



A COMPARATIVE ANALYSIS OF SHEAR BOND STRENGTH OF COMPOSITE AND ACRYLIC TEETH TO HEAT-CURED ACRYLIC RESIN BY DIFFERENCE PREPARATION METHODS

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ABSTRACT

Objectives: One of the basic problems in patients using removable denture is detachment of artificial teeth from the denture acrylic base. The bond strength of artificial teeth to acrylic base may affect this problem.

Materials & Methods: In this experimental study, five groups of artificial teeth (n=150), including 30 phoenix artificial teeth, 30 Emeral artificial teeth, 30 crystal artificial teeth, 30 ECL artificial teeth (Beta Dent Co, Iran), and 30 Ivoclar artificial teeth (Ivoclar Vivadent) were prepared by three different methods: 50 without surface preparation, 50 by methylmethacrylate monomer, and 50 by cavity preparation. Then, wax investment was performed, replacing the heat-cured acrylic resin. To determine the shear bond strength by Universal Testing Machine (UTM), a shear force with a speed of 1mm/min was delivered to samples and the force causing the fracture was recorded. The location and type of fracture were then investigated. The obtained data were analyzed by Kruskal-Wallis test.

Results: The results showed a significant difference in shear bond strength between different artificial teeth in anterior teeth prepared by MM (p=0.004) and CV (p=0.048). Moreover, the findings indicated no significant difference in shear bond strength between different artificial teeth in posterior teeth prepared by MM (p=0.256) and CV (p=0.232).

Conclusion: The findings showed a significant difference between the shear bond strength of acrylic and composite denture artificial teeth to heat-cured acrylic resin.

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Introduction

Satisfaction with the quality of dental services have always been of great importance for both dentists and patients. This is of greater significance for edentulous patients due to loss of all the teeth and high expectation from removable prosthesis. Detachment of artificial teeth from the acrylic base is one of the major problems of complete prostheses which causes problems not only for the patients but also for the dentists and laboratories [1]. Studies have shown that it is possible to change the bond strength by applying physical and chemical changes in the structure of artificial teeth and polymers used in acrylic bases [2-7]. Nowadays artificial teeth are manufactured by various companies where the bond strength of many of them are evaluated by acrylic base [8-11]. Acrylic teeth in dentures, in addition to a physical bond, create a chemical bond to the prosthesis base. Many studies have been carried out on different types of teeth in this regard. The current study was conducted to compare the bond strength of different teeth and the effect of different preparation methods on the bond strength of acrylic artificial teeth at Kermanshah school of dentistry, Iran.

Materials and Methods

After reviewing the studies conducted and consultation with the statistics advisor, a total of 150 artificial teeth, including 30 phoenix artificial teeth (Nano-hybrid composite, Beta Dent Co), 30 Emeral artificial teeth (Nano-composite, Beta Dent Co), 30 crystal artificial teeth (polymethyl methacrylate along with crystal, Beta Dent Co), 30 ECL artificial teeth (polymethyl methacrylate, Beta Dent Co), and 30 Ivoclar artificial teeth (Vivadent Co) (size: N3) were selected in this experimental study. In each group, 15 central incisors and 15 first molars were selected. Each group of artificial teeth was divided into three subgroups according to the preparation method for bonding to acrylic base.

Group 1. Without preparation: before packing acrylic resin, the teeth without any change in the bonding surface were prepared for flasking [21]

Group 2. Methylmethacrylate Monomer etching (MM) Preparation: before packing acrylic resin, methyl methacrylate monomer (SR Tripex hot, Italy Ivoclar, Vivadent) was used twice to moisturize the ridge lap base 1 mm above the cervical area of the artificial teeth [21].

Group 3. Cavity Preparation (CV): before packing acrylic resin, a cavity with 2 mm depth and 2.3 diameter was prepared by an 8 round bur (KG Sorenson) while the teeth were supported by polyvinyl siloxane putty (vinyl polysiloxane impression material heavy body/3M ESPE/USA)[21].

