EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
Vol. 70, 1901:1909, April, 2024
Print ISSN 0070-9484 • Online ISSN 2090-2360
Conservative Dentistry and Endodontics
Submit Date : 21-12-2023 • Accept Date : 13-01-2024 • Available online: 20-04-2024 • DOI : 10.21608/EDJ.2024.257085.2841

THE EFFECT OF DIFFERENT OBTURATION TECHNIQUES ON THE FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH OBTURATED USING BIO-CERAMIC SEALER

Mayada Khaled El-Gamal*, Mahmoud Mohamed Fahim**
and Medhat Taha Elfaramawy***

ABSTRACT

Aim of the study: was to evaluate the Fracture resistance of endodontically treated teeth obturated using bio-ceramic sealer with different obturation techniques.

Materials and method: A total of thirty-two extracted human mandibular premolar teeth were collected. Teeth were decoronated at the cemento-enamel junction to standardize the working length (14 mm). Biomechanical preparation was done using protaper next up to X4 (40/06). Teeth were randomly assigned into four groups, each of eight, according to sealer and obturation techniques to be used: (group CL) ceraseal\lateral compaction, (group CH) ceraseal\hydraulic compaction, (group CW) ceraseal\ warm vertical compaction, and (group AL) AH plus \lateral compaction. After obturation roots were loaded vertically under the Universal testing machine until fracture occurred.

Conclusion: This study concluded that the obturation technique has insignificant effect on fracture resistance of teeth obturated using bio-ceramic sealer (CeraSeal). Teeth obturated using AH plus sealer showed superior fracture resistance than that obturated using CeraSeal sealer.

KEY WORDS: bio-ceramic, AH plus, obturation techniques, fracture resistance.

* Instructor, Endodontic Department, Faculty of Dentistry, October 6 University
** Lecturer Of Endodontics , Faculty of Dentistry, Ain Shams University
*** Professor, Endodontic Department, Faculty of Dentistry, Ain Shams University.

INTRODUCTION

Root canal treatment is a critical procedure that involves diagnosis, chemo-mechanical preparation, and complete filling of the root canal space. The success of this treatment relies on achieving an ideal environment by neutralizing bacterial colonies, destroying biofilms, and sealing the apical and coronal regions to prevent leakage from the peri-radicular tissues. Proper obturation plays a crucial role in preventing bacterial microleakage. Gutta-percha is a commonly used root canal sealer. However, it lacks adhesive penetration into dentinal tubules[1].

Root canal sealers not only fill the spaces between core material and root canal walls but also spread within the complex anatomy of the root canal system forming a fluid-tight seal.

Resin-based sealers have gained wide popularity due to their low solubility, excellent apical sealing ability, and ease of handling. AH Plus has been considered the gold standard sealer due to its resistance to resorption and dimensional stability[2]. However, it has certain drawbacks, including mutagenicity, cytotoxicity, and challenges in adhesion to canal walls due to its hydrophobic nature and moisture retention in dentinal tubules.

In recent years, bio-ceramic-based root canal sealers have gained significant attention in clinical practice owing to their several advantages, including high alkalinity, effective antibacterial properties, biocompatibility, no shrinkage, and chemical stability in the biological environment[3].

In addition to sealers, different obturation techniques have been developed to ensure optimal obturation and hermetic three-dimensional filling of the root canal system including cold lateral compaction (CLC), warm vertical compaction (WVC), and hydraulic compaction (HC).

CeraSeal which is a newly introduced BC sealer to the market. It is available as a premixed paste to be directly injected inside the root canal. The manufacturer claims that it has excellent stability and high sealing ability[4].

Numerous factors make the root filled teeth more brittle and susceptible to fracture including: overcleaning and shaping which results in massive loss of tooth structure and friction between files and dentine may induce cracks[5], tissue dehydration, prolonged disinfection with chemical agents[6], extensive pressure during obturation[7].

To our knowledge there is sufficient data on the impact of various bio-ceramic sealers on the fracture resistance of endodontically treated teeth, but few literatures are available regarding the influence of obturation techniques on the fracture resistance of roots treated with Ceraseal compared to AH plus.

So, the aim of this current study was to evaluate the effect of different obturation techniques using Ceraseal BC sealer on the fracture resistance of endodontically treated teeth.

MATERIALS AND METHODS

Sample size calculated depending on a previous study[8]as a reference. If mean ± standard deviation of control group is 370.05 ± 3.73, while the estimated mean difference of intervention group is 6, when the power was 80 % and type I error probability was 0.05. Minimally the study needed seven subjects in each group. Sample size was performed by using independent t test by using P.S. power 3.1.6.

These calculated numbers were the minimum estimation of the sample size, it could be increased to any number although it is above the estimation.

