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COMPARATIVE EVALUATION OF OBTURATION QUALITY OF FIVE DIFFERENT OBTURATING TECHNIQUES USING CONE BEAM COMPUTED TOMOGRAPHY- AN IN VITRO STUDY

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Conflicts of Interest: Nil

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Abstract:

Introduction: The proper obturation of the root canal system is a key factor in achieving successful results in endodontic treatments. Achieving a fluid-tight seal is the ultimate goal of the obturation technique using gutta-percha and sealer.

Aim: To evaluate the quality of obturation done by five different obturation techniques.

Material and Methods: A total of 50 mandibular premolars with single roots were selected. Biomechanical preparation was done by Wave one Gold file of medium size. Teeth were allocated into five groups of 10 teeth each according to the obturation technique, i.e., Lateral compaction, Vertical compaction, Thermafil, Injection Technique, and Continuous wave compaction. Cone beam computed tomography was employed to measure filling area and voids at the coronal, middle and apical third of the root canal following obturation by different techniques. Obturation time was calculated using Stopwatch. The data was statistically analyzed by One Way ANOVA test followed by Tukey HSD for multiple comparisons.

Results: The continuous wave of compaction technique resulted in more amount of filling area and the least number of voids. Least time for obturation was observed with the Thermafil.

Conclusion: The Continuous Wave of Compaction may be a good alternative for the great quality of 3D obturation, and it may be beneficial in obtaining the fluid tight seal in endodontically treated teeth. Thermafil technique showed the least time for obturation. Further, In vivo research is required in endodontically treated teeth.

Keywords: CBCT, Obturation, Filling area, Obturation time, Wave one Gold

Introduction

The obturation of the root canal system to the cemento-dentinal junction is a very important goal in the endodontic treatment. To attain this goal, root canal filling should seal the pulp area both apically and laterally to stop any apical irritation from incomplete elimination of bacterial byproducts. (1)

A key to successful endodontics and a significant goal of latest nonsurgical root canal treatment is to seal completely, both apical and coronal avenues of potential leakage and maintain the disinfected status reached by the chemical and / or mechanical cleaning, to stop reinfection and percolation of bacterial substrates, permitting the periodontium to take care of its integrity and to achieve healing.(2) Ingle found that almost 60% of the endodontic failures were because of the incomplete obturation of the root canal system.(3)

There is a need to evaluate the quality of five different obturation techniques after biomechanical preparation with the WaveOne Gold reciprocating file using cone beam computed tomography. There is no abundant literature in endodontics comparing the obturating quality of five different Obturation techniques -Lateral Compaction (LC), Vertical Compaction (VC), Carrier based Thermoplasticized (TF), Injection Technique (INJ) and Continuous Wave Compaction (CWC) using cone beam computed tomography (CBCT).

Null hypothesis states that there is no difference in the quality of obturation using five different obturating techniques using CBCT.

Materials and Methods:

Fifty extracted human mandibular premolars with a single root and single canal were included in the study. For standardization, all the samples were decoronated to a length of 13mm by using a double-faced diamond disc (KG Sorensen, Barueri, SP, Brazil). The teeth with calcified canals, cracks or fractures, development defects, multiple canals, root caries, and endodontically treated teeth were excluded. Working length was calculated by inserting a size 10 K file (Dentsply, Maillefer, Tulsa, OK, USA) into the root canal until it was visible at the apical foramen and subtracting 1mm from that length. Biomechanical preparation of the root canal was performed using a single-use instrument, i.e., WaveOne Gold (Dentsply-Maillefer, Tulsa, USA) of medium size. X-smart plus Endo- motor (Dentsply, Maillefer, Tulsa, OK, USA) was used to activate the instrument in a reciprocating motion. Gently an in and out pecking motion was used to reach the apex with an amplitude of approximately 3 mm. A brushing action was combined with a gentle apical pressure against the lateral walls. Irrigation was done by 5 ml 17% EDTA (DESmear, Anabond Stedman pharma research, India), followed by 5 ml of 3% NaOCl aqueous solution (Prime dental PVT LTD., India). 5 ml of 17% EDTA solution was used for final irrigation. The canals were dried with paper points after irrigation. The same operator did all intracanal procedures to eliminate interoperator variability. Teeth were then randomly allocated into five experimental groups according to the obturation technique. Each group contains ten teeth(n=10). Five groups are divided as follows: LC- Lateral Compaction, VC-Vertical Compaction, Thermafil (Carrier-Based Thermoplasticized), NJ-Injection Technique, CWC-Continuous Wave Compaction. Following the endodontic procedure, the teeth were stored under 100% humidity at 37°C. Assessment of quality of obturation was done by calculating the filling area and voids in each tooth at the coronal, middle and apical third of the root canal by CBCT scanner (CRANEX 3D) in the high-resolution dental mode (i.e., 120-micron resolution) at 90kVp and 4mA using the On-Demand 3D App Software. In this study, obturation time was calculated using Stopwatch, from the time of placement of sealer to complete obturation of Gutta-percha up to orifice level.

