ORIGINAL RESEARCH

Comparative Evaluation of the Percentage of Gutta-percha Filled Areas in Canals Obturated with Different Obturation Techniques

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Abstract

Aim: To evaluate the percentage of gutta-percha filled areas (PGFA) in canals obturated with guttacore system, single cone, and lateral compaction techniques.

Materials and methods: A total of 60 single-rooted mandibular premolars were selected and randomly divided into three equal groups depending on the type of obturation technique used. After the obturation, the samples were marked at 2, 4, 6, and 8 mm distance from the apex and sectioned horizontally, and viewed under a stereomicroscope at 25×. The area of the canal and of the filling material was recorded, and the percentage of filling material on the canal wall was calculated.

Results: Guttacore showed the highest percentage of root-filled areas followed by single cone and lateral compaction techniques at 2, 4, 6, and 8 mm from the apex.

Conclusion: None of the filling techniques used in the study was completely able to fill the root canals with gutta-percha and sealer. The guttacore system had a maximum area of root canals filled as compared to the single cone and lateral compaction system.

Clinical significance: Root canals are mostly oval, elongated, or irregularly shaped rather than being completely round. Hence, the obturation technique that fills the maximum area of the root canal must be selected according to the given clinical circumstances.

Keywords: Guttacore, Lateral condensation, Single cone.

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Introduction

The prerequisite for successful endodontics is total debridement of the pulp space and development of an impermeable fluid-tight seal at the apex. Gutta-percha (GP) has been most commonly employed as root canal obturating material.[1] In 1887, the SS White company began to manufacture GP points. With the introduction of radiographs into the assessment of root canal obturations, it became painfully obvious that the canal was not cylindrical, as earlier imagined and that additional filling material was necessary to fill the observed voids. The softening and dissolution of GP to serve as a cementing agent, through the use of rosins were introduced by Callahan in the year 1914. Subsequently, a multitude of various pastes, sealers, and cements was created in an attempt to discover the best possible sealing agent for use with GP. Over the past 70–80 years, the dental community has seen attempts to improve the nature of root canal obturation with these cements and with variation in delivery of GP to the prepared canal system.[2]

Gutta-percha (GP) is not considered an adequate filling material unless cemented in the canal. The sealers form a fluid-tight seal at the apex by filling the minor intricacies between the solid material and the wall of the canal, and also by filling patent accessory canals and multiple foramina.[3] Hence, GP is always used in conjunction with a sealer for the root canal obturation in order to seal the spaces between the solid material and root canal walls.[4–6]

The GP expands on heating from 1% to almost 3%, while cooling it shrinks. However, the degree of shrinkage is always greater than the degree of expansion. Lateral compaction of cold GP is a commonly used technique due to its simplicity and adaptability in most cases and is often used as a standard to compare new techniques. Single cone avoids the additional requirement for accessory cones and this technique is less time-consuming and also does not induce undue forces on root canal walls during obturation. The use of a master cone with a larger taper increases the amount of GP within the canal, thereby reducing the amount of sealer between accessory cones, which is the desired condition to improve the three-dimensional (3D) filling of the root canal.[7] There are different methods to evaluate the GP filled areas in canal-like digital stereomicroscope, 3D cone-beam computed tomography, scanning electron microscope, micro-computed tomography scan, radioisotope, dye extraction, and fluid filtration.

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Table 1: Mean gutta-percha filled canal areas at 2, 4, 6, and 8 mm from the apex

Obturation technique/groups	*Mean ± SD 2 mm from the apex*	*Mean ± SD 4 mm from the apex*	*Mean ± SD 6 mm from the apex*	*Mean ± SD 8 mm from the apex*
Group-A (Guttacore system)	5.3 ± 1.3	4.8 ± 1.2	6.4 ± 0.61	7.8 ± 2.2
Group-B (Single cone)	3.2 ± 1.1	3.5 ± 1.09	5.3 ± 1.10	6.3 ± 1.6
Group-C (Lateral compaction)	3.4 ± 6.4	2.7 ± 0.6	2.5 ± 1.2	2.3 ± 1.3

Traditional methods of evaluating root fillings have shortcomings and allow only partial evaluation of the root canal content. Radiographs provide only two-dimensional (2D) interpretations of the 3D image, dye penetration studies do not correlate clinically and the bacterial leakage studies do not simulate the clinical conditions and require more time. The stereomicroscope is easy to use and the distance between the surface of the object and the device is constant, thus enabling image standardisation.[8–11]

Hence, the present study was undertaken to evaluate the adequacy of the core carrier, single cone, and lateral compaction obturation techniques using a stereomicroscope.

