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Cone beam computed tomography assessment of MTA Efficacy as orthograde root canal filling materials after preparation using reciprocating motion analysis (Ex-vivo study)

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Abstract
Introduction: Three-dimensional seal of homogenous root canal filling material is key for the successful of root canal treatment.
Aim: The purpose of the present study was to compare the quality of two different root canal obturation techniques: MTA and cold lateral compaction technique (CLC) using cone beam computed tomography (CBCT) analysis
Materials and methods: Twenty single rooted extracted teeth were collected. Root canals were prepared using Reciproc file system. The samples were scanned using CBCT before obturation. The roots were randomly allocated into two groups, one group was obturated by CLC using gutta-percha / AH plus sealer, the second group was obturated with MTA. Roots were scanned with CBCT, and volume measurements for voids were carried out by using specialized software**.** The difference between both techniques was evaluated using Mann Whitney U test. Independent t test was used to compare between groups.
Results: Revealed that a higher mean value of percentage of obturated volume (POV) was recorded in MTA group, with no statistically significant difference.
Conclusions: CBCT imaging system produces a clear view of the volumetric measurements of voids. There was no significant difference between the qualities of root canal filling by both techniques. None of the two root canal filling techniques could completely fill the root canal space.

Keywords: Root canal obturation, CBCT, MTA, reciproc files, AH plus, lateral compaction

Introduction
For successful root canal treatment, adequate biomechanical instrumentation, filling of the canal space, and proper coronal seal should be achieved [1]. The final objective of root canal treatment is total filling of root canal space three dimensionally with biocompatible homogenous core material that prevents reinfection and ingress of microorganisms and/or their byproducts to the periapical tissue [2-4].
Nickel –titanium rotary systems have been developed to improve root canal preparation due to the unique properties of that alloy. These instruments are able to enhance the canal shaping. It was concluded that they can preserve the original anatomy of the canal and decrease the transportation [5, 6].
A new concept for NiTi system has been developed that used only a single file. Reciproc (VDW, Munich, Germany) is one of these file systems. It has been speculated that these instrument designs can finish shaping the root canal with single file that is used in a reciprocating motion that improve the cyclic fatigue and will be more comfortable for both the clinician and the patient [7, 8]. Gutta-percha (GP) is widely used material for root canal obturation due to its adequate physical properties [9]. Cold lateral compaction technique is widely used root canal filling technique, as it permits simple insertion of Gutta-percha and could be easily removed in cases of post placement or retreatment [10-12]. Mineral trioxide aggregate (MTA) (ProRoot; Dentsply Tulsa Dental, Tulsa, OK) is highly recommended material as a root-end filling material, direct pulp capping, root perforations repair materials and for apexification [13-17].

The uses of MTA as a filling material for the entire root canal system in closed apex of permanent teeth have been suggested [18-20]. It was also recorded in cases of retained primary teeth with no permanent successors [21]. Many experimental techniques have been used to study the quality of root fillings, such as: dye and bacterial leakage, fluid filtration, scanning electron micoscopic analysis, radiographs and more recently cone beam computed tomography (CBCT) [22-27]. CBCT is a nondestructive three dimensional imaging technique that has been used widely in dentistry [28, 29]. Various appilication for CBCT uses in endodontics, it has been used to identify root canal morphology [30], after instrumentation [31] and assessment of obturation quality [32].

The purpose of present *in vitro* study was to compare the quality of two different root canal obturation materials namely gutta percha and tooth colored MTA utilizing CBCT analysis.

Materials and methods

Samples selection: Twenty extracted mature single rooted teeth with fully formed roots that have no root caries, resorption nor cracks. The teeth were immersed in 5.25% sodium hypochlorite for 24 hours, and then stored in normal saline solution.

Ethical approval was approved at Um Al Qura Univesity (IRB).

Samples preparation

Access cavity in each tooth was performed using round bur and endo-z bur, a #10 K file was inserted into the canals until its tip was just seen at the apex. The working length was determined by subtracting 0.5 mm short of this length. A glide path was established using hand file; samples were prepared using Reciproc 25 that provides clockwise and counterclockwise rotation. Canals were prepared following crown down technique according to manufacturer's instructions. Irrigation was done using 3 mL 2.5% sodium hypochlorite between files. Glyde (Dentsply Maillefer) was used as a lubricant. For smear layer removal a final flush of 1 mL 17% EDTA followed by 3 mL 2.5% NaOCl.

