Qualitative and Quantitative Comparative Evaluation of Sealing Ability of Guttaflow, Thermoplasticized Gutta Percha and Lateral Compaction for Root Canal Obturation: A Cohort, Controlled, *Ex-Vivo* Study

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Abstract

Aims: To compare and evaluate the apical sealing ability of Guttaflow, Thermoplasticized Gutta percha and Lateral Compaction technique using dye penetration method, Robertson's clearing technique and triocular stereomicroscopy.

Methods: A total of eighty extracted human mandibular molars were decoronated, sectioned and instrumented with rotary protapers size F1. Teeth were randomly divided into three experimental groups of 20 each labeled as Group G1 (Guttaflow), G2 (E&Q plus – mechanized thermoplasticized gutta-percha), and G3 (laterally compacted gutta percha). Group G4 containing 20 teeth served as positive control. All the teeth were given two coats of nail varnish leaving 2 mm at the apex. Teeth were immersed in India ink for 48 hrs, demineralized and cleared (rendered translucent) with methyl salicylate using Robertson's technique. The apical dye penetration was examined using a triocular stereomicroscope.

Results: The mean dye penetration was recorded to be maximum for E&Q Plus i.e. 0.69 mm whereas the mean dye penetration value for all canals obturated with Guttaflow was found to be minimum i.e. 0.35 mm which was comparable to that of Lateral compaction technique i.e. 0.36. On statistical analysis (T variance and ANOVA tests), no statistical significant differences were revealed in terms of sealing ability of different obturating materials.

Conclusion: Guttaflow exhibited an acceptable sealing ability, better than thermoplasticized gutta-percha, and comparable to lateral compaction, though the mean comparative leakage scores were found to be statistically insignificant.

Key Words: Guttaflow, E&Q Plus, Sealing Ability, Dye Leakage, Clearing Technique, Obturation, Lateral Compaction, Thermoplasticized Guttapercha

Introduction

Success of endodontic treatment is determined by good biomechanical preparation and three dimensional obturation of the root canal system. The Washington study of endodontic success and failures has attributed nearly 60% of endodontic failures to incomplete obturation of root canal system [1]. Results of obturation further depend upon a well condensed root fill and good coronal and apical seal. Apical seal is a major concern because lack of the same is a common and difficult to manage cause of endodontic failure. Therefore, over the years, pitfalls with obturation techniques have led to development of newer methods of obturation along with the recognition that no method of obturation may fit all clinical cases.

Lateral compaction of gutta percha is the oldest and most frequently used technique of obturation of root canal system. It is easy, inexpensive, clinically effective, does not require any specialized equipment, and is therefore the gold standard to which all other obturation techniques are compared [2,3]. However, lateral compaction technique also has pitfalls, such as creation of voids, non-homogenous mass, spreader tracts, inadequate spreader penetration in curved canals, lack of adaptation to canal walls leading to incomplete obturation of lateral canals, cul-de-sacs, fins etc. [4].

Thermoplasticized obturation was introduced to overcome the limitations of lateral compaction technique [5-7]. Advanced thermoplasticized techniques by Torabinajed et al. [8], Marlin et al. [9] and Yee et al. [10] have come a long way from heated gutta-percha cones. All these techniques exhibit homogenous mass as well as complete obturation of lateral canals, fins, cul-de-sacs etc. The E & Q system (Meta Dental Corp.) is one of the more recent thermoplasticized systems in the market. It takes the best of the other two commercially available and popular thermoplasticized systems, namely SYSTEM B which employs a continuous wave of obturation [11], and OBTURA II [12]. E&Q system does not exhibit breakage and kinking of spreaders as seen in SYSTEM B, and is beneficial in managing canal irregularities like OBTURA II [13,14]. The disadvantages of thermoplasticized techniques are shrinkage of gutta percha and difficulty in miming working length during obturation due to thermoplasticity of gutta percha [6,14].