A line was drawn around the artificial teeth up to 1 mm above the ridge lap base using a caliper. This line indicated the finishing site of wax investment. The teeth were mounted on a wax cone (Poly wax/Desen/Turkiye) forming an angle of 45° between the wax surface and longitudinal axis of the tooth [21]. The height of prepared wax cone was 20 mm. Then a rectangular wax block with the height of 60 mm was prepared using a 15×20 mm aluminum block to which the wax cone was connected (Fig. 1).

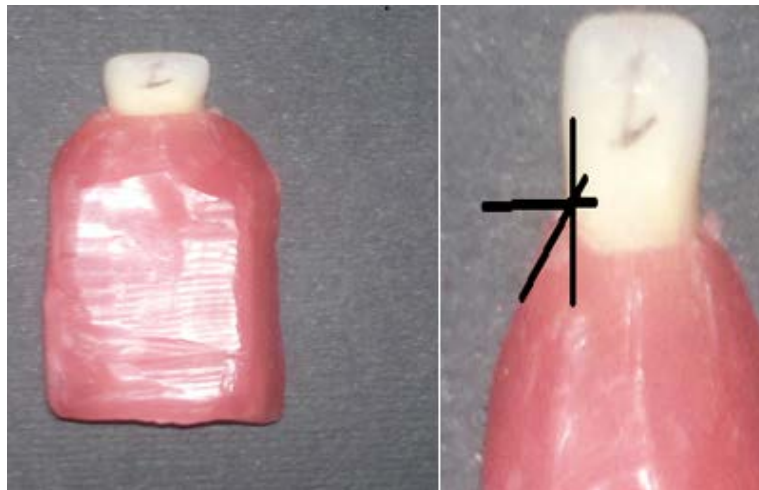


Fig. 1. Preparation of wax cone with 45° angle

The waxes were molded around the cervical area into a crescent-shaped manner [21], and then flasking was done. Three samples were placed in each flask (Brass flask/USA) (Fig. 2).



Fig. 2. Flasking the wax cone

In the lower half of the flask, the dental plaster (Gypsum type II/Pars Dental/ Iran) was used [34]. After 20 minutes when the plaster was set, the first plaster was separated from the second one by Vaseline [34]. Then the upper half of the flask was mounted. The lower and upper parts of the flask were placed on vibrator to prevent bubbles, and dental plaster (Class IV die stone/Pars Dental/ IRAN) was then added [37]. Next, the flasks were placed under the 50 kg press (Hydraulic Press, Koosha Fan Pars/Iran) for 45 minutes [34]. After 45 minutes, the waxes were completely removed using hot water flow, soap and steam. Then the heat-cured acrylic resin (Italy/ Vivadent/ triplex hot Ivoclar) was mixed according to the manufacturer's instructions (23.4g powder, 10ml liquid) and placed in a glass container [21]. According to the manufacturer's instructions, after 10 minutes when acrylic resin turned into dough it was packed into the flask. The flasks were placed under 100 kg hydraulic press for 10 minutes and were then placed in clamp [34]. Next, the flasks were placed in cold water to increase their temperature to 100° and boil them for 45 minutes. After cooling down the water, the flasks were extracted and plaster was removed from the acrylic resin and artificial teeth (Fig. 3).

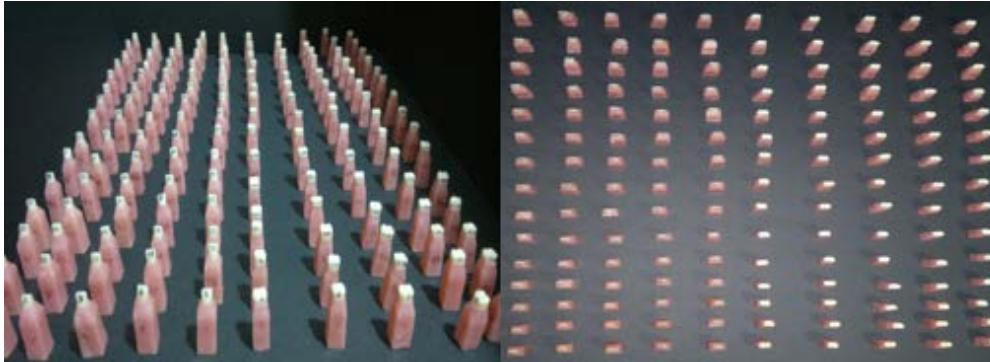


Fig. 3. Prepared samples

To rebuild the mouth, the artificial teeth were kept in distilled water at 37° in incubator (Incubator/Abzar Pezeshki Kavosh MEGA/Iran) for 48-52 hours [34]. They were placed in a thermocycler (Iran/ tc-300/Vafaei Industrial) at 5000 rpm in a cold bath (4°) and a hot bath (55°). The samples were kept in each bath for 30 seconds with an interval of 20 seconds between the two baths [34].

