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Effect of luting cement and thermomechanical loading on retention of glass fibre posts in root canals

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ABSTRACT

Objectives: To evaluate the effect of luting cement and thermomechanical loading on the retention of glass fibre posts in root canals.

Methods: One hundred and forty-four single-rooted human premolars were endodontically treated and restored with RelyX Fibre Posts. The teeth were divided into four groups according to the cements used (Fuji I, Fuji CEM, RelyX Unicem and RelyX ARC). Each group was further divided into two subgroups according to the method of ageing (immediately tested and after thermomechanical loading). Bond strength was evaluated using a pull-out test. Microleakage was examined quantitatively with dye penetration. The dentine–cement-post bonding interface was assessed using scanning electron microscopy. Data were analysed with two-way ANOVA (pull-out test) and Kruskal–Wallis analysis (microleakage).

Results: The pull-out bond strength and microleakage were significantly affected by the type of cement and ageing. Although RelyX ARC showed the highest bond strength before thermomechanical loading ($p < 0.05$), the sealing ability of this cement was worse than those exhibited in Fuji CEM and RelyX Unicem ($p < 0.05$). After thermomechanical loading, pull-out strengths of Fuji I and Fuji CEM were significantly increased, whereas that of RelyX ARC group significantly decreased ($p < 0.05$). The sealing ability of Fuji CEM was significantly better than the two resin cement groups ($p < 0.05$) after ageing.

Conclusion: Fuji CEM demonstrates increased pull-out strength after thermomechanical loading and favourable sealing ability compared with the other cements.

Clinical significance: Resin-modified glass ionomer cements have the potential benefit of achieving long-term retention when used for luting glass fibre post to root canal dentine. So it may be recommended for the cementation of glass fibre post in clinics.

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1. Introduction

Restoration of endodontically treated teeth should aim at providing retention for the coronal tooth structure and preserving the health of the periodontal apparatus and gingival tissues.[1,2] Posts are commonly used to restore the function and aesthetics of teeth with extensive loss of tooth structure.[3,4] Glass fibre-reinforced posts have gained popularity in contemporary oral rehabilitative procedures because of their similar elastic modulus as the modulus of elasticity of human radicular dentine.[5–8] Nevertheless, both *in vivo* and *in vitro* studies have shown that loss of retention is the predominant failure mode in glass fibre post-retained restorations.[9,10] Recent *in vitro* research has been focused on the integrity of the dentine-cement-post 'sandwich interface'[11] that is critical for post retention. Different factors such as the type of root canal dentine (*i.e.* non-sclerotic *vs* sclerotic), the moisture status of radicular dentine, the adhesive systems and the luting cements employed may contribute to the retention of glass fibre posts.[12] Both methacrylate resin cements and glass ionomer cements have been used for cementation of glass fibre posts to root canal dentine; however, there is no consensus on the type of cement that can provide more superior long-term clinical retention of glass fibre post-retained retorations.[13,14]

The immediate bonding effectiveness of methacrylate resin cements is favourable due to the formation of a resin–dentine interdiffusion zone and resin tags that provide micromechanical interlocking between resin and demineralised root dentine. However, the technique-sensitivity[15] and time-consuming bonding procedures associated with the use of multi-step resin cement systems compromise their popularity for clinical use. Self-adhesive resin cement systems do not require complex dentine surface pre-treatment and appear to be more well-received by clinicians for luting of glass fibre posts. However, the high cavity configuration factor (ratio between bonded and non-bonded surface areas) associated with the bonding of fibre posts to long, narrow post-spaces[16–18] may result in the generation of extensive polymerisation shrinkage stresses that jeopardise the integrity of resin-dentine bonding interface. The limited ability of bond post spaces to relieve shrinkage stress by resin flow renders the retention of resin cement-luted glass fibre posts unpredictable, as a substantial part of the retention is derived from friction.[15,19,20]

Glass ionomer cements (GICs) were introduced into dentistry in 1972.[21] They offer many advantages, including the ability to chemical adhere to enamel and dentine, resistance to microleakage, good marginal integrity, dimensional stability at high humidity, similar coefficient of thermal expansion as tooth structures, biocompatibility, fluoride release, less shrinkage than resins upon setting and no release of free monomers.[22] However, the disadvantages of GICs, including moisture sensitivity and low tensile strength, render them less favourable for use as luting cements in root canals where high dislodging stresses are encountered during function. Resin-modified glass ionomer cements (RMGICs) overcome these limitations by having more favourable mechanical properties, decreased moisture sensitivity and extended working time. Although both methacrylate resin cements and RMGICs shrink after polymerisation, hygroscopic expansion after maturation of these cements may result in the relief of shrinkage stresses and compensate for shrinkage-associated defects to some extent.[23] For the more hydrophilic RMGICs, relief of the shrinkage stresses by water sorption may result in an intact interface between the post and dentine.[24]

Although GICs and RMGICs have been studied for the cementation of fibre posts,[13] little information is available on the effect of thermomechanical loading as a technique of simulated ageing[25,26] on the bonding effectiveness and sealing ability of glass fibre posts luted with GICs and RMGICs. Thus the objective of the present study was to evaluate the effects of the type of luting cement and thermomechanical loading on the retention of glass fibre posts to root canal. The first null hypothesis tested was that the type of luting cement has no effect on the pull-out strength and microleakage of the dentine-cement-fibre post bonding interface. The second null hypothesis tested was that thermomechanical loading has no effect on the retention of the glass fibre posts to root canals.

2. Materials and methods

One hundred and forty-four single-rooted, single-canal human premolars that were extracted due to periodontal and orthodontic reasons were selected for the present study. The patients' informed consent was obtained under a protocol approved by the University. The teeth were stored in 1% chloramine T (chloramine T, Sigma–Aldrich Co., St. Louis, USA) at 4 °C, and used within one month after extractions. Soft tissues and calculus were removed by scalers (Cattoni Scaler, Hu Friedy.Mfg Co., LLC, Chicago, USA) and ultrasonic cleaning (Vitasonic II, VITA Zahnfabrik, Berlin, Germany).

2.1. *Specimen preparation*

2.1.1. *Root canal treatment*

The crowns were sectioned along the cementoenamel junction using a low-speed diamond saw (SYJ-150; MTI Corp., Shenyang, China) under water cooling. The root canals were prepared 1 mm short of the apex using K-files (K-files; Dentsply Maillefer, Ballaigues, Switzerland), using a crown down technique. The instrumented canals were irrigated with 5.25% sodium hypochlorite (Sodium Hypochlorite; Kermel Chemical Reagent Co., Inc., Tianjin, China) in-between instrumentation, and with 17% ethylenediamine tetracetic acid (Ethylenediaminetetraacetic acid; Sigma-Aldrich Co., St. Louis, USA) as the final rinse. After the final rinsing, the canals were completely dried with absorbent paper points (Absorbent Paper Points; Meta Biomed Co. LTD, Baotou, China) and obturated by lateral condensation of gutta-percha (Gutta-percha; Meta Biomed Co. LTD, Baotou, China) and an iodoform-containing calcium hydroxide sealer (Metapex; Meta Biomed Co. LTD, Yeonje-ri, Korea).

2.1.2. *Post luting procedures*

The obturated canals were stored at 37 °C and 100% relative humidity to ensure complete setting of the sealer. For each tooth, a post space was prepared in the obturated canal to a