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ORIGINAL RESEARCH

A Comparative Evaluation of the Vertical Root Fracture Resistance of Endodontically Treated Teeth using Different Root Canal Sealers: An *in vitro* Study

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ABSTRACT

Objective: The objective of this study is to evaluate the vertical root fracture resistance of endodontically treated teeth obturated with – Tubli-Seal EWT/Gutta-percha, AH Plus/Gutta-percha, Epiphany SE sealer/Epiphany point.

Study design: Sixty-five single rooted premolars were decoronated and root length was 14 mm for each specimen. Fifty five teeth were enlarged up to ISO size 40 master apical file with stainless steel K-files using standardized preparation and remaining ten teeth were served as negative control. Then teeth were randomly assigned into different groups depending on sealer used for obturation as follows:

Group 1: Negative control—no instrumentation was performed.

Group 2: Positive control—gutta-percha with out the use of any sealer.

Group 3: Experimental group—gutta-percha and Tubli-Seal EWT root canal sealer.

Group 4: Experimental group—gutta-percha and AH Plus.

Group 5: Experimental group—epiphany SE sealer and epiphany points.

After 72 hours, the specimens were embedded in auto-polymerizing resin leaving 7 mm of each root exposed and were subjected to fracture testing under universal testing machine at a crosshead speed of 1.0 mm per minute until the root fractured. Results were statistically analyzed using one-way ANOVA and independent t-test.

Results: Showed that Epiphany SE sealer/Epiphany points showed highest mean fracture resistance and Tubli-Seal EWT group showed the least fracture resistance of all the materials tested. There was no statistically significant difference among experimental groups.

Conclusion: Epiphany SE sealer/Epiphany points demonstrated highest fracture resistance values than the other materials tested and intact tooth had highest resistance against vertical root fracture.

Clinical significance: Epiphany SE sealer/Epiphany points may be one of the materials of choice in the endodontic treatment of teeth.

Keywords: Epiphany sealer/Epiphany points, AH Plus/Gutta-percha, Tubli-Seal EWT, Vertical root fracture.

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INTRODUCTION

Teeth treated endodontically may be more susceptible to fracture because of removal of the tooth structure during endodontic therapy, extensive restorations, reduced amount of tooth structure, and excessive pressure during obturation and dehydration of dentin after endodontic therapy.[1-3] Endodontic treatment inherently requires reduction of tooth structure to provide access and to allow for complete cleaning and shaping of the root canal system. The strength of endodontically treated teeth is related directly to the method of canal preparation and to the amount of remaining sound tooth structure.[4] It has been observed clinically that vertical root fracture occurs most commonly in endodontically treated teeth.[5] Vertical root fracture is a longitudinal fracture of a root, extending throughout the entire thickness of dentin from the root canal to the periodontium.[6] This type of fracture has an unfavorable prognosis and often leads to tooth extraction.

The major objectives of root canal therapy are removal of pathologic pulp, cleaning, and shaping of the root canal system; disinfection of the contaminated root canals and three-dimensional obturation to prevent reinfection.[7,8] Obturation plays an important role in root canal treatment by preventing percolation and microleakage of periapical

exudate into root canal space and preventing reinfection either by adapting to the canal wall or by its antibacterial activity. It also directly influences the fracture resistance of tooth structure. The traditional materials used in endodontics for obturation have remained gutta-percha and root canal sealers. The sealers used had shortcomings in that a fluid tight seal along the dentinal walls was not routinely achieved and the adhesive strength between endodontic sealers, dentin and gutta-percha was shown to be very weak.[4,9]

Considering that the root canal treatment sometimes become necessary to maintain the good condition of the periodontium and to save the tooth from untoward extraction and the procedures like cleaning and shaping, disinfection of the root canal and obturation are important for success of treatment, it would be advantageous if the radicular canal obturation, in addition to providing an adequate seal, could reinforce/strengthen the root against fracture susceptibility through an adhesive filling material.[10,11]

The objective of this study was to:

- To evaluate the effects of different root canal sealers on vertical root fracture resistance of endodontically treated teeth

  Root canal sealers were:
  - Zinc oxide-eugenol based sealer. Tubli-Seal EWT
  - Resin based sealer AH Plus sealer
  - Epiphany SE sealer with Epiphany points obturating system
- To compare the effect of different root canal sealers on vertical root fracture resistance.

