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Evaluation of Three Different Obturation Techniques Using 3-D Cone Beam Computed Tomography - In Vitro Study

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Abstract

Aim: To compare the quality of three different root canal obturation techniques: 1.Conventional lateral compaction 2.Thermoplasticized obturation Technique and 3.Carrier based obturation by using cone beam computed tomography.

Materials and Methods: A total of 30 premolars wereselected. Biomechanical preparation was done using Reciproc file no 25. Teeth were randomly divided into 3 groups of 10 teeth each according to the obturation technique i.e.1.Cold lateral condensation 2.Thermoplasticized obturation technique and 3.Carrier based obturation technique. Cone beam computed tomography was used to measure pulp volume space of the root canal before and after obturation by different techniques. Data was statistically analyzed by One-Way Anova and multiple comparisons of Tukey HSD tests.

Result: There was a statistically significant difference between groups as determined by one way-ANOVA.A Tukey post hoc test revealed that volume difference was statistically significantly lower in the GuttaCore system. There were no statically significant differences betweenThermoplasticized technique and lateral condensation and between thermoplsticized obturation technique and GuttaCore.

Conclusion: Within the limitations of this study, GuttaCore obturators showed the greater POV of Obturation followed by thermoplasticized obturation technique then the lateral condensation.

Keywords: Cone Beam Computed Tomography (CBCT), Root canal obturation, Core Carrier, Cross linked thermoset, Thermoplasticized obturation, Volumetric analysis

Introduction

The most imperative factors for aneffective root canal treatment are biomechanical instrumentation of the root canal for disinfection and dissolution of organic matter to eradicate bacterial pathogens and the three-dimensional obturation of this space[1] for impeding the reinfection and debilitating the flow of microorganisms and toxins to the peri-apical tissue.[2,3,4]

The purpose of a root canal filling is to obliterate and seal the root canal system with the stable,nontoxic material so as to prevent the microorganism and tissue fluids from percolating into the root canal system.[2]the efficacy of an obturation technique is determined by its ability to provide a fluid impervious apical seal.[5]

There are many different root canal obturation techniques,among which Cold lateral condensation with guttapercha is a well-recognized technique and has been the one of choice by many dental practioners for decades.In fact it serves as the gold standard by which we judge other techniques. Advantages of this technique are its predictability, ease of use, conservative preparation and controlled placement of materials. However, the final filling lack homogeneity of gutta-percha mass, less adaptation to canal walls, irregularities and increased number of voids. So clinicians rely on sealers to fill the voids, which may resorb with time. This might decrease the effectiveness of root canal obturation. To overcome these shortcomings recently newer varieties of thermoplasticized guttapercha obturation technique,carrier based guttapercha technique,cold flowable obturation materials that combine gutta percha and sealer have been introduced and number of studies have evaluated the apical seal achieved by these techniques. [6, 7, 8,9,10]

The Calamusthermoplasticized Flow Obturation Delivery SystemHas a hand piece and activation cuff to enable control of the flow and temperature of the gutta percha in to the canal. The activationcuff is released to stop the flow. The gutta-percha is packed in disposable, single use cartridges, and a filling material indicator lets youmonitor the quantity of remaining filling material. The choice of gutta-percha cannula depends on the desired consistency and whether ornot the gutta-percha will be condensed. Thetemperature of the thermoplasticized gutta-percha because it is extruded through the needle tipranges from 38°C to 44°C. The gutta-percha remains ready to flow for 45 to 60 seconds, counting on the viscosity. [11]

Carrier Based Gutta-Percha (Gutta Core) Consists of a plastic core coated with alpha phase gutta-percha and a heating device that controlsthe temperature. The carrier is set to predetermined length and after heating it the clinician has approximately 10 seconds to retrieve andinsert it in to the canal, without rotating and twisting it. The position of the carrier is verified radiographically. The gutta-percha is allowed2 to 4 minutes to chill before resecting the carrier. An advantage to this technique is the movement of gutta-percha in to lateral and accessorycanals; however extrusion of materials beyond the apical extent of the preparation is a disadvantage.[12]

