Original Article

An *In vitro* Comparison and Evaluation of Sealing Ability of Newly Introduced C-point System, Cold Lateral Condensation, and Thermoplasticized Gutta-Percha Obturating Technique: A Dye Extraction Study

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Abstract

Aim: The aim of this study is to compare and to evaluate sealing ability of newly introduced C-point system, cold lateral condensation, and thermoplasticized gutta-percha obturating technique using a dye extraction method. **Materials and Methodology:** Sixty extracted maxillary central incisors were decoronated below the cementoenamel junction. Working length was established, and biomechanical preparation was done using K3 rotary files with standard irrigation protocol. Teeth were divided into three groups according to the obturation protocol; Group I-Cold lateral condensation, Group II-Thermoplasticized gutta-percha, and Group III-C-Point obturating system. After obturation all samples were subjected to microleakage assessment using dye extraction method. Obtained scores will be statistical analyzed using ANOVA test and *post hoc* Tukey's test. **Results:** One-way analysis of variance revealed that there is significant difference among the three groups with *P* value (0.000 < 0.05). Tukey's HSD *post hoc* tests for multiple comparisons test shows that the Group II and III perform significantly better than Group I. Group III performs better than Group II with no significant difference. **Conclusion:** All the obturating technique showed some degree of microleakage. Root canals filled with C-point system showed least microleakage followed by thermoplasticized obturating technique with no significant difference among them. C-point obturation system could be an alternative to the cold lateral condensation technique.

Keywords: *Apical microleakage, cold lateral condensation, C-point obturation system, dye extraction, thermoplasticized obturating technique*

Introduction

The main function of obturation is to fill the whole canal with an inert root canal filling material into space and eliminate all portals of entry between the periodontium and the root canal system.[1] Ingle *et al*. reported that 58% of endodontic treatment failures can be associated, to incomplete obturation of entire root canals.[2]

Cold lateral compaction is the most common and very well-recognized obturating technique. It offers controlled placement with low cost. However, usually, there is presence of sealer voids, spreader tracks, condenser voids, and material welds (where heated technique is used) may be seen postoperatively.[3]

A thermoplastic obturation technique was introduced in 1967 by Schilder. Better adaptation to the root canal walls is shown by this technique as compared to lateral condensation, and result in successful filling of lateral canals with less time.[3] This technique have few disadvantages such as, on heating material expands and throughout cooling contraction (1%–2%) is observed, which may result into voids in the root canal filling. With the use of this technique, there is an increase in the risk of apical extrusion of sealer.[4]

To overcome all these drawbacks, the most recent advancement in endodontic obturating materials uses a hydrophilic polymer in the root canal. The C-Point system (Endo Technologies, LLC, Shrewsbury, MA, USA) consists of obturation points (C-points) containing a polyamide core with an outer bonded hydrophilic polymer coating. These points are designed in such a way that it

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Access this article online
Website: www.contempclindent.org
DOI: 10.4103/ccd.ccd_722_17
Quick Response Code:

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How to cite this article: Sinhal TM, Shah RP, Jais PS, Shah NC, Hadwani KD, Rothe T, *et al.* An *In vitro* comparison and evaluation of sealing ability of newly introduced c-point system, cold lateral condensation, and thermoplasticized gutta-percha obturating technique: A dye extraction study. Contemp Clin Dent 2018;9:164-9.

expands laterally without expanding axially. It uses residual water from the instrumented root canal and moisture which is naturally present into the dentinal tubules for its expansion.[3] Although the C-point is efficient in achieving a relatively good fit in an irregular-shaped root canal, a concomitant sealer has to be used for complete sealing of the gaps which are present between the root canal walls and the expanded C-point. Lateral expansion of C-points, occur nonuniformly, and the expandability of points depends on the extent to which the hydrophilic polymer is prestressed (i.e., contact with a canal wall will reduce the rate or extent of polymer expansion).[5]

According to the entire accessible research database available till date, there is very less reported studies has been done comparing sealing ability of these three obturating technique. Hence, the present study was conducted. The null hypothesis for the study is that, there will be no difference in the sealing ability of c-point system, with cold lateral condensation, and thermoplasticized obturating technique.

