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Original Article

3D CBCT evaluation of sealer placement using different techniques-An invitro study

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ABSTRACT

Introduction: Success of root canal therapy depends upon thorough cleaning, shaping and three dimensional obturation. In order to obtain a fluid impervious seal, the core filling materials and the sealers used to seal the root canal must create different interfaces forming a monoblock. Greater penetration of sealer in root dentine, lesser will be the voids at the dentin–sealer interface. Hence, analysis of the dentin/sealer interface allows the determination of a filling technique which could obturate the root canals with least gaps and voids.**Aim and objective**: The aim of the study is to compare the void volumes of sealer using three different root canal sealer placement techniques under CBCT.**Materials and methods:** Twenty four single‑rooted premolar teeth were selected and prepared. Specimens were assigned randomly into three groups. Bioceramic sealer was applied using gutta percha as Group 1, ultrasonic endodontic tip as Group 2, and lentulo spiral as Group 3. Canals were then obturated with gutta‑percha. Each specimen was then scanned using CBCT.**Result:** Sealer placement techniques had a statistically significant effect on void formation. Maximum voids were observed in Group 1 and minimum in Group 3.**Discussion:** The volume of voids present between the obturating material and dentin walls is analysed for desirable outcome .Therefore, in the present study, three sealer placement techniques were chosen and the sealer distribution was analyzed for voids .**Conclusion:** The volume of voids of sealer were influenced by the type of placement techniques . Lentulo spiral has shown better adaptation of sealer on canal walls than gutta percha and ultrasonics, thus creating lesser volume of voids.

INTRODUCTION

A crucial step in root canal therapy is root canal obturation, which seals the canal to prevent further bacterial contamination or recontamination of the canal space and create a fluid-impervious barrier. Various methods and materials for obturation have been developed over time in an effort to improve the root canal seal. According to in vitro research, the majority of root canal filling methods did not completely fill the root canal system.[1]The ideal core filler material is gutta-percha, although it has the drawback of not adhering to canal walls.[2] Before using guttapercha to obturate the canal, a root canal sealer should be inserted into it to provide an adequate seal.[3]An essential component of an effective endodontic treatment is a root canal sealer. It prevents the growth of microorganisms on the root canal walls or in the tubules by filling in the imperfections and small differences between the root canal wall and core-filling material, creating an impervious seal.[4]The quality of the root canal filling is affected by the thickness of the sealer layer. Bacterial microleakage from the canal into the periapical tissues can occur from improper sealer application, which can leave voids in the root canal filling.[5] S-voids are predominantly seen in the apical third of the canal filling, whereas I-voids are more abundant in the coronal third. In the apical and coronal regions of root canal filling, void detection is challenging. No filling technique or root canal instrumentation guaranteed void-free obturation.[6] Sealers can be placed using a variety of approved techniques, such as endodontic files or reamers, lentulo spirals, master cone gutta-percha , paper points, and most recently, ultrasonic files.[7]Conventional techniques for assessing root fillings have drawbacks and only enable a limited assessment of the root canal material. Radiographs provide a two-dimensional image of a three-dimensional structure. Some of the drawbacks of the conventional procedures may be mitigated by the recently developed three-dimensional computed tomography imaging methods.[8] Cone Beam CT (CBCT) is a relatively recent extraoral radiography

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technique that generates digital radiography data in three dimensions. It was created especially for imaging of the jaws and teeth. It is becoming more readily accessible and has uses in oral surgery, endodontics, and implant dentistry. [9]The aim of this study was to compare the volume of voids using three different root canal sealer placement techniques under cone beam computed tomography.

Materials and methods

This study was conducted in the Department of Conservative Dentistry and Endodontics of Peoples College of Dental Sciences and Research Centre, Bhopal. In this study, 24 extracted human single-rooted premolars which were extracted for periodontal or orthodontic reasons and teeth without caries, root resorption, or fractures were used. Root surfaces were scaled with a curette to remove soft tissue, calculus, and bone. Each tooth was placed in 3% sodium hypochlorite (NaOCl) for 2 h for surface disinfection, and then stored in distilled water until testing was performed.

