Sealing Ability of Single Cone Obturation Technique Using Ultrasonic Activation of Bioceramic Sealer: An In Vitro Study

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Abstract:

The present study aimed to evaluate the filling quality of a bioceramic sealer with a single gutta-percha cone technique using ultrasonic sealer activation. Twenty-four single-rooted mandibular premolars were selected. Canals were instrumented and allocated into three groups randomly according to the method of ultrasonic sealer activation: group 1: single-cone with ultrasonic activation, group 2: single-cone with Vibration Thermo-hydrodynamic obturation (Vibra THO) technique, group 3: single-cone without ultrasonic activation. After setting of sealer, teeth were immersed in methylene blue dye then demineralized and cleared. Microleakage was assessed under stereomicroscope at 20x magnification. ANOVA and Bonferroni post hoc tests were used for the evaluation of dye penetration at the apical three mm of the roots. Single-cone without ultrasonic activation had the highest mean value of apical microleakage (4080.2±1132.1 μm) followed by the Vibra THO technique (2033.3±1754.3 μm) and the least results with single-cone with ultrasonic activation (1389.1±1094.8 μm) with statistically significant difference between the groups ($P<0.05$). In multiple comparisons, only statistical significant difference was found between single-cone without ultrasonic vibration and single-cone with ultrasonic activation. It was concluded that when using premixed bioceramic sealer with SC, ultrasonic activation is recommended to obtain better sealing ability of the canals.

Keywords: Sealing ability, microleakage, bioceramic sealer, CeraSeal, ultrasonic activation, Vibra THO.

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Introduction:

Root canal preparation (cleaning and shaping) determines treatment outcome and the obturation quality play's essential role ensuring successful outcome of endodontic treatment on the long-term. According to studies around 60% endodontic failures are associated with poor canal obturation. Homogeneously filled root canals over the entire working length with appropriate conical tapering that resembles prepared canal's internal shape is said to be properly obturated. Obturated canals' recontamination and micro-organisms penetration with their metabolites into periapical tissues is prevented with high-quality hermetical seal, where filling homogeneity is inversely proportional to pores and voids inside the material. Therefore, the material's porosity can be representative of objective criteria to assess root canal obturation quality. (1)

Hermetic canal filling and coronal restoration guarantee treatment longevity. The utmost complex apical zone is the bacteria and bacterial toxins path of entry. To seal the whole root canal system, three- dimensional hermetic filling is indispensable particularly in the apical few millimetres. To improve gutta-percha/root canal sealer balance, tapered single cones were introduced in the market. Superior quality of obturation to that of the classic single-cone technique is obtained if the diameter and conicity matched exactly the final shaping file especially when using bioceramic (BC) sealer (2) and exhibit filling capabilities similar to multi-steps obturation techniques. (3)

Root canal sealers major functions are sealing-off voids, patent accessory canals, and multiple foramina. Bonding between the filling material's core with root canal wall, lubrication action to facilitate placement of the filling core and entombing any bacterial remnants are added to the aforementioned functions. (4) Although they are available since 1980s; BC sealers have become recently popular after introducing the innovative commercial products based on new formulations. (3) They offer many advantages: their biocompatibility prevents surrounding tissues rejection, in addition BC sealers are based on either calcium phosphate or calcium silicate that enhances bioceramics' setting properties and resulting in crystalline framework with chemical composition similar to tooth or bone apatite material, thereby sealer-to-root dentin bonding is improved. (4)

CeraSeal is one of the BC sealres available in the market. It is a calcium silicate-based sealer available in a premixed form that is injected directly inside the prepared canal. Ceraseal is set to be used with cold obturation

techniques as single-cone (SC) obturation technique.

Although showing good results, SC with BC sealer possess disadvantages as voids, gap formation and poor adaptation with root canal walls. Endodontic sealers' activation ultrasonically has been suggested to improve root filling quality. [5] The effect of US sealer activation on apical microleakage had been studied showing improvement of root filling quality [5] in addition to reducing the percentage of microleakage while increasing the sealer adherence to root dentine. [6]

Therefore, this study aimed to evaluate the sealing ability of SC obturation technique in terms of apical microleakage using two different US sealer activation methods comparing them with SC obturation technique using BC sealer without US activation.