Materials and Methodology

1. After taking an ethical approval from institutional ethics committee (SVEIC/ON/Dent/BNPg14 D15015), a total of 60 extracted human permanent maxillary central incisors having intact mature single root and minimal root length 12 mm were selected. Teeth with fracture, cracks, caries and previously restored, immature apices/root resorption, multiple canals, curvatures, calcified canals were excluded from the study
2. After disinfection in 0.5% chloramine T trihydrate solution for 1 week, teeth were cleaned off calculus and periodontal tissue using an ultrasonic scaler. Then, all samples were decoronated at cementoenamel junction to obtain a standardized root length of 12 mm and canal patency was evaluated using #10 K file and teeth with canal obstructions were discarded. The actual length of each tooth was determined and working length was established by subtracting 0.5 mm from the length and was recorded as actual length. Then, canals were prepared using #10, #15, #20 K files, respectively and then using K3 files (Sybron Endo) up to 35 apical size and 0.06% taper using crown-down technique. After each instrumentation, the canals were irrigated with 5 ml of 5.25% NaOCl using 27-gauge Max-i-Probe needle (Dentsply Maillefer) and 17% ethylenediaminetetraacetic acid gel was used as a lubricant. After complete instrumentation, each canal was irrigated using passive ultrasonic agitation with 2 ml of 5.25%NaOCl solution for 30 s. Followed by 10 ml, distilled water as final irrigant to remove any traces of NaOCl
3. After drying all canals with paper points, the samples were randomly (computerized randomization) divided based on the obturation technique and materials into three experimental groups of 20 sample each [Figure 1].
    1. Group I (control): Cold lateral condensation with sealer
    2. Group II: Thermoplasticized gutta-percha with sealer
    3. Group III: C-Point obturating system with sealer

Group 1: Cold lateral condensation with sealer

1. A standardized gutta-percha master point was selected of 35 apical file size and inserted into the root canal to full working length and was checked for tugback. AH-Plus sealer was mixed according to manufacturer's instruction and applied to the root canal wall using a lentulo spiral. Then, cold lateral compaction was carried out. Excess guttapercha was sheared off with a hot instrument, and the top of the root filling was condensed vertically with a cold plugger.

Group 2: Thermoplasticized gutta-percha with sealer

1. E and Q system was prepared according to manufacturer's instruction, at 200°. AH-Plus sealer was coated to canal walls using lentulo spiral. Corresponding needle was used for all obturations, and a silicon stop was placed 2–3 mm from working length. First, the needle was inserted in the apical direction and removed after injecting a few millimeter of guttapercha near the tip of the preparation. The softened gutta-percha was condensed to the apex with a corresponding hand plugger by vertical condensation, and was conform by taking X-ray. The remaining root canal was then back-filled in increments until, gutta-percha was observed in the cervical portion of the root.

Group 3: C-point obturating system

1. A radio-opaque verifier of master apical file size 35/06 was selected and introduced into the root canal to full working length and was checked for tugback. Corresponding C-Point was selected. Trimmed the coronal end so that it relatively flushed with the canal orifice by measuring the chamber depth and subtract from the canal reference length. C-point was cut with scissors with the aid of the smart gauge. Bioceramic resin-based sealer was injected into the canal according to manufacturer's instruction. Moreover, the master point was inserted slowly into the canal with a slight rotating movement to fully distribute the sealer and seat the C-Point, till the working length was reached. Moreover, the chamber was cleaned with a cotton pledget moistened with sterile water [Figure 1].

Orifices of all the samples were sealed by placing 2 mm of glass ionomer cement and then incubated for 1 week at 37° and 95% humidity to allow complete setting of sealer.

