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Comparative evaluation of the apical sealing ability of different obturation techniques-an in vitro study

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Purpose: The present study aimed to compare the apical sealing ability of three different obturation techniques, namely cold lateral condensation, carrier-based obturation (GuttaCore), and single cone (GuttaFlow bioseal) using a dye penetration method.

Methods: Freshly extracted mandibular premolars were collected. After biomechanical preparation, samples were divided into three groups (n = 15) and were obturated. Each root was coated with nail polish except the apical 3 mm. Samples were immersed in 2% methylene blue for 72 h at 37°C. All the roots were sectioned buccolingually. Samples were then examined under a stereomicroscope at 0.8× . The linear extent of dye penetration was measured in mm from the apical end of the preparation.

Results: Cold lateral condensation technique showed the highest amount of apical microleakage, followed by GuttaCore and GuttaFlow Bioseal. A statistically significant difference was found when GuttaFlow Bioseal was compared with cold lateral condensation and GuttaCore. The results were not statistically significant when cold lateral condensation and GuttaCore were compared.

Conclusion: GuttaFlow Bioseal, in combination with the single cone technique, shows better apical sealing ability when compared to Carrier-based obturation (GuttaCore) and cold lateral Condensation technique.

Keywords: Apical sealing ability, Carrier-based obturation, Cold lateral condensation technique, GuttaFlow Bioseal, Single-cone technique.

Introduction

Proper cleaning and shaping of the root canal system and complete filling with a biologically inert and dimensionally stable material is a major requirement of root canal treatment (1). A key to successful endodontics is to seal completely, both the apical and coronal pathways of potential leakage and maintain the disinfected status reached by the chemical and/or mechanical cleaning, to prevent reinfection and percolation of bacterial substrates (2).

The apical third of a root canal system is the most difficult section to clean and shape because of its ramifications and irregularities. Persisting bacteria in endodontically treated teeth may be located in uninstrumented areas like lateral canals. In this case, the three-dimensional obturation of the root canal system becomes extremely important, as it could prevent reinfection and isolate microorganisms in inaccessible areas, without access to space and nutrients (3)

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Ideal root canal filling achieves a three dimensional obturation with dense, well adapted and homogenour mass of canal filling. (4) Several materials and techniques have been used to achieve three-dimensional filling (5). Over the years, pitfalls with obturation techniques have led to the development of newer methods of obturation along with the recognition that no method of obturation may fit all clinical cases (6). Cold lateral condensation, carrier-based obturation technique and single-cone technique has been used in the following study.

Cold lateral condensation has set the golden standard in endodontics (7,8). It has advantages like low cost, the ability to control the length of the fill, clinically effective, and does not require any specialized equipment (6,9). However, voids, spreader tracts, incomplete fusion of the gutta-percha cones, and lack of surface adaptation have been also reported (2).

Thermoplasticized obturation was introduced to overcome the limitations of the lateral compaction technique. Primarily, a carrier system was introduced in which a core metal carrier was covered with gutta-percha. When the filler is heated, gutta-percha softens and is inserted into the canal (10)

Due to the difficulties encountered in retreatment and in the preparation of post spaces, the original metal carriers were subsequently replaced by plastic obturators. Recently, a new core-carrier system was introduced, i.e., GuttaCore (Dentsply Tulsa Dental Specialties, USA), which contains cross-linked thermoset gutta-percha enabling the carrier (obturator) to be removed more easily during retreatment (11)

Although a more homogeneous filling was produced, voids were still present, and also, there is an issue of shrinkage in the case of thermoplasticized gutta-percha (12) Length control is, however a disadvantage with higher risks of under and over-extended obturations (9)

Recently, GuttaFlow (Coltene/Whaledent, Altstatten, Switzerland) has been introduced, which combines all the advantages of thermoplasticized gutta-percha systems. It is a self-cure, silicone-based shrinkage-free material having good biological properties (6). It contains gutta-percha particles in powder form and a sealer of polydimethylsiloxane with nanometer-sized silver particles added as a preservative (13). It can be used as a sealer as well as a solid obturating paste without a solid core (14). Gutta-Flow 2 is a further development of Gutta-Flow, which has a better seal and good adaptability due to increased flowability, and it expands (0.2%) on the setting (15,16).

GuttaFlow bioseal (COLTENE) is an intelligent bioactive obturation material recently launched containing calcium silicate particles in it which actively supports regeneration in the root canal (14). On contact with fluids, the bioactive material provides the tooth with natural repair constituents, such as calcium and silicates-improving canal regeneration and treatment success (17).

