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Different Application Methods for Endoseal MTA Sealer: A Comparative Study

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ABSTRACT

Introduction: The aim of present *ex vivo* study was to investigate the filling quality and voids, using Endoseal mineral trioxide aggregate (Endoseal MTA) with a single-cone technique with and without ultrasonic application and to compare these methods with lateral compaction technique. **Methods and Materials:** Thirty-six extracted human anterior single-root teeth were prepared and assigned to 3 groups: Group 1: EMS group was Endoseal MTA+ single-cone; Group 2: EMSU group was Endoseal MTA+ single-cone with ultrasonic activation; and Group 3: LC group was Endoseal MTA+ lateral condensation technique. Teeth were sectioned transversely in coronal, middle and apical of the teeth and the existence of voids_and their areas in the slices were measured and scored under a dental microscope. One-way analysis of variance and Post Hoc test were used for statistical analysis and also to detect any significance (α=0.05). **Results:** EMS group showed significantly more void area than lateral compaction group ($P<0.05$), but the difference between the EMSU group and the other two groups were not significant ($P>0.05$). Also, EMS group had significantly higher void score than the other two groups ($P<0.017$). **Conclusion:** Endoseal MTA as a premixed calcium silicate sealer has a better performance when used with gutta-percha cone-mediated ultrasonic activation, so we suggest gentle ultrasonic activation for applying Endoseal MTA in the clinical use.

Keywords: Mineral Trioxide Aggregate; Root Canal Obturation; Root Canal Sealer; Ultrasonic

Introduction

Three-dimensional obturation of root canal space is essential to achieve the objectives of root canal treatment [1]. Presence of voids in the obturated canal makes a dead space in root canal for preserving bacteria, which increases the risk of failure [2].

A limitation of gutta-percha-based root filling material is lack of adhesion to canal wall dentin. Due to this limitation, it is necessary to use sealers to increase the sealing ability of gutta-percha. A fluid tight seal after cleaning and shaping of the root canal is a critical factor for the success of endodontic treatment [3]. Different types of sealers are currently available including zinc oxide eugenol, calcium hydroxide (CH), glass ionomer, silicone, resin and bioceramic based sealers [4, 5].

Several sealer placement techniques have been explained in the literature, including file usage, lentulo spiral, absorbent paper point, gutta-percha cone, and an ultrasonic file. Each technique may distribute sealer into the canal walls differently, which may impact the sealing process [6-8].

Calcium silicate-based sealers consist of calcium silicate and/or calcium phosphate, which its biocompatibility, physical and chemical properties were intensively investigated [9, 10].

Endoseal mineral trioxide aggregate (Endoseal MTA) (Maruchi, Wonju, Korea), a pozzolan-based mineral trioxide aggregate (MTA) sealer, was recently introduced which contains a premixed and pre-loaded substance kept in an air-tight syringe, allowing its direct application into the root canals, consisting of calcium silicates, calcium aluminates, calcium aluminoferrite, and calcium sulfates [11, 12]. During the administration, the environmental moisture is absorbed from atmospheric air by Endoseal which sets without the help of former powder/liquid or base/catalyst mixing [13, 14]. This sealer has pozzolan cement with cementitious features which are obtained following pozzolanic reaction (the main mechanism involves the transportation of calcium hydroxide *via* water within the soil to combine with the aluminate and/or silicate clay minerals[15]) with calcium hydroxide and water. Therefore the flow of the pre-mixed substrate with enough working consistency is allowed and the setting time is reduced [16, 17]. A fast-setting MTA without the need for a chemical accelerator was obtained due to the presence of small particle pozzolan cement as a mineral mass with watery calcium silicate hydration [16, 18].

Previous reports showed the capacity of Endoseal MTA in inducing dentinal tubule biomineralization [17], desirable biological and physical properties [14], favorable cytocompatibility [19] , and superior sealer distribution [13]. On the other hand, Endoseal MTA has some disadvantages like discoloration due to release of ferrous ions, long setting time, working time is less than 4 min, improper handling properties, compressive strength is inadequate and no known solvent for MTA; therefore, it is difficult to remove from root canal [20].

According to the manufacturer's protocol, this sealer is recommended to be used with single-cone obturation technique [21]. The manufacturer also suggested it as a root canal sealer or as a root canal filling material. Regardless of its usage alone or with core material, the entire root canal system (accessory and lateral) undergoes a complete obturation [22]. Hwang *et al.* [13] used this technique with 4% gutta-percha cone to fill a canal with Endoseal MTA, and reported favorable results regarding sealer distribution and bacterial leakage [1].

