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INFLUENCE OF DIFFERENT CANTILEVER EXTENSIONS AND GLASS OR POLYARAMID REINFORCEMENT FIBERS ON FRACTURE STRENGTH OF IMPLANT-SUPPORTED TEMPORARY FIXED PROSTHESIS

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ABSTRACT

In long-term oral rehabilitation treatments, resistance of provisional crowns is a very important factor, especially in cases of an extensive edentulous distal space. The aim of this laboratorial study was to evaluate an acrylic resin cantilever-type prosthesis regarding the flexural strength of its in-balance portion as a function of its extension variation and reinforcement by two types of fibers (glass and polyaramid), considering that literature is not conclusive on this subject. Each specimen was composed by 3 total crowns at its mesial portion, each one attached to an implant component (abutment), while the distal portion (cantilever) had two crowns. Each specimen was constructed by injecting acrylic resin into a two-part silicone matrix placed on a metallic base. In each specimen, the crowns were fabricated with either acrylic resin (control group) or acrylic resin reinforced by glass (Fibrante, Angelus) or polyaramide (Kevlar 49, Du Pont) fibers. Compression load was applied on the cantilever, in a point located 7, 14 or 21 mm from the distal surface of the nearest crown with abutment, to simulate different extensions. The specimen was fixed on the metallic base and the force was applied until fracture in a universal test machine. Each one of the 9 sub-groups was composed by 10 specimens. Flexural strength means (in kgf) for the distances of 7, 14 and 21 mm were, respectively, 28.07, 8.27 and 6.39 for control group, 31.89, 9.18 and 5.16 for Kevlar 49 and 30.90, 9.31 and 6.86 for Fibrante. Data analysis ANOVA showed statistically significant difference ($p<0.05$) only regarding cantilever extension. Tukey's test detected significantly higher flexural strength for the 7 mm-distance, followed by 14 and 21 mm. Fracture was complete only on specimens of non-reinforced groups.

Key words: Acrylic resins. Glass fiber. Polyaramide. Temporary dental restoration. Provisional prosthesis. Cantilever. Flexural strength.

INTRODUCTION

During rehabilitation procedures, temporary prostheses are extremely important because they act as prototypes that promote, among other aspects, an adequate conditioning of the adjacent tissues.

There are some cases involving osseointegrated implants where it is necessary, due to financial reasons or existence of little bone tissue, to construct the dental prosthesis with a distal extension denominated cantilever, which is a type of balancing beam. In these cases, it is frequent the occurrence of fractures located between the most distal implant and the cantilever[22].

Routinely used to fabricate temporary prosthesis, polymethyl methacrylate-based resin (PMMA) presents low resistance under occlusal loads. For this reason, there are various proposals to reinforce this material, such as inclusion of steel wires[5,19], silica[21] or carbon fibers[15,19], polyaramid[1,6,15,19], poly(ethylene)[12,17], glass[6,7,8,15,18,19], aluminum[2] and Nylon[6], or even orthodontic bands[5], in order to increase either its flexural strength or module of elasticity, thus conferring a greater resistance to fracture.[4]

The aim at this laboratorial study was to evaluate the flexural strength to fracture of acrylic resin specimens simulating temporary prostheses with different cantilever lengths (7, 14 or 21 mm), which were reinforced by glass or polyaramid fibers. Fracture pattern was also analyzed.

MATERIALS AND METHODS

The whole laboratorial phase was carried out in a room with temperature of 23±2ºC and air relative humidity of 50±10%.

A stainless steel base (Figure 1) was used both for specimen fabrication and for further testing. Initially, a kit named prosthetic component was mounted with implant pieces (Neodent, Curitiba, PR, Brazil) consisting of a titanium abutment or UCLA type pillar (4.1 mm in diameter; 10.0 height) fixed over its analogous brass implant (same dimensions) with the proper screw. A two-part silicone matrix (lower and upper compartments) was especially constructed to produce specimens that simulated the shape of 5 joined teeth, namely one canine, three premolars and one molar.

To obtain each specimen, three prosthetic components were fixed (with lateral screws) on the metallic base (one in each orifice of the upper surface) over which the lower portion of the silicone matrix was placed (Figure 2). A 32 N/cm torque load was applied to each implant screw, with a Neodent manual torque wrench.

