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FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH OBTURATED WITH DIFFERENT ROOT CANAL SEALERS (IN VITRO STUDY)

Abeer Ahmed Saba* *and* Heba Ahmed ElAsfouri**

ABSTRACT

Aim of the study: was to compare the in vitro effect of three different root canal sealers used with gutta-percha, on the fracture resistance of endodontically treated teeth.

Materials and Methods: Forty extracted human single-rooted mandibular premolars were used for the study. Teeth were decoronated to a standard root length of 14 mm. MPro rotary files up to master rotary size 25/6% were used for preparing the root canals. Teeth were randomly divided into five groups (n = 8 each) based on the type of root canal sealers used and the obturation was completed using gutta-percha; Group I: AH Plus root canal sealer, Group II: Endoseal MTA sealer, Group III: Bioroot RCS sealer, Group IV: Control-1 (prepared- unfilled) and Group V: Control-2 (unprepared-unfilled). Each specimen was embedded in acrylic mold and subjected to fracture resistance test using a universal testing machine under compressive loading at a rate of 1.0 mm/min until fracture. The force required to fracture each specimen was recorded and the data obtained were statistically analyzed (analysis of variance (ANOVA) and paired-t test) with level of significance set at $p \leq 0.05$.

Results: The unprepared-unfilled group showed the highest mean fracture resistance followed by AH Plus group, Bioroot RCS group, then the Endoseal MTA group. While the prepared-unfilled group showed the least mean fracture resistance. There was no statistically significant difference between all groups.

Conclusion: It could be concluded that Bioroot RCS and Endoseal MTA are able to reinforce the tooth against fracture as good as AH Plus.

Keywords: AH Plus, Endoseal MTA, Bioroot RCS, fracture resistance.

* Associate Professor of Endodontics, Faculty of Dentistry, Cairo University.
** Lecturer of Endodontics, Faculty of Dentistry, Cairo University.

INTRODUCTION

Endodontically treated teeth are known to be more liable to fracture than vital teeth. This is mostly due to the removal of tooth structure during endodontic treatment, dehydration of dentin after mechanical preparation, and excessive pressure during obturation[1,2]. In addition, intracanal irrigants and medications may also play role in changing the physical and mechanical properties of dentin, increasing the possibility of fracture [3].

For this reason, one of the goals of root canal filling is to reinforce the root to enhance the fracture resistance, thus using a root canal sealer that can strengthen the root would be beneficial[4,5].

To reinforce the tooth, sealers must have enough cohesive strength to hold the obturation together as well as adhere to both dentin and core material. This hypothesis had led to the development of adhesive root canal sealers[6-8].

Gutta-percha with the epoxy resin-based AH plus sealer, is considered the gold standard in current obturation systems. Conflicting results had been reported regarding using this combination on fracture resistance of endodontically treated teeth. Although some studies [9-12] showed that this combination had significantly increased fracture resistance yet, others showed no significant influence [13–19].

Mineral trioxide aggregate (MTA) has been widely used in endodontics due to its ability to induce tissue repair and to stimulate mineralization. To enhance their clinical performance, several modifications in the composition of MTA-based cements have led to the introduction of novel formulations in the market[20].

Tricalcium silicate-based cements, commonly known as MTA-based cements, are hydrophilic which require water to set. They have good biocompatibility and apatite-forming ability [21, 22].

BioRoot RCS (Septodont, Saint-Maur-des Fosses, France) is a powder/liquid hydraulic tricalcium silicate-based cement marketed since February 2015 and recommended for single cone technique or cold lateral condensation root filling. The powder contains tricalcium silicate, povidone and zirconium oxide; while the liquid is an aqueous solution of calcium chloride and polycarboxylate [23]. Studies showed that BioRoot RCS has lower toxicity than other conventional root canal sealers, may induce hard tissue deposition [24-26], and has antimicrobial activity [26].

The EndoSeal MTA (Maruchi, Wonju, Korea) is another calcium silicate-based sealer containing MTA, and has shown favorable biocompatibility, antimicrobial activity, and good sealing ability [28]. It is introduced in a premixed paste form with the characteristics of hardening at the moist canal environment.

