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ORIGINAL ARTICLE

Assessment of Quality of Root Canal Filling with C Point, Guttacore and Lateral Compaction Technique: A Confocal Laser Scanning Microscopy Study

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ABSTRACT

Objective: The purpose of this in vitro study was to compare the quality of root canal filling of C Point, GuttaCore and lateral compaction using confocal laser scanning microscopy.

Methods: Ninety recently extracted human mandibular incisors with single canal were selected. Canals were prepared with ProTaper instruments to size F3 and obturated using C Point, GuttaCore or lateral compaction technique. Endosequence BC sealer was labeled with Rhodamine B dye to allow analysis under a confocal microscope. The percentages of gutta-percha filled area (PGFA), sealer filled area (PSFA), voids (POV) and interfacial adaptation (IA) was assessed at 2, 5 and 8 mm from the apex, using image analysis software. Kruskal–Wallis followed by Mann Whitney U tests were used for data analysis, and the P value was set at 0.05 (P=0.05).

Results: No significant difference was seen among the three groups at 2 mm level for PGFA, PSFA and voids (P>0.05). At 5 and 8 mm levels, canals filled with GuttaCore had significantly higher PGFA and lower PSFA than lateral compaction and C Point. Highest POV was seen for lateral compaction group followed by C Point and GuttaCore.

Conclusion: Out of the three techniques examined, best results in terms of quality of root canal filling were observed for GuttaCore. C Point system was found to be associated with internal defects such as tears and delamination which may adversely affect the long term performance of this system.

Keywords: C point, confocal laser, GuttaCore, gutta percha filled area, inter facial adaptation, scanning microscopy (CLSM)

HIGHLIGHTS

- This study compared the quality of obturation of C Point, GuttaCore and lateral compaction technique using CLSM and found that Guttacore obturations were most homogeneous at all the evaluated levels (2, 5 and 8mm from the apex).
- C Point obturation system was able to provide good apical seal but was found to be associated with internal defects.

INTRODUCTION

Complete three-dimensional filling of the root canal system is an important requisite for successful endodontic treatment (1). Several root canal filling techniques have been developed over the years to achieve the goal of providing fluid tight seal. These include traditionally developed lateral compaction technique, single cone technique and techniques using thermo plasticized gutta percha. Thermo plasticized gutta percha based root canal filling techniques include warm vertical compaction and carrier based root canal filling system. Several studies indicated that Carrier based systems produce better root canal fills compared to lateral condensation technique (2, 3). Guttacore (GC) is a recently introduced core-carrier system (Dentsply Maillefer, Ballaigues, Switzerland). Even though several developments have been made in core-carrier systems, Thermafil (TF) still remains the gold standard carrier based technique. Long term studies assessing the clinical outcomes of teeth filled with carrier based obturation system have shown high survival and success rate (4, 5). However, the presence of plastic carrier in TF made the retreatment and post space preparation difficult. In contrast, the core of GC is made up of special thermoset cross linked gutta percha which can endure high temperature generated by Thermaprep oven. The distinct advantages of GC over Thermafil are its ability to provide three dimensional filling of root canal system, easier retreatment and post space preparation (6).

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All the above mentioned techniques of root filling use GuttaPercha (GP). However, GP presents certain inherent disadvantages such as lack of rigidity, poor adaptation to canal walls and a limited ability to fill canal irregularities/lateral canals (7). C Point is a recently introduced hygroexpandable nylon polymer based single cone root canal filling material. It is made up of a central polyamide core comprising of two nylon polymers and the outer layer is cross linked co polymer of acrylonitryl and vinylpyrrolidone (8). When in contact with moisture, the outer layer of C point undergoes radial non isotropic expansion which pushes the accompanying sealer in close proximity to canal wall, allowing it to adapt to canal irregularities.

