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Fracture Resistance of Maxillary Premolar teeth with Class II Cavities Restored by Both Direct Composite Restorations and Endodontic Post Systems

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Original Research Article

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Abstract: To evaluate fracture resistance of maxillary premolar teeth with Class II cavities restored with direct composite restorations and endodontic posts.A total of 40 sound, maxillary premolars with similar size and shape will be collected. The teeth will be randomly divided into three groups of ten specimens each (n = 10). Two groups (n = 5) will be remained untreated; G 1: restored with direct composite only; G II: restored with rigid post and direct composite; G III: restored with fiber post and direct composite; G IV: un-prepared and un-restored and G V: prepared and un-restored. Following trepanation, the root canals instrumented to an apical size of ISO 40, obturated and restored as grouped; before fracture using universal testing machine: High significant differences were found between all the tested restorative system except between group I and group III; where there was no statistical significance difference between the two groups [p=0.018] at p<0.05.Endodontically treated premolars with MOD cavities, can be restored to the load-bearing capability of sound premolars when using quartz fiber posts..
Keywords: Fracture resistance, Maxillary premolars, class II cavities, endodontic treated teeth, Post systems

INTRODUCTION

Endodontic treatment is largely performed on teeth significantly affected by caries, multiple repeat restorations and/or fracture. Already structurally weakened, such teeth are often further weakened by the endodontic procedures designed to provide optimal access and by the restorative procedures necessary to rebuild the tooth.

Loss of inherent dentinal fluid may also effect an alteration in tooth properties. It is therefore accepted that endodontically treated teeth are weaker and tend to have a lower lifetime prognosis. They require special considerations for the final restoration, particularly where there has been extensive loss of tooth structure. The special needs involve ensuring both adequate retention for the final restoration and maximum resistance to tooth fracture. Together, and both equally important, retention and resistance features for the final restoration are sometimes collectively termed anchorage. Ensuring optimal anchorage while maintaining adequate root strength for the particular clinical situation can be challenging and the problems encountered have resulted in the development of many different materials and techniques [1].

The restoration of endodontically treated teeth frequently poses a challenge for the clinician. In cases of considerable hard tissue loss, posts are used as an element supporting core foundation when there is insufficient coronal tooth structure [2]. The literature shows that there is no consensus regarding the ideal endodontic post and core system. Clinicians usually choose the post and core system that provides best retention, support, and reduces the possibility of root fracture [3,4]. Generally, posts and cores may be fabricated using indirect or direct techniques. Indirect techniques require an impression and cast during the preparatory stages to produce a cast metal post-core build-up. Direct techniques involve the use of a prefabricated post in a radicular preparation [5].

Until recently, all available prefabricated posts consisted of metal alloys that resulted in a final heterogenous combination of dentin, metallic post, cement, and core material. Fredrikssonet *al*[6] proposed that the major disadvantage of these systems was the stresses concentrated in uncontrolled areas that were sometimes vital to the root.

Fiber-reinforced post systems were later introduced [7-10]. Goldberg and Burstone[9]reported that glass fiber-reinforced post systems were composed of unidirectional glass fibers in the resin matrix that strengthened the structure of the post without compromising the modulus of elasticity. Boschian*et al*. [11] concluded that using fiber posts and resin composite cements might reinforce the remaining tooth structure and reduce root fracture and post debonding. Such effects may be attributed to the chemical bonding between the post and the cement and to the similarity in the elasticity modulus between the post and dentin. Translucent quartz fiber post systems recently were introduced as an alternative to achieve optimal esthetics; they can be light-polymerized during cementation [10].

In retrospective clinical studies, premolars were found to be the most frequently fractured teeth [12,13]. Most published studies on restoration techniques for non-vital premolars with class II (MOD exclusively) defects refer to various minimally invasive coronal approaches without the use of any post [14-18], in this regard, the influence of posts on fracture strength is a subject of interest in only a few number of publications [18]. Adhesive ceramic inlays or composite resin restorations that provide internal reinforcement of teeth without occlusal coverage have been advocated [19]. Nevertheless, it is not proven whether the fracture resistance of sound teeth is completely restored with these treatment modalities [20]. The aim of the present study was intended to evaluate fracture resistance of maxillary premolar teeth with Class II cavities restored with direct composite restorations and endodontic posts. The hypotheses were be as follows: (1) premolars with class II (mesio-occlusal) cavities restored with direct composite restorations and no posts were not show lower fracture resistance than premolars with direct composite restorations and various kinds of posts and (2) no difference were exist between the use of fiber posts compared to rigid post materials concerning the fracture load.