Having prepared the samples, they were numbered and delivered to the operator. To determine the shear bond strength, i.e. the bonding strength between acrylic resin and artificial teeth, a shear force with a speed of 1 mm/min was delivered to the samples by a universal testing machine (Germany/zwick/ roell z050) (Fig. 4). The forces in posterior teeth were delivered at 0.5 mm above marginal acrylic denture in the mesial region so that the blade had 4 mm contact with the teeth; 3 mm contact with polymethyl methacrylate and 1 mm contact with nano-composite [33] (Fig. 4). The forces in anterior teeth were delivered perpendicular to the longitudinal axis of the artificial teeth; 3 mm being in contact with the teeth [38] (Fig. 4). The fracture modes were assessed with a magnifying glass (×5 magnification), according to the following classification: 1) Adhesive - when the separation occurred at the tooth/denture base interface; 2) Cohesive in PMMA denture base - when the denture base material remained bonded to the dislodged teeth, covering it completely; 3) Cohesive in the tooth - when total tooth base remained bonded to the denture base; 4) Cohesive in the tooth associated with cohesive in the denture base; and 5) Mixed - when significant areas of adhesive and cohesive failures occurred simultaneously[21].

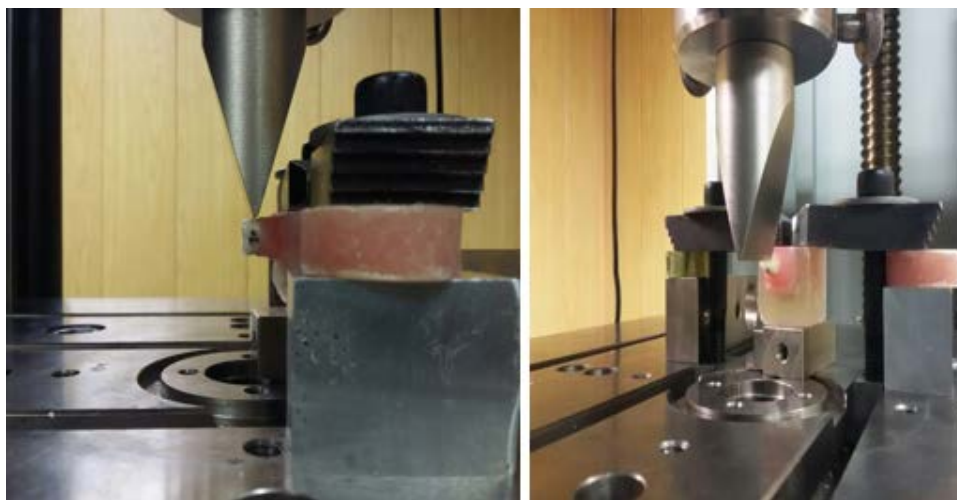


Fig. 4. Location of force delivered to anterior and posterior teeth by UTM

Results

The results showed no significant difference between different artificial teeth, including phoenix, Emeral, crystal, ECL, and Ivoclar in anterior teeth without surface preparation in terms of bonding strength ($p=0.451$) (Fig. 5). The maximum bond strength was reported for phoenix artificial teeth and the minimum strength was found for ECL artificial teeth. However, the findings indicated a significant difference between different artificial teeth, including phoenix, Emeral, crystal, ECL, and Ivoclar in anterior teeth after preparation with methylmethacrylate ($p=0.004$) (Fig. 6).

