a recipient with distilled water inside a kiln at 37ºC for 48 ± 2 hours, according to Paes-Junior et. al.[3].

A three-point flexural strength test was performed on all groups, and the calculation of the flexural resistance given in MPa by applying the formula $\sigma = 3FD/2LH^2$, where F is the maximum load exerted on the centre of the specimens at the time of their probably collapse, which was determined in Newton (N); D is the span distance (50mm); L is the width of the specimens (10mm); H is the thickness of the specimens (2,5mm). The mechanical testing machine (EMIC) had a load cell of 50 Kgf and a crosshead speed of 5 mm/min at the centre of the specimens. The data were recorded and analysed using ANOVA and Tukey and accepting statistical significance at 5% .

RESULTS

ANOVA statistical test detected significant effects (p=0.00027) when comparing the mean values of each group, the Tukey multiple comparison test was used and a statistically significant difference among the groups at the 95% confidence level was found (Table 2).

Table 1. *Experimental Groups*

Group	*Reinforcement*	*n*
G1	None	10
G2	Glass fiber reinforcement Fibrante® - Angelus	10
G3	Composite resin reinforcement Cromasit® - Ivoclar	10

Table 2 – *Tukey multiple comparison test.*

Group	*Mean (MPa)*	*Standard Deviation*	
G1	86.70	± 6.48	A
G2 – Glass fibre	86.60	± 15,01	A
G3 – Composite resin	108.90	± 11,03	B

*Different letters in same column shows statistical difference with a significant level of 5% by the Tukey test.

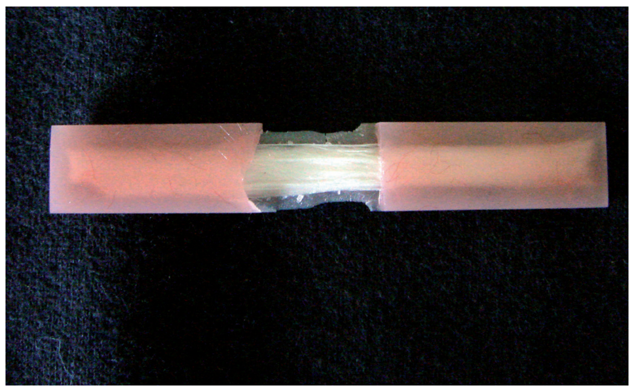

Figure 1 – *Glass fibre reinforcement placed inside the specimen*

The flexural strength of the non-reinforced thermally activated acrylic resin (group G1) was 86.70 MPa ±6.48; reinforced with the Fibrante® glass fibre system (group G2) decreased to 86.60 MPa ±15,01, however not statistically significant. The thermally activated acrylic resin reinforced with the Cromasit® composite resin (group G3) had its mean value increased to 108.90 MPa ±11,03, becoming significantly stronger than the other groups.

DISCUSSION

The risk of total prosthesis fracture is high, whereas some types are associated with flexural fatigue, and these can result from processing deficiencies[2,17]. Some processing and reinforcement means were studied to seek improvement of this material's physical properties. In this study, the results obtained with glass fibre reinforcement were not, statistically, different from the control group. Samadzadeh *et al.*[18] and Uzun & Keyf[19] presented results similar to those found in this study, who did not notice the significant resistance to acrylic resin flexure in groups with the incorporation of glass fibre as reinforcement; this can be explained by incomplete incorporation of the resin, remaining gaps between the fibres.

On the other hand, literature verifies the existence of high success indexes by using glass fibre as reinforcement, which stimulates its usage in different dentistry specializations[20, 21, 22, 23]. This fact is explained by the transfer of the load applied to the resin, since the stress generated will be passed on from the poly-metric matrix to the incorporated fibres, which present greater resistance [28]. It is worth remembering that the fibre used in this work presents unidirectional filaments, whereas they were positioned in the centre of the specimens, different from the results found in the literature that report reinforcement of the acrylic resin, in which sectioned or woven format fibres are used [24, 25, 26, 27, 28].

Using thermopolymerizeable composite resin inside the acrylic resin significantly reinforced the material, whereas polymerization of composite and acrylic resins happened simultaneously, forming one body, without gaps. It is known that composite resins present improved characteristics compared to acrylic resins, which could have contributed to increase the flexural resistance. Values found from reinforcement performed by the composite resin are equivalent to those found in the literature by reinforcements of glass fibre [5,6,7,8,10,13,26,28], which, together with its application practicality and easiness to work with, has shown to be an excellent reinforcement option. However, studies are necessary to evaluate the chemical arrangement between one resin and another, and to identify the ideal positioning and quantity for placing in the prosthesis.

Studies with other glass fibre systems are suggested, since using unidirectional filaments did not reinforce the acrylic resin.

CONCLUSION

Before the inherent restraints of the performed study, and based on the obtained results, it was shown that incorporating thermopolymerizeable composite resin enables obtaining benefits in the physical properties, and it can be used for this purpose. Using glass fibre with unidirectional filaments did not reinforce the thermopolymerizeable acrylic resins, whereas this type of fibre should not be used, in this way, as reinforcement of the acrylic resin.

ADDRESS FOR CORRESPONDENCE

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MANUFACTURERS' DETAILS

- Polident® - Polidental Ind. e Com. Ltda. Brazil.
- Cel-lac® - SS White Art. Dentários Ltda. Brazil.
- VIPI-SIL® – Dental Vipi Ltda. Brazil.
- SR Triplex Hot® - Ivoclar Vivadent AG. Liechtenstein – Switzerland.
- Fibrante® - Ângelus.PR- Brazil.
- Cromasit® - Ivoclar Vivadent AG. Liechtenstein – Switzerland.
- EMIC - model DL 1000, EMIC Equipamentos e Sistemas Ltda., São José dos Pinhais – PR – Brazil.

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