CBCT pre obtuartion imaging

CBCT scanner (Cone Beam I-Cat tomography) was used to scan the samples. Adjusting parameters for scanning, each sample was fixed on the specimen stage and scanned by a high resolution CBCT scanner with exposure time of 26.9 s, operating at 120 kvp and 37.07 mAs. CBCT imaging was performed with 0.25-mm voxel size. Software was used for the 3-dimensional analysis, and volume of the root canal space measurement. The area of prepared root canal in each slice was measured from the orifice to the apical constriction.

Root canal Obturation

The samples were randomly divided into two groups 10 each.

Group I

The roots were filled with gutta-percha and AH Plus sealer (De Trey/Dentsply, Konstanz Germany) using lateral condensation technique. AH Plus sealer was applied to the canal using a lentulo spiral (Dentsply, Maillefer) and standardized gutta-percha cone was coated with AH Plus sealer and inserted into the root canal slowly until fully seated and was checked for tug back at the estimated working length. Lateral condensation with 25 size spreaders (Dentsply/Maillefer) and the matching accessory gutta percha cones (Dentsply/Maillefer). One operator did all the steps to decrease variations.

Group II: MTA group

Tooth-colored ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK, USA) was prepared according to the manufacturer's recommendations. MTA was prepared by mixing powder with distilled water to form a thick mix of MTA that applied incrementally to the canal using a MTA delivery gun and were compacted using the blugger, butt end of paper points was used after each increment to absorb the extra water. The specimens were stored at 100% humidity and room temperature.

CBCT post obturation imaging

All CBCT images were scanned after obturation. To obtain the root canal volume, based on gray values. Thereafter, the 3D model was generated, and the volume of root canal was automatically resulted. One examiner trained to use the software. The root canal was segmented in axial, sagittal, and coronal reconstructions.

Statistical analysis

Statistical analysis was then performed using a commercially available software program (SPSS 19; SPSS, Chicago, IL, USA). As data related to difference in pulp-volume were non-parametric, significance of the difference between both materials was evaluated using Mann Whitney U test. POV was calculated using the formula:

POV=Mean volume after obturation / Mean volume before obturation ×100

Independent t test was used to compare POV between groups, as these were normally distributed. The level of significance was set at $P<0.05$.

Results

Differences in volume of pulp space before and after obturation

A higher mean value was recorded in Gutta percha group. Mann Whitney U test revealed that the difference between groups was not statistically significant (p=0.533), (Table 1, Fig. 1)

Table 1: Differences in volume (cm^3) of pulp space before and after obturation (Mann Whitney U test).

Groups	Mean	Std. Dev	Std. Error Mean	Mean difference	Std error difference	95% Confidence Interval of the Difference		Z	p
						Lower	Upper		
MTA	20.09	13.08	3.94					0.624	0.533ns
Gutta Percha	22.93	9.80	2.96	2.83	4.93	-13.16	7.44		