Materials and methods:

Sample size:

Sample size was calculated using the (PS software). Regarding the primary outcome Sealing ability in (micro leakage (mm)) we found that 8 teeth/group will be appropriate sample size with total of 24 teeth (3 groups) the power is 80% and α error probability =0.05. The magnitude of the effect to be detected was estimated as mean and standard deviation of the variable of interest and obtained from Robberecht et al. 2012. [2]

Selection of specimens:

After the Research Ethics Committee, Faculty of Dentistry, Cairo University, Egypt's approval (no. 14422), twenty-four single-rooted mandibular premolars -with completely formed root and apical constriction- were selected from a pool of extracted teeth and radiographically examined to ensure number of canals and canal patency for each tooth. Teeth with single root canal only were included in the study. Excluded teeth were those with root fractures, root caries, evidence of periapical resorption, or multiple canals. The root surfaces of the selected teeth were cleaned using manual scalers then decoronated at length of 15mm from the apex using diamond disc to uniform the length of the teeth. [7]

Root canal preparation:

The decoronated samples had visible canal orifices through which a K-file #10 (Dentsply Malliefer, Ballaigues, Switzerland) was inserted to check canal patency. A # 15 K-file (Dentsply Malliefer, Ballaigues, Switzerland) with a rubber stopper was inserted into the canal till the file's tip was just seen at the apical foramen. The length of file was determined by measuring it from the file tip to the

stopper then working length was set 0.5 mm from this length; these readings were registered as actual working length. A glide path was performed using manual K-files till # 20. After preflaring the canals' orifices using SX ProTaper file, canals were shaped using ProTaper Next files (Dentsply Malliefer, Ballaigues, Switzerland) starting from file # X1 till file # X4 to the full working length. The manufacturer instructions were followed for the instrument's sequence, speed and torque for biomechanical preparation. In pecking motion instruments were progressively proceeded till the working length. During the biomechanical preparation, the canal patency was maintained by #10 K-file. Canals were constantly rinsed with 1 ml of 2.5% NaOCl between files in addition to the use of EDTA gel (MD-ChelCream, META BIOMED Co. Ltd., Cheongju-si, Korea). Then canals received 1 ml of 2.5 % NaOCl followed by 1 ml of distilled water. Rinsing with 5 ml 17% EDTA solution (Prevest DenPro ltd.) was carried out -to remove any smear layer on the root canal walls- followed by a final rinse with saline to remove the effect of EDTA and NaOCl. [7] Finally root canals were dried with # X4 paper points preparing them to be obturated. The master gutta-percha point # X4 -matching to the final nickel-titanium rotary shaping file- was selected. This protocol was employed for both the experimental groups and the control group. After placing each tooth in a separate small envelop giving each envelop a number from 1-24 (according to the total number of samples), teeth were divided randomly into three groups (8 teeth/group) using www.randomizer.org.

Obturation:

After gathering the samples of each group, obturation using SC technique is carried out as follows:

Group one: CeraSeal (BC sealer) + SC obturation technique with US activation:

An ultrasonic tip E3 (Guilin Woodpecker medical instrument co., LTD) was selected and connected to ultrasonic device Varios 570 (NSK-dental Co. Shimohinata, Kanuma Tochigi, Japan) that was set at ‘‘5’’ in the endo mode (manufacturer's indication for endodontics). After sealer injection inside canals' coronal half, ultrasonic vibration was applied to cotton plier holding the GP cone 20mm from its tip. Then, the cone reached the working length slowly with continuous ultrasonic activation ***(Fig 1)***. The ultra- sonic time of application during master cone placement was 2-3 sec., and excess gutta-percha was cut at canal's orifice using hot instrument. [8]