Total sample size = 8 per group

Study was approved by the ethics committee of Ain Shams University, Cairo, Egypt (FDASU RecEM1121011). Thirty-two single rooted human sound mandibular premolar teeth free of any defects, cracks, caries, restoration, or curvature were collected. Teeth were decoronated at the cemento-enamel junction with a high-speed bur under copious water spray to achieve a standardized length of 14 mm. after working length determination canals were prepared with ProTaper Next rotary file system up to X4 (40/06). During chemo-mechanical preparation canals were irrigated by a 27-gauge needle 1 mm with 5% NAOCL, 17% EDTA and saline as a final flush. Roots were randomly assigned into four groups (n=16) according to sealer\ obturation technique used.

Group CL (n = 8): CeraSeal with a lateral compaction technique

Group CH (n = 8): CeraSeal with a hydraulic technique

Group CW (n = 8): CeraSeal with a warm vertical compaction technique

Group AL (n = 8): AH plus sealer with a lateral compaction technique

For obturation, AH Plus sealer was mixed according to manufacturer's instructions. CeraSeal Sealer required no mixing as it is premixed in airtight syringe ready for injection into root canal.

For the lateral condensation technique, the master cone gutta-percha (#40/0.06) was inserted to fit with tug back at the working length. Then, canal walls were coated with the sealer-dye mixture with the master GP cone. Then, the master cone gutta-percha (#40/0.06) was introduced slowly into the root canal until reaches the working length. A size 25 endodontic finger spreader was inserted 2-3 mm short of the working length, and accessory gutta percha cones (#25/0.02) were used. Repeated insertions of accessory gutta-percha points were done until complete obturation and the spreaders could not penetrate more than 2 mm in the canals. Excess gutta-percha was sheared off by using a heated plugger and vertical compaction was performed at the orifice level.

For hydraulic technique, the sealer was injected in the canal 2-3 mm shorter than working length and then master gutta-percha cone (#40/0.06) was inserted in the canal until reaches the working length, the cone was sheared off at the level of the orifice and lightly condensed by heated plugger.

For warm vertical compaction technique, the sealer and cone were seated as in the haydraulic technique, and then the fast -pack unit of the obturation system (Eighteeth Co., Cairo, Egypt) was used at 180C to remove the gutta-percha 4 mm short of the working length followed by condensation with a plugger. Backfilling was performed with the fast- fill unit 200C followed by condensation with a plugger.

Radiographs were taken to evaluate the obturation quality. Samples with inadequate obturation were discarded. All specimens were stored for 2 weeks at 37C in 100% humidity to allow the sealers to set.

Five mm from the apex of all roots were waxed then it was embedded into acrylic resin using a mold metal leaving 9 mm of the root extruded out of the acrylic block. After acrylic polymerization, roots were removed from the resin blocks, cleaned from wax by curette then coated with polyvinylsiloxane impression material layer then returned into resin blocks. The blocks with the vertically aligned roots were then mounted on the lower fixed compartment of the Instron testing machine. Compressive load was applied to the canal orifice by a ball with 2 mm diameter at a crosshead speed of 1 mm/min until fracture[9] figure (1). The load at fracture was recorded by the computer monitoring software and measured in Newton (N).

STATISTICAL ANALYSIS

Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016. All quantitative data of Penetration depth and push out bond strength were presented as mean and standard deviation in tables and graphs.

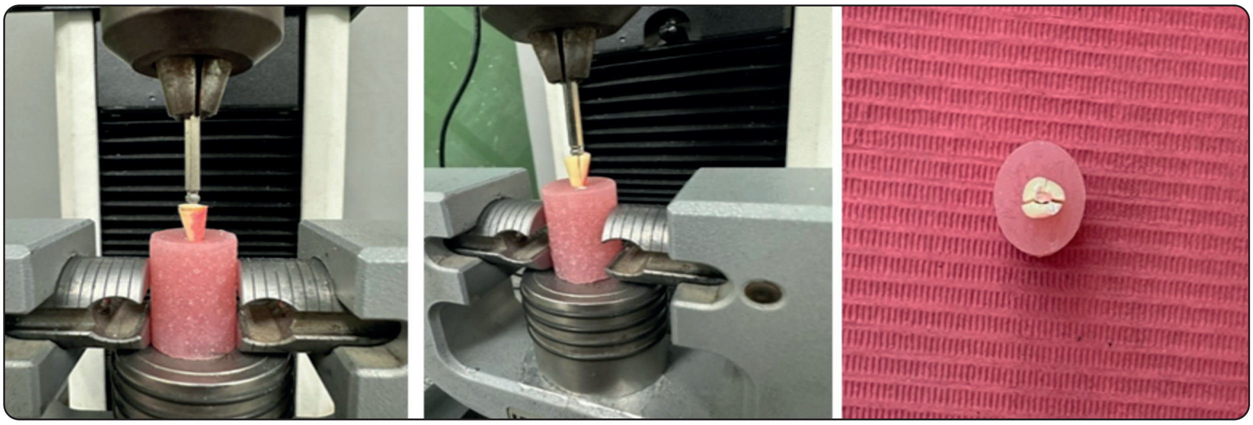

Fig. (1) Sample fracture after vertical loading with the Universal testing machine.