Voids can be very critical in a single cone technique, as it requires more sealer volume in comparison with other techniques [23]. Therefore, sealers should be devoid or exhibit minimal voids when using single cone technique [1]. Due to increase in calcium silicate sealers usage, the single-cone filling technique has become more popular in clinical settings [21].

The Endoseal MTA manufacturer has proposed a new method in which ultrasonic power is applied directly to the master gutta-percha cone in order for it to be able to transfer the energy to preplaced sealer for achieving better filling quality with less voids [24].

In this respect, the aim of this *ex vivo* study was to investigate the filling quality and voids, using Endoseal MTA with a single-cone technique with and without ultrasonic application technique and to compare these methods with lateral compaction technique.

Materials and Methods

Thirty-six extracted human anterior single-root teeth were used in this *ex vivo* study. At first, extraneous tissues and calculus were removed from teeth. Each tooth was placed in 5.25% sodium hypochlorite (Darugar, Tehran, Iran) for 24 h for surface disinfection [25] and then stored in distilled water. To ensure of the same length of all specimens, they were resected 12 mm from the apex, using a water-cooled diamond bur. Based on the obtained radiographs, the presence of a single straight canal was confirmed. Canals were accessible and the working length of the canal was specified by inserting a #15 K-file (Mani, Tochigi, Japan) till it was seen at the apical foramen, minus 1 mm. The canals were instrumented using a crown-down technique with rotary ProTaper Nickle-Titanium files (Dentsply-Maillefer, Ballaigues, Switzerland) to F3 in the presence of a 5.25% sodium hypochlorite (NaOCl) solution. After completing the instrumentation, the canal was irrigated with 5 mL of 17% EDTA for one min and then 2 mL of NaOCl solution. After being cleaned and shaped, the teeth were dried with paper cone #30 (Meta Biomed, Chungcheong Buk-do, Korea) until all remaining moisture was absorbed. To make sure of canal dryness, three extra paper cones were applied after observing the last moist paper and then randomly divided into 3 groups (*n*=12) according to the obturation method. The inside of the root canal system has high humidity due to residual moisture in the dentinal tubules. Endoseal MTA solidifies by absorbing the moisture from the dentinal tubules and producing calcium hydroxide during the process that penetrates into the dentinal tubules.

1-EMS group: Endoseal MTA+single cone technique: The sealer was applied directly into the apical third of the canal from a premixed syringe *via* a disposable canal tip. The selected master gutta-percha cones (0.06 taper, #25 or 30 size) (Meta Biomed, Chungcheong Buk-do, Korea) were slowly placed into the canal and showed a good apical tug back. The excess cone was cut off at the canal orifice by a heated plugger and no extra cone was used.

2-EMSU group: Endoseal MTA+single cone technique with ultrasonic activation: An ultrasonic tip E7 (NSK, Tochigi, Japan) and device (NSK, Tochigi, Japan) were connected together and the latter was set on "8" in the yellow code (recommended by the manufacturer as being appropriate for endodontics). The sealer was then inserted into the canal followed by the application of an ultrasonic vibration to a cotton plier that held the gutta- percha cone at 20 mm from the tip. The cone's working length was gradually obtained during repetitious ultrasonic activation. The period of ultrasonic application during gutta-percha cone placement was 2-3 sec, and the excess cone was cut at the orifice level by a heated plugger.

3-LC group: Endoseal MTA+Lateral condensation technique: A size #25 or 30 master cone (Dent Plus, Chungcheong Buk-do, Korea) coated with sealer was placed in the canal up to the full working length. Lateral compaction technique was performed in each canal, using size 20 accessory gutta-percha cones, slightly

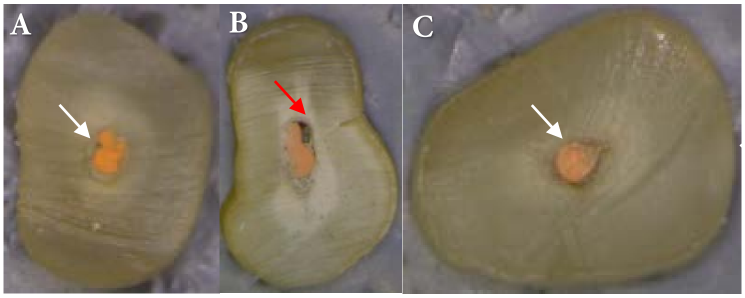

Figure 1. Representative Dental microscopic images of (0-2) section. *A*) score 1 of LC (Endoseal MTA+lateral condensation technique) group; *B*) score 4 of EMS (Endoseal MTA+single-cone) group; *C*) score 2 of EMSU (Endoseal MTA+single-cone with ultrasonic activation) group; White and red arrows indicate small and large sized air bubbles, respectively