Several techniques had been introduced to achieve complete filling of the root canal system. Limited studies are reported comparing the apical sealing ability of cold lateral condensation, GuttaCore, and Gutta-Flow bioseal. The aim of this study was to evaluate and compare the apical sealing ability of three different obturation techniques-cold lateral condensation, carrier-based obturation technique (GuttaCore), and single-cone technique (GuttaFlow Bioseal) using a dye penetration method under stereomicroscope. The null hypothesis taken was that all the techniques had the similar apical sealing ability.

Materials and Methods

Ethical approval was taken by the ethical committee of the College of Dental Sciences and Research Centre, Bhopal, Ahmedabad. Freshly extracted mandibular premolars for orthodontic and periodontal reasons were collected for the study. The samples were stored in 3% sodium hypochlorite solution and were cleaned with the help of an ultrasonic scaler.

Teeth with root fractures or cracks, resorption, dilacerations, and root caries were excluded, and teeth with straight (<5°), single and oval canals were included (Fig. 1). Forty-five extracted single-rooted premolars were selected. All samples were preserved in normal saline until use. The teeth were marked to obtain a standardized root length of 14 mm and were decoronated by a diamond disc (Fig. 2).

The glide path was determined by inserting #10 K file and the working length measured. The root canal was instrumented using rotary Ni-Ti instruments ProTaper Gold (Dentsply Sirona).

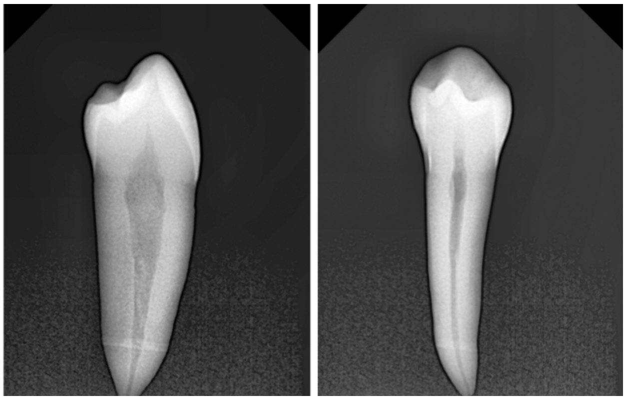

Fig. 1. Buccolingual and mesiodistal radiographs.

Fig. 2. Forty-five decoronated samples

The coronal portion of the canal was enlarged by ProTaper SX. Biomechanical preparation was done till F3. Teeth were irrigated with 1 mL of 3% NaOCl throughout the procedure. After the preparation was completed, the canal was irrigated with 2 mL of 17% EDTA. Finally, the canals were washed with 2 mL saline and dried with paper points.

Samples were randomly divided into three different groups (n = 15) each and were obturated. Two other samples were used as controls, one positive (n = 1) and one negative control (n = 1).

- Group 1-Cold lateral condensation technique
- Group 2-Carrier based obturation technique (Gutta-Core)
- Group 3-Single-cone technique (Gutta-Flow bioseal)
- Group 4-Positive control group
- Group 5-Negative control group

Group 1: Cold Lateral Condensation Technique (n = 15)

A standardized gutta-percha (Diadent Gutta Percha Points) master point (F3) was checked for tug-back and re-confirmed with radiograph. AH plus sealer was (Dentsply, Germany) applied using lentulospiral (Mani, Paste carriers, Japan). Lateral condensation was done using standardized finger spreaders (Mani Inc, Japan). Excess gutta-percha was trimmed with a hot burnisher at or below the canal orifice level.

Group 2: Carrier Based Obturation Technique (GuttaCore) (n = 15)

After the selection of the metal verifier, an obturator of the same size (#30) corresponding to the size of the last shaping file was selected. After drying the canals, AH Plus sealer was applied. Obturator was heated in the oven by placing it in one of the obturator holders. After 90 s, the heating element was switched off automatically. The obturator was carefully taken out of the holder by pulling it, making sure not to scrape the obturator on any part of the holder. Obturator was delivered in one single smooth motion in the orifices of the canal to the working length. Sharp spoon excavator was used to sever the GuttaCore handle at the canal orifice and the remainder reduced to 2 mm below the orifice using ball burnisher.

