Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2019;9:3:111-119.

Microscopic Evaluation of the Sealing Ability of Different Obturation Techniques: An In Vitro Study

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ABSTRACT

Background: The root canal space, including the patent accessory canals and multiple foramina must be completely and densely filled with a biologically inert material. Furthermore, integrity of the root canal filling in the apical few millimetres is one of the criteria believed to be important for achieving successful endodontic treatment.

Aims: The aim of this in vitro study was to evaluate and compare the sealing ability of the cold lateral condensation technique, Obtura II and GuttaFlow 2 under a stereomicroscope. Settings and Design: De-coronation of the teeth up to the cemento-enamel junction with an abrasive diamond disc was done to permit ideal access to the root canal. Teeth were prepared in Crown-Down fashion.

Methods and Material: Teeth were divided into three groups with each containing 20 specimens. Each of the group was obturated with three different techniques and the specimen was observed under the stereomicroscope. Statistical analysis used: Descriptive statistics included computation of percentages and means. Statistical analysis was done using One-way analysis of variance (ANOVA) with post-hoc test, Tukey HSD and Chi-square test.

Results: Obtura II exhibited the best adaptation with less number of voids, as compared to the other two groups. Obtura II group exhibited a homogenous obturation followed by lateral condensation and GuttaFlow 2.

Conclusions: Obtura II exhibited good adaptation to canal walls followed by GuttaFlow 2 and lateral condensation.

Keywords: Lateral Condensation Technique, Obtura Ii, Guttaflow 2, Sealing Ability.

INTRODUCTION

Closing off or obturating a cleaned and shaped radicular space has been described in various ways for well over 100 years and has gained considerable importance.[1] Complete obturation of the root canal with an inert filling material and creation of an "impermeable seal" which are the goals of successful endodontic treatment. The root canal space, including the patent accessory canals and multiple foramina must be completely and densely filled with a biologically inert material. Furthermore, integrity of the root canal filling in the apical few millimetres is one of the criteria believed to be important for achieving successful endodontic treatment.[2] Most obturation methods make use of a solid core material cemented into the canal with sealer. Previous studies have shown that most

Received: Mar. 11, 2019**:** **Accepted**: May. 8, 2019
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pISSN 2278-0076
eISSN 2321-9270

endodontic sealers are soluble and some may shrink slightly. Sealer dissolution may trigger an increase in leakage along the root filling overtime. Therefore reducing the ratio of sealer to gutta-percha may improve the long-term seal provided by the root canal filling.[3] The apical root filling should provide a seal, especially because after post-space preparation only the apical root filling of 3 to 4 mm in length remains.

Moreover, studies have shown that numerous lateral canals are present in the apical third. De Deus(1975) found lateral canals in 27% of 1140 teeth, in 17% of the teeth they were located in the apical third, 9% in the middle third and 2% in the coronal third. Therefore, for optimal result, the sealer components should be kept to a minimum.[4]

Lateral condensation of gutta-percha is one of the most accepted root canal obturation methods. However its ability to confirm to the internal surface of the root canal has been questioned. Studies have shown that plasticized gutta-percha can easily be moved into the canal irregularities, thus replicating the intricacies of the root canal system. There are a number of methods that make use of the plasticized gutta-percha. These include warm lateral condensation, warm vertical condensation, coated carrier system, injection systems and thermo-mechanical compaction.[3]

Gutta-Percha exists in two distinct crystalline forms, alpha & beta. The alpha-to-amorphous phase transition occurs at a higher temperature of between 53 and 59^{o}C. This information is clinically useful when the clinician needs the amorphous form of gutta-percha in order to flow gutta-percha into all parts and utilize thermoplastic techniques.[1]

