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Fracture Resistance of Premolar Teeth Restored with Different Filling Techniques

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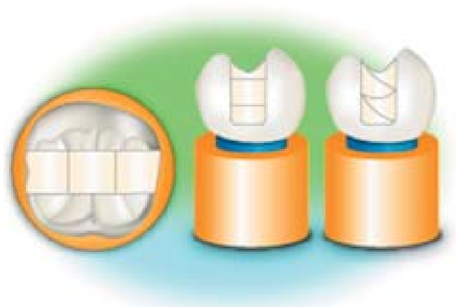

Abstract

The aim of this study is to verify the fracture resistance of premolars with large mesiocclusodistal (MOD) preparations with composite resin using different incremental techniques when subjected to an occlusal load. Forty maxillary premolar teeth were randomly divided into four groups (n=10). Class II MOD cavities were prepared in all specimens with parallel walls and no approximal boxes. The resulting isthmus width was 1/3 the distance between the cusp tips and 3/4 the height of the crown. Teeth in group I, the control group, were not restored. Specimens in group II were restored in three incremental vertical layers. Group III specimens were restored in three horizontal layers, and finally, specimens in group IV were restored in oblique layers. With exception of the placement technique, specimens in groups II, III and IV were restored using the Single Bond adhesive system and P60 composite resin following manufacturer's recommendations. A 4 mm diameter steel sphere contacted the buccal and lingual cusps of the tested teeth at a crosshead speed of 0.5 mm/min until fracture occurred. The values obtained in this study were subjected to Analysis of Variance (ANOVA) and a Tukey–Kramer test. Only group I (non-restored) obtained a minor means of fracture resistance. No significant differences among groups II, III, and IV were found. This study shows on large MOD cavities the incremental filling techniques do not influence the fracture resistance of premolar teeth restored with composite resin.

Keywords: Composite resin, incremental filling, polimerization shrinkage, fracture resistance

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Introduction

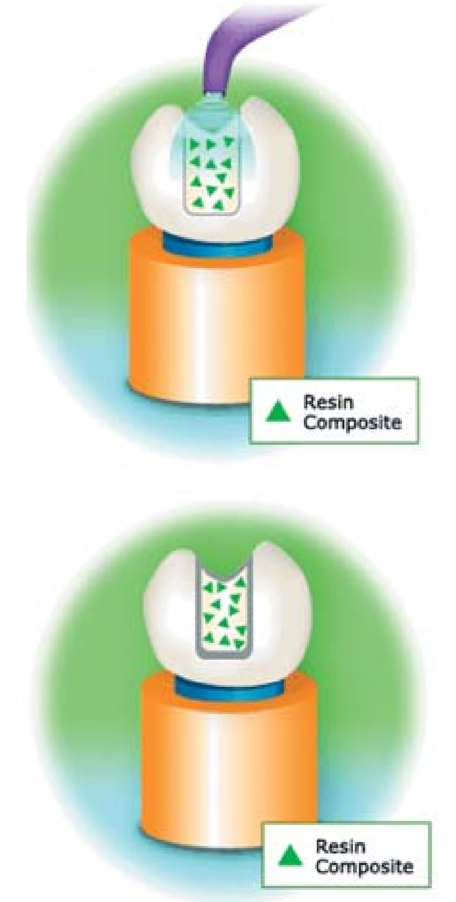
During the polymerization of a bonded resin composite restoration a complex process occurs. As the curing proceeds contraction and flow gradually decrease, while the resin composite stiffness increases; as a result, the stress begins to grow and can cause adhesion failure.[1]

It has been established the more conversion there is in the light cured composite resin material, the more polymerization shrinkage occurs.[2] The total volumetric contraction can be divided into two components: the pre-gel and post-gel phase. During pre-gel polymerization the composite is able to flow, which relieves stress within the structure.[3] However at the gel point and beyond, the material develops a stiffness reflected in the modulus of elasticity. After gelation, the flow is unable to compensate for contraction stresses. Therefore, post gel polymerization results in clinically significant stresses in the composite-tooth bond and surrounding tooth structure.[4, 5]

Besides, when polymerization is restricted in only one direction, a substantial marginal bond occurs to withstand contraction forces because the resin composite can still flow. When composite was restricted in three dimensions rather than one, almost no bond withstood the polymerization shri nkage. Consequently, the cuspal deflection may cause microcracks on enamel structure.[1, 4, 6]