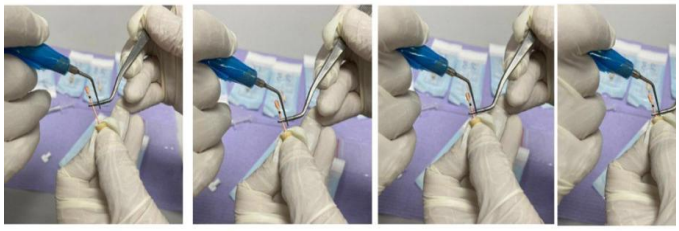

Fig. 1: Single-cone obturation with ultrasonic activation of CeraSeal

Group two: Ceraseal (BC sealer) with Vibration Thermohydrodynamic Obturation (Vibro THO)

Smooth surfaced Woodpecker Endodontic Ultrasonic tips E3 and E4 were used to mimic the ProtoType US tips used by Yong-Sik Cho. [9] The US tip that produces optimum fitting within the 4 mm from the canal orifice and bind to the canal at the needed depth was selected. After the introduction of sealer, the master gutta-percha point was gently inserted to the working length. With the selected endodontic US tip in the activated state: the excess master gutta-percha point was sheared-off 2 mm at canal's orifice. The activated tip acted as ultrasonic heat carrier. Subsequently, the tip in activated mode was held passively against the master cone in the root canal, to transfer ultrasonic vibration and heat, for 2 to 3 seconds only. At that moment, the sealer was displaced apically within the canal by direct ultrasonic sealer activation. This process was followed by short-range down packing of 2-3mm of the heat-softened gutta-percha using manually driven vertical compacting force with the ultrasonic tip in the de-activated state. After one second of cooling, 5-10 sec of sustained pressure was applied. In this step the US tip was acting as a cold hand plugger [9] ***(Fig. 2)***.

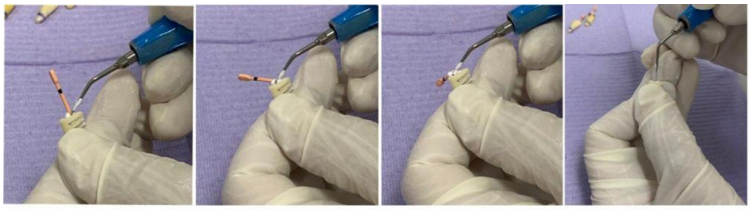

Fig. 2: *Vibration Thermohydrodynamic Obturation (Vibra THO) technique*

Group three: CeraSeal (BC sealer) without US activation (control group)

After drying the canal with paper points and selecting the master cone, a small portion of sealer was delivered into the prepared canal via sealer syringe -with fine tip attached to- not deeper than coronal half of the length. The tip of the master cone was covered with sealer and proceeded to the designated length. Hot instrument was used to cut the cone then stainless-steel hand plugger compacted it at the canal's orifice. [3]

Following the filling procedures in all groups, glass ionomer cement (Ketac Cem Aplicap, 3M ESPE, St. Paul, MN, USA) was used to seal canals' orifices. Samples were kept in 100% humidity for one week allowing

complete setting of the CeraSeal BC sealer. After sealer setting, samples' root surfaces were dried and covered with double coat of nail polish except the apical 3 mm of the root apex, to prevent dye penetration through the root surface, then placed in methylene blue dye.

After 24 hours; samples were rinsed thoroughly under running water for 5 min, nail-polish layers removed and teeth were allowed to dry. Decalcification was carried out using nitric acid of 7% concentration for 3 days, then samples were dehydrated for 16 hours with alcohol and finally cleared and stored in methyl-salicylate solution. [10] The coronal half of the roots were poured into acrylic blocks showing the apical half of it to get a standard position for the teeth showed under stereomicroscope. All samples were studied under stereomicroscope at 20x magnification power by two blinded investigators. [5] The deepest point the dye penetrated was recorded for comparison.

Statistical analysis:

Following data collection, statistical analysis was carried out using one-way ANOVA test with P value ($p<0.05$) and 95% confidence level. Over and above, for multiple comparisons between the study groups Bonferroni post hoc test was used.