The accompanying sealer (i.e. Endosequence BC Sealer, Brasseler, Savannah, GA, USA) is a premixed, injectable calcium silicate based sealer which sets in the presence of moisture. BC sealer has gained good reputation because of its biocompatibility, bioactivity and antibacterial properties. In the presence of biological fluids, calcium and phosphate ions present in BC sealer can precipitate to form apatite. This apatite forming ability is responsible for its bioactivity and excellent sealing ability (9). Furthermore, BC sealer undergoes slight expansion (0.2%) on setting which can further improve the seal (10). The only limitation with calcium silicate based sealers is that they might make retreatment procedure difficult (11).

With this background, the aim of this study was to compare the percentage of gutta-percha filled area (PGFA), sealer filled area (PSFA), voids (POV) and interfacial adaptation (IA) in mandibular incisors obturated with C point, GC or lateral compaction technique using confocal laser scanning microscopy (CLSM). The null hypothesis tested was that there is no difference in the quality of root canal filling in terms of PGFA, PSFA, POV and IA among the three experimental groups.

MATERIALS AND METHODS

Ninety mandibular incisors with straight single canals were selected after confirming with bucco-lingual and mesio-distal radiographic views. Access to the root canal system was made. The working length was determined by deducting 1 mm from the tooth length, which had been determined by inserting a size 10 file into the canal until the tip of the file was just visible at the major apical foramen.

Root canal preparation

After establishment of a glide path using ProGlider file (Dentsply Tulsa Dental, Tulsa, OK), ProTaper rotary files (Dentsply Tulsa Dental, Tulsa, OK) were used to clean and shape the root canals. During preparation and between each file, 1 mL of 5.25% sodium hypochlorite was used as an irrigant. All canals were prepared to F3 ProTaper file. After completion of instrumentation, all specimens were irrigated with 5 mL of 17% EDTA following the manufacturer's instructions and dried with paper points. Following this the specimens were randomly divided into 3 groups (n=30).

Root canal filling

Endosequence BC sealer (Brasseler USA, Savannah, GA, USA) was mixed with Rhodamine B dye to an approximate concentration of 0.1% in order to allow visualization under confocal microscope (12). Using a size 30 lentulo spiral, Rhodamine sealer mixture was applied thoroughly into the root canal keeping the instrument 2 mm short of apex.

Group 1: Lateral compaction - A size 30, 0.02 taper GP cone (Dentsply Maillefer) with tug back was selected. The master cone was coated with sealer and placed into the canal. A size 20 endodontic finger spreader (Dentsply Maillefer) was inserted 2 mm short of the working length. Accessory gutta-percha cones of size 20, 0.02 taper (Dentsply Maillefer) were inserted until the entire length of the root canal was filled. The cones were sectioned with a heated instrument at the level of canal orifice and compacted with plugger.

Group 2: GC - 30/.04 Obturator was heated in a GC oven (Dentsply Maillefer, Ballaigues, Switzerland). Sealer was applied with the help of lentulo spiral and the Obturator was inserted slowly into the canal until it reached the working length. Excess of GP was removed with a heated plugger after breaking the carrier by twisting.

Group 3: C Point - A F3 C point (EndoTechnologies, LLC, Shrewsbury, MA, USA) with tug back was selected. After being lightly coated with a sealer it was inserted into the prepared root canal to the working length. Excess material was removed at the level of canal orifice using bur in a slow speed handpiece without water.

In all the groups, access cavity was sealed with 3 mm thick provisional restorative material (Coltosol F; Coltene) after root canal filling. A single operator performed all the clinical procedures. All the specimens were stored at 37˚C and 100% humidity for 1 week to allow the materials to set completely. The specimens were sectioned horizontally at 2, 5 and 8 mm from the apex using a 0.3 mm Isomet saw at 200 rpm under continuous water cooling to prevent generation of frictional heat. Then, the surfaces were polished using sandpaper under running water to eliminate debris from the cutting procedure.

