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Effect of Different Sealer Systems on the Resistance to Vertical-Root-Fracture of Endodontically Treated Tooth

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Abstract: ***An unfavorable complication of root canal is vertical root fracture. The aim of present study is to evaluate the vertical root fracture of treated teeth filled with gutta percha and Resilon obturating material using different sealers. Forty mandibular premolars used in the study. Canals randomly divided into four groups (n=10). Group-A eugenol-based (Endofill) sealer with gutta percha; Group-B epoxy-amine (AH Plus) sealer with gutta percha; Group-C resin-based (Real Seal) sealer with Resilon; or Group-D epoxide-based (Perma Evolution) sealer with gutta percha. Roots mounted vertically in cold cure acrylic blocks and subjected to vertical loading with a crosshead speed of 1mm/min. The point at which fracture of the roots occurred recorded in Newton. Roots obturated with gutta percha and epoxide sealer show the highest resistance to vertical fracture (p<0.05). While, roots obturated with gutta percha and eugenol sealer revealed the lowest vertical fracture resistance value compare to other groups.***

Keywords: Vertical root fracture, Resilon, Perma Evolution, AH Plus, Endofill

1. Introduction

The most important objective of root canal therapy is complete three-dimensional obturation of the root canal system and reinforce of the root canal toincrease root fracture resistance. It is known that endodontic treatment results in reduction of fracture strength of teeth[1].

Endodontically treated teeth are more susceptible to fracture than unrestored vital teeth. The predisposing factor for fracture are: caries removal, access preparation, canal instrumentation, dehydrating effects of irrigation solutions, long time exposure to calcium hydroxide , excessive pressure during obturation, preparation for the final restoration and loss of proprioception[2-4]. The ageof the patient may also increase susceptibility to root fracture. Research shows the mandibular molars and maxillary premolars are the most affected teeth[5-7].

Vertical root fracture (VRF) is a longitudinally oriented fracture of the root extending from the root canal to the periodontium that may begin in the crown, root apex, or any point in between. It is a serious clinical concern with unfavorable prognosis resulting mostly in the extraction of teeth or the resection of the affected root[8, 9].

Restoringthe endodontically treated teeth with crown reduces the incidence of VRFs, however, in some cases even properly restored teeth fracture. Although, gutta percha with sealer is the most commonly used root canal obturation materials; it does not represent the ideal reinforcement of endodontically treated teeth.Because of its low modulus of elasticity and it does not bond or adhere to the dentinal walls of the root canal, which result in an incomplete obliteration of root canal space[10, 11].

Recently, resin based obturation materials have been proposed as a mean to reinforce an endodontically treated tooth with the use of adhesive sealers in the root canal system. The ability of sealers to bond radicular dentin is advantageous in maintaining the integrity of the sealer-dentin interface during mechanical stresses, then increasing resistance to fracture[12, 13].

Endofill (Promediac Dental material, GmbH) iseugenol-based sealer.It is a radiopaque preparation for permanent root canal filling with dexamethasone.

AH Plus (Dentsply, Germany) is a root canal sealing materials; epoxy-amine based resin offering long term sealing properties, self-adhesive properties and outstanding dimensional stability[14].

Resilon (Resilon Research LLC, Madison CT, USA;Epiphany sealer-Pentron Clinical Technologies, Wallingford,CT ,USA) is a dual curable thermoplastic synthetic resin material, used with a self-etching primer to create a solid monoblock[15].A Real Seal/ Epiphany sealer is a dual cure resin composite sealer, which is used in conjunction with Resilon points. The Resilon system is expected to form a monoblock within the canal space, whereby the core (Resilon) is bonded to the sealer (Epiphany) and the resulting complex is bonded to the root dentin by the resin-based primer[16].

Perma Evolution (Becht,Germany) is a permanent root filling material combines trusted epoxide chemistry

technology with innovative microcapsule technology. The product comes with integrated microcapsules containing a new reactive adhesive to make the two components material more resilient and tight. Perma Evolution sealer is a radiopaque, free from iodoform and paraformaldehyde, with working time 15 minutes and setting time 24 hours, it fulfills the requirements of ISO 6876:2001 for dental root canal sealing materials.

This in vitro study aimed to evaluate the vertical root fracture resistance of endodontically treated teeth using different obturation systems (Endofill with gutta percha, AH Plus with gutta percha, Real Seal with Resilon system and Perma Evloution with gutta percha).

2. Materials and Methods

Teeth selection
Forty caries free, single rooted human mandibular premolar teeth with approximately similar bucco-lingual and mesio-distal dimensions were subjected for the study. They were examined under microscope at 20X magnification to rule out teeth with a pre-existing root fracture. Preoperative radiographs were taken in mesiodistal and buccolingual directions to confirm the presence of a single canal without previous root canal treatment, resorption and calcifications. Teeth with immature apices were excluded from the study.All the collected teeth were immersed in 5% sodium hypochlorite (NaOCl) solutions for 15 minutes to remove organic materials from the root structure[17].