GuttaFlow is a cold, Fluid obturation system that combines sealer and gutta-percha in a single material. It consists of a polydimethylsiloxane matrix which is highly filled with very finely ground gutta-percha. Polydimethylsiloxane has been used in dentistry for many years especially in prosthodontics, as silicone-based impression materials with only limited dimensional change in setting (about 0.6-0.15%) and low water sorption. The finely ground gutta-percha powder and the silicone-based matrix are distributed homogeneously after mixing. According to the manufacture, GuttaFlow contains very small gutta-percha particles in powder form, with particle size of less than 30 µm, and sealer in its mass. Furthermore, the manufacture claims a better seal and good adaptability because of the increased flowability and the fact that this material expands slightly on setting. GuttaFlow has nano-silver in its composition. Nano-silver is metallic silver which is distributed uniformly on the surface of the filling. The chemical type and concentration of the nano-silver do not cause corrosion or colour changes in the GuttaFlow. There is sufficient nano-silver in the material to prevent future spread of bacteria and nano-silver is highly biocompatible. Clinically, GuttaFlow is used with gutta-percha points and compaction.[5]

Yee et al. introduced the concept of obturating root canals using injection-moulded thermoplasticized gutta-percha. Injectable thermoplasticized gutta-percha may be used as primary obturation, or, as it is used most often today, as a back-filling technique to fill the coronal aspects of the canal after the initial placement and compaction of gutta-percha by other techniques in the apical portion of the canal.[1]

As new gutta-percha condensing techniques have been developed to increase the sealing ability of gutta-percha to the canal walls, the purpose of this study is to evaluate and compare the sealing ability of three different obturation techniques- Lateral condensation, Obtura II, and GuttaFlow 2.

Subjects and Methods:

This in vitro study was undertaken to evaluate the sealing ability of three different obturation techniques- Lateral condensation, Obtura II and Guttaflow 2.The study was carried out in the Department of Conservative Dentistry and Endodontics.

Teeth selection:

Sixty freshly extracted human single rooted permanent mandibular premolars with complete root formation were collected for the study from Department of oral and Maxillofacial surgery. Teeth were scaled with a periodontal scaler to remove soft tissues and were stored in 10% formalin until further use. Teeth were selected by direct clinical examination. Selection was based on following criteria.

Inclusion Criteria

Extracted, non-carious, human permanent single rooted single canal mandibular premolar teeth with fully mature apices.

Exclusion Criteria

Carious teeth, Fractured teeth, Restored teeth, Immature apices, Root resorption, Multiple canals, Curved roots.

Materials Used

-Normal Saline (AxalineParenterals Ltd, Uttarakhand, India)
-3%NaOCl irrigating solution (Dentpro,AmritChemicals, Mohali, India)
- EDTA 17%-Glyde (Dentsply, Switzerland)
- AH plus sealer (Dentsply,Konstanz,Germany)
- Paper Points 15-40 size (Dentsply India)
- Gutta-Percha Points Size 15-40 (Dentsply India)
-Obtura II Gutta-Percha pellets (Obtura Corporation)
-GuttaFlow 2(ColteneWhaledent, Raiffeinsenstra, Germany)

Tooth preparation:

De-coronation of the teeth up to the cemento-enamel junction with an abrasive diamond disc was done to permit ideal access to the root canal and to keep the length of each specimen about 12 mm. A size 15 K-file was then inserted into the canal until it was just visible at the apical foramen. Working length was determined by subtracting 1 mm from this length.

Teeth were prepared in Crown-Down fashion. Gates Glidden drills (#2 – 4) were used to flare the coronal third of each canal. The working length was defined to be 1 mm short of the apical foramen, determined by inserting a size #15 K-file into the canal until the tip of the file was just visible at the apical foramen. Patency of the canal wasmaintained throughout the procedure by passing #10 K-file approximately 0.5 mm through the apex.

Instrumentation of the canal was carried out with the help ofK-files.During preparation and between each file 2 ml of 3% sodium hypochloritewas used as an irrigant. All canals wereprepared to 40Master Apical File. The smear layer removal was done using 10 ml of 17% EDTA followed by 10 ml of 3% sodium hypochlorite. The final rinse was done with saline. The canals werethen dried with paper points. Total 60 teeth were divided into three groups of containing 20 teeth each and obturated with three different techniques described below (Table 1).

Obturation Technique:

Group A: Lateral condensation group

A standardized gutta-percha master point was selected and introduced into the root canal to full working length and checked for tug-back criteria. AH plus sealer was mixed according to the manufacturer's directions and applied to the canal wall using file size #20, in a counter clockwise rotation. The master point coated with a sealer, was introduced slowly into the root canal until the working length is reached. Lateral condensation was performed using standardized finger spreaders and obturated with gutta-percha point sizes of # 15, # 20, #25, and # 30.

