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The Effect of AH Plus and GuttaFlow Bioseal Sealers on the Fracture Resistance of Endodontically Treated Roots Instrumented with Reciprocal Rotary Systems

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ABSTRACT

Objective: *The objective of this study was to assess and compare the fracture resistance of roots treated endodontically using WaveOne gold, Reciproc blue, AH plus sealer and GuttaFlow Bioseal sealer.* ***Materials and methods:*** *Total 48 human mandibular premolars with single root were decoronated to a length of 13 mm. The roots were arbitrarily divided into 3 main groups (n=16 each group). Group I control group (roots were instrumented but not obturated), Group II obturated with gutta-percha and GuttaFlow Bioseal sealer and Group III obturated with gutta-percha and AH plus sealer. Each main group was additionally divided into 2 subgroups (n=8 each subgroup) conforming to the system used in root canal preparations, Subgroup A: Reciproc blue system and Subgroup B: WaveOne gold system. All root samples were kept for 1 week at 100% humidity to permit the sealers to set completely. Each sample was then exposed to fracture test utilizing a universal test machine, the data were analyzed statistically with one-way ANOVA test, two-way ANOVA test and Dunnett test (2-sided) at a significant level of 0.05.* ***Results:*** *The results revealed that the highest mean value of fracture resistance was noted in Group IIIB (611.125) followed by Group IIIA (543.250), Group IIB (519.875), Group IIA (511.875), Group IB (270.125) and Group IA (267.875) respectively with statistically highly significant differences among the different groups when compared to the control group.* ***Conclusion:*** *From the results of this study, it seems that the use of AH plus and GuttaFlow Bioseal sealers improved the fracture strength of instrumented roots whereas preparation of the root canals with WaveOne gold and Reciproc blue systems without obturation weakened the tooth structures.*

Keywords: AH plus sealer, GuttaFlow Bioseal sealer, Instron, Reciproc blue, WaveOne gold

INTRODUCTION

Cleaning and shaping of the root canal system along with obturation and restoration of teeth is considered as the main factor for successful endodontic treatment. It is well known that endodontically treated teeth are more prone to fracture than vital teeth. The reasons might be a loss of hydration of dentin after the endodontic treatment [1], loss of dentine during canal preparation, excessive force during obturation and losing some of the tooth structure throughout endodontic treatment [2,3].

Cleaning and shaping of root canal result in removing some of the dentin which may affect the fracture strength of the teeth; therefore, it is considered as a probable cause of root fracture. The rapid evolution in technology led to new techniques in canal preparation in past years. The presentation of rotary instruments made of nickel-titanium (NiTi) and using them in the instrumentation of root canal has changed the shape, size, and taper of the canal when compared to preparation using hand instruments. Numerous previous studies revealed that they showed higher performance over hand instrumentation, they also cause less straightening, apical transportation, and perforations [4,5]. Apart from its physical properties, elements of file design such as size and taper also confer clinical significance. While larger tapered instruments remove more dentin and make tooth debridement and irrigation easier, it can compromise the tooth strength. A balance must be established between sufficient removal of infected tissue and the preservation of remaining tooth structure [5,6]. The shape of the root canal after hand files could be irregular. Many factors affect the fracture strength of endodontically treated teeth including structural defects, cracks or canal irregularities. Preparation of root canal with rotary NiTi result in circular or more round shape and is much smoother [7]. One of

the objectives of root canal obturation is to reinforce the root canal and increase root fracture strength. It is believed that mechanical interlocking between radicular dentin and the filling material of the root canal reduces the risk of fracture and strengthens the remaining tooth structure [8-10]. Gutta-percha is the main obturation material used in the treatment of root canal [2]. Even though it is not perfect, but it satisfies numerous of the characteristics that Grossman declared in 1940. One of the main downfalls of gutta-percha as an obturation material is its incapability to adhere or create a bond with the dentinal walls that result in an imperfect obliteration of the canal space [3,10]. It is believed that sealers with adhesive ability can bond to root dentin increasing the fracture strength of endodontically treated teeth [11]. Resin based sealers have been used for several years to take advantage of adhesion to the dentinal walls which result in less microleakage and is considered to provide a sort of strengthening effect to the teeth. Previous studies have shown that the bond strength of epoxy resin-based sealer was significantly higher than zinc oxide eugenol, calcium hydroxide, and glass ionomer-based Sealers [12,13]. The purpose of this *in vitro* study is to evaluate the effect of various endodontic sealers (Ah plus and GuttaFlow Bioseal) and the effect of two reciprocating endodontic instruments systems (Reciproc blue R25 and WaveOne gold primary file 25) on the fracture strength of endodontically treated roots.