Traditional methods of evaluating root fillings have shortcomings and permit only partial evaluation of the basis canal content. Example on sectioning the root and microscopic analysis, there could be loss of material which might mimic voids.[13] Radiographs give only twodimensional interpretations.[14,15] Dye penetration

studies do not correlate clinically [16] whereas radioisotope, dye extraction, fluid filtration studies evaluate only the apical third of the tooth. [17, 19] Bacterial leakage studies do not simulate exact clinical conditions, need long periods of observation and do not allow quantification of the number of penetrating bacteria. [20]

Cone Beam CT (CBCT) a relatively new extra-oral radiographicmethod of producing three-dimensional digital radiographicinformation. It has been specifically developed for imaging of the teethand jaws. It is becoming widely available and has applications inimplant dentistry, endodontic and oral surgery.[21]

The purpose of this study is to evaluate the adequacy of three different obturation techniques namely,1.Conventional lateral compaction 2.Thermoplasticized obturationTechnique (Calamus,Dentsply Maillefer) and 3.Carrier based obturation(GuttaCore,Dentsply Maillefer), using the Cone beam computed tomography (CBCT, Care Stream S9000) imaging technique by calculating the Percentage of Obturated Volume (POV) using segmentation tool in OnDemand3D software. The null hypothesis is that there would be no significant difference in the obturated volume of the root canal space among the three different obtutation techniques.

Materials and Methods

This is an original in vitro research conducted in Department of Conservative Dentistry and Endodontics, MIDSR dental college, Latur in November, 2018. In this study 30 periodontally compromised freshly extracted human single-rooted premolars, verified radiographically were selected.The consent from patients and ethical board was obtained for procuring the extracted teeth.Teeth withimmature apical foramen, gross caries involving the roots, fractures and for roots with sclerosed canals, with more than one canalor those with root curvature >10° and exceptionally short roots were excluded. They were stored in a 0.1% thymol.

Out of the total (50), thirty teeth were selected and randomly distributed into three groups of ten teeth each. (Fig1)Access cavity preparation was done and working length was determined by inserting a size 10 K file (Dentsply Maillefer) into the root canal until it was visible at the apical foramen and subtracting 1mm from that length. Biomechanical preparation of the root canal with Crown down technique using a single use instrument i.e. Reciproc R25 was done.

A VDW Silver electric motor/ (XSMART PLUS) as used to activate the instrument in a reciprocating motion. Gently an in-and-out pecking motion was used to reach the apex with amplitude of approximately 3 mm. A brushing action was combined with a gentle apical pressure against the lateral walls. Irrigation is done by 25 mL of 2.5% NaOCl followed by 5 mL of 17% EDTA aqueous solution. Five mL of a 2.5% NaOCl 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. (Fig 2,3)A layer of putty was added around each tooth to mimic the tooth-softtissue relationship. Cone Beam Computed Tomography imagingwas used to scan the teeth. Each tooth was scanned separately usingcare stream CS 9000 3D CBCT unit. Each image had thesubsequent parameters: Exposure values-60KV, 3.2 mA. Voxel size- 76 µm × 76 µm× 76 µm. Dose-54 mGy/cm2).CS 3D imaging software 3.4.3 (CARESTREAM HEALTH) was usedfor the 3D volumetric visualization and analysis of the image. Thevolume of the radicular space at the maximum width was measured bydetecting the radiolucency in

the canal space by OnDemand3Dsoftware. (Fig4, 5) Teeth were randomly divided into three experimental groups that were obturated as following-

GROUP I (conventional lateral compaction)

An ISO 0.08matched taper gutta percha master cone of size 25 coated with AH PLUS Sealer was checked for tug back at the estimated working length. Obturation was done using lateral condensation with 25, 20, 15 size spreaders and respective matching accessory gutta-percha cones.[10]

