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Comparitive Analysis of the Fracture Resistance of Four Different Root Canal Sealers and Its Sealing Ability Using Confocal Microscope -An Invitro Study

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Abstract

Introduction: Comparative analysis of fracture resistance of four different root canal sealers and its sealing ability using confocal microscope -an invitro study.

Background & Objectives: To evaluate fracture resistance of root canal sealers AH plus, Guttaflow, BioRoot RCS and MTA fillapex on endodontically treated teeth under universal testing machine and evaluate the sealing ability under confocal microscope.

Methods: 90 single-rooted mandibular premolars were decoronated & divided into 4 groups. Cleaning & shaping of root canals were done using ProTaper rotary files and 3% sodium hypochlorite irrigation. Obturation was done using sealers, AH Plus (Dentsply, Germany) in Group 1 and MTA Fillapex (Angeles, Brazil) in Group 2, GuttaFlow 2 (Roeko-Coltene/Whaledent, Langenau, Germany) in Group 3, BioRoot RCS (Septodont)in Group 4 and gutta-percha.Teeth were subjected to vertical loading using a universal testing machine. Data were subjected to statistical analysis using Tukey’s post hoc test. Apical leakage was estimated by dye penetration test. Root surfaces of 2 specimens from each group were coated with two layers of nail varnish with the exception of the apical 2 mm. Then were immersed in 2% methylene blue solution for 24 h at room temperature.

After removing from the dye solution, the specimens were viewed under Confocal Laser Scanning Microscopy.

Results: AH Plus group showed significantly highest mean Fracture Resistance compared to MTA & BioRoot RCS, both at P<0.001 and also with Guttaflow group at P=0.02. However, no significant differences in the mean Fracture Resistance was observed between BioRoot RCS group and MTA group [P=0.99].

Interpretation & Conclusion: According to the study, it was found that AH Plus group showed significantly highest mean Fracture Resistance followed by Guttaflow group having significantly higher mean Fracture Resistance as compared to BioRoot RCS & MTA group.

Keywords: Confocal Laser Scanning Microscopy, fracture resistance

Introduction

Thorough debridement of the root canal system ts recognized as being essential for successful long-term root canal therapy.[1]

The purpose of the endodontic filling is to seal off the root canal and to prevent ingress of bacteria from the oval environment to the periapical tissues. The physical properties necessary for this function include adaptation and adhesion to the root canal dentine surface and dimensional stability of the filling. It has been shown that root canal fillings may be prone to bacterial penetration along their length.[2]

It is generally accepted that microleakage between the root canal filling and the root canal walls might adversely affect root canal treatment results. Therefore, complete sealing of the root canal system after cleaning and shaping is critical to prevent oral pathogens from colonizating and re-infecting the root and periapical tissues. [3]

In endodontic therapy, a sealer is basically used to fill the irregularities of the root canal system, bond the core material to the root canal walls, and serve as a lubricant . [4]

Some of these paste sealers have been evaluated from the standpoint of their biologic aspects, their physical and mechanical properties and their sealing qualities .[5]

Endodontic sealers can be grouped according to their basic components such as zinc oxide-euogenol, calcium hydroxide, resins, Silicon based sealers, Methaacrylate resin based sealer, Calcium-phosphate based sealers (Gutmann & Witherspoon 2002).

The various root canal sealers used are Sealapex, Diaket, AH Plus, Apexit, Vitapex, MTA Fillapex, RoekoSeal, GuttaFlow, Sealer MTA Obtura ProRoot Endo Sealer, BioRoot RCs, EndoREZ, Realseal, Metaseal SE, Smartseal.[6]

Root filled teeth are more susceptible to fracture than teeth with intact pulps (Oliveira et al. 1987, Assif & Gorfil 1994). 7

Bonding of endodontic sealers to root dentine may enhance the fracture resistance of root filled teeth and their use has been suggested to reinforce the root filled teeth (Johnson et al. 2000).