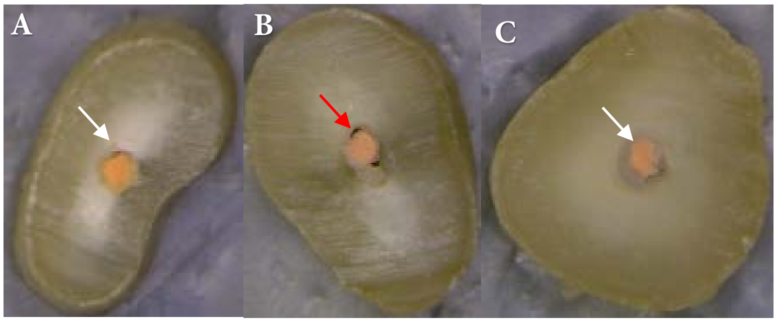

Figure 2. Representative Dental microscopic images of (2-5) section. *A*) score 1 of LC (Endoseal MTA+ lateral condensation technique) group; *B*) score 3 of EMS (Endoseal MTA+ single-cone) group; *C*) score 2 of EMSU (Endoseal MTA+ single-cone with ultrasonic activation) group; White and red arrows indicate small and large sized air bubbles, respectively

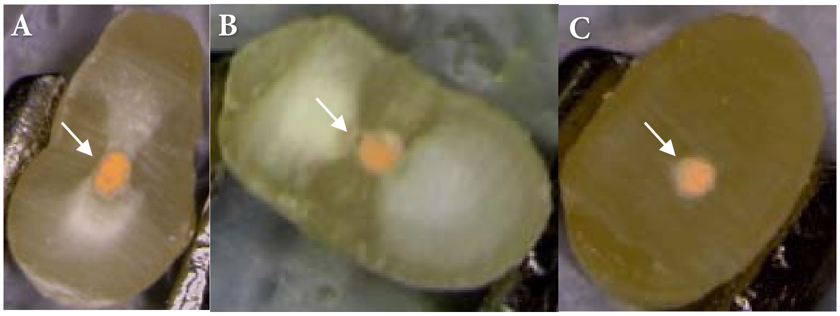

Figure 3. Representative Dental microscopic images of (5-9) section. *A*) score 1 of LC (Endoseal MTA+ lateral condensation technique) group; *B*) score 1 of EMS (Endoseal MTA+ single-cone) group; *C*) score 1 of EMSU (Endoseal MTA+ single-cone with ultrasonic activation) group; White and arrows indicate small sized air bubbles

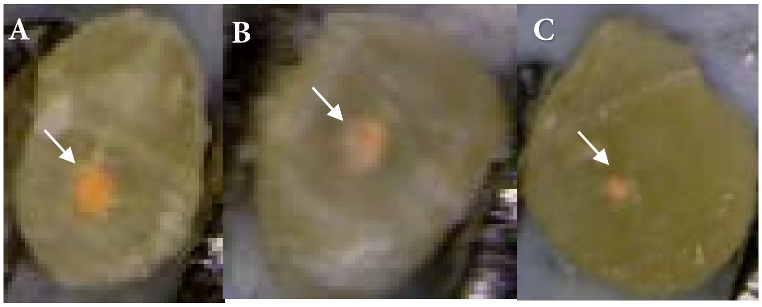

Figure 4. Representative Dental microscopic images of (9-11) section. *A*) score 1 of LC (Endoseal MTA+ lateral condensation technique) group; *B*) score 1 of EMS (Endoseal MTA+single-cone) group; *C*) score 1 of EMSU (Endoseal MTA+single-cone with ultrasonic activation) group; White arrows indicate small sized air bubbles

covered with the sealer, and an endodontic finger spreader size A (Mani, Tochigi, Japan). This spreader was initially reached within 2 mm of the full working length.