The upper portion of the matrix was placed over its lower half and, as illustrated in Figure 3A, a fluid mass of Dencôr acrylic resin (Artigos Odontológicos Clássico Ltda., São Paulo, SP, Brazil) prepared with 2.7 mL of monomer and 6.4 g of powder was injected through its main orifice. Injection was done until small amounts of excess material appeared at the escape orifices. At this moment, a glass lamina was placed over the matrix and a 500 g load was applied. This set was immediately immersed in a plastic container with water and placed in a stove regulated at 37ºC, during 10 min to promote polymerization. Resin appearance before removal of excesses is shown in Figure 3B, after withdrawing the upper portion of matrix. The specimen was removed from the base, immersed in water and stored under the same temperature during 15 days. Thereafter, resin excesses were trimmed and the specimen was polished until achieving the appearance presented in Figure 4A (lateral view) and Figure 4B (occlusal view). A total of 30 specimens were fabricated, which constituted the control group.

For reinforced specimens, the same procedures described above were performed, but inserting either glass fibers (Fibrante; Angelus Indústria de Produtos Odontológicos Ltda., Londrina, PR, Brazil) or polyaramid fibers (Kevlar 49; E. I. Du Pont of Nemours and Co., Wilmington, DE, USA) in the acrylic resin mass. For both materials, an original fiber bundle with a mass of 0.08 g and approximately 50 mm long was immersed in Dencôr liquid for 5 min. Then, the mass was divided in two equal parts and dried with absorbent paper. One first half was placed inside the lower matrix portion, contouring the abutments and extending up to its distal end. This procedure was repeated with the other half, crossing the first half at inter-pillar spaces. A cyanoacrylate-based adhesive (SuperBonder, Loctite-Henkel Ltda., São Paulo, SP, Brazil) was used to fix one half to the other, thus maintaining the aspect illustrated in Figure 5A (upper view). This bundle was located 2 mm below the top of the abutments, as shown in Figure 5B (lateral view). The aforementioned procedures for the control group (from

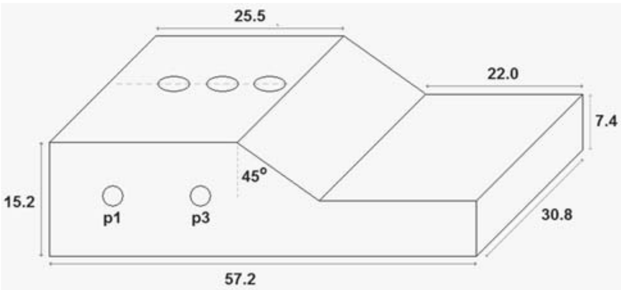

FIGURE 1- Schematic drawing of the stainless steel base (dimensions in millimeters and angle in degrees). Two of the lateral orifices (p1 and p3) used to fix the prosthetic component with screws can be observed

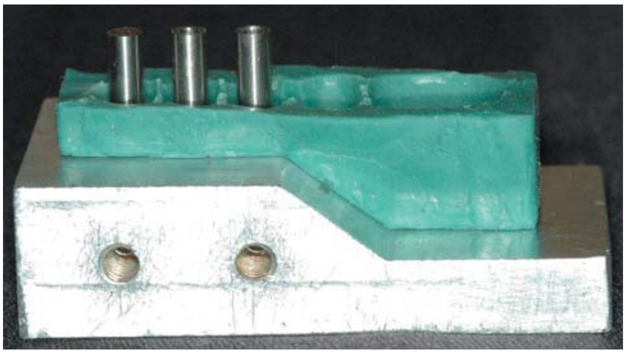

FIGURE 2- Lateral view of 3 prosthetic components attached to the metallic base at the bottom of lower portion of the silicone matrix