Group 3: Gutta-flow Bioseal (n = 15), (Single Cone)

GuttaFlow Bioseal (Coltene Whaledent GmbH, Germany) was available in a double barrel automix system with delivery tip. Masterpoint F3 was selected. The plastic delivery tip of GuttaFlow Bioseal was inserted into the canal passively till 3mm short of working length. The tip was introduced into the canal, and material injected. At the same time, the tip was retracted simultaneously till the material is seen at the coronal third. Masterpoint (F3) was coated with GuttaFlow Bioseal material and placed inside the canal till the desired length with to and fro movement. Excess of the gutta-percha cone was removed with hot burnisher, 2 mm below the canal orifice.

Group 4: Positive Control Group

In this group, biomechanical root canal preparation was done, but the tooth was not obturated and not coated with nail polish at all.

Group 5: Negative Control Group

In this group, biomechanical root canal preparation was done. The tooth was not obturated but was fully coated with nail polish.

After obturation, access cavities were filled with Type II restorative Glass Ionomer Cement, and varnish was applied. (3M Espe ketac molar). Specimens were stored in an incubator at 37°C and 100% humidity for 24 h to allow the sealer to set.

Apical Dye Leakage

Each root was coated with two layers of nail polish except the apical 3 mm. The dental floss was tied to the coronal third of all teeth. One-third of the test tube was filled with 2% methylene blue dye. Samples were suspended by dental floss in a test tube such that the apical 3 mm remained immersed in a 2% aqueous solution of methylene blue for 72 h at 37°C in the incubator. The samples were suspended in the vertical direction so that the dye can penetrate by capillary action. After 72 h, the teeth were removed from the dye and rinsed with tap water.

Two longitudinal grooves, one on the buccal surface and the other on the lingual surface were made parallel to the long axis of the tooth and then were merged, taking care to include the apical foramen in the fracture line. Thereafter, all the roots were sectioned buccolingually in a longitudinal direction with a diamond disc under continuous water-cooling to obtain 90 samples from 45 teeth (Fig. 3). All 90 samples were then directly examined under a stereomicroscope at 0.8× magnification. The linear extent

Fig. 3. Buccolingual sectioning of the sample

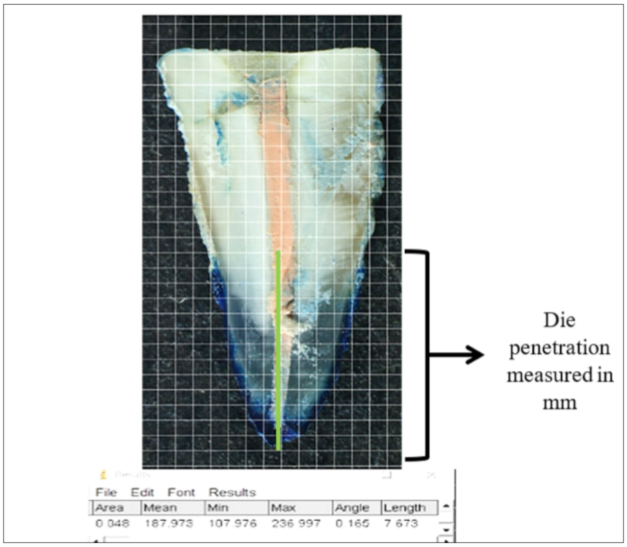

Fig. 4. Measurement in ImageJ software

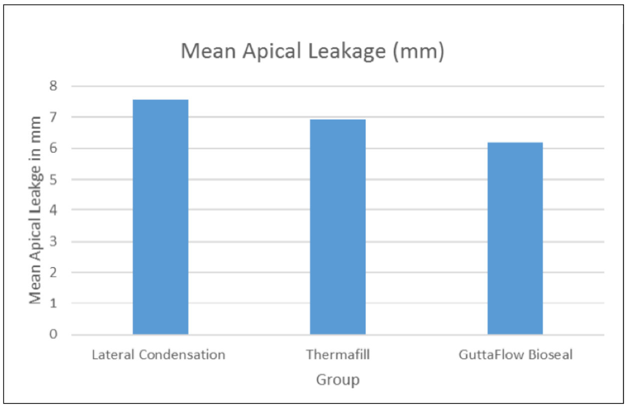

Fig. 5. Mean apical leakage in mm for all groups

of dye penetration was measured in millimeters from the apical end of the preparation. Image J software was used to measure the length (Fig. 4).

Statistical Analysis

Oneway ANOVA and Post hoc Scheffe's test was used to calculate "p" value among different groups using the Statistical Package for the Social Sciences software. $p \leq 0.05$ was considered to be statistically significant.