MATERIALS AND METHODS

Sixty-five single rooted human premolars were collected and cleaned of soft tissue debris and calculus with a bur. The teeth were disinfected using 2.5% sodium hypochlorite solution for half an hour and then stored in physiological saline solution until used. Radiographs were taken mesio-distally and buccolingually to confirm the presence of single and straight canal. Teeth were decoronated with a diamond disk, so that the root length was 14 mm for each specimen. Ten teeth were served as negative control group, while the working length for remaining 55 teeth were determined by placing the 10K file into the canal until it is observed at the apical foramen, then decreasing the length by 1 mm. Fifty five teeth were cleaned and shaped up to ISO size 40K master apical file with stainless steel K-files using standardized root canal preparation technique. Throughout cleaning and shaping procedure irrigation was done with 1 ml of 3% sodium hypochlorite and recapitulation was done with a 15 K-file. After the instrumentation was completed, all the specimens received a final flush with a 3 ml of neutralized 17% EDTA for 3 minutes, followed by 1 ml of NaOCl to remove the smear layer. After that, 10 ml of normal saline was used to remove any remaining NaOCl residue. The canals were dried with sterile paper points and teeth were obturated using lateral condensation technique and the teeth were assigned into groups as follows depending on the sealer used for obturation.

Group 1: Negative control—no instrumentation was done (n = 10).

Group 2: Positive control—obturation was done with gutta-percha but without the use of any sealer using lateral condensation (n = 10).

Group 3: Lateral condensation with Tubli-Seal EWT/Gutta-percha (n = 15).

Group 4: Lateral condensation with AH Plus/Gutta-percha (n = 15).

Group 5: Lateral condensation with Epiphany SE sealer and Epiphany points (n = 15).

The roots were stored for 72 hours to allow the sealer to set completely. After 72 hours the specimens were prepared for mechanical testing (universal testing machine-LLOYD). The roots were embedded in aluminium blocks of dimension of 1 × 1 × 2 cm using autopolymerizing resin leaving 7 mm of each root exposed and rest 7 mm of the roots were embedded in the resin. A carbide bur was used to remove the 1mm of the temporary material and to shape the root canal orifice to accept the loading fixture. The resin embedded teeth were mounted in the testing machine one at a time. The application of vertical loading force was done by a loading fixture with a spherical tip of radius 2 mm with the center of the canal opening of each specimen. Each specimen was subjected to a load at a crosshead speed of 1.0 mm per minute until the root fractured. The 'fracture' was defined as the point at which a sharp and instantaneous drop of the applied force or frank fracture of the specimen was observed. The test was terminated at this point and the force was recorded in Newtons. The data was statistically analyzed using independent t-test and one-way ANOVA test.

RESULTS

Table 1 showing means, SD, minimum and maximum load for different groups.

Results showed that the intact teeth had highest mean fracture load values, while group 2 where instrumentation was done and canals were filled with gutta-percha without the use of sealer had lowest mean fracture load values among all groups. There was statistically significant difference between them which means that root canal procedures can weaken the tooth structure and increase its susceptibility to fracture (Fig. 1).

Table 1: Descriptive Statistics of Means, SD, minimum and maximum load for different groups

	Descriptives value					
	n	*Mean force of fracture in Newtons*	*Std. deviation*	*Std. error*	*Minimum*	*Maximum*
Group 1	10	466.90[a b]	96.7993	30.6106	340.00	675.00
Group 2	10	332.60[a c]	140.3656	44.3875	195.00	594.00
Group 3	15	414.33[a]	168.5631	43.5228	125.00	761.00
Group 4	15	443.46[a]	186.4223	48.1340	162.00	748.00
Group 5	15	453.80[a]	119.5051	30.8561	205.00	616.00
Total	65	425.67	151.4563	18.7858	125.00	761.00

a,b,c: Statistical significance between groups (Same letter indicates no statistically significant difference while different letter indicates a statistically significant difference)

Among experimental groups, group 5 (Epiphany SE) showed highest fracture load values, while group 3 (Tubli-Seal EWT) showed minimum fracture load values. But, comparison between the different experimental groups showed no statistically significant difference between them (Fig. 1).

