Volume-4, Issue-4, April-2015 • ISSN No 2277 - 8160

Research Paper | Dental Science

A Comparative Evaluation of Resistance to Vertical Root Fracture of Endodontically Treated Teeth With Recently Used Sealers:an in Vitro Study

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ABSTRACT

To compare the effectiveness of AH Plus, MTA Fillapex sealer and ZOE based sealer on the resistance of endodontically treated teeth to vertical root fracture. .Materials and Methods: sixty freshly extracted mandibular premolars were used for the study. The length was standardized and all the teeth were biomechanically prepared and divided into five different groups based on the type of root canal sealers used. Group I: negative control group (only RCO done),Group II: positive control (only BMP done) Group III: AH plusroot canal sealer + gutta percha, Group IV: MTA Fillapex sealer + gutta percha, Group V: Zinc oxide-eugenol sealer + gutta percha, The teeth were embedded in acrylic resin blocks and compressive strengths were measured using universal testing machine (Instron). Statistical Analysis Used: One-way ANOVA, unpaired t- test done.Result:Multiple comparisons were performed among all five groups. Group 1 and group 2 show highly significant values and group 1 and group 5 values are significant value. There were significant differences between group 2 and 3($p < 0.001$) and between group 3 and group 5($p < 0.033$).Conclusions: From this study, it has been concluded that AH Plus requires more force to induce fracture amongst all sealer groups followed by MTA Fillapex and ZOE sealer. AH Plus has the ability to bond directly to root canal dentin which creates a monoblock effect that increases the resistance to fracture and provides the best possible seal.

KEYWORDS : - AH plus,MTA Filapex, fracture resistance, gutta percha, universal test machine

INATRODUCTION

Endodontically treated teeth are structurally different from unrestored vital teeth and require special restorative treatment. It is generally accepted that the strength of an endodontically treated tooth is directly proportional to the amount of remaining sound tooth structure.[1,2] Clinically, Vertical Root Fracture (VRF) occurs most commonly in endodontically treated teeth and it is a serious clinical concern.

Ironically, these teeth which were already compromised before root canal treatment are further weakened by the process. A few reasons contribute to the vulnerability of root-filled teeth, chief of which is root dentin dehydration after the endodontic procedures [3]. Other reasons that predispose root-filled teeth to fracture include brittleness of root-filled teeth because of loss of tooth structure [4, 5], excessive pressure during filling procedures [3, 6], and excessive widening of root canals.

After root canal treatment, Gutta percha is the standard material for obturating root canal space but it does not bond to root dentin and therefore, it must be used in association with root canal sealer, to provide a bond between the gutta percha and the root canal wall. Sealers are an essential component for obturating the root canal system to fill any voids and gaps between the main obturating material and root dentin. Good adhesion with the root dentin within the root canal is one of the ideal properties of sealer cement, [7] which potentially influences both, the root strength and the microleakage. [8-11]

The sealers are categorized as zinc oxide eugenol formulations, calcium hydroxide sealer, glass ionomers, mineral trioxide aggregate (MTA) based sealers and resin sealers. Zinc oxide eugenol sealer has a history of successful use over an extended period and the advantage of this sealer group is its antimicrobial activity but it does not bind to root dentin often.

Root canal sealers that bond to root dentin improve the seal and the fracture resistance of endodontically treated roots. AH Plus (Dentsply Maillefer, Ballaigues, Switzerland) is the resin sealer which retained the epoxy resin "glue" of AH26 where new amines were added to maintain the natural colour of the tooth. This sealer bonds to the dentin and root filling materials, creating a monoblock effect [12, 13] i.e. the core material; sealer and root canal dentin form a single cohesive unit. It has been shown that sealers which are developed based on this concept, might strengthen the restored tooth and increase the resistance to fracture, thereby, contributing to the long term success of the endodontically treated tooth.