For assessment of microleakage

1. All tooth surfaces were coated with two coats of nail varnish, except 3 mm around the apical foramen. The

samples were dipped for 24 h at 37°C in a neutralized buffer 2% methylene blue solution, under normal atmospheric pressure. Thereafter, the teeth were removed from die and will be rinsed in tap water for 30 min. Varnish was removed using BP blade and polishing disks. Then, samples were transferred in sterile container containing 6 ml of 65% nitric acid for 3 days. After that, centrifugation of this solution was done at 5000 rpm for 15 min to separate debris from the extracted dye. Supernatant was transferred in the measuring cubets of the Shimadzu spectrophotometer using micro pippets. Moreover, absorbance of each sample was determined by an automatic absorbance UV-VIS spectrophotometer (Shimadzu UV 1800) at 550 nm wavelength [Figure 2].

Obtained scores will be statistical analyzed using ANOVA test and *post hoc* Tukeys test.

Results

ANOVA test for the present study revealed that Group III had lowest mean absorbance value. Group I showed the maximum mean absorbance value among all three groups [graph 1]. One-way analysis of variance revealed that there is significant difference among the three group with P value (0.000 < 0.05) [Table 1].

Tukey's HSD *post hoc* tests for multiple comparisons test shows that the Group II and III perform significantly better than Group I. Group III performs better than group II with no significant difference [Table 2].

Table 1: Mean value and one-way analysis of variance

Group	*n*	Mean	SD	*P*
Group 1: Lateral condensation	20	0.05324	0.028523	0.000<0.05 (HS)
Group 2: Thermoplasticized guttapercha	20	0.02683	0.007199	
Group 3: C-point obturating system	20	0.01915	0.005380	

SD: Standard deviation; HS: High significant

Discussion

In the present study, maxillary central incisor was used in an attempt to avoid the presence of fattening area or isthmus.[6] As it has single root with single circular canal with less variations of canal anatomy.

Samples were decoronated at root length of 12 mm to simplify and standardize the instrumentation and obturation procedures.[7] Canal was prepared till standardized ISO size 35/06 to have more consistent root canal preparation. Kum *et al*. compared smear layer production by K3 with profile, and he found that K3 instruments produces less of smear layer in apical 3rd of root canal system,[8] so it is used in this study.

Dye extraction technique helps to determine the penetrated dye volumetrically. This technique is more advantageous as compared to fluid filtration technique, as the values of fluid filtration technique starts diminishing with time.[9]

In the present study, 2% methylene blue dye was chosen because it is inexpensive and simple. In addition, the internal diameter of the dentinal tubules (1–4 µm) is larger than particle size of dye, so it can show dentin permeability.[10] As suggested by Tifeng Jiao *et al.* shows high removal rate for methylene blue, which reaches above the 95% within 30 min only, regardless of the dimensions of the incorporated Fe_3O_4 nanostructures.[11]

Use of spectrophotometer minimize human errors and provide determinations of volume leakage rather than liner measurement.[12]

In the present study, Group III, i.e., c-point obturating system group perform significantly better than cold lateral condensation, reason behind this maybe, as guttapercha does not chemically bond to dentin wall. As per Teixeira *et al.*[13] gutta-percha is not able to form a monoblock even with the use of a resin-based sealer such as AH Plus. Moreover, on setting sealer tends to pull away from the gutta-percha.[14]

In this study, thermoplasticized group G2 also showed leakage more than c-point obturating system this might

Table 2: *Post hoc* Tukey's tests for multiple comparisons

Groups	Mean difference	SE	Significant	95% CI	
				Lower bound	Upper bound
Group 1					
Group 2	0.026405	0.005460031	0.000*	0.01326588	0.03954412
Group 3	0.034085	0.005460031	0.000*	0.02094588	0.04722412
Group 2					
Group 1	−0.026405	0.005460031	0.000*	0.03954412	0.01326588
Group 3	0.007680	0.005460031	0.344	0.00545912	0.02081912
Group 3					
Group 1	−0.034085	0.005460031	0.000*	0.04722412	0.02094588
Group 2	−0.007680	0.005460031	0.344	0.02081912	0.00545912

