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In Vitro Fracture Resistance of Endodontically-treated Maxillary Premolars

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Clinical Relevance

Horizontal pins alone, or with flowable composite, have no effect on the fracture resistance of endodontically-treated maxillary premolars restored with resin composite.

SUMMARY

Many endodontically-treated teeth require quick, simple, low-cost restorations. This study evaluated the effect of horizontal pins and flowable composites on the fracture resistance of endodontically-treated maxillary premolars directly restored with resin composite.

In this *in vitro* study, 64 intact human maxillary premolars, extracted for orthodontic reasons, were randomly divided into four groups of 16. Standard access cavities were prepared in such a way that the buccal cusp had a buccolingual thickness of 3 mm measured at the height of contour. The palatal cusp was reduced to 1.5 mm coronal to CEJ. The specimens were prepared as follows:

Group 1: resin composite restoration without horizontal self-threading pins or flowable composite (control group).

Group 2: resin composite restoration without horizontal self-threading pins but with a 2 mm thickness of the flowable composite.

Group 3: resin composite restoration with two horizontal self-threading pins in the buccal cusp but without flowable composite.

Group 4: resin composite restoration with two horizontal self-threading pins in the buccal cusp and flowable composite with a thickness of 2 mm.

Subsequent to thermocycling, all specimens were loaded to failure. The data were analyzed using a two-factor ANOVA test (α=0.05).

The maximum mean of fracture resistance was in Group 1 (632.86 ± 119.46 N), and the minimum value was related to Group 3 (533.49 ± 168.07 N).

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DOI: 10.2341/06-149

There was not a statistically significant difference between the groups (*p*>0.05).

Conclusion: Neither horizontal pin placement nor flowable composite had a significant effect on increasing the fracture resistance of endodontically-treated maxillary premolars restored with composite.

INTRODUCTION

One of the most important problems dental practitioners face is the restoration of endodontically-treated teeth. Endodontic treatment weakens tooth structure and makes it susceptible to fracture, since a large portion of tooth structure is lost during the procedure.[1] With appropriate crown reinforcement, it is possible to compensate for the lost tooth structure and restore its optimum function and esthetic. In the past, indirect restorative procedures, such as metallic post and core fabrication, followed by full crown, were customary and experienced great clinical success.[2-3] However, there are cases in which a simple, quick, direct, low-cost restorative procedure is preferred. Resin composites with dentin bonding agents are materials that are considered good candidates for the direct restoration of endodontically-treated teeth. When it comes to strengthening the tooth structure and in increasing its fracture resistance, the role of resin composites with dentin bonding agents has generally been accepted.[4-10]

Using flowable composites can be beneficial. One of the advantages of flowable composites is their close adaptation with the floor and walls of the preparation.[11-12] It has also been reported that the use of flowable composites as cavity liners reduces cuspal flexure.[13-14]

Another method of mechanically splinting and reinforcing cusps is the use of threaded pins placed horizontally in the vertical dentinal walls of the cavity preparation. The efficacy of horizontal pins with or without adhesives has been substantiated in amalgam restorations.[15-17] In the current study, the effect of horizontal pins with or without flowable composite was evaluated in endodontically-treated teeth restored with resin composite. The hypothesis was that the use of horizontal pins with flowable composite would result in an increase in the fracture resistance of endodontically-treated maxillary premolars.

Considering the location of maxillary premolars in the dental arch, subjecting them to a combination of destructive compressive and shearing forces[15] and the important role of these teeth in esthetics, the current study was designed to evaluate these teeth.

METHODS AND MATERIALS

Sixty-four intact human maxillary premolars, extracted for orthodontic reasons, were used in this *in vitro* study. The teeth were free of caries, free of any previous restorations and pre-existing fractures or cracks, when surveyed under 2x magnification,[13] and stored in normal saline at room temperature immediately after extraction. The teeth were then immersed in 0.5% chloramine T solution (Merck, Germany) at 4°C for disinfection and stored up to one month in the same solution. Before use, the premolars were debrided with hand-scaling instruments and cleansed with a rubber cup and slurry of pumice. Using a simple random sampling method, premolars of similar size were divided into four groups of 16.

