



Fracture resistance of endodontically treated root obturated with AH plus, MTA Fillapex, OneFill and Neosealer (A comparative in vitro study)

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Abstract

Aim: The objective of this study was to compare the fracture resistance of root canals that have undergone endodontic treatment and have been filled with four distinct types of root canal sealers. **Material and Methods:** Sixty extracted palatal root of upper molars were collected and sectioned to get a 11mm root length. All root canals were instrumented using edge endo X7 system rotary files, and 35# size was the final size used to finish all the canals. After instrumentation, the samples were separated into four groups of 15 samples each according to the type of sealer, a single cone obturation technique was used : Group 1: obturated with Neosealer and gutta-percha. Group 2: obturated with AH plus sealer and gutta-percha. Group 3: Obturated with Onefill BC sealer and gutta-percha. Group 4: Obturated with MTA-Fillapex sealer and gutta-percha. After incubation period of 7 days at 37°C and 100% humidity the samples covered with thin layer polyvinylsiloxane impression material to simulate a periodontal membrane and then molded in acrylic blocks so as to set the samples ready for fracture resistance test using universal testing machine at a cross head speed of 0.5mm/min. One-way ANOVA and Post hoc tests assessed the data statistically. **Results:** The findings indicated that fracture resistance was significantly higher in those canals that were filled with Neosealer BC sealer (69.90 N) in comparison to the other different sealers used in the study ($p \leq 0.05$). A non-significant differences were found between (AH Plus and MTA- Fillapex) ($p > 0.05$), although Onefill BC showed highest mean of fracture resistance (65.07 N) than MTA- Fillapex and AH plus sealer (63.80 N, 63.64 N) respectively. AH plus sealer which is the least mean fracture resistance (63.64 N).



Conclusion: Neosealer Bioceramic sealer group demonstrated the highest fracture resistance compared to Onefill bioceramic. Both MTA Fillapex and AH plus showed the lowest fracture resistance.

Keywords: bioceramic sealer, edge file X7, fracture resistance, OneFill sealer, Neosealer, AH plus.

Introduction

The strength of teeth that have received endodontic therapy is contingent upon the quantity of tooth structure that remains following canal preparation. Root fractures during root canal therapy are impacted by three factors: excessive obturation without proper pressure control, instrumentation, and dentin dryness during endodontic treatment. (phukan *et al.*, 2017). The confluence of these variables, in conjunction with the occlusal stress on the teeth, augments the probability of a root fracture. Furthermore, the synergistic influence of Intracanal irrigants and medicaments may have an impact on both mechanical and physical characteristics of the root dentin, potentially leading to the failure or fracture of teeth that have undergone endodontic therapy. (Bhat *et al.*, 2012).

For teeth that have had endodontic treatment to be as strong as possible, obturation materials are crucial. As stated by Khan *et al.* (2015). A common material for root canal filling is gutta-percha mixed with a sealant. As stated in the 2007 study by Gulsahi *et al.* Because dentin's elastic modulus is higher than gutta-percha's, the latter has a more significant impact on the reinforcement of roots following root canal treatment (Ribeiro *et al.*, 2008).

The Zinc Oxide Eugenol (ZOE) sealer is the most often utilized root canal sealer, it has been utilized for numerous years. because of its commendable physicochemical properties. However, the constant hydrolysis of eugenol or zinc oxide might lead to leakage and recontamination of the root canal system, resulting in post-treatment complications. (Kumar & Shruthi, 2012). Various study approaches have devised materials that improve the ability to stick to the root canal system. This procedure is believed to enhance

both adhesion and mechanical interlocking, so strengthening the residual root structure and reducing the chance of fracture. (Uppalapati & Mandava, 2012).

AH Plus sealer is an epoxy resin-based sealer that possesses characteristics such as convenient manipulation, the possibility for enhanced adhesion to dentine and Gutta-percha surfaces, and effective sealing capabilities, Resin-based root canal sealers are preferred because to their capacity to penetrate dentinal tubules. These qualities are regarded as crucial among root canal sealers. (Patil *et al.*, 2013).