PATIENTS AND METHODS

Sample Selection

Total 84 freshly extracted mandibular second premolars were used in this study. The criteria for teeth selection included the following characteristics: straight roots of comparable sizes, no visible root caries, restoration, open apices, calculus or anatomical irregularities, diagnostic radiographs were taken to confirm the existence of single straight canal, mature apex with no signs of internal resorption, calcification or pervious endodontic therapy and fully formed apex with centrally located apical foramen [14].

Samples Grouping

The samples were randomly divided into 3 groups (n=16) according to types of sealer used in the obturation technique:

- Group I: Control group (prepared without obturation)
- Group II: Obturated with gutta-percha and GuttaFlow Bioseal sealer
- Group III: Obturated with gutta-percha and Ah plus sealer

Then each group was further divided into two subgroups (n=8) according to the type of reciprocating endodontic file used in the instrumentation procedure

- Subgroups A: Instrumentation with Reciproc blue files
- Subgroups B: Instrumentation with WaveOne gold files

Sample Preparation

To make sure that each sample used had standardized dimensions, the mesiodistal and buccolingual diameter of the roots were measured in which the widest faciolingual and mesiodistal dimensions for each root were measured and recorded. The sum of these 2 dimensions was used in the distribution of specimens among groups to provide uniformity of a root size in each group so that the mean BLW (Maximum Bucco Lingual Width) of each group of teeth differed by no more than 5% [15]. To standardize the root length for all samples, the length of 13 mm from anatomical apex was determined; each root was sectioned perpendicular to its long axis by using diamond disc mounted on a straight handpiece with water coolant. The pulp tissue was extirpated using barbed broach and the patency of the canals was verified by insertion of size10 K-file into the root canal and advancing it until it is visualized at the apical foramen [12]. The correct WL was established by subtracting 1 mm from root length. Also, size 10 K-file was used to determine the initial size of the canal, only roots with initial file size 10 K-file were included in the study [14].

Root Canal Instrumentation

To facilitate handling of the sample during instrumentation and obturation procedures, each sample was embedded in silicone rubber base impression material; the roots were placed in the center of the putty material with the aid of dental surveyor in order to position the long axis of the roots parallel to that of the mold. For maintaining a

standardized constant position of the samples during instrumentation and obturation, the samples were fixed at the base of the dental surveyor and the handpiece of the endodontic micromotor was fixed to the handle of the surveyor eliminating any variability during the entire root canal filling procedure. The sequences of preparation of the root canal were performed just like the manufacturer's instructions of the file system used in each group. Irrigation was performed using a 30-gauge endodontic needle. The depth of needle penetration into the canal was determined by introducing the needle passively into the canal 3 mm shorter of the WL without any binding of the needle to the canal wall to allow backflow of irrigation solution easily [16]. After each 3 pecking motion (reciprocating instruments), the instrument was moved out of the canal then irrigation of the canal was done with 3 ml of 5.25% of NaOCl irrigation. For standardization, each canal was irrigated with a total amount of 12 ml of 5.25% of NaOCl. After complete instrumentation, the root canals were irrigated with 5 ml of 17% ethylene diamine tetraacetic acid to remove the smear layer followed by a final flush of 10 ml of distilled water [14].

The Reciproc blue system canal instrumentation was accomplished using R25/08 file according to the manufacturer's instructions. First, a glide path was established using ISO No.10 stainless steel k-file followed by size 15 K-file. R25/08 was used in a reciprocating motion using electric speed and torque-controlled endodontic micromotor X Smart Plus which had a pre-programed setting to operate Reciproc instruments.

The WaveOne gold files canals preparation was performed by WaveOne gold primary files. This was obtained by forming a smooth glide path with ISO No.10 stainless steel k-file followed by size 15 K-file, then primary reciprocating (WOG) file size 25/0.07 was used according to the manufacturer's instructions using electric speed and torque-controlled endodontic micromotor X Smart Plus which had a pre-programed setting to operate WaveOne instruments.

Obturation Procedure

- Group I (control group): Each subgroup (8 roots) was instrumented and left without obturation; Subgroup A was prepared using Reciproc blue R25 files and Subgroup B was prepared with WaveOne gold primary files 25 as mentioned previously
- Group II: After complete instrumentation, irrigation and dryness of both Subgroups (A, B), the samples were obturated with GuttaFlow Bioseal sealer and gutta-percha of corresponding size and taper (according to the file system used during the instrumentation procedure) using single cone obturation technique [14]
- Group III: After complete instrumentation, irrigation and dryness of both Subgroups (A, B), the samples were obturated with and AH plus sealer and gutta-percha of corresponding size and taper (according to the file system used during the instrumentation procedure) using single cone obturation technique [14]

Then all specimens were stored in an incubator for 7 days at 37°C to allow for a complete set of the sealers. Fracture resistance test in order to replicate a periodontal membrane, 5 mm apically of all samples were covered with wax to attain a 0.2 mm to 0.3 mm-thick layers prior to inserting the roots into the acrylic resin to create a mold. The acrylic block was positioned at the lower plate of the Instron machine, the upper plate consists of a spherical steel tip 3 mm in diameter, the tip was centered over the canal orifice then a vertical force that was slowly increasing was applied (1 mm/min) until fracture happened. The determination of fracture moment was accomplished when an abrupt drop in force happened and was detected by the testing machine and characterized by a distinguished audible sound. The maximum force needed to fracture each sample was documented in Newton's [14].