Group B: Obtura II group

The Obtura II system was prepared according to the manufacturer's instructions. Silver injection needles of 23 gauge were used for all obturations and a silicone stopplaced2 – 5 mm from the working length. The AH-Plus sealer was placed into the canal using a file size #20 using counter clockwise rotation. At the time of obturation, the injection of the thermoplasticized gutta-percha was performed twice, separately. First, the needle was inserted in the apical direction until it binds to the canal wall, and the thermoplasticized gutta-percha, heated to 185°C in the delivery system, was injected. The needle was removed after injecting a few millimetres of gutta-percha at the apical end of the preparation. The softened gutta-percha in the apical portion was then vertically condensed to the apex with a finger plugger dipped in alcohol, to avoid adherence to the gutta-percha. Then the remaining root canal was back-filled in increments until the gutta-percha is observed in the cervical aspect of the root.

Group C: GuttaFlow 2 group

A standardized gutta-percha master point was selected and introduced into the root canal to full working length and was checked for tug-back criteria. The GuttaFlow 2 syringe (Coltene Whaledent, Raiffeinsenstra, Langenau / Germany) was uncapped, an auto mixing tip was attached and pressed to mix the content of both syringe and loaded on the dispenser pad to coat the master GP point. First the mixed material was loaded directly in apical third of root canal with auto mixed syringe tip and then coated master GP point (2%) inserted slowly to reach upto full working length. Remaining lateral space was again filled up with auto mixed material and thus all the teeth were obturated according to the manufacturer's instructions.

Once filling was complete, radiographs of all specimens were obtained in the buccal and proximal planes to check the adequacy of filling with regard to homogeneity and apical extension. All specimens had the radiographic appearance of well-compacted fillings extending to 1 mm short of the apical foramen. The specimens were then stored for 7 days at 37°C and 100% humidity, to allow complete setting of the sealer. Specimens with any sign of failure were excluded from subsequent analysis and were replaced to maintain 20 specimens in each group.

Sectioning and Microscopic Observations:

All roots were marked at 3mm, 6mm and 9 mm from the apex using vernier calliper. All roots were cut horizontally at these markings with double-ended diamond disks at low speed, with water cooling. Slices were then viewed and photographed through a stereomicroscope at a magnification with an eyepiece of 10X and an objective of 1.5Xusing a cold light source.

Number of voids in each section were counted by two observers and summarized to achieve maximum accuracy in counting the number of voids. The area occupied by the gutta-percha and that enclosed by the total canal circumference were measured in terms of pixel counts.

The following parameters were recorded:

1. Number of voids
2. Location of the voids
3. Area of voids (AV)

- The number of voids and mean number of voids per surface were calculated.
- The location of gaps and voids were evaluated to check whether they were in the filling core or along the root canal wall.
- The images were transferred to a computer and a software program (Image J software) was used to measure the surface area of all the gaps and voids and calculated as a percentage of the canal area per sections.

Statistical Analysis Tests Used:

The data were statistically analyzed using the SPSS version 19 software programme. Descriptive statistics included computation of percentages and means. Statistical analysis was done using One-way analysis of variance (ANOVA) with post-hoc test, Tukey HSD and Chi-square test.

RESULTS

The result obtained in the present study clearly demonstrate that group B ie. Obtura II has lesser number of voids (14) as compared to the other groups; whereasGuttaflow 2 group showed the highest number of voids (80) among the three. Similarly, the mean no. of voids per surface also followed the same pattern with group B showing the least mean number of voids (0.12) and group C showing the maximum mean number of voids (0.67). (table 2, graph 1).

On application of the Tukey HSD test for Intergroup comparison of mean number of voids per surface among the three study groups it was observed that the group C gave statistically significant mean difference values when compared to group A and group B both (p=0.00), whereas the difference between groups A and B was not statistically significant (p=0.189). (table 3).