MTA-FILLAPEX is a mineral trioxide aggregate (MTA)-based, The root canal sealer contains a salicylate resin with 13% MTA, which is included for its antibacterial and biocompatibility characteristics. (Shantiaee *et al.*., 2010). MTA Fillapex liberates free calcium ions (Ca^{2+}) that facilitate the healing procedure by provoking the regeneration of tissues. (Sagsen *et al.*, 2011).

In 2021, Medicus plans to take the lead in the dental industry's endodontic solution market with the launch of one-fill PT, a high viscosity bioceramic sealer designed to repair orifice recapping, block-out perforation, and emergency cases. A recent study contrasted one fil with a competing product. (Medicus instruction manul, 2021)

In 2022, Root canal sealers made of bioceramic material and epoxy resin were tested for their cytocompatibility. Based on the findings, bioceramic root canal sealers are the most practical and risk-free option for preventing the following issues: severe sealer leaking past the apical foramen and compromised perforation of the canal wall (Jose Kuis Sanz, 2022).

The Neosealer flow is specifically designed to enhance the efficiency and cost-effectiveness of both heated vertical and

single cone obturation techniques.

The MTA-based bioactivity hydroxyapatite form of the bioceramic sealer contains a higher amount of bioactive cement compared to the original version. This ensures a bioactive sealing effect. In contrast, the resin-based sealer Neosealer Flo is dimensionally stable and free of resin, allowing for maximum bioactivity. It does not cause staining and has an extended working time of 40 minutes, with a setting time of 11 hours, fine particles size allows excellent flow to fill and seal lateral canal, high radiopacity, high pH to promote osteogenic response. (avlon biomed-instruction manual, 2020).

The aim of this study was to compare the fracture resistance of endodontically treated root obturated with gutta percha and four types of sealers; AH plus, MTA Fillapex, OneFill and Neosealer.

Materials And Methods

The current study included sixty individual maxillary molar teeth with a single palatal root, from patients aged 18 to 25 years. First, periodontal curettes were used to remove soft periodontal tissue from teeth. Then, 0.1% thymol was used to store the root. A dental microscope 24x (Koolertron, Shenzhen, China) was used to examine the extracted teeth for any signs of damage, such as cracks, fractures, or external resorption. When choosing these teeth, much attention was paid to making sure their buccolingual and mesiodistal dimensions were similar. To achieve a standardized root length of 11 mm, crowns were cut using a diamond disk attached to a straight hand-piece that was under water coolant. To ensure the correct working length, A k-file of size #15 was inserted into the canal until its tip reached the apical opening. Subsequently reducing the length of the file by 1 millimeter. Getting clean and shaping of the root canals were done using edge endo X7 heat treated rotary NiTi files (EdgeEndo, USA) Electric Motor Endo-Mate instruments were

used to instrument the canal. (manufactured by Woodpecker in China) operating at a pace of 300 revolutions per minute. The instrument used to prepare the canal was a 35# master apical file. After completing the instrumentation, a 5 mL solution of 17% ethylenediaminetetraacetic acid was used to remove the smear layer in the root canals. This was followed by flushing 5 mL of a 3% sodium hypochlorite solution for irrigation. Finally, a total of 10 milliliters of distilled water was employed to flush the canals in each of the samples.

Grouping Samples

Group 1: Obturation with gutta percha and neosealer BC sealer.

Group 2: Obturation with gutta percha and AH Plus sealer.

Group 3: Obturation with gutta percha and Onefill Bc sealer.

Group 4: Obturation with gutta percha and MTA-Fillapex sealer.

Different types of root canal sealers were used to divide the samples into four groups, For all sealed groups, The sealers were mixed in accordance with the requirements set forth by the maker, and the single-cone obturation method was used to fill all of the canals.