Results:

The greatest mean value of apical microleakage was recorded in the group without ultrasonic activation (group 3: control group) (4080.2±1132.1 μm) followed by the group with Vibra THO (group 2) (2033.3±1754.3 μm) with the least values recorded in the third group with US activation method (1389.1±1094.8 μm) ***(Fig. 3)***. ANOVA test revealed that the difference between the study groups was statistically significant as the recorded p-value=0.010, which is lesser than 0.05 ***(Tables 1&2 and Fig. 4)***.

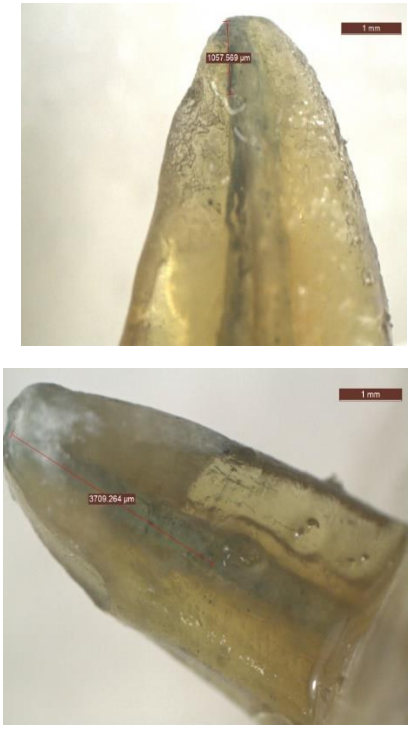

Fig. 3: *Stereomicroscopic images of samples with the depth of methylene blue dye penetration*

Table (1): *Mean values of microleakage in the study groups.*

Study groups	Mean	StD. Deviation	Std Error	Min.	Max.	Confidence interval	
						lower	upper
Group 1: ultrasonic activation	1389.1	1094.8	446.9	446.9	3356.3	240.18	2537.98
Group 2: Vibration Thermohydrodynamic Obturation (Vibra THO)	2033.3	1754.3	716.2	505.6	4759.6	192.25	3874.37
Group 3: control group without ultrasonic activation	4080.2	1132.1	462.2	2189.9	5319.4	2892.18	5268.33

Table (2): *Comparison between groups (ANOVA test)*

Study groups	F-value	P-value	DIFFERENTIATION
Group 1: ultrasonic activation	6.39	0.010*	Statistical significant difference
Group 2: Vibration Thermohydrodynamic Obturation (Vibra THO)			
Group 3: control group without ultrasonic activation.			
Significance level P<0.05. *Significant			

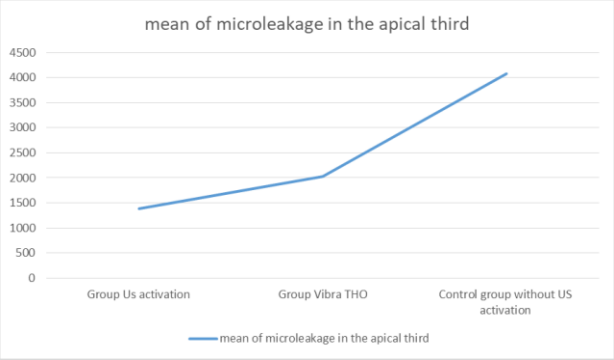

Fig. 4: *Line chart showing the mean values of microleakage in the three study groups*

Bonferroni post hoc test for multiple comparisons revealed that the only statistical significant difference was found between group 1: CeraSeal (BC sealer) + SC obturation technique with US activation and group 3: Control group without ultrasonic activation as p-value= 0.011. There is no statistical significant difference between other study inter-groups ***(Table 3)***.