Exploration of the given data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality. It was revealed that the significant level (P-value) was shown to be insignificant as P-value > 0.05, which indicated that data originated from normal distribution (parametric data) regarding all sections of different groups.

One-way ANOVA test was used to compare between all groups followed by Tukey`s Post Hoc test for multiple comparisons.

The significance level was proved at $p \leq 0.05$. The results were statistically significant if the p-value was less than 0.05.

TABLE (1) Normality exploration of all data:

	Group CL	Group CH	Group CW	Group AL
Fracture resistance	>0.05 ns	>0.05 ns	>0.05 ns	>0.05 ns
	>0.05 ns	>0.05 ns	>0.05 ns	>0.05 ns

Non-significant difference as P>0.05 (normal data).

RESULTS

Minimum, maximum, mean and standard deviation of fracture resistance in all groups were presented in table (2) and figure (2).

Comparison between different groups was performed by using One Way ANOVA test which revealed significant difference between them as P=0.95, as Group AL (2916.84 ± 802.91) was insignificantly the highest, while Group CL (2683.86 ± 682.92) was insignificantly the lowest.

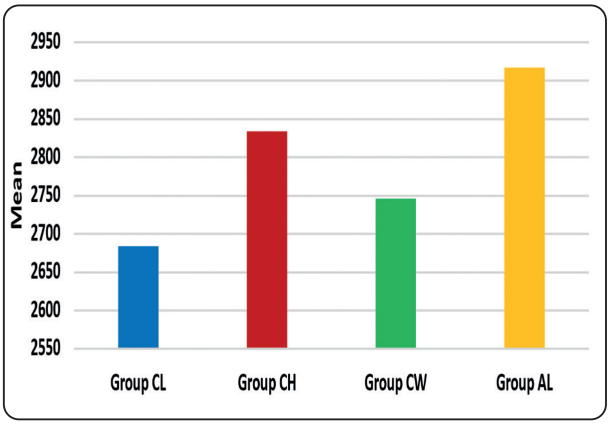

Fig. (2) Bar chart showing Fracture resistance of all groups.

TABLE (2) Fracture resistance of all groups and comparison between them using One Way ANOVA test:

	Minimum	Maximum	Mean	Standard Deviation	P value (One Way ANOVA test)
Group CL	2200.96	3166.758	2683.86 [a]	682.92	0.95 ns
Group CH	2169.485	3498.016	2833.75 [a]	939.41	
Group CW	2229.993	3261.599	2745.80 [a]	729.46	
Group AL	2349.099	3484.59	2916.84 [a]	802.91	

Means with different superscript letters were significantly different as P<0.05.
Means with the same superscript letters were insignificantly different as P>0.05.
Ns: non-significant difference as P>0.05.

DISCUSSION

Successful endodontic treatment aims to effectively eliminate microorganisms and prevent reinfection by sealing anatomical complex structures of the root canal which contribute to treatment failure. Creating a tight seal between the canal wall and core material is crucial and various obturation techniques have been developed for this purpose, intending for obtaining good strength in addition to better seal, including cold lateral compaction (CLC), warm vertical compaction (WVC), and hydraulic compaction (HC) techniques.

Sealers play a mandatory role due to the lack of gutta-percha adhesiveness to canal walls. Their primary function is to create a bond between obturation material and canal walls plugging the spaces between them[10]. They adhere to the root canal dentin surface and strengthen the remaining tooth structure, thereby contributing to the long-term success of an endodontically treated tooth[11,12] by increasing the tooth resistance to fracture. Furthermore, they spread within anatomical irregularities of the root canal system, and tubules of the dentin improving the sealing ability[13]. Consequently, Sealer choice significantly influences the obturation success and there has been continuous enhancement of root canal sealers.

This study aimed to assess teeth fracture resistance of a new bio-ceramic sealer (CeraSeal) compared to a widely used resin-based sealer (AH plus). Bio-ceramic sealers have gained popularity over the past three decades, they have bioactive characteristics promoting tissue growth without negative effects, high alkalinity, effective antibacterial property, biocompatibility, no shrinkage, and chemical stability in the biological environment[14].

In this study, CeraSeal, is a distinctive newly introduced bio-ceramic sealer known for its ability to form a chemical bond with dentin during setting, it produces hydroxyapatite, creating a “mineral infiltration zone”. The manufacturer claims that it has a unique stability as it utilizes the existing moisture within dentinal tubules to complete its setting reaction without any shrinkage, establishing a fluid tight and gap free interface between the obturation and root dentin[15]. Moreover, claims that it has superior sealing ability[16]. Additionally, it readily diffuses into the dentinal tubules, ensuring a hermetic seal[17].

