A Three-Dimensional Evaluation of Density and Homogeneity of Root Canal Obturation with Guttaflow® using Backfilling Technique in Comparison with Conventional Lateral Compaction Technique using Spiral Computed Tomography - An In Vitro Study

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ABSTRACT

The objective of the study was to three dimensionally compare the density and homogeneity of "**GuttaFlow®**" using backfilling technique with conventional lateral compaction technique using spiral computed tomography.

30 human extracted maxillary central incisors were used for this study. Following access cavity preparation, working length was determined and root canal preparation was carried out using standard step-back technique. Root canal irrigation was performed using 2.5% NaOCl ,saline and final flushing with 17%EDTA and normal saline.

After root canal preparation, the specimens were randomly divided into 3 groups with 10 teeth in each group. Specimens in Group-I were obturated with GuttaFlow® using backfilling technique, Group-II were obturated by lateral compaction technique using GuttaFlow® as the sealer and Group-III were obturated by lateral compaction technique using zinc-oxide and eugenol as the sealer.

The specimens were then analyzed in both horizontal and vertical sections from the apex to the cemento-enamel junction of each specimen with section thickness of 1mm each using Spiral Computed Tomography.

The data obtained was statistically analyzed using one way ANOVA test followed by FISHER'S test and TUKEYS HSD test.

Results showed that specimens of Group -I was denser, more homogenous compared to other groups and was statistically significant. In the evaluation of obturation in the apical, middle and coronal third individually, Group -I showed better results than other groups in apical and middle third which was statistically significant, but showed inferior results in the coronal third though it was not statistically significant. And Group-II and Group-III showed inferior results in the middle third when compared with Group-I and was statistically significant.

From the results of the study it can be concluded that, Obturation done using GuttaFlow® with backfilling technique is superior in the apical and middle third but is inferior in the coronal third of the root canal system when compared to lateral compaction technique.

Spiral computed tomography is a very useful tool fo checking the density of obturation in endodontics.

Key words: Gutta-Flow, Spiral Computed Tomography, Obturation density, Homogeneity.

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INTRODUCTION

The success of endodontic treatment depends on the complete obturation of the complex root canal system with an inert material[1]. To seal this system, the obturating material must adapt to all the portions of the root canal[2]. The Washington study of endodontic success and failures indicates that nearly 60% of the failure is apparently caused by incomplete obturation of the radicular space[3].

Several materials and techniques have been developed for achieving a successful obturation, Gutta-percha is the most commonly used root canal obturation material and its physical properties have made it possible to use it in several different techniques[4].

One of the most recent techniques which uses cold flowable filling system for obturation of the root canal system is "GuttaFlow®" which is combination of sealer and gutta percha powder. It consists of polydimethylsiloxane matrix highly filled with finely ground gutta-percha. Several studies have shown that GuttaFlow® offers excellent flow and satisfactory physical properties[5] according to ISO standards[6].Unlike thermoplasticized gutta-percha which shows shrinkage on cooling, GuttaFlow® expands slightly by 0.2% on setting further enhancing its sealing properties.

Computed Tomography and Micro Computed Tomography are currently the leading technologies for endodontic research[7]. With spiral computed tomography three dimensional volume analyses are possible without sectioning the specimen and thus avoiding the loss of material during sectioning[8] and it is possible to reconstruct overlapping structures at arbitrary intervals and thus the ability to resolve small objects is increased [9].

The purpose of the study is to analyze the three-dimensional sealing ability of cold flowable gutta percha (GuttaFlow®) and compare it with cold lateral compaction technique using spiral computed tomography.

MATERIALS AND METHODS

Mechanical Preparation of the Teeth

Thirty freshly extracted single rooted human teeth with type I root canal anatomy were stored in normal saline. Following access cavity preparation, working length was determined and root canal preparation was carried out using standard step-back technique. Root canal irrigation was performed using 2ml of 2.5% NaOCl and normal saline and final flushing using 17%EDTA and normal saline. The apical portion of the canal was enlarged to a maximum of size 50. Any tooth requiring a size larger than #50 file was discarded. The coronal third of each canal was flared using a #2 and #3 Gates Glidden drills.

Obturation Techniques

After drying the canals with paper points, the teeth were randomly selected and divided into three experimental groups of 10 teeth each.