Also, Three-dimensional sealing of the root canal system is one of the main goals of endodontic treatment and is essential for prevention of canal re-infection and maintenance of healthy periapical tissues. For such purpose, several types of endodontic sealers have been developed and the evaluation of the apical sealing ability of these materials is extremely important. Therefore, leakage studies that investigate the sealing properties of endodontic materials are still considered important and relevant.[8]

There are several methods for evaluating the apical sealing of root canal sealers, such as bacterial penetration, fluid transport, clarification, penetration of radioisotopes, electrochemical methods and gas chromatography. Dye penetration tests, however, seem to be the most widely used.[9]

The purpose of this *in vitro* study was to compare the fracture resistance of AH Plus, GuttaFlow 2, BioRoot RCS and MTA Fillapex root canal sealers under universal testing machine and using a dye penetration test to evaluate the sealing ability of four root canal sealers under confocal scanning electron microscope.

Methodology

A total of ninety teeth were decoronated apical to the cement enamel junction to standardize the canal length to 16 mm. The canal patency was determined by passively placing a no. 8 size k-file in narrow canals and10 k-file in medium sized root canals until the tip of the file was visible at the apical foramen using a magnifying loupe and adjusted to the apical foramen. Working lengths were established by subtracting 1mm from the measurement obtained when a size 10 file was placed into the canal until its tip was visible at the apex namely working length of 15mm.

During instrumentation of all canals, 2ml of NaOCl (3%) was used as an irrigant during instrumentation of all canals using 30 gauge side vented needle for 1 minute.

The samples were prepared up to file size 30/0.06 taper using Protaper Universal (Dentsply Maillefer) Ni-Ti rotary instruments at a rotation of 300 r.p.m .This was followed by rinsing of the canals with 5ml of 0.9% saline to minimize potential interaction of NaOCl with any EDTA that will be employed as a final rinse.

The samples were divided into 4 groups (n=20) according to the root canal sealer used :

Group 1: Obturation with gutta-percha and sealer as MTAFillapex

Group 2: Obturation with gutta-percha and sealer as BioRoot RCS

Group 3: Obturation with gutta-percha and sealer as AH Plus

Group 4: Obturation with gutta-percha and sealer as GuttaFlow 2

Root canals will be dried with paper points and then sealer will be mixed according to manufacturer's directions and will be introduced into canal using lentilospiral instrument and obturated with gutta percha.

The obturated teeth will be allowed to set for 1 week before fracture resistance assessment in 37°C with 100% humidity in an incubator.

Preparation for Fracture Resistance Test

For all specimens, the root surface was covered with a paste of silicon-based impression material (Aquasil) up to 2 mm apical to the CEJ to simulate a periodontal ligament and kept in 100% humidity for 24 h. Each tooth was then mounted vertically to a depth of 2 mm below the CEJ in polystyrene resin block using ice cube holder molds.

The resistance offered was tested using the universal testing machine for root samples of all groups against vertical fracture. A cylindrical hardened steel rod (2.2 mm diameter) with a sharpened conical tip was attached to the upper part of the universal testing machine (Asian Universal Testing Machine) to apply force to the root causing vertical root fracture.

A vertical load was applied at a crosshead speed of 0.5 mm/min until the root fractured. For most specimens, an audible crack also was heard, and the amount of force required for fracture was recorded in Newtons.

Dye Penetration Test

The root surfaces of all specimens were coated with two layers of nail varnish with the exception of the apical 2 mm. The root surfaces teeth were entirely coated with two layers of nail varnish to prevent possible leakage. Specimens were then immersed in 2% methylene blue solution for 24 h at room temperature. After removing from the dye solution, the specimens were washed, and nail varnish was scraped away from the surface. The samples were then sectioned bucco-lingually in a longitudinal direction and subjected under Confocal Laser Scanning assessing sealing ability.