Materials and Methods

A total of 60 extracted human mandibular premolars extracted for orthodontic purposes were collected from the Department of Oral and Maxillofacial Surgery, Pacific Dental College and Hospital, Debari, Udaipur. Teeth with crack/craze line, calcification, caries, fractures old restoration, resorption defects, root-canal-treated teeth, and teeth with more than one root/canal were excluded from the study. The teeth were stored in 10% formalin until further use. It was a double-blinded study involving two investigators.

Access cavity was prepared and canal patency was established using a size #10K file, working length was determined by passing a #15 K-file into the canal until the tip was just visible at the apical foramen and then reducing 1 mm from the length. This was kept as the actual working length. The specimens were randomly divided into three groups of 20 samples each ($n = 20$) (group A, group B, and group C).

Group A

The root canals of specimens in the group A were prepared using a ProTaper rotary file system till size F4. The size of the canal was verified by verifier size #40. The guttacore obturator was heated on a therma-prep oven and placed immediately to the working length. The placement handle was removed at the orifice by bending side to side.

Group B

The root canals of specimens in the group B were prepared similar to group A but were obturated with a single-cone technique using F4 GP.

Group C

For group C, the apex was performed till #40(2%) and step back till #55(2%). The master cone was verified radiographically. After the placement of the master cone in the root canal, the lateral compaction was achieved using accessory cones (2% taper) and a spreader.

Throughout the instrumentation, the root canals were irrigated with 3% NaOCl and 17% EDTA followed by a final rinse with saline. The AH Plus Sealer was used in all the groups. The excess GP was seared off, and the GP at the orifice was compacted with the hand plugger in all the groups. The obturation was verified using a radiograph. The access cavities of the specimens were sealed with type II glass ionomer cement.

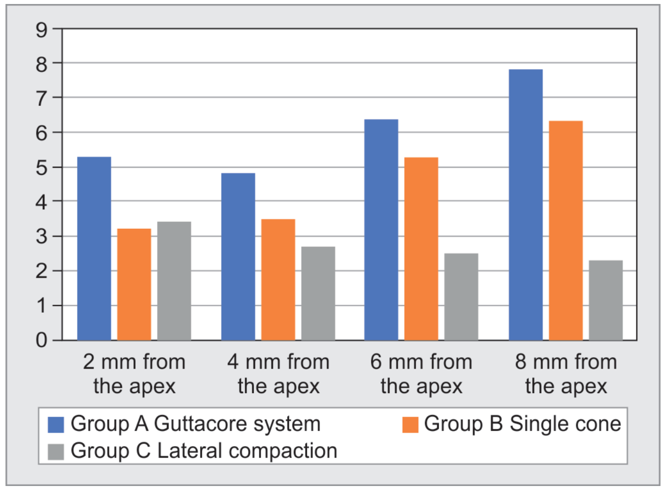

Fig. 1: Mean gutta-percha area from the apex

The samples were marked at 2, 4, 6, and 8 mm from the root apex using a marker and caliper, then were sectioned horizontally and analyzed under a stereomicroscope at 25×. The images were captured with a Nikon Coolpix S2500 Camera. The measurement of the area was done with the help of ImageJ analysis software. The area of the canal and of the filling material was recorded, and the PGFA on the canal wall was calculated with the following equation:

$$\text{PGFA} = \frac{\text{Area of filling materials}}{\text{Area of canal wall}} \times 100$$

Percentage of gutta-percha filled areas (PGFA) was calculated for all the groups at four different lengths of the root canal. The data obtained were tabulated and statistically analyzed using the one-way analysis of variance (ANOVA) and the Bonferroni test.

Results

One-way analysis of variance (ANOVA) test was applied to compare and analyze PGFA in a canal obturated by three different techniques: Guttacore, single cone, and lateral compaction.

The highest percentage of root canal filled areas with GP was found as: Group A > Group B > Group C (Table 1). Guttacore system had the highest mean GP from apex at all respective lengths 2 mm, 4 mm, 6 mm, and 8 mm, respectively, when compared to single cone and lateral compaction (Fig. 1).

When intergroup comparison was made at 2 mm from the apex, it was found as group A–group B, group A–group C, and group C–group B values were found statistically significant (Table 2).