In all groups, the teeth received a standard access cavity for root canal treatment using a coarse tapered flat-end diamond bur (TF-13C, MANI, Inc, Tochigi, Japan) in a high-speed handpiece with water spray. A new bur was used after every 10 preparations. The root canals were then debrided. For filing, #15, #20 and #25 K-files (MANI) were used in the apical third of the canals, and #2 and #3 Gates Gliden drills (MANI) were used to flare the coronal two-thirds of the canals. Using a diamond disk (Sinter Flex DMZ 935-220 Diamant, Derendel + Zweiling, Berlin, Germany), the palatal cusp of each tooth was reduced so that the pulpal floor at the palatal side was 1.5 mm coronal to the CEJ and the thickness of the buccal cusp in each tooth was 3 mm at the height of contour when measured by an orthometer (Figure 1). The canal orifices were then obturated with 2 mm diameter resin-modified glass-ionomer cement plugs (Fuji II LC, GC Corporation, Tokyo, Japan) and cured using a light-curing unit (Astralis7, Ivoclar Vivadent, Amherst, NY, USA). The following procedures were carried out separately in each group.

Group 1: The enamel and dentin of the premolars were etched simultaneously for 15 seconds using 35% phosphoric acid gel (Scotch Bond Etchant, 3M ESPE, St Paul, MN, USA). The teeth were washed for 10-15 seconds and dried in a way that the glossy appearance of the dentin and its moist condition were preserved. One-bottle adhesive (Adper SingleBond, 3M ESPE) was applied to the prepared tooth surfaces according to the manufacturer's instructions and cured for 10 seconds at an intensity of 400 $^{mw}/_{cm^2}$. The teeth were then restored incrementally (1.5-2 mm thickness) with A3-shaded resin composite

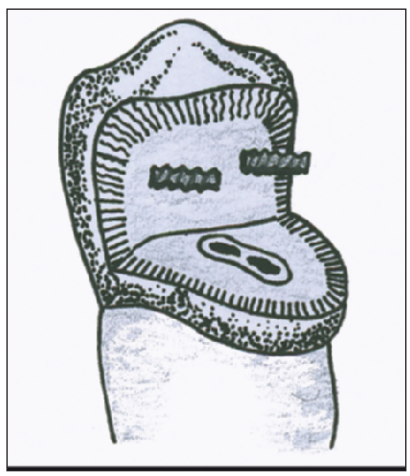

Figure 1. *Schematic representation of palatal cusp reduction and pin placement.*

(Filtek Z250, 3M ESPE) using a metallic Tofflemire matrix band and cured for 40 seconds with the pulse program of the light-curing unit from the occlusal aspect. After removing the matrix band, light curing continued for 40 seconds at an intensity of 700 $^{mw}/_{cm^2}$ both mesially and distally.

Group 2: Subsequent to enamel and dentin etching and bonding, a 2 mm thick layer of flowable composite (Filtek Flow, 3M ESPE) was used in the pulp chamber. The 2-mm thickness of the composite layer was checked by marking the tooth wall before placement. The material was light-cured for 40 seconds in the pulse program and covered by Z250 resin composite in a manner similar to Group 1.

Group 3: Two 0.5 mm diameter and 4 mm long self-threading pins (PINLOCK, Coltene/Whaledent, Cuyahoga Falls, OH, USA) were used. Pinholes were prepared perpendicular to the dentin in the palatal side of the buccal cusp 0.5 mm from the DEJ on the mesial, distal or occlusal aspects. The minimum distance between the pins was 3 mm (Figure 1). A new drill was used after every 10 drilling procedures. The pins were threaded with a hand wrench. The length of the pins that remained outside of the tooth structure was 2 mm. The teeth were then restored in a manner similar to the procedure described in Group 1.

Group 4: Both flowable composite and horizontal pins were used similarly to Groups 2 and 3.

The restorations were finished and polished after 24 hours. A 45° bevel from the long axis of the tooth was placed on the palatal slope of the restored buccal cusp. The specimens were stored in 37°C water for one week until all the specimens were ready for the experiment. After thermocycling, which consisted of 500 cycles at 5°C ± 5°C/55°C ± 5°C with a dwell time of 30 seconds and 10 seconds for specimen transfer, the teeth were mounted in a block of cold-cured acrylic resin to a depth of 1.5 mm apical to the CEJ. Using Hounsfield Test Equipment (Model H5K, Tinius Olsen Ltd, Surrey, UK), a compressive force was applied to the lingual slope of the buccal cusp 1 mm from the cusp tip at a strain rate of 2 mm/minute (Figure 2). A flat-end device with a contact surface area of 1 mm^2 was used to apply the force. The applied force was measured until the teeth fractured.

The two-factor ANOVA test was used to compare fracture resistance among the groups at a significance level of 0.05.