To overcome the main disadvantage of thermoplasticized gutta percha systems, namely 'shrinkage', a self cure shrinkage free material, Guttaflow (Coltene/Whaledent, Altstatten, Switzerland), has been introduced in the market, which combines the properties of both sealer and gutta percha. It has all the advantages of thermoplasticized gutta percha systems such as homogenous mass and reduced stresses on roots. In addition, manufacturers claim that this material exhibits a better seal as well as adaptability to the root canal, due to increased flowability imparted by its smaller particle size, and the fact that it expands slightly by 0.2% when set [15-17]. It is gaining popularity as a sealer, but studies have not evaluated its potential for apical sealing, which is one of its chief intended purposes. Neither has the obturation of molar roots been

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studied with this material, though they are probably some of the most common candidates for endodontic treatment.

Aim

This qualitative and quantitative comparative evaluation was therefore conducted to determine whether the apical sealing ability of Guttaflow actually compares favourably to thermoplasticized gutta percha and lateral compaction techniques, in mandibular molar roots, in a cohort, controlled, *ex-vivo* setting.

Materials and Methods

This study was conducted between 2006-2008 (as dissertation for completion of Masters Degree in Conservative Dentistry and Endodontics). The study, being a dissertation, was approved by the institution's ethical committee as well as the committee of the state university of health sciences.

Eighty freshly extracted human mandibular molars (n=20 for each group) with closed apices, and without any evidence of root fractures, cracks or external resorption, from patients in the age group of 20-40 years, were selected for this study with their due consent. A single operator (duly trained) performed the whole procedure for standardization of technique. All the selected teeth were immersed in 5.25% sodium hypochlorite solution for 24 hours to remove adhered tissues. Calculus and surface deposits if any were removed with hand scalers. Then selected teeth were sectioned into mesial and distal halves. The mesial roots thus obtained were decoronated using a high speed fissured bur and water spray to 13 mm length, giving us standardized cohort study samples.

After decoronation and root sectioning, the patency of the mesio–buccal and mesio-lingual canals was determined using No. 10 stainless steel K file (Dentsply). The canal length was determined by placing No. 15 stainless steel K file into the canal until the tip was seen flushing with apical foramen. From this canal length, one mm was subtracted and the length thus obtained was recorded as the working length. After working length determination, the root canals were prepared using a crown down pressureless technique with Rotary Protaper (Dentsply) up to size F1 with reduction handpiece (Anthrogyr, Sybron Endo) of 1:64 reduction. During canal preparation, 17% EDTA (Glyde Prep) (Dentsply) was used as the lubricant and 5.25% sodium hypochlorite was used as the irrigant. After instrumentation, irrigation was done with combination of 5.25% sodium hypochlorite & EDTA solution (Pulpdent) to remove the smear layer. A final flush with saline, to neutralize the effect of sodium hypochlorite and EDTA, completed the biomechanical preparation. The canals were dried with absorbent points (Dentsply).

After cleaning and shaping of the root canal system, a randomised block design was employed to divide the teeth randomly into four groups of twenty each. The experimental groups were obturated with Guttaflow (group G1), E&Q Plus (G2) and Lateral Compacted gutta percha (G3). The fourth group (G4) served as positive control which was instrumented but not obturated.

Group G1 (Guttaflow) (*Figure 1*)

In group G1 (Guttaflow), selected F1 Protaper gutta percha point was inserted to working length, before the guttaflow was mixed according to manufacturer's instruction. Then, the material was gently dispensed into the apical one third of canal. After this, guttaflow was placed directly onto the master cone which was then placed into the canal up to working length. The point was pulled back and forth to ensure complete wetting of the master cone as well as the canal. Finally, the master point was seated into the canal.

Group G2 (E&Q plus) (*Figure 2*)

In group G2, heated gutta-percha obturation involved two main steps, namely: Vertical condensation and Back fill.

Vertical condensation (Down Pack): AH plus sealer (Dentsply Detray, Konstanz, Germany) was mixed and applied onto the canal with a no. 10 file, following which master point was placed 1 mm short of the working length. Then, the appropriate temperature of E&Q Pen (250 degree Celsius) was set and activated by touching the spring switch on the hand piece. First the excess of gutta percha over the orifice was severed off using the activated E&Q Pen Tip. Then gutta percha was warmed by inserting the pen tip 7 mm short of the working length. At this canal length, the activated pen tip was placed for 2-3 seconds and then deactivated for 8-10 seconds as the spring switch was released so that apical gutta percha was uniformly warmed. Finally the pen tip was again activated for two seconds so that gutta percha in the

