academicJournals

Vol. 7(11), pp. 183-189, November 2015
DOI: 10.5897/JDOH2015.0181
Article Number: 1DB9AC755777
ISSN: 2141-2472

http://www.academicjournals.org/JDOH

Journal of Dentistry and Oral Hygiene

Full Length Research Paper

Evaluation of resistance to fracture of temporary implant-supported prosthesis with extension in cantilever enhanced with glass fibre

Rodrigo Lorenzi Poluha[1]*, Clóvis Lamartine de Moraes Melo Neto[1], Luiz Guilherme de Paula Constantino[1], Eliseo Braga Junior[1] and Sérgio Sábio[2]

[1]Department of Dentistry, State University of Maringá –UEM, Maringá, Paraná, Brazil.
[2]Department of Dentistry, Graduate School of Denstistry, State University of Maringá, Mandacaru Avenue, Maringá, Parána, Brazil.

Received 23 September, 2015; Accepted 9 October, 2015

This study aims to evaluate the fracture resistance of acrylic resin used in temporary prosthesis with an extension cantilever, using glass fibers treated with silane as reinforcement, varying the distribution and positioning within the matrix. Fifty specimens were produced and divided equally into five groups: Group I, without reinforcement; Group II, reinforced with continuous, concentrated and aligned fibers; Group III, enhanced with simple fiber laminate; Group IV, a doubly reinforced fiber laminate; Group V, reinforced with fibers surrounding the implants and parallel to the occlusal surface. There was statistical variation between Groups I and III, I and IV, I and V, II and III, II and IV, II and V, and III and IV. The results demonstrated that temporary prosthesis reinforced with glass fibers treated with silane exhibited an increased resistance to fracture.

Key words: Dental implants, dental prosthesis, material resistance.

INTRODUCTION

The oral prosthetic rehabilitation using osteointegrated implants is becoming a daily clinic routine (Rosa et al., 2008; Cooper, 2009). An alternative for this treatment, being the provisional cantilever with distal extension is important (Zurdo et al., 2009). This prosthesis can provide comfort and facilitate adaptation for the patient. However, the masticatory forces are concentrated in these extensions. Often we can see fractures in the union between the cantilever and the last implant (Van Zyl, 1995).

The material choices for making temporary prosthesis is polymethylmethacrylate (PMMA), that presents favorable aesthetic property, easy handling and low cost. However, the mechanical properties of PMMA present low resistance under occlusal force (Berrong et al., 1990). Thus, several authors have proposed the inclusion of ribs in these polymers which are: nylon fibers (John et al., 2001), silica fibers (Vallittu et al., 1998), aluminum

*Corresponding author. E-mail: rodrigopoluha@gmail.com. Tel:+554299459674.

fibers (Grant and Greener, 2009), polyethylene fibers (Bae et al., 2001; Dixon and Breeding, 1992; Samadzadeh et al., 1997), steel wires (Carroll and von Fraunhofer, 1985; Hazelton et al., 1995; Powell et al., 1994), polyaramid fibers (Bae et al., 2001), carbon fibers (Ekstrand et al., 1987; Larson et al., 1991) and glass fibers (Vallittu, 1993; Keyf et al., 2003; Nohrström et al., 2000) in order to improve their properties, among them, the flexural strength and modulus of elasticity (Haselton et al., 2002). The purpose of these reinforcements is to improve its strength properties and flexural modulus.

According to Fonseca et al. (2011), among the types of observed reinforcements, the glass fiber treated with silane stood out by virtue of better incorporation of the fibers and the matrix, increased fracture resistance, easy handling and low cost. The development of resistant temporary prosthesis to be used in cantilever can bring greater functional and aesthetic comfort for edentulous patients.

This study aims to evaluate the fracture resistance of acrylic resins (PMMA) with the use of glass fibers treated with silane, depending on their distribution and positioning within the PMMA matrix used in temporary prosthesis with extension cantilevers.