RESULTS

The mean fracture resistance in four experimental groups is presented in Table 1. Using two-factor ANOVA analysis, it was demonstrated that there were no significant differences among the groups ($F(1,60)=1.02$, $p=0.31$).

DISCUSSION

The fracture resistance of endodontically-treated teeth decreases due to tooth structure loss during access cavity preparation.[18] The restorative procedures carried out on such teeth should not only restore the missing tooth structure, but also compensate for the decreased fracture resistance and establish an appropriate seal between the root canal and oral environment.[19] In the current study, fracture resistance of the maxillary premolars was evaluated subsequent to root canal therapy and restoration of the teeth with resin composite in the presence versus absence of horizontal pins and flowable composite.

Evaluating the effect of flowable composite showed that there was no significant difference in fracture resistance between Group 2 (pin [-], flowable composite [+]) and Group 1 (pin [-], flowable composite [-]). According to the results of this study, the use of flowable composite as a base under composite restorations does not influence the fracture resistance of maxillary premolars. This finding is consistent with the results of other studies.[19-21] It appears that flowable composite, in a manner used in this study, does not increase fracture resistance in endodontically-treated teeth due to its low modulus of elasticity. In addition, the load may not be transferred in exactly the same direction to the flowable composite.

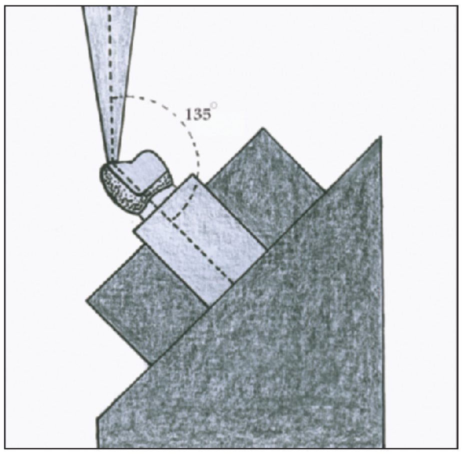

Figure 2. *Schematic representation of force application to the specimens.*

Table 1: *Results of Fracture Resistance in N with Standard Deviation for Each Group*

Group	Number	Mean	Std Deviation
1 Pin - Flow -	16	632.86	119.46
2 Pin - Flow +	16	583.92	186.24
3 Pin + Flow -	16	533.49	168.07
4 Pin + Flow +	16	556.22	99.69

F(1,60)=1.02; p*=0.31*

In evaluating the effect of horizontal pins, it was observed that there was no significant difference in fracture resistance between Group 3 (pin [+], flowable composite [-]) and Group 1 (pin [-], flowable composite [-]) (p>0.05); however, the fracture resistance decreased slightly. Therefore, it may be concluded that horizontal pins do not contribute to an increase in the fracture resistance of endodontically-treated maxillary premolars restored with composite, which is consistent with the results of a study by Qualtrough and others,[22] who reported that pins do not influence the fracture resistance of endodontically-treated teeth restored with composite. The slight decrease in fracture resistance of teeth in the presence of horizontal pins may be due to the pins being parallel with dentinal tubules, their wedging effect[17] and the close proximity of the horizontal pins to the occlusal surface of the teeth.[23]

Simultaneous use of horizontal pins and flowable composite (Group 4) revealed that the difference in fracture resistance between this group and Groups 1 through 3 was not statistically significant (p>0.05). Therefore, due to the reasons mentioned previously, simultaneous use of horizontal pins and flowable composite does not increase fracture resistance of the teeth.

In the current study, the fracture resistance of teeth in all the groups was greater than the normal masticatory forces exerted on the maxillary premolars that have been reported to range between 100 and 300 N[24], but measuring fracture resistance in the manner carried out in this study is a destructive test that does not always simulate *in vivo* conditions.[25] In such experiments, a static compressive force is used; however, the forces in the oral cavity are dynamic, with constantly changing rate, magnitude and direction.[26] Therefore, long-term clinical studies are suggested. The relatively low standard deviation in this study, compared to other studies, indicates an adequate control of confounding variables.

CONCLUSIONS

It seems that the use of flowable composite as a base under composite restorations and pin placement has no effect on increasing the fracture resistance of endodontically-treated maxillary premolars.

Acknowledgement

The authors thank the vice chancellors for research of Tabriz University of Medical Sciences for their cooperation, Dr Majid Abdolrahimi (DDS), who edited the English manuscript of this article, and Dr Morteza Ghojazadeh for statistical analysis.

(Received 4 November 2006)

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