Significance level P<0.05, ns= non-significant

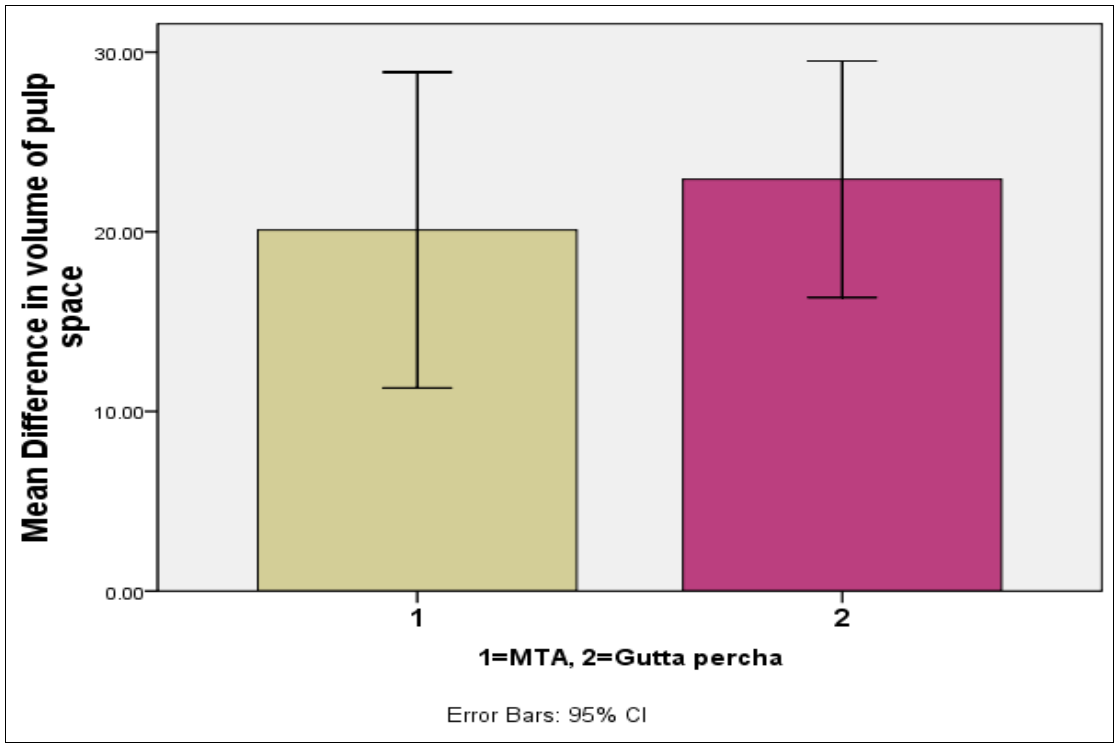

Fig 1: Column chart showing differences in volume of pulp space (cm^3) pre and posr obturation.

POV

A higher mean value was recorded in MTA group. Mann Whitney U test revealed that the difference between groups was not statistically significant (p=0.518), (Table 2, Fig. 2).

Table 2: Percentage (%) of the Obturated Volume (POV), (independent t test).

Groups	Mean	Std. Dev	Std. Error Mean	Mean difference	Std error difference	95% Confidence Interval of the Difference		t	p
						Lower	Upper		
MTA	315.39	138.26	41.69	31.76	48.04	-70.12	133.64	0.66	0.518ns
Gutta Percha	283.63	79.20	23.88						

Significance level P<0.05, ns= non-significant

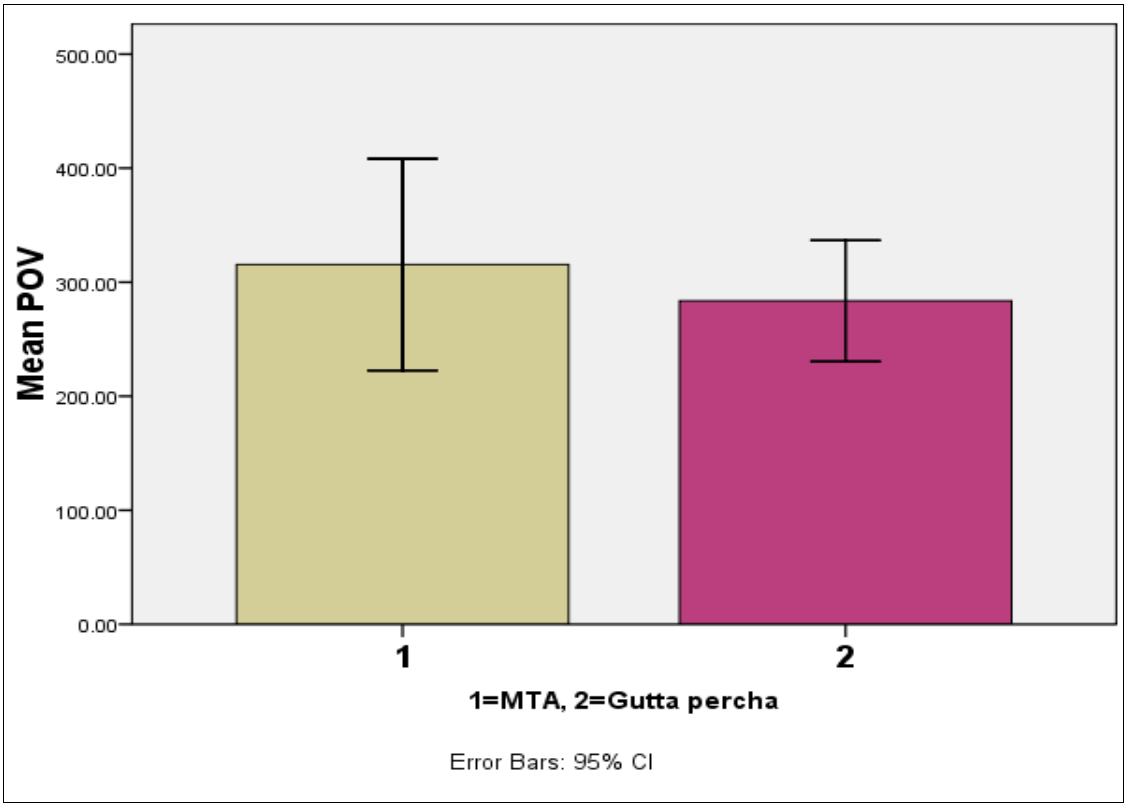

Fig 2: Column chart showing mean percentage (%) of the obturated volume (POV), (independent t test).