Results:

The maximum amount of gutta-percha was found at coronal third and least in the apical third of the root canal in all the groups. (Table 1) The CBCT images of the obturated tooth are shown in coronal, sagittal, axial, and 3D view (Figure 1). Voids were observed in all obturated samples, regardless of the groups examined. IBM SPSS Software version- 22 was used for statistical analysis. The data was statistically analyzed by One Way ANOVA test followed by Tukey HSD for multiple comparisons. A p-value of 0.05 was considered to be statistically significant. ($p<0.05$). These results demonstrated that CWC resulted in a maximum filling area followed by INJ, TF, VC, and LC. The amount of filling area in all the five groups was shown in (Table 2).

Obturation time

A statistically significant difference was found among the five techniques in Obturation Time. Least time for obturation was observed with Carrier based Thermoplasticized-Thermafil, and maximum time for obturation was seen with Vertical compaction technique. The mean times of root canal obturation for the five techniques are shown in Table 3.

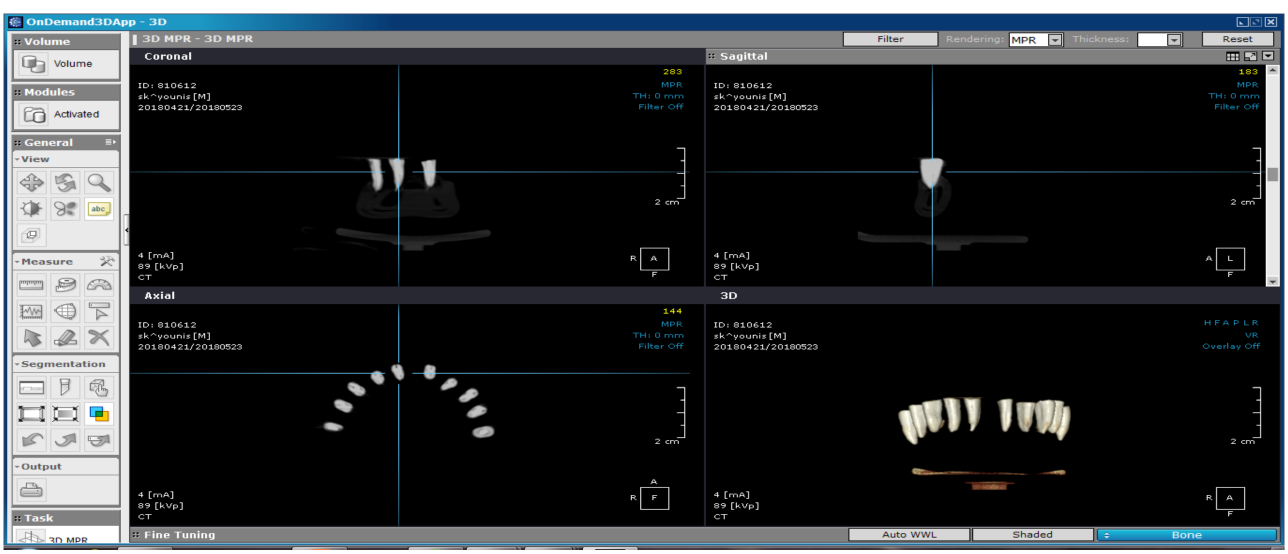

Figure 1: The CBCT images of the obturated tooth are shown in 3D view- coronal, sagittal, axial

Table 1: Mean values and standard deviation values of Filling Area in apical, middle, and coronal area.

Descriptive Data						95% Confidence Interval for Mean			
		n (Number of specimens)	Mean in mm^2	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Apical	LC	10	2.7580	.14297	.04521	2.6557	2.8603	2.52	2.98
	VC	10	2.9970	.01767	.00559	2.9844	3.0096	2.97	3.02
	TF	10	3.0680	.03706	.01172	3.0415	3.0945	3.00	3.11
	INJ	10	3.0880	.02044	.00646	3.0534	3.0826	3.04	3.10
	CWC	10	3.1600	.02981	.00943	3.1387	3.1813	3.11	3.19
	Total	50	3.0102	.15252	.02157	2.9669	3.0535	2.52	3.19
Middle	LC	10	4.6420	.10952	.03463	4.5637	4.7203	4.49	4.80
	VC	10	4.8820	.07757	.02453	4.8265	4.9375	4.75	4.98
	TF	10	4.9490	.04067	.01286	4.9199	4.9781	4.89	5.01
	INJ	10	5.0670	.03561	.01126	5.0415	5.0925	5.01	5.11
	CWC	10	5.0940	.02119	.00670	5.0788	5.1092	5.06	5.12
	Total	50	4.9268	.17524	.02478	4.8770	4.9766	4.49	5.12
Coronal	LC	10	5.0780	.03425	.01083	5.0535	5.1025	5.02	5.12
	VC	10	5.1090	.02685	.00849	5.0898	5.1282	5.07	5.15
	TF	10	5.1480	.03048	.00964	5.1262	5.1698	5.11	5.20
	INJ	10	5.2690	.03143	.00994	5.2465	5.2915	5.22	5.31
	CWC	10	5.4180	.02700	.00854	5.3987	5.4373	5.39	5.46
	Total	50	5.2044	.12948	.01831	5.1676	5.2412	5.02	5.46