This in vitro study was performed on lower premolar teeth as the occlusal forces on them are three times higher than those on other teeth[18]. So, they were chosen because of the high occurrence of vertical root fractures[19 20] aiming to have an accurate assessment for the effect of sealer on teeth fracture resistance. To generate similar occlusal forces, Universal testing machine has been used and a vertical load was applied by a head into the coronal canal orifice[21] by a ball with 2 mm diameter at a crosshead speed of 1 mm/min, this method produces force starting from the canal inner which is similar to clinical status[22]. Also, load was applied by 90 degrees to the long axis of the teeth, this method permits load to be entirely transferred to the root[23] [24] with decreased bending moments and maximum load located more cervical, leading to smaller stresses. This study is designed to mimic the clinical situations, as it simulates the support provided to teeth by periodontal ligaments and alveolar bone by coating the roots with polyvinylsiloxane impression material layer and resin blocks[25].

Regarding teeth mechanical preparation, root canals were prepared using ProTaper Next (PTN) rotary files. PTN has been manufactured from M-wire, a heat-treated NiTi alloy known for its high flexibility. This makes them assumed to apply less pressure on tooth structures during root canal preparation[26] hence inducing less cracks formation.

Concerning the irrigation protocol, 5% sodium hypochlorite was used owing to its effectiveness in organic content disintegration, which was also performed in previous studies[27,28,29]. A final flush was done using 17% EDTA which acts as a chelating agent removing the organic part of the remaining pulp. Removal of the smear layer will enhance the sealer tubular penetration. After cleaning and shaping, all canals were dried with paper points to eliminate moisture which affect the penetration of resin-based sealers[30].

Various obturation techniques were used to achieve the 3D filling concept, CLC was chosen because it has always been the standard obturation technique[31]. It is easy, cost effective and allows for good apical control. WVC obturation method was also selected as it improves the homogeneity and surface adaptation of GP allowing proper filling of root canal complexities and adequately adapt to the canal abnormalities and isthmuses resulting in a three-dimensional obturation[32]and a tight seal at all root canal entry portals[33]. HC technique was chosen as it is a simple and fast process, additionally, bio-ceramic sealers were intended by the manufacturer to be used with cold obturation techniques, in particular HC technique[34].

Results of the current study showed that AH Plus sealer showed the highest mean value for fracture resistance than CeraSeal, with no statistically significant differences between all groups. This may be attributed to the covalent bond formed between the epoxy resin sealer open epoxide ring and the exposed collagen network amino groups in the radicular dentin that might result in a stronger bond of AH plus to dentin[35] [36]

Although the results of CeraSeal in this study are not significantly different from AH Plus, yet the lower mean could be attributed to the fact that CeraSeal does not bond to dentin, but it forms hydroxyapatite interfacially, which increases the frictional resistance of the filling material[37]. these results agree with a study by Mandava et al[38] in which the resin-based sealer exhibited higher fracture resistance than MTA sealers. Similarly, Mittal et al.[39] showed that resin sealer AH Plus had higher fracture resistance than MTA Fillapex without significant difference.

On the other hand, there is a disagreement with studies by Patil et al[40] and Elfaramawy et al.[41], in which roots obturated with bio-ceramic sealer exhibited higher fracture resistance than those obturated with resin-based sealer.

Regarding CeraSeal the highest mean fracture resistance values were found in CH group followed by CW then CL groups with no significant difference, which can be explained by the large spreaders size and the stress generated on the root canal wall by them during CLC that may result in tooth weaking leading to less fracture resistance[42].

Also, forces by the hand pluggers and heat applied during WVC cause thermal expansion in the canal dentin and consequently influence the fracture resistance adversely[43]. Another explanation may be due to extensive dentin removal to facilitate the insertion of pluggers [44].

This comes in line with the study of Alkahtany et al.[45] Who showed that roots obturated with gutta-percha and bio-ceramic sealer (TotalFill) with SC showed higher fracture resistance than CLC. Yadav et al.[46] reported higher fracture resistance values by Downpack backfill obturation technique followed by CLC technique. In contrast to study performed by Mandhane et al.[47] In which CLC showed superior fracture resistance than Thermoplasticised gutta percha.

CONCLUSION

Within the limitation of this study, it was concluded that:

- Obturation techniques have no effect on teeth resistance to fracture.
- Teeth obturated with AH plus sealer show superior fracture resistance than CeraSeal.

However, Future studies need to consider the application of cyclic loading to mimic oral conditions where load and forces are in different directions.

CONFLICT OF INTEREST

The authors state that they do not have any conflict of interest.

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