GROUP II (Calamus thermoplasticized obturation Technique) (fig 6)

The Calamus Flow handpiece was used with a one-piece gutta percha cartridge and integrated cannula to dispense warm gutta-percha. The cartridges were used on a single patient. The Calamus dual 3D obturation system (Dentsply Maillefer, Ballaigues, Switzerland) was used along with AH Plus root canal sealer (DentsplyDeTrey,Konstanz,Germany).[11]

GROUP III (Guttacore carrier based obturation) (fig 7)

A size #25 verifier was checked for its fitting in the canal at the working length. The same size obturator was selected and heated within the ThermaPrep plus Oven (Dentsply Maillefer, Holland). The canal was dried followed by application of AH Plus sealer to the coronal portion of the canal. Then the obturator was slowly placed during a single motion at the working length. The obturator was severed at canal orifice after cooling the gutta percha.The above mentioned three experimental groups were compared with control group which consists of two teeth without obturation. The canal access of all the teeth was restored with Cavit-G (3M Espe, Germany), and the teeth were stored under 100% humidity at 37°C. Teeth were radiographed in buccolingual and mesiodistal direction to verify the adequacy of root fillings.[12]

Assessment of quality of obturation was done by calculating the filling area and voids in each tooth at coronal, middle and apical third of the root canal by CS9300 CBCT scanner (Carestream Healthcare India (P) Ltd, India) within the high resolution dental mode (i.e. 90 micron resolution) using the On Demand 3D App software.(Fig 8,9,10)

Results

The mean and standard deviation of the volume of pulp space of the three different obturation techniqueswere calculated before and after and their volume insufficiency determined. One-WayANOVAs (Table 1) and Multiple-Range Tukey Test (Table 2)was used to analysethe collected data. The p value (p=0.006) was calculated to evaluate the statistical significance among groups. The one-way ANOVAdetermined there was a statistically significant difference between groups. The inter group comparison (Tukey post-hoctest) revealed that the volume difference was statistically significantly lower in the GuttaCore system as compared to conventional lateral condensation technique.The percentage of volume obturated in Guttacore system is higher when compared to conventional lateral condensation technique.There is no statistical significance between the lateral condensation technique and thermoplasticized guttapercha obturation technique and thermoplasticized guttapercha obturation technique with Guttacore carrier based obturation technique with regards to the adequacy of obturation. (Table 3)

Table 1

	N	Mean Difference	Std Difference	Std Error
1	10	0.0048	0.0015	0.0005
2	10	0.0044	0.0012	0.0005
3	10	0.0040	0.0009	0.0003
Total	10	0.0044	0.0010	0.0002

Table 2

Technique (1)	Technique (2)	Mean Difference	Std Error	Sig
1	2	0.0008	0.0002	0.804
	3	0.0012335*	0.0002	0.002
2	1	0.0010	0.0002	0.804
	3	0.0006	0.0002	0.248
3	1	0.00123335*	0.0002	0.002
	2	0.0008	0.0002	0.248

Table 3

Sample	Mean	N	Std Deviation
1	94.40	10	1.77762
2	96.595	10	1.89654
3	98.2691	10	1.298
Total	96.421	30	2.239

Discussion

The main objectives of Endodontic therapy are cleaning andshaping, disinfection and obturation of the root-canal system in 3D.GP is the most widely used and accepted obturation material [22]. Dueto improper obturation there could be post-operative complicationsresulting in failure of endodontic therapy. The quality of obturationmay be influenced by various types of techniques.[23]

The present study evaluates the adequacy of three different obturation techniques namely, 1. Conventional lateral compaction technique 2. Calamus thermoplasticized obturation Technique and 3. Carrier based obturation, using the Cone beam computed tomography (CBCT, Care Stream S9000) imaging technique by calculating the Percentage of Obturated Volume (POV) using segmentation tool in OnDemand3D software. The null hypothesis was rejected as the results showed astatistically significant difference in the obturated volume of the root canal space between three tested groups.