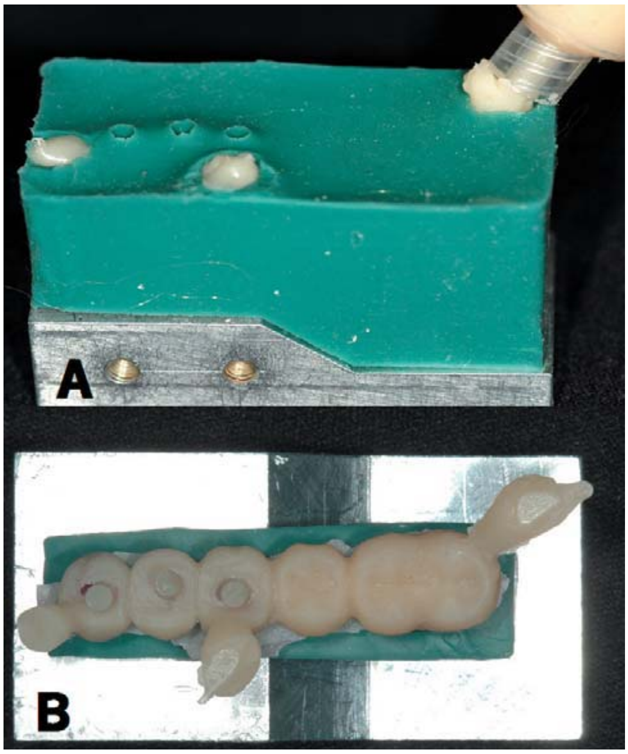

FIGURE 3- Acrylic resin being injected through the proper orifice of the upper portion of the matrix (A); Appearance of the polymerized resin after removal of this portion (B)

resin injection to polishing) were undertaken, totalizing 30 specimens *per* fiber group.

Each specimen was considered ready for testing only when an imaginary transversal section at the interproximal regions of all teeth was 5.0±0.1 mm high and 5.5±0.1 mm wide, as measured with a Starrett 727 digital pachymeter.

It is important point out that Kevlar 49 is originally a tissue used for making clothes, wich was undone in order to obtain fiber bundles with similar dimensions of Fibrante ones.

The specimens were tested by fixing them initially on the metallic base and reapplying the 32 N/cm torque load to each implant screw. This device was then fixed at the table of a universal testing machine (Kratos-Dinamômetros Ltda., São Paulo, SP, Brazil) fitted with a 500 kgf load cell, set to exert a pre-load of 0.060 kgf and then develop a constant speed of 1.0 mm/min, until specimen fracture.

Each group of 30 specimens was divided into 3 sub-groups (n=10). In the specimens of first sub-group, the load was applied on the oclusal surface of the first cantilever tooth, on its distal fossa, that is, 7 mm distant from the nearest implant. In the specimens of second sub-group, the load was applied on the oclusal surface of the second cantilever tooth, on its central fossa, that is, 14 mm distant from the nearest implant. In the specimens of third sub-group, the load was applied on the oclusal surface of the second cantilever tooth, on its distal fossa, that is, 21 mm distant from the nearest implant. These points are circled in Figure 6A (oclusal view). The load was applied on each point by means of the rounded tip of a stainless steel pin with 8.0 mm in diameter (Figure 6B, in a lateral view). Fracture strength of each specimen was recorded and data were analyzed statistically by ANOVA and Tukey's test at 5% significance level.