Access opening and canal preparation

Access cavity preparation was done in all teeth using number #4 round diamond bur through the occlusal surface. Subsequently, a size #10 K-File was inserted into the root canal until the tip was just visible beyond the apex. Working length was determined by subtracting 1 mm from this length. Canal preparation was done in all teeth using Protaper Gold Rotary file upto size 25. Irrigation was performed with 2 mL 3% NaOCl between each instrument. A final rinse with 2 mL 3% NaOCl, 2 mL 17% EDTA for 1 min, and 10 mL distilled water was performed. Then, the canals were dried with paper points.

Sealer Placement

Teeth were assigned randomly into three experimental groups. Each group of 8 teeth had sealer applied by one of three methods: Master cone Gutta Percha, Ultrasonic Endodontic tip, Lentulo spiral. Bioceramic sealer (BIOCERA) was used for all study groups. It was mixed according to the manufacturer's recommendations.

Group 1 teeth had sealer applied with the master gutta-percha cone, which was placed to working length and gently pumped up and down at least 5 times. Excess sealer which extruded apically or coronally was cleaned from the tooth
surface with cotton gauze.

Group 2 had sealer placed via ultrasonically activated size 25 endosonic file with the irrigation system off, for 10 s, inactivated and withdrawn.

Teeth in Group 3 had sealer placed with a 25 mm, #2, engine-driven lentulo spiral, which was gently rotated to working length and worked gently up and down within the canal at least 5 times.

Canal Obturation

Following sealer placement, all teeth were obturated with single cone technique. No additional sealer was applied before gutta-percha cone insertion. The master gutta-percha cone was gently inserted into the canal, allowing excess sealer to escape. Following obturation, a heated plugger was used to remove excess gutta-percha and sealer to the canal orifice. The root access was sealed with Cavit temporary restorative material. Teeth were then stored in 100% humidity at 37 degrees C for five days to allow the sealer to set.

CBCT Evaluation

The samples were embedded in wax for precise positioning on CBCT machine. CBCT scans of samples were taken. Each tooth was divided into three regions for the evaluation of voids, from the apical end of the root at a level of 0–4 (apical), 4–8 (middle), and 8 12 mm (coronal). The volume of internal voids distributed inside the root canal filling material, the external voids along the canal walls, and the combined voids in materials communicating with the canal walls, were calculated with the CBCT analysis.

RESULT

Descriptive Interpretation of Sealant Density by Location

The study evaluates the sealant density using three distinct techniques- Guttapercha, Ultrasonic, and Lentulospiral—across different root locations: apical, middle, and coronal.

Apical Region

In the apical region, the Guttapercha technique demonstrates a mean sealant density of 0.2517 with a standard deviation of 0.0371. The Ultrasonic technique, on the other hand, achieves a higher mean density of 0.4754 with a standard deviation of 0.04541. The Lentulospiral technique stands out in the apical region with the highest mean density of 0.7227 and a standard deviation of 0.06124, indicating significantly better sealing quality. A significant p-value of confirms the superior performance of Lentulospiral in achieving effective seals at the apical end.

Middle Region

In the middle region, the Guttapercha technique shows the lowest mean density of 0.2154 with a higher standard

(1) (2) (3)

