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Assessment of laminate technique using glass ionomer and resin composite for restoration of root filled teeth

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ABSTRACT

Objective: To evaluate the open laminate technique using glass ionomer cements (GIC) in association with a low shrink composite for restoring root filled premolars.

Methods: Extensive MOD cavities plus endodontic access and root filling were performed in intact extracted maxillary premolars. Three restoration types were evaluated: (1) resin composite alone; (2) resin-modified GIC (RM-GIC) open laminate plus resin composite; (3) conventional GIC open laminate plus resin composite ($n = 8$ for all groups and tests). Three tests were conducted to assess restorations: (A) inward cusp deflection during light curing, using DCDTs; (B) fracture strength using a ramped oblique load at 45° to the long axis in a servohydraulic testing machine in comparison with intact and unrestored teeth; (C) proximal marginal leakage using methylene blue dye and the effect of thermocycling. Data were analysed using 1-way ANOVA for cuspal deflection and fracture strength and Fisher's exact test for leakage.

Results: Laminate restorations resulted in significantly less cuspal deflection compared with resin composite (4.2 ± 1.2 μm for RM-GIC and 5.1 ± 2.3 μm for conventional GIC vs. 12.2 ± 2.6 μm for composite, $P < 0.001$). Fracture strength was not significantly different among all groups. Failure with all restorations was predominantly adhesive at the tooth-restoration interface. The two laminate groups showed significantly better marginal seal than composite alone, but sealing ability of conventional GIC deteriorated after thermocycling.

Conclusions: Laminate restoration of root filled teeth had beneficial effects in terms of reducing cuspal deflection and marginal seal, with acceptable fracture strength.

1. Introduction

Restoration of root filled teeth must be planned to maximize the strength of these teeth and increase their longevity. Moisture content and stiffness of teeth with an endodontic access were not found to be different from those of untreated vital teeth[1,2]; however the loss of strategic tooth structure as a result of caries and subsequent restorative procedures severely compromises the strength of these teeth. An extensive MOD cavity plus endodontic access with loss of the proximal dentine walls, which is a common clinical finding, results in reduction of tooth stiffness and fracture strength by approximately 60%.[3–5] This loss of strength constitutes a restorative challenge in terms of restoring fracture resistance.

Direct restorations with resin composite have been investigated in both experimental and clinical studies, with favourable reports.[6–10] However an inherent problem with

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resin composites is polymerization shrinkage and associated stresses in tooth structure and at the tooth-restoration interface, with subsequent problems of marginal leakage, recurrent caries and possible tooth fracture, (summarized in 11–13). The use of low shrink composites, flowable liners and bases has been suggested to overcome this problem,[14–17] considering the increased placement of resin composite in posterior teeth.[17–19]

Glass ionomer cement (GIC) has a long history of use in dentistry by virtue of its ability to bond chemically to tooth structure and its cariostatic effect from fluoride release, (reviewed in 20–22). In the special case of root filled teeth, different types of GIC have been used as a core or in a laminate (''sandwich'') restoration, with favourable reports in terms of improving the marginal seal but conflicting results in terms of fracture strength.[4,9,23–25] Generally the physical and mechanical properties of the material used may influence the behaviour of the restored tooth under testing conditions.[8]

Removal of tooth structure during restorative procedures increases cuspal flexure upon subsequent loading.[26] Polymerization shrinkage of adhesive restorations results in inward cusp deflection and subsequent strain within the tooth and at the tooth-restoration interface, particularly in large cavities.[15,16,27] Methods to reduce polymerization shrinkage and cuspal movement have included modifying the resin composite formulation and the introduction of low-shrink composites, modifying the light curing source and irradiation sequence and the use of low elastic modulus liners under the resin composite.[15,28,29]

The aim of this study was to evaluate the open laminate (''sandwich'') technique using both conventional and resin-modified GIC in association with a low shrink composite for restoring root filled maxillary premolars. The extent of inward cusp deflection during polymerization, fracture strength and proximal marginal integrity and the effect of thermocycling were investigated. The null hypothesis was that the open laminate is not different from resin composite restoration in terms of fracture strength and marginal seal.

2. Materials and methods

2.1. *Overview*

Three separate experiments were conducted to evaluate the open laminate technique using both conventional GIC (Fuji IX, lot # 0902245. GC Corporation, Tokyo, Japan) and resin-modified GIC (Fuji II LC, lot #1005136). GC Corporation, Tokyo, Japan). The tests included: (1) cusp deflection during light curing; (2) fracture strength; (3) proximal marginal leakage and the effect of thermocycling on leakage.

Non-carious sound maxillary first and second premolars extracted for orthodontic reasons were used in these experiments and measured from both bucco-lingual and mesio-distal directions to standardize the size, allowing a maximum deviation of 10% from the determined mean. The project was approved by the Ethics in Human Research Committee of the University of Melbourne. 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*

Extensive MOD cavities, plus endodontic access with the proximal axial walls removed, were prepared as previously described[20] using a tungsten carbide round-ended fissure bur (Komet H21R, Brasseler, Lemgo, Germany). The bucco-lingual width of the occlusal isthmus was one third of the width between buccal and lingual cusp tips, and the bucco-lingual width of the proximal box was one third of the bucco-lingual width of the crown. The gingival floor of the box was 1 mm coronal to the cemento-enamel junction; total depth was 5–6 mm. The cavosurface margins were prepared at 90° and all internal angles were rounded.

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 AHPlus 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° and 100% relative humidity.

2.3. *Restorations*

Three restoration types were evaluated in the study. The materials used are summarized in Table 1.

2.3.1. *Group 1: Resin composite restoration*

Cavities were acid-etched with 37% phosphoric acid (Super Etch, SDI Limited, Bayswater, Australia; batch no. 030648) for 20 s, rinsed with air–water spray for 10 s and gently air dried for 20 s. A bonding agent (Adper™ Single Bond, 3M ESPE, St Paul, USA, lot no. 184141) was applied and light cured for 20 s. The cavity was incrementally restored with a low-shrink resin composite (Glacier OD3 shade, SDI limited, Bayswater Australia, batch no. 071089). Three increments were placed and cured using a LED light curing source (Bluephase C8, CE Ivoclar, Vivadent AG, F1-9494 Schaan, Liechtenstein) at an intensity of 800 mW/cm^2 for 40 s. The first increment was packed into canal orifices and both proximal boxes to a depth of approximately 1 mm and subsequently two increments were added. A matrix band was not used during placement of the resin composite, because it interfered with the measurement of cuspal displacement (in the first experiment below), and therefore was excluded from the subsequent two experiments for standardization.

2.3.2. *Group 2: Resin-modified GIC open laminate plus resin composite restoration*

A 10% polyacrylic acid dentine conditioner was applied to the entire cut dentine surface for 10 s. A 1–2 mm GIC base (Fuji II LC, lot #1005136, GC Corporation, Tokyo, Japan) was then placed above the gutta percha and in the proximal boxes to a thickness of 1.5–2 mm and light cured for 20 s using a LED light curing source (Bluephase C8, CE Ivoclar, Vivadent AG, F1-9494 Schaan, Liechtenstein) at an intensity of 800 mW/cm^2. The cavity preparation was then acid-etched and resin composite was placed as above, except that only two increments of resin composite were used.