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RESEARCH ARTICLE

AN IN-VITRO EVALUATION AND CORRELATION OF HOMOGENEITY, ADAPTATION AND MICROLEAKAGE OF A SILICONE BASED ROOT CANAL FILLING MATERIAL GUTTAFLOW: A STEREOMICROSCOPIC STUDY

[1]Nishant K. Vyavahare, *[2]Akash K. Baranwal and [3]Mohan L. Paul

[1]Department of Conservative Dentistry and Endodontics, Singhad Dental College, Pune, Maharashtra, India
[2]Faculty of Dental Sciences, IMS, B.H.U., Varanasi-221005, India
[3]Department of Conservative Dentistry and Endodontics, Dr. R. Ahmed Dental College and Hospital, Kolkata (W.B.) – 700014, India

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ABSTRACT

Context: Total obliteration of root canal space and accessory canals is necessary for successful endodontic root canal treatment. On the horizon, GuttaFlow which has some properties like cold yet flowable, expansion instead of shrinkage, greater density of gutta-percha have made this material to be chosen for study.

Aims: Aim of study was to evaluate homogeneity and adaptation of GuttaFlow to canal walls and to evaluate apical microleakage of obturated teeth at the interface in comparison to the laterally and vertically condensed G.P.

Methods and Material: 124 human maxillary central incisors were decoronated followed by root canal preparation. Teeth were then randomly divided into 3-groups of laterally condensed (LC), vertically condensed (VC) and GuttaFlow (GF). To check the homogeneity, the 3-groups divided in to sub-groups A, B, and C respectively while to check the microleakage, the 3-groups divided in to another sub-groups I, II, and III respectively (sub-groups having 20 teeth each, with 2 negative and 2 positive control). Group A, B, C were horizontally sectioned at two levels and digitally photographed at 20X magnification using stereo-microscope. Area of voids was measured using AutoCAD image analyzing software. Group I, II, III specimen were prepared and sectioned longitudinally to measure linear extent of dye penetration using 2% methylene blue dye. Finally, the collected data were statistically analyzed.

Results: Group A and C showed statistically significant difference for presence of voids. Considering apical microleakage, an extremely statistically significant difference was found between group I and II and group I and III. Also, the single cone technique using GuttaFlow showed a superior result as compared to LC technique

Conclusion: In terms of apical micro-leakage, the sealing ability of GuttaFlow is superior to the gold standard of lateral compaction with sealer and comparable to that of thermo plasticized G.P. technique.

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INTRODUCTION

The optimal goal of non-surgical root canal treatment is to seal completely both apical and coronal avenues of potential leakage and maintain complete disinfection of root canal achieved by chemical and or mechanical cleaning, so that it can prevent the re-infection and leakage of bacterial substrates. (Davalou *et al*., 1999; El Ayouti *et al*., 2005)

****Corresponding author: Akash K. Baranwal***
Faculty of Dental Sciences, IMS, B.H.U., Varanasi-221005, India.

Biologic objectives promote the elimination of the protein degradation products, bacteria, and bacterial toxins which results from necrotic and gangrenous root canals (Schilder, 2006). It is postulated that bacteria reside in the deep portions of the root canal system even after attempting adequate disinfection and this may favor a lesion because of inability of host defense mechanism to eliminate them (Matsumiya *et al*., 1960). Incomplete obliteration of the root canal space and inadequate seal of apical foramen may contribute nearly 60% of root canal failures. (Dow and Ingle, 1955)

It is unfortunate that most available root canal filling materials are not able to completely seal the root canal system for longer duration (Chailertvanitkul, 1997). Various types of gutta-percha and sealer are available in different commercial, physical and chemical forms in order to enhance the success rate of root canal treatment and the methods of obturation may differ by the direction of compaction (lateral or vertical) and/or temperature of gutta-percha, either cold or warm (thermo plasticized).

