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ORIGINAL RESEARCH

Evaluation Of The Apical Sealing Ability Of Gutta-Percha With Bio-C Sealer, Activ GP With Bio-C Sealer And Activ GP With Activ GP Sealer As Root Canal Obturation Materials- An In-Vitro Stereomicroscopic Study

[1]Dr. Srikumar G.P.V., [2]Dr. Shripriya Rahane, [3]Dr. Anjali Gurnani, [4]Dr. Nivedita Jaipuriar, [5]Dr. Vaishnavi Gadbail, [6]Dr. Vaishali Shukla

[1]M.D.S., Professor and H.O.D., [2-6]PG Student, Department of Conservative Dentistry and Endodontics, Triveni Institute of Dental Sciences, Hospital and Research Centre, Bilaspur, Chhattisgarh, India

Correspondence:
Dr. Srikumar G.P.V.
M.D.S, Professor and H.O.D., Department of Conservative Dentistry and Endodontics, Triveni Institute of Dental Sciences, Hospital and Research Centre, Bilaspur, Chhattisgarh, India
Email: drsrikumar2611@gmail.com

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ABSTRACT

Fifty freshly extracted human permanent mandibular single rooted premolar teeth were included. The anatomical crowns of the selected teeth were removed using a diamond disc and pulp tissue was extirpated using barb broaches. Working length was determined by subtracting 0.5mm from the length achieved with the tip of the trial file just visible at the apical foramen of each root canal in all the specimens. Biomechanical preparation was done in all the specimens in crown-down technique using ProTaper Next rotary file system. The master apical file was set to; X4 (Size 40 and 6% Taper). Specimens were randomly divided into 5 groups with 10 specimens per group. Group 1: Master Gutta-percha point coated with Bio-C sealer, Group 2: Master Activ GP point coated with Bio-C sealer. Group 3: Master Activ GP point coated with Activ GP sealer used as obturation materials with single-cone technique. Group 4 (Negative control): Root canals were not obturated. Group 5 (Positive control): Master Gutta-percha point without any root canal sealer used as obturation material. All canal orifices were sealed with restorative Glass ionomer cement. Specimens were then double coated with nail varnish, except at the apical 3mm of roots and were placed in petri dishes containing Indian ink dye for 48 hours. After removal from the dye, nail varnish was completely removed and specimens were longitudinally sectioned with a diamond disk. For each specimen, the half containing the most visible part of the entire root canal was selected and extent of linear dye penetration was measured using Stereomicroscope following Escobar's criteria. The readings were recorded, tabulated and statistically analysed using One Way ANOVA and Tukey's-Post hoc tests. Gutta-percha coated with Bio-C sealer used as root canal obturation material showed the maximum apical sealing ability compared to Activ GP with Bio-C sealer and Activ GP with Activ GP sealer. Activ GP with Activ GP sealer exhibited least or poor apical sealing ability.

Key words: Activ GP; Apical sealing ability; Bio-C sealer, Dye leakage; Guttapercha.

INTRODUCTION

The main objectives of root canal treatment are to effectively clean, shape and completely fill the root canal system 3-dimensionally by providing a fluid tight hermetic seal. This aimed to prevent any penetration of microorganisms and their by-products from peri-radicular tissues into the root canal system.[1] 60% of endodontic failures are due to incomplete obturation of the root canal space.[2,3]

Microleakage is the most common conceivable cause of root canal treatment failure due to inversion of the bacteria and its toxins through the gap present within the root filling and/or between the root filling and dentin walls of root canal. Thus a fluid-tight apical seal is considered as the most necessary to prevent any re-infection of the root canal system. Gutta-percha (GP) is considered as the gold standard root canal filling or obturation material and it is commonly used in combination with root canal sealers to completely seal the entire root canal system. Although GP has many advantages; its biocompatibility, non-staining and radiopacity.[4,5] But, despite the close proximity of gutta-percha to the dentinal walls of root canal, it does not have a complete dentinal seal and potential unfilled spaces exists allowing leakage along the interfaces of sealer-dentin and sealer-obturation material(GP) or through voids within the sealer. Thus, the ability of a root canal sealer to effectively bond both to the dentinal walls of root canal and also to obturation material is of considerable importance for the success of endodontic therapy.[6] In recent years, there has been an increasing concern about the poor sealing properties of the conventional root canal filling materials; gutta-percha and sealers to the root canal walls. One of the recent trends in endodontics has been the development of obturating materials that are capable of bonding to dentin walls of canal to eliminate interfacial gaps, with the dentin adhesive technology adapted from restorative dentistry to obturating materials.[7]