TABLE 4 and GRAPH 2 illustrate the location within the obturation where voids were observed. Obtura II and Gutttaflow 2 demonstrated more voids to the central region compared to periphery, whereas Lateral condensation showed more voids along the periphery of the obturation. The Chi-square test showed that the mean difference between these three groups was statistically significant (p=0.002).

TABLE 5 and GRAPH 3 illustrate the mean percentage of the area of voids as seen on each surface. Group B shows the smallest area of voids as compared to groups A and C. Group C had the highest mean area percentage of area of voids per surface (4.74%).

Table 1: Study Groups.

Group	Obturation Technique
A	Cold Lateral Condensation
B	Obtura II
C	Gutta flow 2

Table 2: Total no. of voids & mean no of voids per surface in the three study groups.

Group	Total No of surfaces	No of Voids	Mean no of voids per surface	Std. Deviation
A	120	26	0.21	0.408
B	120	14	0.12	0.322
C	120	80	0.67	0.473

Table 3: Intergroup comparison of mean number of voids per surface among the three study groups.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
A	B	0.092	0.052	0.189
	C	-0.458	0.052	0.000*
B	A	-0.092	0.052	0.189
	C	-0.550	0.052	0.000*
C	A	0.458	0.052	0.000*
	B	0.550	0.052	0.000*

Test applied: TukeyHSD , * The mean difference is significant at the 0.05 level.

Table 4: Location of voidsamong three groups N (%).

Location	Group A	Group B	Group C	χ^2 value	P value
Periphery	24 (92.3)	6 (42.9)	19 (23.7)	12.16	0.002*
Centre	2 (7.7)	8(57.2)	61(76.3)		
Total	26 (100)	14 (100)	80 (100)		

Test applied:Chi-square

Table 5: Comparison of percentage of area distribution of voids per surface among three groups.

Group	No of surfaces with voids	Mean percentage of voids per surface	Std. Deviation	Std. Error	p value
A	16	2.41	1.04	0.26	0.001*
B	8	1.28	0.22	0.07	
C	44	4.74	3.338	0.503	
Total	68	3.90	3.064	0.372	

Test applied: ANOVA *p<0.05 statistically significance

Table 6: Intergroup comparison of the percentage of area distribution of voids per surface between the three test groups.

		Mean Difference	Std. Error	Sig.
A	B	1.13	1.19	0.11
	C	-2.32	0.80	0.01*
B	A	-1.13	1.19	0.11
	C	-3.45	1.06	0.005*
C	A	2.32	0.80	0.01*
	B	3.45	1.06	0.005*

Test applied: Post hoc test (Bonferroni), *The mean difference is significant at the 0.05 level.

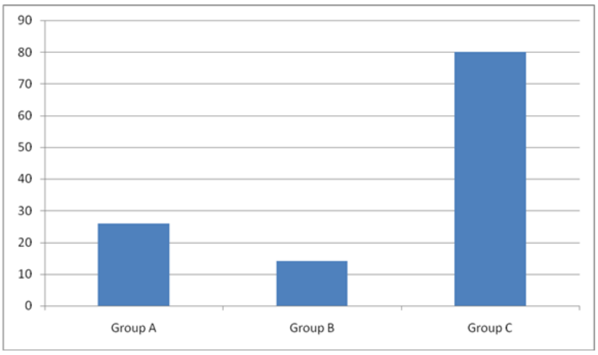

Fig 1: Mean number of voids per surface in all three test groups.

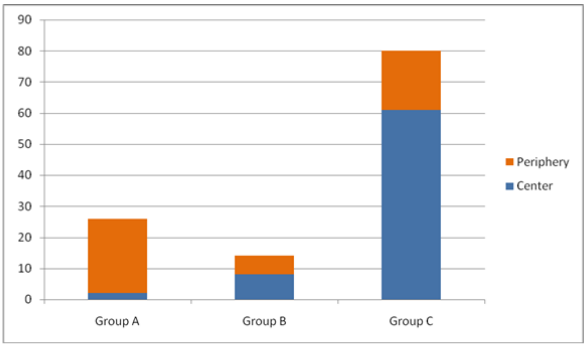

Fig 2: Location of Voids among three groups N(%).