Result

Table 1

Comparison of mean Fracture Resistance (in N) between 4 study groups using One-way ANOVA Test						
Groups	N	Mean	SD	Min	Max	P-Value
MTA	20	674.58	167.72	382.2	984.1	<0.001*
Bioroot RCS	20	689.59	112.33	473.5	872.4	
AH Plus	20	997.12	204.79	682.1	1400.1	
Guttaflow	20	849.86	126.67	628.4	1068.4	

* - Statistically Significant

The test results demonstrate the comparison of mean Fracture Resistance between different groups. The mean Fracture Resistance for MTA group was 674.58 ± 167.72, BioRoot RCS was 689.59 ± 112.33, AH Plus group was 997.12 ± 204.79 and Guttaflow group was 849.86 ± 126.67. This difference in the mean Fracture Resistance between 04 groups was statistically significant at P<0.001. [***Refer Graph no. 1***]

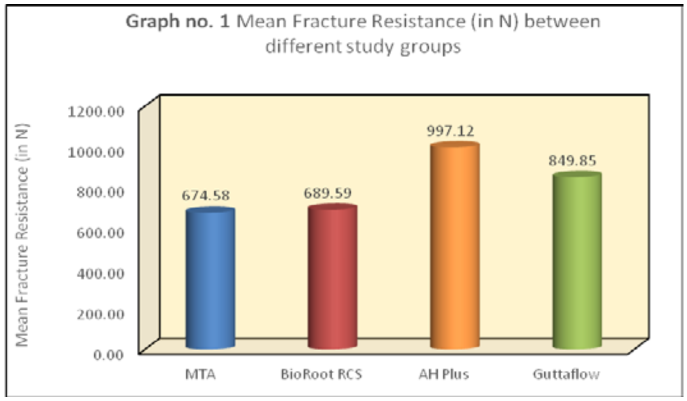
Table 2

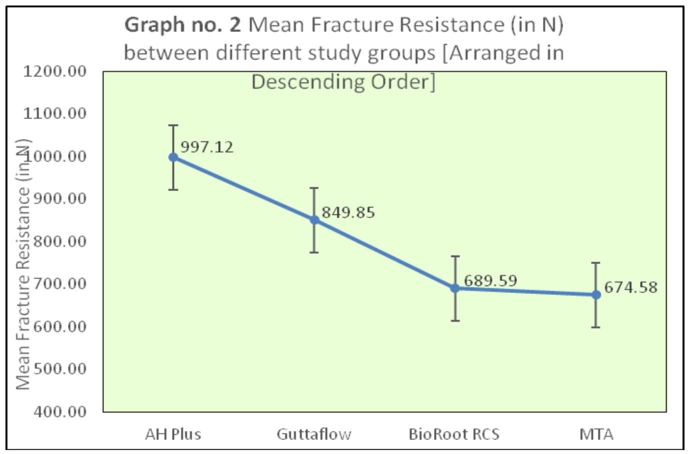
Multiple comparison of mean diff. in Fracture Resistance (in N) b/w 4 study groups using Tukey's HSD post hoc Analysis					
(I) Groups	(J) Groups	Mean Diff. (I-J)	95% CI for the Diff.		P-Value
			Lower	Upper	
MTA	Bioroot RCS	-15.01	-145.51	115.50	0.99
	AH Plus	-322.54	-453.05	-192.04	<0.001*
	Guttaflow	-175.28	-305.78	-44.77	0.004*
Bioroot RCS	AH Plus	-307.54	-438.04	-177.03	<0.001*
	Guttaflow	-160.27	-290.78	-29.77	0.01*
AH Plus	Guttaflow	147.27	16.76	277.77	0.02*

* - Statistically Significant

Multiple comparison of mean difference in the Fracture Resistance between groups revealed that AH Plus group showed significantly highest mean Fracture Resistance as compared to MTA &BioRoot RCS, both at P<0.001 and also with Guttaflow group at P=0.02. And this was followed by Guttaflow group having significantly higher mean Fracture Resistance as compared to BioRoot RCS at P=0.01& MTA group at P=0.004 respectively.

However, no significant differences in the mean Fracture Resistance was observed between BioRoot RCS group and MTA group [P=0.99]. [***Refer Graph no. 2***]





Discussion

Obturation of root canal systems is done to achieve a three dimensional, fluid-tight or hermetic seal throughout the canal including the apical foramen and canal irregularities and minor discrepancies between the dentinal wall of the root canal and the core filling material. [51]

Sealing ability, biocompatibility, and antimicrobial activity probably influence the success of the root canal treatment. To create and maintain a three-dimensional seal of the entire root canal system, sealers should have adhesiveness, be dimensionally stable, be insoluble to oral and tissue fluids, and have an adequate flow rate. This latter property allows the material to penetrate into irregularities, isthmus, fins and ramifications, which increases the likelihood of obtaining an adequate seal of the root canal system. [52]