Table (3): *Bonferroni post hoc test results*

Study groups (I)	Study groups (J)	Mean Difference (I-J)	Std. Error	95% Confidence Interval		P-value	Differentiation
				Lower Bound	Upper Bound		
Group 1: Ultrasonic activation	Group thermohydrodynamic obturation	-644.23	785.840	-2761.07	1472.62	1.000	NS
	Control group without ultrasonic activation	-2691.17	785.84	-4808.02	-574.32	0.011	S
Group 2: Vibration Thermohydrodynamic Obturation (Vibra THO)	Group Ultrasonic activation	644.23	785.84	-1472.62	2761.07	1.000	NS
	Control group without ultrasonic activation	-2046.94	785.84	-4163.79	69.90	0.060	NS
Group 3: Control group without ultrasonic activation	Group thermohydrodynamic obturation	2046.94	785.84	-69.90	4163.79	0.060	NS
	Group ultrasonic activation	2691.17	785.84	574.32	4808.02	0.011	S

Results for multiple comparisons

The mean difference is significant at the 0.05 level.
NS= not statistical significant difference & S=statistical significant difference

Discussion:

Endodontic treatment success mainly relies on convenient instrumentation, irrigation and void free obturation of root canals. Obturation seals the apex from the periapical tissue fluids in addition to preventing bacterial contamination, leakage and irritants seepage into the canal. [11] Treatment lifespan is measured by hermetic apical filling and coronal restoration. The three-dimensional obturation is a key factor for successful endodontic treatment. Recently SC obturation technique was introduced and some authors claimed that it is a perfect obturation technique since it represents technical simplification requiring little time and less skill of the operator to be done. [3]

Bioceramic material was introduced in endodontics by Dr. Torabinejad in 1993 as MTA and was initially recommended as root-end filling material then subsequently for pulp capping, pulpotomy, apexogenisis. It is used also for formation of apical barrier in incompletely formed roots, perforation repair and as root canal filling material. [(11)] Some authors claimed that the usage of SC obturation technique in combination with bio-ceramic sealer is a perfect obturation technique since bio-ceramic sealer have preferable properties as: it is biocompatible and has mechanical properties similar to dental hard tissues. In addition, recent bio-ceramic sealer material. [(11)] Some authors claimed that the usage of SC obturation technique in combination with bio-ceramic sealer is a perfect obturation technique since bio-ceramic sealer have preferable properties as: it is biocompatible and has mechanical properties similar to dental hard tissues. In addition, recent bio-ceramic sealer exhibits higher bond strength with dentine walls through the formation of hydroxy-apatite crystals. [(12)]

However, some concerns regarding presence of voids and gaps -that can negatively affect successful endodontic outcome- are present. [(13)] This has led to suggesting the activation of sealer using ultrasonic method. Application of ultrasonic activation to endodontic sealers have shown effective improvement in push-out bond strength, interfacial adaptation between sealer and canal wall and sealer penetration into lateral canal. [(6)]

Therefore, we evaluated the sealing ability of CeraSeal (a premixed bioceramic sealer) using ultrasonic activation and Vibra THO in comparison to application without ultrasonic sealer activation. Dye penetration test was used as evaluation method as it is simple & applicable, and to validate the results; decalcification and clearing of the samples was carried out to help showing the areas of dye penetration all around the apical area. [(5)]

Results of sealer application without ultrasonic activation showed higher microleakage values in comparison to ultrasonic activation groups. Our results are in agreement with results obtained by Angerame et al. 2020 [(3)] and Damade et al. 2020 [(11)] who proved microleakage of bioceramic sealer with the use of single cone obturation technique without US sealer activation. Drukteinis et al. confirmed in 2021 the presence of voids in all root canal thirds with the highest percentage in the fillings' apical third. [(1)] Hasnain et al. in 2017 were against our research results showing better sealing ability of SC obturation with bioceramic sealer without US activation. [(14)] This may be due to the fact that Hasnain and his partners used BC gutta-percha with the BC sealer where a chemical bond is formed

between the sealer and the gutta-percha causing less leakage.

Ultrasonic sealer activation leads to better adaptation and deeper penetrationof BC sealer into the dentinal tubules. This yielded significantly better bond strength between the sealer and dentinal walls and in accordance less apical microleakage. [6]

Cho YS in 2020 introduced the Vibra THO obturation technique incorporating not only sealer US activation in cone mediated form, but also short-range warm vertical compaction of 2-3mm of US energy-driven heat-softened gutta-percha. [9] In this technique hydraulic pressure was generated, promoting hydrodynamic movement of endodontic sealer. Results of our study showed better sealing ability with the use of Vibra THO obturation technique in comparison to non-activated BC sealer application. On the other hand, teeth obturated using US activation as described by Kim et al. in 2018 -who applied US activation to a cotton plier holding the gutta-percha cones into the canals [8] - showed better results than Vibra THO with no statistical significance. This may be due to the fact that in Kim et al. activation method, there is spontaneous activation of the sealer during mechanical advancement of the gutta-percha cone to the full working length that may have helped in sealer advancement apically.