Results

Dye penetration was seen in the positive control, whereas it was absent in negative control, suggesting the model was appropriate for the present study.

The results suggest that group 1 showed maximum dye penetration and hence highest amount of apical microleakage, followed by group 2 and group 3 (Table 1) (Fig. 5).

Here, the p value was set to 0.05 to get the analysis of variance between the groups. The value obtained is $p = 0.000$, which is $p < 0.05$ and hence the variation among groups is statistically significant (Table 2).

Table 1. Mean value of apical microleakage for each group.

Group	(Sample size-n)	Obturation technique	Mean apical leakage (mm)	Standard Deviation	Standard error mean
1	30	Cold lateral condensation	7.58133	1.498868	0.273655
2	30	Carrier based (GuttaCore)	6.92600	0.898415	0.164027
3	30	Single cone with Gutta-flow Bioseal	6.17767	0.866864	0.158267

Table 2. Analysis of Variance of apical microleakage for all groups

ANOVA Value (mm) Group	Sum of squares	df	Mean square	F	Sig.
Between groups	29.597	2	14.799	11.667	0.000
Within groups	110.351	87	1.268		
Total	139.948	89			

Table 3. Post hoc Tukey's Test for intergroup analysis

Group		Mean Difference	SE	Sig. (p)
1	2	0.655333	0.290792	0.085
	3	1.403667*	0.290792	0.000
2	3	0.748333*	0.290792	0.041

The inter-group analysis was carried out to determine whether the mean results obtained is statistically significant or not, for which Post-hoc Tukey's test was conducted. The mean difference is significant at $p < 0.05$, thus, the results showed that a statistically significant difference was found when Group 3 was compared with Group 1 ($p = 0.000$) and Group 2 ($p = 0.041$). The results were not statistically significant when Group 1 and Group 2 were compared ($p = 0.085$) (Table 3).

Discussion

Three-dimensional obturation is essential to avoid reinfection of the root canal space (18-20). Complete chemo-mechanical preparation remains the most important step in root canal disinfection, but it fails to eliminate the bacteria present deep inside the dentinal tubules. These bacteria may remain active and the toxins secreted by them may reach the periapical tissues if the apical seal is not adequate. Thus, creating the proper apical seal helps to prevent the micro-organism and their toxins to cause periapical pathology (21).

Gutta-percha is most commonly used as a solid core obturating material, as it satisfies the majority of Grossman's criteria. However, gutta-percha has got some disadvantages, like lack of rigidity and adhesiveness, and it is easily displaced under pressure (22). Epoxy resin-based sealer, i.e., AH plus, when used with gutta-percha has served as the gold standard in various leakage studies due to its long setting time, better adhesion and penetration to root dentin, high radio-opacity, and relatively less polymerization shrinkage (23-25).

The classic obturation technique is cold lateral condensation (26-28). Although a time-consuming procedure, lateral condensation is preferred due to its low cost and controlled placement of Gutta-percha in the canal (27,28) Therefore, it served as a standard with which other techniques could be compared (2). Even though a commonly used technique, it has some limitations like lack of homogeneity of obturation, increased number of voids, spreader tracts, inadequate spreader penetration in curved canals, and poor adaptation leading to incomplete obturation of lateral canals, cul-de-sacs, fins, etc (6).

In a recent advance in obturation materials, a new carrier system with GuttaCore was introduced, a cross-linked gutta-percha core obturator without a plastic core, making post-placement and retreatment easier (29). The gutta-percha used for the external coating in GuttaCore is alpha phase (α) gutta-percha. Indeed, chemically pure gutta-percha exists in two distinct, different crystalline forms: alpha (α) and beta (β). GuttaCore gutta-percha can be defined as a modified α phase polymer with excellent flow and sealing ability depending mainly on its low viscosity and ability to penetrate lateral canals and dentinal tubules (Cantatore, Johnson, 2009). The β phase gutta-percha shows a disordered molecular arrangement, is stable, flexible, and compressible at room temperature but becomes less adhesive and flowable when heated (30).

The disadvantages of carrier-based obturation techniques are shrinkage of gutta-percha and difficulty in simulating working length during obturation. To overcome its main disadvantage of, namely "shrinkage," a self-cure shrinkage-free material, Guttaflow, has been introduced, which combines the properties of both sealer and gutta-percha. It is a non-eugenol, radiopaque material with a homogeneous mass and reduced stresses on roots. It 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. It is gaining popularity as a sealer, but studies have not evaluated its potential for apical sealing, which is one of its main intended purpose (6,31).

