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# Evaluation of Density and Homogeneity of Three Different Root Canal Obturation Techniques: A Three –Dimensional Computed Tomography In Vitro Study

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**Key words**
computed tomography, density, homogeneity, cold lateral compaction, warm vertical compaction, guttaflow.

## Abstract

The aim of this in vitro study was to compare three dimensionally the density and homogeneity of cold lateral compaction, warm vertical compaction and guttaflow root canal obturation techniques using computed tomography. Thirty canals of 12 mm from extracted lower single canal premolars were selected then instrumented and divided randomly into 3 groups with 10 roots in each group. Group I was obturation with cold lateral compaction technique, group II was obturated with warm vertical compaction technique and group III was obturated with guttaflow system. The specimens were then analyzed for the density and homogeneity in both vertical and horizontalsections in apical, middle and coronal third with 1 mm section thickness using computed tomography. The data obtained in hounsefield units were subjected to statistical analysis. In conclusionguttaflow was superior in the apical part and none of the tested obturation techniques can achieve three dimensional dense and homogenous obturation from apical to coronal parts of root.

## Introduction

Three-dimensional obturation of the prepared root canals is essential to long-term clinical success of root canal therapy. The root canal system should be sealed apically, coronally, and laterally and the obturation material should be of uniform density [(1)]. Epley et al[(2)] and Schilder[(3)] suggested that the ideal root canal obturating material should be well-adapted to the canal walls and its irregularities and the entire length of the canal be densely compacted with homogenous mass of gutta-percha. 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)] . Lateral condensationoffers the advantage of controlled placement of the gutta-perchainto a root canal. However, the final root canal filling may lackhomogeneity and must rely on sealer to fill the voids between theindividual cones [(5)]. Vertical condensation, as described by Schilder[(6)], uses heat to produce a homogeneous and dimensionallystable gutta-percha mass for obturation of the root canalsystem. However, the improved flow of the thermoplasticizedgutta-percha can result in overextension of the gutta-percha intothe periapicaltissues[(7)]. Additionally, this technique can betime consuming to perform [(8)]. In recent years, new endodontic pastes and sealers have been proposed as innovativefilling materials. The root canal filling paste GuttaFlow (Coltène/Whaledent, Langenau,Germany) includes the combination of gutta-percha in powder form and polydimethylsiloxane. Nanometer-sized particles of silver were

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added to gutta-perchapowder, acting as a preservative. GuttaFlow is a modification of the RoekoSeal (RSA;Roeko, Langenau, Germany)[9]. It was reported that GuttaFlow was fairly stable and expanded slightly duringhardening [10]. This could be beneficial in preventing gap formation and decreasingmicroleakage.Also, ElAyouti et al. [11] reported that despite the presence of voids within the material, GuttaFlow showed good adaptability to root canal walls[12]. Computed Tomography (CT) is currently the leading technology for endodontic research[13].With this technology, three dimensional volume analyses arepossible without sectioning the specimen and thusavoiding the loss of material during sectioning[14]. Micro-CT scanning has been used previously to evaluate the quality of root canal fillings. Jung et al [15] have shown that the root canal filling may be differentiated from the canal wall in a micro-CT scan using digital root slices. Former studies of root canal obturation quality commonly used two-dimensional analysis of either root slices [16–18] or digital cross-sections generated from micro-CT scans [15]. A three-dimensional analysis of CT images was first applied by Zakizadeb et al [19] to evaluate intraorifice barriers. It was also recently applied by Hammad et al [10] for the analysis of the volume of voids and gaps present in root canal fillings**.** Metzger et al[20] also analyze the quality of root canal preparation and root canal obturation using micro-computed tomography. Following the concept of the previously mentioned computed tomography analysis methods, the purpose of this invitro study was three dimentional evaluation of the density and homogeneity of cold lateral condensation, warm vertical condensation in comparison with the recent GuttaFlowobturation system in apical, middle and coronal parts using computed tomography.