Table 2: Mean Values of Total Filling Area

MEAN VALUE OF TOTAL FILLING AREA	
LC	12.47 mm^2
VC	12.98 mm^2
TF	13.16 mm^2
INJ	13.42 mm^2
CWC	13.67 mm^2

Table 3: Mean values, standard deviation values of Obturation Time

	n	mean in seconds	Std. Deviation	Std. Error	95% confidence interval for Mean		Minimum	Maximum
					Lower bound	Upper bound		
LC obturation	10	279.6000	1.64655	.52068	278.4221	280.7779	277.00	282.00
VC obturation	10	370.4000	2.67499	.84591	368.4864	372.3136	365.00	374.00
TF obturation	10	41.8000	1.93218	.61101	40.4178	43.1822	40.00	45.00
INJ obturation	10	147.8000	3.22490	1.01980	145.4930	150.1070	144.00	153.00
CWC obturation	10	183.4000	5.62139	1.77764	179.3787	187.4213	176.00	192.00
Total	50	204.6000	113.69867	16.07942	172.2872	236.9128	40.00	374.00

Discussion:

The goal of three-dimensional obturation is to attain an impervious fluid-tight seal inside the whole root canal, which can further facilitate in preventing oral and apical microleakage. Gutta-percha, in conjunction with root canal sealers, is that the worldwide accepted combination accessible until the date and is taken into account because of the gold standard.

One widespread method for research in obturation is two-dimensional radiography. These radiography techniques offer some disadvantages, such as image superposition, image distortion, and the simple fact that the images are of two-dimensional only. However, CBCT overcomes many of these problems. CBCT images do not superimpose anatomical structures, and are more useful in identifying processes.[4] CBCT can provide 3D, multi-slice imaging information, none of which is possible using other radiography techniques.[5] CBCT images permit the accurate diagnosis of the density and the apical extent, the quality of the root canal fillings, and the periapical tissue condition. CBCT imaging also has advantages over the traditional computed tomography scans such as higher resolution, greater accuracy, shorter scan times, and fewer actual radiation doses to patients.[6] However, CBCT disadvantages include its greater cost and the higher overall radiation exposure to the patient.[7] In this study cone beam computed tomography was used because to outweigh the limitation of the methodologies antecedently applied in endodontic treatment studies, such as the displacement of the filling debris during the cleavage and the two-dimensional imaging on a three-dimensional structure in a very noninvasive manner.[8,9]

In this study, the finest results were shown by the Continuous wave compaction technique with a significantly greater amount of total filling area is simulated in root canals when compared with other techniques. Each canal was instrumented to the same size, so the volume of each canal occupied by gutta-percha should be the same. Therefore, an increase in gutta-percha mass corresponds to an increase in gutta-percha density and more filling area. The other techniques in this study have shown to form a nonhomogeneous mass of the gutta-percha that poorly adopts the prepared root-canal space and does not adequately obturate simulated canals when compared with CWC technique. The continuous wave of compaction technique uses the advantages of warm gutta-percha technique, creating a homogenous mass that flows to obturate grooves and depressions of canal spaces more effectively than another compaction. And provides a more effective seal against coronal microbial penetration than the other compaction technique. [10]

This might be because of continuous wave compaction technique produced the streaming effect that developed between the electrically heated plugger and the canal wall as the plugger penetrates the canal simultaneously warming and displacing of gutta-percha along its length in lateral and coronal directions. Interestingly, the sealer acts as a lubricant that helps the softened gutta-percha slip through the root canal space. This technique is called as Continuous Wave Technique because it allows a single tapered electric heat plugger to capture the wave of condensation at the orifice level of a canal and ride it, without release, up to the apical extent of down packing in a single, continuous movement. The Continuous Wave technique provides the obturation potential to fill up to the orifice level throughout the down pack due to its centered position within the gutta-percha, simultaneously condensing it along the full length of the plugger. This was best shown in post-obturation sagittal dissections by Sharp [11] and Carr [12]. As the post obturation sagittal sections show better results for comparing obturation quality of the root canal; So, in this study, sagittal sections of the CBCT is used for calculation of the filling area.

