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The Seal Quality of Two Bioceramic Materials Used as Retro-grade Filling Utilizing Different Compaction Techniques (An In-vitro Study)

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Aim: This aim of the current study is to measure the porosity index of two bioceramic materials using Manual versus Manual /Ultrasonic assisted condensation.
Materials and methods: Sixty maxillary central incisors were used in the current research. Orthograde endodontic filling was performed followed by root tip excision perpendicular to long axis of the root. A 3 mm ultrasonic tip retrograde preparation was prepared. Samples were then divided into four groups (n=15). ProRoot MTA condensed manually, EndoSequence BC putty condensed manually, and both with and without ultrasonic assisted condensation. Porosity index for the root end filling was measured using CBCT.
Results: No significant difference was found in ProRoot MTA porosity index between groups. For Manual condensation, the mean value was 1.559±0.628%, whereas for Manual /Ultrasonic assisted condensation, it was 1.711±0.706%. (p-value = 0.539). Meanwhile For Endo Sequence BC putty the mean value of porosity index was 2.915± 1.004% and 1.868±0.36% for Manual and Manual /Ultrasonic assisted condensation respectively ($p<0.001$)
Conclusion: it was concluded that the utilization of Manual /Ultrasonic assisted condensation resulted in a noteworthy reduction in quality for the Endo Sequence BC putty utilized as a root end filling material.

Keywords: Roo-End Filling material, Porosity Index, Bioceramic materials, Condensation techniques

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Introduction

After Endodontic therapy, teeth with persistent periapical pathosis may benefit from endodontic apical surgery. Researchers have found a 53–98% success rate for initial non-surgical root canal treatment (NSRCT). However, NSRCT alone may not be enough to fulfil a total recovery for the endodontically treated teeth. Despite non-surgical root canal retreatment has a lower success rate than initial NSRCT (69%), it can still be a convenient line of treatment for tooth with apical pathosis. [1-4].

Clinical circumstances may recommend the performance of endodontic surgery. Endodontic root-end surgery involves resection, root canal preparation, and filling. Numerous studies show the method has a 92.4–95% success rate [5-11]. Efforts to improve endodontic root-end surgery have improved methodology and materials. The dental operating microscope, endodontic microsurgery, and other devices have improved clinician efficiency. Micro-instruments can easily identify anatomical features, eliminating the need for extensive osteotomies or root-end tip resection and the application of biocompatible materials results in better outcomes for the treatment [12-14]

One of the most important factors in endodontic root-end surgery is the quality of marginal seal for the surgical root preparation, according to research. The best method is to make a 3-mm preparation and seal it with root end filling [17,18]. Bioceramics represents an advancement in endodontic therapy as they can mimic biological hydroxyapatite thus improving their biocompatibility. Compounds as bioactive glass and hydroxyapatite, may help regenerate human tissues. Surgical endodontic procedures involving bioceramics include perforation repair, and retrograde filling [19,20].

In 1824 Portland cement was the first proposed bioceramic composed of Calcinating limestone and silicon-argillaceous. Mineral trioxide aggregate (MTA) Bioceramic was then proposed it is formed of tricalcium silicate, tricalcium aluminate, and dicalcium silicate. Hydration starts the MTA setting reaction. Calcium ions (Ca^{++}) form hydroxyapatite with phosphate ions, allowing the substance to integrate biologically. MTA due to the presence of Calcium hydroxide had an alkaline pH making the material antibacterial. Torabinejad et al. report a 2 hour and 45-minute as MTA setting time, with a ± 5-minute margin of error. The Radiopaque material bismuth oxide was added to the mixture [21,24].

EndoSequence root restoration material another bioceramic material is mostly tricalcium silicate presented in two consistencies syringable paste or condensable putty. It can be used to manage perforations and as a retrograde filling during surgery. Numerous studies have shown the material's biocompatibility, osteogenic potential, and antibacterial characteristics. EndoSequence BC putty contains radiopaque zirconium oxide/tantalum oxide and monocalcium phosphate, which produces hydroxyapatite. Hydration reactions begin. The manufacturer states that the material lasts 30 minutes and solidifies when moistened. After four hours, setup often gets more stable [25,28].

