Original Article

Comparison of the Effects of Four Pre-Bonding Preparation Methods on the Bond Strength between a Multilithic Tooth and Denture Base Resin

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ABSTRACT

Introduction: With introducing composite teeth, their wear resistance has been well investigated, but there are few papers about their bonding to acrylic denture base resins. The aim of this study was to compare the four pre-bonding preparation methods on the ridge lap surface of one multilithic denture tooth by determining its bond strength to denture base resin.

Materials and Methods: In this experimental laboratory study, 84 maxillary anterior teeth were divided into four groups based on four different pre-bonding methods (untreated, grinding, 2 retention grooves and diatorics). The teeth were mounted on 2 sides of triangular shaped wax models. Then, the laboratory procedures (wax elimination and resin packing) were done. Each of the specimens was tested by universal testing machine with cross head speed of 5 mm/min. The data were analyzed by Kruskal-Wallis and Mann- Whitney tests.

Results: The mean bond strength in untreated group was 287.38 ± 51.82 N, in grinding group was 301.52 ± 113.65 N, in retention grooves group was 374.38 ± 88.22 N and in diatorics group was 415.19 ± 226.37 N. The highest mean bond strength was seen in diatorics group (P=0.009). The percentage of cohesive fractures in this group (90.5%) was significantly more than that in other groups (P<0.001).

Conclusion: The results of this study showed that creating retention hole in the ridge lap surface of the multilithic tooth can increase its bond strength with denture base resin.

Keywords: Acrylic resins, Composite dental resin, Denture bases.

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Introduction

Composite resin denture teeth were developed in the 1980s in an effort to achieve greater wear resistance and bond strength to denture bases [1]. However, some clinical problems of these teeth were poor bonding to denture bases [2], brittle properties [3], and superficial staining [4]. To overcome these problems, one of the improvements in composite teeth involved the combination of composite resins with conventional tooth acrylic resins to create the multilithic teeth [5]. The polymerization process of methyl methacrylate (MMA) and Bis-GMA follows a similar pattern of activation and cross-linking, because the reactive methacrylate groups of the molecules are similar [6]. So, this tooth combines the abrasion resistance of the composite resin with the denture base bonding capabilities of the acrylic resin [4,5]. This new type of composite resin tooth is more widely used than porcelain or acrylic resin teeth in the fabrication of removable dentures because of its high fracture toughness and high abrasion resistance [6-10]. Debonding of denture teeth from denture bases is a major problem in prosthodontic practice [11,12]. This may be related to the basic properties of the materials (teeth or denture base materials), processing factors (such as contaminations or curing cycle duration) and available monomer during processing [5,13-15]. Attempts to increase the strength of the bond between acrylic resin teeth and denture base resin included grinding the glossy ridge lap surface [13,15-17],

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painting the ridge lap surface of the teeth with solvents [14,16,18] and cutting mechanical retention features in the ridge lap surface of the teeth [11-22]. But, the papers during the last 50 years presented conflicting results [14]. With introducing composite teeth, the wear resistance of these denture teeth has been investigated in the literatures [4,7-10,19], but there are few papers about their bonding to acrylic denture base resins. The aim of this study was to compare the four pre-bonding preparation methods on the ridge lap surface of one multilithic denture tooth by determining the strength of their bonding to the denture base PMMA.

Materials and Methods

In this experimental-laboratory study, 84 maxillary anterior multilithic teeth (Yaghoot, Ideal Makou, Tehran, Iran) were selected. Teeth were divided into four groups. According to ISO-3336 specification, each group consisted of 7 central incisors, 7 lateral incisors, and 7 canine teeth of the same molds.

In group A, no further ridge lap preparation was carried out. In group B, the glossy ridge lap surface was grounded to a matte finish. In group C, two mesiodistal grooves, 1.5 mm deep and 1.5 mm width, were cut into the ridge lap surface of the each tooth with a fissure bur. In group D, a hole, 2.5 mm in depth and diameter with a round bur, was drilled into the ridge lap surface of each tooth. Teeth were mounted on 2 sides of six triangular shaped wax models and covered with silicone putty (Optosil, Bayer Dental, Leverkusen, Germany) to facilitate later deflasking. Each model was flasked and the wax was boiled out. The monomer of MMA was applied to the tooth bonding surfaces using a cotton bud for 20s. Then, mold was packed with denture base resin (Meliodent Multicryl, Heraeus-Kulzer GmbH, Wehrheim, Germany) and cured in a curing machine (Automatic curing device, KAVO EWL type 5518, Germany) in accordance with the manufacturers' instructions. After curing cycle was completed, the models were deflasked and conditioned at 23°C ± 1°C and 50% ± 5% relative humidity for 24 hours [15]. All specimens were adjusted and fixed for a shear compressive testing and tests were performed on a Universal testing machine (Instron Corp, Canton, MA, USA). Force was applied by a stainless steel pin, 1 mm in diameter at an angle of 130 degrees to the long axis of the tooth at a cross-head speed of 5 mm/min until fracture occurred. The data were analyzed using Kruskal-Wallis, Mann-Whitney and Chi-Square tests (α=0.05).

Results

Mean values of the fracture forces in four groups are summarized in table 1. The Kruskal-Wallis test showed a significant difference among four groups (P=0.009). The highest bond strengths was found in the teeth with retention holes (group D). The Mann-Whitney statistical test indicated significant differences between groups A and D (P=0.017) and between groups B and D (P=0.042).