CBCT Images: (A) Coronal section , (B) Middle section, (C) Apical section

GROUP 1

(A) **(B)** **(C)**

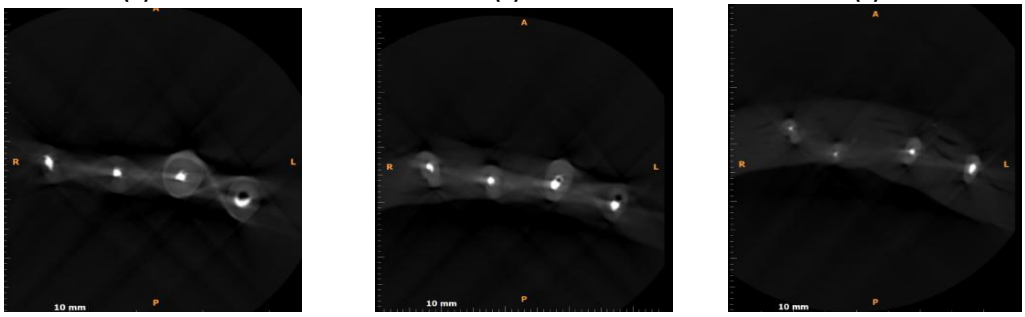

Fig (1.1) **Fig (1.2)** **Fig (1.3)**

GROUP 2

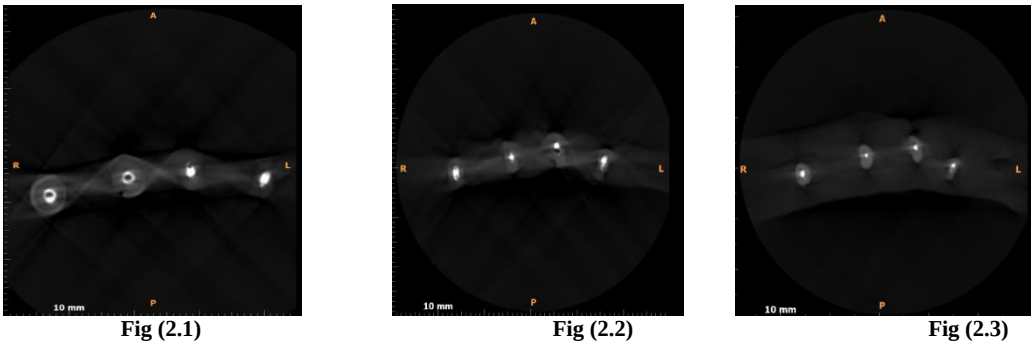

Fig (2.1) **Fig (2.2)** **Fig (2.3)**

GROUP 3

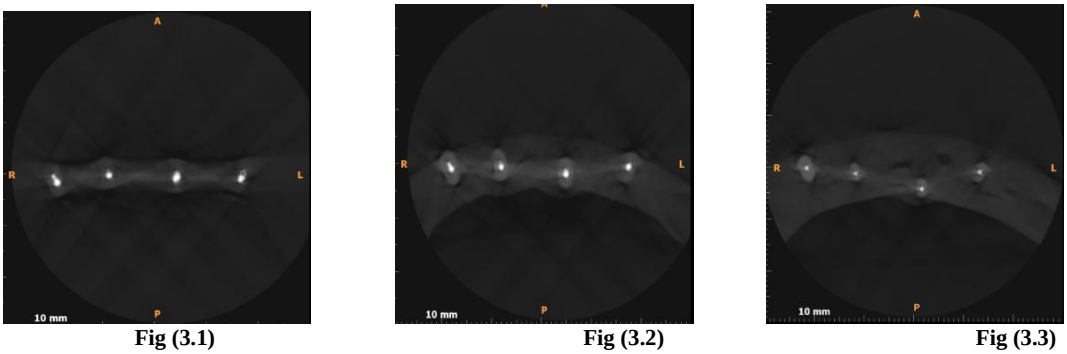

Fig (3.1) **Fig (3.2)** **Fig (3.3)**

CROSSECTION IMAGES OF CBCT

GROUP 1 **GROUP 2** **GROUP 3**

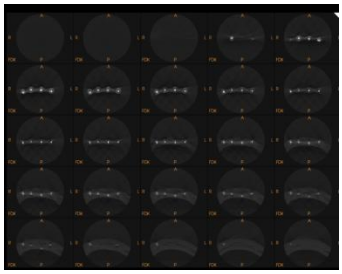
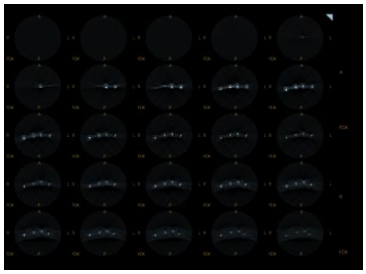
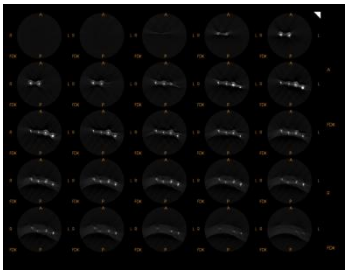

Table 1: Descriptive values of sealant density in all techniques

Sealant Technique	N	Minimum	Maximum	Mean	Std. Deviation
Master Cone –Guttapercha					
Apical	12	.21	.32	.2517	.03711
Middle	12	.15	.32	.2154	.04996
Coronal	12	.33	.48	.3773	.04498
Ultrasonics					
Apical	12	.39	.55	.4754	.04541
Middle	12	.45	.59	.5376	.04294
Coronal	12	.55	.69	.6213	.04578
Lentulospiral					
Apical	12	.60	.81	.7227	.06124
Middle	12	.78	.90	.8452	.03662
Coronal	12	.88	1.04	.9465	.03962

