The Saudi Dental Journal (2016) **28**, 49–55

King Saud University

**The Saudi Dental Journal**

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ORIGINAL ARTICLE

# Fracture resistance of endodontically treated teeth restored with indirect composite inlay and onlay restorations – An *in vitro* study

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Received 17 December 2014; revised 17 July 2015; accepted 13 September 2015
Available online 2 December 2015

**KEYWORDS**

Fracture resistance;
Composite;
Inlay restoration;
Onlay restoration;
Endondontics

**Abstract** *Objective:* The purpose of this *in vitro* study was to evaluate and compare the fracture resistance and fracture mode of extensive indirect inlay and onlay composite resin restorations performed for endodontically treated premolars.

*Materials and methods:* A total of 55 extracted maxillary premolars were randomly divided into four groups. The first group ($n = 15$) remained untreated to serve as a positive control; the second group ($n = 15$) was endodontically treated with inlay cavities prepared and restored with indirect composite inlay restorations; the third group ($n = 15$) was also endodontically treated with onlay cavities prepared and restored with indirect composite onlay restorations; and the fourth group ($n = 10$) was endodontically treated with mesio-occlusodistal (MOD) cavities prepared and left unrestored to serve as negative controls. Dual cure indirect composite resin was used to fabricate the inlay and onlay restorations performed for the second and third groups, respectively. All teeth were subjected to compressive axial loading test using a metal ball (6 mm in diameter) in a universal testing machine (Instron 1195) with a cross-head speed of 0.5 mm/min until a fracture occurred. Statistical analysis of fracture resistance and fracture mode were performed with analysis of variance (ANOVA) ($\alpha = 0.05$) and Kruskal–Wallis ($\alpha = 0.05$) tests, respectively.

*Results:* For the four treatment groups, the mean fracture resistance values were 1326.9 N, 1500.1 N, 1006.1 N, and 702.7 N, respectively. Statistical analyses showed no significant differences between the mean fracture resistance of the intact tooth group and the inlay restoration group

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sdentj.2015.09.001

($p > 0.05$), while significant differences were observed between the mean fracture resistance of all the other groups ($p < 0.05$). The Kruskal–Wallis test showed statistically significant differences between the fracture modes of the four groups.

*Conclusion:* Within the limitations of this study, endodontically treated teeth were successfully restored with indirect composite inlay and onlay restorations. However, the fractures that accompanied the inlay restorations were more severe and were unable to be restored.



## 1. Introduction

Endodontic treatment is generally associated with reductions in the resilience and fracture resistance of the treated teeth (Reeh et al., 1989; Hansen et al., 1990). The primary factors for loss of tooth structure include dental caries, cavity preparation, endodontic access, and root canal preparation (Huang et al., 1992; Papa et al., 1994). Moreover, the depth and design for cavity preparations are critical factors for fracture resistance. When a cavity preparation involves a greater depth, this typically generates stress in the enamel (Hansen and Asmussen, 1990; Lin et al., 2001). One of the most important factors for maintaining the stability of dentin is the remaining axial thickness (Hansen and Asmussen, 1990). Preparation of an endodontic access cavity compromises the strength of a tooth, resulting in an increased susceptibility to fractures (Yamada et al., 2003; Plotino et al., 2008). Consequently, loss of dentin, as well as anatomic structures such as cusps, ridges, and an arched roof of the pulp chamber, may result in the fracture of tooth tissue after the final restoration (Trope et al., 1986; Reeh et al., 1989). Randow and Glantz (1986) previously reported that teeth have a protective feedback mechanism that is lost when pulp is removed, and this may also contribute to occurrence of tooth fractures. Mesio-occlusodistal (MOD) intracoronal preparations commonly result in the creation of elongated cusps (González-López et al., 2006), and these may reduce the original strength of tooth structures (Hannig et al., 2005; Habekost et al., 2007).

After a root canal treatment (RCT), a reinforcing ferrule design for the restoration is commonly recommended to reduce fracture susceptibility (Steele and Johnson, 1999). Partial-veneer crowns that cover all cusps or laboratory-fabricated complete crowns are usually included in the restoration of the endodontically treated teeth. Recently, composite resin restorations or adhesive ceramic inlays that provide internal reinforcement of teeth without occlusal coverage have been advocated (Van Dijken, 2000; St-Georges et al., 2003; Hannig et al., 2005). However, these techniques do not guarantee a full restoration of the fracture toughness of a sound tooth (Costa et al., 1997). Studies have also shown that after endodontic treatment, teeth that are restored with bonded restorations are more resistant to fracture compared with those that are restored with silver amalgam (Oliveira et al., 1987; Wendt et al., 1987); yet, both bonded silver amalgam and bonded cast metal inlays have been recommended for the reinforcement of prepared teeth (Zidan and Abdel-Keriem, 2003).

Clinicians often prefer composite resin due to its excellent esthetic and mechanical properties, its ease of handling, and its reported ability to reinforce weakened dental structures (Bremer and Geurtsen, 2001). Although hybrid composite resins are mostly preferred for restoration of small- and medium-sized occlusal cavities, direct composite resin restorations are highly technique sensitive, presenting disadvantages related to polymerization shrinkage, postoperative sensitivity, and wear resistance (Ritter and Baratieri, 1999). Recent generation of indirect composite encourage using this material for a large cavity as an inlay or onlay restoration. However, the disadvantages associated with hybrid composite resins include postoperative sensitivity, polymerization shrinkage, and wear resistance (Ritter and Baratieri, 1999). Indirect composites have recently been generated and these have been recommended for inlays or onlay restorations of large cavities.

The purpose of this *in vitro* study was to evaluate and compare the fracture resistance and type of fractures that occur in endodontically treated premolars that receive extensive indirect inlays versus onlay composite resin restorations.

## 2. Materials and methods

A total of 55 intact human, caries-free, and recently extracted maxillary premolars that met orthodontic treatment requirements were obtained. All the teeth had two canals and the bucco-palatal dimension of the crowns ranged from 9 to 9.5 mm. The teeth were properly cleaned using sodium hypochlorite and any cracks were observed under magnification (×30) with a stereomicroscope (Stemi SV6; Carl Zeiss SpA, Arese, Italy). The teeth were stored in a 0.5% chloramine T solution until being randomly distributed into four different groups. For Group 1 ($n = 15$), the teeth received no cavity preparation or RCT in order to serve as positive controls. For Group 2 ($n = 15$), the teeth underwent RCT followed by inlay preparation and indirect composite inlay restoration. For Group 3 ($n = 15$), the teeth underwent RCT, onlay preparation, and indirect composite onlay restoration. For Group 4 ($n = 10$), the teeth underwent RCT and inlay preparation with no restoration to serve as negative controls. A single operator performed all the RCTs, the inlay and onlay preparations, and the restorations.

### 2.1. RCT

An access cavity was prepared for each tooth using a water-cooled, high-speed handpiece tool with a 2.3 mm round bur and 1.4 fissure bur (Komet, GEBR, Brasseler, Germany). Each canal orifice was enlarged with a Gates Glidden size III (JS Dental, Switzerland) and the canals were prepared with NiTi rotary instruments (ProTaper; Dentsply Maillefer, Ballaigues, Switzerland) until size 25 was reached. A root canal conditioner, Glyde (Dentsply Maillefer), was used to facilitate the canal preparations, and 6% sodium hypochlorite (Henry