In table 2, the site of fracture of the tooth from the resin model is showed as through the tooth, through the acrylic resin (cohesive fractures), or at the tooth/acrylic interface (adhesive fracture). By considering fracture type, Chi-square test revealed a significant difference among four groups (P<0.001). Only in group D, 90.5% of the fractures occurred significantly as cohesive type (P<0.001).

Table 1. Mean fracture forces of the four groups (Newton).

Group	N	Mean (SD)	Min.	Max.
A (untreated)	21	287.38 (51.82)	198	435
B (ground)	21	301.52 (113.65)	118	588
C (2 grooves)	21	374.38 (88.22)	237	533
D (retention hole)	21	415.19 (226.37)	144	1094

Table 2. Sites of fractures (%).

Group	Bond (Adhesive)	Cohesive		
			Tooth	Acryl
A (untreated)	33.3	66.7	66.7	0.0
B (ground)	66.7	33.3	33.3	0.0
C (2 ground)	57.1	42.8	33.3	9.5
D (retention hole)	9.5	90.5	76.2	14.3
Total	41.7	58.4	52.4	6.0

The remaining three groups showed a combination of fracture types (P>0.05). Fisher's Exact test showed significant differences between groups D and B ($P<0.001$) and between groups D and C ($P=0.031$). Fracture of the teeth did not occur in groups A and B.

Discussion

There are many studies about bond strength between acrylic resin teeth and denture base resins [2,5,7,11,13-19], but little has been published on bond strength between multilithic denture teeth and PMMA base materials. In the present study, an attempt was made to study the fracture force of a multilithic tooth to denture base resin by applying a shear compressive force to the lingual surfaces of the teeth at an angle of 130 degrees to the long axis of the teeth. This angle was chosen to simulate the average angle of contact found in a class I occlusion [15]. The bonding strength of an adherent material to another is dependent on their ability to establish an intimate contact and form some kinds of physical (electrostatic bonding), chemical (atomic or molecular bonding), or mechanical (material inter-locking) bonds at their interface [20]. Modification of the denture tooth ridge lap surface by various methods is often carried out in practice in the belief that it increases the bond to the denture base [12,21]. However, the results of studies in which various mechanical methods of improving the adhesion were compared have mainly been contradictory [11,12,15,18].

In this study it was found that drilling 2.5 mm retention holes (group D) improved bonding strength significantly ($P=0.009$). Grinding of the joint surface of the tooth improved the adhesion (group B vs. group A) but there was no significant difference between these two groups ($P=0.174$). The poorer strength of the bond to the PMMA base material of the tooth with two grooves compared with that with retention hole seems to be due to improper penetration of PMMA dough into the two narrow grooves. This improper penetration may be caused by more trapping air in narrow grooves in comparison to wider retention hole, when the acrylic resin dough was pressed. This together with the larger contact area [18] could explain the higher bond strength in group D. In other studies, retention grooves were more effective than diatorics (hole) in increasing bond strength. This may be due to wider but less deep retention hole in our study [11,15,18]. The technical laboratory factor that contributes the bond strength of the denture tooth to the denture base resin is ridge lap surface contamination with wax or tinfoil substitute residues [13-15,21]. This contamination can be cleaned with monomer application on ridge lap surface of denture teeth before packing PMMA into mold [6,14,22]. So, the wider retention hole can be better cleaned than two narrow grooves. This fact can explain the higher bond strength in comparison between groups D and C, but can not explain the higher bond strength of group D in contrast to groups A and B, that can be cleaned better due to ridge lap flat surface of denture tooth. Grinding of the joint surface of the denture tooth (group B) improved adhesion but it was not significantly different from untreated samples (group A) ($P=0.987$). This is in agreement with some studies [6,14,21] but, there are other studies that showed the opposite (i.e., grinding decreased bond strength) [19,22]. The initial objective of this research was to test the bond strength of the denture base acrylic resin to the teeth, but it was demonstrated that most of the fractures occurred within the teeth (52.4%) or through the joint between teeth and denture base resin (41.7%). This means that either the teeth are structurally weak or the bond strength between the teeth and acrylic resin is low. Unlike the results of this study, the multilithic teeth used in the study of Kawara et al [5] were not fractured during testing. Instead, the adhesive failures were equally divided between the acrylic resin segment ridge-lap portion and the transitional composite resin portion that was in contact with the denture base resin [2]. This difference may be due to differences in testing methods or denture teeth construction. In teeth with retention holes (group D) most of the fractures occurred significantly as cohesive type (90.5%) ($P<0.001$). This means that creating diatorics (retention hole) in this type of tooth can increase the bond strength.

In groups A and B, none of the fractures occurred within the denture base resin, but by creating mechanical locks (groups C and D) some of the fractures occurred within the acrylic resin. This agrees with the findings of some previous studies on mechanical locks benefits [12,15,18]. Visual examination of the failure surfaces showed that the number of adhesive failures increased in group B in comparison to group A. It is in agreement with some authors that believed grinding the ridge lap area makes its cleaning difficult due to surface irregularities [19,22].

Conclusion

Within the limitations of this study, retention holes produced significantly better bond strength between the multilithic tooth and denture base resin.

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