CLSM Evaluation

Images were recorded at 100X using an Olympus FV1000 confocal microscope (Olympus FluoView™ FV1000). Image analysis was performed using Adobe Photoshop 7.0 (Adobe Systems, San Jose, CA). From the images obtained, total canal area, sealer filled area and void occupied area was measured in mm^2. For calculating gutta percha filled area, following equation was used:

Gutta percha filled area=Total canal area–(sealer filled area+void filled area)

Next, the percentages of gutta-percha, sealer and voids in each section were calculated. The measurements were repeated twice to ensure reproducibility. To evaluate interfacial adaptation, all sealer-dentine interfaces were checked for gap containing region. The interface adaptation was determined by calculating the ratio between the gap-containing regions and total sealer/dentine interface at 2, 5 and 8 mm.

Statistical analysis was performed using the nonparametric Kruskal–Wallis test followed by Mann Whitney U test ($P<0.05$) in the SPSS 17 software (SPSS Inc. Chicago, USA).

RESULTS

From the 90 teeth, 270 sections were evaluated. No significant differences were found amongst the groups for the interfacial adaptation and percentage of voids in all the evaluated levels (P>0.05). The median and range of the percentage of the evaluated criteria are shown in Table 1.

The results in terms of PGFA, PSFA and POV at the 2 mm level revealed that the gutta-percha, sealer and voids area were similar amongst the three groups. At 5 and 8 mm levels, GC had significantly more gutta-percha and less sealer percentages than lateral compaction and C Point. Overall, lateral compaction technique had a higher incidence of voids. Coronal sections showed greater percentage of voids as compared to apical and middle sections for all the groups. Figures 1, 2 and 3 show representative sections of the gutta-percha filled area and sealer filled area in lateral compaction, GC and C Point group, respectively. Figure 4a and 4b show the presence of void and a gap containing region at sealer-dentine interface, respectively.

Internal defects were observed in root canals obturated with C Point; in some of the samples tears in outer hydrogel layer of C point (Fig 5a) and delamination between the outer hydrogel and sealer layer (Fig 5b) was also observed.

DISCUSSION

In the present study, gutta percha and sealer filled area were taken as the parameters for assessing quality of root canal filling of two novel materials (i.e. GC and C Point). In past, the quality of root canal filling was usually assessed by measuring apical or coronal leakage. However, the clinical significance

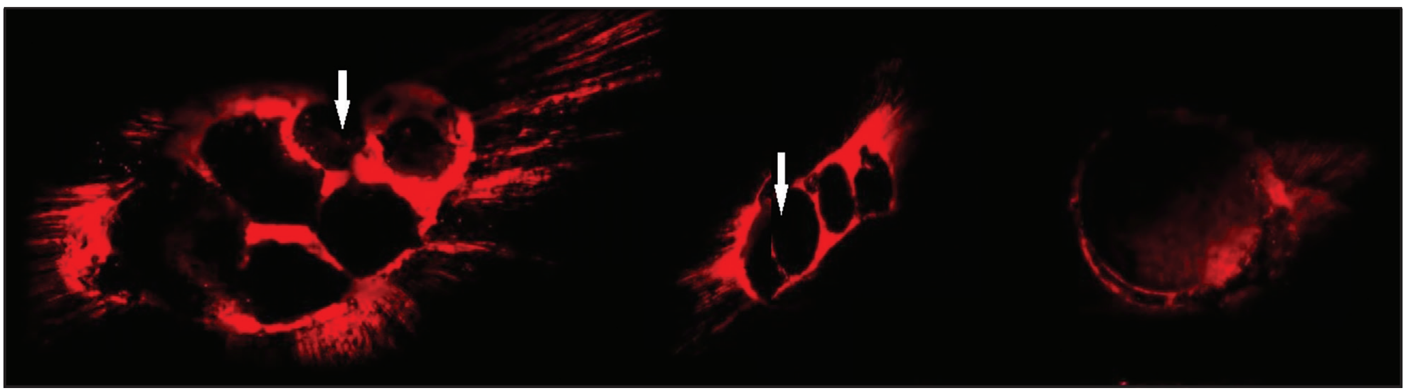

Figure 1. Representative CLSM images taken at 2, 5 and 8 mm levels in lateral compaction group. The presence of accessory cones can be easily appreciated in 5 and 8 mm level sections (marked with arrow)