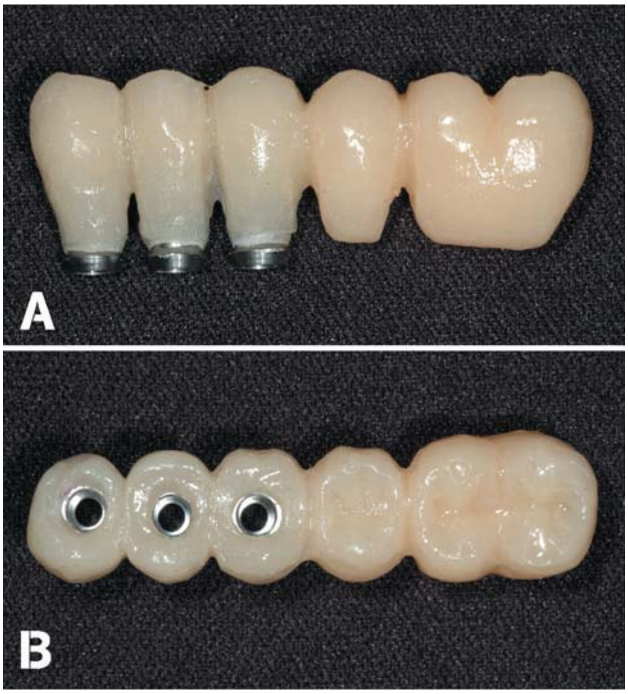

FIGURE 4- Lateral (A) and occlusal (B) view of a specimen ready to be tested

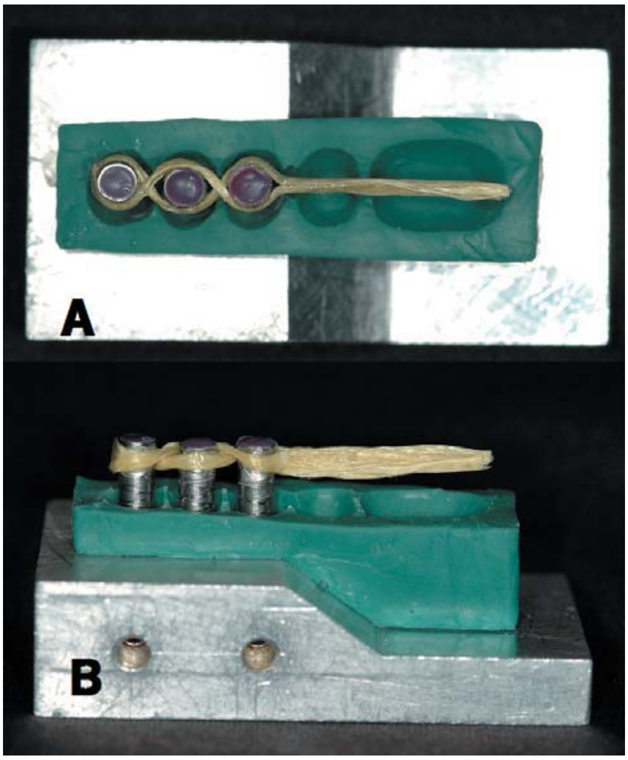

FIGURE 5- Arrangement of fibers (both materials) contouring the abutments and extending to distal portion of the matrix (upper view) (A). In a lateral view (B), the fibers can be seen close to the top of abutments

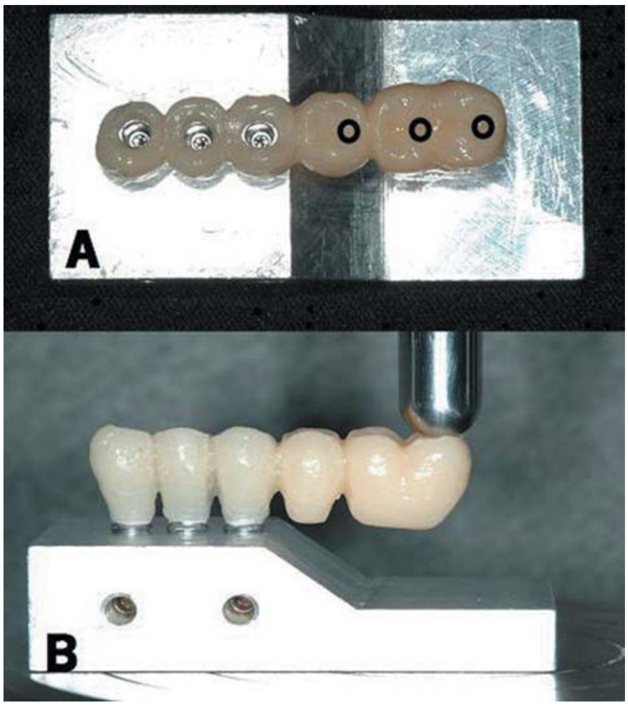

FIGURE 6- Specimen fixed on metallic base (upper view) (A) where the circles on the occlusal surface show possible load application points; Lateral view (B) where a metallic pin is applying force at the cantilever most distal point

RESULTS

Results (in kgf) for each specimen of each studied sub-group are presented in Table 1.

TABLE 1- Flexural strength values (in kgf) of each specimen (sp) of each studied sub-group, with the respective arithmetic mean (m) and standard deviation (sd)