Such techniques generally consist of Gutta Percha (G.P.), and a zinc oxide eugenol (ZOE) based sealer, but neither of these have ability to bond with dentin or restorative materials. Also, the problem of solubility is associated with majority of sealers. In case of inappropriate filling of root canal three dimensionally, the tissue fluids may leach out the sealer over time (Carrotte, 2004). On the other side, the thermo-plasticized techniques provide better adaptation to the dentinal walls and improved homogeneity of the obturated mass and their outcome is somewhat canal's shape-dependent (Kersten *et al*., 1986). It was further clarified by *De-Deus et al.* (2008) that root canal obturation in oval shaped canals may not give surety of perfection while using thermo-plasticized techniques. Also, ultimate shrinkage may occur in case of thermo-plasticized gutta-percha which is another disadvantage associated with it. Recently, a silicon based GuttaFlow/Gutta-fill system which has property of cold yet flowable, expansion on setting, greater density of gutta-percha, insolubility, non-toxicity, have made this material to be chosen for study.

GuttaFlow is a root canal filling system that consisting of two products in combination; gutta-percha in powder form and a silicone based sealer. GuttaFlow is categorized as Type II material i.e. it can be used with or without core material or other sealer (Cohen and Hargreaves, 2011). This system is based on cold and flowable gutta-percha and it is provided with an application system which confirms a simple and hygienic procedure. GuttaFlow is considered to be a successor of Roekoseal (A sealer). The inclusion of gutta-percha powder and nano-silver with Roekoseal components generates a big difference and enables GuttaFlow to be a root canal filling material along with sealing property. (Kontakiotis *et al*., 2007a, b) Therefore, the aim of present study was to evaluate homogeneity and adaptation of GuttaFlow to canal walls in terms of percentage of area of voids and to evaluate apical microleakage of obturated teeth in terms of linear dye penetration at the interface in comparison to the laterally and vertically condensed G.P.

MATERIALS AND METHODS

Sample Selection and Size

124 human maxillary central incisors freshly extracted for periodontal cause at the department of oral and maxillofacial surgery, Dr. R. Ahmed Dental College and Hospital, Kolkata-14 were selected. Teeth were stored in normal saline after cleaning. Sample exclusion criteria included were incompletely formed apex, resorbed root apices, evidence of fracture, canal curvature.

Sample Design

Selected teeth were decoronated at the cervical margin with the help of diamond cutting disc. Teeth were then randomly divided into 3-groups of laterally condensed (LC), vertically condensed (VC) and GuttaFlow (GF). Also, 4 teeth were selected for control group (two as negative and two as positive control). To check the homogeneity (in terms of percentage of area of voids), the 3-groups divided in to sub-groups A, B and C respectively while to check the micro leakage (in terms of dye penetration), the 3-groups divided in to another sub-groups I, II, and III respectively (Sub-groups having 20 teeth each).

Study Technique

Working length of decoronated tooth was measured with # 10 K file with 1mm short of apex. Biomechanical preparation was done with the help of Pro Taper rotary files (Dentsply, Tulsa Dental) and X-Smart (Dentsply) rotary system. Irrigants used for removal of the smear layer included 2.5% sodium hypochlorite (NaOCl), normal saline and 17% EDTA solution. Canal was dried with paper points. Finally, the root canal obturation was done according to assigned groups:

Lateral Condensation Group (LC)

A standardized G.P. master point was fitted in the root canal at the working length and checked for tug-back criteria. AH plus sealer (Dentsply India Pvt., Ltd.) was applied to the root canal The master point coated with sealer, introduced into the root canal till working length. Lateral condensation was done using standardized finger spreaders and colored G.P. points (size #15, #20, and #25).

Vertical Condensation Group (VC)

For the purpose, we used E and Q Plus system (Meta Biomed Co. Ltd., Korea) which consisted of a heat carrying unit (pen) and thermo plasticized G.P. Dispensing gun. Appropriate G.P. cone was checked for fit and tug back, a sealer applied as in lateral condensation and master point was introduced into the canal till required length. At set temperature of 200^{o}c, a suitable pen tip was selected, excess gutta-percha was seared off and tip of the instrument was introduced till it penetrates apical 3-5 mm short of apex in activated mode. Now, tip was deactivated and pressure was maintained for 10 seconds and again reactivated for a few seconds and removed quickly to complete down packing. For backfilling, α phase G.P. pellet was loaded into the gun (set temperature of 160^{o}c), introduced into canal and the mass was condensed using suitable plugger.