MTA Fillapex is a recently introduced root canal sealer. It has high radiopacity and low solubility in tissue fluids, low expansion rate during setting and excellent viscosity for insertion. It has good mechanical properties like having the modulus of elasticity similar to that of dentin, no discolouration of the tooth and promotes deposition of hard tissue at the root apex and perforation sites. [14] However, the ability of these MTA based sealers in enhancing the fracture resistance of endodontically treated teeth has not been studied much until now.

So the purpose of this *in vitro* study was to evaluate the influence of MTA Fillapex, AH plus and zinc oxide eugenol sealer on the fracture resistance of endodontically treated teeth.

MATERIALS AND METHODS

Root canal preparation sixty freshly extracted, intact, mandibular premolar with single straight root canals were selected for this study. They were stored in saline until use.

To ensure that incisor roots with standardized dimensions were used in this study, buccolingual and mesiodistal dimensions of the root canals were measured using a digital caliper.

The access cavity was prepared using endo-access bur with high speed airotor handpiece under air-water spray. De-roofing of the pulp chamber was done using Endo Z bur and the root canal orifice was located using DG-16 explorer.

After access cavity preparation all samples were randomly divided in to five groups.

GROUP	PROCEDURE

Group I	Only access cavity prepared. No instrumentation or obturation was performed.
Group II	Access cavity prepared, Biomechanical preparation was carried out but no obturation was performed.
Group III	Access cavity prepared, Biomechanical preparation was carried out and the canals were obturated with AH Plus with gutta percha points.
Group IV	Access cavity prepared, Biomechanical preparation was carried out and the canals were obturated with MTA sealer with gutta percha points.
Group V	Access cavity prepared, Biomechanical preparation was carried out and the canals were obturated with ZOE sealer with gutta percha points.

Glide path was established using #10 K- file, working length was determined using # 15 k file and was confirmed radiographically. Except for group I, in remaining four groups, root canals were prepared with ProTaper universal rotary system using crown down technique. After confirming working length, initial shaping was completed with 2% taper # 15 no K-file. The coronal 1/3rd of the canal was cleaned and shaped with Sx ProTaper file; the middle 1/3rd and apical 1/3rd were then enlarged by first utilizing S1 followed by S2 ProTaper as per the manufacturer's instructions. During instrumentation procedure, canal was flooded with 3% sodium hypochlorite and between each change of instruments; recapitulation was done to maintain patency of the canal. The apical preparation was finished with F1, F2 and F3 ProTaper Universal files.

After completion of cleaning and shaping, the canal was flushed with 17% EDTA solution for 1 minute followed by normal saline to remove the smear layer. Finally, the canal was dried with sterile paper points.

After drying the canal in group III, IV and V, master cone was selected and confirmed with radiograph. Three dimensional obturation was carried out using F3 gutta percha point. For **group III**, a thin mixed resin sealer was prepared by mixing equal volume units (1:1) of Paste A and Paste B and mixed to a homogeneous consistency. The sealer was then coated on the root canal walls using lentulospiral mounted on a slow speed contra angle handpiece. The master cone was coated with the sealer and positioned into the canal till the working length. Thereafter, accessory cones were laterally compacted using finger spreaders. Similarly MTA sealer and ZOE sealer were used according to manufacturer's instruction in **group IV** and **group V** respectively and three dimensional obturation was done till the working length and canal were sealed up to CEJ.

The sample teeth were then radiographed in buccolingual and mesiodistal directions to confirm the adequacy of root canal obturation. Finally the access cavities in all the samples were sealed using temporary filling material, Orafil -G. All the samples were then stored in incubator at 37 ^{0}C at 100% humidity for 2 weeks to ensure complete setting of sealer.

All the samples were mounted vertically in 2 cm^3 self-curing acrylic resin blocks, with 7 mm of the apical root end embedded. Each sample was then placed on lower plate of the Universal testing machine and vertical loading force was applied at a crosshead speed of 1 mm per minute until fracture occurred. The force required to fracture the roots was recorded in Newton. The data was subjected to statistical analysis.

