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Stability of endodontically treated teeth with differently invasive restorations: Adhesive vs. non-adhesive cusp stabilization

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ABSTRACT

Objectives. Aim of the present study was to evaluate fracture strength of endodontically treated molars with different preparations/restorations after thermomechanical loading in vitro.

Methods. 264 extracted human third molars were used. Beside the control group, 256 teeth in 32 test groups ($n = 8$) received root canal treatment (MTwo #40/.6) and root canal obturation with AH Plus and Guttapercha. After postendodontic sealing and build-up (Syntac, SDR), specimens were additionally prepared MO or MOD. Postendodontic restorations were: Direct restorations (Tetric EvoCeram Bulk Fill bonded with Syntac; as filling or direct partial crown (PC) after reducing the cusps 3 mm; amalgam as filling or direct pin-retained partial crown (PC)), vs. indirect adhesive restorations (I: Inlay vs. PC; IPS Empress I/PC; Celtra Duo I/PC; e.max CAD I/PC; Lava Ultimate I/PC; Enamic I/PC – all inserted with Syntac/Variolink) vs. cemented cast gold I/PC. After 300,000 thermocycles (5/55 °C) and 1.2 Mio. 100 N load cycles, specimens were loaded until fracture.

Results. Whereas IPS Empress showed no difference between I and PC ($p > 0.05$), in all other groups PC were significantly more stable than fillings/inlays ($p < 0.05$), this effect was more pronounced after MOD preparations. Cast gold PC exhibited the highest fracture strengths ($p < 0.05$), inlays the lowest ($p < 0.05$). IPS Empress was generally inferior to the other bonded materials under investigation ($p < 0.05$) which as PC almost reached the level of control specimens. Amalgam fillings showed the worst outcome ($p < 0.05$).

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Significances. Less invasive preparation designs were not beneficial for the stability of postendodontic restorations. Except for IPS Empress, PC were generally more successful in restabilization of weakened cusps after endodontic treatment and preparation. Cast gold PC remain the ultimate stabilization tool for ETT in terms of fracture resistance.

1. Introduction

Since decades, vital teeth can be safely restored and kept vital using amalgam and more and more resin composites in order to act minimally invasive [1–5]. During and especially after completed endodontic treatment, the situation considerably changes due to the weakening effect of endodontic access preparation and the often large amount of tissue having been lost by extensive caries excavation [6–12]. It is proven that the biomechanical stability of posterior teeth after access cavity and even further preparation is dramatically decreased with a high risk of vertical root fracture [13–18]. Thus, it is logical that clinical studies focusing on endodontically treated teeth (ETT) reveal inferior outcomes compared to vital teeth [19–24], although recent studies could not find less tactile sensitivity of ETT compared to vital teeth which makes the "cherry stone" theory questionable, i.e. that the opening reflex for ETT is be delayed, involving heavier load input during routine mastication of hard items [25].

However, a deeper look into clinical data exhibits that vertical root fractures accounted only for 12% of extractions of ETT, compared to 15% cusp fractures and 40% periodontal problems [20]. Nevertheless, this altogether sums up to 27% fractures as reason for ETT loss [20]. So the appropriate preparation and/or restoration was always a matter of concern in the literature, having been reflected by several studies and reviews with a special focus on postendodontic restorations [26–34]. Whereas for the restoration of vital teeth it is generally accepted that minimally invasive preparations are supporting clinical long-term success [1,4,35], the influence of preparation invasiveness with ETT is still not fully understood. For eample, the clinical outcome of direct resin composite restorations is discussed contradictorily in the literature of the field ranging from simply catastrophic to acceptable [14,20,36–41]. The same is true for the preclinical estimation of innovative ceramics and hybrid materials, which have been claimed to act as better shock absorbers during mastication which also makes them interesting as ETT restorations [28,51]. Although prospective, randomized clinical long-term trials are the optimum instrument to investigate clinical behavior of different restorative procedures in vivo, these studies are time-consuming, expensive, and permanently suffering potential patient drop out which is finally corroborating statistical impact [3,35]. Therefore, in vitro studies are still of concern, especially when thermomechanical loading scenarios are applied being close to the clinically observed circumstances [7,8,42,43].

Aim of the present study was to evaluate the fracture resistance and behavior of different preparation/restoration concepts of ETT. The null hypothesis was two-fold, that (1) the preparation and (2) the restoration would have no influence on fracture strength of previously thermomechanically fatigued ETT.

2. Methods and materials

264 intact, non-carious, unrestored human lower third molars with similar size and fully developed roots, extracted for therapeutic reasons under informed consent of the patients and upon approval by a local ethics committee (Ref no. 143/09), were stored in an aqueous solution of 0.5% chloramine T at 4 °C for up to 30 days. The teeth were debrided of residual plaque and calculus, and examined to ensure that they were free of defects under a light microscope at ×20 magnification. Beside the control group without any preparation ($n = 8$), 256 teeth in 32 groups ($n = 8$) received endodontic access cavities and root canal preparation at a working length of −1 mm from the apical foramen using MTwo rotary instruments (VDW, Munich, Germany) up to size .04/#40. Tooth length was established using a C-Pilot file ISO 10 (VDW) that was inserted into the root canal until it could be visualized at the apical foramen. Working length was determined by subtracting 1 mm from this length. Root canals were filled with laterally compacted gutta-percha (VDW) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany), and immediately sealed (Syntac and SDR/Dentsply).

Specimens were additionally prepared MO or MOD. The cavities were cut using coarse diamond burs under profuse water cooling (80 μm diamond, Komet, Lemgo, Germany), and finished with a 25 μm finishing diamond (one pair of diamonds per four cavities). Inner angles of the cavities were rounded and the margins were not beveled except for direct restorations where margins received a 0.5 mm bevel. Polymerizable materials were light-cured with a Bluephase light-curing unit (Ivoclar Vivadent, Schaan, Principality of Liechtenstein). The intensity of the light was checked periodically with a radiometer (Demetron Research Corp, Danbury, CT, USA) to ensure that 1000 mW/cm^2 was always delivered during the experiments.

The different restorative procedures are displayed in Table 1. Direct adhesive procedures: cavities (MO, MOD, partial crown preparations, Figs. 1 and 2) were surrounded with a metal matrix band, bonded with Syntac, and restored with Tetric EvoCeram Bulk Fill in oblique layers of 2–4 mm thickness. The increments were separately light-cured for 40 s each with the light source in contact with the coronal edge of the matrix band. After removal of the matrix band, the restorations were light-cured from their buccal and lingual aspects for an additional 20 s on each side. Prior to the finishing process, visible overhangs were removed using a posterior scaler (A8 S204S,

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