Teeth preparation
The teeth were decoronated at the cemento-enamel junction with diamond disk in slow speed hand piece under copious water coolant[18], with a standard root length of 15 mm as measured from the apex to the facial CEJ. Coronal access to the root canal of all samples was prepared using spherical diamond burs at high speed according to the pulp chamber size.

Working length estimation
The working length was established by the visual method by inserting a size 15 K- file (Dentsply malliefer, Switzerland) until the tip of the instrument was first visualized at the apical foramen, then backing up 1 mm from the apex. The patency of the canal was ensured by passing a size 15 K- file through the apical foramen of the canal before and after instrumentation[19].

Root canal preparation
Crown down preparation technique carried out in all the teeth, using nickel-titanium rotary instruments (ProTaper, Dentsply Maillefer, Switzerland). ProTaper shaping and finishing files Sx, S1, S2, F1 and F3, were used at 250rpm, in accordance with the manufacturer's instructions. After each instrument, irrigation with 2ml of 5% NaOCl solution was performed. The prepared specimens received a final flush with 5ml of 2.5% NaOCl solution followed by 5 ml of 17% EDTA then rinsed by deionized water to remove the smear layer[20]. All root canals were dried with sterile paper points before filling.

Sample grouping and obturation
All the roots were divided randomly into four groups of ten teeth each. Sealers were mixed according to the manufacturer's instructions. Root canals were coated with sealers using lentulo-spirals at 300rpm and obturated using F3 gutta percha points (ProTaper).

- **Group A:** specimens were obturated with zinc oxide eugenol based sealer (Endofill sealer) and gutta percha cone of size F3 using single cone technique (Diadent group International, Korea).
- **Group B:** specimens were obturated with epoxy-amine (AH Plus) sealer and the matched-taper single cone gutta percha technique.
- **Group C:** specimens were obturated with Resilon master points and resin-based sealer (Real sealer).
- **Group D:** specimens were obturated with gutta percha cone of size F3 and epoxide-based sealer (Perma Evolution sealer).

All of the root canals were enlarged and obturated by the same operator.The quality of the fillings is confirmed with radiographs to ensure homogenous adequate root filling without voids. The coronal part of specimens was filled with glass ionomer cement (Ketac cement, Germany, 3M ESPE). All roots were kept at 37ºC with 100% humidity for at least 72 hours for complete setting of sealers[21].

Preparation for mechanical testing
The roots were wrapped with a sheet of lead foil and Vaseline were applied on the samples, centralized vertically in a cylindrical mold made with addition silicon rubber material. Autopolymerisable acrylic resin was poured into the mold leaving 8mm of each root exposed coronally[22].The blocks were allowed to set for 24 hours. The lead sheet was removed from each tooth and a paste of silicon-based impression material up to 2mm apical to the CEJ was inserted into the artificial socket to mimic the periodontal ligament. A carbide bur was used to remove the temporary filling from the canal orifices to accept the loading fixture. The blocks were mounted into universal testing machine. The vertical loading force was applied with a spherical tip of radius 2mm and a cross head speed of 1mm/min until the roots fractured . The force when fracture occurred was recorded in Newton for each root.

3. Results

Themean, standard deviation, minimum and maximum values of vertical fracture resistance in Newton for all groups are illustrated in Table 1 and Figure 1. The roots in group D, which obturated with gutta percha epoxide-based sealer (Perma Evolution sealer) showed the highest mean of vertical fracture resistance followed by roots obturated with gutta percha and epoxy-aminebased sealer (AH plus, group B) and Resilon with resin sealer(Real Seal) sealer in group C,respectively. While roots obturated with gutta percha and eugenol sealer, (Endofill),in group A, showed the lowest mean value of vertical fracture resistance.

The data statistically analyzed by using the one way analysis of variance (one-way ANOVA) test showed that there was significant difference among the tested groups

p<0.001.Further investigation using Student's T-test confirm there was a statistical significant difference in the fracture resistance values between gutta percha with epoxide based sealer (group D) and all the other tested groups. Comparative group by group follow up shown in (Table 2).

4. Discussion

Thegold role of root canal filling material is the ability of these materials to reinforce and significantly strengthen the endodontically treated roots. As removal of tooth structure increases, fracture resistance of the tooth decreases[9].

Root canal procedure starting from the access cavity preparation, cleaning, shaping of the canals in addition to wedging forces of the spreader during lateral condensation or excessive dentin removal to facilitate pluggers for vertical condensation lead to weakening of the tooth and more susceptibility for vertical root fracture[11]. Furthermore, the root fracture may progress to more extensive fractures within time and occlusal stress[1].