The access cavities of all samples were filled with a flowable composite resin (G-aenial Flo; GC, Tokyo, Japan), and the teeth were kept at 100% humidity for 7 days at 37°C to let the sealer completely set.

The teeth were sectioned at 2, 5 and 9 mm from coronal to apical, perpendicular to longitudinal axis of the root, using a low-speed diamond-coated saw (Isomet, Buehler, IL, USA) under water cooling. Four slices per root were obtained and all slices were observed under a dental microscope (Labomed, Magna Model, Culver City, CA, USA) under 8× magnification, and pictures were taken by a camera (Canon EOS 1000D, Tokyo, Japan) from each slice surface (Figures 1 to 4). The images were then analyzed using the image software ImageJ (National Institutes of Health, Bethesda, MD, USA) to calculate the area of voids. The scoring was done by 2 independent observers blinded to treatment protocols and degree of agreement was calculated using Cohen's kappa (k) values (kappa: 0.9). For each section, measurements were repeated twice, the mean was calculated and the void area in each slice was noted in μm^2.

Statistical analysis

Area of void

The data were statistically analyzed using one-way analysis of variance and Post Hoc tests to detect any significance ($P<0.05$). The analysis was performed with SPSS software (SPSS version 16, SPSS INC., Chicago, IL, USA).

Void score

Void score values did not follow a normal distribution as determined by Kolmogorov-Smirnov. Hence, the statistical analysis was performed using Kruskal-Wallis test and Mann-Whitney test with adjusted $\alpha=0.017$. The analysis performed with SPSS software (SPSS version 16, SPSS INC., Chicago, IL, USA).

Result

Area of void

As shown in Table 1 the difference between lateral compaction group and EMS group was significant ($P<0.05$). EMS group had significantly more void area than lateral compaction group ($P<0.05$), but the differences between the EMSU group and the two other groups were not significant ($P>0.05$). In coronal section the difference between EMS group and the two other groups were significant ($P<0.05$) and this group showed significantly more void area than the two other groups. In middle section the difference between lateral compaction group and EMS group was significant ($P<0.05$), and EMS group showed significantly more void area than lateral compaction group. Whereas in the apical section, no significant difference was observed between groups ($P>0.05$).

Table 1. The average void area and void score in dental microscopic images of each sectioned specimen

Section	**Void area**			**Void score**		
	EMS	**EMSU**	**LC**	**EMS**	**EMSU**	**LC**
1(0-2)	B	A	A	b	a	a
	4.67 (3.84)	0.74 (1.06)	1.33 (1.97)			
2(2-5)	B	AB	A	b	a	a
	1.94 (2.01)	1.02 (2.48)	0.01 (0.08)			
3(5-9)	B	AB	A	b	ab	a
	1.32 (1.92)	1.08 (2.10)	0.00 (0.00)			
4(9-11)	A	A	A	a	a	a
	0.56 (1.94)	1.87 (4.37)	1.87 (6.49)			
Total	B	AB	A	b	a	a
	1.96 (2.68)	1.16 (2.65)	0.55 (2.79)			

EMS group: Endoseal MTA+ single-cone; EMSU group: Endoseal MTA+ single-cone with ultrasonic activation; LC group: Endoseal MTA+ lateral condensation technique. Values are shown as the mean ± standard deviation. Groups identified by the same letter horizontally are not significantly different (P>0.05)

Table 2. Scores used for evaluating the filling quality by void detection

Score	**Definition**
1	Well-condensed filling that showed only a few and minor air bubbles (less than 1 μm^2 in volume)
2	An imperfectly condensed filling that showed some minor air bubbles (more than 3 defects) or medium-sized air bubbles (2 μm^2 to 4 μm^2 in volume)
3	Inadequately condensed filling that showed many minor air bubbles (more than 5 defects) or large air bubbles (4 μm^2 to 20 μm^2 in volume)
4	Poorly condensed filling that showed many minor air bubbles (more than 7 defect or more than 20 μm^2 in volume) or empty spaces

Void score

Void scores are shown in Table 2. There were significant differences between EMS group and the two other groups in terms of void score ($P<0.017$) and EMS group had higher void score in comparison with the two other groups. As shown in Table 1, the results of void score were similar to void area results, and merely in the middle section, the difference between EMSU group and EMS group was significant ($P<0.017$).

Discussion

This study showed that EMS group showed significantly more void area than lateral compaction group, but the difference between the EMSU group and the other two groups were not significant. Also, EMS group had significantly higher void score than the other two groups but the differences between EMSU group and LC group was not significant.