*HS: Highly significant. SE: Standard error; CI: Confidence interval

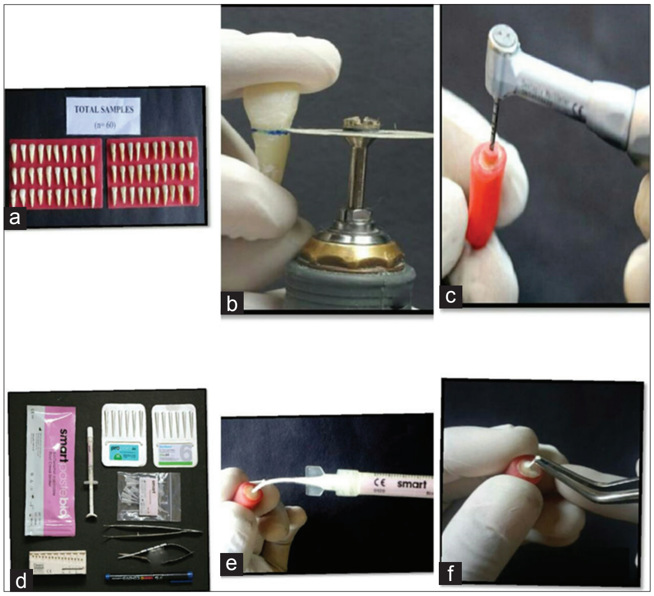


Figure 1: (a) Sixty extracted human permanent maxillary central incisors (b) decoronation using straight handpiece (c) canals prepared using K3 file system (d) armamentarium For C-point obturating system (e) the bio-ceramic resin-based sealer placed in canal (f) C-point is placed in the canal and plugged

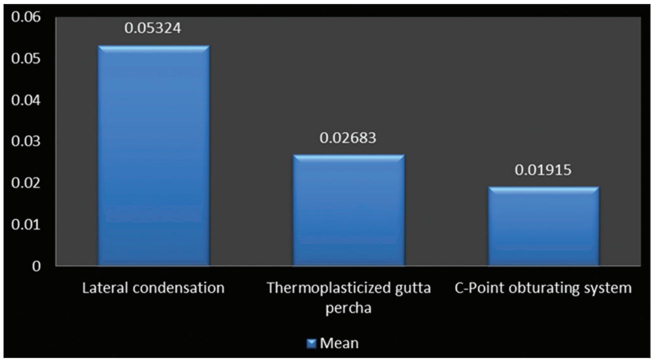
Figure 2: (a) Nail varnish applied (b) Samples kept in methylene blue solution for 24 H (c) teeth kept in 6 ml of 65% nitric acid for 3 days (d) Centrifuged at 5000 Rpm for 15 min (e) coagulum formed after centrifugation (f) automatic spectrophotometer reading

be because sufficient heating of gutta-percha is essential in achieving a good adaptation to canal wall. According to Venturi and Breschi, multiple heating causes phase transformations in gutta-percha which led to change of crystalline phase gutta percha to amorphous phase.[15] Only with extremely slow cooling (0.5°C/h) of gutta-percha can the original phase be regained. However, with routine cooling, beta phase would be expected to reform which leads to shrinkage and increased leakage throughout the canal wall.[16-18]

The lack of adhesiveness of gutta-percha to the root canal walls and to sealers makes it absurd to completely prevent microleakage. It is one of the fragile links in root canal therapy.[19] Due to this limitation of gutta-percha, there is a failure of a veraciously prepared root canal. Results of our study were in accordance of Boussetta *et al*. showed that lateral condensation technique results in more leakage than thermomechanical compaction technique.[20]