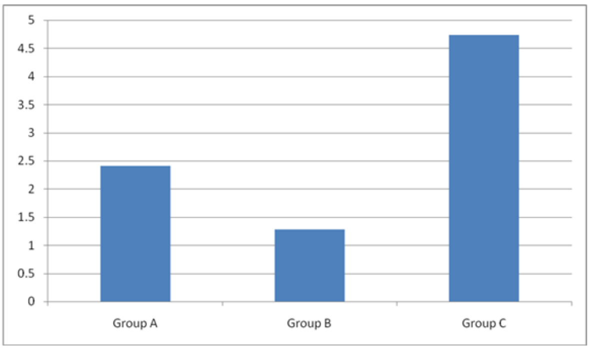

Fig 3: Percentage of area distribution of voids per surface.

TABLE 6 shows the intergroup comparison of the mean percentage of area of voids as obtained by the post hoc Bonferroni test. The mean difference between groups A and C, and groups B and C shows statistically significant resultsi.e ($p=0.01$& $p=0.005$)

DISCUSSION

Obturation, the three dimensional sealing of the entire root canal system is the last step in endodontic treatment. The seal has to be perfect to protect the treated surface because, while incomplete removal of etiological factors is a major cause of endodontic failure according to Ingle, 60% of failures can be attributed to apical percolation due to inadequate obturation.[6,7,8]

It has been shown using canal sampling culturing techniques that microorganisms remain in the canal after biomechanical preparation and medication, albeit in reduced numbers and type. These results should be viewed with the knowledge that a negative culture does not mean an absence of microorganisms in the root canal system.[9]

Traditionally the apical point of termination has been 1 mm from the radiographic apex. The dentino-cemental junction has been described by Kuttler as an average of approximately 0.5 to 0.7 mm from the external surface of the apical foramen. Based on biological and clinical principles, instrumentation and obturation should not extend beyond apical foramen.[10]

Often smaller apical accessory canals remain unfilled or partially filled. Accessory/lateral canals are often obturated by chance and only serendipitously identified on the postoperative radiograph.

Gutta-percha is by far the most popular and commonly used root canal filling material. Although, it does not meet all the criteria for an ideal filling, it satisfies most of them. The use of gutta-percha for obturation of canals has been enhanced by its ability to change volumetrically upon heating. The major disadvantage of gutta-percha as a root canal filling materials is its lack of rigidity.[11]

Gutta-percha exists in 2 distinct crystalline forms. Raw gutta-percha as it comes directly from the tree is in α (alpha) form. Once purified, gutta-percha as it appears commercially is in the β (beta) crystalline form. Although there is apparently no difference in the mechanical properties of the two crystalline forms, there are thermal & volumetric differences which have clinical implications.

If the natural α form is heated above 65^{o}C, it will melt & become amorphous. If it is slowly cooled at a rate of 0.5^{o} per hour, the original α form will recrystallize. Schilder et al investigated the temperatures that when dental gutta-percha in β crystalline form was heated, a crystalline phase transition to α form took place between 42^{o}& 49^{o}. The α-to- amorphous phase transition occurred at a higher temperature of between 53^{o} & 59^{o}.[1]

Traditionally β form was used to manufacture endodontic gutta-percha points to achieve animprovedstability &to reduce stickiness. When α-phase gutta-percha is heated and cooled it undergoes less shrinkage, making it more dimensionally stable for thermoplasticized techniques so the use of α-phase gutta-percha has increased as thermoplastic techniques have become more common. This information is useful clinically, when the clinician needs the amorphous form of gutta-percha in order to flow gutta-percha into all part of the canal & utilize thermoplastic techniques.

Over the past 70 to 80 years, dental community has seen attempts to improve on the nature of the root canal obturation with variation in the delivery of gutta-percha to the prepared canal system.

Cold lateral condensation of gutta-percha is one of the most common obturating techniques used in endodontics. Its ability to replicate the internal surface of the root canal has been questioned because of the voids, spreader tracts, and incomplete fusion of the gutta-percha cones and lack of surface adaptation.[12]

To overcome the drawback of lateral condensation, thermoplasticized injectable obturation technique was introduced to improve the homogenicityand surface adaptation of gutta-percha.[13] Many studies have shown that despite the enhanced adaptation of thermoplasticized gutta-percha to the dentine of root canal, the use of a root canal sealer is essential to achieve the optimal seal.[14] Hence, in the present study, both the techniques were compared for its sealing ability using AH plusas sealer.