Activ GP (Brasseler, USA) is a new Glass-Ionomer (GI)-based obturation system. The manufacturer claims the product to be superior to previous GI-based systems in terms of handling characteristics, working time and radiopacity. But, there was inadequate bonding between GI-based root canal sealer and gutta-percha, so to enhance the bonding; Activ GP has a 2 μm coating of GI particles on its surface and these particles are also incorporated into the body of the cone.[6] These cones are available in 0.04 and 0.06 taper cones; the sizes of cones are precisely defined by laser to affirm a more accurate fit. These cones are used singly with GI sealer to enchance its bonding with sealer and also to the dentinal walls of the root canal.[7]

Bio-C(Ceramic) (Brasseler, USA) is a calcium silicate based root canal sealer. It is composed of zirconium oxide, dicalcium silicate, tricalcium silicate, calcium phosphate monobasic, calcium hydroxide, fillers and thickening agents. It is insoluble, radiopaque and aluminum-free material which requires the presence of water to set and harden. It is a pre-mixed, ready-to-use, injectable root canal sealer developed for its use in single cone as well as in lateral condensation obturation techniques. The working time is 4 hours at room temperature. The setting time is also 4 hours, however the setting time can be more than 10 hours in very dry root canals.[8,9]

The aim of this in-vitro study was to evaluate the apical sealing ability of Gutta-percha with Bio-C sealer, Activ GP with Bio-C sealer and Activ GP with Activ GP sealer used as root canal obturation materials by stereomicroscopic analysis.

MATERIALS AND METHOD

Fifty freshly extracted human permanent mandibular single rooted premolar teeth were collected in Triveni Institute of Dental Sciences, Hospital and Research centre, Bilaspur. India. Inclusion criteria: Non-carious, non-fractured, un-restored, matured teeth with closed root apices, teeth were visually and radiographically examined for the presence of single root, single canal, absence of calcifications, resorptive defects and other anatomical anamolies.

Teeth extracted only for orthodontic purpose or periodontally compromised teeth were included. Exclusion criteria: Carious, fractured, restored, open root apices, multi-rooted and multiple canal teeth. All the teeth were cleaned of superficial debris, calculus, residual tissue tags with ultrasonic instruments and immersed for 30 minutes in 3% sodium hypochlorite solution for its disinfection, washed with tap water and were then stored in 0.5% thymol at room temperature until used.

The anatomical crowns of the selected teeth were removed using diamond disc (DFS, Germany) fitted into low-speed contra-angled handpiece (NSK, Japan) at the level of cemento-enamel junction perpendicular to the long axis of teeth to standard root length of all specimens upto 16 mm. In all the specimens, pulp tissue was extirpated using barb broaches (Mani, Japan) and K(Kerr)-file No.10 (Mani, Japan) was placed into the root canal to establish the patency till the apical foramen and the working length was determined by subtracting 0.5mm from the length achieved with the tip of the trial file just visible at the apical foramen of each root canal. Biomechanical preparation was done in all the specimens in crown-down technique using ProTaper Next rotary file system (Dentsply Maillefer; Ballaigues, Switzerland) following manufacturer's instructions at 300 rpm, 2 Ncm of torque in a torque-controlled Endomotor handpiece (Canal Pro CL2, Coltene Endo, Coltene Whaledent, Germany). The master apical file was set to finishing file; X4 (Size 40 and Taper 0.06). In each specimen during root canal instrumentation, 2ml of 17% EDTA solution (EthylineDiamineTetraAcetic acid) (Prevest Denpro, Jammu, India) and 2ml of 3% Sodium hypochlorite solution (Neelkaanth Health Care Pvt Ltd, Ahmedabad, India) were used as root canal irrigants with the aid of a Max-I-Probe (Dentsply Maileffer, Switzerland) irrigation needle. Root canals were then finally rinsed with 2ml of distilled water (Sadbhavna Chemicals, Gujarat, India) and dried with sterile paper points (Dia Dent International, Korea). All specimens were then randomly divided into 5 groups with 10 specimens per group.

Figure 1: Extracted Human mandibular single rooted premolar teeth

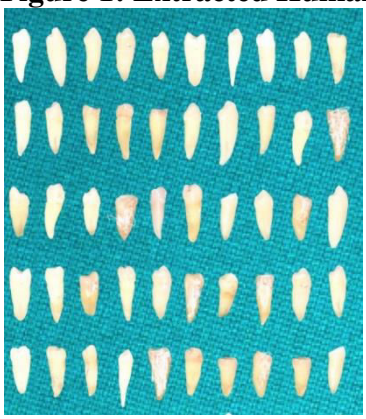


Figure 2: Decoronation of mandibular single rooted premolar teeth

Figure 3: ProTaper Next Rotary files with Canal-Pro Endomotar handpiece

Figure 4: Activ GuttaPercha(GP)

Figure 5: Bio-Ceramic sealer

Group 1: Master Gutta-percha point (Size 40, Taper 6%) (Dentsply Maillefer; Ballaigues, Switzerland) was uniformely coated with Bio-C sealer (Brasseler, USA), slowly placed into the root canal until the pre-determined working length was reached, checked for tugback and obturated with single-cone technique.