Table 2: Sealant density of various techniques at different location

Location	Technique	Mean	S.D	95% Confidence Interval		'F' statistic	P value
				Lower bound	Upper bound		
Apical	Guttapercha	.2517	.03711	.2282	.2753	277.835	0.000*
	Ultrasonic	.4754	.04541	.4466	.5043		
	Lentulospiral	.7227	.06124	.6838	.7616		
Middle	Guttapercha	.2154	.04996	.1837	.2472	628.388	0.000*
	Ultrasonic	.5376	.04294	.5103	.5649		
	Lentulospiral	.8452	.03662	.8219	.8684		

Coronal	Guttapercha	.3773	.04498	.3488	.4059	515.986	0.000*
	Ultrasonic	.6213	.04578	.5922	.6504		
	Lentulospiral	.9465	.03962	.9213	.9717		

*=Significant; NS=Not Significant

Graph 2: Sealant density of various techniques at different location

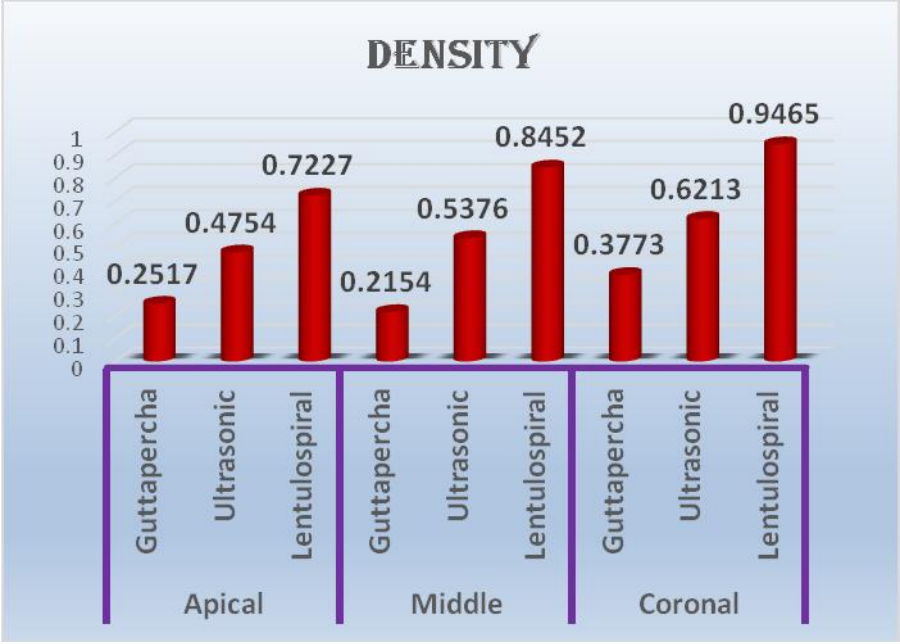

Table 3: Pairwise comparison of various technique at various locations

Pairs	Mean Difference	Std. Error	Significance
Apical			
Guttapercha versus ultrasonic	-.22367*	.01999	.000*
Guttapercha versus Lentulospiral	-.47092*	.01999	.000*
Ultrasonic versus Lentulospiral	-.24725*	.01999	.000*
Middle			
Guttapercha versus ultrasonic	-.32217*	.01777	.000*
Guttapercha versus Lentulospiral	-.62975*	.01777	.000*
Ultrasonic versus Lentulospiral	-.30758*	.01777	.000*

Apical			
Guttapercha versus ultrasonic	-.24400*	.01778	.000*
Guttapercha versus Lentulospiral	-.56917*	.01778	.000*
Ultrasonic versus Lentulospiral	-.32517*	.01778	.000*

*=Significant; NS=Not Significant

deviation of 0.04996, The Ultrasonic technique provides better sealing in the middle region, with a mean density of 0.5376 and a standard deviation of 0.04294. The Lentulospiral technique again demonstrates the highest mean density in the middle region at 0.8452 with a standard deviation of 0.03662, A statistically significant p-value confirm the superior performance of the Lentulospiral technique in this region, achieving the best overall seal.