sp	Control			Kevlar 49			Fibrante		
	7 mm	14 mm	21 mm	7 mm	14 mm	21 mm	7 mm	14 mm	21 mm
1	30.50	6.35	8.25	28.40	13.25	4.05	31.70	7.60	9.65
2	32.00	8.45	5.85	33.30	6.25	4.55	35.70	10.65	7.50
3	22.00	8.70	5.20	36.05	9.20	4.85	32.55	9.18	7.53
4	22.50	7.15	5.55	30.15	10.50	5.60	25.20	13.98	7.65
5	26.75	8.75	5.50	28.60	9.30	5.35	36.15	8.58	3.73
6	32.45	10.10	6.50	35.20	10.40	6.30	33.75	12.33	6.98
7	21.75	10.30	6.60	33.95	8.60	4.60	31.80	9.43	7.55
8	37.50	6.85	6.55	27.40	6.45	6.25	32.40	7.88	4.50
9	23.75	10.80	7.65	33.15	8.45	5.15	22.90	5.13	8.20
10	31.50	5.30	6.30	32.65	9.35	4.95	26.80	8.33	5.35
m	28.07	8.27	6.39	31.89	9.18	5.16	30.90	9.31	6.86
sd	5.47	1.83	0.96	3.03	2.02	0.73	4.45	2.51	1.80

ANOVA showed statistically significant difference among the sub-groups ($f=620.9702$; $p<0.05$) only for cantilever length, without interaction of factors. Tukey's test detected significant differences ($p<0.05$) among all cantilever lengths. To transform kgf in Newton (N), these values must be multiplied by factor 9.807.

DISCUSSION

Some authors[3,6-9,15,16,18] have reported that glass and polyaramid fibers promote an increase in flexural strength of PMMA resin specimens. Unlike these findings, the present results found no statistically significant difference between reinforced and non-reinforced specimens, which is in agreement with those of other authors[5,12,14].

The type of treatment applied to the reinforcing fiber immediately before its inclusion in PMMA is a relevant variable. Immersion of these fibers in MMA monomer (liquid) is seen, by some authors, as the cause of air bubble formation at the fiber-resin interface. The use of a fluid resin mass composed of a mixture of PMMA and MMA, has been proposed, instead of fiber immersion in MMA monomer[20]. However, other studies have pointed out that the increase of the amount of MMA monomer around the fibers, before its incorporation into PMMA resin, seemed to contribute to its better wettability and less incorporation of air bubbles[16]. On the other hand, the use of a PMMA-MMA fluid mass would not promote an adequate impregnation of the fibers by the PMMA resin[21]. Because of these disagreements, in the present study, both fibers were immersed in MMA monomer, as several authors[12,16,17] have reported that this method enhances the adhesive resistance between resin and reinforcement fibers.

Any specimen prepared under the same conditions as those of the present study, when subjected to a compression load applied on cantilever distal extreme, suffers traction throughout the full extension of its occlusal surface, which indicates that the best location of the fiber is as higher as possible[10,17].

The specimens of all groups presented higher fracture strength values with the 7mm cantilever than that with 14- and 21-mm long cantilevers. Different suggestions are found in the literature with regard to cantilever behavior, but most authors agree that, in cases with adequate osseous quality, an extension of 10 or 20 mm is acceptable[11,13,22]. The longer the cantilever, the greater the stress on its mesial end. From a clinical point of view, other factors must be taken consideration, such as patient biotype and parafunctional signs, since they impart strong influence on this aspect[11].

Basically, the objective of reinforcement has always been to restrain or avoid crack propagation. The testing machine stops force exertion immediately when crack formation begins, when an abrupt drop of resistance occurs. In spite of this fact, both fragments of a reinforced specimen almost never suffer a complete separation from each other. This is an important clinical aspect, as it might hinder patient swallowing. Similar results to those of the present study have been described by other authors, who found no significant difference in fracture resistance between specimens with or without reinforcement. Several authors have reported that the fibers generally kept both fragments together and that, under clinical conditions, there was a reduction of the risk of losing part of the temporary denture, which implies that the restoration procedure would consume less time[1,5,12].

Reinforcing a temporary prosthesis with fibers, as done hereby, is a relatively simple and very beneficial task with benefits mentioned by several researchers. Although the behavior of both fibers here analyzed was very similar, Fibrante seems to present some advantages, such as the fact of being transparent, which allows using this fiber in anterior teeth as well, where esthetics is an important factor. Moreover, it is more easily found in the Brazilian market at a lower cost than that of Kevlar.

CONCLUSIONS

Under the tested conditions, it may be concluded that: 1. The flexural strength of acrylic temporary dentures increased with the decrease of cantilever length; 2. It was not found significant difference between the groups with reinforcement (Kevlar 49 and Fibrante) and the control group; and 3. A fracture pattern was observed, always as non-separated fragments in all specimens of the reinforced groups and as separated fragments in all specimens of the control group.

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