Original Article

Effect of Fiber Post and Stainless Steel Wire on the Flexural Strength of Repaired Denture Base Acrylic Resin

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Abstract

The objective of this study is to evaluate the efficacy of fiber post and stainless steel wire on the flexural strength of repaired denture base acrylic resin. The forty-eight heat-polymerized acrylic specimens size 10x65x3.3 mm were divided into four groups; Group1: repaired with auto-polymerized acrylic resin (control), Group2: repaired with auto-polymerized acrylic resin reinforced with smooth surface fiber post, Group3: repaired with auto-polymerized acrylic resin reinforced with grooved surface fiber post, Group4: repaired with auto-polymerized acrylic resin reinforced with stainless steel wire. All groups were tested the flexural strength by using three-point bending machine. Statistical analyses were performed using one-way ANOVA. Values of $p<0.05$ were considered statistically significant. The results demonstrated that the flexural strength of the control group was not significantly different from the other groups, and the flexural strength of group 2-4 revealed no significant difference among themselves ($p=0.067$). In conclusion, the flexural strength of denture base acrylic resin repaired with auto-polymerized acrylic resin is not different from those repaired with auto-polymerized acrylic resin reinforced with fiber post or stainless steel wire. The fiber post and stainless steel wire are not effective in increasing the flexural strength of the repaired acrylic resin.

Keywords: Denture base repair, Flexural strength, Fiber post, Stainless steel wire

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Introduction

Tooth loss is an oral problem that decreases oral health-related quality of life.[1] Dental prosthesis is used to replace missing teeth. Denture fracture has been a common problem in removable dentures.[2-4] Those fractures are often related to the faulty design, poor denture fit, poorly balanced occlusion, artificial tooth wear, faulty fabrication, defect in acrylic base such as porosity and scratches, material breakdown, incorrect artificial teeth position, and denture dropping.[4-6] Complete denture breakage mostly occurs at the acrylic resin midline of both upper and lower dentures. The main causes of upper and lower denture fracture are poor fit of denture base and accidental dropping of the denture, respectively.[6]

There are various materials and methods for repairing fractured dentures. The satisfaction of the dentist when repairing the denture can be defined by less time consuming, good physical properties, inexpensive, and be able to retain the original shape and strength of the denture. Repairing materials include heat-polymerized acrylic resin, auto-polymerized acrylic resin, visible light-cured resin and microwave cured acrylic resin.[7-14]

The most common material used in repairing fractured dentures is auto-polymerized acrylic resin. Auto-polymerized acrylic resin takes less time to repair compared to heat- polymerized acrylic resin which takes hours to cure. Moreover, it does not require additional instruments, such as water bath and light chamber for temperature control, in the repair. It also provides convenience in the matter of time and cost for the patients. However, the major disadvantage of auto-polymerized acrylic resin is the lower transverse strength compared to heat- polymerized acrylic resin.[7,15]

Apart from various surface designs, some materials such as glass fiber, metal inserts, carbon fiber, and aramid fiber have been added to strengthen the repaired denture base. Each material has advantages and disadvantages. For example, glass fiber can improve the mechanical properties of acrylic resin, but poor wetting fiber may decrease the bond strength of acrylic resin. Metal inserts can also improve the mechanical properties of acrylic resin, but they have poor esthetics.[11,16-21]

The aim of this study was to evaluate the efficacy of fiber post and stainless steel wire on the flexural strength of repaired denture base acrylic resin.

Materials and Methods

The forty-eight heat-polymerized acrylic resin (SR Triplex®, Ivoclar Vivadent, Liechtenstein) specimens were fabricated and polished to the dimension of 10 mm x 65 mm x 3.3 mm, according to the ISO 20795-1: 2013 protocol.[22] Each specimen was inserted into the stainless steel holding device with T-shaped groove (Fig. 1, 2). Next, the holding device was placed on the surveyor table (Fig. 3). A straight handpiece with fissure bur was attached to the surveyor arm and adjusted until the end of the fissure bur touched the bottom of the T-shaped groove. Each specimen was cut through the middle with a 2 mm space between the two surfaces and formed a rabbet joint surface design (Fig. 4). The interface surfaces of the prepared joints were wetted with auto-polymerized acrylic resin monomer for 180 seconds. All specimens were randomly divided into 4 groups of 12 each. Group 1 was repaired with auto-polymerized acrylic resin (TOKUSO CURE FAST®, Tokuyama Dental Corporation, Japan) (Control). Group 2 was repaired with auto-polymerized acrylic resin reinforced with smooth surface fiber post (FRC Postec Plus®, Ivoclar Vivadent, Liechtenstein). Group 3 was repaired with auto-polymerized acrylic resin reinforced with grooved surface fiber post (ReforPost®, Angelus, Brazil). The smooth and grooved surface fiber posts (Fig. 5, 6) were marked 6 mm from the parallel tip and cut using a carborundum disc. Group 4 was repaired with auto-polymerized acrylic resin reinforced with stainless steel wire (remanium®, DENTAURUM, Germany). The stainless steel wires were also marked 6 mm from the end and cut using cutting pliers. Smooth surface fiber post, grooved surface fiber post, and stainless steel wire were placed at the middle of the specimens (Fig. 7). All specimens were placed in a pressure pot at the pressure of 2 bars for 15 minutes. According to the ISO 20795-1:2013 protocol[22], all specimens were stored in distilled water at 37°C for 48 hours prior to the flexural testing. The repaired specimens were tested for flexural strength with a three point bending test using the Universal Testing Machine (SHIMADZU®, SHIMADZU, Japan). The load was applied to the center of 2 mm repaired area of each specimen with crosshead speed of 5 mm/min until fracture. All specimens were assessed for cracks using a stereo microscope (Nikon®, Hollywood International Group, Canada).

