



Apical Microleakage of Root Filled Tooth Using New Bioceramic Sealers Used with Two Different Obturation Techniques

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Abstract

Background and objective: The choice of different root canal sealers can influence the amount of apical microleakage. This study aims to assess the microleakage of four different sealants used in root canals.

Methods: This *in vitro* study was conducted from June 2022 to June 2023 in Duhok city in research medical lab at college of medicine. A total of eighty human extracted 1st premolar teeth were extracted and used. The crowns were removed, and the root canals were prepared. The specimens were assigned at random to four groups (n=10) according to the type of sealer used and the two obturation techniques applied. The outer sides of the samples were coated with nail polish to provide insulation. Following the completion of the endodontic procedure, the samples were immersed in methylene blue dye for a duration of 72 hours. Each group was assessed for microleakage using graduated microscope.

Results: The study showed that maxima Mineral trioxide aggregate bioceramic had the lowest level of microleakage of 0.5mm, on other hand, Zinc Oxide Eugenol-Single Cone exhibited the greatest level of microleakage of 2.5mm, the difference was significant with p-value <0.0001, and for the thermafill technique the mean value was 0.68 while for the single cone was 2.19 with the p-value < 0.0001 which was also significant.

Conclusion: maxima showed the best results in microleakage however, there is no technique or materials that completely eliminate leakage at all.

Keywords: Apical Microleakage, Bioceramic, Endoseal Mineral trioxide aggregate, Methylene Blue, Sealer

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Introduction

The primary objective of root canal treatment is to thoroughly disinfect the endodontic region by employing mechanical instruments and chemical solutions.¹ The ultimate goal is to achieve a three-dimensional infill that creates a stable and impermeable barrier. This barrier serves to protect the peri radicular tissues from the bacteria found in the oral cavity.² Endodontic fillings often employ a type of gutta-percha, a semi-solid core substance, and a liquid sealer as the main materials. This combination has traditionally been employed in cold gutta-percha processes, such as single-cone or lateral condensation, as well as warm compaction methods. The apical seal's three-dimensional efficacy in cold obturation techniques is solely governed by the sealer.³ In contrast, warm techniques effectively create a thorough and hermetic seal at the apex of the tooth by employing both the sealer and heated gutta-percha. Zinc oxide-eugenol-based sealers are formulated by combining a liquid solution of eugenol with a zinc-containing powder. They are extensively utilized in endodontics because of their antibacterial properties.⁴ The ability to be absorbed if they are inadvertently pushed into the surrounding tissues and their extremely slow hardening rate.⁵ Nevertheless, there are also drawbacks associated with them, including the possibility of tooth discoloration, shrinkage during the hardening process, cytotoxicity, and disruption of adhesive operations due to the release of eugenol in tissue fluids and dental tissues.⁶ The emergence of calcium silicate-based endodontic sealers has led to a transition towards a more biologically oriented treatment. Bioceramics have garnered significant attention due to their ability to interact with tissue fluids, and their high compatibility with peri radicular tissues, resulting in minimal pain.⁷ There is a small increase in size when the material is inserted,

which helps create a tightly sealed barrier. The material also contains calcium phosphate, which helps it develop a crystalline structure like the materials found in teeth and bones, enhancing its ability to stick to the underlying dentin of the tooth.⁸ Cold gutta-percha techniques have faced criticism due to their limited capacity to completely cover the entire endodontic area in specific situations, such as when dealing with widely elliptical canals or very intricate anatomies.⁹ Conversely, thermal obturation procedures are seen as more suitable for achieving a fully sealed and three-dimensional apex of the root. Several in vitro studies have explored the potential enhancement of the apical seal quality through the utilization of a combination of root canal sealers based on tricalcium silicate and hot vertical compaction.¹⁰ Nevertheless, the results of this study have proved inconclusive. Microleakage is the primary risk factor for the development of apical periodontitis. A variety of methods are employed to detect dental leakage, such as radioisotope penetration, animal research, fluid filtration, bacterial and endotoxin infiltration, dye diffusion, glucose, caffeine, and protein infiltration, and electrochemical or three-dimensional assessment.¹¹ The aim of this study is assess and measure microleakage of bioceramic sealer and ZOE sealer when used with two different obturation techniques.

