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Evaluation of the effect of dental cements on fracture resistance and fracture mode of teeth restored with various dental posts: A finite element analysis

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ABSTRACT

Endodontic treatments of teeth with post-core systems is generally accompanied by increased brittle fracture of the restored teeth. This research aimed to evaluate the combined effect of dental posts and luting cements on fracture resistance and failure mode of the endodontically-treated teeth. Sixty endodontically-treated upper central incisors were randomly restored using titanium, fiber, or stainless steel posts and luted by zinc phosphate or composite resin cements. The teeth were then thermocycled and loaded at 135° until failures were observed. Moreover, a three-dimensional model of teeth was analyzed using the finite element method to compare the stress distributions generated by different post-core systems. The results showed that zinc phosphate cement provided relatively higher fracture resistances, whereas luting with composite resin resulted in more restorable failures. Moreover, the teeth restored by fiber posts exhibited desirable fracture resistances with more restorable failure modes, compared to those treated by stainless steel or titanium posts.

1. Introduction

Utilization of the post–core system is known as one of the earliest methods for retention of the restorations and reinforcement of the endodontically-treated teeth [1]. Provision of an appropriate range of fracture resistance, effective protection of the remaining tooth structure, and long-term retention of the crown, are the critical parameters which determine the clinical success of a post–core system [2]. In addition, the fracture restorability has recently become an increasingly significant feature for evaluation of a post–core system [2].

Dental posts are often casted or prefabricated from biomedical-graded materials such as stainless steel, titanium, gold, chromium–cobalt alloys, fiber, and zirconium which have shown high success rates in improving the fracture resistance of the endodontically-treated teeth [2–9]. However, a number of studies have reported an increased risk of vertical fracture in the teeth restored by ceramic and metallic posts, probably due to their high elastic moduli compared to natural dentin [8,10]. In contrast, restoration by fiber posts, with elastic moduli close to that of dentin, could reduce the susceptibility of root fracture and increase the tooth survival rate [1].

Mechanical properties of the adhesive luting materials used for cementation of the posts to the internal dentin could also significantly influence the success of endodontic tooth restoration [6]. A number of luting cements including zinc phosphate, zinc polycarboxilate, glass ionomer, modified glass ionomer resin, and composite resin have been shown to increase the post-dentin bond strength and provide an improved root retention and fracture resistance [7,11–14]. Zinc phosphate is the preferred choice of cementation material which reduces the susceptibility of root fracture due to its high compressive and tensile strengths [15,16]. However, recent studies have proved that the resin cements not only provide a short-term root reinforcement, could also result in better root retention and reduced leakage compared to other cementation materials [11,17,18].

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In spite of the extensive research on the influence of different posts and cements on the fracture behavior of the endodontically-treated teeth, the combined effect of both these parameters on the root fracture resistance and failure mode is mostly neglected. The restoration longevity is not only affected by the post characteristics, a sufficient post-dentin bond strength provided by the luting cement plays also a role in lowering the risk of root fracture. Different luting cements may not provide identical bond strengths when used with various post materials. Therefore, the current study aimed to investigate the combined impact of post type (i.e., titanium, fiber, and stainless steel) and cement type (i.e., zinc phosphate and composite resin) on the fracture resistance, and failure mode of the endodontically-treated teeth which allows to further determine the posts and cements that provide superior fracture behavior in the restored teeth.

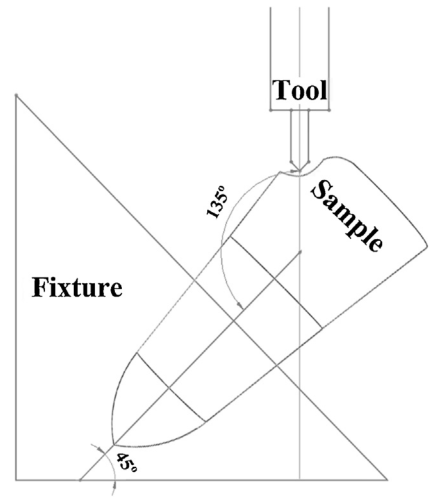

Fig. 1. Experimental design applied for fracture tests.