Many studies have shown that adhesive resin based obturationsystems has a potential to strengthen the root structure and increases fracture resistance of tooth[11, 13].

In this study, single canal mandibular premolars were selected because they have high prevalence in vertical root fracture[1]. They have approximately similar buccolingual and mesiodistal dimensions to eliminate variations in dimensions, also decoronated at the cemento-enamel junction to eliminate variations in access cavity preparation.

Instrumentation of all samples are done using NiTi rotary instruments (ProTaper) up to F3 to avoid thinning of the root dentin. Before obturation of the root samples, irrigation was done with 5ml of 2.5% NaOCl solution and 5ml of 17% EDTA solution respectively, because any remaining sodium hypochlorite might inhibit the setting of the resin-based materials.In addition, EDTA flows easily into the dentinal tubules because of its low surface tension.Thus removes the smear layer up to a depth of 2.5-4μm[23].

After the removal of smear layer, there was surface energy alteration allowing the flow of root canal sealer to adapt more easily, enhancing its adhesion to the root canal wall, and thereby increasing sealing efficiency[24].

Single cone obturation technique was used in this study to exclude both the excessive dentin removal required to facilitate the plugger's insertion during vertical compaction and the wedging forces of the spreader's during lateral compaction.Several studies have shown that the single cone technique would increases the fracture resistance of teeth more than other obturation techniques [11, 25].

The periodontal ligament and alveolar bone were simulated using silicon impression material and acrylic resin blocks. The periodontal simulation prevents stress concentration in one particular region, and transfers the stresses produced by load application all along root surface, while the alveolar bone simulation reduces stresses caused by unrealistic bending movements and to simulate the support given to healthy teeth by alveolar bone[26].

In the present study, a single load to fracture was applied vertically.This force primarily resulting in a splitting stress applied above the access opening. As in many studies that evaluated the effect of root canal sealers on the fracture resistance of root filled teeth reported, applying the forces vertically to the long axis of the tooth transmits the force uniformly [2, 11, 14].

The present study shows that the vertical root fracture resistance among the obturation systems was in the following order epoxide-based (Perma Evolution) + gutta perch > epoxy-amine (AH Plus) + gutta percha > Resilon + resin-based (Real Seal) > eugenol-based (Endofill) + gutta percha.

Epoxide-based sealer (Perma Evolution)with gutta percha group shows the highest fracture resistance among other groups. It is a permanent root filling material based on proven epoxide technology with a high adhesion to dentin,which attributed to its hydrophilic formulation. It comes with integrated microcapsules containing a new reactive adhesive to make the two components material more resilient and tight. Fine cracks caused by physical strength are reliably sealed, even after the material has set.

Epoxy-amine based sealer (AH Plus) and gutta percha group shows the second highest vertical fracture resistance. This can be related to the fact, the epoxy-amine based root canal (AH Plus) sealer has low solubility and disintegration.It also penetrates into the surface micro-irregularities deeply inside the lateral root canals.This increasing the mechanical locking and adhesion to dentinal tubules that can improve resistance to fracture. This is also because of itshigh flow, resin nature, and long setting time [27].Since pretreatment of the dentin surfaces with EDTA and NaOCl resulted in a smear layer removal,it is proven that AH Plus sealer showed the highest bond strength with these surfaces.AH Plus was able to react with the exposed amino groups in collagen to form covalent bond between the resin and collagen when the epoxide ring opens [28].

Resilon and resin-based sealer (Real Seal) showed lower vertical root fracture resistance than that of epoxide and the epoxy-amine based sealers (Perma Evolution and AH Plus, respectively) with gutta percha, however, higher than that of eugenol sealer (Endofill).This may be related to that the sealer is a dual-cured resin based composite.It requires forty seconds of light to cure the sealer in coronal 2mm of canal; whereas the remaining filling will be self-cure in 15-30 min [(31)]. Even though, Epiphany sealer has a capacity to bond to root canal filling material (Resilon)it was not sufficient to prevent fracture. It is wise to mention Resilon system is affected by several other factors.These factors include the polymerization shrinkage during setting, and the very high C-factor. Inside the root canal systemand during polymerization,the sealer may cause gaps along dentin/ filling interface. Which is caused during the photo-polymerization. Also, the volume of monomer is significantly reduced promoting enough shrinkage stresses to de-bond the material from dentin, thereby reducing

adaptation increasing microleakage[29]. All of that might interfere with the bonding of these materials to dentin walls minimizing its supporting effects.

5. Future Scope

Within the aim of this study, it can be concluded that among the tested sealer systems, epoxide based (Perma Evolution) combined with gutta percha being the best in preventing vertical root fracture of endodontically treated teeth compared to epoxy-amine, resin-based and eugenol-based sealers.