To our knowledge, no studies have compared the effect of AH Plus sealer, BioRoot RCS and EndoSeal MTA, on the fracture resistance of roots filled with them in combination with gutta-percha, which was the aim this study.

The null hypothesis is that; there is no significant difference in fracture resistance between roots filled with either AH Plus, BioRoot RCS or EndoSeal MTA when used with gutta-percha.

MATERIALS AND METHODS

Ethical approval was obtained from the ethical committee (19/2/29) of Faculty of Dentistry, Cairo University.

Sample selection

Forty freshly extracted, single-canalled human mandibular premolars with comparable dimensions were selected and stored in distilled water until use. Teeth were examined for root cracks, abnormal curvatures, calcifications and internal or external resorption.

Sample size calculation was done using R statistical package, version 3.3.1 (21-06-2016). Copyright (C) 2016, the R Foundation for Statistical Computing.* One-way analysis of variance power calculation for more than two groups was used to detect the proper sample size. Means and standard deviations were determined according to Guneser et al. 2016 [29] based on the fracture resistance of obturated roots. The results showed that, at a power of 90% and a two-sided significance level of 5%; a total sample size of 40 single rooted teeth (equally allocated to five groups) will be adequate to reject the null hypothesis that the group means are equal; i.e. there is no difference between groups regarding fracture resistance.

All crowns were sectioned to obtain a standardized root length of 14 mm using a diamond saw under coolant. The working length was determined by subtracting 1 mm from the length of an inserted #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) with its tip visualized at the apical foramen. All teeth were instrumented up to a master apical file size of 25/6% with MPro rotary files using torque and speed-controlled electric motor (X Smart; Dentsply, Maillefer, Ballaigues, Switzerland) according to the manufacturer's instructions. A 3 mL of 5.25% Sodium hypochlorite solution (NaOCl) was used between each file size. After instrumentation of the root canals, the smear layer was removed by rinsing the root canals with 5 mL of 5.25% NaOCl and 5 ml of 17% EDTA solution (Merck, Darmstadt, Germany). The canals were finally flushed with 5 mL distilled water and dried with 25/6% paper points.

Sample grouping

Teeth were randomly divided into five equal groups (n=8) according to the sealer used; Group I: AH Plus root canal sealer (Dentsply DeTrey, Konstanz, Germany), Group II: Endoseal MTA sealer (Maruchi, Wonju, South Korea), Group III: Bioroot RCS sealer (Septodont, Saint-Maurdes Fosses, France), Group IV: Control-1 (prepared- unfilled) and Group V: Control-2 (unprepared-unfilled).

In AH Plus and BioRoot RCS groups, the sealers were prepared according to manufacturer's instructions and introduced into the canal with size 25 Lentulospiral (Dentsply, Maillefer, Ballaigues, Switzerland) at 300 rotations/min to the working length until complete filling of the canal. In Endoseal MTA group, the sealer was injected into the root canal using intracanal tip supplied by the manufacturer, to fill the apical part then slowly withdrawn while sealer was injected until complete filling of the canal.

In the obturated groups, single ISO size 25/6% master gutta-percha (GP) cone was used. Excess GP was seared off with a hot plugger and radiographs were taken to ensure adequate root filling without voids. All samples were stored at 37°C and 100% humidity for two weeks to ensure complete setting of the sealers.

Fracture resistance testing

For fracture resistance test, roots were mounted in acrylic resin blocks with the apical 10 mm of root ends embedded in the resin exposing only 4 mm of the coronal part of each root. A protractor was used to ensure vertical alignment of the long axis of the roots. The blocks with the vertically aligned roots were then mounted on the lower fixed compartment of the Instron testing machine (Model 3345; Instron, UK). Vertical loading force of 5kN was applied directly over the canal opening of each root with increasing force at a rate of 1.0 mm/min, until the root fractured. This point was recorded by the computer monitoring software (BlueHill, Instron) and measured in Newton. Figure (1)

* R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Fig. (1): Fracture resistance test setup.