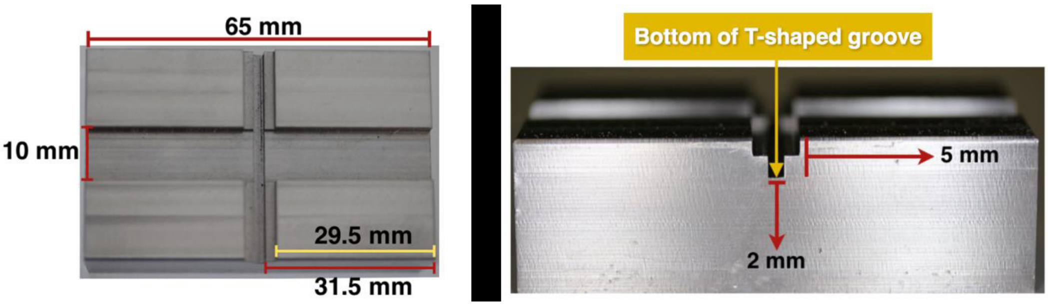

Figure 1 *The stainless steel holding device with T-shaped groove*

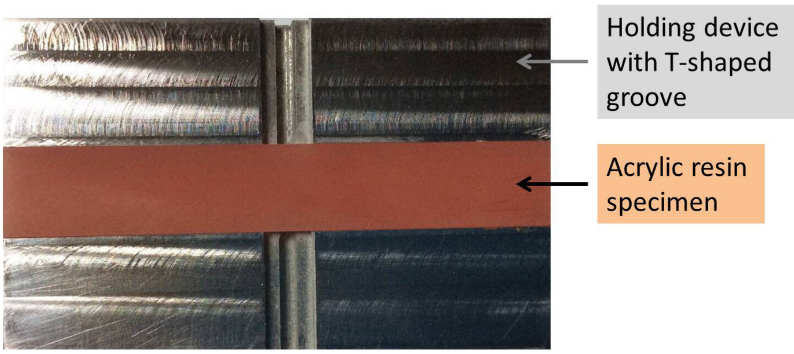

Figure 2 *The acrylic resin specimen was inserted into the stainless steel holding device with T-shaped groove*