## Materials and Methods

Thirty single canal extracted lower premolars were collected and stored in sterile water. The teeth were carefully examined, teeth with immature apices, had undergone root canal treatment, had root caries or restoration or had root factures or cracks were excluded from the study. Also any root curvature more than 10 degree according to Schilder'stechnique [21] was excluded from this study. The teeth were decoronatedwith a diamond wheel saw to achieve a length 12 mm access into the canals was carried out, and the working length was determined by introducing a size 10 file(DentsplyMaillefer, Ballaigues, Switzerland) into the canal until it exit from the apex; this length was measured, and the working length was set 1mm short of that length. The coronal and middle thirds of each canal were prepared using Gated Glidden drills (DentsplyMaillefer, Ballaigues, Switzerland) numbers 3, 2, 1 sequentially. The apical third was prepared with flexofile (DentsplyMaillefer, Ballaigues, Switzerland) sequentially to #45 using balanced force technique. During instrumentation procedures, 2 ml of 2% NaOCl solution was used before each file. All specimens received a final flush of 2 ml of 17% EDTA for 3 min. and 5 ml of saline solution. Then the root canals were dried with sterile paper points (DentsplyMaillefer). The prepared teeth were randomly divided into three groups of 10 teeth each. All teeth were obturated by the same operator following manufacture's instruction.

### Lateral Compaction Group

A size 45 master gutta-percha point (Dentsply Maillefer, Ballaigues, Switzerlnd) was fitted at the working length. The root canals were filled with lateral compaction technique with AH26 sealer using size B endodontic finger spreader (DentsplyMaillefer,Ballaigues, Switzerland) inserted 2-3 mm short of the working length, and 6-8 accessory gutta-percha points size 20 with 0.02 taper (DentsplyMaillefer,Ballaigues, Switzerland) were used until entire length of the root canal was filled and the excess of gutta-perch was removed with heated instrument and condensed vertically with cold plugger.

### Warm Vertical Compaction Group

A master point was checked for fit and length, the AH 26 sealer was applied and the master cone size #45 gutta-percha point was introduced into the root canal until the working length was reached. The cordless heat-carrier pluggers (E&Q Master, Meta Biomed Co., Korea) was introduced 3-4 mm from the tip of master cone, then cutting and plugging for apical one-third obturation. Cordless gutta-percha obturation gun of the same company was used for obturation of the middle and coronal two-thirds of the root canals through injecting warm gutta-percha in back fill procedure.

### GuttaFlow Group

A size #45 master gutta-percha point (DentsplyMaillefer) was checked for fitness at the working length. The activated capsule was mixed for 30 seconds in a triturator. The tip of the GuttaFlow device was introduced into the root canal 3 mm short of the working length and GuttaFlow was inserted. The master gutta-percha point was coated with GuttaFlow and inserted to the working length. By pressing the master gutta-percha point laterally, the tip of the device was inserted again into the canal to seal the back fill space. Excess gutta-percha was removed with a heated instrument.All roots were stored at 37C° with 100% humidity for four days to allow the seal to set completely.

All the experimental specimens of the three groups were fixed on a sheet wax longitudinally and placed on the couch of the computed tomography machine (Brilliance CT,Philips)figure(1). It was moved longitudinally toward the gantry and scanned with exposure 120 Kv and 150 mA for 2.5 second. Both vertical and horizontal sectioned of 1 mm thickness were made which was followed by three dimensional reconstructions of the sections. The specimens were analyzed for variation in density in 1 to 4 mm from the apex (apical third), 5 to 8 mm from the apex (middle third) and 9 to 12 mm from the apex (coronal third) table(1), with the aid of Philips software machine in both vertical and horizontal sections, and the density of the filling materials was measured in HOUNSEFIELD UNITS figure (2).