RESULTS

Table 2. Multiple comparisons were performed among all five groups. Group 1 and group 2 show highly significant values and group 1 and group 5 values are significant value.

There were significant differences between group 2 and 3($p < 0.001$) and between group 3 and group 5($p < 0.033$).

TABLE 2. TUKEY'S MULTIPLE COMPARISONS TESTS BETWEEN THE GROUPS SUBJECTED TO FORCE APPLIED FOR VERTICAL ROOT FRACTURE

Comparisons		Mean Difference	p value
Group 1	Group 2	466.67	<0.001
	Group3	25.56	0.999
	Group 4	243.87	0.146
	Group 5	335.85	0.017
Group 2	Group 3	-441.11	0.001
	Group 4	-222.80	0.216
	Group 5	130.82	0.717
Group 3	Group 4	218.31	0.234
	Group 5	310.29	0.033
Group 4	Group 5	91.98	0.901

DISSUSION:

Loss of tooth structure because of caries, tooth preparation, ultimately, decreases the fracture resistance of the tooth. [15] Non-carious lesionsand aging are the other factors that also have an influence on fracture resistance of teeth.[16, 17] Amongst all these factors, "extensive tooth preparation and endodontic treatment" are the most common reasons for tooth fragility. Proper access opening and thorough cleaning and shaping of the canals are must for long term success of endodontic treatment. However, it is understood that, as root dentin is removed during the instrumentation phase, weakening effect on the root is inevitable. Moreover, while obturating the canals, if we add excessive wedging force through the spreader during lateral condensation, or remove excessive dentin to facilitate pluggers for vertical condensation, the potential for root fracture increases. [18] Therefore, many attempts have been made in the past to reinforce an endodontically treated tooth.The ability of various root canal obturating materials to reinforce an endodontically treated root is controversial and contradictory. [19]

The root canal sealer plays an important role in the obturation of the root canal as it fills up all the voids and irregularities in the root canal space, lateral and accessory canals and the space between gutta percha points. Sealers also serve as a lubricant during the obturation. The root canal sealers used in endodontic practice are zinc oxide-eugenol (ZOE) formulations, calcium hydroxide sealers, glass ionomer, resin based sealers and MTA based sealers.

In many studies, epoxy resin-based sealers showed higher adhesion to root canal dentin and deeper penetration into the dentinal tubules than glass ionomer and ZOE based sealers, [20,21] indicating that retention of the obturating material might be improved by mechanically interlocking it with the dentinal tubules, hence increasing the fracture resistance. Johnson *et al* [22] recommended the use of adhesive sealers in the root canal system to reinforce the endodontically treated teeth. AH Plus has good physical properties, namely, less shrinkage and more radio opacity. It has an added advantage of having less film thickness and is adhesive to the dentinal walls. Due to its better adhesive properties to the root dentin, it forms a single unit within the root canals and bonds to the dentinal walls. The effect of AH Plus on the fracture resistance of endodontically treated teeth was compared

with other types of root canal sealers, namely, MTA Fillapex and ZOE based root canal sealers, in this study.

Recently introduced root canal sealer is MTA Fillapex. It contains salicylate resin, diluting resin, natural resin, nano-particulated silica and bismuth trioxide. [23] In some studies [24.25]it was shown that MTA, when used as an obturating material, strengthened the root against fracture. But as it does not bond to dentin, the resin component was introduced into MTA (MTA Fillapex). The presence of resins in the MTA Fillapex sealer increases the flow properties and forms resin tags into the dentinal tubules, which enhances bonding to the dentin.

Plain ZOE sealer was also used with gutta percha in this study, as it is the most commonly and conventionally used material.

As the endodontic treatment leads to change in the mechanical properties of the tooth, fatigue failures might result from normal functional stresses and from increased functional and Para functional stresses. Finite element analysis study has found that circular canals have lower and more uniform stress distribution than oval canals in which greater stresses are present at the labial and lingual canal extensions and at the cervical and middle thirds. [26] In majority of the premolar samples obtained, the middle thirdtoapical third region had a circular cross section, which would result in uniform distribution of load.