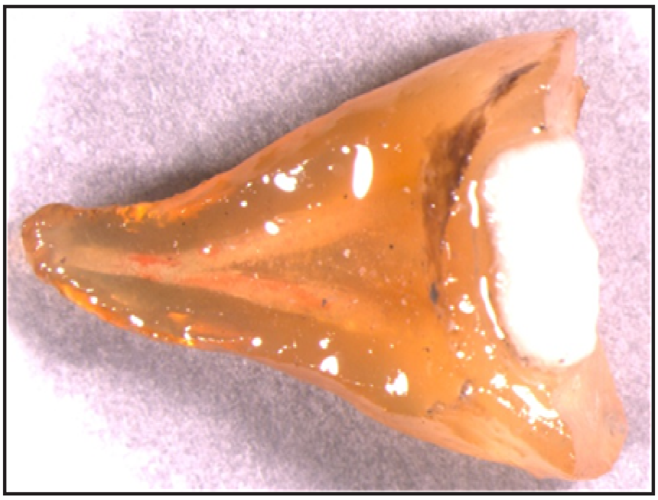

Figure 1. *Maximum leakage (E&Q plus).*

Figure 2. *Minimum leakage (Gutta flow).*

coronal portion was retrieved. This procedure also prevented the retrieval of gutta percha in apical portion. The softened gutta percha was compacted using the widest plugger, which led to perfect obturation of the apical area and accessory canals.

Backfill: The gutta percha bar was placed into the activated Gun and the Gun needle was inserted into the root canal up to the level of the already placed gutta percha in apical portion. The trigger was pulled slowly and backfill was completed up to the root canal orifice. During backfill, Gun needle was pushed back simultaneously by gutta percha being filled. The heated gutta percha was compacted using a bigger plugger which led to complete obturation of the root canal system.

Group G3 (Lateral compaction) (*Figure 3*)

In group G3, the samples were obturated by lateral compaction technique. AH plus sealer was mixed and applied into the canal, following which master cone coated with sealer was placed up to the working length, and tug back achieved. An appropriate spreader 1 mm short of working length was applied under vertical loading for 10–60 seconds. Following spreader withdrawal, the first accessory cone (smaller than the selected spreader) was slid promptly to length with a light coating of sealer. Compaction and accessory cone insertion continued with subsequent shorter accessory cone insertion, until the spreader reached no further than 2-3 mm into the canal.

After obturation of the root canals with the respective materials, the teeth were filled with Intermediate Restorative Material (IRM) (Caulk, Dentsply), 3 mm in thickness and covered with a layer of ethyl cyanoacrylate to achieve adequate coronal seal. All the teeth were stored at 37°C for 48 hours at 100% humidity to allow root canal sealer to set . All the roots were given two full layers of nail varnish except 2 mm apically. The teeth were then immersed in India ink for 48 hours; in an upright position such that the apices of roots did not touch the floor of the container. The specimens were then washed under tap water for half an hour to remove any excess dye. The varnish was removed with acetone. The specimens were then cleared using Robertson's technique [18]. The extent of apical dye penetration in all the four groups was measured from anatomic apex in millimeters using a Triocular Stereomicroscope (10x magnification). *Figure 4* illustrates a control group sample with complete dye penetration.