TABLE. 1
Experimental Groups

Groups	Obturation technique	Number of teeth
I	Obturation using Gutta Flow® (back filling technique)	10
II	Obturation using using 2%ISO gutta percha points and Gutta Flow® as sealer (lateral compaction technique)	10
III	Obturation using 2% ISO gutta percha points and zinc oxide eugenol sealer.(lateral compaction technique)	10

Analysis of the experimental specimens using Spiral Computed Tomography.

All the experimental specimens were mounted on a wax block and placed on the *couch* of the computed tomography machine. It was moved longitudinally towards the *gantry* at the *pitch* of "**1**"and exposure with *120kv* and 1*80mA* was done for one second.

Both vertical and horizontal sections of 1mm thickness were made which was followed by three dimensional reconstruction of the sections. The specimens were further analyzed for variations in density in **1 to 5mm** from apex (SUBGROUP I), **6 to 10mm** from the apex(Subgroup-II) and **11 to 16mm** from the apex (Subgroup-III) individually in both vertical and horizontal sections.

TABLE. 2
Sub-Groups

SUB-GROUP -I	1 to 5 mm from the apex
SUB-GROUP II	6 to 10 mm from apex
SUB-GROUP III	11 to 16 mm from apex

The specimens were analyzed using *Windows Advantage Work Station* software for

- Density of the filling material.
- Homogeneity and adaptation to the canal wall.
- Voids.

The analysis of all the specimens was done followed by statistical analysis.

OBSERVATION AND RESULTS

The assessment was done using spiral computed tomography for variation in the density and homogeneity. The values were recorded in both horizontal and vertical sections. The results were tabulated and graphically analyzed.

All the experimental groups were compared statistically using ONE WAY ANOVA test and the sub groups were compared using TUKEYS HSD test.

In all the groups ($p > 0.05$) was considered statistically significant.

RESULTS

The Density was measured in HOUNSEFIELD UNITS

TABLE. 3

Analysis of density among experimental groups in vertical section

VERTSCT

	N	Mean	Std. Deviation	Minimum	Maximum
1.00	148	3344.4459	440.82321	2000.00	4000.00
2.00	152	3228.2237	507.57835	1989.00	4000.00
3.00	153	3205.8758	644.29639	1676.00	4000.00

a. F=2.854 p=.05 sig

TABLE. 4

Analysis of density among sub-groups in vertical section

VERTSCT

SUBGRP		N	Mean	Std. Deviation	F	p
1.00	1.00	50	3182.2600	282.98459		
	2.00	49	2767.1837	393.41230		
	3.00	50	2727.6800	457.40999	21.374	0.001 vhs
2.00	1.00	50	3169.3200	515.48117		
	2.00	50	3153.9600	260.38997		
	3.00	50	3145.4600	557.78155	.034	.967
3.00	1.00	48	3695.8125	246.11281		
	2.00	53	3724.5283	291.07173		
	3.00	53	3714.0000	486.37003	.082	.922

TABLE. 5

Analysis of density among experimental groups in Horizontal section

HORZSCT

	N	Mean	Std. Deviation	Minimum	Maximum
1.00	148	3120.9291	240.03147	2554.50	3722.50
2.00	152	3011.3092	244.14430	2545.00	3484.50
3.00	153	3069.2876	250.31049	2448.00	3500.00

a. F=7.524 p=.001 vhs

TABLE. 6

Analysis of density among sub-groups in Horizontal section

HORZSCT

SUBGRP		N	Mean	Std. Deviation	F	p
	1.00	50	3156.4600	189.46083		
1.00	2.00	49	3082.0714	170.44831		
	3.00	50	3040.6100	221.53307	4.524	0.012 sig
	1.00	50	3074.5800	280.80096		
2.00	2.00	50	2786.7000	196.27415		
	3.00	50	3015.1400	248.55811	19.340	.001 vhs
	1.00	48	3132.1979	238.35903		
3.00	2.00	53	3157.7830	186.74737		
	3.00	53	3147.4245	262.39521	.155	.856

DISCUSSION

Achieving a complete seal of the root canal system is of greatest importance in endodontic therapy, The Washington study has concluded that nearly 60% of all endodontic failure is due to incomplete obturation of the root canal[10].