MATERIALS AND METHODS

A stainless steel base I was used for the specimens and the other tests. Three sets of abutments (Neodent, Curitiba, Brazil) constitute a component of type titanium UCLA (4.1 mm diameter, 10.0 mm height) set on an analog of implant external hexagon platform (HE) titanium (same dimensions) with the same diameter Neotorque screw by means of lateral screws (Figure 1; 1).

A second metallic matrix II is constructed in two parts (upper and lower) to produce standardized samples simulating teeth 5, a canine, three pre-molars and molars, with interproximal areas of all teeth 5.0 ± 0.1 mm high and 5.5 ± 0.1 mm wide, with the area of cantilever of 21 mm. All dimensions were measured with a digital caliper (Figure 1; 2).

The preparation of specimens occurred positioning the bottom of the array II on the matrix I. A precision scale was used to weigh the portion of acrylic resin Dencrilay (Dencril, São Paulo, SP, Brazil). 3.8 g powder and 4.0 ml of monomer was used. The resin was mixed according to the manufacturer's specifications. When the resin reached the sandy phase, it was applied into the matrix II (Figure 1; 3). The upper part II to the matrix was coupled in the matrix I during the plastic phase of the resin and excesses were removed (Figure 1; 4). At that moment, an elastic was applied to about two matrices, and immediately taken to the orthodontic pan (VH Essence Dental Equipment, Araraquara, SP, Brazil) with water and under pressure of 20 psi for 10 min to complete the polymerization, facilitating subsequent polishing and avoiding the formation of bubbles inside, thereby eliminating this interference.

A single evaluator produced fifty specimens. The specimens were equally divided into 5 groups. The Group I was the control group. This group did not receive fiber reinforcement. In the other groups, samples were produced with glass fiber. All groups received 0.1 g of glass fibers (Maxi Rubber, Diadema, SP, Brazil). These fibers are treated with silane (Prosil, FGM, Joinville, SC, Brasil).

In Group II, the glass fibers were shredded and regrouped. These fibers were arranged in parallel bundles (Figures 2; 5). The specimens were produced in two stages. At first, the resin was inserted into the individual matrix in the sandy phase (Figure 2; 6). The glass fibers were treated with a silane and inserted into this matrix, making a previous strengthening infrastructure. This structure was taken to orthodontic pan. In the second step, these infrastructures were placed on the components for it to be located at the same level at the top of the pillars. Then, the specimens' preparation process continued being equal to the control group.

The specimens of Group III were constructed with a laminated glass fiber weft (Figure 2; 7). These fibers were positioned in the center of the specimens (Figure 2; 7.1). The glass fibers of the Group IV has been divided into two parts (Figure 2, 8). One of the parts was positioned at the level of the pillars. The other part was positioned in the upper portion of the matrix II (Figure 2, 8.1). In Group V, the specimens were produced with fibers arranged in two ways: encircling the three abutments and parallel to the occlusal surface. The beams which surrounded the implants were placed in the bottom of the matrix and measured 2 cm each, with a quantity of three filaments for each abutments (Figure 2; 9). The beam parallel to the occlusal surface was positioned on top of the matrix which contained ten glass fiber filaments with 3.5 cm in length (Figure 2; 9.1) (Table 1).

The specimens were evaluated for the presence of defects and bubbles, and were discarded when necessary. The specimens were polished and stored for 72 h in deionized water at 37°. The samples were tested in a universal testing machine (EMIC, São José dos Pinhais, PR, Brazil). An independent evaluator, conducted compression tests on the central groove of the molar. The end point of the tests was to fracture the specimen (Figure 3). Fracture strength of each specimen was recorded, and data were analyzed statistically by analysis of variance (ANOVA) and Tukey's test at 99%. Statistical analysis was performed using the statistical software BioEstat 5.3 (Mamirauá Civil Society/CNPq).

RESULTS

Table 2 shows the fracture resistance values for each specimen. The mean and standard deviation can also be observed in this table. ANOVA and Tukey test showed statistically significant difference among groups. Groups III, IV and V were significantly more resistant to fracture as compared to Groups I and II. Assessing the means obtained by groups, it is observed that Group IV was the best. The other groups (Groups V, III, II and I respectively) showed lower performance. Comparing the group with each other, this study observe a statistically significant difference between Groups I and III (4.076); I and IV (5.826); I and V (4.484); II and III (3.188); II and IV (4.939); II and V (3.596). However, there were no statistically significant difference between Groups I and II (0.888); III and IV (1.75); III and V (0.408), IV and V (1.342), respectively.