The maximum shear bond strength was reported for Ivoclar, crystal, phoenix, Emeral, and ECL, respectively. Further, the results revealed a significant difference between different artificial teeth regarding shear bond strength after cavity preparation ($p=0.048$) (Fig. 7). The maximum shear bond strength was reported for Ivoclar, phoenix, crystal, Emeral, and ECL, respectively. Moreover, the findings showed a significant difference between different artificial teeth with regard to bond strength in posterior teeth without surface preparation ($p=0.42$) (Fig. 8). The maximum shear bond strength was reported for Ivoclar, crystal, Emeral, ECL, and phoenix, respectively.

In addition, the findings showed no significant difference in the bond strength of posterior artificial teeth after preparation with methylmethacrylate ($p=0.256$) (Fig. 9). The maximum and minimum bond strength were reported for Ivoclar and ECL artificial teeth, respectively. Furthermore, no significant difference was observed for bond strength after cavity preparation in posterior teeth ($p=0.232$) (Fig. 10). The maximum and minimum bond strength were reported for phoenix and ECL artificial teeth, respectively.

The highest frequency of fracture in anterior teeth without preparation was reported for mixed fracture in Ivoclar and Emeral artificial teeth. The maximum frequency of fracture in anterior crystal artificial teeth was reported for cohesive fracture within the tooth and acrylic resin. For ECL and phoenix artificial teeth, the most frequent type of fracture was found for cohesive fracture within the teeth. The type of fracture in the artificial teeth prepared with methylmethacrylate was the same as that of the artificial teeth with no preparation; the only difference however was that the most frequent type of fracture in Ivoclar and Emeral artificial teeth was mixed fracture. In the case of preparation with diatoric cavity in phoenix artificial teeth, cohesive fracture within the tooth was reported to be of the highest frequency. As for the rest of the teeth, cohesive fracture within acrylic resin was found to be the most frequent fracture. In posterior teeth, the most frequent fracture in Ivoclar and crystal artificial teeth without preparation was reported to be mixed fracture, and in ECL, phoenix and Emeral artificial teeth, the most frequent fracture was cohesive fracture within the tooth and acrylic resin. In preparation with MM and diatoric cavities, the most frequent fracture in Ivoclar and crystal artificial teeth was found to be cohesive fracture within acrylic adhesive, and in ECL, phoenix and Emeral artificial teeth, it was cohesive fracture within the tooth and acrylic resin.