Group 2: Master Activ GP point (Size 40, Taper 6%) (Brasseler, USA) was uniformely coated with Bio-C sealer, slowly placed into the root canal until the pre-determined working length was reached, checked for tugback and obturated with single-cone technique.

Group 3: Master Activ GP point (Size 40, Taper 6%) was uniformely coated with Activ GP sealer, slowly placed into the root canal until the pre-determined working length was reached, checked for tugback and obturated with single-cone technique.

Group 4(Negative control): Root canals were not obturated; neither obturation material or root canal sealers were used.

Group 5(Positive control): Master Gutta-percha point (Size 40, Taper 6%) was slowly placed into the root canal until the pre-determined working length was reached, checked for tugback and were obturated with single-cone technique, without the use of any root canal sealer.

Both Bio-C and Activ GP sealers were manipulated according to their manufacturer's instructions. Once the root canals were obturated, Gutta-percha and Activ GP cones were

seared off 2mm beneath the canal orifices and were sealed with Glass ionomer restorative cement (GC Corporation, Tokyo, Japan).

After the completion of root canal filling, radiographs of all specimens were taken to assess the quality of obturation. All the specimens were then stored at 37°C in 100% relative humidity for 10 days and were then double coated with nail varnish, except at the apical 3mm of roots. The first layer of nail varnish was allowed to dry completely before applying the next layer. The specimens of each group were then placed in separate petri dishes completely and passively immersed in Indian ink dye (Himedia Laboratories Pvt. Ltd. Mumbai, India) for 48 hours at 37°C. After removal from the dye, teeth were rinsed under copious running tap water for 10 minutes and nail varnish was completely removed with a scalpel blade. Each root was then longitudinally sectioned in bucco-lingual direction with a diamond disk (0.3 mm in thickness) using a low-speed handpiece and carefully split into two halves by wedging a fine chisel into the groove and then gently twisting the chisel. For each specimen, the half containing the most visible part of the entire root canal (from root apex to the orifice) was selected and the other half was discarded. Root canal instrumentation and handling of all specimens among the five groups were done by a single endodontist, to prevent any inter-operator variability and is not blind to the groups.

The extent of linear dye penetration was measured to the nearest millimetre from the root apex to the coronal extent of each sectioned specimen using a Stereomicroscope (Labline, India) at 20X magnification. To analyse the extent of apical dye penetration/leakage in this in-vitro study, Escobar's criteria[10] was used. All specimens were analyzed by one examiner who was specialist in Endodontics and the data was recorded.

Score 0: Infiltration loss (dye penetration 0–<1.5 mm).

Score 1: Simple infiltration (dye penetration 1.5–3 mm)

Score 2: Medium infiltration (dye penetration > 3 mm).

Figure 6: Indian Ink Dye

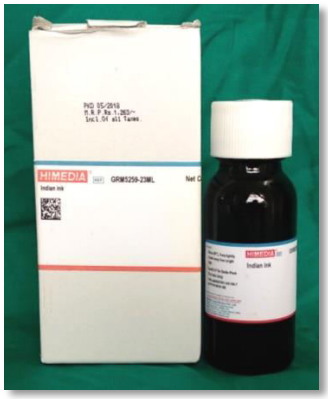
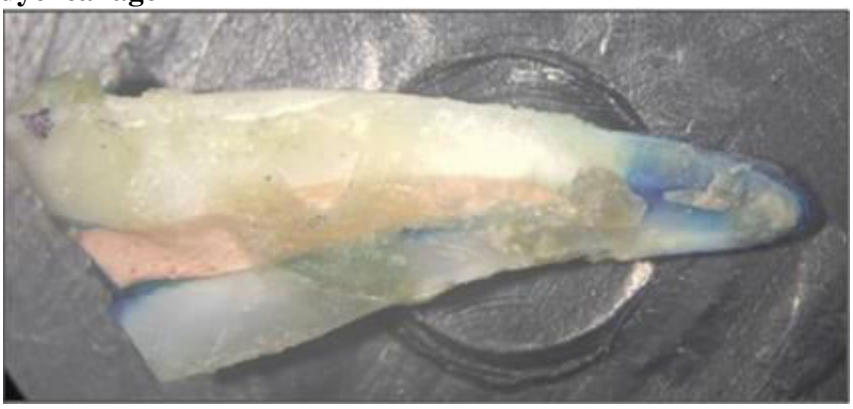


Figure 7: Stereomicroscope

Figure 8: Group 1(Guttapercha with Bio-C sealer as obturation material): Least dye leakage

Figure 9: Group 3(Activ GP with Activ GP sealer as obturation material): Maximum dye leakage



RESULTS

The recorded readings of the apical dye penetration/dye leakage of all specimens were tabulated and statistically analysed with computer software; Statistical Package for Social Sciences(SPSS) version 24, Using Analysis of variance(One Way ANOVA) and Tukey's - Post hoc test.