The bonding of endodontic sealers to intraradicular dentin after root obturation might possibly enhance resistance to fracture of endodontically treated teeth. The use of a root canal sealer with properties similar to those of other sealers and with the additional quality of strengthening the root against fracture would then be of value.[53]

However, before arriving to definite conclusions more evidence regarding the sealers, depth of penetration in the dentinal tubules verses increased antibacterial activity is needed. Chemical adhesion between dentin and sealers (with the exception of glass ionomer sealers) cannot be achieved; [55] therefore, it has been suggested that the sealer plugs inside the dentinal tubules provide a mechanical interlocking, improving the retention of the filling material by the root canal walls. The fact that the sealer penetration into the dentinal tubules increases the interface between the filling material and the dentin might influence the sealing ability of the obturation.[56] Hence several new resin cement sealants have been developed to be used instead of ZOE, thereby improving the root canal seal and imparting it more strength as compared to the conventional materials.These include silicon-based sealers which are well tolerated by tissues, have low water sorption, and have a potential of forming monoblock, thus reinforcing root canal, epoxy resin–based sealers with the possibility of adhesion to dentin and with lower rates of water solubility, and a mineral trioxide aggregate (MTA)-based sealers which have the predilection toward mineralization along with all the viable properties of orthodox sealers.[57]

Therefore, the aim of the present in-vitro study is to compare the fracture resistance of AH Plus, MTA Fillapex, BioRoot RCS and GuttaFlow 2 and their sealing ability into dentinal tubules under Confocal microscopy.

Root canal instrumentation is performed using Protaper Universal system. The canals in this investigation were prepared with a combination of the passive step-back technique and rotary nickel-titanium instruments. This technique is an effective method to prepare root canals with rotary instruments. Rotary nickel titanium instruments (RNT) represent a relatively new approach to rapid and simplified canal preparation with a standardized uniform taper. Even though the effective cleansing of the entire root canal system is still challenging as every available file system generates a smear layer and more so in the apical thirds where the cleaning efficiency is limited. In general, the flute as well as cross sectional design of RNT files plays an important role in the cleaning efficiency of these instruments. In recent years RNT instruments with advanced blade designs have been developed to improve cleaning efficiency during root canal preparation. The ProTaper file system has been one of the most frequently used and widely recommended RNT system. The ProTaper crosssectional design resembles that of a reamer, with three machined cutting edges and convex core [58]. Thus protaper universal is selected for this study.

Injecting the irrigation solution by means of a syringe can control the volume and depth of syringe penetration and results in the flow of the solution to the apical third of the canal. So, all irrigation protocols were done using 30 - guage needles(close-ended single side vented) as it allows the clinician to place these as apical as clinically possible without canal binding amongst all the endodontic needles according to Gopikrishna et al. [60]

Van der Sluis et al also showed that there was a significant difference in presence of Smear layer between apical and middle thirds of the canals and also showed that irrigation with 5% NaOCl solution during 3 min PUI could remove more smear layer than 0.5% NaOCl from the apical and middle part of the root canal [61]. So the removal of smear layer in the apical region remains unpredictable[62,63]. Therefore smear removal will in turn effect the pushout bond strength in apical third and middle third of canals and thus it was evaluated in this study.

In the present study, between each instrumentation canals were irrigated with 2 ml of 3% of NaOCl using a 30 gauge needle according to Tuncer et al [64]. Studies done by Baumgartner et al on efficacy of several concentrations of sodium hypochlorite for root canal irrigation have shown that irrigation with 3 ml of NaOC1 after each instrument in the study did an excellent job of removing superficial debris whether delivered with an endodontic irrigation needle or the ultrasonic device[65]. This was followed by rinsing of the canals with 5 ml of 0.9% saline to minimise potential interaction of NaOCl with any acidic irrigants that were employed as a final rinse.To prevent the escape of irrigants from the apex by simulating a clinical situation, the apex was sealed with aluminum foil coated with molten wax, simulating the clinical conditions.This method is similar to what was used by Hasnainet al[66]. This is the root is enclosed in the bone socket it behaves as a closed-end channel, producing a vapor lock effect during the delivery of irrigating solutions, which hampers access to the apical third.