A well-prepared retrograde preparation is essential for successful apical surgery. Many studies tried to find the best root-end filling materials and condensation methods to accomplish best sealing. One of the advancements in the field of Endodontics is the application of Ultrasonics. In 1880 Jacques Curie reported the piezoelectric phenomenon where mechanical vibrations in the ultrasonic frequency range result from this phenomenon, Richman introduced ultrasonics to endodontics in 1957. Piezo surgery devices were developed to cut bone atraumatically using ultrasonic vibrations and to provide an alternative to the mechanical and electrical instruments key features of piezosurgery instruments include their ability to selectively cut bone without damaging adjacent soft tissue, to provide a clear operative field, and to cut without generating heat [15-16]

A recent literature review found few studies comparing condensation methods for retrograde filling materials. Few studies have used cone beam computed tomography (CBCT) to assess the quality of retrograde preparation seal. This aim of the current study is to compare the porosity index for two bioceramic materials ProRoot MTA and Endo Sequence BC putty using Manual and Manual /Ultrasonic assisted condensation.

Materials and Methods

The current research was ethically approved by the Research Ethics Committee of October 6 University (RECO6U/23-2021). A total of sixty maxillary central incisors from patients were acquired. The teeth underwent autoclaving and were thereafter preserved in a sterile water solution. Ultrasonic scalers were used for debridement of the root surfaces. Only single canal teeth confirmed radiographically was used. The exclusion criteria include teeth with open apices, cracks, or perforations, as well as samples exhibiting extensive caries in the crown or root, sample with resorption, or teeth that having prior endodontic therapy.

Subsequently, dental radiographs were obtained from the buccolingual and mesiodistal perspectives. The access cavity was prepared with a round bur. The patency of the canals was confirmed with a size 10 K-file. Determination of the working length involved subtracting 0.5 mm from the length at which K-file was observed to be visible at the apical foramen. The crown-down instrumentation approach, utilizing the Protaper Next Rotary File was for canal preparation. The canal was prepared up to a size X2 file with a .06 taper, following the instructions provided by the manufacturer.

The canals were irrigated by using 1.0 ml solution of 5.25 % sodium hypochlorite (NaOCl). This irrigation process was repeated after each file application, using an endodontic needle placed 1 mm away from the WL. A 1.0 ml final flush of a 17% solution of ethylenediaminetetraacetic acid (EDTA), followed by sodium hypochlorite (NaOCl) was used then the root canal was dried using paper Protaper Next X3 paper points. Obturation was performed using Conform Fit Gutta-Percha for ProTaper Next with vertical compaction technique. Radiographic imaging was conducted post-operatively confirm the quality of the endodontic obturation.

Root tips were surgically removed at 3 millimeters from the apex, The resection was performed perpendicularly to the long axis of the tooth. An ultrasonic tip was utilized to generate a retrograde preparation of a standardized depth of 3 mm. The cavity was subjected to a drying process. All the Endodontic procedures was performed by a single operator, utilizing an operating microscope. Samples were then divided into four groups (n=15 / group) in a random manner, based on the retrograde filling materials and the condensation techniques used.

Table 1**:** Sample classification and grouping.

Group	Material	Compaction Technique	Sample Size
Ia	ProRoot MTA	Manual	15
Ib	ProRoot MTA	Manual /Ultrasonic	15
IIa	EndoSequence BC putty	Manual	15
IIb	EndoSequence BC putty	Manual /Ultrasonic	15

The MTA was mixed following manufacturer recommendations. EndoSequence BC putty requires no preparation. However, EndoSequence BC putty comes with EndoSequence BC Sealer, a fluid root repair ingredient. A droplet of EndoSequence BC Sealer was applied to the retro-cavity before applying BC putty in this study. Root-end filling material was gradually applied to preparations. Manual hand pluggers or ultrasonic assisted compaction with a Channels Endo Piezo Tip and the ultrasonic system compacted this material. Ultrasonic assisted compaction was of one second at 10% power.