Techniques are used to minimize the effect of shrinkage polymerization like progressive photopolymerization and incremental insertion technique.[7, 8, 9, 10] In the progressive photopolymerization the composite is irradiated by a low initial light intensity followed by normal light intensity. With a low initial light intensity, the resin stays for a longer period in the pre-gel stage of contraction whereby volumetric change can be compensated for by continued flow of the material.[2, 10] Afterwards, high light intensities are necessary for a complete polymerization and optimal mechanical properties.[1]

The purpose of the incremental techniques is to minimize the stress generated by polymerization contraction, inserting resin layers into the cavity reducing the bonded areas. As a result, we have a lower C-factor, which allows the resin to flow at the free surfaces.[8, 11] However if the polymerization shrinkage is not compensated, it can disrupt the adhesion of resin composite to the tooth structure and results in microleakage and coronal deformation causing postoperative sensitivity and microcracks in the cervical enamel, which predisposes tooth fracture.[2, 5, 12] It is known teeth with cavity preparations become weaker as the occlusal isthmus is widened, and they fracture more easily than do intact teeth.[13]



polymerization shrinkage

It is important to verify the effects of incremental techniques, used to compensate polymerization shrinkage, on fracture resistance of premolar teeth with large mesiocclusodistal (MOD) preparations. The goal of this paper is to analyze the fracture resistance of premolars with large MOD preparations restored using different incremental techniques when submitted to occlusal load.

Methods and Materials

Forty maxillary premolar teeth removed for orthodontic purposes were collected immediately after extraction and placed in 10% formalin solution at room temperature before being evaluated for use in this study.

All of the teeth selected were intact, noncarious, and unrestored. They were cleaned with pumice and examined under a dissecting microscope to detect any pre-existing defects.

To simulate the periodontium, root surfaces were dipped into melted wax to a depth of 2 mm below the facial cementoenamel junction to produce a 0.2 to 0.3 mm layer approximately equal to the average thickness of the periodontal ligament. Teeth were than mounted in polystyrene resin cylinders. Each tooth was removed from the resin cylinder when the polymerization was observed. The wax spacer was removed from the root surface and from the alveolus of the polystyrene resin cylinders. Polyeter (Impregum, ESPE, Seefeld, Germany) was delivered into the polystyrene resin alveolus. The tooth was than reinserted into the test cylinder, and the polyeter material was allowed to set. Excess polyeter material was removed with a scalpel blade to provide a flat surface 2 mm below the facial cementoenamel junction of each tooth. The thin layer of polyeter material simulated the periodontal ligament.[14] Care was taken to prevent dehydration of the specimens. They were then stored in physiological saline.

The distance from the buccal cusp tip to the cementoenamel junction and the intercuspal distance on the occlusal surface of each tooth were measured using a digital caliper to standardize the cavity preparations. Class II MOD cavities were prepared in all specimens with convergent walls and no approximal boxes. The preparation was cut under air water spray with a #245 bur in a high speed hand piece that was fixed in a specially designed jig that allowed their bucco-lingual and mesio-distal dimensions to be accurately prepared. The resulting isthmus width was 1/3 the distance between the cusp tips and 3⁄4 the height of the crown (Figure 1A).

After preparation, the teeth were randomly divided into four groups (n=10). The teeth in group I were not restored. With exception of the placement technique, specimens in group II, III, and IV were restored using the Single Bond adhesive system and P60 composite resin (3M-ESPE, Campinas/SP Brazil) following the manufacturer's recommendations. A Tofflemier retainer and a metal matrix band were placed on each specimen. Specimens in group II were restored in three incremental vertical layers, first filling and polymerizing the proximal faces and than the central. Group III specimens were restored in three horizontal layers, and finally, specimens in group IV were restored in oblique layers; the restorative material was placed against the lingual wall up to the pulpal floor and polymerized. Material was then placed against the facial wall up to the pulpal floor and polymerized. This procedure was repeated to fill the preparation in 4 layers (Figure 1B).

The specimens were stored for 24 hours in 100% relative humidity at 37°C, and the fracture test was conducted in an Instron testing machine (Instron Corp, Canton, England 02021 – 1089) with 500 Kgf load. A 4 mm diameter steel sphere contacted the buccal and lingual cusps of the tested teeth at a crosshead speed of 0.5 mm/min until fracture occurred (Figure 1C).