## Results

The descriptive statistics and P-value between the three groups in vertical section were shown in table (2), in which we can notice that there is a high significant difference. Further statistic analysis (ANOVA test) was applied between the subgroups and showed very high significant difference in the apical part were the cold lateral condensation group has the inferior result (less density) and the guttaflow the more dense one, while in the middle and coronal thirds there were non significant difference as shown in table (3). The descriptive statistics and P-value between the three groups in horizontal section were shown in table (4), in which we can notice that there is a very high significant difference. Further statistic analysis (ANOVA test) was applied between the subgroups and showed very high significant difference in the apical part were the warm vertical condensation group has the inferior result (less density) and the guttaflow the more dense one, and there was significant difference in the middle part were the cold lateral condensation group has the inferior result and the guttaflow was the more dense one while in the coronal thirds there wasvery high significant difference were the lateral condensation group showed more dense one warm vertical condensation showed the least one as shown in table (5).

## Discussion

Root canal obturation is an essential stage of root canal treatment aimed to seal the root canal in order to prevent future bacterial contamination / recontamination of the canal space [(22)]. 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 [23]. In an attempt to standardized the root canal dimensions; the root length were adjusted to 12 mm and root curvature not more than 10 degree. Also instrumentation and obturation were done by one operator. 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 and three dimensional reconstructions [24]. According to the result of the present study, there is a significant difference among the groups in vertical section and very highly significant differences in horizontal section. Furthermore; data analysis among the subgroup in vertical section showed lateral condensation groups have more dense and homogenous mass in apical part and no significant difference in the middle and coronal parts among the subgroups. Also in horizontal section; lateral condensation group showed best result in apical and coronal thirds and inferior result in middle third among the subgroups, this result will agree with Kumar et al[23] and also with Torabinajedand Skobe[25] who 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 voids in the mid root section. Warm vertical condensation group in vertical section showed comparable result with the other groups while in horizontal section shows inferior result in apical and coronal third and moderate result in the middle third. This result may coincide with the finding of Elayouti[26] who demonstrate higher percentage of area of voids in comparisons with lateral condensation and gutta flow groups. This finding also confirming with the result of Bowmen and Baumgartner [27] who noted that increase numbers of voids with obtura II and give two possible reasons for voids; (a) the injection needle was not seated completely in the canals and (b) there was entrapments of air. Gutta flow groups showed best result in apical and middle third and least result in coronal third which is more obvious in horizontal section. This finding could be due to technique used with this system that there is no vertical condensation using a cold plugger in the coronalthird as stated by manufacturer's instructions. This finding noted by Kumar et al[23]. Furthermore; guttaflow group showed more denseobturation among the subgroups in the apical parts in both vertical and horizontal section. This could be attributed to the filling technique as the manufacturers of gutta flow recommended that it is dispensed first in the apical part of the root canal, and then a master guttapercha cone with gutta flow is placed. This ensures the least amounts of voids and gaps in the apical third as stated by Hammad et al [10]. In conclusion; within the limitation of this in vitro study there is a differences in the measurement between vertical and horizontal sections and GuttaFlow was superior in the apical part,also none of the tested obturation techniques achieve three dimensional dense and homogenous obturation from apical to coronal parts of root. None of the tested obturation techniques can a achieve ideal three dimensional dense and homogenous obturation from the other compared techniques. In all areas of root.

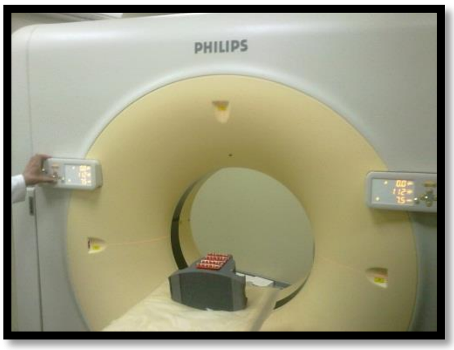
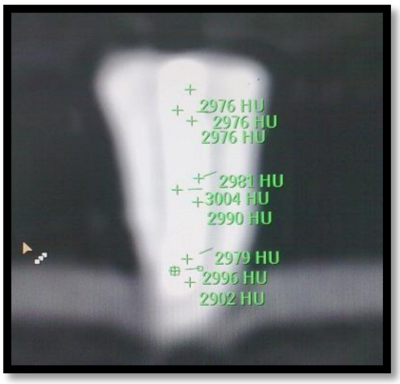



Fig.(1):- Specimens on the computed tomography machine.