For seven days, All the samples were stored at temperature of 37 °C and relative humidity of 15%. CBCT was used to assess porosity in the teeth. To assess the porosity index Cone Beam Computed Tomography (CBCT) was used to scan the samples. Data Viewer was employed to assess and realign the images to ensure uniformity across the various samples.

The greyscale photos underwent processing. The boundary of samples was determined within a 3-mm span. The location where the filling material and porosity are located using the Regions of Interest (ROI) tool. The (ROI) was conserved, resulting in the computation being only conducted inside the confines of this location. The Hounsfield unit (HU) and Greyscale (GS) thresholds cutoff points were established to distinguish between porosity and filling. The total volume of the retrograde filling material for ProRoot MTA and EndoSequence BC Putty was determined by assigning Hounsfield Units (HU) ranging from 2662 to 11451, with greyscale thresholds between 75 and 225. The Hounsfield Units (HU) ranging from -1000 to 2661.9, with a greyscale threshold of 0-74, were allocated to represent the areas of porosity.

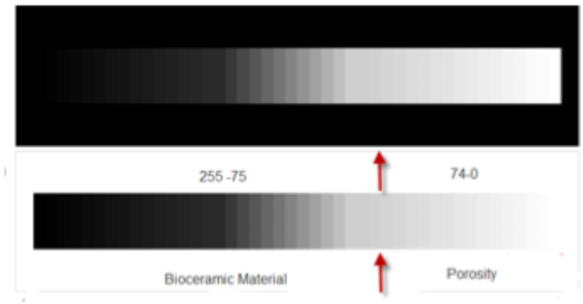


Figure 1. Gray scale Adjust threshold for the filling material and porosity.

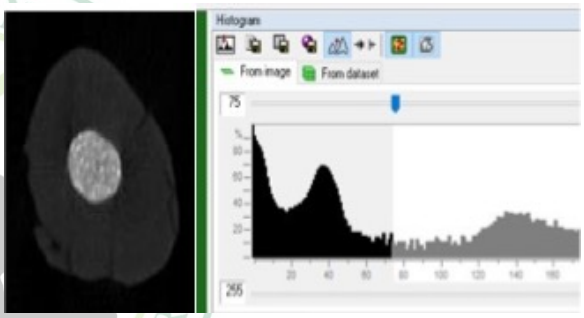


Figure 2. Gray scale histogram at a threshold for the retrograde filling (Tooth and porosity excluded)

Porosity index was calculated as (the ratio between the total volume of the voids / the total volume of the retrograde filling X100). Statistical analysis was conducted to evaluate the difference in the overall volume of porosity between two condensation techniques, namely Manual condensation and Manual /ultrasonic condensation . For each of the materials employed in the current study

Results

The mean of the porosity index for Manual condensation and Manual /ultrasonic condensation for both ProRoot MTA and Endo Sequence BC putty are shown in table 2,

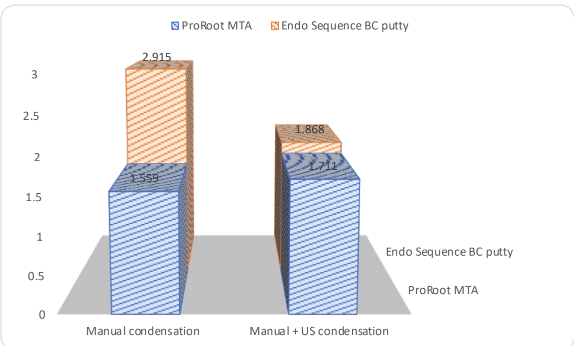
Table 2: Mean and SD of porosity index comparing Manual condensation and Manual / ultrasonic condensation.