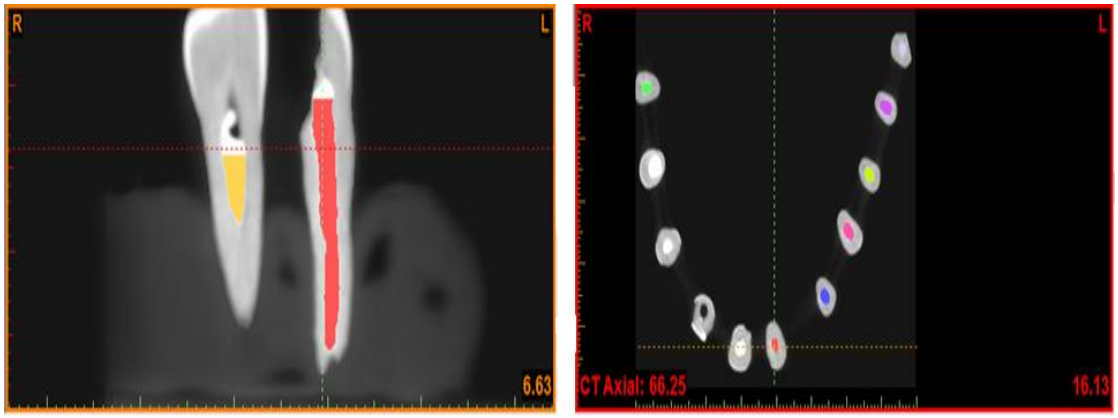

Fig 3: Axial and sagittal cross sections of CBCT

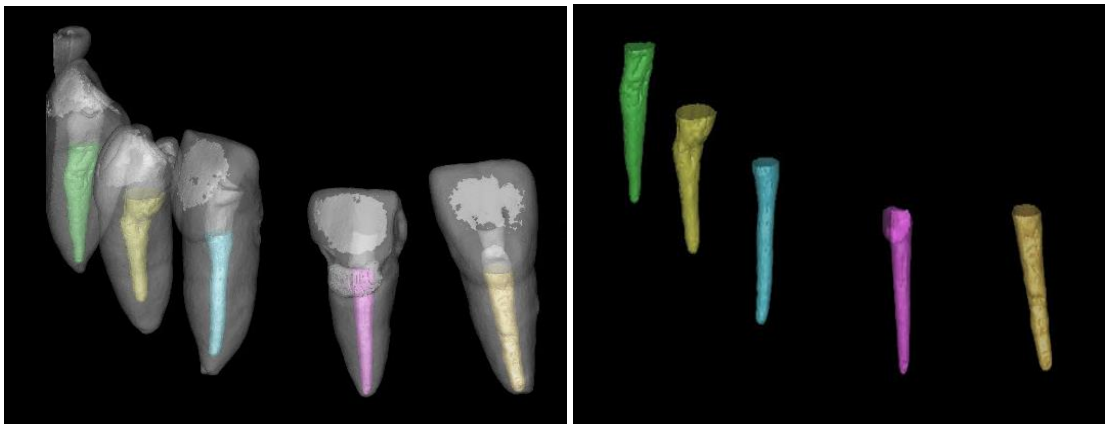

Fig 4: Showing CBCT scanning of root canal filling using lateral condensation technique