GuttaFlow Group (GF)

GuttaFlow was provided in a double barrel automix system along with gun. Master point was selected. Plastic tip was inserted into the canal till it binds and then retracted for 3mm and marked with a stopper. GuttaFlow cartridge was pressed to break the separating membrane, placed in the amalgamator and allowed to vibrate for 30 seconds. Then, the tip was attached to the cartridge and then attached to gun. Now tip introduced into the canal and material injected as well as tip was retracted simultaneously till material is seen at coronal third. Thereafter, master point was coated with material and placed inside the canal till desired length with to and fro movement. Material was allowed to set and excess gutta-percha cone was seared off. These obturated specimens were stored at 37^{o}c and 100% humidity for 7 days to ensure that the sealer cement had set.

Sectioning of teeth for studying Homogeneity

Each root of group A, B, C was horizontally sectioned at two levels (Level one was at the junction of apical and middle 3rdand level two at the junction of middle and coronal 3rd) with electric diamond saw at low speed with water cooling. Coronal surfaces of each section were labeled, digitally photographed at 20X magnification using stereo-microscope and area of voids was measured using AutoCAD image analyzing software. [Figure 1 - Stereomicroscopic images of three different groups to check for voids (%) using image software analysis: A1 and A2 (Group A specimen images at level 1 and 2 respectively); B1 and B2 (Group B specimen images at level 1 and 2 respectively); C1 and C2 (Group C specimen images at level 1 and 2 respectively)].

Dye penetration and Sectioning of teeth for studying Microleakage

Each root of group I, II, III was coated with two layers of nail paint except the apical 1 mm and allowed to dry. Roots were placed in 2% methylene blue dye for 24 hours. The negative control teeth, including the apical region were fully coated with nail varnish and positive controls were left as it is which were unprepared and unobturated. Samples were suspended by dental floss in a test tube such that, the apical 2-3 mm remained immersed in 2% aqueous solution of methylene blue for 24 hours at 37^{0} C. After 24 hours; the teeth were removed from the dye and rinsed with tap water. Nail varnish was gently removed with scalpel blade and apical third wiped using ethyl alcohol to remove excess dye. All the roots were sectioned longitudinally with a diamond disc under continuous water-cooling taking care to include the apical foramen in the fracture line; both surfaces were then directly examined under a stereomicroscope at 20 X magnification. The linear extent of dye penetration was measured in millimeter from the apical end of the preparation coronally using a digitally calibrated scale. [Figure 2 – Stereomicroscopic images of Group I, II and III at 20X to check for apical microleakage by measuring the linear dye penetration]

Statistical Analysis

The data were checked for normal distribution by Kolmogorov-Smirnov goodness-of-fit test. The collected data were statistically analyzed with Chi-Square test, Student's t test, and Pearson's Product moment correlation. p value- <0.005 was set as significant, while r value > 0.7 set as strong correlation and value <0.3 as poor correlation.

RESULTS

Presence of voids at level 1: (at the junction of apical third and middle third)

Group A showed presence of voids in 9 out of 20 sections with mean area of voids (%) of 2.37±0.812.