The specimens were placed in an incubator set at 37°C with 100% relative humidity for 7 days so that the sealers could fully set. By applying a thin layer of polyvinylsiloxane impression material to the root surface, extending up to 2 mm below the top of the root, it was possible to replicate the characteristics of a periodontal ligament. Subsequently, each tooth was positioned in an upright manner within acrylic resin, with only 2 mm of the root exposed. This was achieved by utilising Using a plastic ring as a mold to compress the acrylic. Fracture resistance testing was conducted with a universal testing equipment. (Instron Corp, model H50KT, England) figure (1). The blocks containing the samples were set on the base of the testing apparatus. The top section was

connected with a metal-like spreader with a tip diameter of 0.8 mm, and pressure was exerted vertically along the root's long axis. The metal tip was centered over the canal orifice. A crosshead speed of 0.5 mm/minute was used to gradually increase the vertical force on each sample until the root was fractured. A fracture occurs when the applied force abruptly and significantly decreases by more than 25%. During the moment of fracture, a distinct sound can be perceived and heard, and the amount of force exerted on each sample was measured in Newtons. Figure (2)

The fracture load data was analyzed statistically using SPSS V.25 (IBM, New York, USA) to investigate the forces

The ANOVA analysis (Table 2) revealed a statistically significant variance among the groups, with a significance level of 0.05. A Tukey's test was performed to conduct post hoc multiple comparisons among the groups, as shown in Table 3. Neosealer BC sealer exhibited a statistically significant disparity in comparison to the other groups ($p < 0.05$).

No statistically significant difference was found between the AH Plus group and the MTA-Fillapex group.

Discussion

During this investigation, certain criteria were established to standardize the study groups. The criterion involved choosing maxillary molars with a palatal root that is straight, has just one root canal, a foramen placed in the center, and an apical diameter that is the same as the initial file size of 20#. Furthermore, to ensure that the root samples did not lose any moisture, they were irrigated regularly during the examination.

Anatomical differences, age, and the time of tooth extraction all play a role in influencing the results, making it difficult to standardize the assessment of fracture strength in human teeth. (Marshall, 1993). It is essential to standardize features like root canal diameter and length (both buccolingual

responsible for causing root fractures. The objective was accomplished by employing one-way ANOVA. Afterwards, Tukey's multiple post hoc test was used to compare the groups.

Result

The normality of the data in the current study was evaluated using the Shapiro-Wilk test, which confirmed a normal distribution. ($p > 0.05$) (Table 1). The group with the highest average fracture resistance was Group 4 (neosealer BC), with a value of 69.90 N. This was followed by Group 2 (onefill BC) with a value of 65.07 N, Group 3 (MTA-Fillapex) with a value of 63.80 N, and Group 1 (AH Plus) with a value of 63.64 N. (Fig. 3).

and mesiodistal) when testing with extracted teeth. In this study, all roots were standardized in terms of size of preparation, root width and length. (Sagsen et al., 2007)

A study looked at how different rotary files made of nickel and titanium affected the root dentin. Utilizing this method revealed a diminished capacity to resist root fractures and increased susceptibility to craze lines and dentin cracks when contrasted with the use of hand files. (Tavanafar *et al.*, 2015), One possible advantage of using rotational methods to prepare root canals is that they produce a more circular cross-section, which may help distribute stresses and forces better when the root canal is filled. (Versluis *et al.*, 2006). Research has demonstrated that edge endo X7 rotary files do a better job of preserving the original canal location, cause less deformation to the canal shape, and reduce the occurrence of micro-cracks in the tooth's root dentin than other modern mechanical tools used for root canal therapy. (Sobh *et al.*, 2021; Majumdar *et al.*, 2022) Conversely, irrigants cause dentin to lose moisture, which in turn reduces its elasticity and root fragility. (Sim *et al.*, 2001).