	Manual condensation		Manual + US Condensation			
	Mean	SD	Mean	SD	t-value	p-value
ProRoot MTA	1.559	0.628	1.711	0.706	-0.622	0.539
Endo Sequence BC putty	2.915	1.004	1.868	0.36	3.806	<0.001*
t-value	4.437		0.767			
p-value	0.001*		0.449			

Where *Significant at 0.05

In the case of the ProRoot MTA, comparing the porosity index statistically insignificant difference was observed between the two groups. The mean values for manual condensation and manual /ultrasonic condensation were 1.559± 0.628% and 1.711±0.706% respectively (p=0.539). However, for the Endo Sequence BC putty, statistically significant difference was reported between the manual condensation and manual /ultrasonic condensation. The mean values for manual condensation and manual /ultrasonic condensation were 2.915± 1.004% and 1.868±0.36% respectively (p<0.001).

The mean porosity index for Manual condensation was found to be 1.559± 0.628% for ProRoot MTA and 2.915± 1.004% for Endo Sequence BC putty. The observed difference in porosity between the two groups was statistically significant (p<0.001). The average porosity index for the manual /ultrasonic condensation technique was found to be 1.711±0.706% for ProRoot MTA and 1.868±0.36% for Endo Sequence BC putty. However, difference in porosity index among the groups was statistically insignificant (p=0.449).



Graph 1. A Bar chart showing mean porosity values for different study groups

Discussion

Endodontic root-end surgery long-term success can be influenced by many factors one of which is the filling materials, potentially due to the presence of porosity within the material leading to micro-leakage. The observed porosity may arise from either the application method employed, or the inherent characteristics of the filler materials utilized. Therefore, it is crucial to identify strategies to mitigate such leakage. The aim of current research was to compare the porosity index in two bioceramics retro grade filling material applied either by manual condensation and manual /ultrasonic assisted condensation

Acris De Carvalho et al. examined how ultrasonic activation affected the flowability of Mineral Trioxide Aggregate (MTA) to other dental cements. The results showed that ultrasonic application has no effect to MTA flow [29]. The property has been examined, suggesting that an ultrasonic tip could optimize root-end filling material positioning. This is because ultrasonic vibrations help material flow, set, and compact. This study suggests that an ultrasonic tip may improve root-end filling placement. Ultrasonic vibrations improve material flow, setting, and compaction.

The findings of the present investigation align with the findings reported by Aminoshariae et al [30]. In their study, Aminoshariae et al. found that hand condensation yielded superior adaptation and fewer voids compared to ultrasonic techniques, which is consistent with the results obtained with ProRoot MTA in the current study.

In contrast, Celikten et al conducted an evaluation of RetroMTA and Bioaggregate, and their findings indicated that the utilization of ultrasonic activation resulted in a more compacted structure of the material. Previous studies have demonstrated that the utilization of indirect ultrasonic activation during hand condensation leads to a denser mineral trioxide aggregate (MTA) fill compared to hand condensation alone [31-33]. The findings of the current research are in accordance with Toia et al., comparing Endo Sequence BC putty and Biodentine. Quantifying gap, void, and porosity percentages. All root-end fillers evaluated failed to plug gaps and Endo Sequence BC putty has the most pores of the compared to Biodentine [34]. Aminoshariae et al. compared ultrasonic and manual application of MTA.the results of the study revealed that Hand condensation had less vacant space than ultrasonic condensation results that are in accordance to the current study [35]

Flow is a crucial characteristic that enables the material to effectively occupy challenging regions, such as the tight and irregular spaces within the dentin and voids. This property plays a significant role in ensuring the retrograde cavities are adequately sealed. The reported flow rates for EndoSequence BC have been documented as 23.1 mm and 26.96 mm [36]. The utilization of ultrasonic assisted compaction may have the potential to enhance the flow of the Endo Sequence BC putty, resulting in a reduction of voids and a more compact filling.

