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Effect of smear layer on fracture resistance of endodontically treated teeth with different root canal sealers: An in vitro study

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Abstract

Aim: Evaluate the effect of smear layer on fracture resistance of endodontically treated teeth with different root canal sealers.

Methodology: Fifty extracted human single rooted teeth were decoronated and root canal preparation was done using Pro Taper rotary file system till size F3, the canals were irrigated with 2 ml of 1% sodium hypochlorite solution after each instrument change followed by final Irrigation with saline . Teeth were divided into five groups (n=10), group I specimen selected as control group in which obturation was not done, smear layer removal was done in group II & III and obturated with AH plus and MTA fill apex respectively while in group IV & V smear layer was not removed and obturated with AH PLUS and MTA fill apex respectively, all the roots were subjected to a universal testing machine. , all the roots were subjected to a universal testing machine, Statistical analysis was done using one- way ANOVA and turkey HSD test.

Result: Group I showed lowest fracture resistance (57.18 ± 2.47) Mpa when compared with other groups and Group IV (112.91 ±2.179) Mpa showed highest fracture resistance when compared with other groups. Group IV (112.91 ±2.179) Mpa > Group II (109.15 ± 8.66) Mpa,> Group V (84.82 ±4.27) Mpa > Group III (83.09 ±4.16) Mpa, > Group I (57.18 ± 2.47) Mpa .

Conclusion: Positive control group displays lesser resistance to fracture when compared to AH plus & mta Fill apex group , the roots that were obturated with two sealers & gutta-percha were significantly stronger than roots whose canals were instrumented but not obturated. AH plus showed the highest fracture resistance then mta fill apex sealer group regardless of the presence or absence of smear layer. Presence or absence of smear layer did not cause any significant effect on the root fracture resistance.

Keywords: Ethylenediaminetetraacetic acid, Sodium hypochlorite, AH plus, MTA fill apex, final irrigation fracture resistance.

Introduction

The success of root canal therapy depends on the method and the quality of instrumentation, irrigation, disinfection, and three dimensional obturation of root canal, so different types of hand or engine driven instruments and irrigation solutions have been employed for instrumentation of root canals. The aim of instrumentation and irrigation is to prepare a clean, debris free canal for obturation [1] but Preservation of endodontically treated fragile teeth is also an integral part of restorative dentistry.[2] Mechanical instrumentation of the root canal produces smear layer. Removing the smear layer allows for more cleaning and disinfecting root canal walls and better adaptation of root canal filling materials. However, the presence of smear layer can act as a seal to the dentinal tubules and minimize the ability of bacteria and its toxins from penetrating the dentinal tubules. [3]An ideal root canal filling material should be used so that it can reinforce the remaining tooth structure against fracture to improve the long-term success of an endodontically treated tooth.[4]So in this in vitro study we tested an effect of smear layer on fracture resistance of endodontically treated teeth with different root canal sealers .

Materials And Methods

Fifty single rooted human teeth, freshly extracted for orthodontic reasons with complete root development and mature apex were obtained and were stored in normal saline solution. Soft tissue and calculus were mechanically removed and the crown of each tooth were sectioned perpendicular to the long axis of the root below the cementoenamel junction using a diamond disc under a water coolant so that the length of root can be adjusted to 13mm. The working length of each root was determined by inserting K-file until it just exited the apical foramen and then 1 mm was subtracted from the obtained length. The root canals were prepared with the Pro Taper rotary file system till size F3according to manufacturer's instructions. During biomechanical preparation, the canals were irrigated with 2 ml of 1%sodium hypochlorite solution after each instrument change. This procedure was followed by irrigation with 2 ml saline solution. Specimens were divided into five groups (n=10) according to the final irrigation procedure for smear layer removal and sealer used for obturation of canal. The final irrigating solutions was delivered through irrigation needles within2 mm of the working length.

GROUP I: Selected as control group in which only biomechanical preparation was completed without final irrigation &obturation procedure.

GROUP II: (Smear layer negative group) The instrumented canals were irrigated with a with 10 ml of 17% EDTA solution, followed by a final irrigation with 10 ml of 5.25% NaOCl. The canals were dried with F3 paper points. The canals were obturated with F3 gutta-percha by using AH Plus.

