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Pull-out bond strength of a fibre-reinforced composite post system luted with self-adhesive resin cements

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ABSTRACT

Objectives: Due to morphological differences along the root canal, serious structural damage, or extensive endodontic preparation, cement thickness of luted fibre-reinforced composite (FRC) post systems can largely vary. This study aimed at evaluating the effects of a self-etch (Multilink Automix, MLA) and various self-adhesive resin cements (G-Cem, GCM; Maxcem Elite, MXE; RelyX Unicem, RLX; SmartCem 2, SMC) on the pull-out bond strengths of FRC posts to root canal dentine, and to compare the effects of different cementation thicknesses.

Methods: 100 bovine incisor roots were embedded in acrylic resin and randomly assigned to two groups. Root canals of group 1 were prepared with RelyX Fiber Post drill size one (Ø 1.3 mm), whereas in group 2 drill size three (Ø 1.9 mm) was used to attain different cement thicknesses (thicknesses 1 and 2). Each group was then subdivided into five subgroups ($n = 10$). RelyX Fiber Posts size one (Ø 0.70 mm) were luted with the respective resin cements. All specimens were subjected to pull-out evaluation using a universal testing machine. Post surface areas covered with cement were measured by means of stereomicroscopy.

Results: RLX revealed the significantly highest pull-out bond strengths in both groups ($p < 0.05$), while MXE exhibited the significantly lowest pull-out bond strengths in group 2 ($p < 0.05$). Main failure modes were determined as adhesive at the cement-post surface for all examined groups (except for SMC, group 2).

Conclusions: The different resin cements influenced the pull-out bond strengths, whereas the cement thickness itself was not responsible for any differences.

Clinical significance: Self-adhesive resin cements can provide an acceptable retention of FRC posts even in case of use with wider post space conditions.

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1. Introduction

Fibre-reinforced composite posts (FRC) are frequently used to contribute to the support and the retention of coronal restorations and crowns, and are considered a practical and economical option for restoring teeth suffering from increased hard tissue loss. However, post-retained crowns often present failures due to loss of retention.[1] Therefore, retention of posts in root canals is a fundamental property for clinical function. The minimum tensile bond strength needed for clinical success has been estimated at 200 N.[2]

Resin cements are extensively used as luting materials for FRC posts. They have occasionally shown superior retention,[3] and this has been attributed to their adhesive properties to dentine.[4] In addition to conventional resins, self-adhesive resin cements have also been proposed for adhesive cementation of posts and indirect restorations.[5] These materials are expected to overcome the problems of the technique-sensitive application of multi-step resins and adhesive bonding agents. This is a matter of great importance in a confined space like the root canal, where limited control of moisture and absence of direct field of vision impede the various procedures, and make bonding to root canal dentine hardly predictable.[6] Therefore, self-adhesive resin cements appear very promising, as they are applied in a single clinical step, overtaking the tooth substrate's pre-treatment, and, thus, should reduce treatment duration.

Many factors seem to influence the retention of posts in root canals. Considering the root canal dentine, as a result of the dentinal tubules' decreased density from the coronal to apical region (and due to their variable orientation),[7] different responses to acid-etching procedures and varying bond strengths along the root canal have been demonstrated.[8] Moreover, due to dentine age variations, alterations of the mineral-organic phase, and proportional changes, deposition of sclerotic and tertiary dentine occur,[9] and this might jeopardize the substrate's adhesive capacity.

Irrigation agents have been found to have an adverse (e.g., NaOCl, H_2O_2, and EDTA),[6,10] or a favourable (e.g., chlorhexidine)[11,12] effect on adhesion to root canal dentine. Moreover, (eugenol-containing) sealers,[13] traces of gutta-percha, condensation procedures of gutta-percha,[14] or Ni–Ti rotary instruments[15] have been shown to negatively influence adhesion, and, thus, post retention.

Several studies have reported adhesive failures at the post-cement interface.[7,8,13,16,17] Moreover, silanization and/or adhesive application, acid etching, sandblasting and silica coating as well as alternative conditioning procedures (e.g., potassium permanganate or sodium ethoxide) have been proposed to enhance bonding of posts and post retention.[18]

Notwithstanding, previous studies presenting SEM observations[19] or evaluating bond strengths[20,21] have identified the contribution of the interfacial sliding friction to the dislocation resistance of FRC posts cemented with resin materials. Those papers concluded that the role of adhesion in root canals is rather an unrealistic assumption as the configuration factor within the prepared root canal is highly unfavourable.[22] Thus, friction would seem to be the primary factor provoking the dislocation of the bonded FRC posts.

Albeit little information is available on the role of cement thickness of resin cements on post retention, some studies have reported lower push-out[16] or pull-out[13] strengths after increasing the cement thickness. However, these reports were in contrast to other studies revealing that increased cement thicknesses resulted in higher pull-out strengths.[23] While, in the clinical situation, cement thickness can largely vary because of the mentioned morphological differences along the root canal[8] and increased structural damage caused by carious lesions. Additionally, operator-driven differences occur, and these might be simply due to variably extensive endodontic preparation techniques.[13] Moreover, while post-treatment effects seem to refer to thermal stress,[24] different techniques of cementation can also lead to a different proximity of the post to the dentine walls, and, thus, to a different cement thickness.[8]

Therefore, the purpose of the present study was to evaluate the effects of various self-adhesive resin cements with different thickness on the pull-out bond strengths of fibre-reinforced composite posts, along with a determination of the failure modes. The null hypothesis (H0) tested was that neither the kind of resin cement nor the resin cement thickness would affect the pull-out strength, nor that any cement could provide bond strength values exceeding 200 N. H0 was tested against the alternative hypothesis of a difference.

2. Materials and methods

One hundred bovine mandibular incisors of the second dentition were collected. After their extraction, periodontal tissues were removed with curettes (Hu-Friedy, Rotterdam, The Netherlands), and all teeth were kept in distilled water until further preparation. The crowns were removed by separating the teeth at the cemento-enamel junction (CEJ) using a band saw (EXAKT Apparatebau, Norderstedt, Germany), and pulps were removed with 25 K files (VDW, Munich, Germany). Two notches on the surface of each root were created with a diamond disc (Frank Dental, Gmund, Germany). Apices were sealed with blue wax (Morsa Dental, Krumbach, Germany), and roots were embedded into epoxy resin (Technovit 4710; Heraeus Kulzer, Hanau, Germany) using cubic matrices (Bonin, Heubach, Germany; in cooperation with Albert-Ludwigs-University Freiburg, Germany). Specimens' heights were reduced to 17.50 (±0.05) mm (Micrometer; Mitutoyo, Neuss, Germany) by means of a grinder unit (EXAKT Apparatebau). After preparation, the specimens were randomly assigned to two groups.

Then, the root canals of the specimens of group 1 were prepared to a depth of 12 mm using a precision drilling unit (Harnisch + Rieth, Winterbach, Germany), equipped with a RelyX Fiber Post Drill (size 1; Ø 1.3 mm; 3M ESPE, Seefeld, Germany). The root canals of group 2 were prepared using a size 3 drill (Ø 1.9 mm; 3M ESPE). Hence, regarding cement thickness around the designated posts, a thin (thickness 1) and a thick (thickness 2) layer were created. All root canals were irrigated using NaOCl solution (pharmacy-made, 3%; Albert-Ludwigs-University Freiburg, Germany), rinsed with water, and dried with paper points (VDW, Munich, Germany).