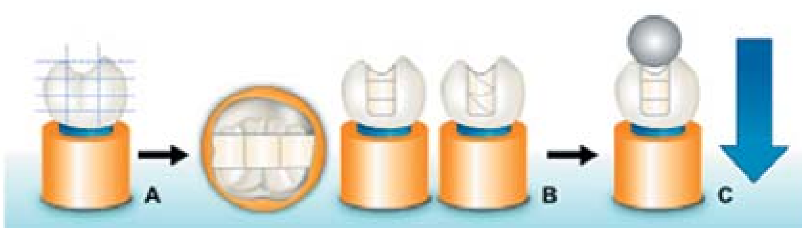


Figure 1. A. Cavity preparation, 1/3 the distance between the cusp tips and 3⁄4 the height of the crown; **B.** Vertical, horizontal, and oblique filling layers; **C.** Fracture test.

Results

Data obtained by the fracture test for each of the studied treatments were submitted to ANOVA for a totally random design. The estimated F value was 22, 49, showing significant differences at a 5% level. The Tukey-Kramer's test was performed to better explain individual comparisons (Table 1).

The ANOVA test revealed significance between specimen treatments (α > 0.001). The Tukey-Kramer test showed only group I (non-restored) obtained a minor means of fracture resistance as shown in Table 1. No significant differences among groups II, III, and IV were found.

Discussion

The polymerization shrinkage of a resin composite can create contraction forces that may disrupt the bond to cavity walls and lead to microleakage.[8] If the composite-tooth bond is able to withstand the deformation, stresses induced by the contracting composite can cause deformation on the surrounded tooth structure.[5] The resulting coronal deformation may result in postoperative sensitivity and microcracks in the cervical enamel, which predisposes the tooth to fracture.[5, 6, 10]

This study evaluated the effect of incremental layering on the resistance to cuspal fracture of structurally weakened premolar teeth. Research has been completed on placement and polymerization techniques used for composite resins; horizontal, vertical, and oblique incremental techniques have all been recommended.[15] By filling the box-like cavities in several increments, the clinician can greatly lower the effective C-factor of the preparation and, consequently compensate for the polymerization shrinkage.[8] In our study it had been found the effect of incremental filling was not significant on resistance to cuspal fracture.

Ellis et al.[16] (1999) reported the most critical factor associated with crown fractures is the weakening of tooth structures by caries and large unsupported intracoronal restorations. Sound teeth rarely fracture under normal masticatory forces and, theoretically, unrestored teeth should be stronger than those restored.[13, 17, 18] This is supported by studies demonstrating a cavity preparation significantly reduces dental fracture resistance.[19, 20 21]

The fracture resistance is intimately related to the reminiscent tooth structure in spite of the restorative material used.

The preparations made were proportional to the tooth dimensions (1/3 of intercuspal distance and 3/4 of crown height); perhaps this fact lead to the same fracture resistance of all tooth structure specimens.

Table 1. Means and standard deviations of fracture resistance.

Group	N	Mean (Kgf) and SD	Tukey
Oblique.; Group IV	10	108.6 (± 11.26)	a
Horizontal, Group III	10	110.09 (± 13.13)	a
Vertical; Group II	10	97.44 (± 10.17)	a
Non-restored; Group I	10	54.59 (± 26.09)	b

DMS = 21.03

In relation to incremental fillings Versluis et al.[22] reported a finite element method study. According to them the total amount needed to fill a cavity is lower when using an incremental filling technique compared to a single bulk filling to the same occlusal contour. This results in higher residual shrinkage stresses for an incremental filling method. The polimerization contraction of each individual incremental filling will cause some deformation on the cavity decreasing its volume. Such a situation must result in a higher stress state of the tooth-restoration complex. Also, the type of incremental technique affects the amount of applied restorative material and, therefore, cusp displacement. These findings are in contrast to some studies that propose the incremental technique reduces the polymerization shrinkage effects.[8, 23]

However, there were no differences among incremental techniques used in this fracture resistance test study, but there were differences between the incremental technique groups and the negative control group (unrestored teeth) demonstrating the restorative material reforced tooth structure.

Conclusion

It may be concluded there are many factors involved during the polymerization process that may affect the resulting shrinkage stresses and their impact upon the integrity of the tooth-restoration complexes. However, this study shows, on large MOD cavities, the incremental filling techniques do not influence the fracture resistance of premolar teeth.

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