JOURNAL OF DENTISTRY 43 (2015) 309–316

Available online at www.sciencedirect.com

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Bulk fill restoratives: To cap or not to cap – That is the question?

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ARTICLE INFO

Article history:
Received 12 December 2014
Received in revised form
16 January 2015
Accepted 19 January 2015

Keywords:
Resin-based composite
Cuspal deflection measurement
Cervical microleakage score
Bulk fill flowable base materials
Bulk fill resin restorative
Restoration protocol

ABSTRACT

Objectives: To assess the cuspal deflection and cervical microleakage scores of standardised large mesio-occlusal-distal (MOD) cavities filled with different restoration protocols: (1) conventional resin restoratives, (2) bulk fill flowable base materials 'capped' with a conventional dimethacrylate resin-based composite (RBC) or (3) bulk fill resin restorative materials.

Methods: Standardised MOD cavities were prepared in sixty-four sound maxillary premolar teeth and randomly allocated to eight groups. Restorations were placed in conjunction with a universal bonding system and resin restorative materials were irradiated with a quartz-tungsten-halogen light-curing-unit. Restoration protocol (eight oblique increments of conventional resin restorative, bulk fill flowable base and two occlusal 'capping' RBC increments (three increments in total) or bulk fill resin restorative (two increments)) was the dependent variable. A twin channel deflection measuring gauge measured the buccal and palatal cuspal deflections. Teeth were thermally fatigued, immersed in a 0.2% basic fuchsin dye for 24 h, sectioned and examined for cervical microleakage score.

Results: Post hoc Tukey's tests highlighted significant differences in the mean total cuspal deflection values between resin restoratives ($p < 0.0001$) and restoration protocol ($p < 0.005$). In general (albeit product dependently), an increase in mean total cuspal deflection and concomitant decrease in cervical microleakage score was evident for bulk fill flowable base materials with occlusal 'capping' RBC increments (restoration protocol 2) compared with bulk fill resin restoratives (restoration protocol 3).

Conclusions: Not all bulk fill flowable materials or bulk fill resin restoratives behave in a similar fashion when used to restore standardised MOD cavities in maxillary premolar teeth and material selection is vital in the absence of clinical data.

Clinical significance: Poorly performing bulk fill flowable materials or bulk fill restoratives can be identified using the cuspal deflection and cervical microleakage protocol which could save the complications encountered clinically when restoring Class II restorations.

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http://dx.doi.org/10.1016/j.jdent.2015.01.010

1. Introduction

Resin-based composite (RBC) materials were first reported by Bowen in 1958[1] with commercial exploitation of RBCs only possible following the patenting of 'a vinyl-silane treated fused silica and binder' by the author in 1962.[2] Chemically cured RBCs became a realisation when introduced to the dental market in 1970, although they were limited by bulk placement without an etchant and were therefore contra-indicated for Class I and Class II restorations.[3] The patenting of 'a method of repairing teeth using a composition which was curable by visible light' by Dart in 1974[4] and the development of 'total-etch' adhesives in the 1980s paved the way for light-irradiated BRCs which could be advocated for clinical use as Class I and II restorations.[5]

Over the last 30 years, manufacturers have focused on reducing the shrinkage stress generated in RBC materials by exploring beyond methacrylate resin-formulations[6] and reducing the filler particle size and distribution through nanotechnology.[7] These key approaches are based on the ultimate goal of reducing shrinkage stress generation by modifying the material components of an RBC, namely the monomeric resin formulation and the reinforcing glass filler particles. However, in an effort to reduce RBC placement times manufacturers have introduced simplified dental adhesives,[8] bulk fill flowable base materials[9] and/or bulk fill restorative materials[10] to the dental market. The advantage of the bulk fill restorative materials over the bulk fill flowable base materials is that the former are reported to have increased wear resistance. While there are numerous laboratory studies exploring the effectiveness of simplified bonding systems[11,12] or the light irradiation potential of bulk fill materials,[13,14] clinical data is harder to find. Interestingly, the first randomised clinical studies (controlled three[15] and four year[16] evaluations of bulk filled posterior resin restorations) were published in 2010[16] and 2014,[15] years after adoption by the dental profession. While the results in the randomised controlled three[15] and four year[16] evaluations were extremely positive, it is not possible to translate these results across all bulk fill flowable base materials or extrapolate the data to bulk fill resin restorative materials.