In the present study, GuttaFlow 2 was also used as an obturating material. 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 ofincreased flowablity and the fact that material expands slightly by 0.2% on setting.[15]

Since GuttaFlow 2 is a cold flowable material, there is no need for rise in the temperature of the material like thermo plasticized materials and as per manufacturer's instructions there is no need for compaction of the material during obturation andhence there are no disadvantages like shrinkage on cooling, vertical fractures due to undue forces and is relatively easy to use compared to other systems.[16]

However it should be noted that GuttaFlow 2belongs to the category of root canal filling pastes, which has a high risk of void formation,over filling or under filling. Therefore GuttaFlow was chosen to study the sealing ability, density, homogeneity and adaptability.

Obtura II system, being thermoplasticized, has several advantages like improved homogeneity, better adaptation to the canal walls that fulfills the criteria of 3-dimensional obturation.[17] In this study after placing heated gutta-percha fromObtura II into canal using 23 guageneedles, gutta-percha was condensed upto apex using hand pluggers.

Main drawback is the inability to control the apical extrusion of softened gutta-percha and temperature rise on external root surface.[18]

The presence and absence of a smear layer plays an important role in the apical seal produced by various obturating techniques.[19] Studies have shown that the smear layer can serve as an avenue for leakage of microorganisms and as a source for the growth and activity of variable bacteria, which remain entrapped in dentinal tubules.[20] Hence, the root canals were irrigated with 3% sodium hypochlorite solution and 17% EDTA to remove the smear layer.

Stereomicroscopic examination was chosen for this study as this provides a three-dimensional view of the surface to be examined, it requires no pretreatment of the specimen (as in the Scanning Electron Microscopic Examination) and is associated with an image analysis software, which aids in eliminating human errors, in the interpretation of the parameters.[21]

The areas of voids were calculated in this study to quantify the adaptation of the filling. The influence of this parameter on the leakage of the filling depended on the type (through and through or dead end voids) and location of the voids (within the filling or at the canal wall).[22]

Based on results of the study, Obtura II group showed the lowest number of voids and percentage of area of voids per surface (1.28%). Thus,Obtura II provided the most compact obturation of all the groups.

The Guttaflow2 group showed the highest number and percentage area of voids per surface (4.74%). Maximum numbers of voids were seen within the core surrounded by the gutta-percha which could be attributed to the manufacturing process and not the condensation technique. These results are in accordance with the earlier studies suggesting that the adaptation to the root canal walls was almost complete.[23,24]

Despite the presence of voids within the core of the material, Gutta Flow seems to be a promising filling material because of the good adaptability to root canal walls, the ease of handling, and application of the material. It has also been seen in a recent computed tomography study that it had the highest volume of obturation when compared to the vertical compaction thermoplasticized technique.[25] This may be a result of the mode of application of the highly viscous Gutta Flow 2 paste, which provides an extended condensation of the filling material into the narrow parts of the root canal, throughout the working time of the material.

Based on these observations, Obtura II was found to be the best in adaptability, in comparison with the other obturating techniques used. These results were in accordance with the results obtained by Anantula et al, who conducted a study comparing similar obturating systems.

Although these are *in vitro* results, they are of clinical significance because these factors cannot be easily and quantitatively determined *in vivo*. Nevertheless, further clinical studies are necessary to confirm these results and evaluate their relevance to the treatment outcome.

CONCLUSION

The following conclusions can be drawn: Obtura II exhibited the best adaptation with less number of voids, as compared to the other two groups. The lateral condensation group had more voids when compared with the Obtura II and most of the voids were seen at the periphery. The GuttaFlow 2 group, although they showed more number of voids, these voids were remarkably enclosed within the material, and hence, they exhibited good adaptation to the dentinal walls. Overall, the Obtura II group exhibited a homogenous obturation followed by lateral condensation and GuttaFlow 2. Obtura II exhibited good adaptation to canal walls followed by GuttaFlow 2 and lateral condensation.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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