MATERIALS & METHODS

A total of thirty sound extracted maxillary first premolar teeth were collected from Clinics of College of Dentistry at Prince Sattam Bin AbdullazizUniversity, as well as from a group of private practitioners and orthodontists. In order to be included in the study, the premolars were required to have the following crown dimensions: 9mm bucco-lingual distance; 11mm mesio-distal distance. The collected premolars were observed under magnification (x10) in binocular-stereomicroscope(LOMO SF-100 Binocular Stereo Microscope (MBC-10). Russia.); teeth which had preexisting cracks, caries, developmental defects or attrition were discarded. The selected premolars were carefully cleaned using ultra sonic scalar (UDS-J ultrasonic scalar, Ningbo Sunglow Imp &Exp Co., Ltd. No.11,Lane 173,Yongfeng North Road, China) and then debrided with pumiceusing rotary brush (Merssage Brush; ShofuInc, Kyoto, Japan). The selected premolars were disinfected with 0.2% sodium azide solution (Laboratory of College of Pharmay, Sattam Bin Abdullaziz University) for 48 hours.Premolars were stored in normal saline at 37^{o}C, until the time of the test, to prevent dehydration.

The samples were divided into three main groups (10 premolars of each) relative to the restorative system used; two groups (n = 5) were remained untreated; one group was remained unprepared and unrestored (-ve control group) and the other group was prepared but was remained unrestored (+ve control group) and served as the control groups; as follow: Group I: restored with Tetric N Ceram only, Group II restored with rigid post and direct composite, Group III restored with fiber post and direct composite, Group IV:-ve control group and Group V: +ve control group.

A non-retentive MOD slot cavity was prepared, with dimensions of 4±0.3millimetersin depth (without axial wall) and 2±0.3millimeters in facio-lingual width following the conventional outline form. Each cavity was prepared using carbide bur No.59 (Komet Dental Uk). The depth of the cavity was checked by using a graduated periodontal probe. Polyvinylchloride (PVC) retention tubes, with a diameter of three centimeters, were used for mounting the prepared teeth. The roots of each tooth had been positioned at the center of the tube, with the long axis parallel to the sides of PVC tube. Each tube was filled with acrylic resin(Dentsply, Limited, England) in the dough stage, leaving the crown and two millimeters of the root below the amelo-cemental junction uncovered. Fig. 1

Fig-1: Occlusal view of the MOD cavity preparation

Following trepanation with a diamond bur and water-cooling, the root canals of the remaining 35 teeth was instrumented manually in a step-back technique to an apical size of ISO 40 (Hedstro¨m, VDW, and Munich, Germany). Canals were dried with absorbent paper points and obturated with gutta-percha (Roeko, Langenau, Germany) and sealer (AH plus, DentsplyDeTrey, Konstanz, Germany) using cold lateral condensation. All teeth were embedded in an acrylic resin (PalapressVario; HeraeusKulzer GmbH, Hanau, Germany) cube (1.6mm_ 1.6 mm), using a custom-made silicone mould (Adisil; Siladent-technik GmbH, Munich, Germany). The acrylic level was adjusted 2 mm below the buccal cement-enamel junction.