Material and methods

An in vitro study was carried out on 80 humans extracted lower first premolars. excluding teeth with cavities, fractures, open apices, or resorption sites. After a thorough ultrasonic cleaning to remove any remaining tissue and calculus, the samples were stored in an aqueous solution containing 0.4% chloramine-T until they were required. With a cylindrical diamond bur running at 200,000 rpm on an electric handpiece and plenty of irrigation, the crowns were split horizontally





at the canal entry level. About 12 mm was the new adjustment made to the root lengths. Instrumentation: The instrumentation procedure was carried out using the Protaper Next system. A K-file #15 (produced by Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the canal until the tip was just barely visible at the apical foramen in order to measure the working length. Protaper Next rotary system files were used to carefully shape and enhance the canals. Each instrument was alternated, and a 5.25% sodium hypochlorite (NaOCl) solution was liberally irrigated during the process. All canal's dimensions were tripled in order to match the operating length. Following completion of the required preparations, the canals were washed for 60 seconds with a 5 mL solution of 17% ethylenediaminetetraacetic acid (EDTA) and a 5 mL solution of 5.25% sodium hypochlorite (NaOCl). This process was carried out in order to remove the smear layer. The specimens were then rinsed with distilled water to counteract the effects of the EDTA and NaOCl solutions, and paper points were used to dry the canals. Ultimately, three coats of clear nail polish were applied to the exterior surfaces of the roots, excluding the apical foramen. Before applying the nail polish, a K-file with a diameter of 25 was inserted into the tip to retain the size of the small opening. Obturation of root canal & grouping: According to obturation technique teeth will be divided into two groups: Single cone obturation: Single cone obturation: A solitary gutta-percha cone, which was tapered to match the final shaping tool X3 cone, was placed into the root canal after confirming its position visually and through resistance to pulling. The accuracy of the working length was verified by inspecting the tooth at the apex using a stereomicroscope with a 20× magnification and by conducting periapical radiography. The canal was desiccated, and

the sealer was mixed in accordance with the instructions provided by the manufacturer. The single cone was thereafter covered with sealer and delicately inserted to the working length using a gentle motion, allowing the sealer to move back towards the top of the tooth and preventing any surplus from being pushed towards the tip. In the end, the excess gutta-percha in the crown area was removed using a heated instrument. Carrier based obturation technique: This method involves the use of endodontic files combined with thermoplasticized gutta-percha (GP) material, namely the Goodacre® for ProTaper Next® obturators. A modern carrier-based technology called Thermafil utilizes customized plastic carriers that are coated with GP and undergo thermoplasticization in a ThermaPrep® 2 Oven before being inserted into the canal. Following the cleaning and shaping process, a size verifier that corresponds to the final shaping instrument, specifically the X3 cone, was inserted. The canal walls were thinly covered with sealant, and a heated TF obturator was inserted with strong but gentle pressure. The plastic carrier was cut at the canal opening, resulting in the plastic carrier and GP becoming the permanent filling. The main benefit of this approach is its ability to quickly compress thermoplasticized GP and sealer both horizontally and vertically utilizing a carrier, surpassing the speed of previous methods: Zinc-Oxide-Eugenol-Based Canal Sealer, endoseal MTA Sealer, NEO sealer, MTA bioceramic sealer 'Maxima'. Microleakage test: Prior to conducting the other experimental procedures, the microleakage test necessitated the storage of specimens from each group at a temperature of 37 °C and 100% humidity for a duration of 72 hours. After applying three additional coats of nail polish to the top of the tooth apex, it was submerged in a solution containing a 2% concentration of methylene blue dye.





Afterwards, the tooth was moved to an incubator that was set to a temperature of 37 °C for an additional period of 72 hours. Following color exposure, the roots were meticulously rinsed with flowing water. Subsequently, the samples were submerged in self-curing acrylic resin and placed on coverslips. The teeth were dissected longitudinally on both sides using a diamond disc and handpiece. Pure water was utilized to lower the temperature throughout the cutting process. The slices were meticulously aligned parallel to the elongated axis of the tooth and extended completely towards the tip to uncover the canal area. The specimens were evaluated for microleakage using A graduated microscope from Carl Zeiss Meditec AG in Oberkochen, Germany, with a 20× magnification to measure the degree of dye penetration (in mm). the measurement was done by three examiner and repeated three time for each specimen. Photographs were captured and stored utilizing digital equipment. To evaluate microleakage, the photos were imported into specialized software. The assessment of microleakage start from the apical foramen to dye infiltration. The microleakage data were measured using either medians and interquartile ranges or means and standard deviations. The sealers were compared using Wilcoxon/Kruskal-Wallis tests (Rank Sums), and pairwise comparisons were conducted using the Steel-Dwass method due to the small sample size. An independent t-test was conducted to compare the microleakage of various sealing techniques. The significance level was set at a p-value of less than 0.05. The statistical analyses were performed using JMP®, Version 17.0 (SAS Institute Inc., Cary, NC, 1989–2023). Ethical approval is given by Kurdistan higher council of medical specialties.