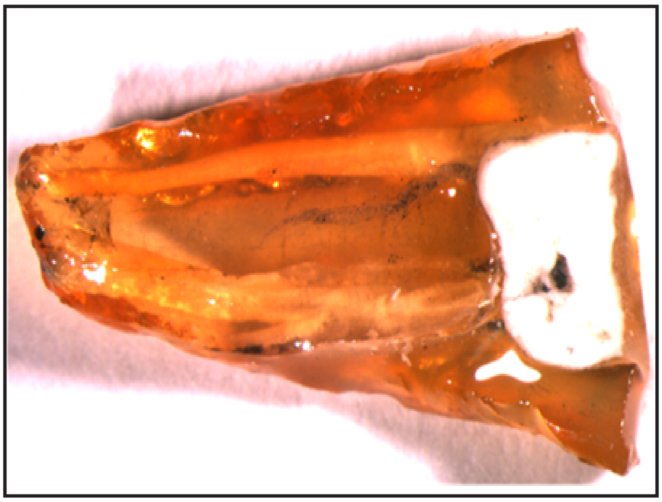

Figure 3. *Leakage in lateral compaction technique.*

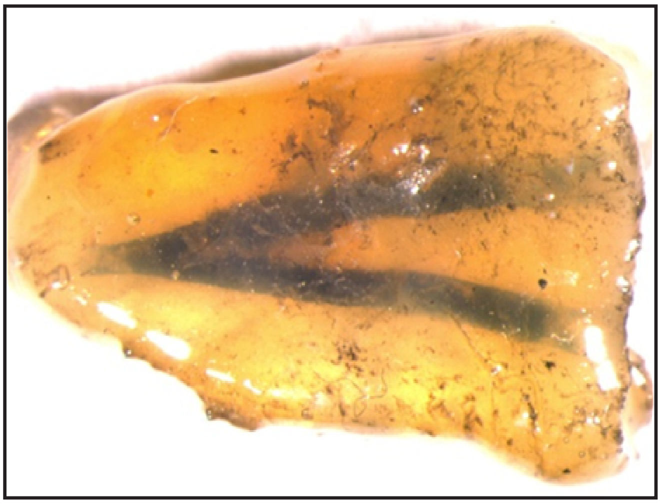

Figure 4. *A positive control sample.*

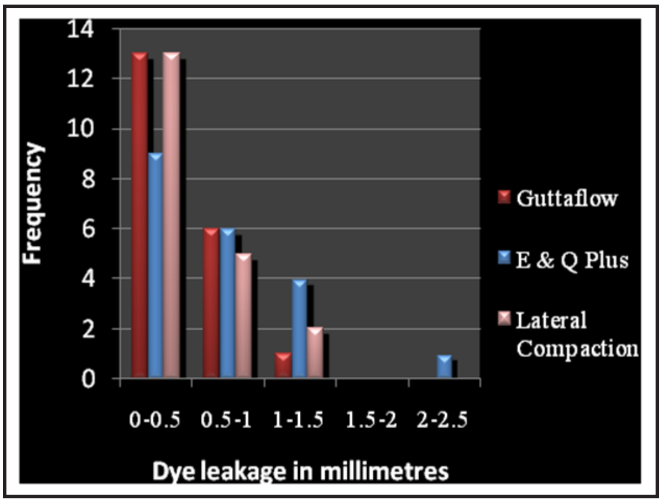

Figure 5. *Bar diagram showing the distribution of leakage in various groups.*

Leakage scores were noted (*Figure 5* and *Table 1*), and the mean leakage scores of all the groups were evaluated and compared through statistical analysis by one way analysis of variance (ANOVA) test and unpaired T test (*Tables 2* and *3*).

Results

Figure 5 illustrates the leakage scores in the three experimental groups (excluding controls). A large numbers of specimens (58.33%) in all three experimental groups had leakage scores ranging between 0.00-0.5 mm (and therefore best apical seals), with relatively larger numbers in groups G1 and G3 (*Figure 5*). The highest leakage score was found in G2. *Figure 5* and *Table 2* show that the highest mean leakage score pertained to the group G2 (0.69 mm) whereas the lowest mean leakage score pertained to G1 (0.35 mm), which was comparable to G3 (0.36 mm). However, the difference in mean leakage scores of the three groups was statistically insignificant i.e. ($p \geq .05$) (*Tables 2* and *3*).

Discussion

Mesial roots of human mandibular molars were selected, because a previous study [19] had found that the rounded cross section of mesial root canals enabled rotary Protapers (Dentsply) to effectively clean and shape the root canal system

Table 1. *COne way Anova test.*

Descriptives						
Dye penetration extent in millimeters(mm)						
	N*	**Mean**	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
1	20	.3500	.50731	.11344	.00	1.80
2	20	.6900	.60428	.13512	.00	2.20
3	20	.3650	.46710	.10445	.00	1.30
Total	60	.4683	.54384	.07021	.00	2.20

ANOVA					
Dye penetration extent in millimeters(mm)					
	Sum of Squares	**Df****	**Mean Square**	**F#**	**Sig.**
Between Groups	1.476	2	.738	2.634	.081
Within Groups	15.974	57	.280		
Total	17.450	59			