DISCUSSION

Root canal instrumentation is an unavoidable step in endodontic treatment. However, it is understood that as root dentin is removed during the instrumentation phase, a weakening effect on the root is inevitable. If we add the wedging forces of the spreader during lateral condensation, or perform excessive dentin removal to facilitate pluggers for vertical condensation, the potential for root fracture increases. Any material that can reinforce the tooth against this weakening effect would thus be useful.[12] Therefore; many attempts have been made in the past to reinforce an endodontically treated tooth. Although the use of gutta-percha with an insoluble root canal sealer can be seen as the gold standard of root canal fillings, the ability of these materials to reinforce an endodontically treated root is discussed with some controversy because in some studies different root canal filling materials were able to significantly strengthen the roots, whereas in other investigations these materials did not increase the fracture resistance of root-filled teeth.[13]

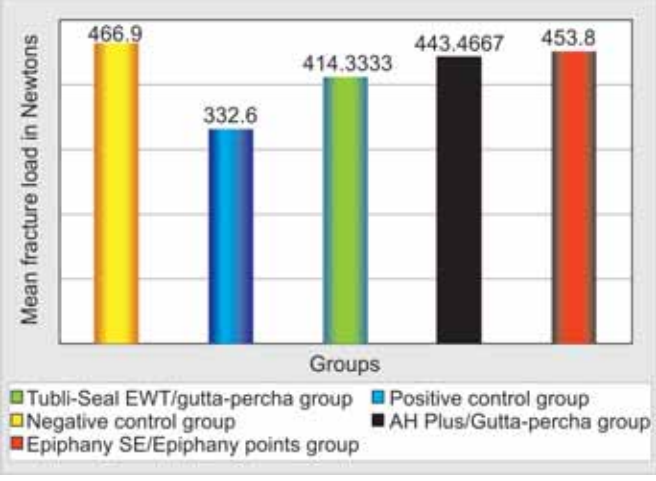

Fig. 1: Comparison between different groups

The sealer plays an important role in the obturation of the root canal. The sealer fills-up all the space that the gutta-percha is unable to fill. The sealer acts as a binding agent, to the dentin and to the gutta-percha.

The adhesion between dental structures and resin-based sealers is the result of a physicochemical interaction across the interface, allowing the union between filling material and root canal wall. This process is important in static and dynamic situations. In static circumstances, the adhesion eliminates spaces that allow the infiltration of fluids into the sealer/dentine interface. In dynamic situations, the adhesion is necessary to avoid the sealer dislodgment during operative procedures. Therefore, the endodontic filling materials may enhance the ability of root-filled teeth to resist fracture.[14] The present study was undertaken to evaluate the effects of root canal sealers on the vertical fracture resistance of the endodontically treated teeth and to compare the effects of different root canal sealers on vertical root fracture resistance of endodontically treated teeth.

Vertical root fracture can be contributed to over-instrumentation (overflaring) of the canal, resulting in unnecessary removal of dentin along the canal walls, with subsequent weakening of tooth structure. As teeth selected were premolars with straight and tapered root canals, this technique allowed us to clean and shape the canals with minimum removal of root canal dentin. EDTA was used as a final rinse followed by NaOCl to enhance the bonding of the materials tested to the dentinal surface of the root. EDTA removes the smear layer and opens up the dentinal tubules. The removal of smear layer has been shown to increase the sealing effect and adaptation of root canal sealers to root canal dentin.[15,16] Weiger et al[17] recommended using EDTA followed by NaOCl to optimize adhesion of sealers to the root canal walls. Final flush was done with normal saline to remove any residue of sodium hypochlorite, which can hamper the adhesion of resin to the root canal dentin.

In our study, as in other mechanical studies,[10,18] the force was applied along the long axis of the root with a rounded punch, which produced root fracture when contact was made between the punch and the walls of the canal opening (Fig. 2). It has been reported that applying the force vertically to the long axis of the tooth transmits the force uniformly.[19] The specimens had only 7 mm of root projected above the embedding material. This would result in smaller stresses because of decreased bending forces and maximum stresses located much more cervically. Also, this design was chosen because it simulates the clinical condition in which at least 50% of bone support should be present for premolars to have fair periodontal prognosis providing other factors are favorable. The roots used were narrower in a mesiodistal direction, and the majority fractured in a buccolingual direction. As can be seen from the Table 1, the standard deviations within the groups were rather high. This is not unusual in these types of studies, and it reflects the differences found in extracted teeth like mesiodistal, buccolingual dimensions and canal diameters.