Results

The findings of the apical microleakage test for each study group are displayed in Table

(1). There was a notable and meaningful distinction observed among all study groups, as shown by a statistically significant difference ($p < 0.0001$). The results depicted in Figure (1), indicate that Maxima MTA Bioceramic displayed the lowest level of microleakage, followed by Neo Seal Bioceramic and Endo Seal MTA. Conversely, Zinc Oxide Eugenol demonstrated the highest degree of microleakage. The statistical analysis revealed substantial differences among all the experimental groups. Intergroup comparisons in Table (2). showed significant differences in all groups, except for the comparison between Zinc Oxide Eugenol and Maxima MTA Bioceramic ($p < 0.0001$), Table (3), figure (2) and (3).

Table (1): Comparisons of microleakage among different root canal sealers

Sealers	Microleakage mm		P (two-sided)
	Median	IQR	
Endo seal MTA - Single cone	2	0.88	<0.0001
Neo seal bioceramic- Single cone	1.75	0.50	
Zinc oxide eugenol- Single cone	4.25	1.25	
Maxima MTA Bioceramic- Single cone	0.5	0.50	
Endo seal MTA- Thermofil	0.4	0.43	
Neo seal bioceramic- Thermofil	0.4	0.20	
Zinc oxide eugenol- Thermofil	1.4	0.45	
Maxima MTA Bioceramic- Thermofil	0.55	0.10	
Wilcoxon / Kruskal-Wallis Tests (Rank Sums) was performed for statistical analyses. IQR: Interquartile range			





Figure (1): the test spacemen for microleakage

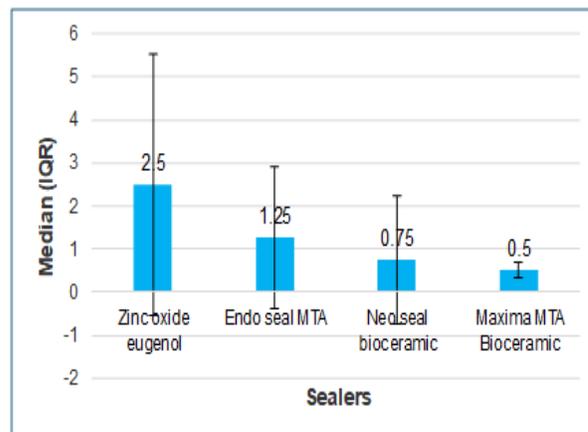


Figure (2): Microleakage of different sealers

Table (2): Significant pairwise comparisons of microleakage between different root canal sealers

Sealers	Sealers	P-Value
Endo seal MTA	Neo seal bioceramic	0.9165
Endo seal MTA	Zinc oxide eugenol	0.0572
Endo seal MTA	Maxima MTA Bioceramic	0.5190
Neo seal bioceramic	Zinc oxide eugenol	0.0193
Neo seal bioceramic	Maxima MTA Bioceramic	0.9703
Zinc oxide eugenol	Maxima MTA Bioceramic	<.0001

Nonparametric Comparisons for All Pairs Using Steel-Dwass Method was performed for pairwise comparisons.

Table (3): Comparisons of microleakage between sealing techniques

Sealing technique	Mean	SD	P (two-sided)
Single cone	2.19	1.39	<0.0001
Thermofil	0.68	0.42	

An independent t-test was performed for statistical analysis.

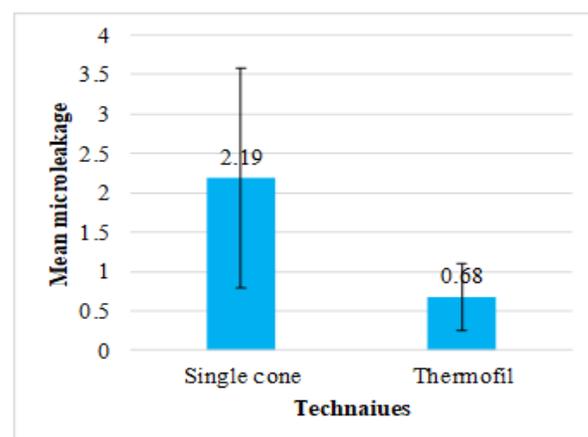


Figure (3): Microleakage of different obturation techniques

The mean values (mm) and standard deviations (mm) of apical microleakage in the examined samples are shown, categorized based on the criteria considered, namely the endodontic sealer and obturation technique. The Thermofil obturation technique is known to have the lowest amount of apical microleakage among other obturation techniques.