In this study, Injection group technique showed better than the Thermafil group because Thermafil showed some space usually remained between the obturator and the lateral surface of the root canal wall which accounted for the high incidence of voids in all Thermafil groups because Stripping of the gutta-percha from the carrier surface is seen. The vertical and lateral condensation technique demonstrated the lowest overall mean scores for the filling area when compare to Thermafil because the gutta-percha was usually close to the working length, probably due to the master cone being pre-fitted 1 mm from the working length. Voids and folding of the gutta-percha were commonly seen, and very few of the surface depressions were replicated.

The third best results of the total filling area in this study were obtained with Thermafil when compared with CWC, INJ technique. This can be explained by the fact that as in Thermafil obturation, gutta-percha can extrude through the apical foramen. Thermafil obturation has some other disadvantages, like the carrier in the gutta-percha may get stripped off in the canals. Thermafil technique in this study showed superior results than vertical compaction and lateral condensation technique in the filling area. Least results were shown by vertical and lateral compaction due to less adaptation to canal walls, which lack homogeneity of gutta-percha mass, increased irregularities, and increased number of voids. This is supported by previous studies by Zuolo AS at al. [13]

Thermafil technique is less time consuming, resulted in the filling of the alpha phase of gutta-percha with more homogeneous mass when compared with vertical and lateral compaction technique, had fewer voids, and replicated the surface of the roots better. The major part of the research confirms these results, [14-16] except for some studies from the early ’90s, a time when Thermafil was neither well known nor perfected. [17]

In this study, the vertical compaction technique found superior to the Lateral compaction technique in the total filling area. This might be because the force is exerted in a “closed”

space where significant hydraulics is produced. Coronally, the plugger of adequate size, exerts its pressure against the maximal amount of heat-softened gutta-percha that is compacted, will make immediate contact with the dentinal walls, while the cone, at the other end by virtue of its “tug-back,” occludes the apical foramen. Thus, the force is dissipated in a closed environment, and the hydraulic pressure that develops within causes the sealer and the heat- softened gutta-percha to fill all the available spaces in a true corono-apical "wave of condensation." The working level of compaction of the gutta-percha moves increasingly apically for two reasons. The first is that the gutta-percha mass is softened and compacted vertically in the cone-shaped canal automatically assumes a lateral component of forces; this follows the routine laws of physics and needs no lateral direction of the instrument on the part of the operator.(18) The second reason is that each introduction of the heat-carrier into the root canal is followed by the removal of a certain amount of the gutta-percha, which remains attached to the tip of the instrument as it begins to cool. For these two reasons, the wave of condensation and the working level of the pluggers are displaced increasingly apically, so much so that at a certain point, it becomes necessary to advance to the plugger of narrower size.

In the present study, the lateral compaction technique had been used because it is the most commonly used and studied technique, and so, it served as a standard with which the other techniques should be compared.(19,20) Lateral Compaction Technique showed the least amount of total filling area lesser than Vertical compaction this might be due to considering that heat is not used, the most apical part of the master cone does not undergo any change if one does not deeply descend with the spreader. The seal is therefore completely entrusted to the sealer, while the gutta-percha cone would serve the same function as that of a silver cone or a single cone of gutta-percha would have. Being a "cold" technique, the gutta-percha cones never merge into a homogeneous, compact mass, but this technique will always result in obturation comprising a number of gutta-percha cones separated by a greater or lesser amount of sealer, depending on the dentist's ability.

Least amount of filling area was observed with LC, followed by VC, TF, NF, CWC techniques, a greater number of voids are also seen in these techniques, respectively. Another parameter that was calculated was Obturation time. TF was significantly the fastest technique, followed by IN, CWC, which was significantly faster than the other techniques. This finding was in agreement with previous reports.(21,22) The two most time-consuming techniques were cold lateral and warm vertical compaction, as already reported previously for the lateral compaction technique.(23,24) The reason vertical compaction took significantly more time than cold lateral compaction might be because the pluggers were heated using a flame. It can be assumed that using an electric heat carrier would have resulted in markedly shorter obturation times.

The null hypothesis was rejected in this study as there is a significant difference in the quality of obturation between the five techniques.

Conclusion

The distribution of filling material in root canals was influenced by different obturation techniques but not on a similar standard biomechanical preparation technique. The Continuous wave of compaction technique resulted in more amount of filling area and the least number of voids. The Lateral Compaction technique resulted in the least amount of a filling area with a greater number of voids. Least time for obturation was observed with the Thermafil technique.

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