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Effect of bulk-fill base material on fracture strength of root-filled teeth restored with laminate resin composite restorations

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A R T I C L E I N F O

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A B S T R A C T

Objectives: To evaluate the effect of using a bulk-fill flowable base material on fracture strength and fracture patterns of root-filled maxillary premolars with MOD preparations restored with laminate restorations.
Methods: Fifty extracted maxillary premolars were selected for the study. Standardized MOD cavities with endodontic treatment were prepared for all teeth, except for intact control. The teeth were divided randomly into five groups ($n = 10$); (Group 1) sound teeth, (Group 2) unrestored teeth; (Group 3) MOD cavities with Vitrebond base and resin-based composite (Ceram. X One Universal); (Group 4) MOD cavities with 2 mm GIC base (Fuji IX GP) and resin-based composite (Ceram. X One Universal) open laminate, (Group 5) MOD cavities were restored with 4 mm of bulk-fill flowable base material (SDR) and resin-based composite (Ceram. X One Universal). All teeth were thermocycled and subjected to a 45° ramped oblique load in a universal testing machine. Fracture load and fracture patterns were recorded. Data were analyzed using one-way ANOVA and Dunnett's T3 test.
Results: Restoration in general increased the fracture strength compared to unrestored teeth. The fracture strength of group 5 (bulk-fill) was significantly higher than the fracture strength of the GIC laminate groups and not significantly different from the intact teeth (355 ± 112N, $P = 0.118$). The type of failure was unfavorable for most of the groups, with the majority being mixed failures.
Conclusions: The use of a bulk-fill flowable base material significantly increased the fracture strength of extracted root-filled teeth with MOD cavities; however it did not improve fracture patterns to more favorable ones.
Clinical significance: Investigating restorative techniques that may improve the longevity of root-filled premolar teeth restored with direct resin restorations.

1. Introduction

Loss of structural integrity of root-filled teeth by caries and restorative procedures makes them more vulnerable to fracture than sound teeth. The choice of materials selected for intracoronal restoration of root-filled teeth plays an important role in tooth longevity. The most commonly used direct restorative materials are, amalgam, resin-based composites (RBCs) and glass ionomer cements (GICs). Adhesive RBCs have considerable advantages in the treatment of weakened tooth structure. The good esthetic combined with the possibility of establishing adequate adhesion between tooth structure and restorations may eliminate the need for extending cavity preparations, to cover the cusps particularly in teeth with moderate loss of tooth structure [1–4]. While the rationale for using GIC materials is based on their cariostatic effect resulting from fluoride release and their ability to bond to tooth structure; it's use as a sole buildup material is not recommended due to moderate mechanical properties and high failure rates [5].

The inherent problem with RBCs is polymerization shrinkage and its associated stresses at the tooth restoration interface. Methods proposed to reduce these effects included the use of incremental placement technique, the use of low modulus liners or bases, modification of the light curing method, and the use of low shrink materials [6–8]. The use of incremental techniques with conventional RBCs is time consuming and may increase the risk of contamination and air entrapment between increments [9], with reports of higher stresses induced at the interfacial margins [10]. The main concern in applying thicker increments of conventional RBCs is to ensure adequate curing to obtain optimum mechanical properties. Therefore; manufacturers have marketed bulk-fill RBCs, these can be placed in a single 4-mm increment and still have adequate light polymerization [11], have low polymerization shrinkage compared to conventional composites, and reduced cuspal deflection [12,13]. Bulk-fill RBCs are classified according to their rheological properties either as a flowable base material to be covered with 2 mm of posterior hybrid composite, or as a final restorative composite that does

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not require an overlying occlusal layer [11].

The earliest approach to apply RBCs in thicker layers was introduced as a high translucent composite, followed by materials with modification in the monomers, or the addition of a polymerization modulator embedded in the resin as in the bulk-fill flowable materials marketed as the stress decreasing resin (SDR). This modulator has viscoelastic behavior that results in polymerization stress values up to 60–70% less than methacrylate and nano-hybrid flowable RBCs [14].

The use of a flowable bulk-fill base in class II cavities significantly reduced cuspal deflection with adequate marginal seal compared to the incremental layering technique [13,15]. Acceptable clinical results similar to the conventional layering technique over a 3-year evaluation period were also reported for bulk-fill materials including; good surface characteristics, marginal adaptation, color stability, low frequency of secondary caries and lower fracture rates [16,17].

Generally positive effects have been reported by using flowable composites as stress decreasing intermediate layers in class II restorations [8,18]. The bulk-fill flowable liners combine the advantages of low stress, low shrinkage values and adequate mechanical properties, which is particularly important in restoration of root-filled teeth. The aim of this study was to evaluate a flowable bulk-fill base material for restoring root-filled maxillary premolars compared to laminate technique using both conventional and resin modified GICs in association with RBCs. The null hypothesis was that the bulk-fill base material will not improve the fracture resistance and fracture patterns of root-filled maxillary premolars restored with direct resin composite.

2. Materials and methods

2.1. Teeth selection

Fifty non-carious sound maxillary premolars with mature apices were used in the study. Teeth were measured from both intercuspal, bucco-lingual and mesiodistal directions to standardize the size, allowing a maximum deviation of 10% from the determined mean. Teeth were stored in 1% chloramine T solution in distilled water (pH 7.8) (Sigma- Aldrich Co., St. Louis, MO, USA) until use.