EDTA administration has a harmful impact on dentin, however this effect can be reduced by using a lower amount and shorter duration

of EDTA exposure. (Mai et al., 2010). Additionally, the EDTA's low surface tension enables it to effortlessly penetrate the teeth's tubules and remove the smear layer at a depth ranging from 2.5 to 4 micrometers. (Jhamb et al., 2009; Yilmaz et al., 2011), Following the elimination of the smear layer, there was a modification in the surface energy, facilitating the flow and adaptation of the root canal sealer. This improvement enhances its ability to adhere to the root canal wall, resulting in a higher sealing efficiency. (Çalt & Serper, 2002). Distilled water was employed as a last rinse to counteract the impacts of irrigating solutions.

The tooth's reinforcement by an obturation material is dependent upon its ability to penetrate the dentinal tubules. These elements, including the tubules' size, the diameter of the material particles, and the substance's reaction rate, influence tooth fracture resistance. It is believed that root canal sealers that can bond to root dentin have the potential to enhance the resistance of teeth that have undergone endodontic treatment to fractures. (Bird et al., in 2012).

In the present study, a single cone technique was used. This technique has the benefit of speeding up the root canal filling and reduces the pressure that applied to the root canal walls compared with lateral condensation technique (Chybowski et al., 2018). However, in this technique, more sealer is coated on the canal walls and the risk of intracanal voids would be higher (Wu et al., 2000; Whitworth & Baco, 2005).

Silicone paste was employed to replicate the periodontal ligament and alveolar bone. Replicating the alveolar bone is essential because it can absorb the stresses generated while chewing and endure the compressive forces in fracture resistance testing. The simulation of the periodontal ligament inhibits the accumulation of stress in a specific area and distributes the strains generated by

applying a load across the entire surface of the root. (Mittal et al., 2017)

The vertical root fracture occurred as a result of putting a metal tip like a spreader into the tooth's canal along its longitudinal axis. This method ensures the even distribution of force within the root canal and closely resembles a root fracture that originates from endodontic procedures. In addition, the teeth had a mere 2 mm of root dentin visible above the embedding substance. This form is clinically more attractive because it effectively enhances the support provided to healthy teeth by the alveolar bone and reduces the occurrence of severe strains caused by bending movements. (Patil et al., 2017; Phukan et al., 2017).

Fracture resistance

The present study conducted a comparison of the impact of four different sealers on the strength of root dentin. The results indicate that the Neosealer group had the highest average fracture resistance of root dentin, followed by the Onefill sealer group, MTA-Fillapex group, and AH plus sealer group, The increased degree of adhesion of Bioceramic to root dentin, compared to MTA Fillapex and AH Plus, may explain the much superior fracture resistance shown in the present investigation for Bioceramic.

Bioceramic forms a chemical bond with dentine due to the development of hydroxyapatite during the setting process. Its hydrophilic characteristics also allow it to spread easily across canal walls because of its low contact angle. The result is a strong and reliable hermetic seal. [Gada VJ et al., 2015] Because of its dentin-like compressive elastic modulus, MTA Fillapex sealer can increase root strength. This substance can also produce hydroxyapatite. Conducted by Mandava et al. (2014) and Buraksagsen et al. (2012), the results are in close agreement with the current findings.

The neosealer bioceramic demonstrated superior outcomes in comparison to the other

sealers examined, with statistical significance ($P < 0.05$). Bioceramic-based endodontic sealers form a chemical link with the radicular dentin by producing hydroxyapatite during the setting process (Cobankara et al., 2002). Another reason for its hydrophilic nature is its low contact angle, which facilitates easy spreading across the canal walls. This results in agreement with other studies as Patil et al. (2017); Yendrembam B et al. (2019); Nermine H & Reham H. (2023).

The study disagrees with the findings of Dibaji et al. (2017), who reported that the bioceramic group had lower fracture resistance compared to AH Plus. Additionally, Topçuoğlu et al. (2013) reported a greater fracture resistance value for bioceramic, although the difference between the groups was not statistically significant. This discrepancy could be attributed to variations in methodology.