The voids and crevices in the obturating mass can interconnect with each other opening up either apically or coronally. Further the tissue fluids, proteins and bacteria can seep into these empty spaces which act as a reservoir of irritants leading to failure of endodontic treatment.

In the present study was used GuttaFlow® as an obturating material. The ingredients include gutta-percha powder, polydimethylsiloxane matrix, silicone oil, paraffin oil, platinum catalyst, zirconium dioxide, nano -silver(preservative) and coloring agents.GuttaFlow® is obtained by adding nano silver particles to its initial version Roekoseal (Coltene / Whaledent) .

The material is cold flowable and sets within 10 minutes. It is supposed to be easily applied using lentulo spirals or application syringes. The material flows into the smallest dentinal tubules, because of the small particle size (< 0.9microns). The manufacturer claims a better seal and good adaptation because of increased flowablity and the fact that material expands slightly by 0.2% on setting[11].

Since GuttaFlow® is a cold flowable material, there is no need for rise in the temperature of the material like thermo plasticized materials and as per manufacturers instructions there is no need for compaction of the material during obturation and hence there is no disadvantages like shrinkage on cooling, vertical fractures due to undue forces and is relatively easy to use compared to other systems.

However it should be noted that GuttaFlow® belongs to the category of root canal filling pastes, which has a high risk of void formation,over filling or under filling. There fore this material (GuttaFlow®) was chosen to study the flowablity, density, homogeneity.

Spiral computed tomography was chosen over other diagnostic aids for analysis of the specimens because of its various advantages like Three-Dimensional volume measurements are possible without sectioning the specimens and thus avoiding the loss of material during sectioning[8] and three-dimensional reconstructions[9].

Here we chose 30 freshly extracted maxillary central incisors and divided into three groups with 10 teeth each. This allowed adequate statistical analysis and comparison with earlier studies. the canals of all the groups were prepared using a step back technique such that a continuously tapering funnel shape from the apical third to the coronal third was obtained. This facilitated for the ease of obturation with the two techniques in the study.

In this study alternating solutions of NaOCl and normal saline were used for canal irrigation.

The canals were finally irrigated with 17% EDTA and normal saline to facilitate removal of dentin debris and smear layer from the root canal[12].

The specimens were then mounted on a wax block and subjected for analysis using Spiral Computed Tomography. Each section was analyzed for variations in the density in the obturation in **Hounsefield Units (HU),** and for voids if any.

It was observed that the Hounsefield units increase from the apex to the cemento- enamel junction in vertical sections. This could be attributed to the increase in the obturation mass from the apex to the CEJ. Similarly there was a decrease in the Hounsefield units from the centre towards the periphery in horizontal sections. This could be due to due to the decrease in the obturation mass towards the periphery. These findings were observed in all the samples. However there were no voids in any of the specimens.

According to the result of the present study, **Group - I** showed the best results among the experimental groups with denser and more homogeneous obturation in both vertical and horizontal sections which was statistically significant. This can be attributed to Highly filled homogeneous matrix, good flow, 0.2% expansion on setting ,ability to penetrate into the dentinal tubules due to small particle size of the fillers and apart from fluid and injectable nature of GuttaFlow®, use of a master cone could also be the reason for the denser obturation. This finding is supported by studies done earlier by MarthaG [13] and Taranu R [14].

Group-II and **Group-III** showed inferior results than **Group-I** which was statistically very highly significant in the horizontal section and statistically significant in the vertical section.

This could be attributed to the studies done earlier by Torabinajed[15] and others reported that "a pattern of voids was frequently noticed in the case of lateral compaction where the fillings adapted reasonably well at the apical and coronal parts and showed longitudinal voids in the mid root section, thus confirming earlier findings by Goldman and associates and Schilder[16] noted that with lateral compaction at no time a homogenous mass is developed. The final filling consists of a large number of separate gutta-percha cones tightly compressed together and joined by frictional grip and cementing substance only.

The results showed that among the subgroup-III**, Group-I** showed inferior results than **Group-II** and **Group-III** but was statistically insignificant. This could be due to the reason that vertical condensation using a cold plugger in the coronal third was not done to the specimens in Group-I as per manufacturer's instructions,and the possible reason for **Group-II and Group-III** to give better results might be due to the vertical compaction of the gutta-percha using a cold plugger following lateral compaction.