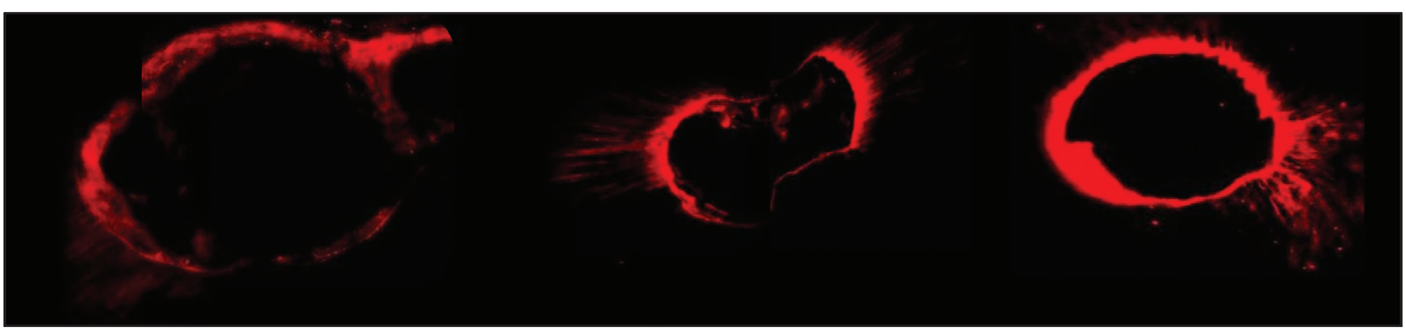

Figure 2. Representative CLSM images taken at 2, 5 and 8 mm levels in Guttacore group. Dense filling with minimum sealer thickness can be noted at all the levels

TABLE 1. Values for interfacial adaptation (IA), PGFA, PSFA and POV at 2, 5 and 8 mm sections

	2 mm				5 mm				8 mm			
Group	IA	PGFA	PSFA	POV	IA	PGFA	PSFA	POV	IA	PGFA	PSFA	POV
Lateral compaction	0^{a}	88.25^{a}	9.35^{a}	0^{a}	7.15^{a}	67.3^{a}	28.25^{a}	1.05^{a}	7.9^{a}	70.9^{a}	26.15^{a}	1.85^{a}
	(0-24)	(49.5- 96.1)	(3.7-43.3)	(0-13.2)	(0-26.4)	(41.9-82.8)	(17.2-45.8)	(0-17.2)	(0-23.8)	(50.1-89.6)	(10.4-36.9)	(0-25.6)
GC	0^{a}	93.2^{b}	6.8^{a}	0^{a}	1.45^{a}	81.25^{b}	17.25^{b}	0^{a}	2.95^{a}	82.3^{b}	16.4^{b}	0^{a}
	(0-16.5)	(64.9-98.5)	(1.5-33.8)	(0-5.9)	(0-20.6)	(61.1-92.4)	(7.6-31.5)	(0-10.5)	(0-19.4)	(65.4-93.8)	(6.2-27.1)	(0-10.9)
C Point	0^{a}	94.2^{b}	5.55^{a}	0^{a}	1.25^{a}	77.85^{c}	21.05^{c}	0.5^{a}	2.2^{a}	78.4^{b}	18.85^{c}	0.6^{a}
	(0-10.3)	(76.2-97.6)	(1.3-23.6)	(0-8.1)	(0-20.7)	(53.2-89.4)	(10.6-37.4)	(0-13.6)	(0-21.7)	(56.2-92.6)	(7.4-27.9)	(0-17.8)
P value	0.061	0.006	0.038	0.009	0.281	<0.001	<0.001	0.038	0.075	<0.001	<0.001	0.204

Values represent median and range. Different letter in each column indicates statistically significant differences (P<0.05). IA: Interfacial adaptation, PGFA: Percentages of gutta-percha filled area, PSFA: Percentages of sealer filled area, POV: Percentages of voids