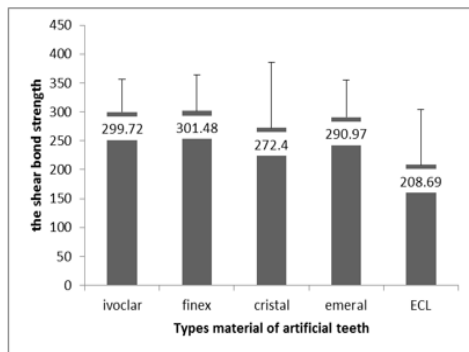


Fig.5

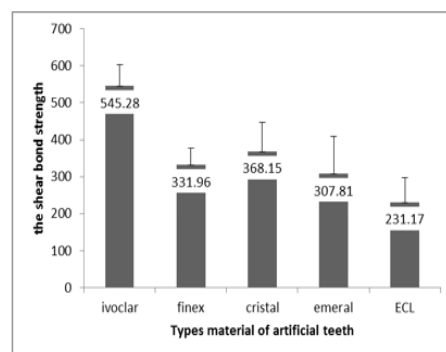


Fig.6

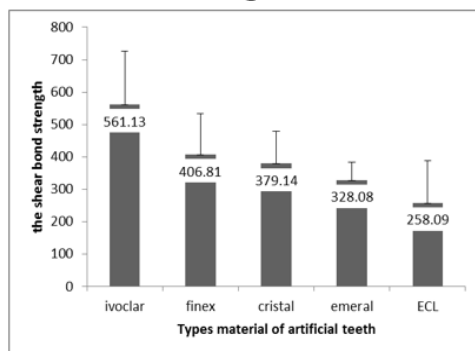


Fig.7

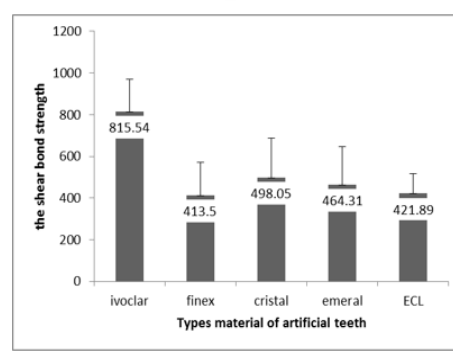


Fig.8

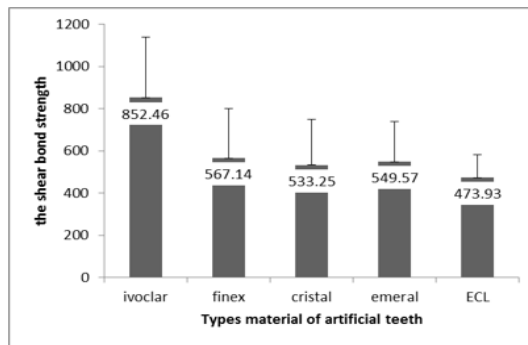


Fig.9

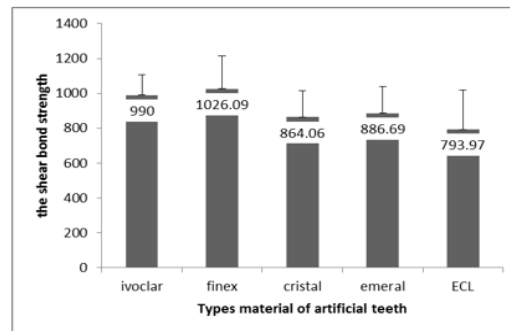


Fig.10

Discussion

The results of study for different preparation methods showed that in all samples, both in anterior and posterior teeth, the maximum levels of shear bond strength was reported for cavity preparation, methylmethacrylate preparation, and artificial teeth without preparation. The increased bond strength in MM technique could be due to the fact that when there are two solid surfaces, or one solid and one liquid surface that soak the surface well, the surface tension value is greater than the surface active one and increases the bond strength [40]. Also, after some time the speed conversion of monomer to polymer is reduced due to two reasons: first, the number of reactive monomers is reduced and second, the propagation velocity of monomers in a substance with high viscosity is highly reduced toward the reaction sites [41]. Therefore, putting the monomer in the ridge lap area increases the number of monomers as well as polymerization in this area, thereby increasing the bond strength. The increased bond strength in artificial teeth prepared with diatoric cavity than teeth prepared with methylmethacrylate and teeth without preparation can be associated with the micro- and macro-mechanical attachment generated by diatoric cavities [40].

The results of the study regarding the bond strength of anterior teeth without preparation indicated no significant difference among different artificial teeth, including phoenix, Emeral, crystal, ECL, and Ivoclar artificial teeth ($p=0.451$). The maximum and minimum levels of bond strength were found for nano-hybrid composite phoenix and ECL artificial teeth, respectively. The equal bond strength of the artificial teeth could be possibly due to this fact that in all samples polymethyl methacrylate resin was used in the ridge lap area and the ridge lap surface of anterior teeth was less than that of posterior teeth.

Adhesive fracture was the most frequent type of fracture in Ivoclar denture possibly because the teeth were monolithic, indicating their high structural strength. Also, cohesive fracture within the tooth and acrylic resin was the most frequent type of fracture in crystal artificial teeth, and cohesive fracture within the tooth was the most frequent type of fracture in ECL artificial teeth. These findings for crystal and ECL artificial teeth indicate their lower structural strength than Ivoclar teeth. The maximum frequency of fracture in phoenix teeth was reported for cohesive fracture within the tooth probably because these teeth were multilithic, and bonding strength of composite to acrylic resin was low. Despite the multilithic nature of Emeral denture, the most frequent type of fracture in these teeth was adhesive fracture, which might be due to low polymerization of polymethyl methacrylate at the ridge lap area.