The aims of the current project were to assess the cuspal deflection of standardised large MOD cavities filled with different restoration protocols: (1) conventional resin restoratives, (2) bulk fill flowable bases 'capped' with a conventional dimethacrylate RBC or (3) bulk fill resin restorative materials. 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 on comparing between bulk fill flowable base materials with occlusal 'capping' RBC increments (restoration protocol 2) and bulk fill resin restoratives (restoration protocol 3).

2. Materials and methods

Human maxillary premolars were obtained in accordance with the ethical guidelines of the Trinity College Faculty Research Ethics Committee. The selection criteria were the teeth were caries-free, hypoplastic defect-free and crack-free with a range of maximum buccal–palatal-widths (BPWs) varying from 8.4 to 8.8 mm when measured with a digital micrometre gauge (Mitutoyo, Kawasaki, Japan). All calculus deposits were removed by hand-scaling. The teeth underwent randomisation and distribution into eight groups with eight individual human maxillary premolars assigned to each group. Cavity preparation under copious water irrigation was performed after the teeth were mounted in stainless steel moulds with orthodontic resin (Meadway Rapid Repair, Mr Dental Supplies Ltd., Surrey, UK) extending to 2 mm of the amelocemental junction (ACJ). Individual MOD cavities were prepared using a standardised protocol: cavosurface margins at 90° (rounded internal line angles); width of the proximal box (two-thirds the BPW); the occlusal isthmus (half the BPW); cavity depth at the occlusal isthmus (3.5 mm from the tip of the palatal cusp and 1 mm above the ACJ at the cervical aspect of the proximal boxes).[17–22] The prepared teeth were stored in high-purity double distilled water (23 ± 1 °C) and prepared for bonding with a one-step adhesive (Futurabond U SingleDose; Ref 1572, Lot 1418206; Voco GmbH, Cuxhaven, Germany).[23] A SingleDose blister was activated, which allowed the liquid contained in the blister to flow into the mixing and dispensing chamber. The supplied Single Tim applicator (Voco GmbH, Cuxhaven, Germany) was used to pierce through the film of the mixing and dispensing chamber. By stirring thoroughly, a homogeneous, streak-free mixture of the two liquids was created, applied homogeneously to all cavity surfaces and rubbed in for 20 s using the Single Tim provided. The adhesive layer was dried-off with dry, oil-free air for 5 s to remove solvents and the adhesive layer was light irradiated with a quartz tungsten halogen (QTH) (Optilux 501, Kerr Mfg. Co., Orange, CA, USA) light curing unit (LCU) operating for 10 s at an output intensity of 620 ± 26 mW/cm^2,[23] prior to the application of the appropriate resin restorative (Table 1) and restoration protocol.

2.1. Restoration protocol

Restoration protocol 1 was applied to the resin restorative materials and involved an oblique incremental placement technique where three triangular-shaped increments (~2 mm thickness) were placed in the mesial proximal box, three in the distal proximal box and two oblique occlusal increments (Fig. 1a). In accordance with restoration protocol 1: Group A teeth were restored with Filtek™ Supreme XTE (Shade A3, Lot no. N549509; 3M ESPE, St. Paul, MN, USA), Group B teeth with GrandioSO (Shade A3, Lot no. 1410653; Voco GmbH, Cuxhaven, Germany) and Group C teeth with Admira Fusion (Shade A2, V55530; Voco GmbH, Cuxhaven, Germany) – an ormocer restorative (Table 1).

Restoration protocol 2 was for bulk fill flowable base materials where the first increment was made with the flowable base material placed in the mesial and distal proximal boxes (Group D: Filtek™ Bulk Fill Flowable (Shade U, Lot no. N390577; 3M ESPE, St. Paul, MN, USA) and Group E: Beautifil Bulk Flowable (Shade U, Lot no. 121301; Shofu, Kyoto, Japan)). Two oblique occlusal increments were placed with