However, it has been demonstrated that the presence of pores in the sealer, shrinkage during the solidification process, and dissolution can result in the formation of empty spaces and openings. (Sen et al., 1996; Kim et al., 2010; Pawar et al., 2014).

In this study, the fracture force was applied using a spreader-like metal tip with an 0.8 mm diameter that was positioned over the orifice of the obturated canal (Osiri et al., 2018). Then, the vertical force was slowly increasing to exert a load parallel to the long axis of the root. This method affords a force distribution from the internal surface of the root canal which leads to wedging action to simulate a root fracture of endodontic origin (Osiri et al., 2018). Furthermore, the roots had only 2 mm out of the acrylic block which is more appealing clinically as it simulates the support by alveolar bone efficiently that is given to healthy teeth (Patil et al., 2017; Phukan et al., 2017).

Another potential factor may be associated with the polymerization shrinkage of resin that contains AH Plus sealer. According to Wu et

al. in 2000 and Whitworth and Baco in 2005, there is a correlation between the amount of sealer used within the canal and the extent of polymerization shrinkage. It has been reported that higher amount of sealer in the canal is needed when using a single cone obturation technique. Therefore, polymerization shrinkage might occur that disrupts the close initial contact between the surrounding dentin and the sealer and produces shrinkage gaps and reduce the fracture resistance of obturated roots (Omran & Alhashimi, 2018).

Neosealer is more fracture resistance than onefill bioceramic sealer. This might be due to different in composition and amount of bioceramic, amount of neosealer bioceramic more than onefill sealer bioceramic about 17% according to instruction manual.

The observed fracture in the present investigation had a buccolingual orientation. Buccolingual fractures have been found to be the most prevalent in numerous investigations. The study conducted by Zamin C et al. in 2012 found that the direction of force applied can potentially impact the direction of fracture. (Lertchirakarn V et al., 2002).

Based on the limitations of this investigation, it may be concluded that the Bioceramic Sealer enhances the fracture resistance of teeth that have had endodontic treatment more effectively than the MTA-based sealer (MTA Fillapex) or the epoxy resin-based sealer (AH Plus).

However, it is recommended to evaluate the long-term effect and the ability of all the sealers to enhance the resistance to fracture of the endodontically treated root.

Conclusion

The use of root canal sealers resulted in an increase in the resistance to fracture of teeth that had undergone endodontic treatment. Among the different groups, The Neosealer Bioceramic sealer exhibited highest level of fracture resistance compared to Onefill bioceramic whereas MTA Fillapex, and AH plus had the lowest fracture resistance.

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Conflict of interest

The authors reported that they have no conflicts of interest.

(22Conflicts of Interest

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Figure1 : universal test machine (model H50KT, England)

Table1: Descriptive statistics including Mean (N), SD, Min and Max for all groups.