In our study AH Plus showed better result than Tubli-Seal EWT sealer. AH Plus sealer has an inherent property of volumetric expansion which contributes to better bond strength.[20] The sealer penetrates the tubules after smear layer removal with EDTA and this has been shown to increase the fracture resistance of endodontically treated teeth.

In our study Tubli-Seal EWT has shown increased fracture resistance than group where obturation was done without using any sealer which may be explained by a chelating reaction that occurs while zinc oxide-eugenol mixture is setting. This reaction affects both the gutta-percha core material and the root canal dentin. The zinc ion of the zinc-oxide may react with the mineral component of the dentin as well as with the zinc oxide constituent of gutta-percha. Also, the eugenol may have a softening effect on gutta-percha, thus creating an interlocking meshwork that will increase adhesion between the two materials.

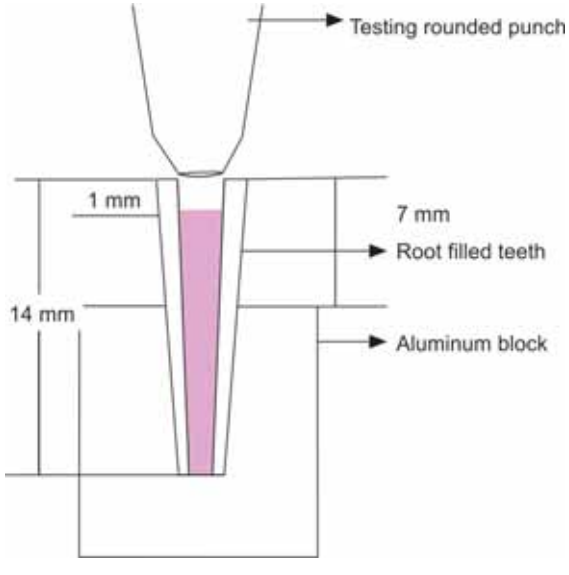

Fig. 2: Depicting fracture testing of the specimens

After fracture testing, the fragments were analyzed with magnifying glass (25X) to assess the failure mode, which was considered adhesive (when occurred in the dentin/sealer interface, between sealer/core material), cohesive (when the rupture happened in teeth itself, or when occurred in the filling material), and mixed (when combined both modes). In AH Plus group, majority of failure was of adhesive to gutta-percha type, i.e. majority of failure occurred in the core/sealer interface, whereas, in Epiphany SE majority of failure was of adhesive to sealer/dentin interface type.

The epoxy resin-based sealers (e.g. AH Plus) penetrate better in the microirregularities due to their creep capacity and high polymerization time. Those properties facilitate the interlocking between sealer and dentine, which allied to the cohesion among molecules, promotes larger adhesion and higher resistance to the sealer dislodgement from dentine surface. Fisher et al[21] theorized that one explanation for the superior adhesiveness to root dentin shown by AH Plus can be based on the creation of a covalent bond by an open epoxide ring to amino groups in collagen network. However, the bonding capacity is not able to totally reduce the susceptibility of roots to fracture.

In Epiphany SE majority of failure was of adhesive to sealer/dentin interface type, which may be due to limited ability of self-etch type of adhesive sealer used. As has been found that Epiphany SE has less etching potential as compared to epiphany, the penetration of Epiphany SE sealer into dentinal tubules may be limited which can cause less strength/bonding at sealer/dentin interface. Also, methacrylate-based materials undergo large volumetric shrinkage during polymerization process, as a result of this separation can occur at sealer/dentin interface.

Considering the aforementioned facts, the expectation of resin-based sealers to reinforce the root resistance to fracture was not confirmed in this study, although the specimens filled with the Epiphany SE/Epiphany points system displayed the higher mean values.

CONCLUSION

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

1. Intact tooth has highest fracture resistance and root canal procedures can weaken the tooth leading to susceptibility of tooth fracture.
2. Epiphany SE root canal sealer demonstrated higher mean fracture resistance to vertical root fracture than the other materials tested but it was not more than that of intact teeth which showed highest resistance against vertical root fracture.

3. Epiphany SE along with Epiphany points can increase the tooth resistance after endodontic procedures through its adhesive properties and may be an alternative obturating material to the conventional gutta-percha in roots which are already weak and has thinner root canal dimensions or more prone to root fracture.

Further studies are required to evaluate the fracture resistance of endodontically, treated teeth obturated with these new resin materials with more standardization of experimental techniques and under dynamic clinical situations where forces act on different angulations.

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