The findings of anterior teeth prepared by methylmethacrylate showed a significant difference between different artificial teeth, including phoenix, Emeral, crystal, ECL, and Ivoclar ($p=0.004$). Ivoclar, crystal, phoenix, Emeral, and ECL were found to have the maximum strength, respectively. The increased bond strength in acrylic teeth compared with composite artificial teeth might be due to increased polymerization at the ridge lap area while using methylmethacrylate. Although polymethyl methacrylate was used at the ridge lap region in all samples, the reduced bond strength in ECL teeth than other teeth could be due to the use of cross linking monomer in ECL structure, which caused higher cross linking at the ridge lap region and reduced the bond strength. The type of fracture in the teeth prepared with methylmethacrylate was the same as that of the teeth with no preparation; the only difference, however, was that the most frequent type of fracture in Ivoclar and Emeral teeth was mixed fracture. Mixed fracture is a kind of adhesive fracture with this difference that some acrylic resin remains in the cervical region possibly due to the wax investment method.

The results of anterior teeth prepared by diatoric cavity revealed a significant difference between various anterior artificial teeth after cavity preparation with regard to bonding strength ($p=0.048$). The maximum levels of bond strength were found for Ivoclar, phoenix, crystal, Emeral, and ECL artificial teeth, respectively. The possible reason for the increase of bond strength in phoenix than in Emeral denture is higher content of filler in phoenix denture. The presence of inorganic fillers (particle or fibrous) has a remarkable impact on the properties of polymers, which in turn increases the modulus of elasticity and strength [41]. The higher bond strength of phoenix artificial teeth than crystal artificial teeth may be due to micro- or macro-mechanical attachment in the structure of nano-composite dentins. The most frequent type of fracture in phoenix denture was cohesive fracture within the tooth, which might be due to the multilithic nature of these artificial teeth. The most frequent type of fracture in the rest of the artificial teeth was cohesive fracture within the acrylic resin, which could be due to attachment of acrylic resin within diatoric cavities. The results of posterior teeth could not be compared with those

of anterior teeth because the ridge lap surface of anterior teeth was lower than that of posterior teeth and forces were delivered at different locations.

The results of posterior artificial teeth without preparation showed a significant difference between different artificial teeth in terms of the bonding strength ($p=0.042$). The highest level of bond strength was reported for Ivoclar, crystal, Emeral, ECL, and phoenix artificial teeth, respectively. The enhanced bond strength in Ivoclar and crystal artificial teeth is possibly because they are monolithic and acrylic, but the reduced bond strength in phoenix denture may be due to the delivery of force. Because the posterior teeth receive more forces along the longitudinal axis, the string fillers should be oriented in such a manner to be resistant against these forces. On the other hand, in phoenix artificial teeth some degree of anisotropy occurs (delivery of force in different directions changes the bond strength). The most frequent type of fracture in Ivoclar and crystal artificial teeth was found to be mixed fracture, which is indicative of the higher structural strength of these artificial teeth than ECL in which the most frequent type of fracture was cohesive fracture within the tooth and acrylic resin. As for phoenix and Emeral artificial teeth, cohesive fracture within the tooth and acrylic resin was the most frequent type of fracture, which could be because of the multilithic nature of these artificial teeth and location of forces applied.

The findings related to the posterior teeth revealed no significant difference between the bond strength of different artificial teeth following preparation with methylmethacrylate ($p=0.256$). The maximum and minimum levels of bond strength were reported for Ivoclar and ECL artificial teeth. The improved bond strength of phoenix artificial teeth might be due to increased polymerization at the ridge lap region of the teeth. The most frequent type of fracture in Ivoclar and crystal artificial teeth was found to be cohesive fracture within acrylic resin possibly because of increased polymerization at the ridge lap region as a result of application of methylmethacrylate. In the case of ECL artificial teeth, cohesive fracture within the tooth and acrylic resin was reported to be the most frequent fracture, which is indicative of low bond strength in these teeth. In phoenix and Emeral artificial teeth, cohesive fracture within the tooth and acrylic resin was the most frequent type of fracture, which could be because of the multilithic nature of these teeth and location of forces delivered.