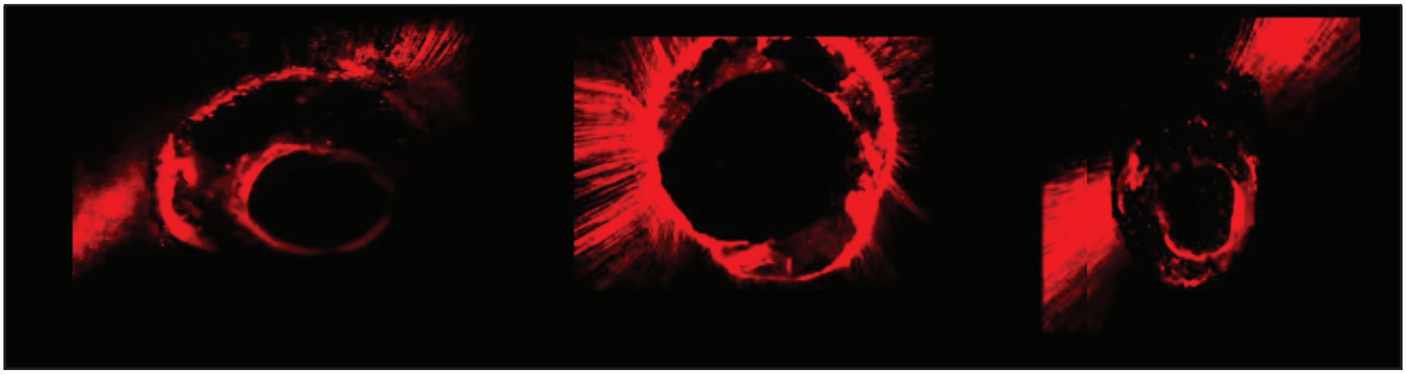

Figure 3. Representative CLSM images taken at 2, 5 and 8 mm levels in C Point group