The means volume of a single adult human pulp is 0.02 cc.[24] Volume of the pulp space is the maximum amount ofspace which gutta-percha has to accommodate for hermetic seal of thecanal. The root canal volume is measure before and after obturationwith the help of 3D CBCT unit and an external program (on Demand3D software) for more accurate mode of depiction of 3D volume of theobturated canals.

In current study, difference in volume (voids) was detected with inall three materials, indicating that none of the three root canal filling materials completely fills the entire canal space. The conventional lateral condensation technique showed the highest inadequacy from root canal volume of prepared canal without obturation. The mean of volume difference was statistically significantly lower in the GuttaCore obturation technique as compared to lateral condensation technique. There were no statistically significant differences between lateral condensation technique and thermoplasticized guttapercha obturation technique (Calamus,Dentsply Maillefer) and between thermoplasticized guttapercha obturation technique (Calamus,Dentsply Maillefer) and Guttacore obturation technique.The POV was highest in the GuttaCore group followed by the thermoplasticizedtechnique (Calamus,Dentsply Maillefer) then the conventional lateral technique (Table 3).

The inadequacy of Cold lateral compaction could be due to the use of spreaders during compaction, as this can lead to a greater risk ofvoid creation between the accessory points and may leave spacesbetween the Gutta-percha and the dentinal walls producing lesshomogenous mass. The presence of voids and the inability to adapt tothe walls of

root canal create a less condense mass which givesdifference in the measured volume calculation before and after obturation.In accordance to our study, other studies have shown highestobturation inadequacy with the lateral condensation technique compare to thermoplacitized techniques.[25, 26]

Using three-dimensional spiral computerized tomography , Anbu et al.[27] showed the best post obturation volume was obtained with System B and Thermafil techniques with no statistically significant difference between the 2 groups, while lateral compaction, produced significantly the least post obturation volume.

In an analogous study[28], The Obtura II technique utilizing the injection-molded thermoplasticized gutta-percha had better adaptability to the canal walls when compared to the GuttaFlow obturation and lateral condensation techniques.Goldberg F et al and Aghdasi et al[29, 30]calculated the core (gutta-percha and carrier) to sealer ratio and the sealing ability of four different gutta-percha techniques and they concluded that warm compaction of gutta purcha and injection-molded thermoplasticized gutta-were superior to the lateral condensation technique in terms of core/sealer ratio.

Conclusions

1. GuttaCore obturators showed the greater POV of obturation followed by the thermoplasticized guttapercha obturation technique (Calamus,Dentsply Maillefer) then by lateral condensation technique.
2. There was a statistically significant difference in the mean difference of the obturated volume of the root canal space between the Gutta Core group and lateral condensation group.However,no statistically significant obturated volume differences were detected between lateral condensation and thermoplasticized guttapercha technique(Calamus, Dentsply Maillefer)or between thermoplasticized obturation technique(Calamus,Dentsply Maillefer) and GuttaCore system.
3. GuttaCore obturators are simple,efficient and promising system,however,long term clinical studies are needed to evaluate the performance of those single core carrier obturators.