The present study was done *in vitro* on teeth with straight canals, further *in vivo* studies are required to find its applicability in curved and narrow canals before accepting this material for routine obturation procedure.

CONCLUSION

From the results of the study it can be concluded that

1. Obturation done using GuttaFlow® with backfilling technique is better than lateral compaction technique.

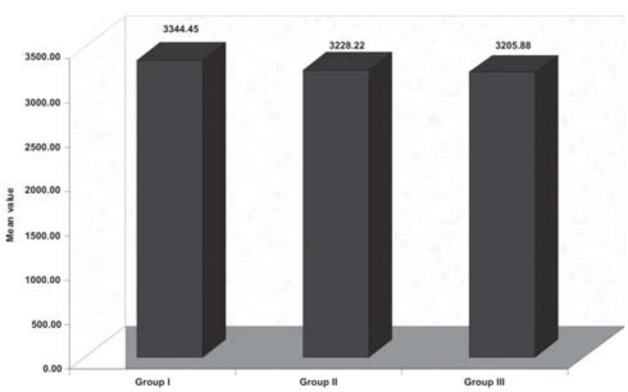
2. Obturation done using GuttaFlow® with backfilling technique is superior in the apical and middle third of the root canal system but is inferior in the coronal third.

3. Lateral compaction is better in the coronal third of the root canal, and is inferior in the middle third compared to GuttaFlow® with backfilling technique