The materials for the restorative procedures are listed in Table 1. Group I (Tetric N ceram), each cavity was blotted with cotton bellet for drying, then enamel surface was first etched with 37% phosphoric acid gel, and then the dentin was conditioned during the last 15 s. of the 30 s, etching time. After that the cavity was rinsed thoroughly with copious water for 10 s, and then dried with a dry cotton bellet. Tetric N bond adhesive was applied to thoroughly wet all the cavity walls for 20 s. Excess solvent was removed by gently drying with clean, dry oil free air from a dental syringe for at least 5 s, and light cured for 20 s. Resin composite was applied into the bonded cavity in an incremental technique. The thickness of each increment was not exceeding 2mm. The first proximal increment was horizontally applied to the gingival floor and adapted to the cavity margins using a Teflon coated condenser (OptraSculpt/IvoclarVivaDent). Then a contact forming instrument(OptraContact/IvoclarVivaDent) was placed into the composite material along the matrix band and pressed against the adjacent tooth. This layer light cured according to manufacturer's instructions for 20 s. The contact forming instrument was removed so a contact bridge of dental composite was created and helped in holding the matrix and creating a tight contact, the restoration was completed incrementally. The restoration was then cured for additional 20 s on each side after matrix removal.

In all roots, 11-mm deep post spaces were prepared as measured from the bottom of the approximal cavity. For all post systems, the system-specific preparation instruments were used according to the manufacturer's recommendations. In group II (BKS titanium post/Tetric N ceram), a thread was cut using the system-specific thread cutter (118BKS.000.2, Brasseler). The root canal surfaces in group III (Dentin post/Glass fiber post/ Tetric N ceram) was roughened with a special instrument (196D, roughness 52 mm; Brasseler). Prior to fixation, all screws and posts were cleaned with ethanol and dried with an air blow. The root canals were rinsed with 0.5% sodium hypochlorite and dried with paper points. The posts in groups II was cemented in the conventional way using automatically mixed (Rotomix; 3M ESPE, Seefeld, Germany) glass ionomer cement, which was applied to the total post surface. Subsequently, the post was seated in place using finger pressure. Excess cement was removed using a sharp instrument and cotton pellets. In groups III, the dentinal surfaces were conditioned by applying a self-etching primer (ED primer). This was left for 60 s, and a gentle air blow was used to evaporate the dissolution fluid. Resin cement (Panavia F) was mixed for 30 s and applied to the total post surface. Subsequently, the post was seated in place using finger pressure. Excess cementwas spread with a brush in a thin layer covering the coronalportion of the posts to guarantee a better bonding to the fillingcomposite. Finally, light curing took place for 20 s.After placement, all screws and posts were reduced to atotal length of 15 mm. The direct restorations were built upin the same manner like Group I. Finally, the restorations were adjusted and polished withcorresponding rotating instruments (9400, 9401, 9402, Brasseler,Lemgo, Germany).

Table-1: the restorative systems tested

Brand name of posts	BKS	DentinPost
material	titanium	Glas-FRC
manufacturer	Brasseler,Lemgo,Germany	Brasseler, Lemgo, Germany
Diameter apical	1.6mm	0.9mm
Diameter coronal	1.6mm	1.75mm
Color code	Yellow	Red
Post length	15 mm	15–mm
Post shape	Screw	Cylindroconical
Conus angle	Cylindrical	4.2
Post cementation	KetacCem;3MEspe,Seefeld, G	Panavia F;Kuraray,Osaka, J
Preparation design	Class II mesio-occlusal-Distal	Class II mesio-occlusal-Distal
Composite resin	Tetric N ceram/IvoclarVivadent, Schaan,Liechtenstein	Tetric N ceram/IvoclarVivadent, Schaan,Liechtenstein
Adhesive system	Tetric N bond/ IvoclarVivadent, Schaan, Liechtenstein	Tetric N bond/ IvoclarVivadent, Schaan, Liechtenstein

All of the specimens subjected to a compressive load in a universal Instron Testing Machine(digital tritest, ele/Danaher/USA) at a crosshead speed of 0.5 mm ⁄min until fracture was occurred. The specimens were placed on the lower platen of the testing machine. A steel sphere (8 mm in diameter) rigidly attached to the upper cross head was brought into contact with both the buccal and lingual cusps of the tooth. The areas of contact were modified by round diamond rotary instrument to prevent lateral deflection of the steel sphere[23]. A sudden decrease in force of more than 30 N was regarded as an indication of failure, and the maximum force up to this point was recorded as the force at fracture.