2. Materials and methods

2.1. Sample preparation

A number of sixty extracted maxillary incisors, collected from dental surgery and orthodontic clinics of University of Malaya, were stored in distilled water and disinfected in 0.5% chloramine-T trihydrate solution for a week according to ISO/TS 11405:2003. The teeth were scaled using ultrasonic scaler (Peizon Master 400, Switzerland) and examined under a stereomicroscope to detect any defects within their structure. The teeth without caries, cracks, abnormalities, or previous endodontic treatment, with fully formed roots were only selected for further experiments. The crowns were sectioned 16 mm from the apex using a diamond disc (Edenta, Diamantscheibe, Switzerland) attached to a straight hand-piece. Root canals were prepared using the step-back technique, while 45 K-file (Dentsply/Maillefer, Switzerland) was performed as a master file at 15 mm. After obturating the root canals using gutta-percha cones (Dentsply/Asia, Hong Kong) with resin-based canal sealer (AH-plus, Dentsply/DeTrey, Germany), the teeth were further incubated in distilled water for 24 h. Post-space preparations were performed by removing gutta-percha using Gates-Glidden drills (Dentsply/Maillefer, Switzerland) to place the dental posts with constant working lengths of 10 mm.

The teeth were then randomly assigned into two groups, where each group was in turn divided into three subgroups containing 10 teeth. The teeth in the first group were all restored using zinc phosphate cement (Elite Cement 100, GC Corporation, Japan) in combination with three different posts including titanium (Para Post XP, Coltene/Whaledent, USA), fiber (Para Post Fiber Lux, Coltene/Whaledent, USA), and stainless steel (Para Post XP, Coltene/Whaledent, USA) posts. The specimens of the second group were also restored in a similar manner, with the notable exception

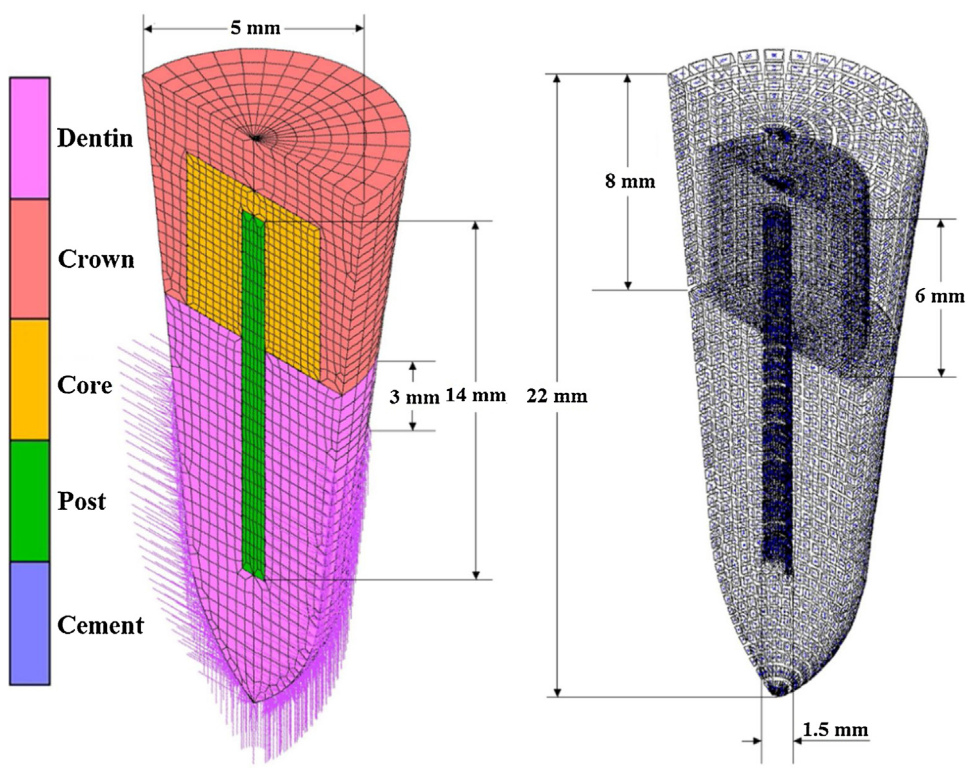

Fig. 2. Schematic illustration of the geometry used in finite element analysis.