Before obturation all the specimens were irrigated with EDTA.[67] EDTA is normally used in a concentration of 17% and can remove the smear layers when in direct contact with the root canal wall for less than 1 minute according to Doumani et al . SemraÇalt et al on the study on time-dependent effects of EDTA on dentin structures found ou that EDTA followed by NaOCl completely removed the smear layer in 1 min. In turn when EDTA is applied for 10 min, excessive erosive effects were observed with dissolution of peritubular and intertubular dentin. According to the study findings, to inhibit the erosion on dentin, EDTA solution must not be applied for longer than 1 min[68]. Thus EDTA was used for 1 min in this study so that sufficient time is available for EDTA to act in apical third and at same time erosion of the dentinal tubules does not take place.

The application of sealers was done by mixing according to manufacturers directions. Many techniques have been used to place sealer into root canals, including the use of files or reamers, GP cones, paper points, lentulo spirals or ultrasonic files. Before placement of the root filling, the ultrasonic and lentulo spiral methods have been found to produce a greater degree of sealer coverage (Hoen*et al* . 1988,Hall *et al*. 1996, Kahn *et al*. 1997). Using evaluation of radiographs, it appeared that 90% of the canal wall was covered with sealer after using a lentulo spiral (Hall*et al*. 1996).[69] Then canals were obturated using single cone technique using F3 gutta percha as a master cone.

Single‐cone obturation was done in the present study to simulate most common method employed in clinical scenario and to maintain homogeneity among groups.[70]

The specimens obturated using AH Plus sealer (DentsplyMaillefer, Switzerland) which is an epoxybased endodontic sealer and presents with no photopolymerization system on its composition. It is believed that homogeneous polymerization occurs, leading to higher mean values of bond strength along the canal root. Along with that chemical polymerization occurs at a low rate, delaying the gel point state and allowing for shrinkage stress relaxation, and avoiding a decrease in bond strength. This is in accordance with the study conducted by Wunderlich Rocha et al [71] . Moreover it is biocompatible, radiopaque, has a short-setting time, low solubility, and good flow characteristics[72.] Also the teeth filled using AH-Plus in combination with Gutta-percha has been reported to have no difference than a natural tooth in terms of resistance.[73]

Another newly introduced root canal sealer is MTA Fillapex. Its MTA-based composition contains salicylate resin, diluting resin, natural resin, nanoparticulated silica, and bismuth trioxide. In several studies, it was shown that MTA as a root canal fi lling material strengthened the root against fracture.[74]

MTA fillapex is first paste; paste MTA- based salicylate resin root canal sealer, versatile for every obturation method. It delivers easily and without waste exhibits excellent handling properties with an efficient setting time.[75]

Half of MTA Fillapex paste; paste formula contains 13.2% MTA. MTA known for its biocompatibility, yields an impressive, hermetic seal in which the MTA particles expand, preventing microfiltration. The other half of MTA Fillapex paste; paste formula conatins biologically compatible salicylate resin(1,3 butylene glycol disalicylate resin) which is tiisue friendly and therefore a better choice over epoxy-resin based resins, which have been shown to have mutagenic and more cytotoxic effects.[76]

MTA Fillapex two pastes combine in a homogenous mix to form rigid but semipermeable structure with excess MTA dispersed throughout. The MTA activity is possible because of the permeability.[77]

In 2004, (Roeko-Coltene/Whaledent, Langenau, Germany) introduced a cold, flowable, self-curing obturation material for root canals that combines gutta-percha and sealer into one injectable system. GuttaFlow 2 is a siliconebased root canal sealer. GuttaFlow contains gutta-percha in particle form combined with a polydimethylsiloxane-based sealer. GuttaFlow. The particle size of its powder form is less than 30 µm, and it contains gutta-percha powder, poly dimethyl siloxane, platinum catalyst, zirconium dioxide and micro-silver. It is used in combination with a master gutta-percha cone and does not require any form of manual compaction for placement. The material is believed to flow into lateral canals and completely fill the space between the root canal wall and the master cone. In addition, because no heat is used with placement of the material, no shrinkage is believed to occur, and the manufacturer reports that the material expands 0.2% upon curing [78,79]