GROUP III: (Smear layer negative group) The instrumented canals were irrigated 3 with 10 ml of 17% EDTA solution, followed by a final irrigation with 10 ml of 5.25% NaOCl. The canals were dried with F3 paper points. The canals were obturated with F3 gutta-percha by using MTA Fill apex.

GROUP IV: (Smear layer positive groups)The instrumented canals were irrigated with a 10 ml of 5.25% NaOCl, the canals were dried with F3 paper points and they were obturated with F3 gutta- percha and with AH Plus.

GROUP V: (Smear layer positive groups) The instrumented canals were irrigated with a 10 ml of 5.25% NaOCl, the canals were dried with paper points, and they were obturated with F3 gutta percha and MTA Fillapex.

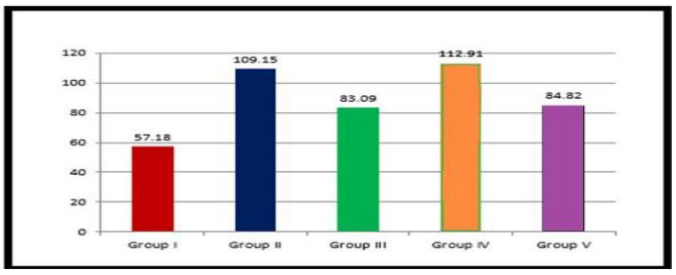
All the roots were coronally sealed with Cavit and were kept in 100% humidity for 1 week. Specimens from all groups were prepared for test, The root surface of all the specimen were covered with a paste of silicon-based impression material to simulate the periodontal ligament The apical 5 mm of the roots were embedded along the long axis in self- curing acrylic blocks with 8 mm of each root exposed. The root samples were tested for resistance in universal testing machine, steel rod (2.2 mm diameter) with a sharpened conical tip was attached to the upper part of the universal testing machine to apply force to the root causing vertical root fracture. Amount of force at which for fracture of specimen occurred was recorded in Megapascal. The load of fracture in mega- pascal's was converted to Newtons by using the following formula.

$$\text{Mpa} = \frac{\text{maximum load in newton}}{\pi/4 \times (\text{area of crossection of plunger } 2.2)^2}$$

$\pi = 3.14$ (constant value).

Area of cross section of plunger = 2.2 (uniform for all specimens).

Result



Comparison of fracture resistance among different groups.

Post Hoc Analysis

Dependent Variable	(I) GPS	(J) GPS	Mean Difference (I-J)	Std. Error	Sig.
MPA	Group I	Group II	-51.96873*	3.48748	0.001 (Sig)
		Group III	-25.91199*	3.48748	0.001 (Sig)
		Group IV	-55.73248*	3.48748	0.001 (Sig)
		Group V	-27.64910*	3.48748	0.001 (Sig)
	Group II	Group I	51.96873*	3.48748	0.001 (Sig)
		Group III	26.05675*	3.48748	0.001 (Sig)
		Group IV	-3.76375	3.48748	0.298 (Non-Sig)
		Group V	24.31963*	3.48748	0.001 (Sig)
	Group III	Group I	25.91199*	3.48748	0.001 (Sig)
		Group II	-26.05675*	3.48748	0.001 (Sig)
		Group IV	-29.82050*	3.48748	0.001 (Sig)
		Group V	-1.73712	3.48748	0.626 (Non-Sig)
	Group IV	Group I	55.73248*	3.48748	0.001 (Sig)
		Group II	3.76375	3.48748	0.298 (Non-Sig)
		Group III	29.82050*	3.48748	0.001 (Sig)
		Group V	28.08338*	3.48748	0.001 (Sig)
	Group V	Group I	27.64910*	3.48748	0.001 (Sig)
		Group II	-24.31963*	3.48748	0.001 (Sig)
		Group III	1.73712	3.48748	0.626 (Non-Sig)
		Group IV	-28.08338*	3.48748	.000

Comparison of fracture resistance between different groups.

Positive control group displays lesser resistance to fracture (57.18 ± 2.47) Mpa when compared to AH plus & mta fillapex group, the roots that were obturated with two sealers & gutta-percha were significantly stronger than roots whose canals were instrumented but not obturated. AH plus showed the highest fracture resistance then mtafillapex sealer group regardless of the presence or absence of smear layer.