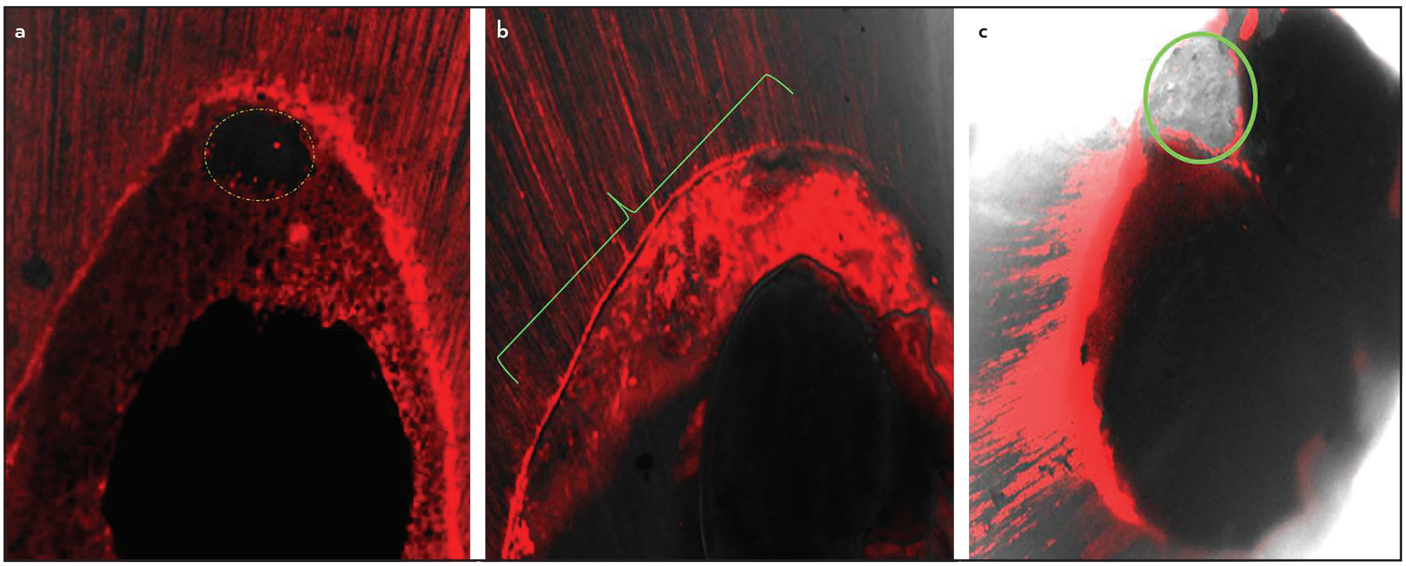

Figure 4. (a) Voids can be appreciated within the sealer mass (circled area). (b) Presence of gap at sealer-dentine junction (bracket) is clearly distinguishable. (c) Unclean debris filled area (circled) in the root canal cross section which can be readily appreciated in CLSM images

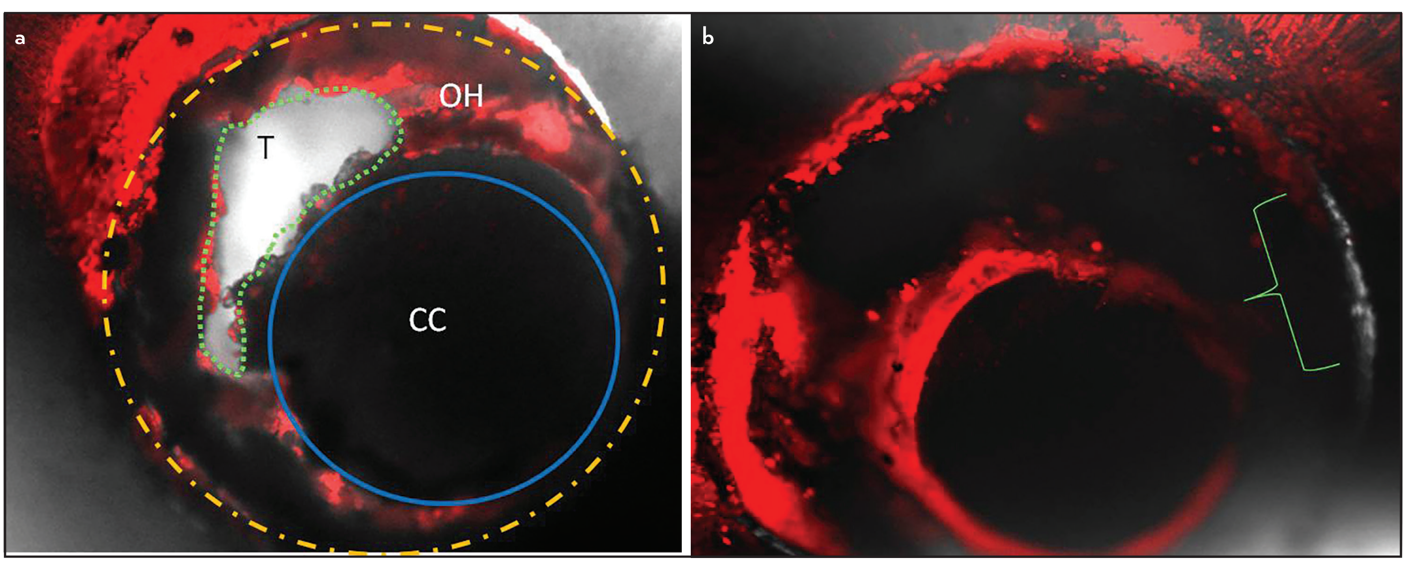

Figure 5. (a) The two layers of C point i.e central core (CC) and outer hydrogel (OH) are clearly distinguishable in CLSM images. Non uniform expansion of OH layer is also evident. One accidental finding was the presence of tear/rupture (T) seen in OH layer. (b) Delamination between the OH layer and sealer layer can be observed

of these methodologies is doubtful (13). The techniques that measure the PGFA or PSFA are often preferred because of their reliability. It is based on the fact that most of the sealers show some sort of solubility with time, and also shrinks on setting, whereas gutta-percha is comparatively more dimensionally stable (14). Hence, a good quality root canal filling should comprise of maximum amount of gutta percha and minimal sealer thickness.

Stereomicroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM) and CLSM are the most commonly used techniques to assess PGFA (15, 16). CLSM offers several advantages over SEM. It doesn't require special specimen processing, and observations are made under near normal conditions. Compared to SEM, CLSM specimen processing is nondestructive and is associated with lesser artifacts (17). Also presence of debris in some of the root canal sections could also be easily appreciated in CLSM (Fig 4c). Both voids and debris filled areas appear as dark zones, and it is not possible to discern between the two in other modes of image acquisition such as stereomicroscopy.

In the present study, GC and C point represented the carrier based technique and single cone technique, respectively. These two techniques were compared to lateral compaction technique which is still considered a gold standard technique (18). It has been proven in several studies that GC results in high quality homogeneous canal filling as compared to single cone obturation systems (19, 20). But to the best of knowledge, no study has compared GC and C Point in terms of quality of root canal filling using CLSM. That's why the current study was designed to compare the quality of root filling using GC and C Point.

BC sealer was used with both warm and cold canal filling technique in our study. It has been documented in the literature that properties of calcium silicate based sealers are adversely affected by heating (21), and hence, it should not be used with warm canal filling techniques. However, a recent study has shown that properties of BC sealer are superior to resin based sealer when used with warm root canal filling techniques (22).

No significant difference was observed in terms of PGFA and PSFA at 2 mm level ($P>0.05$). The results are in accordance with several studies which have concluded that single cone filling technique can effectively fill the apical third (23, 24). Although C Point is technically used in a single-cone obturation technique, this material uses the property of hygroscopic expansion to fill the gaps present between canal wall and obturation point.

At 5 and 8 mm levels, canals filled with GC produced significantly higher PGFA and lower PSFA than that in the other groups ($P<0.05$). Even after hygroscopic expansion, C Point was not able to provide effective seal at 5 mm and 8 mm level and was found to be heavily dependent on sealer. These results are in agreement with previous studies (24, 25) which concluded that single cone filling techniques are often associated with lower PGFA and higher PSFA.

Percentage of voids was least for canals filled with GC at all assessed levels. This observation substantiates the results of a micro computed tomography and SEM analysis done by Li et al in 2014 (26), which concluded that GC filling was associated with lesser number of voids as compared to lateral compaction (26). Maximum percentage of voids was found for lateral compaction group followed by C Point. This could be attributed to the limitation of the lateral compaction technique to allow a homogeneous layer of sealer in the entire root canal walls as previously shown (27). The results for C point are in accordance with previous studies which state that single cone filling techniques are heavily dependent on sealer particularly in middle and coronal third leading to greater number of voids within the sealer mass (25, 28).

Internal defects (tears and delamination) are one accidental finding observed in this study with C Point root canal filling. A study done by Didato et al investigated the percentage change in C Point diameter when in contact with water, and concluded that C Point undergoes a maximum of 14.4% increase in diameter within first 20 minutes of water immersion (29). This huge amount of expansion might result in rupture of the cross linked polymer present in hydrogel layer. Presence of tearing defects and delamination in C Point filling was also confirmed by Phase Contrast-enhanced Micro–Computed Tomographic study done by Moinzadeh et al (30). Presence of such defects might result in microleakage and can potentially reduce the long term performance of C Point root filling.

In future, research should be done to study the impact of internal defects seen in C Point filling on the long term clinical performance of this material. Also C Point undergoes a large amount of expansion within a very short period of time (29). Whether such rapid expansion leads to crack initiation in the radicular dentine needs to be evaluated in the future investigations.

CONCLUSION

Within the limitations of this study, it can be concluded that root canal filled with GC exhibited homogenous filling with high PGFA and lower voids at all the evaluated levels. In case of C Point, the unique property of hygroscopic radial expansion could not translate into better root canal filling quality. The presence of internal defects in C Point root canal filling system is a matter of concern and needs further investigation.

Disclosures

Conflict of interest: None declared.

Ethics Committee Approval: Ethical clearance was obtained from institutional Ethical Committee (Date: 02 September 2016 Number: MAIDS/ethical committee/15).

Peer-review: Externally peer-reviewed.

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