Statistical analysis

Fracture resistance was described in terms of mean, median, standard deviation (SD) and range according to each group. Bar graph representing means and standard deviation were used to demonstrate the data.

To test for normality of the data, the Shapiro-Wilk test for normality was applied (Table 1) to choose the proper comparative analysis tests. For normally distributed data, the parametric ANOVA was applied to assess differences regarding fracture resistance. Multiple pairwise comparisons using paired-t test to assess differences in fracture resistance between groups were done. The significance level was verified at $p \leq 0.05$. The results were considered to be statistically significant if *p*-value was less than 0.05.

Statistical package used for this study was R statistical package, version 3.3.1 (2016-06-21). Copyright (C) 2016. The R Foundation for Statistical Computing. [Reference: *R Core Team (2016). R: A language and environment for statisticalcomputing. R Foundation for Statistical Computing, Vienna, Austria.URL https://www.R-project.org/.]

RESULTS

Results were summarized in Table (2) and Figure (2). Unprepared unfilled roots had the highest mean fracture resistance of 519.84 (±152.62) N, followed by that of AH Plus group with a mean of 453.14 (±97.47) N, then that of the Bioroot RCS group (393.8 ±136.02) N, then that of the Endoseal MTA group (391.47 ±121.17) N, and prepared unfilled group had the lowest mean fracture resistance of 355.25 (±128.45) N.

ANOVA test showed that the difference in means between groups was statistically insignificant.

As shown in Table (3), all pair-wise comparisons were statistically insignificant. Hence, there was no statistically significant difference between every two groups with each other.

Table (1): Shapiro-Wilk Test for Normality for fracture resistance regarding each group

Group	Shapiro-Wilk	Interpretation
	p-value*	
Unprepared-unfilled	0.2993	Data are Normally distributed
Prepared-unfilled	0.7827	Data are Normally distributed
AH Plus	0.9022	Data are Normally distributed
Endoseal MTA	0.8141	Data are Normally distributed
Bioroot RCS	0.5429	Data are Normally distributed

**Significance level at p-value ≤0.01.*

TABLE (2): Descriptive analysis of fracture resistance (N) regarding each group and results of the Parametric ANOVA Test for comparing between groups

Group	Mean	SD	Median	Range		Parameric ANOVA test	
				Min	Max	p-value*	Interpretation
Unprepared- unfilled	519.84	152.62	507.5	344.69	728.12	0.1553	Statistically insignificant difference
Prepared-unfilled	355.25	128.45	368.78	160.95	525.16		
AH Plus	453.14	97.47	436.4	292.17	613.44		
Endoseal MTA	391.47	121.17	390.37	240.56	581.22		
Bioroot RCS	393.8	136.02	432.28	151.02	554.94		

**Significance level at p-value ≤0.05.*

TABLE (3): Multiple pair-wise comparisons using paired t test to assess differences in fracture resistance between groups- results showing p-value*

	Prepared-unfilled	Unprepared-unfilled	AH Plus	Endoseal MTA	Bioroot RCS
Prepared-unfilled	-				
Unprepared-Unfilled	0.07748	-			
AH Plus	0.3475	0.0915	-		
Endoseal MTA	0.1722	0.3732	0.627	-	
Bioroot RCS	0.2109	0.627	0.3468	0.3413	-

**Significance level at p-value ≤0.05.*

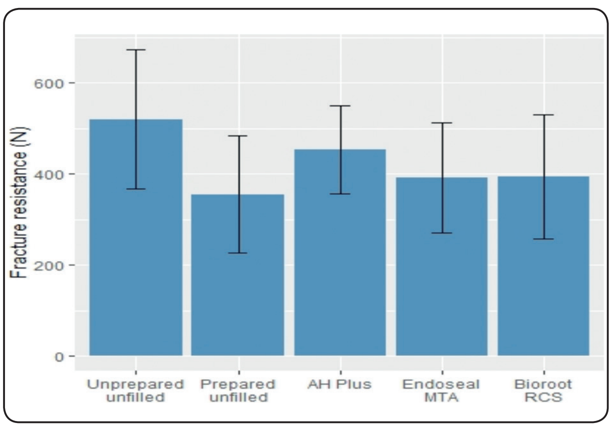

Fig. (2): Comparison between different groups regarding mean fracture resistance– Means and standard deviations

DISCUSSION

Results of this study showed that there was no statistically significant difference between all groups, so the null hypothesis failed to be rejected. There is a certain believe that root canal preparation weakens the tooth structure exposing it to fracture [30]. Hence selection of a material that has a potential to reinforce tooth structure against fracture is of prime concern [31].