Table 1. Statistics for area of voids (%) for each group at level 1

Group	Lateral condensation	Vertical condensation	Gutta-Flow	Comparison between groups	p-value
No.(n)	9	6	11	Group A and B	0.182
Mean	2.37	1.80	1.37	Group A and C	0.002
Standard Deviation	0.812	0.664	0.371	Group B and C	0.098

Table 2. Statistics for area of voids (%) for each group at level 2

Group	Lateral condensation	Vertical condensation	Gutta-Flow	Comparison between groups	p-value
No.(n)	10	5	10	Group A and B	0.011
Mean	3.26	1.88	1.82	Group A and C	0.001
Standard Deviation	0.931	0.624	0.267	Group B and C	0.794

Table 3. Descriptive statistics for apical micro-leakage for each group

Group	I	II	III	Comparison between Groups	p value
Sample Size	20	20	20	group I & II	<0.0001
Mean Apical Leakage (mm)	1.19	0.979	1.01	group I & III	<0.0001
Standard Deviation	0.120	0.054	0.051	group II & III	0.053

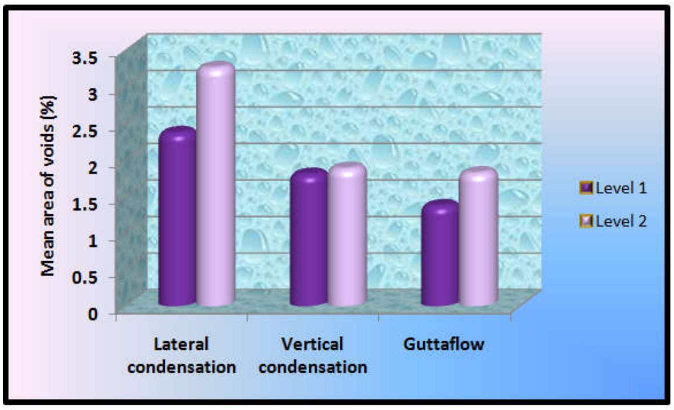
Table 4. Pearson's product moment correlation between area of voids (%) and micro-leakage for all groups

Groups	r value	Pearson's correlation
Lateral condensation	0.097	poor
Continuous wave of warm vertical condensation	-0.317	negative
GuttaFlow	0.178	poor

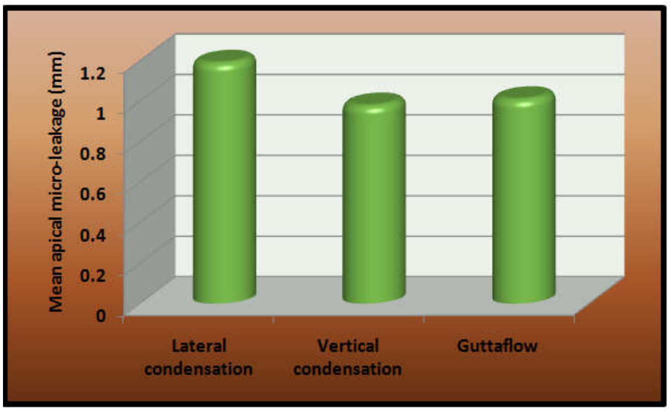
Group B showed presence of voids in 6 sections among 20 with mean area of voids (%) 1.80±0.664.Whereas in group C mean area of voids (%) was 1.37±0.371 with 11 sections out of 20 showing voids. There was non-significant difference between group A and B and between group B and C, but group A and C showed statistically significant difference for presence of voids. (Table 1 – Statistics for area of voids (%) for each group at level 1)

Presence of voids at level 2: (at the junction of middle and coronal 3rd)

Group A showed presence of voids in 10 out of 20 sections and mean area of voids (%) 3.26 ±0.931.



Graph 1. Mean area of voids (%) in groups at level 1 and 2



Graph 2. Comparison of mean apical micro-leakage (mm) among groups

Group B showed least presence of voids i.e. in 5 out of 20 sections with mean area of voids (%) 1.88±0.624. Group C showed presence of voids in 10 sections with mean area of voids (%) 1.82±0.267. It was found a significant difference between group A and B, and between A and C but difference was non-significant between group B and C. (Table 2 - Statistics for area of voids (%) for each group at level 2) Also, at these two different levels, the comparative mean area of voids (%) of all three groups has been shown in graph – 1. (Graph: 1 - mean area of voids (%) of all three groups at level 1 and 2)