*N: Number of observations

*Df: Degrees of freedom, **F:Variance ratio

Table 2. *Post Hoc Tests.*

Multiple Comparisons Dependent Variable: Dye penetration extent in millimeters(mm) Bonferroni						
(I) gp*	**(J) gp***	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
1	2	-.34000	.16740	.141	-.7529	.0729
	3	-.01500	.16740	1.000	-.4279	.3979
2	1	.34000	.16740	.141	-.0729	.7529
	3	.32500	.16740	.171	-.0879	.7379
3	1	.01500	.16740	1.000	-.3979	.4279
	2	-.32500	.16740	.171	-.7379	.0879

*gp – Group

without leaving any uninstrumented area, while maintaining the original canal shape at the same time. Relatively few teeth are extracted in the age group of twenty to forty years, which, along with other exclusion criteria, limited our sample size (n=20), which was nevertheless adequate for biostatistical purposes.

Investigators have many options for evaluation of apical seal, such as dye penetration tests, bacterial and toxin infiltration studies, reverse diffusion, chemical tracers, fluid filtration techniques etc. The pros and cons of different methodologies for the assessment of endodontic filling materials have been discussed in a comprehensive review by [20]. Out of these, dye penetration method is capable of adequately demonstrating leakage without the need for a chemical reaction, exposure to hazardous radiation, or destruction of experimental material and no specialized equipment is required [20,21]. Many recent studies have found no significant difference between results using fluid filtration and dye penetration techniques [22,23]. Long term studies are not feasible with dye penetration method, but were not an aim of this study.

For the dye leakage evaluation, India ink was chosen over other dyes because its particles remain stable during the process of decalcification and clearing of teeth, thus enabling a better three dimensional view for evaluating the exact extent of dye penetration [24]. Its small particle size (3 microns) further ensures that no bacteria may enter where this dye cannot, because most bacteria are much larger than its size [20]. Pathomvanich and Edmunds [21] recommended 48-72 hours of dye exposure to allow maximum dye penetration in root canals, which was duly incorporated in our methodology.

After dye penetration, the teeth were cleared, or rendered translucent, using Robertson's technique [18]. Clearing allows three dimensional viewing of the tooth and avoids the potential hazards of sectioning, radiation exposure, or both, used in other methods of examining root fillings, and is therefore preferable, though time consuming [18,20]. Linear dye penetration from the root apex was measured under a triocular stereomicroscope, and the readings were measured to the nearest 0.1 mm with the help of Autocad software. Stereomicroscope was used because the exact extent of dye penetration could be viewed and measured accurately with ease.

The mean dye penetration was maximum for G2 (E&Q Plus) (0.69 mm) whereas the mean dye penetration value for all canals obturated with Guttaflow (G1) was found to be minimum i.e. 0.35 mm, while being almost similar to G3 (Lateral compaction, 0.36 mm).

The most probable explanation for low mean leakage scores in G1 (0.35 mm, with range of 0.00-1.8 mm) would be the setting expansion of Guttaflow by 0.2% as claimed by manufacturers, and corroborated in studies [15,25]. The presence of small sized gutta percha particles (nano-particles less than 30 microns) further imparts increased flowability to Guttaflow, resulting in better spreading capacity and adaptation to root canal walls, and into dentinal tubules [15,25-27], also implying decreased leakage.

A high value of mean leakage score (0.69 mm) was

Table 3. *T tests to determine Statistical significance of differences between the three groups.*

Group Statistics					
	G	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Dye penetration extent in millimeters (mm)	1	20	.3500	.50731	.11344
	2	20	.6900	.60428	.13512

3a. *Between G1 and G2*

Independent Samples Test (G1 & G2)				
		t-test for Equality of Means		
		t	**df**	**Sig. (2-tailed)**
Dye penetration extent in millimeters (mm)	**Equal variances assumed**	-1.927	38	.061

3b. *Between G1 and G3*

Group Statistics					
	G	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Dye penetration extent in millimeters (mm)	1	20	.3500	.50731	.11344
	3	20	.3650	.46710	.10445

Independent Samples Test (G1 & G3)				
		t-test for Equality of Means		
		t	**df**	**Sig. (2-tailed)**
Dye penetration extent in millimeters (mm)	**Equal variances assumed**	-.097	38	.923

