Original Article

Comparison of the effects of microfilled and hybrid composite resin restorations on the fracture resistance of extensively weakened teeth

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Abstract

Background and Aim: Composite resins can play an important role in dentin support and enamel strength via bonding to tooth structure. The purpose of this study was to compare the effects of hybrid and microfilled composite restorations on the fracture resistance of extensively weakened teeth.

Materials and Methods: In this case control study, 40 intact maxillary premolars were mounted in transparent acrylic resin blocks. The samples were divided into 4 groups (n=10 each). Group PC comprised of intact teeth, without preparation and restoration. In other three groups MOD preparations with constant depths and converged walls toward occlusal surfaces were prepared. Group NC composed of teeth with preparations but without any restoration. Group HR included prepared and restored teeth using a hybrid composite and Group MR contained prepared and restored samples with a microfilled composite. Samples were thermocycled (500 cycles at 5-55° C), then were placed under compressive loads in a universal testing machine, and the curves were drawn with Test Xpert software.

Results: Mean fracture resistance in HR, MR, PC, and NC groups was 48.1010, 59.1773, 83.1420, and 21.9220, respectively. There was a statistically significant difference among the groups ($P<0.05$).

Conclusion: The increasing effect of microfilled group on the fracture resistance of restored teeth is significantly more than that of hybrid group.

Key Words: Fracture resistance, microfilled composite, hybrid composite

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Introduction

Healthy teeth rarely break due to pressures caused by normal chewing and most cusp fractures occur due to extensive caries or weakening by large cavities [1-2]. Different studies have shown that cavity preparation significantly weakens remaining tooth structure [2-7]. In this case, a major clinical problem in large cavities that have lost dentin support is cuspal fracture The restorative materials that are not able to bond to teeth cannot resolve the problem.

Amalgam has good mechanical properties and easy placement and removal. It is frequently used for posterior restorations because of resistance against pressures of chewing [8], but its high modulus of elasticity does not allow it to reinforce weakened cusps [9]. Furthermore, it needs more extensive preparation of healthy enamel and sometimes installing components which makes teeth more prone to fracture.

Composite resins may play a key role in supporting dentin and strengthening enamel through bonding

capabilities. Moreover, it allows for the cavities to be prepared more conservatively [10]. Most of the studies have shown that restored teeth with composite resins are stronger than those restored with amalgam [1, 11-14]; however, a few studies have reported similar results for strength of amalgam and composite [5-6].

Schwartz et al believed that composites are effective for better transmission and distribution of functional stresses due to their ability to bond to the tooth tissue. They also believed that composites are capable of strengthening tissues whereas metal intra-coronal restorations may act like a wedge between buccal and lingual cusps and increase the risk of cuspal fracture. On the other hand, in composite restorations, cuspal deflection is under less heavy occlusal load. Therefore, propagation of cracks which eventually lead to fracture of tooth structure is postponed [15].

Wear of new composite materials is close to amalgam and incidence of marginal microleakage, discoloration, polymerization shrinkage and postoperative sensitivity is reduced to a large extent [16]. In addition, they have a special position in dentistry studies due to their strengthening effect on resistance of weakened teeth tissues and large cavities. Nevertheless, most of the studies have compared amalgam and composite, but no comparative investigation has been conducted on the reinforcing effect of two types of composites. Due to different properties of different composites, there may be different influences on strength and reinforcement of tooth structure. The aim of this study was to compare the effect of microfilled and hybrid composite restorations on fracture resistance of severely weakened teeth.

Materials and Methods

In this case-control study, forty healthy human maxillary premolar teeth which had no cavities, cracks or restorations were included. The teeth were collected from patients with 15 to 20 years of age due to orthodontic reasons. The time interval between tooth extraction and testing was less than eight months. After removing, the teeth were maintained under tap water at room temperature and prevented from drying during the study. The teeth were mounted in transparent acrylic resin and then divided to four groups.