Apical Microleakage

The two negative control samples showed no leakage and the two positive control samples showed complete leakage in the canal system. The mean apical leakage of group I was 1.19± 0.12 mm. This group showed the maximum dye penetration when compared with other groups. Group II showed the least amount of dye penetration with mean reading of 0.979 ± 0.054 mm. The mean apical leakage of group III was 1.01 ± 0.051 mm. The comparison of mean apical microleakage among all three groups has been represented in graph – 2. (Graph 2 - Comparison of mean apical microleakage (mm) among groups) An extremely statistically significant difference was found between group I and II and group I and III but it was not statistically significant between Group II and III. (Table 3 – Descriptive statistics for apical microleakage for each group) The relation between presence of voids and apical micro-leakage was determined with *Pearson's correlation test*. In this study, it was found that in all groups, presence of voids does not affect the apical leakage of obturated teeth.

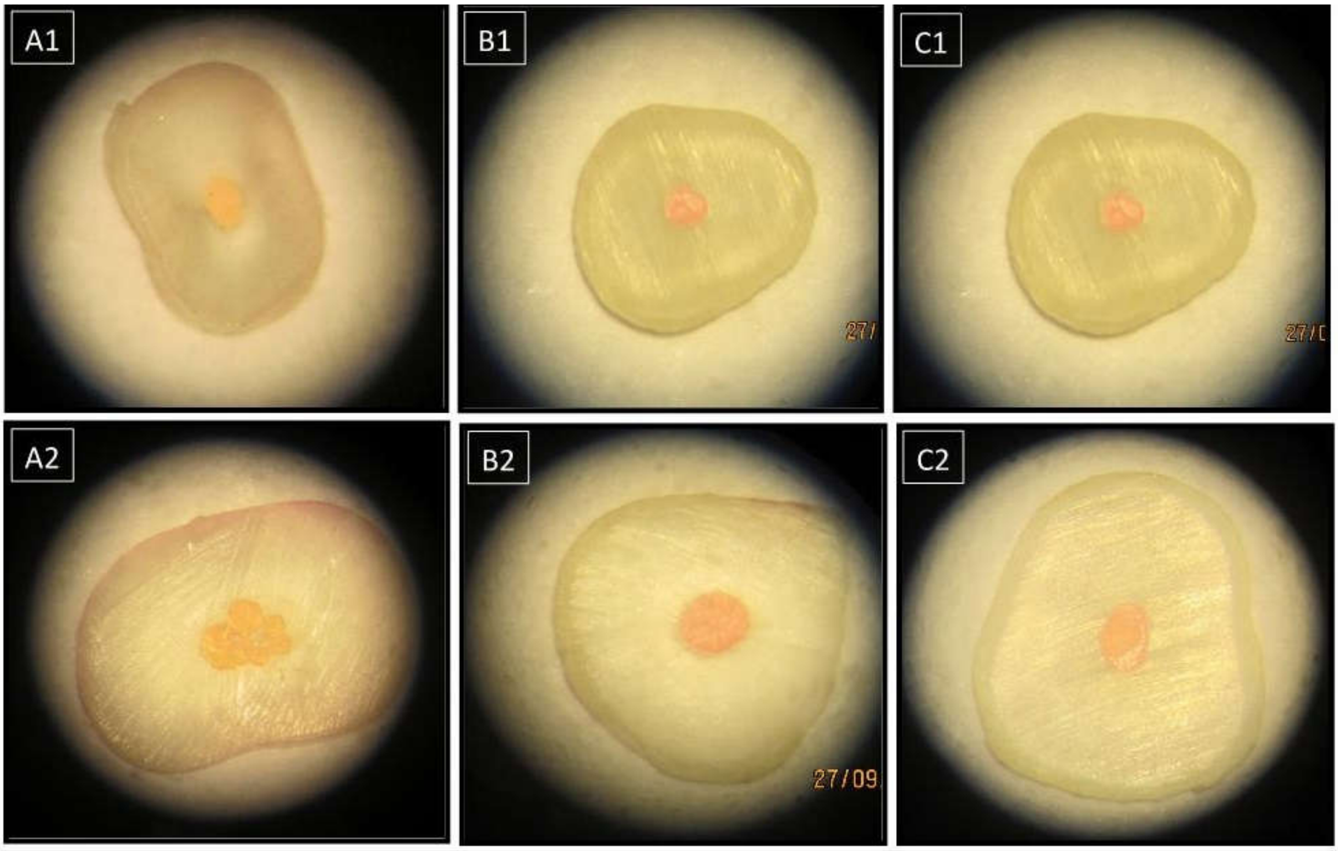