The results of posterior teeth prepared by diatoric cavity indicated no significant difference between the bond strength of different artificial teeth after cavity preparation ($p=0.232$). The maximum and minimum levels of bond strength were reported for phoenix and ECL artificial teeth. The increased bond strength in phoenix and Emeral artificial teeth might be due to the mechanical attachment in the structure of the nano-composite, which reduced the effect of forces delivered to the nano-composite. Cohesive in the acrylic fracture within Ivoclar and crystal artificial teeth was found to be the most frequent type of fracture possibly because the acrylic resin was stuck within diatoric cavity. As for ECL artificial teeth, cohesive fracture within the tooth and acrylic resin was the most frequent fracture, indicating their low structural strength. With regard to phoenix and Emeral artificial teeth, cohesive fracture within the tooth and acrylic resin was observed to be the most frequent type of fracture, which might be due to the multilithic nature of these artificial teeth and location of forced delivered.

Similar to the present study, the studies of Farid Bahrani [25], Lauro Egídio Bragaglia [21], and Adelina Stoia [31] showed that preparation with methylmethacrylate increased the bond strength. Farid Bahrani reported preparation by diatoric cavity enhanced the bond strength but the research by Lauro Egídio Bragaglia showed a reduction in bond strength in preparation by diatoric cavity. This difference might be due to the fact that in the present study acrylic resin was packed at diatoric cavity while adding acrylic resin by condenser, which was intended to make sure air entrapment did not prevent chemical bonding at this region.

Ghahramani [34] reported that the bond strength of composite artificial teeth was lower than that of acrylic artificial teeth in posterior teeth, which is in line with the results of present study considering less bond strength of composite teeth than acrylic teeth. Using bending strength test, Kawara [17] reported that the bond strength of acrylic monolithic teeth was significantly higher than that of resin-based multilithic teeth. Compared with the results of the current study, this difference may be associated with different types of artificial teeth used as well as the structural difference of multilithic artificial teeth manufactured by Beta Dent Company compared with the artificial teeth tested in Kawara's study.

In their study analyzing the . Effect of surface treatments on the bond strength of different resin teeth to complete artificial teeth base material, Carolina et al. [20] studied four types of polymethyl methacrylate artificial teeth manufactured by various companies. The results showed no significant difference considering the effect of surface preparation on intragroup bond strength of commercial brands. In this study, a different acrylic resin was used, so the results cannot be compared with the results of the current research.

Rostamkhani et al. [27] evaluated the tensile strength of four types of acrylic artificial teeth (Italian Ivoclar, Yaghoot, Herasit plus and Acradent) in vitro in the presence of artificial saliva. Their findings showed the highest tensile strength for Ivoclar, Herasit plus, Yaghoot, and Acradent artificial teeth, respectively. In the present study, Ivoclar denture was reported to have the maximum bond strength but due to different types of artificial teeth used, type of preparation, and measurement of tensile strength, this study is not comparable with the current study.

Ghasemi et al. [28] examined the bond strength of several composite artificial teeth (Glamour, Yaghoot, Ivoclar, and Apple) to acrylic resin-based denture. The findings indicated that the mean bond strength of Apple composite artificial teeth was higher than that of the other artificial teeth. Because of the differing types of artificial teeth used in this study, the results cannot be compared to the findings of the present research. Also, Mosharaf et al. [10] investigated the bond strength of three

types of Iranian resin-based artificial teeth (Marjan, Super Newclar, and Diamond) made by Ideal Makoo Company and compared them with a German denture. Their results revealed no significant difference between the Iranian and the foreign artificial teeth. This study is also not comparable with the present study because of the different types of artificial teeth evaluated.

Conclusion

1. In all samples, the maximum level of shear bond strength in both anterior and posterior artificial teeth was reported for teeth with CV preparation, teeth with MM preparation, and teeth without preparation, respectively.
2. In posterior teeth, there was only a significant difference in Ivoclar artificial teeth regarding shear bond strength from among different preparation techniques. No significant difference was found for other artificial teeth.
3. In posterior artificial teeth, no significant difference was found for the shear bond strength of Ivoclar and crystal artificial teeth from among various preparation methods. There was a significant difference between the shear bond strength of other artificial teeth.
4. In all anterior artificial teeth, no significant difference was reported for the shear bond strength of the artificial teeth without preparation. Methylmethacrylate and cavity preparation methods were reported to show a significant difference.
5. In all posterior artificial teeth, a significant difference was found for the shear bond strength of the artificial teeth with no preparation. However, no significant difference was found for methylmethacrylate and cavity preparation methods.

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