4. GuttaFlow® when used as sealer is comparable to zinc-oxide eugenol sealer.

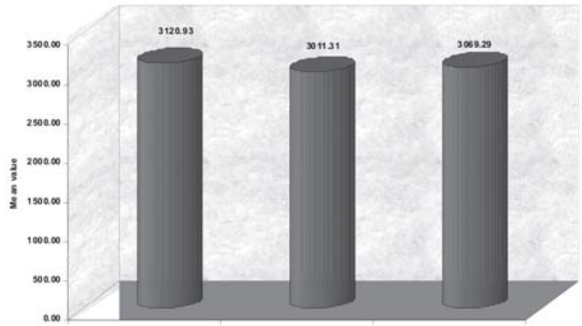
GRAPH - I

Comparison of mean density (HU) Vertical section



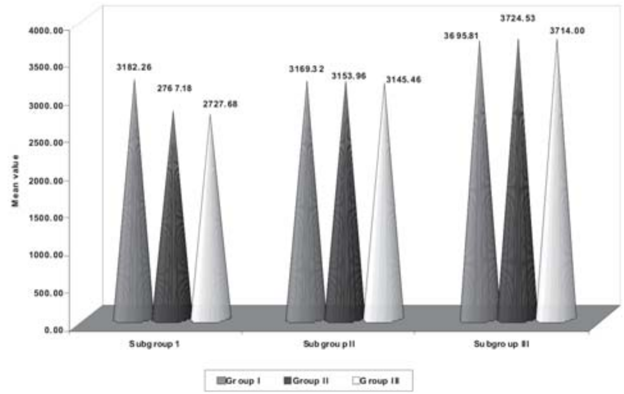
GRAPH - II

Comparison of mean density (HU) Horizontal section



GRAPH - III

Comparison of mean density (HU) Vertical section – Sub group wise



GRAPH - IV

Comparison of mean density (HU) Horizontal section – Sub group wise

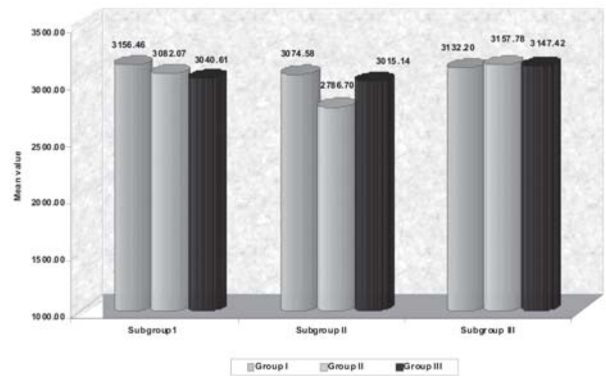


FIGURE 1 - Spiral computed tomography machine used for analysis of the specimens

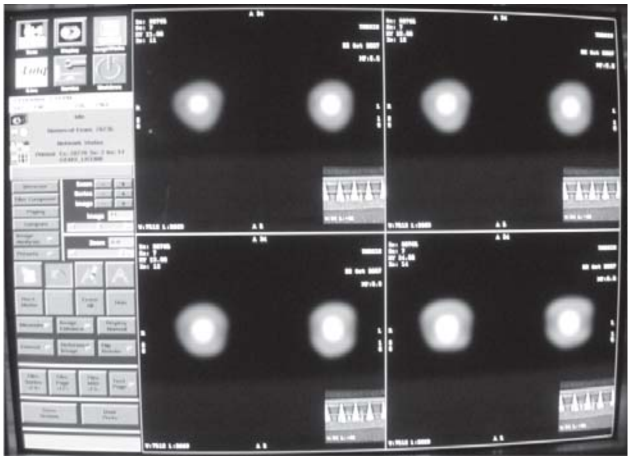


FIGURE 2 - Image showing horizontal sections of the specimens

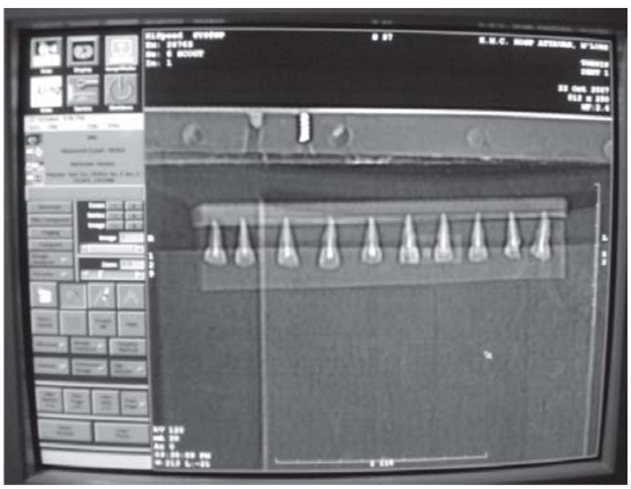


FIGURE 3 - Image showing vertical sections of the specimens.

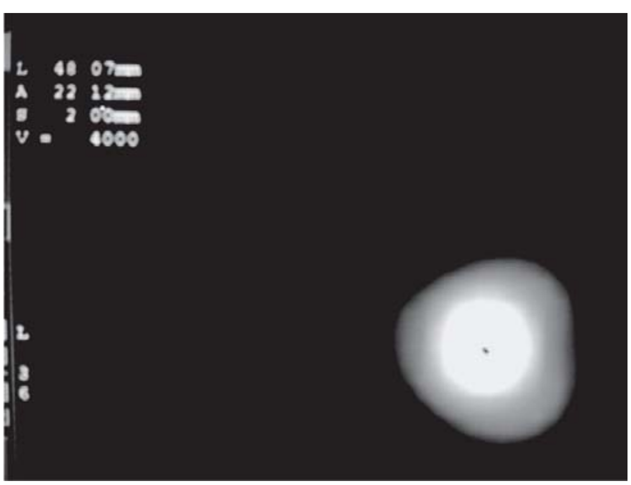


FIGURE .4 - Section showing maximum value in Group-I.

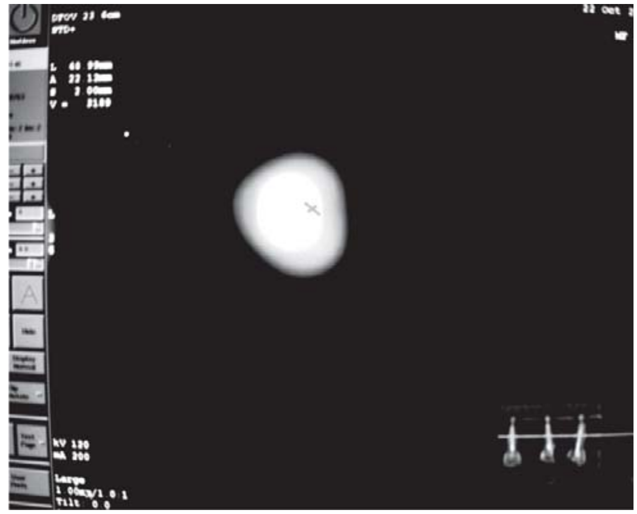


FIGURE 5 - Section showing minimum value in Group-I.

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