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List of Figures

Fig 1: Thirty teeth selected for study

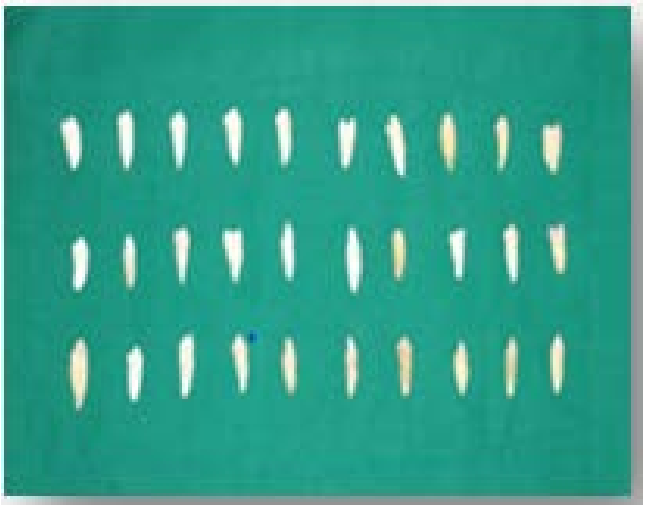

Fig 2: patency checked with 10 k file

Fig 3: Biomechanical preparation done

Fig 4:Teeth embedded in the putty

Fig 5: Volume of radicular space checked with CBCT

Fig 6: Thermoplasticized obturation technique

Fig 7: Carrier based obturation technique

Fig 8,9,10: Assesement of percentage obturation volume of lateral condensation,thermoplasticized technique,Guttacore technique respectively

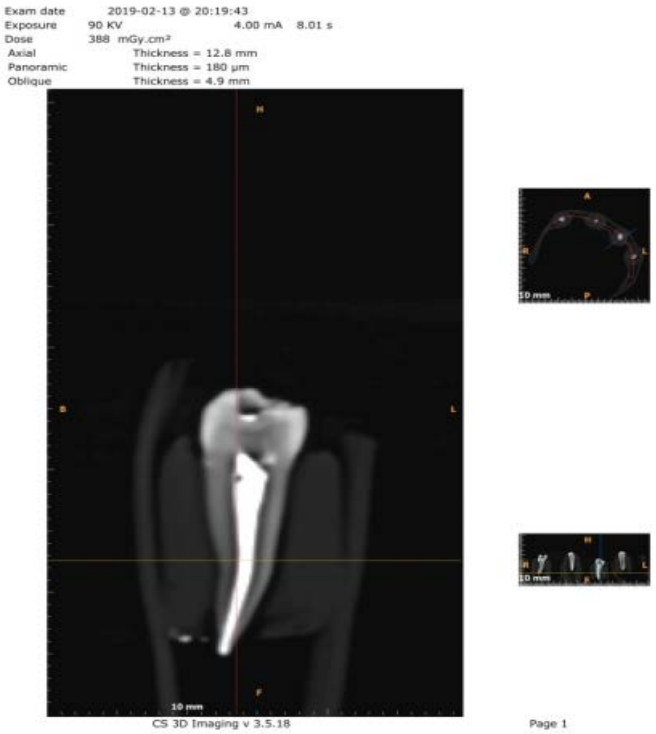

Fig 8

Fig 9

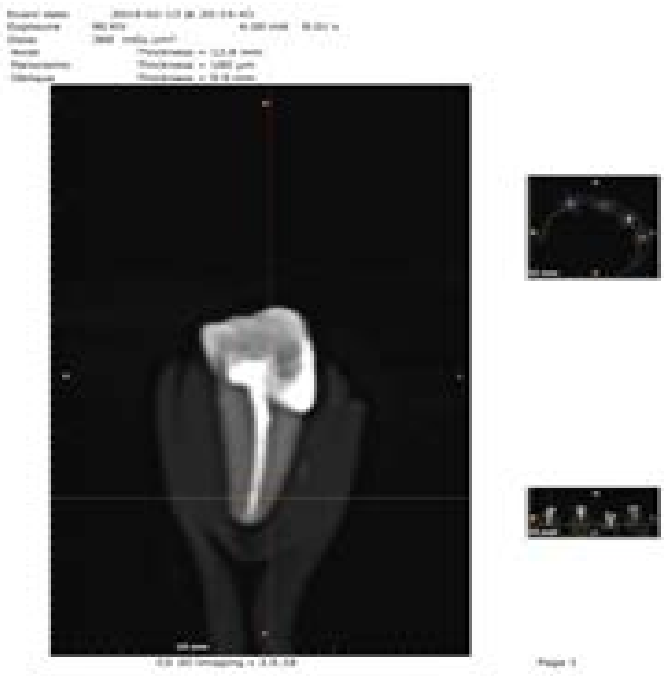

Fig 10