DISCUSSION

A composite material is formed by a combination of two or more materials. These materials differ in form and chemical composition being insoluble in each other. In the case of polymer matrix composites (PMC), materials are a polymer resin matrix and glass fibers (Smith, 2008; Callister, 2007; Narva et al., 2004).

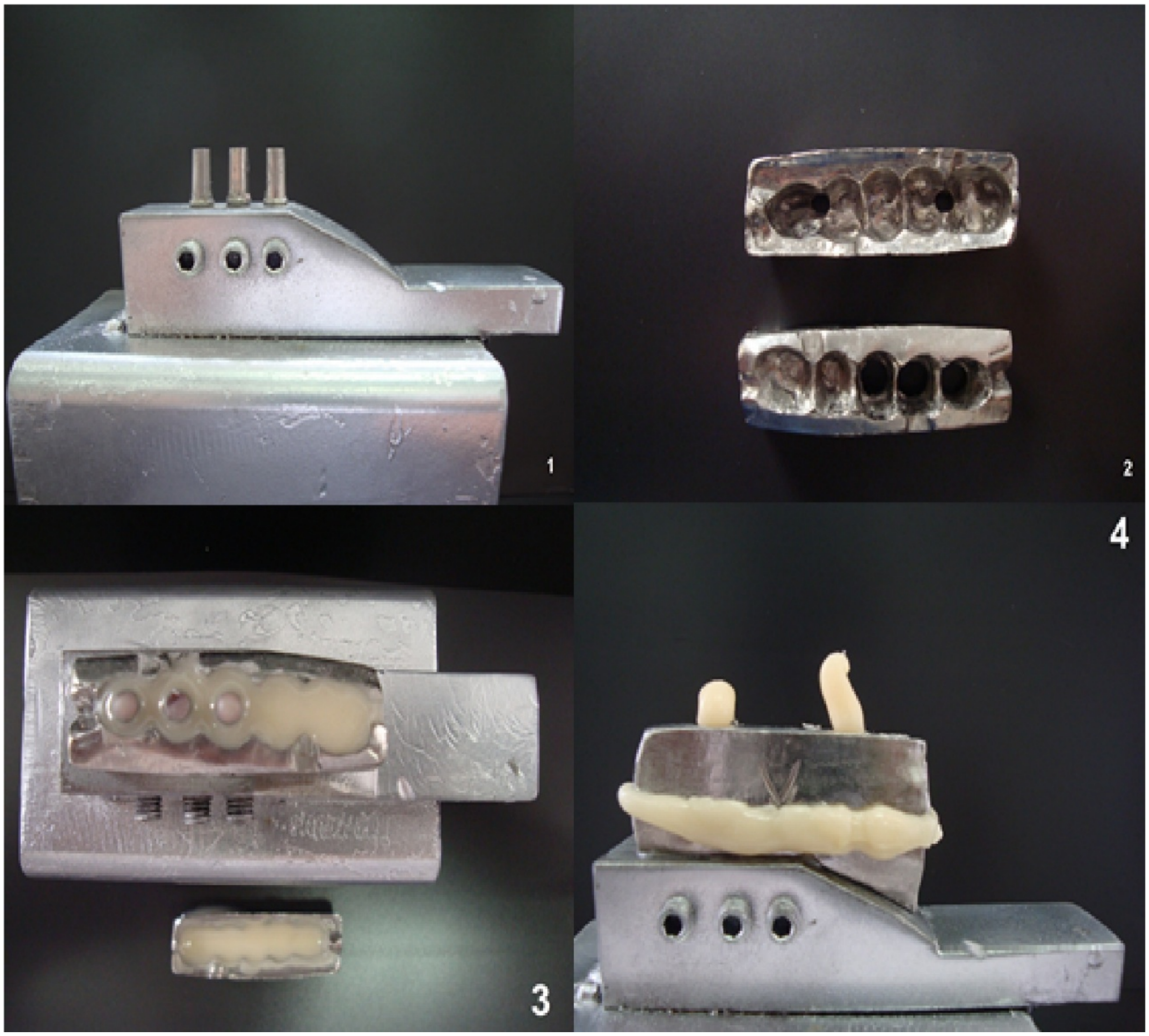

Figure 1. 1. Metallic mould I used as support for the production of specimens and tests in universal testing machine (EMIC); 2. Metallic mould II, top and bottom, used for production of standard specimens; 3. Acrylic resin Inclusion in the upper and lower portion of the metallic mould II in position on the metallic mould I; 4. Top positioned on the bottom of the metallic mould II when reaching the plastic phase.

The resistance of the composites is influenced significantly by factors such as arrangement, orientation and distribution of fibers. Composites with uniform distribution of the fibers should have better properties (Callister, 2007; Colán et al., 2008; Uzun et al., 1999; Hazelton er al., 1995). Another factor is expected that the use of the silane promotes an effective bond between the fiber and resin (Ekstrand et al., 1987; Vallittu, 1993). The results of this study showed that Group III (single laminated glass fibers), IV (double laminated glass fibers) and V (glass fibers surrounding the implant and parallel to the occlusal surface) significantly increased fracture toughness when compared with the Groups I (control group) and II (aligned glass fibers).

Group II (aligned glass fibers) was constructed with the addition of glass fibers. However, the specimens showed no resistance to fracture which was significantly higher, than that in the control group. This finding can be explained by the manufacturing process in two steps of these specimens. In this group, the fibers were applied to the element constructed in different time and after separate manufacture, these reinforcements were added to specimens, assuming a central position within the resin matrix. This device does not seem to interact with the provisional acrylic resin. The fiber reinforcement behaves independently with the acrylic matrix. So, the interim did not benefit from the addition of fiberglass. A union between these two similar materials built and polymerized at different times does not form a composite. Some manufacturers provide glass fibers impregnated