It has been reported that preparing root canals with a round cross-section leads to equal distribution of stresses in the root during filling, which decreases the risk of root fracture [32]. For this reason, rotary files were used in this study for root canal preparation.

All roots were prepared to MPro size 25/6, in order to standardize the apical canal diameter of the enlarged root canals. A standard irrigation regimen, using EDTA and NaOCl combination, was used to remove the smear layer, to increase bonding of the sealers to the root dentin [33].

In order to exclude both the wedging forces of the spreaders during lateral condensation and the excessive dentin removal required to facilitate the pluggers insertion during vertical condensation, a single-cone obturation technique was used in this study[2,34]. Several studies have shown that the single-cone technique would enhance the fracture resistance of teeth better than other obturation techniques [5, 35].

Universal testing machine has been used for measurement of fracture resistance of teeth in many studies. In this study, load was vertically applied along the longitudinal axis of the teeth; because in this method, load entirely transfers to the root [36, 37]. This would result in decreased bending moments and maximum stresses located much more cervical, leading to smaller stresses. This study design is believed to mimic the clinical status, as it simulates the support given to teeth by alveolar bone [6].

The results of the study showed that the fracture resistance of the unprepared-unfilled group was higher than prepared-unfilled group, which proofs that root canal preparation weakens the root. On the other side, the results of all prepared-filled groups were higher than that of the prepared-unfilled group, showing that all tested filling combinations had somehow, reinforced the root against fracture.

The highest mean fracture value was found in the GP and AH Plus group. This might be attributed to the higher adhesion of AH Plus to root dentin. Sağsen et al.[38], showed that AH Plus sealer increased the fracture resistance of prepared root canals because of its creep capacity and long polymerization period leading to better penetration into the micro-irregularities [39]. Besides, the covalent bonds between the epoxy resin and the amino groups of the dentinal collagen might result in a stronger bond of AH plus to dentin[40, 41].

The results of our study came in accordance with Mandava et al. [42], who showed that teeth obturated with AH Plus had a higher fracture resistance than those with the MTA sealer; MTA Fillapex.

Previous studies also showed that AH Plus/GP combination had higher bond strength to dentin than the monoblock system; Resilon/Epiphany, which might be another clue for the ability of this combination to increase fracture resistance of prepared root canals [43,44].

Endoseal MTA is a premixed material supplied in syringes. Its flow is increased by low mean particle size of 1.5 µm [45] which is supposed to facilitate its penetration into ramifications and irregularities of root canal system leading to reinforcement of the tooth [46].

Although the results of Endoseal MTA in this study did not significantly differ from AH Plus, yet the lower mean obtained could be attributed to the fact that Endoseal MTA does not actually bond to dentin, rather it deposits hydroxyapatite interfacially, which only increases the frictional resistance of the filling material[45].

BioRoot RCS is a high-purity, tricalcium silicate-based sealer. According to the manufacturer, this sealer is similar in composition to Biodentine (Septodont). Trying to integrate the ideal properties of Biodentine in a root canal sealer, it had been found that there was a mineral infiltration zone when the sealer came in contact with dentin [47]. Camilleri[48], had shown the formation of calcium hydroxide in early setting process, which would probably enhance bioactivity and adhesion of BioRoot RCS to the canal walls. The interaction of this sealer with root canal walls because of its bio-mineralization activity, might explain its ability to improve fracture resistance.

CONCLUSIONS

Within the limitation of this in vitro study, it can be concluded that Endoseal MTA, and Bioroot RCS, are able to reinforce the tooth against fracture as good as AH Plus.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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