RESULTS

The descriptive statistics including the mean, standard deviation, minimum and maximum values of the fracture strength in Newton of all groups are shown in Table 1.

Table 1 Descriptive statistics for all the groups measured in Newton

Groups	Mean	Std. Deviation	Std. Error	Minimum	Maximum
RB+GFlow	511.8	65.821	23.271	416	615
Group IIA	75				
WaveOne gold+GFlow	519.8	144.813	51.199	304	739
Group IIB	75				

RB+AH	543.2	108.235	38.267	353	702
Group IIIA	50				
WaveOne gold+AH	611.1	132.572	46.871	419	789
Group IIIB	25				
Reciproc blue only	267.8	54.773	19.365	188	358
Group IA	75				
WaveOne gold only	270.1	71.317	25.214	130	347
Group IB	25				

It can be noticed from the above table that the highest mean in fracture resistance was recorded by Group IIIB (611.125) followed by Group IIIA (543.250), Group IIB (519.875), Group IIA (511.875) and Group IB (270.125) respectively whilst the lowest mean value of fracture was recorded by Group IA (267.875). Two-way ANOVA test was used for comparison of significance among the obturated Groups (IIA, IIB, IIIA, and IIIB) as seen in Table 2.

Table 2 Two-way ANOVA test for comparison of significance among the obturated groups

Files	Sealer	Mean	Std. Deviation	F	p-value
Reciproc blue	GuttaFlow bioseal	511.875	65.82105	1.045	0.388 NS
	AH plus	519.875	144.81263		
WaveOne gold	GuttaFlow bioseal	543.250	108.23486		
	AH plus	611.125	132.57175		

The results demonstrated a statistically non-significant difference between these groups. Comparison of significance between groups (IB, IIA, IIB, IIIA, IIIB) with Group IA using one-way ANOVA test showed a high statistical significant difference among groups (p=0.01) just as shown in Table 3.

Table 3 One-way ANOVA test for comparison of significance between Groups (IB, IIA, IIB, IIIA, IIIB) with Group IA

Variables	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	545713.4	4	136428.35	11.844	0.000
Within Groups	403153.0	35	11518.657		
Total	948866.4	39	-		

The results of this test signified that there was a statistically highly significant difference among all tested samples (p=0.01). Therefore, Dunnett (2-sided) test was utilized to assess the significance of the difference between groups at a level of the confidence interval of (95%) and demonstrated a statistically highly significant difference (p=0.01) between all groups.

Comparison of significance between groups (IA, IIA, IIB, IIIA, IIIB) with Group IB using one-way ANOVA test revealed a statistically highly significant difference among groups (p=0.01) just as shown in Table 4.

Table 4 One-way ANOVA test to compare the significance between Groups (IA, IIA, IIB, IIIA, IIIB) with Group IB

Variables	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	870363.104	5	174072.62	16.663	0.000 HS
Within Groups	438755.875	42	10446.568		
Total	1309118.98	47	-		

Furthermore, comparisons between groups using Dunnett (2-sided) test revealed statistically highly significant differences (p=0.01) between all groups.

DISCUSSION

Root fracture is a major complication which may happen during or after root canal treatment and often leads to failure of root canal treatment [17]. Root canal obturation is classically performed using gutta-percha with a root canal sealer to provide complete filling of the canal in all dimensions [14]. In order for the root canal filling material to improve a long-term success of endodontic treatment, it should form a bond with the dentin thereby reinforcing the remaining tooth structure, since gutta-percha has no ability to bond to root canal walls, endodontic sealers may have an essential

role in creating such bond [18]. In this study the fracture strength of AH plus and GuttaFlow Bioseal sealers where evaluated when the roots were instrumented with 2 types of preparation systems (WaveOne gold and Reciproc blue). The results demonstrated that both sealers increased the fracture strength when compared to the control groups (prepared but not filled) with no statistically significant difference between the two sealers. It is noteworthy that a comprehensive literature review indicated that there were limited studies to compare the fracture strength of roots treated endodontically; prepared with Reciproc blue and WaveOne gold file systems and obturated with GuttaFlow Bioseal and AH plus sealers, so it was not possible to directly compare the result of the current study with others. In the present study, the highest fracture resistance was observed among the group obturated with AH plus sealer when compared to the control groups this may be explained by Nunes, et al., who found the highest value obtained with AH plus sealer is due to its adhesive properties [19]. Infiltration into the micro irregularities because of the creep capacity and good prolonged polymerization Carneiro, et al., attributed that to its low shrinkage and inherent property of time also volumetric expansion (4%-5%), enhancing the mechanical bond between the sealer and dentin resulting in better bond strength [20]. Bird, et al., explained that the capability of a material used in obturation to strengthen the tooth relies on its ability to inflow into the dentinal tubules, depending on the size of the tubules, the material particles diameter and the reaction rate of the material [21]. These findings were in favor of the previous studies of Cobankara, et al., Sagsen, et al., and Ersev, et al., [18,22,23]. They observed roots obturated with epoxy resin based sealers were significantly stronger than just instrumented roots.