When intergroup comparison was made at 4 mm from the apex for obturation techniques, it was found as group C–group A values

Table 2: Intergroup comparison of obturation techniques at 2 mm from the apex with one-way ANOVA and Bonferroni

Obturation technique/groups		*p value*
Group-A (Guttacore system)	Group-C (Lateral compaction)	0.05
	Group-B (Single cone)	0.03
Group-B (Single cone)	Group-C (Lateral compaction)	1.0
	Group-A (Guttacore system)	0.03
Group-C (Lateral compaction)	Group-B (Single cone)	1.0
	Group-A (Guttacore system)	0.05

Table 3: Intergroup comparison of obturation techniques at 4 mm from the apex with one-way ANOVA and Bonferroni

Obturation technique/groups		*p value*
Group-A (Guttacore system)	Group-C (Lateral compaction)	0.04
	Group-B (Single cone)	0.31
Group-B (Single cone)	Group-C (Lateral compaction)	0.96
	Group-A (Guttacore system)	0.31
Group-C (Lateral compaction)	Group-B (Single cone)	0.96
	Group-A (Guttacore system)	0.04

Table 4: Intergroup comparison of obturation techniques at 6 mm from the apex with one-way ANOVA and Bonferroni.

Obturation technique/groups		*p value*
Group-A (Guttacore system)	Group-C (Lateral compaction)	0.01
	Group-B (Single cone)	0.36
Group-B (Single cone)	Group-C (Lateral compaction)	0.01
	Group-A (Guttacore system)	0.36
Group-C (Lateral compaction)	Group-B (Single cone)	0.01
	Group-A (Guttacore system)	0.01

were found statistically significant and no statistically significant difference was found when intergroup comparison was made between group C–group B and group A–group B (Table 3).

When intergroup comparison was made at 6 mm from the apex, it was found as group C–group B and group C–group A shows statistically significant differences and there was no statistically significant difference found when intergroup comparison was made between group B and group A (Table 4).

When intergroup comparison was made at 8 mm from apex, it was found as group C–group A and group B–group C shows statistically significant difference and there was no statistically significant difference found when intergroup comparison was made between group A and group B (Table 5).

Table 5: Intergroup comparison of obturation techniques at 8 mm from the apex with one-way ANOVA and Bonferroni

Obturation technique/groups		*p value*
Group-A (Guttacore system)	Group-C (Lateral compaction)	0.001
	Group-B (Single cone)	0.77
Group-B (Single cone)	Group-C (Lateral compaction)	0.009
	Group-A (Guttacore system)	0.77
Group-C (Lateral compaction)	Group-B (Single cone)	0.009
	Group-A (Guttacore system)	0.001

Discussion

Successful endodontic therapy is critically dependent on the elimination of the microorganisms and their byproducts through root canal instrumentation, irrigation, and 3D filling of the root canal space in order to provide a hermetic seal. Obturation of root canal space prevents reinfection and subsequent leakage into the periradicular tissues. Makandar et al. evaluated and suggested root canal curvature and its maximum values in molar teeth, the filling of the canal will also depend on its curvature, hence it is essential for the clinician to be aware of the anatomic variabilities present in teeth to be treated endodontically.[12] Khandagale et al. evaluated the shaping for a proper 3D filling of canal spaces, proper shaping and cleaning have to be accomplished with the help of hand or rotary instrumentation and the use of irrigating solutions. The introduction of NiTi in endodontics, since 1988, has not only made canal instrumentation faster and easier, but also with the continuous development in its metallurgy and surface treatment, has even enabled the clinician to shape canals without much risk of instrumentation separation.[13]

Beatty et al.[14] compared the average apical dye penetration observed after obturation with single non-condensed GP lateral condensation, ultrafil and thermafil techniques, they found that the thermoplasticized guttapercha techniques of ultrafil and thermafil were more effective than the single one or lateral condensation in restricting apical dye penetration.

Barthel et al.[15] conducted a study to compare bacterial and dye leakage tests, commonly to determine the seal of root canal fillings. The result of this study suggests that the molecular size of the penetrating agent may not be the relevant parameter when attempting to determine an appropriate test for the seal ability of root canal fillings.

Al-Dewani et al.[16] evaluated and compared the radiographic quality and seal ability of root fillings in extracted human teeth using lateral condensation of GP and low-temperature thermoplasticized gutta-percha (ultrafil). Under laboratory conditions, the low-temperature thermoplasticized gutta-percha had a better seal but poorer radiographic quality than lateral condensation.

Wu et al.[17] investigated the quality of cold and warm GP fillings in oval canals. The percentage of GP filled canal areas using warm GP was greater than that of the cold GP in oval canals.

Clinton et al.[18] designed a study to compare a warm GP obturation technique, thermafil plus with lateral condensation for the ability to adapt GP to the walls of a root canal system.

Gutta-percha using thermafil was better able to flow into lateral spaces, had fewer voids, and replicated the surface of root better.

Hauman et al.[19] reviewed the biocompatibility of contemporary orthograde and retrograde root canal filling materials. Results from *in vitro* and *in vivo* tests show that endodontic materials possess both beneficial and undesirable properties.

De-Deus et al.[20] conducted a study to determine the PGFA in the apical third of root canals when filled with thermafil, system B, or lateral condensation, and concluded that the thermafil system produced a significantly higher PGFA than lateral condensation and system B techniques.