Discussion

Endodontic treatment may not always provide favorable outcomes, and failure can transpire in a certain proportion of cases due to numerous factors.¹² An effective seal along the root canal is crucial for a successful root





canal treatment, as it guarantees the healing and long-term health of the peri radicular tissue. Ensuring a robust three-dimensional seal is crucial for achieving successful endodontic therapy, as it effectively prevents both initial infection and subsequent reinfection. Root canal sealers serve the purpose of effectively closing empty spaces, additional canals, and extensions at the root tip.¹³ They should possess strong sealing properties to dentin, low solubility, good compatibility with living tissue, the ability to promote the creation of mineralized tissue on dentin, and the ability to seal the root tip. Various sealers have been examined for this objective, including traditional zinc oxide eugenol sealers to the most recent resin, bioceramic, and calcium hydroxide-based sealers.¹⁴ After cleaning and shaping the root canal, one of the main objectives of endodontic treatment is to completely fill the root canal system. The success of obturation depends on the capacity of root canal filling materials to create a seal, as well as the utilization of different obturation techniques. Sealers play a vital role in this process by reducing microleakage during the filling of the root canal system.¹⁵ There is a variety of sealers to choose from, including eugenol-based and non-eugenol sealers, as well as the most recent calcium silicate sealers. Although every form of sealer has its own inherent disadvantages, the quest for the perfect sealer persists.¹⁶ There are several ways used to evaluate the quality of apical microleakage, including dye penetration, dye diffusion, bacterial and endotoxin infiltration, fluid filtration, glucose, caffeine and protein infiltration, radioisotope penetration, animal studies, and electrochemical approaches.¹⁷ Leakage in a sealed root canal usually happens at the points where the sealer and dentin, the sealer and gutta-percha, or within the sealer itself meet. The sealing quality of a root canal filling is mostly determined by the sealing

power of the sealer used.¹⁸ The findings of the present investigation revealed that both the single cone and thermoplasticized obturation methods, employing bioceramic sealers, displayed notably reduced apical microleakage in comparison to all other groups that were examined. These findings are similar with earlier studies that suggest the decrease in microleakage is due to the sealer's mineral content infiltrating the intertubular dentin.¹⁸ This aligns with the results of several prior studies.¹⁷ The groups that using ZOE sealer demonstrated the greatest apical leakage. Studies have shown that ZOE sealers lack chemical bonding with root dentin and possess a significantly low tensile strength.¹⁹⁻²⁰ Thermoplastic condensation techniques showed less apical leakage compared to other obturation procedures. This is because they effectively filled lateral canals and had a three-dimensional filling feature. The single cone obturation approach has demonstrated limitations, including the potential for void formation and challenges in its application in curved canals.²¹⁻²³ The existing literature does not agree on the connection between a bioceramic-based sealant and heated obturation procedures. Qu et al. shown that the application of heat caused a decrease in the setting time and flow of a root canal sealer made from bioceramic materials.¹⁸ This reduction could have a detrimental effect on the effectiveness of the obturation process and the overall success of the treatment. Camilleri et al. found that heat did not have an impact on the material chemistry and physical qualities.¹⁹ However, they still advised adhering to the manufacturer's specifications, which encourage using a single cone approach. Additional research, has confirmed that the method of filling does not impact the effectiveness of bioceramic sealers.²⁴ A comparative study was conducted to evaluate the performance of a new bioceramic-based root canal sealer,





specifically designed for use with a warm obturation technique, in comparison to a sealer advised for the single cone technique. The study results indicated that there were no discernible differences between the two sealers when used with a warm filling technique. Empirical evidence has demonstrated the stability of bioceramic sealers when employed in heated vertical compaction. However, it is imperative to do additional research to thoroughly examine the impact of heat on the properties of these sealers. According to Atmeh et al., heat does not modify the chemical composition of bioceramics, but it does induce microstructural changes by causing water to evaporate.²⁴ FT-IR examination of a heated bioceramic sealer showed a decrease in the peaks corresponding to the vibrational modes of the OH group in water, indicating that water loss occurred above 100 °C through evaporation.²⁵ Based on the current investigation, it seems that a warm obturation approach shows promise in reducing microleakage in newly sealed samples, even when combined with a tricalcium-silicate root canal sealer. Within each group, there was a discernible difference in the average scores for apical microleakage between the carrier-based obturation strategy and the single cone approach.

Conclusions

Carrier-based obturation approach when used instead of a cold single-cone obturation technique, the amount of dye infiltration is reduced. When filling the root canal with a consistent approach, root canal sealers based on tricalcium silicate perform better in terms of microleakage than typical sealers based on zinc eugenol. Procedures for carrier-based obturation have potential, especially when combined with a sealant based on tricalcium silicate for root canal therapy. Comparing the bioceramic group to the resin, calcium hydroxide (CaOH), and zinc oxide eugenol

(ZOE) sealers, a significant decrease in apical microleakage was observed.

Limitation

The study was carried out using light microscope 20 x and not on scanning electron microscope in additionally the criteria of teeth selection were limited in 1st premolars only.

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Conflict of interest

Authors declare no conflict of interest.

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