Group IV (112.91 ±2.179) Mpa > Group II (109.15 ± 8.66) Mpa,> Group V (84.82 ±4.27) Mpa > Group III (83.09 ±4.16) Mpa, > Group I (57.18 ± 2.47) Mpa .

Discussion

Mechanical instrumentation of the root canal produces a smear layer [16].Removing the smear layer allows for more cleaning and disinfecting root canal walls and better adaptation of root canal filling materials. Chelating agents should be applied on instrumented root canal surfaces to remove the inorganic components of the smear layer. [14,15] . Studies have shown that 17%EDTA is more efficient in smear layer removal than other decalcifying agents.[16]For removal of both organic and inorganic components of the smear layer, it is generally recommended to use EDTA followed by NaOCl.[5]Single-rooted teeth with similar dimensions

were used in this study to standardize the experimental teeth. Length differences were compensated by decoronating the teeth to a standardized root length of 13 mm. Biomechanical preparation was performed with Pro Taper rotary files in a crown down manner as this technique allows for adequate cleaning and penetration of irrigant to the apical third of the root canal.[6]One percent sodium hypochlorite was selected for its antimicrobial and tissue dissolving property. Furthermore, at this low concentration, it has minimal effect on the mechanical properties of dentin[7] .Single cone technique of obturation was used in the study as it excluded both the wedging forces of the spreaders during lateral compaction and the excessive dentin removal required to facilitate the plugger's insertion during vertical compaction. [4,8]The purpose of the sealer is to obliterate discrepancies such as grooves and lateral depressions [9,10] that cannot be filled with Gutta-percha, to improve the marginal adaptation to the dentinal walls,[11] and to fill lateral canals.[12] A prime requisite fora sealer to be ideal is having a high fracture resistance and forming a successful Monoblock in conjunction with the obturating material. Thus, assessment of fracture resistance of sealers needs to be judged. Therefore, this study was undertaken to test the fracture resistance of the roots receiving different canal sealer materials using the universal testing machine. Here, vertical force with a compressive load was used which is similar to the technique used by Sedgley and Messer to test the brittleness of endodontically treated teeth.[13]In this study, the force was used in 0°angle, resulting in splitting stress applied over the access opening. This resulted in smaller stresses because of decreased bending movements and maximum stresses located more cervically.[17]

The fracture was found to occur parallel to the dentin bonding surface. Same as the studydone by Johnson et al.[18]

Periodontal ligament simulation prevents stress concentration in one particular region, and transfers the stresses produced by load application all along the root surface.[38]

Thus, artificial periodontal ligament modifies the fracture modes, by fracturing the root at different locations and may have a significant effect on fracture resistance. To simulate the periodontal ligament and alveolar bone, silicone paste and polystyrene resin blocks were used to test the root fracture resistance in the study, Same as the study done by Mandava et al. [19]

The results of the present study AH Plus showed significantly high resistance to fracture than MTA fill apex. These results are in accordance with the previous study of Fisher et al.[20]

where they found that AH Plus showed a significantly greater bond strength compared with all other groups. They related the higher fracture resistance of AH Plus to formation of a covalent bond by an open epoxide ring to any exposed amino groups in the collagen.[19]

The low fracture resistance of MTA Fillapex than AH Plus might be due to the lower adhesion capacity of these tag-like structures as related by Nagas et al. [21] and Amin et al. [22]The results showed that the fracture resistance of AH Plus and MTA Fillapex sealer reinforced teeth was superior when compared to the fracture resistance of unreinforced teeth (control group). This may be because of the decrease in the stiffness of intratubular dentin matrix caused by heterogeneous distribution of mineral phase within the collagen matrix As a 5% sodium hypochlorite depletes the organic phase and causes a mechanical change by release of hypochlorous acid, which reacts with insoluble proteins

to form soluble polypeptides, amino acids and other by products.[23]In this study it was observed that the smear layer removal improves the fracture resistance of specimen, but the difference was not statistically significant than the specimen obturated in the presence of smear layer with sealer. This may be due to the demineralizing ability of 17% EDTA , its low surface tension, which allows it to easily flow into the dentinal tubules. After the removal of smear layer, there was an alteration in the surface energy allowing the sealer to flow and adapt more easily, enhancing its adhesion.[23]

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