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Implications of resin-based composite (RBC) restoration on cuspal deflection and microleakage score in molar teeth: Placement protocol and restorative material

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ABSTRACT

Objective. To assess the cuspal deflection of standardised large mesio-occluso-distal (MOD) cavities in third molar teeth restored using conventional resin-based composite (RBC) or their bulk fill restorative counterparts compared with the unbound condition using a twin channel deflection measuring gauge. Following thermocycling, the cervical microleakage of the restored teeth was assessed to determine marginal integrity.
Methods. Standardised MOD cavities were prepared in forty-eight sound third molar teeth and randomly allocated to six groups. Restorations were placed in conjunction with (and without) a universal bonding system and resin restorative materials were irradiated with a light-emitting-diode light-curing-unit. The dependent variable was the restoration protocol, eight oblique increments for conventional RBCs or two horizontal increments for the bulk fill resin restoratives. The cumulative buccal and palatal cuspal deflections from a twin channel deflection measuring gauge were summed, the restored teeth thermally fatigued, immersed in 0.2% basic fuchsin dye for 24 h, sectioned and examined for cervical microleakage score.
Results. The one-way analysis of variance (ANOVA) identified third molar teeth restored using conventional RBC materials had significantly higher mean total cuspal deflection values compared with bulk fill resin restorative restoration (all $p < 0.0001$). For the conventional RBCs, Admira Fusion (bonded) third molar teeth had significantly the lowest microleakage scores (all $p < 0.001$) while the Admira Fusion x-tra (bonded) bulk fill resin restored teeth had significantly the lowest microleakage scores compared with Tetric EvoCeram Bulk Fill (bonded and non-bonded) teeth (all $p < 0.001$).
Significance. Not all conventional RBCs or bulk fill resin restoratives behave in a similar manner when used to restore standardised MOD cavities in third molar teeth. It would appear that light irradiation of individual conventional RBCs or bulk fill resin restoratives may be problematic such that material selection is vital in the absence of clinical data.

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1. Introduction

Patient demand for the delivery for tooth coloured teeth has driven the development of resin-based composite (RBC) materials and today there is increased usage [1,2] and teaching [3,4] of RBCs worldwide. From a materials science perspective, one of the major disadvantages of RBCs is the excessive shrinkage stress generation on light irradiation [5]. Depending upon the compliance conditions, dental manufacturers have with relative success, developed RBCs with reduced shrinkage stress by investigating beyond methacrylate monomeric resin-blends [6] and increasing the filler volume fraction with and without nanotechnology approaches [7]. However, from a clinical perspective, RBCs are technique sensitive even for experienced operators [8] and the time required to adequately place a posterior RBC restoration can be up to two and a half times longer than an equivalent dental amalgam restoration [9]. The increased RBC restoration placement time is accounted for by the adhesive system application, incremental RBC placement and light irradiation [9]. Manufacturers have recently reduced RBC placement times by marketing 1-step adhesive bonding systems to replace 3-step (gold standard) adhesives which included a separate etch with phosphoric acid and rinse (conditioning) step, a priming step before subsequent application of the adhesive [10,11]. Conventional RBC materials, where the depth of cure is limited to a maximum of 2 mm, require an incremental restoration technique [12–14] with the number of increments dependent upon cavity size and configuration [15]. The RBC monomeric resin-formulation [16] can significantly impact irradiation times (20–40 s) such that incremental RBC restoration is time consuming and costly to the patient [17]. Therefore, manufacturers' have marketed a range of bulk fill flowable base materials [18] and/or bulk fill restorative materials [19] to the dental market with reported depth of cure of 4 mm which significantly reduce RBC placement times. It is interesting to note the departure in thinking from a focus on reducing shrinkage stress generation in RBCs to ultimately employing RBCs with lower filler volume fractions and/or increased TEGDMA as bulk fill flowable base materials [20,21] or bulk fill restorative materials with novel chemistry [22,23].