Conclusion:

Based on this study results, it is concluded that whenever using the SC obturation technique in combination with BC sealer it is better to apply US sealer activation method to reduce microleakage and obtain better endodontic outcome.

References:

1. Drukteinis S, Bilvinaite G, Tusas P, Shemesh H, Peciuliene V et.al. Microcomputed tomographic assessment of the single cone root canal fillings performed by undergraduate student, postgraduate student and specialist endodontist. *J. Clin. Med.* 2021; 10:1080.
2. Robberecht L. Colard T. and Claisse-Crinquette A. Qualitative evaluation of two endodontic obturation techniques: tapered single-cone method versus warm vertical condensation and injection system: An in vitro study. *J. Oral. Sci.* 2012; 54(1): 99-104.
3. Angerame D, Matteo DB, Raffaella P, Rossella B. Filling ability of three variants of the single-cone technique with bioceramic sealer: a micro-computed tomography study. *J Mater Sci* Materials in Medicine 2020; 31: 91.

4. Al-Haddad A, Ab Aziz ZAC. 'Bioceramic-Based Root Canal Sealers: A Review'. *Int J Biomater*. 2016; 2016: 1-10.
5. Alafandi A, Akil S, Ajalyakeen H, Adi A, Alkhouli M. Effectiveness of ultrasonic activation of Endosequense BC Sealer and the type of gutta-percha point on the root canal filling quality (An in-vitro study). *IJDOS* 2020; 7(12): 956-959.
6. Chadgal S, Farooq R, Purra AR. Effect of ultrasonic activation of a bioceramic sealer on its radicular push out bond strength- an in vitro study. *IJRR* 2018; 5(10):112-116.
7. Somma F, Cretella G, Carotenuto M, Pecci R, Bedini R, De Biasi M, et al. Quality of thermoplasticized and single point root fillingsassessed by micro-computed tomography. *Int Endod J*. 2011; 44:362-9.
8. Kim JA, Hwang YC, Rosa V, Yu MK, Lee KW, Min KS. Root canal filling quality of a premixed calcium silicate endodontic sealer applied using gutta-percha cone-mediated ultrasonic activation. *J Endod*. 2018.44, 133–138.
9. Cho Y. Ultrasonic vibration and thermo-hydrodynamic technique for filling root canals: Technical overview and a case series. *Int Endod J*. 2021; 54 (9): 1668-1676.
10. Ko SU, Choi HW, Jeong ED et al. Main and accessory canal filling quality of a premixed calcium silicate endodontic sealer according to different obturation techniques. *Materials* 2020; 13(19): 4389.
11. Damade Y, Gaddalay S, Kabir R, Deshpande S, Kale A, Nagargoje D. Comparative evaluation of root canal filling quality of newly developed endodontic sealers applied using gutta-percha cone mediated ultrasonic activation: An in-vitro study. *IJAR* 2020; 8(04): 568-575.
12. Hwang YC, Kim J.A, Rosa V, Yu MK, Lee KW, Min KS. Root canal filling quality of a premixed calcium silicate endodontic sealer applied using gutta-percha cone-mediated ultrasonic activation. *J Endod* 2018; 44, 133–138.
13. Kim SY, Jang YE, Kim BS, Pang EK, Shim BS et al. Effects of ultrasonic activation on root canal filling quality of single-cone obturation with calcium silicate-based sealer. *Materials* 2021; 14: 1292.
14. Hasnain M, Bansal P, Nikhil V. An in vitro comparative analysis of sealing ability of bioceramic- based, methacrylate-based, and epoxy resin-

based sealers. *Endodontology* 2017; 29:146-50.