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

Rasha Sameh1, Mohamed M.N El-Tayeb2, Mohamed Nabeel3

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 fulfill 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 buccolinguual 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>
<thead>
<tr>
<th>Group</th>
<th>Material</th>
<th>Compaction Technique</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>ProRoot MTA</td>
<td>Manual</td>
<td>15</td>
</tr>
<tr>
<td>Ib</td>
<td>ProRoot MTA</td>
<td>Manual/Ultrasonic</td>
<td>15</td>
</tr>
<tr>
<td>IIa</td>
<td>EndoSequence BC</td>
<td>Manual</td>
<td>15</td>
</tr>
<tr>
<td>IIb</td>
<td>EndoSequence BC</td>
<td>Manual/Ultrasonic</td>
<td>15</td>
</tr>
</tbody>
</table>

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.

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.

<table>
<thead>
<tr>
<th>Material</th>
<th>Mean</th>
<th>SD</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProRoot MTA</td>
<td>1.559</td>
<td>0.628</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endo Sequence BC putty</td>
<td>2.915</td>
<td>1.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-0.622</td>
<td>0.539</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.806</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

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).

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
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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
6. Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate using two
7. Hirschberg CS, Patel NS, Patel LM, et al. Comparison of sealing ability of MTA and
44: e157-e162.
32: 165-70. 56. Jung M, Lommel D, Klinek J. The imaging of root canal obturation using micro-CT.
11. Dorn SO, Gartner AH. Retrograde filling
16. Richman MJ. The use of ultrasounds in root
18. Sutumantanukul S, Worayoskowit W, Mangkornkarn C. Retrograde seal in ultrasonomically
20. Prati C, Gandolfi MG. Calcium silicate bioactive
21. Viola NV, Filho M, Cerri PS. MTA versus
hydroxyapatite/beta-tricalcium phosphate
bioceramics in mice with a fractured fibula. Acta
Biomater 2010; 6: 1569-74.
Physico-chemical properties of MTA and a novel
24. Torabinejad M, Hong CU, McDonald F, et al.
Physical and chemical properties of a new root
25. EndoSequence BC RRM. Brasseler USA Dental
28. Zhang S, Yang X, Fan M, BioAggregate and
iRoot BP Plus optimize the proliferation and
mineralization ability of human dental pulp cells.
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 MTA produced 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
34. Toia CC, Teixeira FB, Cucco C, et al. Filling
ability of three bioceramic root-end filling
materials: A micro-computed tomography
Y.-F., Haapasalo M. Physical properties of 5
10.1016/j.joen.2013.06.012.
36. Antunes HS, Gominho LF, Andrade-Junior CV,