The use of newer root-filling materials containing bioactive substances in recent practice could be due to the advantages like the ability to provide an effective seal, promote hard tissue formation, and biocompatibility. These bioactive materials have the ability to release calcium ions and calcium hydroxide, and to form an interfacial layer between the cement and dentinal wall. These materials often interact with periapical tissues and may allow, or even stimulate, the deposition of cementum, producing a biological seal and inducing the healing process (32).

GuttaFlow Bioseal is a silicone-based obturation material, that has improved flow properties, and does not require the heat source to soften the gutta-percha (GP). GuttaFlow bioseal contains gutta-percha, zinc oxide, barium sulfate, polydimethylsiloxane, bioactive glass ceramic, zirconia, platinum catalysis, color pigments, micro silver (33). It has two components that automatically mix bubble free and it is easy to use. GuttaFlow Bioseal provides natural repair compounds, such as calcium and silicates, that forms hydroxyapatite crystals when it comes into contact with fluids (33).

Dye penetration method is capable of adequately demonstrating leakage without the need for a chemical reaction and no specialized equipment is required (6).

When using dyes, 2.0% methylene blue is favored for microleakage evaluation for its cost-effectiveness, high degree of staining, has a molecular weight lower than that of bacterial toxins and easier to perform with a minimum of armamentarium (34). Its molecular size is analogous to a bacterial by-product, i.e., butyric acid, that is said to leak from diseased root canals, leading to periapical irritation (35). It is readily detectable under visible light, which allows for rapid, artifact-free direct measurements under stereomicroscope (36).

The 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 and is associated with an image analysis software, which aids in eliminating human errors, in the interpretation of the parameters and the exact extent of dye penetration could be viewed and measured accurately with ease (6,2).

The lateral condensation technique showed the highest mean apical dye infiltration when compared to other groups (37). Teeth obturated with Gutta core presented less mean apical infiltration when compared with lateral condensation. This can be due to better adaptation to the canal walls and no voids. The observations of the present study are similar to the results of a previous study by Gençoğlu N et al. (38).

Single cone technique with GuttaFlow bioseal showed the least mean apical dye infiltration when compared to other groups. Statistically significant difference was seen between Group I (lateral condensation) and Group III (single cone technique with GuttaFlow Bioseal). This finding can be justified on the basis of the setting expansion of the GuttaFlow Bioseal system combined with the close adaptation of the gutta-percha cone to the instrumented canal wall, enhancing the sealer flow and adaptation to the dentinal walls in the apical part of the root canal. The presence of the powdered gutta-percha in GuttaFlow Bioseal may have helped in the better bonding between the GuttaFlow Bioseal and the gutta-percha core material (2,12).

There was no statistically significant difference in mean apical leakage between the teeth obturated by lateral condensation (Group I) and the teeth obturated by Carrier-based obturation technique (Group II). It stated that lateral condensation was as effective in sealing the apex as the continuous wave of condensation technique (12). Thus, Group III (single-cone technique with gutta-flow bioseal) showed better results than both Group I (lateral condensation) and Group II (Carrier-based obturation technique), which were statistically significant.

GuttaFlow Bioseal seems to be a promising filling material due to its effective seal, expansion on the setting, increase flowability, excellent adhesion, good adaptability, low solubility, ease of handling and application, ability to form hard tissue, and biocompatibility. Least dye penetration was seen with GuttaFlow Bioseal when compared to the other two groups stating that Gutta-Flow bioseal obturation system with single-cone technique shows better apical sealing ability compared to carrier-based obturation (GuttaCore) and cold lateral Condensation technique.

The initial apical diameters of teeth were not standardized. In vitro studies are done in a controlled environment and do not accurately resemble clinical settings. In the oral cavity, blood and intercellular fluids decrease the concentration of materials. Furthermore, the temperature of the oral cavity is different from the laboratory temperature. By simulating oral cavity conditions as much as possible, valuable results can be obtained (39).

Conclusions

Within the limitation of the present in-vitro study, it can be concluded that GuttaFlow Bioseal in combination with single-cone technique shows better apical sealing ability when compared to carrier-based obturation (GuttaCore) and cold lateral Condensation technique.

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Conflict of Interest: None declared.

Ethical Approval: The study protocol was approved by the Ethical Committee of College of Dental Sciences and Research Centre Bopal, Ahmedabad on March 2021.

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