The C-point system bonds with dentine inside the root canal thus forming a monoblock effect. C-point system is consists of polyamide polymer cones and a resin sealer with additional polymer powder to be mixed during manipulation of the sealer. C-points consist of a radiopaque core coated with a radiopaque hydrophilic polymer, which can expand laterally without expanding axially after absorbing remaining water present in the canal, thus adopting the shape of the canal. According to Didato *et al*.,[5] it can expand up to around 17% with the same X-ray appearance as with conventional root canal filling materials.[3,5] Inner core of C-points is a mixture of two proprietary nylon polymers, i.e., Trogamid T and Trogamid CX. The polymer coating is a cross-linked copolymer of acrylonitrile and vinyl pyrrolidone which has been polymerized and cross-linked using allyl methacrylate and a thermal initiator. Zirconium dioxide particles provide the radiopacity to both the core material. As per Pathivada *et al*.,[21] the hydrophilic makeup of C-points leads to absorption of minute amount of water present in the root canal after instrumentation. This water causes expansion within the polymeric chains by forming hydrogen bond to the polar sites.[5,21] The rate and extent of this expansion are controlled by the manufacturing process. The expansion occurs with a diminutive force that is believed to be well below the recorded tensile stress of dentine and a amount of the force generated while using techniques such as warm vertical compaction. This genial expansion occurs within the 1st 4 h after placing the C-point into the canal and allows the point to gently adapt to any root canal irregularities. This resulted in, polymer and sealer being expressed into the dentinal tubules. The slight positive pressure that is created against the root canal wall, forms a seal that is assumed to be nearly impermeable to bacterial microleakage.[21]

Sealer recommended with C-point is smart paste bio which is a resin-based sealer designed to swell through the addition of ground polymer. It contains zirconium oxide, calcium phosphate monobasic, calcium silicates, calcium hydroxide, thickening agents, and filler. The manufacturer claims that the addition of bioceramics, gives the sealer exceptional dimensional stability which makes it nonresorbable inside the root canal system.[21] Sealer produces calcium hydroxide and hydroxyapatite as byproducts of its setting reaction, achieving both antibacterial at the time of setting and very biocompatible once set. It is hydrophilic in nature, thus allowing the C-point to hydrate and swell to fill any voids in the root canal with setting time of 4–10 h.[21] This might be the reason of best performance of Group III, i.e., C-point c smart paste bio.



Graph 1: Graphical representation of the mean values of all the groups

Result of this study was in accordance with study by Hegde and Arora who, compared sealing ability of a novel hydrophilic versus conventional hydrophobic obturation systems using a bacterial leakage study and found that hydrophilic obturations of the root canal shows a better resistance to bacterial leakage as compared to hydrophobic obturations.[22]

To interpret our results, it should be also taken into consideration that, leakage studies reported that, single-cone obturation methods to be inferior in their capability to bring out 3 dimensional fluid-tight seal.[23-27] The use of expandable obturating materials to improve the seal has been reported even for the gutta-percha. Gutta-percha also expands in the presence of eugenol, which then further reduces gaps within the filled canal space.[28,29] As per Wu *et al*.,[30] who stated that, besides expansion induced by eugenol, closure of micro gaps in Gutta-percha filled root canals is by moisture present within the canal space may compensate for leakage which arises from sealer dissolution to certain extent.[30] The delayed hygroscopic expansion of the C-points when coated with a hydrophilic sealer that impedes water sorption may partially compensate for the gaps arising from sealer dissolution.[5]

The null hypothesis stated in the study was rejected. Limitations of this study, the actual expansion shown by the polyamide polymer system, its long-term microleakage properties as well as its ability to adapt in irregular-shaped canals was not evaluated, and sample size used in the present study was also less. Hence, future studies are required to evaluate the efficacy C-point system in comparison to other obturating materials and techniques.

Conclusion

Within the limitations of this *in vitro* study, none of the techniques was able to prevent leakage seen in apical third of the root canal. One should keep in mind the hydrophilic/hydrophobic nature of material before selecting an obturating technique/material as it plays very important role in the success of treatment. C-point obturation system can be a game changer in the field of endodontics and could be an alternative to the cold lateral condensation technique.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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