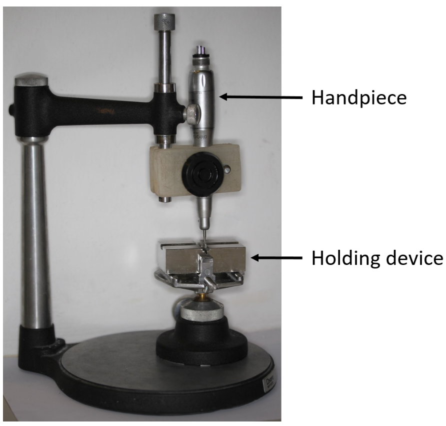

Figure 3 *The holding device was placed on the surveyor table.*

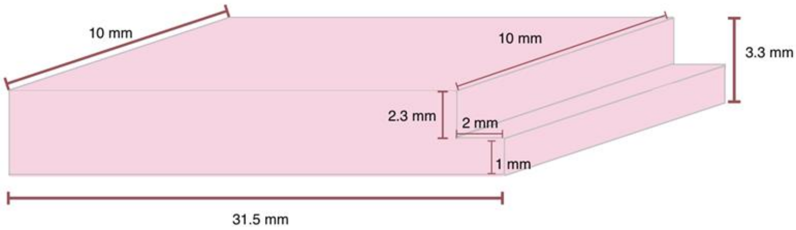

Figure 4 *Each specimen was prepared into rabbet joint surface design.*

Figure 5 *Smooth surface fiber post*

Figure 6 *Grooved surface fiber post*

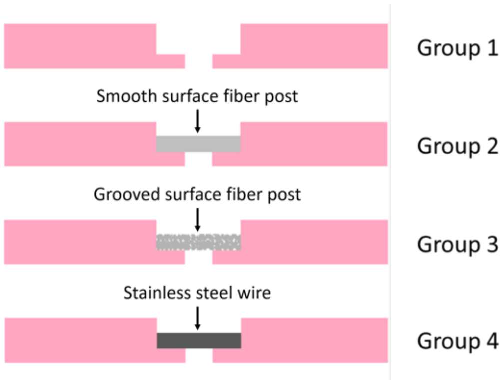

Figure 7 *The specimens in Groups 1-4*

Group 1: Repaired with auto-polymerized acrylic resin (Control)

Group 2: Repaired with auto-polymerized acrylic resin reinforced with smooth surface fiber post

Group 3: Repaired with auto-polymerized acrylic resin reinforced with grooved surface fiber post

Group 4: Repaired with auto-polymerized acrylic resin reinforced with stainless steel wire

Data analysis

Statistical analyses was performed using one-way ANOVA test. The data was analyzed using the statistics package for the Social Sciences (SPSS) version 20.0 (SPSS (Thailand) Cp., Ltd., Bangkok, Thailand). Values of $p<0.05$ were considered as statistically significant.

Results

Table 1 shows the flexural strength of all groups of specimen. The group repaired with auto-polymerized acrylic resin reinforced with grooved surface fiber post (group 3) had the highest flexural strength, while the group repaired with auto-polymerized acrylic resin reinforced with stainless steel wire (group 4) had the lowest flexural strength. However, the flexural strength of the control group was not significantly different from other groups, and the flexural strength of groups 2-4 revealed no significant difference among themselves (*p*=0.067).

To determine the type of fracture failure, the fractured site was investigated under a stereo microscope. The specimens repaired with auto-polymerized acrylic resin reinforced with smooth surface fiber post (group 2), grooved surface fiber post (group 3) and stainless steel wire (group 4) resulted in 100% mixed failure, while the specimens repaired with auto-polymerized acrylic resin (group 1) resulted in 3 types of failure. (Table 1, Fig. 8)

Table 1 *Mean flexural strength (MPa) ± standard deviation (SD) and the percentage of fracture failure type of all specimen groups*

Group	Type of specimen	Mean flexural Strength (MPa) ± SD	Types of failure		
			Cohesive failure	Adhesive failure	Mixed failure
1	Repaired with auto-polymerized acrylic resin only (Control)	43.30 ± 5.8	5.88 %	35.29 %	58.82 %
2	Repaired with auto-polymerized acrylic resin reinforced with smooth surface fiber post	41.45 ± 3.5	-	-	100 %
3	Repaired with auto-polymerized acrylic resin reinforced with grooved surface fiber post	45.66 ± 7.0	-	-	100 %
4	Repaired with auto-polymerized acrylic resin reinforced with stainless steel wire	39.38 ± 6.2	-	-	100 %

One-way ANOVA test (p = 0.067)