This can be useful clinically in weaken teeth or teeth that can serve an abutment for fixed prosthesis. Continuing research in this topic can provide the clinicians with important tools to make an informed evidence based clinical decision.

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Tables:

Table 1: Descriptive statistics of vertical fracture resistance values in Newton for all groups. Group A eugenol-based sealer (Endofill), group B epoxy-amine based sealer (AH Plus), group C resin-based sealer, and group D epoxide-based sealer (Perma Evolution)

Tested Groups	*Min.*	*Max.*	*Mean*	*Std. Deviation*
Group A	370	441	402.67	25.936
Group B	531	632	586.33	39.722
Group C	460	562	507.00	38.730
Group D	650	740	694.17	33.078

Table 2: Group by group comparison using Student's t- test for vertical fracture resistance among groups A eugenol-based sealer (Endofill), group B epoxy-amine based sealer (AH Plus), group C resin-based sealer, and group D epoxide-based sealer (Perma Evolution)

Compared Groups	*T-test*	*p-value*
A vs. B	7.070	.001
A vs. C	8.039	.000
A vs. D	12.175	.000
B vs. C	2.998	.030
B vs. D	13.184	.000
C vs. D	7.163	.001

Figures Legends:

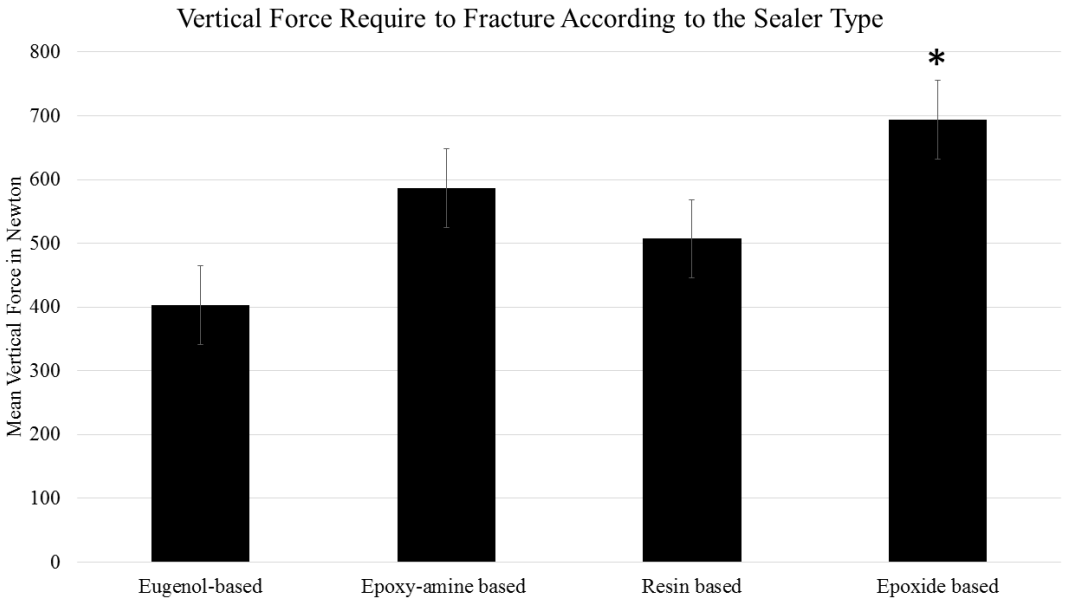

Figure 1: Bar chart showing mean of vertical root fracture values in Newton for all groups. * donates statistical significant difference of $p<0.05$ or less.

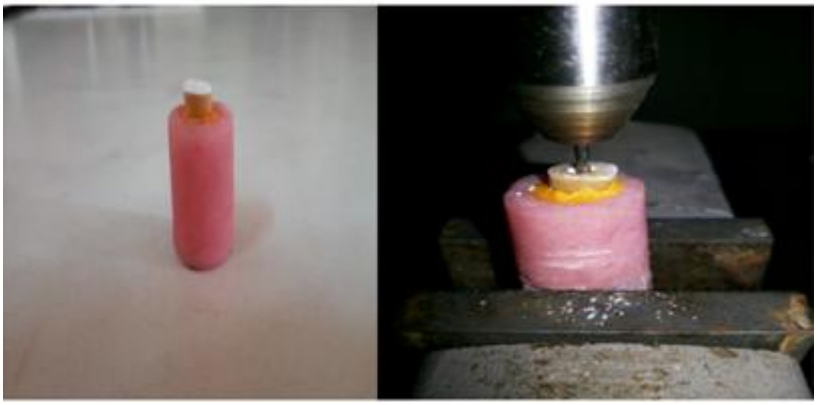

Figure 2: Right, the tested sample preparation, on the left is specimen under load

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