Anisha *et al.* [1] used stereomicroscope and indicated that single cone obturation with MTA Fillapex sealer had void free apical and middle third section and significantly least area of voids than AH-26 and pulpdent. Celikten *et al.* [26] used µ-CT evaluation and reported that bioceramic sealers produced similar voids which had the fewest in the apical third of root canals, these voids are closely related to the root canal anatomy rather than the root canal filling material or technique. Bahlakeh *et al.* [25] used microleakage measurement and showed that mean apical leakage of Endoseal MTA sealer was significantly lower than that of AH-Plus when used with single cone technique obturation, and humidity had no significant effect on the mean apical leakage of the used sealers. Despite using different types of bioceramic sealers, the results of these studies are in line with our results in terms of void presence and void areas. All of these are bioceramic sealers with the same base and same properties and it could be the reason of results similarity.

Kim *et al.* [24] used µ-CT evaluation and stereomicroscope observation and indicated that similar to our results the void number and void score were higher in EMS(Endoseal MTA+ Single cone technique) group compared with EMSU (Endoseal MTA+ single cone technique with ultrasonic activation) and APW (AH-Plus with warm vertical compaction technique) group. They used single gutta-percha cone 0.04, but in our study single cone gutta-percha 0.06 was used. The volume of sealer with gutta-percha cone 0.06 might be less, which might affect the void area. Furthermore, gutta-percha cone 0.06 can spread the sealer to the root canal walls much better, consequently affecting the void area. On the other hand, in this study, void area instead of void number was measured, since it is more accurate.

Moreover, Wilcox *et al.* [27] observed that during retreatment, most of the remaining material is sealer; hence, the sealer is essential to be completely removed. Since it is difficult to remove Endoseal MTA from the root canal using conventional retreatment techniques, including heat, chloroform, rotary instruments or hand files, using gutta-percha cone 0.06 and less amount of sealer may cause easier retreatment procedure.

Void in the sealer of root canal is a great concern, since it creates porosity, reduce the filling quality, acts as a hub for microbial housing, and might even transmit contaminants along the filled root canals [28].

Root canal sealers mainly function as a sealer of voids, patent accessory canals, and multiple foramina, by bonding the filling material core and the root canal wall, which entombs any remaining bacteria [29]. Generally, the sealability of obturating materials in canals is evaluated by two approaches: (1): measurement of the microleakage and (2): assessment of the filling quality [24]. The former, however does not attract research attention anymore due to some limitations. In December 2007, the “Journal of Endodontics” temporarily prohibited the use of leakage test and sealability studies in which two endodontic techniques were compared [30]. Most previous studies used microleakage model, which is considered to be non-reproducible, and they showed large standard deviations [31]. Furthermore, there are limited number of studies regarding the assessment of filling quality. The journal, in return, encouraged researchers to examine the validity of the methods.

Micro-CT is another way to evaluate the obturation quality and void in canals, but radio opacity of gutta-perca and most of sealers may affect the accuracy of this technique [24]. Kim *et al.* [24] stated that µ-CT observation might be less sensitive compared to the sectioning method in terms of void detection, so we decided to use sectioning and direct observation method. For this purpose, we evaluated the void area in different parts of the root canal because it is a relevant parameter for assessing the quality of a root canal obturation system [32].

During the application of calcium silicate cement to the root canal, vibration minimizes the flaws by producing a series of rapid pulses that reduce the surface friction between the cement particles [33]. Accordingly, we applied ultrasonic vibration to the sealer through a master gutta-percha cone, achieved better filling quality, by producing fewer voids. Parashoes *et al.* [34] reported that excessive ultrasonication adversely affected MTA properties by creating voids, and according to the manufacturer’s instruction, the generated ultrasonic vibration frequency of the device (P-5 Newtron XS; Satelec, Mount Laurel, NJ, USA) should range from 28 to 36 KHz [24]. Therefore, we suggest gentle ultrasonication to obtain more favorable results.

This study was an *ex vivo* study and should be considered with caution for clinical use. This is one of the limitations of this study.

Conclusion

Based on the results, Endoseal MTA as a premixed calcium silicate sealer has a better performance when used with gutta-perca cone-mediated ultrasonic activation, so we suggest gentle ultrasonic activation for applying Endoseal MTA in the clinical use.

Conflict of Interest: 'None declared'.

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