3c. *Between G2 and G3*

Group Statistics					
	G	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Dye penetration extent in millimeters (mm)	2	20	.6900	.60428	.13512
	3	20	.3650	.46710	.10445

Independent Samples Test (G2 & G3)				
		t-test for Equality of Means		
		t	**df**	**Sig. (2-tailed)**
Dye penetration extent in millimeters (mm)	**Equal variances assumed**	1.903	38	.065

observed in the thermoplasticized group (G2), with range of (0.00-2.2 mm). The cause for the expectedly high leakage scores with this system would be phase transformations induced by heating of the gutta percha, which led to change of crystalline phase gutta percha to amorphous phase [28]. Only with extremely slow cooling (0.5 degree celsius per hour) of gutta percha can the original phase be regained [29]. However, with routine cooling as found in clinical situations, the beta phase would be expected to reform, which leads to shrinkage and increased leakage throughout the canal wall. Lack of operator's efficiency with thermoplasticized systems, lack of material control, lack of measurement guidelines to monitor the progress of filling material, presence of slender and under condensed fillings in apical one third of the root canal may be other contributing factors [29]. Other studies contrasting Guttaflow to warm vertical compaction have also found Guttaflow to have better sealing ability [12,30,31], even at 12 month follow up [26], and even with enlarged apical preparations [32], except in one study by Monticelli [33]. Only one of these studies was focused on the apical seal though, and that too with enlarged apical preparations.

A comparative low value of mean leakage score (0.36 mm) was observed in samples of Group G3 (lateral compaction with gutta-percha cones and AH Plus sealer) with a range of 0.00-1.3 mm. Hardly any study has contrasted the apical seal with lateral condensation to that with Guttaflow, though Guttaflow has been found to display a lesser percentage area of voids [15], greater percentage of gutapercha filled area [30], better volume of obturation [13], better resistance to microbial leakage [2], and better long term seal all along the root canal at 12 months [26], compared to lateral compaction.

A major factor contributing to low leakage in G3 could be the use of AH Plus sealer. Due to its good mechanical properties, high radio opacity, relatively less polymerisation shrinkage, and good bond strength to dentin, AH Plus (as sealer) with gutta-percha has served as the gold standard in various leakage studies [1,2,33-35]. It was therefore an apt choice for this study too. Its maximum setting expansion of 0.9% and decreased solubility implies better adaptation to the canal walls and decreased leakage [25,36,37]. The close leakage values with the use of Guttaflow and AH Plus are reflected in numerous other studies comparing Guttaflow to resin based sealers, of which some favor Guttaflow in terms of sealing ability [2,16,28,38,39], while others found resin based ones better [17,36,37,40], implying that the debate is still open.

Another reason of decreased leakage scores in G3 in this study could be greater spreader penetration. Since master cone used in this study was not in close approximation with the canal walls, it could have led to greater spreader penetration within 1-2 mm of working length, and adequate compaction of the master cone in the apical portion of the canal, thereby leading to less apical leakage [41,42].

In group G4, all the teeth were instrumented but not obturated, as extensive ink penetration in this group would demonstrate the validity of the experimental design to demonstrate leakage around the gutta-percha into the canal system.

To summarize, the apical sealing ability of Guttaflow is comparable to the gold standard of lateral condensation. The problems of lateral compaction, however, are usually concerned with inadequate root filling rather than apical sealing ability, and would therefore serve as the hypothesis for another study. More importantly, apical sealing ability of Guttaflow in the apical root region is acceptable, and in fact quite remarkable, in comparison to thermoplasticized guttapercha techniques, to which it is closest in indications and technique. Guttaflow's biocompatibility and low tissue toxicity [4,39,43], low water sorption and solubility [44], antimicrobial resistance due to presence of silver particles [2], and adequate radiopacity [45] further recommend it as an acceptable alternative obutration material.

It is therefore recommendable for regular clinical usage, especially as an alternative to thermoplasticized guttapercha techhniques, and / or where lateral compaction is not indicated.

Conclusion

As per the results of this study, it may be concluded that Guttaflow is a good alternative to thermoplasticized guttapercha where lateral compaction is not indicated, and has good apical sealing ability, making it a clinically viable obturating material.

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