The aims of the current study were to assess the cuspal deflection of standardised large mesio-occluso-distal (MOD) cavities in human maxillary and mandibular third molar teeth restored with conventional RBCs or their bulk fill resin restorative counterparts compared with the unbound condition using a twin channel deflection measuring gauge. Following thermocycling, the cervical microleakage of the restored teeth was assessed to determine marginal integrity. The hypotheses proposed were that there would be an increase in total cuspal deflection and concomitant decrease in cervical microleakage score for conventional RBC restoratives compared with their bulk fill resin restorative material counterparts.

2. Materials and methods

Caries-free, hypoplastic defect-free and crack-free human maxillary and mandibular third molar teeth, extracted for pericorinitis, periodontal disease or atypical facial pain reasons, were used in accordance with the ethical guidelines of the Trinity College Faculty Research Ethics Committee. The inclusion criteria for third molar tooth selection was the maximum bucco-palatal-width (BPW) of the teeth varied between 10.25–10.75 mm when measured with a digital micrometer gauge (Mitutoyo, Kawasaki, Japan) reading to 0.01 mm. In the dental literature, third molar teeth have increased anatomical variances compared with premolar teeth [24] and as a result form and shape inclusion criteria were also introduced so that only maxillary and mandibular third molar teeth with four cusps (two buccal and two lingual) were included in the study. When necessary evidence of calculus deposits were removed by hand-scaling prior to random distribution of the teeth into six groups (Groups A–F) with eight individual teeth assigned to each group (n = 8). The teeth were fixed, crown uppermost with the long axis vertical, into a cubic stainless steel mould facilitated by a cold curing denture base material (ProBase® Cold, Ivoclar Vivadent, Schaan, Lichtenstein) which extended to within 2 mm below the amelo-dentinal junction (ADJ) prior to storage in high purity double distilled water (23 ± 1 °C) until required for cavity preparation [24].

Standardised MOD cavities were prepared under copious water irrigation using an established clinical protocol previously employed for maxillary premolar teeth [25–36]. The width of the approximal box was standardised at two-thirds the BPW of the third molar teeth, the occlusal isthmus was prepared to half the BPW and the cavity at the occlusal isthmus standardised to a depth of 3.5 mm from the tip of the highest cusp with the proximal boxes extended to 1 mm above the ADJ and all cavosurface margins prepared at 90° with internal line angles rounded. Following preparation, the MOD cavity dimensions were checked with the digital micrometer gauge and the teeth were stored in high purity double distilled water at 23 ± 1 °C unless moisture isolation was required for aspects of the experimental protocol.

Groups A and D third molar teeth were rinsed thoroughly with high-purity double distilled water, air-dried for 30 s and restored in the absence of a bonding agent which served as the unbound conditions (negative control) for the experiment (Table 1). Groups A teeth were restored with Tetric EvoCeram RBC (Shade A3, Lot T04946; Ref. 590314WW: Ivoclar Vivadent) using the oblique incremental technique. This involved the placement of three triangular-shaped increments (~2 mm thickness) in the mesial proximal box (up to half the mesio-distal width of the third molar teeth), three triangular-shaped increments (~2 mm thickness) in the distal proximal box (up to half the mesio-distal width of the third molar teeth) and two further triangular occlusal increments (one buccal and one palatal). The teeth in Group D were restored using Tetric EvoCeram Bulk Fill (Shade IVA, Lot T02443, Ref 638244WW; Ivoclar Vivadent) and involved the placement of one increment for both the mesial and distal proximal boxes up to a maximum increment depth of 4 mm before the application of a final occlusal increment.

The teeth in Groups B-C and E-F were prepared for bonding with a 1-step dual-curing universal adhesive (Futurabond® U SingleDose (Ref 1574, Lot 1547600; Voco, Cuxhaven, Germany)) by firstly cleaning the MOD cavity preparations with high purity double distilled water, prior to air-drying for 30 s [37].