Figure 1 – Stereomicroscopic images of three different groups at 20X to check for voids (%) using image software analysis: A1 & A2 (Group A specimen images at level 1 & 2 respectively); B1 & B2 (Group B specimen images at level 1 & 2 respectively); C1 & C2 (Group C specimen images at level 1 & 2 respectively)

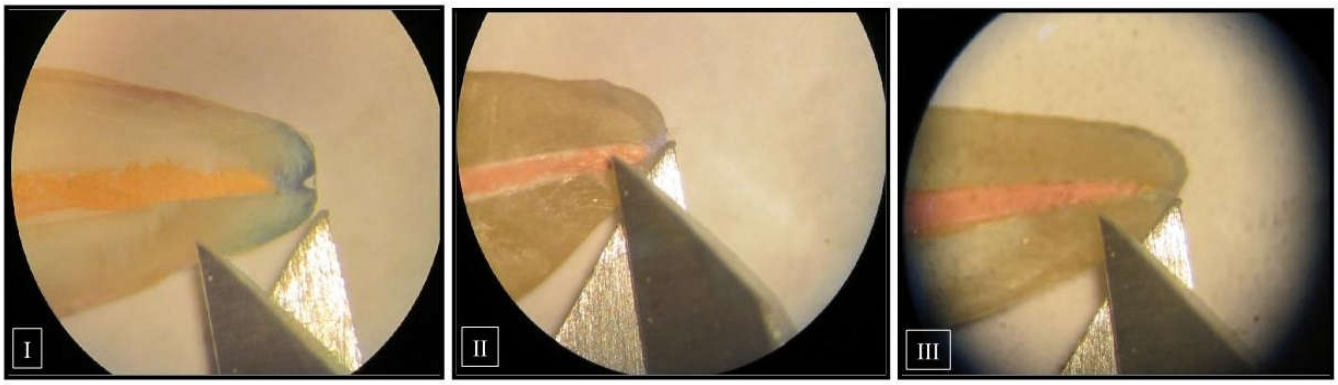


Figure 2 – Stereomicroscopic images of Group I, II & III at 20X to check for apical microleakage by measuring the linear dye penetration

In the groups I and III correlation was poor whereas in group II it was a negative correlation. (Table: 4 – Pearson's product moment correlation between area of voids (%) and microleakage of all groups)

DISCUSSION

A successful endodontic treatment always relies on complete obturation of the root canal with an inert filling material and creation of an appropriate apical seal (Alwan-Al *et al*., 2006; Gencoglu *et al*., 2007). The single cone obturation technique was one of the early popular methods of root canal obturation. In spite of being fast and easy to use, the single cone technique declined because of using excess of sealer and giving an unpredictable apical seal (Bindslev-Horsted *et al*., 2007). Lateral condensation technique was introduced later and it is a gold standard against which the other methods of root canal obturation are compared. (Kececi *et al*., 2005)