The first group comprised of healthy teeth which were considered as the positive control (PC) and preparation was done in other three groups. In other three groups of NC (negative control), MR (microfilled restoration) and HR (hybrid restoration), MOD cavity preparations were done using 008 bur (Tizkavan, Iran, Tehran). The depth of cavity remained fixed and preparation walls were convergent to the occlusal side. Buccolingual widths of each preparation in occlusal aspect was two-thirds that of intercuspal distance of tooth, which reached two-thirds of intercuspal distance plus 1.5 mm on two sides on pulp surface tooth (0.75 mm on each side). For greater accuracy, tip of cusps was checked by a copy paper and this distance was measured and recorded by a caliper. Then, two-thirds of the recorded number was determined as the width of isthmus in occlusal aspect, in a way to have the same distance from buccal and lingual walls in order for the hole to be exactly in the middle of tooth and both cusps become equally weakened. All internal angles were rounded and no bevels were made on enamel margins.

After the preparation, HR and MR groups were restored, but NC group was left unrestored to serve as the negative control group.

After cavity preparation, the teeth were rinsed and dried by a gentle air stream. Then, metal matrix tape was closed around the tooth so that its edge was 1 mm above the occlusal level. All prepared enamel surfaces were etched by 37% phosphoric acid gel (Ivoclar, Vivadent, Schaan, Liechtenstein) for 30 s and then rinsed with water and slowly dried.

SE bound (Kuraray medical Inc, Tokyo, Japan) was homogenously placed over the surface according to its manufacturer's instructions (20 s use of primer and drying with gentle air stream; then, using resin bond and narrowing it by gentle air flow) and was cured by a light curing device for 10 sec.

Clearfil AP-X hybrid composite (Kuraray medical Inc, Tokyo, Japan) was used for HR group and Heliomolar composite (Ivoclar/Vivadent, Schaan, Liechtenstein) as a microfilled one was applied for MR group in posterior restorations. Restorative materials were placed in two separate layers so that the thickness of each layer was about 1.5 mm and each layer was cured for 40 sec. At the end, they were cured from buccal and lingual aspects sides for another 40 sec. After 24 h, the samples were polished by a polishing bur. Samples were kept under tap water during this period.

All the samples were thermocycled (500 rpm at 5 and 55°C) and eventually subjected to compressive forces using Universal Testing Machine (Zwick/ Roell ZO2O). To apply the force, the 4-5 mm (in diameter) bars were used proportional to intercuspal distance of each tooth. The bar was placed vertically on the tooth in order to be only in contact with slopes of buccal and lingual cusps, not restorative material. Stress-strain curves for each tooth was recorded by Test Xpert V10-11 software and Fmax was obtained for each sample. The data were analyzed by analysis of variance (ANOVA) and Tukey test to assess the differences between groups in SPSS software.

Results

Mean of forces required for group fracture, standard deviation and maximum and minimum resistance in each group are shown in Table 1. Mean resistance to fracture was 48.1010, 59.1773, 83.1420 and 21.9220 in HR, MR, PC and NC groups, respectively. There was no significant difference between the groups (p <0/05).

NC group, showed the least fracture resistance and had no statistically significant difference from three other groups (PV<0/05). PC group, i.e. showed the highest fracture resistance (PV<0/05). MR group, had less resistance than PC group, but the difference was not statistically significant. HR group, had less resistance than MR group and again the difference was not statistically significant. However, the difference between PC and HR groups was statistically significant (PV<0/05).

Table 1: Mean of groups' fracture resistance, standard deviation and minimum and maximum resistance in each group

Groups	No	Mean (kg force[1])	SD	Min resitance (kg force)	Max Resistance (kg force)
PC	10	83/1420	19/9074	52/12	110/60
NC	10	21/9220	11/7656	11/16	51/69
HR	10	48/1010	22/9778	18/23	93/63
MR	10	59/1773	23/2299	33/16	110/28

Discussion

Ability of restorative composites to maintain and strengthen weakened tissues is one of the most important issues that are discussed in dentistry today. This study investigated differences between two types of microfilled and hybrid composites to increase strength in weakened teeth against fracture. According to the results, tooth restoration with microfilled and hybrid composites or hybrid (MR and HR groups) increased resistance of teeth against fracture (compared with NC group).