BioRoot™ RCS is the newest endodontic sealer based on tricalcic silicate materials benefiting from both Active Biosilicate Technology and Biodentine™. The first provides medical grade level of purity and, unlike “Portland cement” based materials, it ensures the purity of the calcium silicate content with the absence of any aluminate and calcium sulfate. BioRoot™ RCS is a mineral based root canal sealer using tricalcium silicate setting system. The powder part additionally contains zirconium oxide as biocompatible radiopacifyier and a hydrophilic biocompatible polymer for adhesion enhancing. The liquid part contains mainly water, calcium chloride as a setting modifyier and a water reducing agent. BioRoot™ RCS is bioactive by stimulating bone physiological process and mineralization of the dentinal structure (Camps 2015, Dimitrova-Nakov 2015,). Therefore it creates a favorable environment for periapical healing and bioactive properties including biocompatibility (Reichl 2015), hydroxyapatite formation, mineralization of dentinal structure, alkaline pH and sealing properties. BioRoot™ RCS is indicated for the permanent root canal filling in combination with gutta-percha points and is suitable for use in single cone technique or cold lateral condensation (Camilleri, 2015). [80]

A prime requisite for a 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.[81] 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. This design was found to be more clinically relevant as it better stimulates the support given to healthy tooth by alveolar bone and results in less catastrophic stress build‑up caused by unrealistic bending movements.[82] The fracture was found to occur parallel to the dentin bonding surface.

The results of the present study showed that AH Plus had significantly high resistance ($P < 0.001$) to fracture than all other tested root canal sealers. These results are in accordance with the previous study of Fisher *et al*.,[83] where they found that AH Plus showed a significantly ($P < 0.05$) 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. AH Plus has a better penetration into the micro‑irregularities because of its creeping property and long polymerization period, which increases the mechanical interlocking between the sealer and root dentine.[84]

Nagas *et al*.[85] related high fracture resistance of AH Plus to its low shrinkage while setting and long‑term dimensional stability. It is resilient, and in combination to Gutta‑percha, it forms a perfect seal with dentinal walls giving it a good strength and resistance to fracture. McMichen *et al.* in their study showed that AH Plus had low solubility and greater film thickness than other sealers which might play a role in its better bond strength and fracture resistance.[85]

Better adaptation of GuttaFlow to root canal dentin is also found in studies of Nawal *et al*., Bouillaguet *et al*., Vujasković and Teodorović, and Teodorović and Matović. Better sealing ability of GuttaFlow is also found in other leakage studies. This better sealing ability exhibited by the GuttaFlow could be attributed to its ability to flow into the main root canal, into lateral canals, recesses, or any grooves, and also it has shown good penetration into the dentinal tubules.[86] Apart from this, GuttaFlow obturation system exhibits a linear setting expansion of 0.16%, following obturation in the canal. In addition, placement of gutta‑percha cone pushes the material into the lateral and accessory canal which may be responsible for its better seal as pointed by Ozok *et al*., possibly because of its thixotropic nature as claimed by manufacturer.[87,88]

The good adaptation to the root canal walls and to the gutta-percha of GuttaFlow, over time, shows a greater apical and coronal sealing capacity and this could be attributed to its capacity to expand slightly on setting.[89]

Gutta-Flow showed good spreadability in the group where root dentin surface was treated with both EDTA and NaOCl. The reason for this could be the increase in the surface energy of the root dentinal wall which was free of the smear layer.[90]

This was followed by BioRoot RCS and MTA Fillapex. BioRoot RCS which is a water based root canal sealer is shown to preserve the pulpal stem cells in mouse which possess osteo-odontogenic intrinsic properties. They have decreased flow and an increased film thickness. According to Viapiana et al , he reported that there were voids in root canals filled with BioRoot Rcs compared to an epoxy resin based root canal sealer. [91]