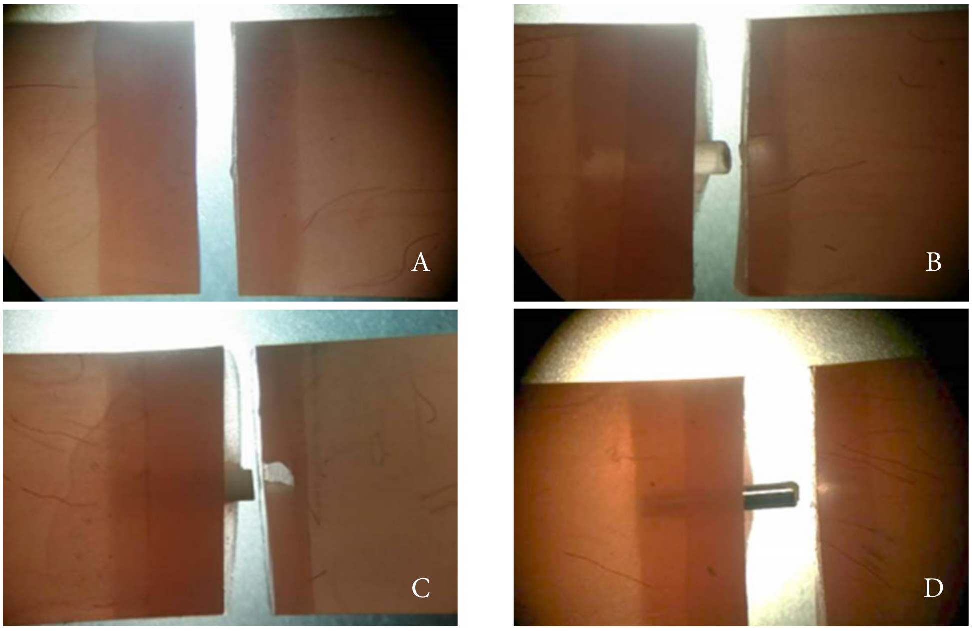

Figure 8 *A - Example of fracture site of specimen in group 1*
B - Fracture site of specimen in group 2
C - Fracture site of specimen in group 3
D - Fracture site of specimen in group 4

Discussion

According to this study, we found that the flexural strength of denture base acrylic resin repaired with auto-polymerized acrylic resin was not significantly different from that repaired with auto-polymerized acrylic resin reinforced with stainless steel wire. This finding is consistent with the study of Golbidi and Mousavi[23] which showed that there was no significant difference between the transverse strength of denture base resin repaired with auto-polymerized Acropars® acrylic resin with and without metal wire, and the transverse strength of denture base resin repaired with auto-polymerized Meliodent® acrylic resin reinforced with metal wire was significantly lower than that of the specimen without metal wire. These results may be due to the poor adhesion between the acrylic resin and the metal wire surface.[23,24] However, our result was not similar to the study of Minami *et al*[18] which showed that the flexural strength of denture base acrylic resin repaired with auto-polymerized acrylic resin reinforced with 1.2 mm diameter stainless steel wire was significantly higher than that of the specimens without metal wire reinforcement.

In this study, we were interested in reinforcing the repaired auto-polymerized acrylic resin with fiber posts because the fiber posts are commonly used in the endodontically treated teeth. We expected that auto-polymerized acrylic resin would have much higher flexural strength after reinforcing with fiber posts. After the experiment was done, we found that reinforcing with both smooth surface fiber posts and grooved surface fiber posts did not significantly increase the flexural strength of acrylic resin. This result may be due to the poor adhesion between the acrylic resin and the fiber post surface. The result of this study is not in accordance with the results of previous studies[20,21,25-29] which revealed that the strength of denture base acrylic resin repaired with auto-polymerized acrylic resin reinforced with glass fiber was significantly higher than that of the specimens without glass fiber. Stipho[25] revealed that the fracture strength of PMMA acrylic resin reinforced with 1 %, 2 % and 5 % glass fiber was significantly higher than those without reinforcement. Polat *et al*[20] found that the transverse strength of denture base acrylic resin repaired with auto-polymerized acrylic resin reinforced with stick glass fiber was higher than that of acrylic resin repaired with auto-polymerized acrylic resin reinforced with woven and chopped glass fibers. On the other hand, Uzun and Keyf[29] revealed that the strength of repaired acrylic resin reinforced with woven form glass fibers was higher than that reinforced with longitudinal form and chopped form glass fibers. However, this study might not be comparable to the previous studies[20,21,25-29] because those studies used the glass fiber as filler, not the fiber post form, mixed in the repaired resin.

The fracture site of specimens in groups 2-4 in this study did not occur in the fiber posts and metal wires, but in the auto-polymerized acrylic resin, and at the junction between the heat-polymerized acrylic resin and the auto-polymerized acrylic resin (mixed failure). It may be due to the lower strength of auto-polymerized acrylic resin, the insufficient polymerization process, and the fact that the elastic modulus of auto-polymerized acrylic resin is less than that of fiber posts and stainless steel wires.[30-34] Studies by Leong and Grant[30], and Berge[31] showed that the denture base repaired with cold-cured acrylic resin broke at repaired site, due to the lower strength of cold-cured acrylic resin.

Based on our results, the fiber posts and stainless steel wires are not effective in increasing the flexural strength of repaired acrylic resin. We must stress that the present study is preliminary in nature. Therefore, we suggest further investigations to create good adhesion between acrylic resin and metal wires by applying 4-META on stainless steel wires, to create good adhesion between acrylic resin and fiber posts by applying bonding on fiber posts, and to strengthen the reinforcement by increasing the number of fiber posts and stainless steel wires in the repair sites.

Conclusion

The flexural strength of denture base acrylic resin repaired with auto-polymerized acrylic resin, which reinforced or not reinforced with fiber post and stainless steel wire, is not different. The fiber posts and stainless steel wires are not effective in increasing the flexural strength of the repaired acrylic resin.

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