The findings of the present study align with Antunes et al.'s where the result indicates that both white MTA and Endo Sequence BC putty exhibit comparable retro grade sealing quality . Friedl et al. examined MTA density using hand condensation and indirect ultrasonic assisted compaction. The results reported revealed that indirect ultrasonic condensation for MTA root-end fills increased filling density over manual condensation. [37]

Shokouhinejad et al. found that MTA had less dentinal wall gaps than ES-BCRR paste in longitudinal sections. Three root-end filling materials had similar gap sizes statistically. MTA-like adaptation was found in ES-BCRR [38]

The study's significance stems from the limited number of reports in the endodontic literature that explore the correlation between ultrasonic and hand condensation of retrograde filling materials. The findings of this study will enhance the clinician's comprehension of the application of ultrasonics in relation to retrograde filling materials.

Limitations

Results of this study may or may not affect biological research. In addition different canal diameters may cause minor differences in canal preparation.

Conclusions

In the context of the current in vitro investigation, it was found that both hand compaction and hand/ultrasonic compaction techniques yielded comparable total porosity volumes when used with ProRoot MTA for root-end sealing. However, the utilization of hand/ultrasonic combined compaction resulted in a noteworthy reduction in total porosity volume for the Endo Sequence BC putty.

References

1. Kim S, Kratchman S. Modern endodontic root-end surgery concepts and practice: a review. J Endod 2006; 32: 601-23.
2. Bergenholtz G, Lekholm U, Milthon R, Heden G, Odesjo B, Engstrom B. Retreatment of endodontic fillings. Scand J Dent Res 1979; 87: 217–24. 32
3. de Chevigny C, Dao TT, Basrani BR, et al. Treatment outcome in endodontics: the Toronto study--phases 3 and 4: orthograde retreatment. J Endod 2008; 34: 131-7.
4. Gorni FG, Gagliani MM. The outcome of endodontic retreatment: a 2-yr follow-up. J Endod 2004; 30: 1-4
5. Chan S, Glickman GN, Woodmansey KF, et al. Retrospective analysis of root-end microsurgery outcomes in a postgraduate program in endodontics using calcium silicate based cements as root-end filling materials. J Endod 2020; 46: 345-51.

6. Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate usingtwo different techniques. J Endod 2003; 29: 679-82.
7. Hirschberg CS, Patel NS, Patel LM, et al. Comparison of sealing ability of MTA and EndoSequence bioceramic root repair material: a bacterial leakage study. Quintessence Int. 2013; 44: e157-e162.
8. Antunes HS, Gominho LF, Andrade-Junior CV, et al. Sealing ability of two root-end filling materials in a bacterial nutrient leakage model. Int Endod J 2016; 49: 960-5.
9. Nielsen RB, Alyassin AM, Peters DD, et al. Microcomputed tomography: an advancedsystem for detailed endodontic research. J Endod 1995; 21: 561-8.
10. Rhodes JS, Ford TR, Lynch JA, et al. Micro-computed tomography: a new tool for experimental endodontology. Int Endod J 1999; 32: 165-70. 56. Jung M, Lommel D, Klimek J. The imaging of root canal obturation using micro-CT. Int Endod J 2005; 38: 617-
11. Dorn SO, Gartner AH. Retrograde filling materials: a retrospective success-failure study of amalgam, EBA, and IRM. J Endod 1990; 16: 391-3.
12. Kim S. Principles of endodontic microsurgery. Dent Clin North Am 1997; 41: 481–97.
13. Carr GB. Microscope in endodontics. J Calif Dent Assoc 1992; 20: 55-61
14. Carr G. Surgical endodontics. In: Cohen S, Burns R, eds. Pathways of the pulp, 4th ed. St Louis: Mosby; 1994: 546-52
15. Park, E. Ultrasonics in endodontics. Endodontic Topics 2013; 29; 125-59.
16. Richman MJ. The use of ultrasonics in root canal therapy and root resection. J Dent Med 1957; 12: 12-18.
17. Carr G. Surgical endodontics. In: Cohen S, Burns R, eds. Pathways of the pulp, 4th ed. St Louis: Mosby; 1994: 546-52
18. Sutimuntanakul S, Worayoskowit W, Mangkornkarn C. Retrograde seal in ultrasonically prepared canals. J Endod 2000; 26: 444-6.
19. Raghavendra SS, Jadhav GR, Gathani KM, et al. Bioceramics in endodontics - a review. J Istanb Univ Fac Dent 2017; 51(3 Suppl 1): S128-37.
20. Prati C, Gandolfi MG. Calcium silicate bioactive cements: Biological perspectives and clinical applications. Dent Mater 2015; 31: 351-70.
21. Viola NV, Filho M, Cerri PS. MTA versus Portland cement: Review of literature. Rev Sul bras Odontol 2011; 8: 446-52.
22. Cheng L, Ye F, Yang R, et al. Osteoinduction of hydroxyapatite/beta-tricalcium phosphate bioceramics in mice with a fractured fibula. Acta Biomater 2010; 6: 1569-74.
23. Santos AD, Moraes JC, Araújo EB, et al. Physico-chemical properties of MTA and a novel experimental cement. Int Endod J 2005; 38: 443-7.
24. Torabinejad M, Hong CU, McDonald F, et al. Physical and chemical properties of a new rootend filling material. J Endod 1995; 21: 349-53.
25. EndoSequence BC RRM. Brasseler USA Dental Instrumentation. Available at: https://brasselerusadental.com/products/bc-rrm/ . Accessed December 5, 2021.
26. Jingzhi M, Shen Y, Stojicic S, et al. Biocompatibility of Two Novel Root Repair Materials. J Endod 2011; 37: 793-8.
27. Alanezi AZ, Jiang J, Safavi KE, et al. Cytotoxicity evaluation of endosequence root repair material. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010; 109: e122-e125.34
28. Zhang S, Yang X, Fan M. BioAggregate and iRoot BP Plus optimize the proliferation and mineralization ability of human dental pulp cells. Int Endod J 2013; 46: 923-9.
29. Acris De Carvalho FM, Silva-Sousa YTC, Saraiva Miranda CE, et al. Influence of Ultrasonic Activation on the Physicochemical Properties of Calcium Silicate-Based Cements. Int J Dent 2021; 2021: 6697988.
30. Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate using two different techniques. J Endod 2003; 29: 679-82.
31. Yeung P, Liewehr FR, Moon PC. A quantitative comparison of the fill density of MTAproduced by two placement techniques. J Endod 2006; 32: 456-9.
32. Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate using two different techniques. J Endod 2003; 29: 679-82.
33. Sisli SN, Ozbas H. Comparative Micro-computed Tomographic Evaluation of the Sealing Quality of ProRoot MTA and MTA Angelus Apical Plugs Placed with Various Techniques. J Endod 2017; 43: 147-51.
34. Toia CC, Teixeira FB, Cucco C, et al. Filling ability of three bioceramic root-end filling materials: A micro-computed tomography analysis. Aust Endod J 2020; 46: 424-31.
35. Zhou H.-M., Shen Y., Zheng W., Li L., Zheng Y.-F., Haapasalo M. Physical propertiesof 5 root canal sealers. *Journal of Endodontics.* 2013;39(10):1281–1286. doi: 10.1016/j.joen.2013.06.012.
36. Antunes HS, Gominho LF, Andrade-Junior CV,

et al. Sealing ability of two root-end filling materials in a bacterial nutrient leakage model. Int Endod J 2016; 49: 960-5.
37. Friedl CC, Williamson AE, Dawson DV, et al. Comparison of mechanical and indirectultrasonic placement technique on mineral trioxide aggregate retrofill density in simulated root-end surgery. J Endod 2016; 42: 650-3.
38. Shokouhinejad N, Nekoofar MH, Ashoftehyazdi K, et al. Marginal adaptation of new bioceramic materials and mineral trioxide aggregate: a scanning electron microscopy study. Iran Endod J 2014; 9: 144-8.