On the other hand, previous studies performed by Tanalp et al. and Mandava et al. concluded that MTA Fillapex did not strengthen endodontically prepared teeth significantly. The results of the current study are consistent with their findings as MTA Fillapex did not reinforce the endodontically treated teeth significantly when compared with the positive control group. In the present study, MTA Fillapex had the lowest fracture resistance. MTA Fillapex contains MTA as one of its ingredients. It is anticipated that release of calcium and hydroxyl ions from the set sealer will result in the formation of apatites as the material exposed to phosphate-containing fluids. Reyes- Carmona et al. [92] reported that the apatite formed by MTA and phosphate-buffered saline was deposited within collagen fibrils, promoting controlled mineral nucleation on dentine, seen as the formation of an interfacial layer with tag-like structures at the cement-dentin interface. The reason for the low fracture resistance of MTA Fillapex in the present study might be due to the low adhesion capacity of these tag-like structures. [93]

These results were in accordance with the dye penetration test conducted in the present study, in which AH Plus root canal sealer showed significantly higher penetration than the other sealers. This was in accordance with Arikatla, *et al*, The flow of a sealer which is determined by its consistency and particle size is one of the important factors to influence the tubular penetration.[94] The flow of AH Plus sealer is superior due to the presence of higher concentration of epoxy resin.[95]

The degree of adhesion depends on several interacting factors including the adherent's (dentin) intermolecular surface energy and cleanliness and the adhesive (sealer) surface tension and wetting ability.[96] AH Plus sealer exhibited the least number of gap-containing areas, a finding which is consistent with the previous studies. The superior adaptation of AH Plus could be due to its chemical bonding to root dentin by forming covalent bonds between the epoxy resin and collagen. Although the alkaline nature of bioceramic by-products have been reported to denature dentinal collagen fibers facilitating sealer penetration, both hydrophilic sealers MTA Plus and Bioroot RCS exhibited more interfacial gaps. The reason for inferior adaptation of MTA Plus could be due to poor microtags formed on setting.[97] Further studies need to be conducted to substantiate the results of the current study.

CONCLUSION

- Within the limitations of the current study it may be concluded that AH Plus root canal sealer showed the highest fracture resistance.
- This was followed by GuttaFlow 2. The mean fracture resistance was significantly more compared to BioRoot RCS and MTA Fillapex root canal sealers.
- Also, no significant differences in the mean Fracture Resistance was observed between BioRoot RCS group and MTA group**.** However, difference in the mean Fracture Resistance between 04 groups was statistically significant.
- Further studies using different obturation methodologies must be carried out to substantiate the results.

References

1. Baumgartner JC, Mader CL. A scanning electron microscopic evaluation of four root canal irrigation regimens. Journal of Endodontics. 1987 Apr 1;13(4):147-57.
2. Ørstavik D, Nordahl I, Tibballs JE. Dimensional change following setting of root canal sealer materials. Dental Materials. 2001 Nov 1;17(6):512-9.
3. Zhang W, Li Z, Peng B. Assessment of a new root canal sealer's apical sealing ability. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2009 Jun 1;107(6):e79-82.

4. Lee KW, Williams MC, Camps JJ, Pashley DH. Adhesion of endodontic sealers to dentin and gutta-percha. Journal of endodontics. 2002 Oct 1;28(10):684-8.
5. Younis O, Hembree Jr JH. Leakage of different root canal sealants. Oral Surgery, Oral Medicine, Oral Pathology. 1976 Jun 1;41(6):777-84.
6. Singh H, Markan S, Kaur M, Gupta G, Singh H, Kaur MS. Endodontic sealers: Current concepts and comparative analysis. Dent Open J. 2015;2(1):32-7.
7. Sagsen B, Er O, Kahraman Y, Akdogan G. Resistance to fracture of roots filled with three different techniques. International endodontic journal. 2007 Jan;40(1):31-5.
8. Dultra F, Barroso JM, Carrasco LD, Capelli A, Guerisoli DM, Pécora JD. Evaluation of apical microleakage of teeth sealed with four different root canal sealers. Journal of Applied Oral Science. 2006 Oct;14(5):341-5.
9. Al-Haddad A, Ab Aziz C, Zeti A. Bioceramic-based root canal sealers: a review. International journal of biomaterials. 2016;2016.