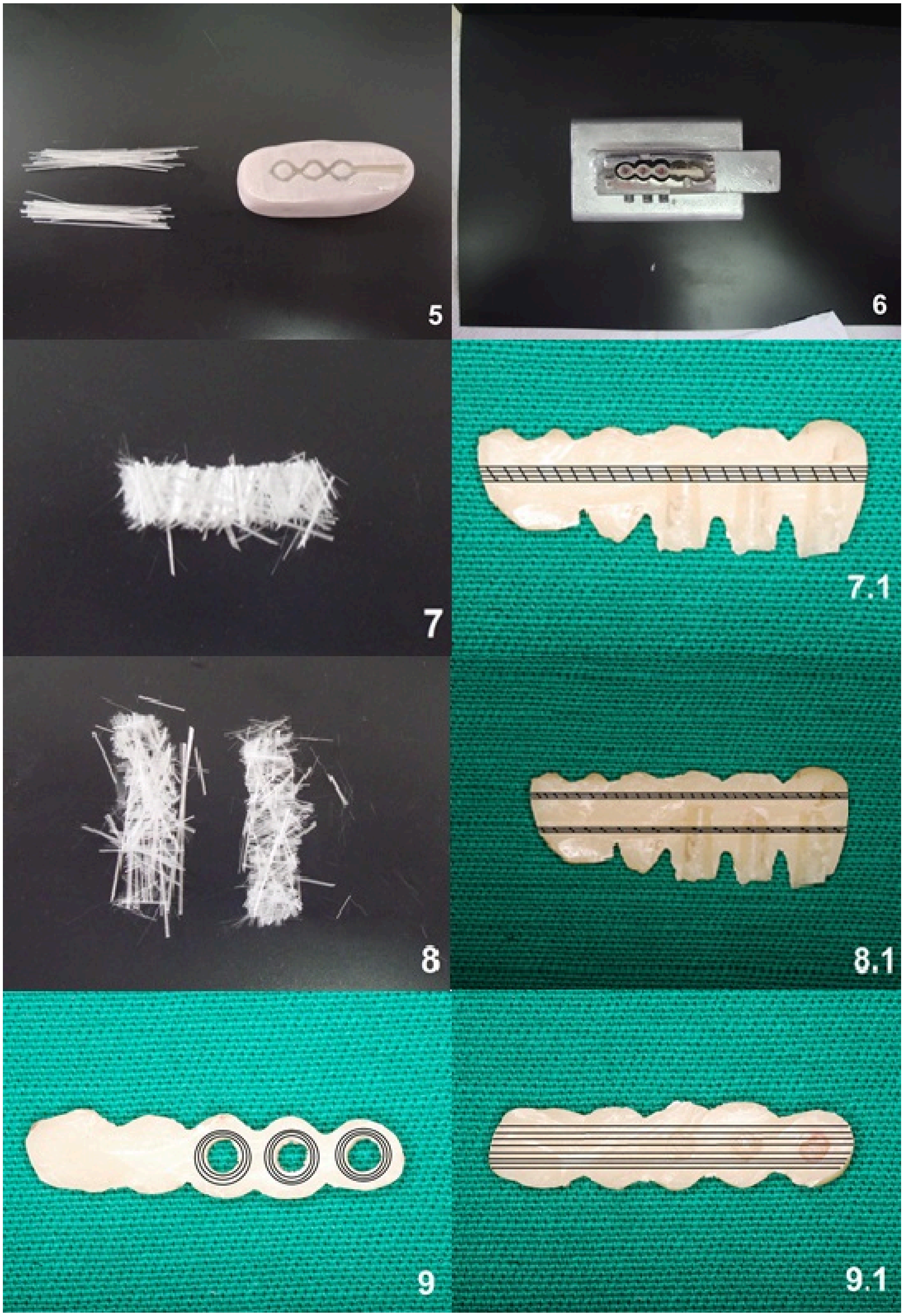

Figure 2. 5. Individual matrix for production of reinforcements for the Group II; 6. Strengtheningproduced in the individual matrix within the matrix II; 7. Glass fiber strips treated with silane; 7.1. Group III illustrates the position of the simple laminated glass fibers within the provisional prosthesis in the sagittal section; 8. Glass fiber strips treated with silane and separated into two parts; 8.1. Double laminated acrylic resin within the matrix of the Group IV (sagittal); 9. Arrangement of glass fibers surrounding the pillars in Group V in a cross section in the provisional prosthesis; 9.1. Continuous fibers and parallel to the occlusal surface.

Table 1. Composition groups.

Group	Composition
I	Control group, without reinforcement
II	Reinforced with continuous, concentrated and aligned fibers
III	Enhanced with simple fiber laminate
IV	Doubly reinforced fiber laminate
V	Reinforced with fibers surrounding the implants and parallel to the occlusal surface.

Table 2. Fracture resistance values (kgf) per specimen (sp) of each study group, with respective mean (m) and standard deviation (SD).

sp	Group I	Group II	Group III	Group IV	Group V
1	6.39	12.79	12.4	13.9	15.05
2	7.61	8.06	9.24	14.0	12.75
3	7.78	8.83	14.94	18.14	14.07
4	6.5	10.25	13.41	13.45	12.79
5	9.03	7.02	14.94	9.83	12.23
6	7.71	7.37	12.3	17.27	11.19
7	9.8	9.9	11.67	14.98	13.13
8	8.41	7.92	12.13	16.3	12.79
9	11.08	11.95	11.12	11.4	15.36
10	10.91	10.01	13.83	14.21	10.7
m	8.52	9.41	12.6	14.35	13.01
dp	[1.66]	[1.93]	[1.76]	[2.52]	[1.49]

Figure 3. Moment of specimen fracture when tested in the universal testing machine.

with resin composite.