Amin Salem Milani (2012) stated that canal preparation, whether hand or rotary, produces structural defects in dentin. [27] Rotary instrumentation consumes less time and is more effective for cleaning and shaping of the canal walls as compared to hand instrumentation. According to Amin Salem Milani (2012) the ProTaper rotary system, when used according to the manufacturer's instructions, tends to produce fewer cracks. So ProTaper rotary system was used for cleaning and shaping in the current study. To standardize the apical canal diameter of the root canal, each root was prepared with Pro-Taper size F3, corresponding to an apical size ISO #no. 30.

The results of our study are in contradiction with results of study done by Ismail D et al who stated that the ProTaper Next and HyFlex instruments tended to cause fewer dentinal cracks compared to the ProTaper Universal instrument.[28]

In this study, at all times during the instrumentation, the canal was flooded with 3% sodium hypochlorite; and in between each change of instruments, recapitulation was done to maintain patency of the canal. The apical preparation was finished with F1, F2 and then F3 ProTaper files while sequentially irrigating with 3% Sodium Hypochlorite, 17% EDTA and normal saline.

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In several studies, test of fracture strength was done using the cyclic loading (Heydecke et al, 2001; Eakkinga et al, 2005) *i.e.* applying the forces from different direction to simulate the clinical conditions. [29, 30] But again, in many studies, it has been reported that applying the force vertically to the long axis of the tooth transmits the force uniformly (Chen et al 2000, Lindemuth et al 2002) [31, 32]. Hence, in this study, force was applied vertically, to evaluate the effect of root canal sealer on the fracture resistance of endodontically treated teeth. The roots used were narrow in a mesiodistal direction than buccolingual direction, and majority fractured in a buccolingual direction.

In the present study, one way ANOVA test result (Table no.2) shows that there issignificant difference in all groups and multiple comparisons between each group show that the negative control group has the highest fracture resistance values in all groups. There is significant difference between all groups and positive control group.

Andreasen et al [24] and Cauwels et al [25] found that MTA increased the fracture resistance of immature teeth. Results of our study are in accordance with theirs, as MTA Fillapex showed significantly higher fracture resistance than the positive control group and was not significantly different from groups in which AH Plus and ZOE sealers were used.

The reinforcing effect of AH Plus root canal sealer on fracture resistance has already been evaluated in numerous studies.[33,34] In the present study (Table no.2), no significant difference in fracture resistance has been found amongst roots filled with AH Plus and MTA Fillapex. The results of this study are in agreement with the studies of Karapinar Kazandag *et al* [35] and Cobankara *et al*[36] in which all the experimental groups (AH Plus sealer and Real Sealer) showed significantly superior fracture resistance than the negative control group. On the other hand, our results are in contradiction with those of Grande *et al* [37] and Kim *et al*[38], in which they found no clear benefits with the use of root canal sealers, namely, Resilon Epiphany system, EndoREZ (methacrylate based root canal sealer) and Pulp Canal sealer; in improving the fracture resistance of root canal dentin.

In our study, ZOE sealer showed increased fracture resistance than positive control group where obturation was not done, which may be explained by chelating reaction that occurs while zinc oxide- eugenol mixture is set; this reaction affects both, the gutta percha and the root canal dentin. Eugenol may have a softening effect on gutta percha, thus creating an interlocking meshwork that will increase adhesion between the two materials.

On the basis of the previous studies and present study results, we can state that AH Plus requires more force to induce fracture within all sealer groups followed by MTA Fillapex and ZOE sealer. But further investigations are needed to prove the bond strength and other physical properties of the material.

CONCLUSION

Within the limitations of this study, we conclude that AH Plus requires more force to induce fracture amongst all sealer groups followed by MTA Fillapex and ZOE sealer. AH Plus has the ability to bond directly to root canal dentin which creates a monoblock effect that increases the resistance to fracture and provides the best possible seal.

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