Coronal Region

In the coronal region, the Guttapercha technique shows an improved mean density of 0.3773 with a standard deviation of 0.04498. The Ultrasonic technique reveals a higher mean density in the coronal region at 0.6213 with a standard deviation of 0.04578. The Lentulospiral technique exhibits the highest mean density in the coronal region at 0.9465 with a standard deviation of 0.03962, indicating exceptional sealing quality, significant at p=0.000.

In summary, across all locations—apical, middle, and coronal—the Lentulospiral technique consistently demonstrates the highest mean sealant densities with the least variability, making it the most effective method among the three techniques studied. The Ultrasonic technique provides better sealing quality than Guttapercha, with consistent and reliable results across all regions. The Guttapercha technique shows the lowest sealant densities and the highest variability, indicating less effective sealing performance compared to the other methods.

DATA ANALYSIS

The data obtained were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS Version 25; Chicago Inc., IL, USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the comparisons.

Shapiro Wilk test was performed to determine the normality of the data for determining density outcomes between various sealant techniques. The test showed no significant difference and hence confirmed that the data obtained were normally distributed.

Variables were compared using mean value and standard deviation. The mean for different readings for sealant density was assessed using one way Analysis of Variance (ANOVA). Tukeys post hoc test was applied to find significant difference between pairs. P value lesser than 0.05 was considered to be statistically significant.

DISCUSSION

The creation of a fluid-impervious apical seal is widely acknowledged to be one of the main goals of obturation. Typically, to create this seal, a solid or semisolid core material is inserted into the canal together with sealer. The gaps between the core material and the canal wall as well as any imperfections in the walls must be filled with a sealer in order to fully cover the walls [10].

All of the techniques used in the present study, such as , master gutta percha cone, ultrasonics and lentulo spiral,were used for the placement of bioceramic sealer. The favorable properties of this material include excellent sealing ability, dimensional stability, and low solubility[11]. Because of these characteristics, the sealer ensures a tight seal, limiting bacterial leakage and lowering the possibility of reinfection.[12]

The sealer/dentin interface can be assessed using a variety of methods, including stereomicroscopy, scanning electron microscopy, confocal laser scanning microscopy (CLSM), digital radiography, dye penetration procedures, radioisotopes, fluid filtration, bacterial leakage, and Cone beam computed tomography(CBCT).[6,7]

CBCT offers a far more accurate evaluation of canals, which is useful for 3D imaging of the dentofacial

anatomy. This technology uses a faster scanning machine, creates images with significantly thinner slice thicknesses than traditional CT procedures, and has a low radiation exposure.[13]

Thus, the most precise method of representing the 3D volume of the obturated canals is by the use of CBCT. Unlike radiography, which only provide two-dimensional images, it enables the clinician to see the filling from every perspective. The voids can be computed at different levels.[1]

The results of this study indicate that across all locations—apical, middle, and coronal—the Lentulo spiral technique consistently demonstrates the highest mean sealant densities with the least variability, making it the most effective method among the three techniques studied. The Ultrasonic technique provides better sealing quality than Guttapercha, with consistent and reliable results across all regions. The Guttapercha technique shows the lowest sealant densities and the highest variability, indicating less effective sealing performance compared to the other methods. This may be due to the fact that ultrasonic files propel the sealer along the length of the file, whereas lentulo spirals push the sealer centrifugally. Along the length of the file, ultrasonic energy can form several nodes. One possible explanation for the low percentage and depth of sealer penetration in the apical region could be that the activated ultrasonic file touched the canal wall in a more confined area, which prevented it from creating the nodes required for cavitation and acoustic streaming.[7]
A limitation of this study is that it was based on the single-cone technique; the bioceramic root canal sealers used in this study should also be tested with other filling techniques.

CONCLUSION

Within the confines of this study, it can be concluded that the root canal level and the type of placement technique affect the depth and percentage of sealer penetration, with penetration decreasing apically. Every placement technique examined was unable to demonstrate a consistent sealer adaptability to the whole root canal wall circumference. Compared to the master gutta percha cone and ultrasonics, the lentulo spiral has demonstrated superior sealer penetration.

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