This result was in line with the results of Newman and Pisko-Dubienski in 1984, Mc Cullock and Smith in 1986 and Bakke in 1985, which showed that posterior composite restorations significantly increased fracture resistance compared to the groups which were not restored [11, 17-18].

Simonsen in 1986 also found that composite restorations could increase fracture strength of teeth, even higher than healthy teeth [14].

Liberman and Ausiello showed that use of dentin bonding agents and posterior composite could significantly increase resistance of the remaining walls of cavities compared with amalgam [19-20].

Results of most studies in which composite resin was compared with amalgam show that composite resin can increase fracture resistance of the remaining tooth structure as well as its beauty [21]. However, Stampalia and Joynt expressed the same fracture resistance for composite resin and amalgam [5-6].

The difference between results of their study and

the present one may be attributed to the point that they used bulk insertion technique instead of layering the composite, which may cause cracks in composite during polymerization process and reduce strength and fracture resistance of the remaining walls or polymerization shrinkage may cause cusp movement and reduce fracture resistance against occlusal forces.

In the present study, strength of the teeth in NC group was about 26% in healthy teeth, 57% in HR group and 71% in MR groups. It can be stated that microfilled composites are able to reinforce tooth to a relatively high extent.

Considering elastic modulus of two materials, elastic coefficient of hybrid composite AP-x (16.7 Gpa) was more like that of dentin (Gpa19) (22-23). So, the teeth restored with hybrid composite showed higher resistance. This issue was also approved in studies by Farid and Abdel-Mawla and Llie et al. [24-25]. However, the results of this study showed that restored teeth with microfilled composite of Heliomolar and lower elastic coefficient (Gpa 6/10) had high resistance to fracture [8]. It indicates that, to increase tooth resistance, elastic coefficient of restorative material is not the only factor to predict outcome; therefore, strengthening degree of tooth tissue is multifactorial and other factors such as bending coefficient of material, flow, etc. are also involved.

The reason for the observed difference in the experimental groups of this study can be attributed to polymerization process of these materials. Plastic deformation occurs as a result of flow in composite during polymerization which compensates for the pressure from contraction [26]. Considering flexibility of microfilled composite and its more flow power for reducing pressures caused by polymerization shrinkage during gel process, it can be concluded that these composites absorb pressure and like a shock absorber decrease transfer of polymerization stress to tooth.

Hardness of hybrid composites caused it not to relieve pressure in itself and impose it onto the bond between restoration and tooth; probably, this may cause cracks in teeth during polymerization.

In the study by Bayne, filler reduction in flowable composites compared with hybrid groups increased flow and decreased elastic modulus and acted as a layer for absorbing pressure to release them in the material itself rather than the teeth or bond between restoration and teeth [27]. Rigidity and hardness of hybrid composites stopped releasing pressure in them and thus entered it onto the bond between restoration and tooth; probably, it can cause cracks in teeth during polymerization.

As shown in samples under stereomicroscope, some hybrid group samples had a higher number of cracks. It seems that percent of microfilled composite contraction was more because of high resin content. Nevertheless, according to the company's claims, contraction of the two materials was the same [23]. This issue seems logical since the microfilled composite used in this study was of heavy filled type. Therefore, the stress induced by contraction was equal in both groups. Thus, flow of microfilled group during polymerization process could compensate for the contraction caused by polymerization and also make plastic deformation and pressure release in itself in order to increase teeth resistance against fracture compared with the hybrid group.

In this study, the force was static and was different from "frequent dynamic forces" which are entered into the teeth in the mouth environment. In order to generalize these results to clinics, more studies, especially clinical ones, with higher number of samples and other similar materials are necessary.

Finally, properties of all types of composite resins such as hardness, microleakage, water absorption and flexural strength of resistance were evaluated against fracture. Other researches on other aspects of restoration are necessary for more general results.

Conclusion

Considering the limitations of this study, fracture resistance of "prepared without restoration" teeth was significantly lower than "restored" teeth against occlusal forces. Dental restoration by microfilled composites could increase dental re-

sistance as much as healthy teeth. Increase of resistance against fracture in microfilled composite restoration was superior to restoration by hybrid composite.

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