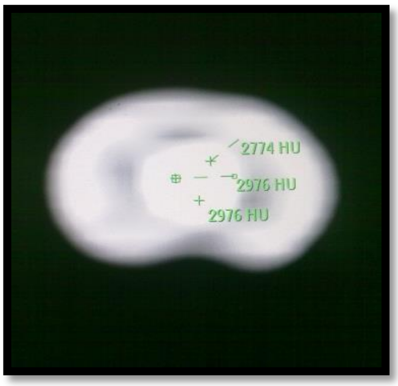



Fig.(2):- Vertical and horizontal measurement.

Table (1):- Subgroups of root

| | | |
|---|---|---|
| **Subgroup I** | **Apical part** | **1-4 mm** |
| **Subgroup II** | **Middle part** | **5-8 mm** |
| **Subgroup III** | **Coronal part** | **9-12 mm** |

Table (2):- Descriptive statistics and P-value between groups in vertical section.

| Obturation Technique | Sample size | Number of reading(N) | Mean | SD | Min | Max | F | P-value |
|---|---|---|---|---|---|---|---|---|
| ColdLateral Cond.(CLC) | 10 | 120 | 2973.6 | 39.3 | 2790 | 3020 | 4.625 | $0.010^{**}$ |
| Warm vertical cond.(WVC) | 10 | 120 | 2982.8 | 25.2 | 2823 | 3034 | | |
| GuttaFlow(GF) | 10 | 120 | 2983.1 | 10.6 | 2951 | 3012 | | |

Table (3): ANOVA test between the subgroups in vertical sections

| Subgroup | group | N | Mean | SD | F | P -value |
|---|---|---|---|---|---|---|
| Apical | CLC | 40 | 2956.1 | 63.6 | 7.429 | $0.014^{***}$ |
| | WVC | 40 | 2981.3 | 9.10 | | |
| | GF | 40 | 2986.3 | 11.4 | | |
| Middle | CLC | 40 | 2983.7 | 7.87 | 0.1403 | 0.87 |
| | WVC | 40 | 2984.4 | 14.1 | | |
| | GF | 40 | 2984.9 | 8.64 | | |
| Coronal | CLC | 40 | 2981.0 | 11.1 | 0.3329 | 0.72 |
| | WVC | 40 | 2982.7 | 40.6 | | |
| | GF | 40 | 2978.2 | 9.82 | | |

Table (4): Descriptive statistics and P-value between groups in Horizontal section.

| Obturation Technique | Sample size | Number of reading | Mean | SD | Min | Max | F | P |
|---|---|---|---|---|---|---|---|---|
| ColdLateral Cond. | 10 | 120 | 3007.5 | 63.3 | 2727 | 3080 | 20.18 | $0.0001^{***}$ |
| Obtura II | 10 | 120 | 2974.7 | 7.61 | 2960 | 2989 | | |
| Gutta-flow | 10 | 120 | 2995.1 | 28.9 | 2970 | 3065 | | |

Table (5): ANOVA test between the subgroups in horizantal sections.

| Subgroup | group | N | Mean | SD | F | P |
|---|---|---|---|---|---|---|
| Apical | CLC | 40 | 3017.6 | 22.8 | 39.01 | 0.0001*** |
| | WVC | 40 | 2973.0 | 5.77 | | |
| | GF | 40 | 3019.2 | 39.5 | | |
| Middle | CLC | 40 | 2956.3 | 83.5 | 3.668 | 0.029* |
| | WVC | 40 | 2975.7 | 7.40 | | |
| | GF | 40 | 2985.1 | 3.80 | | |
| Coronal | CLC | 40 | 3048.6 | 14.3 | 579.9 | 0.0001*** |
| | WVC | 40 | 2975.5 | 9.16 | | |
| | GF | 40 | 2980.9 | 7.35 | | |

*significant difference
**high significant difference
***very high significant difference

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