Over the years, several filling materials and techniques have been suggested to accomplish a hermetic seal of the root canal system.[10,11,21,22]

A number of variations with GP itself were experimented like thermomechanical compaction (using McSpadden compactors), chemically plasticized GP (using materials like chloroform/xylol/eucalyptus oil), and finally variations in thermoplasticized gutta-percha techniques (using metal/plastic core carriers or injectable materials supplied in the form of pellets). The thermoplastic root filling methods, based on the principles of vertical compaction of warm GP conceived and described by Schilder, have been widely investigated over the years with good results regarding filling of the root canal system, homogeneity of the filling material, and apical seal.[23]

Vasundhara[24] analyzed the PGFA using a single cone, continuous wave compaction, thermafil, and obtura II in 0.06 taper root canals and found that the thermoplasticized technique is an effective method to fill canals.

In the present study, horizontal markings were made at four levels from apical foramen at 2, 4, 6, and 8 mm. Teeth were sectioned and slices were viewed under the stereomicroscope (25× magnification). The stereomicroscope is easy to use and the distance between the surface of the object and the device is constant, thus enabling image standardization.[11]

Therefore, this study was designed to quantify the GP component on a percentage basis in order to provide a measure of quality.[10]

Under the experimental conditions of the current *in vitro* study, group A (Guttacore) showed the highest mean GP-filled canal areas at 2 mm, 4 mm, 6 mm, and 8 mm at the apex (Tables 2 to 5). One possible reason that the Guttacore system gave the highest percentage of volume (POV) of GP could be the use of a heated core carrier system allowing less viscosity, more fluidity, and enhanced canal wall adherence.

Ingle JI et al.[5] and Marques-Ferreira M et al.[6] in similar *in vitro* studies observed better results with heated core carrier obturation technique as compared to lateral compaction. In this study on overall comparison between the experimental groups, the highest core to sealer ratio was observed in group A (Guttacore) followed by group B (single cone) and then group C (lateral condensation).

At 2 mm from the apex, a significantly higher PGFA was observed in group A (Guttacore) compared to group B (single cone) and C (lateral compaction). This can be attributed to the uniqueness of the guttacore system being made entirely of GP with the core obturator prepared with cross-linked GP and also its plasticization and efficient flow into the canal intricacies as compared to single cone and lateral compaction technique.

However at 4, 6, and 8 mm from the apex, non-significant results were observed between group A (Guttacore) and group B (single cone) though on mean comparison superior results were exhibited by group A (Guttacore) (Table 1). This can be attributed to the use of variable tapered cone (F4) which occupies the greater girth of the canal as compared to the lateral compaction technique.

Among comparison between the experimental groups, the highest mean value of GP filled area was noted with group A (Gutta ore) and least with group C (lateral compaction). However, statistically significant differences were observed between group A (Guttacore) and group C (lateral compaction)) only and no statistically significant difference between group A (Guttacore) and group B (single cone) was observed which is in accordance with studies done by Al-Dewani et. al,[16] Wu et al.,[17] De-Deus et al.,[20] Vasundhara,[24] Ingle JI et al.,[5] and Marques-Ferreira M et al.[6]

The present results does not depict that lateral compaction and single cone obturation technique are the poor obturation techniques but rather access the POV of GP filled root canal areas only. The single cone technique with higher tapered GP cones covers the larger area in the canal and the sealer coating on the canal walls and GP, increasing the predictability of successful results in endodontics.

This study has certain limitations like during sectioning the root and microscopic analysis, there is a possible loss of material while sectioning and also gives no information on fluid leakage. Moreover, evaluation of sliced sections only allows 2D assessment, and the resolution of stereomicroscope might not be sufficient to detect the root canal filling and canal walls. Despite higher PGFA with thermoplasticized obturation technique, inherent problems exist is that there may be an extrusion of material into apices.[25,26]

Further studies on issues such as the degree of voids and sealer extrusion should be done. With the use of Guttacore-carriers, the potential of stripping of the thermoplasticized gutta-percha core from the cross-linked thermoset gutta-percha carrier should provide valuable information for clinicians to make an evidence-based decision in the selection of a root canal obturation technique.[11]

Moreover, evaluation of sliced section only allows 2D assessment and possibility of material loss.

Conclusion

Within the limitation of the study, it was concluded that: (i) No filling technique in the present study produced absolute filling of the root canal system with GP, (ii) Gutta-core carrier system in combination with root canal sealer does improve the microleakage resistance compared to lateral compaction and single cone techniques, and (iii) Guttacore system produced more homogeneous obturation with a higher percentage of GP-filled areas at 2, 4, 6, and 8 mm from the apex.

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