Groups III (single laminated glass fibers) and IV (double laminated glass fibers) made use of laminated fibers, interwoven and oriented in strategic positions over the specimens. The fibers were similar in weight and interlacing. However, they were distributed at different positions in the acrylic resin matrix. The oriented positioning is beneficial because it is stable and reduces flexing of the specimen. However, there was no statistically significant difference between these two groups despite heterogeneity of distribution of the fibers position. Possibly, this happened because the vertical length of the specimens does not have enough greatness to be influenced by the fiber positioning. In addition, the reduced size of the samples probably also helped that there was no significant divergence.

Glass fibers (Group V) were separated by removing the interlacing. With this change, it was possible to arrange the fibers in parallel. Thus, the fibers were distributed with greater uniformity in the positioning. In this group, the fibers also was arranged to involve the implants at the level of the pillar. Thus, it was possible to increase the resistance in this region. The results of fracture toughness of these specimens were higher than those of Groups I and II. These results came from the fact that all reinforced species has the same amount of fibers. Once groups were positioned in two different ways between them, they seem to be acted with individual entity and so with the half of quality of the fibers of the other groups. However, there was no statistically significant difference when compared with Groups III and IV. These results seem to indicate that the disposition of the fibers is less important than the weight used. This study did not aim to evaluate the variation of the weight of glass fibers.

The results obtained from the Group III (single laminated glass fibers), IV (double laminated glass fibers) and V (glass fibers surrounding the implant and parallel to the occlusal surface) are similar to those reported by John et al. (2001), Keyf et al. (2003), Kim and Watts (2004), Vallittu (1993, 1998), Vallittu and Lassila (1992), Vallittu et al. (1994), and Narva et al. (2004) who found a significant increase of the flexural strength of specimens PMMA resin reinforced by glass fibers compared to non-reinforced specimens. New research should to be developed with the aim of greater fracture resistance and the assessment of this prosthesis in testing fatigue and thermal cycling.

Conclusion

According to the methodology used and the results obtained in this study, it could be concluded that the provisional prosthesis with an extension cantilever is reinforced with glass fibers, which can be a viable alternative to oral rehabilitation treatment because Group III (single laminated glass fibers), IV (double laminated glass fibers) and V (glass fibers surrounding the implant and parallel to the occlusal surface) increased significantly with the fracture resistance compared with provisional built without reinforcement.

Conflicts of interest

The authors declare that they have no conflicts of interest.

REFERENCES

Bae JM, Kim KN, Hattori M, Hasegawa K, Yoshinari M, Kawada E, Oda Y (2001). The flexural properties of fiber-reinforced composite with light-polymerized polymer matrix. Int. J. Prosthodont. 14(1):33-39.

Berrong JM, Weed RM, Young JM (1990). Fracture resistance of Kevlar-reinforced poly (methyl methacrylate) resin: a preliminary study. Int. J. Prosthodont. 3(4):391-395.

Callister W (2007). Materials Science and Engineering: An Introduction. In: Ltd. JWS. pp. 428-448.

Carroll CE, von Fraunhofer JA (1984). Wire reinforcement of acrylic resin prostheses. J. Prosthet. Dent. 52(5):639-641.

Colán GP, Freitas FF, Ferreira PM, Freitas CA, Reis KR (2008). Influence of different cantilever extensions and glass or polyaramide reinforcement fibers on fracture strength of implant-supported temporary. J. Appl. Oral Sci. 16(2):111-115.

Cooper LF (2009). The current and future treatment of edentulism. J. Prosthodont. 18(2):116-122.

Dixon DL, Breeding LC (1992). The transverse strengths of three denture base resins reinforced with polyethylene fibers. J. Prosthet. Dent. 67(3):417-419.

Ekstrand K, Ruyter IE, Wellendorf H (1987). Carbon/graphite fiber reinforced poly (methyl methacrylate): properties under dry and wet conditions. J. Biomed. Mater. Res. 21(9):1065-1080.

Fonseca RB (2011). Próteses Reforçadas. Revista Unopar Científica Ciências Biológicas e da Saúde. 271-278.

Grant AA, Greener EH (2009). Whisker reinforcement of polymethyl methacrylate denture base resins. Aust. Dent. J. 12(1):29-33.