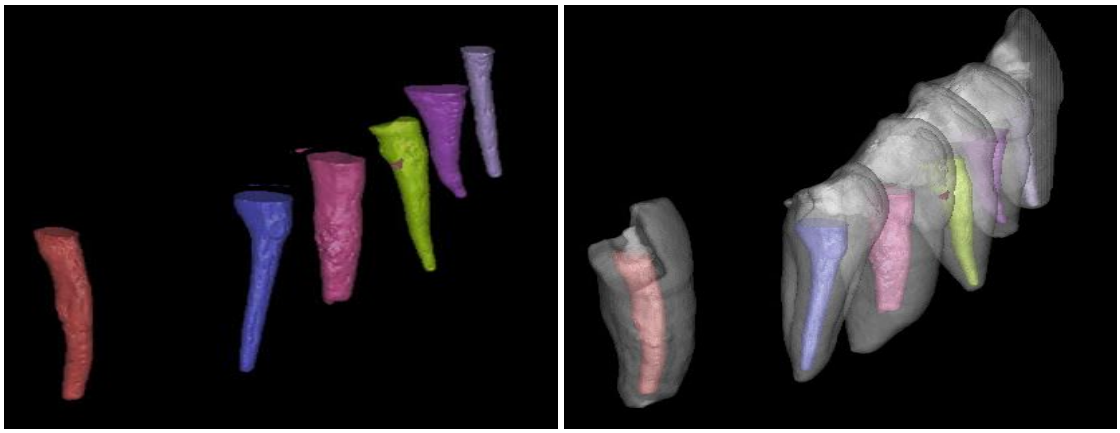

Fig 5: Showing CBCT scanning of root canal filling using MTA filling technique.

Discussion

The main goal of root canal treatment is to prevent the ingress of microorganisms to the root canal system**.** One of the critical determinants of the success of endodontic treatment is the material used for root canal filling. Gutta-percha with sealer has been used for decades as the main root canal-filling material, due to its merits as proper filling of the root canal space, favorable handling properties, and biocompatibility. However, gutta-percha canal fillings were found to have variable degrees of leakage when tested *in vitro* studies [33, 34]. The lateral condensation obturation technique was selected using gutta percha with AH Plus sealer because it is a simple, well-standardized and recognized root filling technique and therefore, it was used as a standard with which other filling techniques could be compared [11]. Mineral trioxide aggregate (MTA) was investigated as an orthograde canal-obturation material due to its favorable chemical, physical and biologic characteristics [16, 35, 36]. Root canal preparation using a single instrument, with reciprocating motion provides great advantages. It has been reported that reciprocating motion increase cyclic fatigue resistance and decreases apical debris extrusion [37]. Few studies have demonstrated the obturation quality after root canal preparation using reciproc file system [38]. The cone beam computed tomography imaging system used in the present study utilized a clear view of the volumetric measurements of gaps and voids owing to its highly nondestructive and accurate properties [28]. But Eguchi *et al*. reported that there is more sealer proportion in the lateral condensation technique that might cause some voids in the root canal, therefore; the final core is composed of excessive number of Gutta-percha cones that compressed together with root canal sealer, rather than a homogeneous core of Gutta-percha [10]. Bortoluzzi *et al*. reported that grey MTA applied in the coronal third of the root canal caused

tooth discoloration, so in this study it was recommended to use white colored MTA to avoid discoloration [15, 39]. In current study, difference in volume before and after obturation means the presence of voids that were detected in the two groups, that proving that none of the two root canal filling materials could completely fill the canal space. The lateral condensation technique showed the higher voids in the root canal after obturation, but was statistically non-significant.

The POV was higher in the MTA group (315.39±138.26) than the gutta percha group (283.63±79.20) than the lateral condensation group (92.4000 ± 1.57762) (Table 2), with no significant difference. Al – Hezaimi *et al*. and Mohammadi *et al*. reported that the sealing ability of MTA is better than gutta percha and Kerr Canal Sealer, Their results regarding MTA cements are in accordance with the findings of the present study [40, 41]. While, the results of the present study differ from those of Vizgirda *et al*. [19] who reported that the apical seal produced by laterally- condensed gutta percha and sealer was superior to that produced by MTA. Other Studies have compared root canal filling with a variety of MTA materials and concluded that MTA is an effective root apex filling products [42, 43]. The difference in outcomes from the present study could be attributed to the different methodologies and techniques used for measuring the root filling quality. Kim *et al* recommended using a GP cone and epoxy resin-based sealer when filling the root canals of mature permanent teeth as their results showed that GP has superior sealing ability than MTA [44]. Therefore, further studies regarding the sealing ability and dentinal tubules penetration are recommended.

Conclusions

Within the limitations of the present study we conclude that CBCT imaging system produce three dimentional imaging and a clear view of the volumetric measurements of gaps and voids. There was no significant difference between the qualities of root canal filling produced by gutta percha with sealer versus MTA filling materials. None of the two root canal filling materials could completely fill the canal space.

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