It should be ensured that there was no contact between the restoration and the sphere before the test was performed. Fracture loads were recorded and interpreted using one-way analyses of variance (ANOVA). Tukey Post Hoc test was then performed to determine the significant differences between each two groups. The level of significance was set at (P <0.05).

RESULTS

One way analyses of variance (ANOVA) was performed to determine the effect of restorative system tested on the fracture resistance. Table 2 showed the results of One-way ANOVA and revealed high statistically significant difference between the tested materials (P <0.0001).

The Tukey Post Hoc test (Table 3) was then performed to determine the significant intra-group differences and showed that, high significant differences were found between all the tested restorative system except between group I and group III; where there was no statistical significance difference between the two groups [p=0.018] at p<0.05.

The highest fracture resistance mean value was found in the (-ve) control group (un-prepared un-restored teeth; group IV) and was 636.39 N. While, the lowest fracture resistance mean value was recorded in (+ve) control group (prepared un-restored teeth; group V) and was 255.23 N.

Table-2: Mean and SD of fracture resistance values (N) of the tested restorative system

Materials	N	Mean(kgf)	Std. Deviation
Group I	10	472.60[b]	4.437
Group II	10	489.51[a]	6.982
Group III	10	475.94[b]	5.00
LSD	5.123		
P value	<.0001[**]		

*Significant difference at p< 0.05: Means with the same letter are not significantly different

Table-3: One way ANOVA test results of comparison of fracture resistance values of the tested restorative system

By material	Sum of Squares	Df	Mean Square	F value	*P* value
Between Groups	1603.823	2	801.911	25.73	<0.0001
Within Groups	841.587	27	31.169		
Total	2445.410	29			

*Significant difference at p< 0.05

Table-4:Tukey Post Hoc test results of fracture resistance of tested restorative system specimens

Material	*P* value
Group I versus Group II	<0.0001
Group I versus Group III	0.018
Group II versus Group III	<0.0001

*Significant difference at $p < 0.05$

DISCUSSION

Naturally, endodontically treated teeth show a higher degree of substantial loss of hard tissue, and these situations are more challenging to the practitioner performing restorations. Nevertheless, an evidence-based restorative treatment protocol for premolars with minor loss of hard tissue is needed, and our estimation, cannot be derived from the published scientific literature [24-28].

Two different post systems were used in combination with direct composite restorations, being aware of the fact that minimally invasive intracoronal restorations without posts delivered promising results in ex vivo and clinical studies [17]. However, a direct comparison between these two approaches is rarely to be found in scientific literature. Nevertheless, two published studies from Sorrentino*et al* [18] and Siso*et al.*[19] indicated that a reinforcing effect of an additional post placement is possible when restoring premolars with MOD cavities directly with composite. These results were confirmed in the present study, showing an increased load-bearing capacity when using fiber posts or titanium screws additionally to direct composite restorations. This finding is in contrast with the results from a previous study investigating the fracture behavior of crowned endodontically treated premolars with class II cavities[29]. In an identical experimental setting, the additional placement of posts did not result in increased fracture loads. Therefore hypothesis 1 cannot be accepted. A limitation of the present study is the standardized cavity preparation and loading angle; in a clinical setting varying amount of remaining tooth structure and loading situations may occur. However, in a clinical study on endodontically treated premolars with class II cavities, adhesive restorations with fiber posts were found to be effective over an observation period of 5 years[30]. Placing rigid posts delivered no enhanced fracture strength values.

The superiority of posts with a dentin-like modulus of elasticity, in general, which was started by a number of publications [31] and is attributed to more advantageous stress distribution to the residual tooth structure[28],could not be reproduced for the tested situation. The reason for unfavorable failures was not attributed to the rigidity of the endodontic posts or their cementation mode alone. Hypothesis 2 can be accepted partially.

CONCLUSION

Within the limitations of this study, it can be concluded that

- The use of intraradicular posts can increase the fracture resistance of endodontically treated premolars with MOD cavities and direct composite restorations.
- Endodontically treated premolars with MOD cavities, can be restored to the load-bearing capability of sound premolars when using fiber posts.

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