Haselton DR, Diaz-Arnold AM, Vargas MA (2002). Flexural strength of provisional crown and fixed partial denture resins. J. Prosthet. Dent. 87(2):225-228.

Hazelton LR, Nicholls JI, Brudvik JS, Daly CH (1995). Influence of reinforcement design on the loss of marginal seal of provisional fixed partial dentures. Int. J. Prosthodont. 8(6):572-579.

John J, Gangadhar SA, Shah I(2001). Flexural strength of heat-polymerizedpolymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. J. Prosthet. Dent. 86(4):424-427.

Keyf F, Uzun G, Mutlu M (2003). The effects of HEMA-monomer and air atmosphere treatment of glass fibre on the transverse strength of a provisional fixed partial denture resin. J. Oral Rehabil. 30(11):1142-1148.

Kim SH, Watts DC (2004). Effect of glass-fiber reinforcement and water storage on fracture toughness (KIC) of polymer-based provisional crown and FPD materials. Int. J. Prosthodont. 17(3):318-322.

Larson WR, Dixon DL, Aquilino SA, Clancy JM (1991). The effect of carbon graphite fiber reinforcement on the strength of provisional crown and fixed partial denture resins. J. Prosthet. Dent. 66(6):816-820.

Narva KK, Lassila LV, Vallittu PK (2004). Fatigue resistance and stiffness of glass fiber-reinforced urethane dimethacrylate composite. J. Prosthet. Dent. 91(2):158-163.

Nohrström TJ, Vallittu PK, Yli-Urpo A (2000). The effect of placement and quantity of glass fibers on the fracture resistance of interim fixed partial dentures. Int. J. Prosthodont. 13(1):72-78.

Powell DB, Nicholls JI, Yuodelis RA, Strygler H (1994). A comparison of wire- and Kevlar-reinforced provisional restorations. Int. J. Prosthodont. 7(1):81-89.

Rosa LB, Zuccolotto MCC, Bataglion C, Coronatto EAS (2008).

Odontogeriatria – a saúde bucal na terceira idade. RFO UPF. 13(2):82-6.
Samadzadeh A, Kugel G, Hurley E, Aboushala A (1997). Fracture strengths of **provisional** restorations reinforced with plasma-treated woven polyethylene fiber. J. Prosthet. Dent. 78(5):447-450.
Smith W (1998). Princípios de Ciência e Engenharia de Materiais(1998). In: McGRAW HILL, editor pp. 767-770.
Uzun G, Hersek N, Tinçer T (1999). Effect of five woven fiber reinforcements on the impact and transverse strength of a denture base resin. J. Prosthet. Dent. 81(5):616-620.
Vallittu PK (1993). Comparison of two different silane compounds used for improving adhesion between fibres and acrylic denture base material. J. Oral Rehabil. 20(5):533-539.
Vallittu PK (1998). The effect of glass fiber reinforcement on the fracture resistance of a provisional fixed partial denture. J. Prosthet. Dent. 79(2):125-130.
Vallittu PK, Lassila VP (1992). Reinforcement of acrylic resin denture base material with metal or fibre strengtheners. J. Oral Rehabil. 19(3):225-230.
Vallittu PK, Lassila VP, Lappalainen R (1994). Acrylic resin-fiber composite--Part I: The effect of fiber concentration on fracture resistance. J. Prosthet. Dent. 71(6):607-612.
Vallittu PK, Ruyter IE, Ekstrand K (1998). Effect of water storage on the flexural properties of E-glass and silica fiber acrylic resin composite. Int. J. Prosthodont. 11(4):340-350.
Van Zyl PP, Grundling NL, Jooste CH, Terblanche E (1995). Three-dimensional finite element model of a human mandible incorporating six osseointegrated implants for stress analysis of mandibular cantilever prostheses. Int. J. Oral Maxillofac. Implants. 10(1):51-57.
Zurdo J, Romão C, Wennström JL (2009). Survival and complication rates of implantsupported fixed partial dentures with cantilevers: a systematic review. Clin. Oral Implants Res. 20(Suppl 4):59-66.