On the contrary, the result of the present study disagrees with Grande, et al., Wilkinson, et al., and Kim, et al., who discovered no clear benefits in using a resin based root canal sealers when it comes to increasing the fracture strength of endodontically treated roots [1,24-26]. GuttaFlow Bioseal is a newly introduced sealer developed recently in 2015 and was launched to the market in 2016, to the extent of our knowledge, there are limited researches of this sealer, in the literature. Moreover, there is no study of the effect of GuttaFlow Bioseal sealer on the fracture strength of teeth treated endodontically. In the present study GuttaFlow Bioseal sealer showed high increase in the fracture resistance that were statistically significant when compared to the control groups which may be attributed to the physical and chemical properties of the novel polysiloxane gutta-percha calcium Silicate-bioglass containing root canal sealer demonstrated by Collado, et al., in which the sealer showed water sorption that results in volumetric expansion, excellent alkalinizing activity along with low solubility, minimal calcium release and perfect Ca/P ratio (1,56) rendering GuttaFlow Bioseal an apatite forming bioactive sealer [27]. Calcium ions are essential for the process of differentiation and mineralization of mineralizing cells. Gandolfi, et al., demonstrated that the formation of calcium phosphate in biological-like environment reduces the interface open porosity with the time [28]. Thus, in the clinical condition sealers that are capable of forming calcium phosphate might be predicted to enhance sealing with time there by increasing the fracture resistance of endodontically treated teeth. Additionally, they are capable of creating a bone-like apatite, also creating an osteoinductive one promoting cell bioadhesivity [29]. The result of the present study also demonstrated that both sealers were capable of improving the fracture resistance, however, there was no statistically significant difference in the ability of both sealers in increasing the fracture resistance, which might be because of the fact that both sealers are supplied as a paste-paste system. Sealers with a paste formulation enhance the fracture strength due to the superior flow and greater penetration into dentinal tubules when compared to sealers with a powder/liquid formula. Moreover, zirconium oxide found in the formulation of both sealers has a high fracture and tensile strength along with low Young's modulus as cleared out by El-Ma'aita, et al., [30]. The control groups revealed the lowest fracture resistance. This is in accordance with many previous studies like Sağsen, et al., Topcuoglu, et al., and Celikten, et al., [14,18,31]. This could be due to the fact that preparing a root canal may lead to weakening the roots as the amount of remaining dentine thickness was reduced and there was no filling material to reinforce tooth structure rendering them more prone to fracture, moreover during the connection between instruments and walls of dentin. Those contacts generate several transient stress concentrations in dentine that may leave dentinal defects in which root fracture can initiate. The results also revealed that there was no significant difference in the fracture strength between the control groups (prepared with WaveOne gold and Reciproc blue systems and not filled). This might be due to the fact that both files are of single file systems operating in the reciprocating movement working in a 150º CCW and 30º CW reciprocating motion with the same apical diameter of 25 mm, with 2 cutting edges, and a non-cutting tip for both. WaveOne gold primary file has 0.07 taper in the apical 3 mm, Reciproc Blue file R25 has a taper of 0.08 over the first apical millimeter claimed that large tapered instruments may result in excessive removal of dentine, weakening of the root and may exert more stress on the canal wall which might generate cracks on the dentin and the apical surface

that could lead to root fracture [32]. Another factor may be related which is the debris transportation, previous studies clarified that the reciprocation motion appeared to increase debris transportation towards the apex of the tooth thereby increasing the torsional forces exerted on the dentine; this may result in the creation of crack that may lead to root fracture as a consequence of crack propagation [33,34].

CONCLUSIONS

Within the limitations of this *in vitro* study, it can be concluded that the highest mean in fracture resistance was observed in roots obturated with AH plus sealer and it was statistically significant when compared to the control groups, the fracture strength of roots obturated with GuttaFlow Bioseal sealer was greater than the control groups. Both sealers (AH plus and GuttaFlow Bioseal) improved the fracture resistance of obturated roots without statistically significant difference between them. The lowest mean value of fracture resistance was seen in the control group.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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