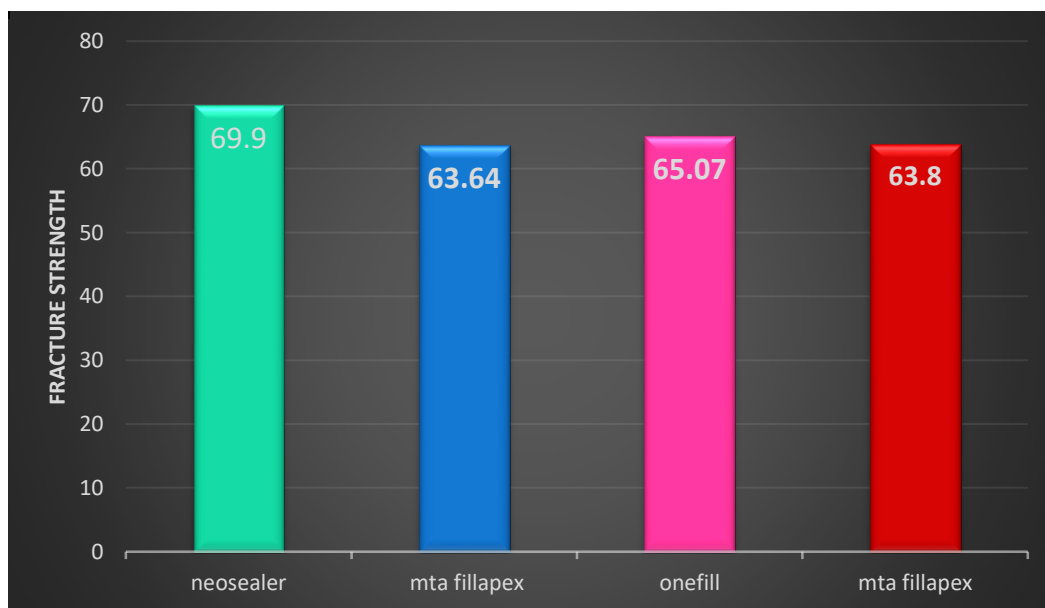
Groups	No.	Mean(N)	SD.	SE.	Min.	Max.
Group1 neosealer	15	69.90	1.93	0.50	66.29	73.27
Group 2 Ah plus sealer	15	63.64	0.95	0.25	62.64	65.14
Group 3 Onefill sealer	15	65.07	1.18	0.30	62.89	67.55
Group 4 Mtafillapex	15	63.80	1.04	0.27	62.04	65.27

SD = Standard deviation , max= maximum , min = minimum

Table2: ANOVA test for detection of statistical difference among groups

Groups	SS	df	MS	F	p-value
Between Groups	388.52	3	129.51	72.917	.000
Within Groups	99.461	56	1.776		
Total	487.98	59			

From table (1+2) a significant difference was found among groups.

figure3: Bar chart graph for mean fracture resistance of different groups

From table (1) and Fig (3), group1(neosealer) shows the highest mean value (69.90)

Table3: Tukey HSD test for multiple comparisons between groups.

Groups		p-value	Sig.
Group 1	Group 2	0.000	S
	Group 3	0.000	S
	Group 4	0.000	S
Group 2	Group 3	0.024	S
	Group 4	0.988	N.S
Group 3	Group 4	0.055	N.S

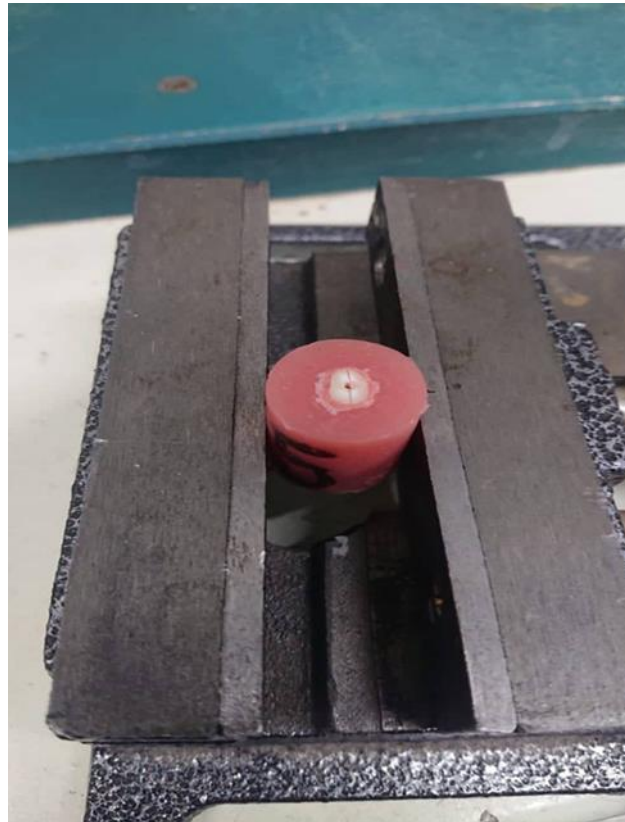


Figure2: root fracture after test