2.2. Cavity preparations and root filling

Teeth were randomly divided into 5 groups (n = 10) using a random sequence number generator.

2.2.1. Group 1

Sound teeth were left intact as a positive control group.

2.2.2. Groups 2, 3, 4 and 5

A standardized mesio-occlusal-distal (MOD) cavity was prepared on all teeth in these groups using tungsten carbide high speed fissure bur (DIA-BURS; MANI, Tochigi, Japan) with water coolant so that the buccopalatal width of the occlusal isthmus was one third of the intercuspal width, and the proximal box width was one third of the buccopalatal width of the crown. The gingival floor was located 1 mm above the cemento-enamel junction (CEJ) and the cavity floor was prepared with no gingival step (no axial walls). The total depth of the cavity was between 5 and 6 mm. All internal angles were rounded and the cavosurface margins were at 90 ° (Fig. 1).

Root canals were prepared using the ProTaper rotary nickel–titanium system (Dentsply, Maillefer, Ballaigues, Switzerland) to a standard apical size up to F2 file and canals were filled using gutta percha and AH Plus root canal sealer (Dentsply, Maillefer Detrey, Konstanz, Germany). Gutta percha was removed to 2 mm below the CEJ. The access cavity was cleaned with a cotton pellet moistened with alcohol. The sealer cement was allowed to set for 7 days at 37 °C and 100% relative humidity.

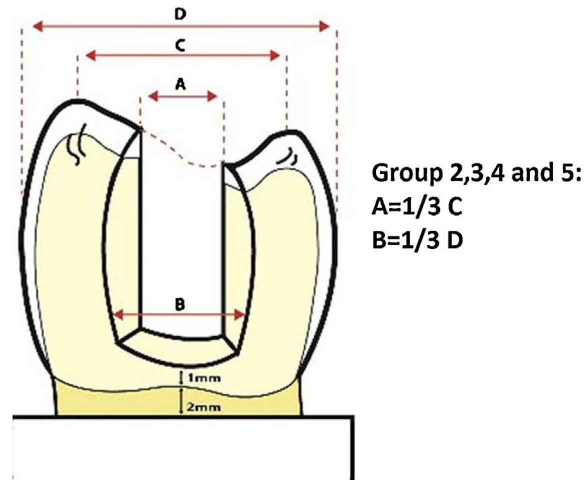

Fig. 1. A schematic diagram of the MOD cavity preparation for prepared groups; (A) Occlusal isthmus width, (B) Gingival floor width, (C) Intercuspal width, and (D) Buccopalatal width.

2.3. Restoration of teeth

2.3.1. Group 2

Teeth were left unrestored to act as a negative control group.

2.3.2. Group 3

A layer of resin modified GIC (Vitrebond; 3 M ESPE, MN, USA) was packed into the canals above the gutta percha to the level of the canal orifice and light cured for 30 seconds using a LED light curing source at 1,000mw/cm2 intensity (Translux Power Blue; Heraeus kulzer, Hanau, Germany). Both enamel and dentine were etched with 36% phosphoric acid etchant (DeTrey Conditioner 36; Dentsply DeTrey, Konstanz, Germany) for 15 seconds, and rinsed thoroughly with air-water spray. A transparent polyester matrix (TDV Polyester Matrix; TDV Dental Ltda., Pomerode, SC, Brasil) was placed on each tooth, then a universal total-etch adhesive system (Prime & Bond XP; Dentsply DeTrey, Konstanz, Germany) was applied according to manufacturer's instructions then light cured for 10 seconds. The MOD cavity was then restored incrementally (1.5–2 mm) with shade A2 nano-ceramic composite resin (Ceram.X one UNIVERSAL; Dentsply DeTrey, Konstanz, Germany) and each increment was light cured for 20 seconds.

2.3.3. Group 4

The cavity was conditioned using 10% polyacrylic acid (Dentin e conditioner, GC Corporation, Tokyo, Japan) for 10 seconds and a GIC base (Fuji IX, GC Corporation, Tokyo, Japan) was placed above the gutta percha and in the proximal boxes to a thickness of 2 mm (open laminate). Both enamel and dentine were etched with 36% phosphoric acid etchant (DeTrey Conditioner 36; Dentsply DeTrey, Konstanz, Germany) for 15 seconds, and rinsed thoroughly with air-water spray. Resin composite was then incrementally placed as in group 3.

2.3.4. Group 5

After acid etching with 36% phosphoric acid etchant (DeTrey Conditioner 36; Dentsply DeTrey, Konstanz, Germany) for 15 seconds, the cavity was rinsed thoroughly with air-water spray and then a universal total-etch adhesive system (Prime & Bond XP; Dentsply DeTrey, Konstanz, Germany) was applied according to manufacturer's instructions then light cured for 10 seconds, a bulk-fill flowable base (SDR; Dentsply DeTrey, Konstanz, Germany) was applied above gutta percha and light cured for 20 seconds and then in the cavity up to 4 mm thickness, and then light cured for 20 seconds. The remaining 2 mm were then restored with one increment of Ceram. X one universal as in group 3 and 4.