The sealing ability is a basic property that needs to be examined for every new root canal filling material or technique. A silicon- based root canal filling material, GuttaFlow (Coltene Whaledent) is a modification of the RSA (Roeko Seal Automix) which has been shown to generate a proper seal over a period of 18 months. According to the manufacturer, GuttaFlow consist of very small G.P. particles in powder form (particle size <30μm) and sealer in its mass. Furthermore, the manufacturer emphasize over better sealing and good adaptability because of its flowable nature and expansion slightly on setting. The present study evaluated and compared the efficacy of single cone technique using the GuttaFlow system with lateral condensation technique using AH Plus sealer and continuous wave of condensation technique. Statistical Analysis of area of voids (%) between three groups showed significant difference between group A and B, and between A and C but difference was non-significant between group B and C. The above data implies that Warm condensation group showed least number of sections with voids and GuttaFlow group was with maximum number of section with voids. But it is fairly clear that even though GuttaFlow group had highest number of sections with voids, same was not true with respect to mean area of voids (%) which was least when compared to Group A and B. This can be due to the reason that voids were of smaller size than compared with other groups. A comparison of the leakage values of all the groups showed that Group II demonstrated the least dye penetration and Group I the highest.

The negative control group showed no leakage whereas the positive control group showed complete leakage of the canal system. As in a relative study done by *Punia et al.* (2011) who compared the apical microleakage of Resilon to Thermafil, GuttaFlow and Cold lateral condensation using a dye penetration method under stereomicroscope, where Resilon exhibited minimum and GuttaFlow exhibited maximum microleakage. In this study cold lateral condensation showed less mean microleakage compared to GuttaFlow i.e. the present result was not in consistent with result as per observed above. The similar related study (Bhandi and Subhash, 2013) showed that Group II (Resilon with Epiphany sealer) had least amount of microleakage when compared to Group I (GuttaFlow) and Group III (Thermafil with AH-plus sealer). Group III showed lesser microleakage when compared to Group I. Regarding adaptation to the dentinal wall, a comparative SEM evaluation of dentinal adaptation of root canal obturation with GuttaFlow (group B) and zinc-oxide eugenol sealer and gutta-percha cone using cold lateral obturation technique (group A) was done (Upadhyay *et al*., 2011) and this study concluded that Group B samples showed significantly superior seal when compared with Group A. Result of this study favors the findings of our study.

The findings of our study can be justified on the basis of the setting expansion of the GuttaFlow system combined with the close adaptation of the gutta-percha cone against the prepared root canal wall promoting the sealer flow and adaptation against the dentinal walls in the apical part of the root canal (Monticelli *et al*., 2007a,b; Kontakiotis *et al*., 2007a,b). The presence of the powdered gutta-percha in GuttaFlow may have helped in the better bonding between the GuttaFlow and the gutta-percha core material. In case of the lateral condensation technique using AH Plus sealer, the reason for the higher leakage values could be due the fact that the lateral condensation technique results in a less homogenous obturation. (Brosco *et al*., 2003) A recent study by Ebert *et al.* (2014), compared the sealing ability of different versions of recent GuttaFlow 2 with GuttaFlow (normal setting and fast setting) and AH Plus, using linear dye penetration with 5% methylene blue dye and concluded that both forms of GuttaFlow 2 showed very good and predictable sealing ability when compared with the former versions of GuttaFlow as well as with the established sealer AH Plus. Favorable results for GuttaFlow 2 compared with AH Plus could also be found in a recently published study using a glucose leakage model (El

Sayed *et al.*, 2013). Although this study favors superiority of GuttaFlow 2 over the GuttaFlow, but still considering the present study, which showed a superior result of GuttaFlow to lateral condensation technique in terms of apical micro-leakage and comparable result to continuous wave of warm condensation technique, the GuttaFlow may be a good alternative choice to gold standard of lateral compaction with sealer. The findings of the present study are in agreement with those of *Brackett et al.* (2006) who found no significant difference in dye penetration when GuttaFlow system was compared with the continuous wave of condensation technique using AH Plus sealer. Our findings are also in agreement with the study of *Monticelli et al*. (2007a, b).

Conclusion

Within the limitations of study it can be concluded that in terms of apical micro-leakage, the sealing ability of GuttFlow with master cone is superior to the gold standard of lateral compaction with sealer and comparable to that of thermo plasticized G.P. technique. Still considering some demerits of this system, further, long-term in-vivo studies are required for evaluation of its sealing ability and its correlation with natural conditions.

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