Analysis of Variance tests the equality of three or more means at one time by using variances. One way ANOVA showed statistically significant difference in the mean values of the apical dye leakage among the groups as P(Probability) value is < 0.05 (Table 1).

Table 1: Analysis of Variance (One Way ANOVA)

GROUPS	**No. of Specimens**	**Mean ± SD***	***P value**
Group 1 (Guttapercha[GP] with Bio-C sealer)	10	0.4 ± 0.5	**P < 0.05**
Group 2 (Activ GP with Bio-C sealer)	10	1.0 ± 0.67	
Group 3 (Activ GP with Activ GP sealer)	10	1.5 ± 0.52	
Group 4 (Negative control)	10	2.0 ± 0.2	
Group 5 (Positive control)	10	1.8 ± 0.48	

***P**: Probability

***SD:** Standard Deviation

It was found that Group 1; Guttapercha coated with Bio-C sealer used as obturation material showed the maximum apical sealing ability with least dye penetration/dye leakage with the Mean and Standard Deviation(SD) of 0.4±0.5 compared to all other groups (Table 1 and Figure 8). Whereas, Group 3; Activ GP coated with Activ GP sealer used as obturation

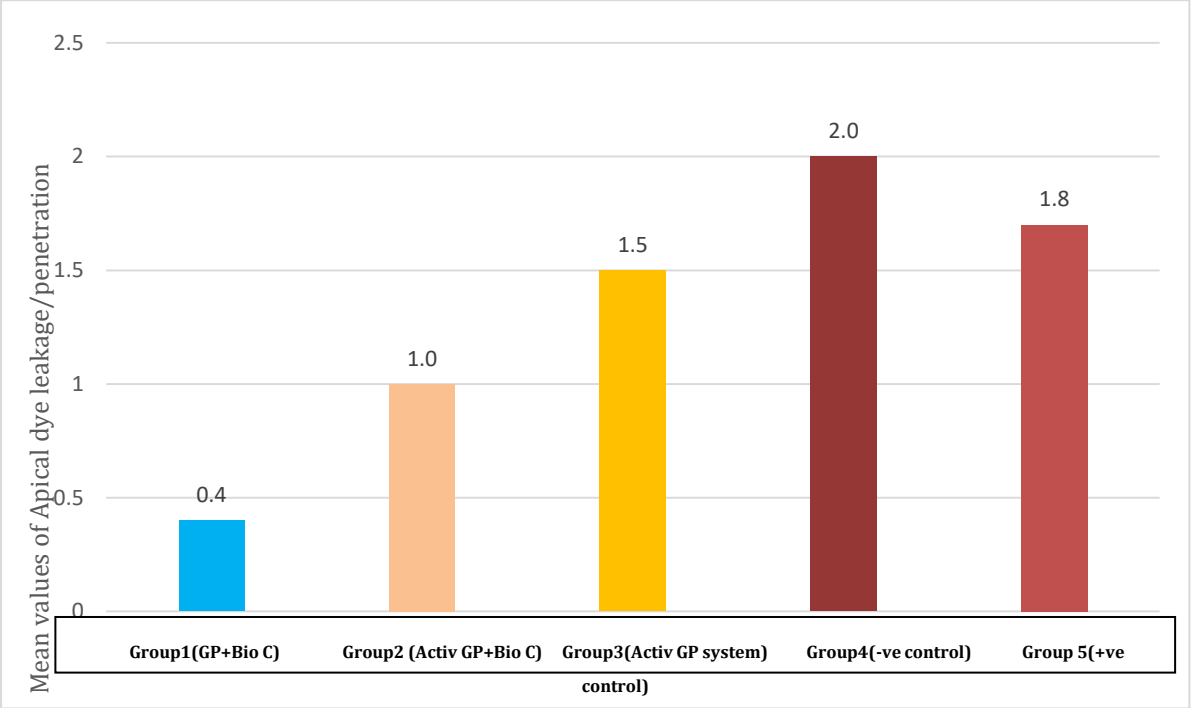
material showed the least or poor apical sealing ability with large or maximum dye penetration/dye leakage with Mean and Standard Deviation(SD) of 1.5±0.52 (Table 1 and Figure 9).

To find where exactly the statistically significant difference is, Tukey's-Post hoc test (Table 2) was done for inter-group comparison between the five groups (Table 2). There was no statistically significant difference ($P > 0.05$) in the apical sealing ability of Activ GP with Bio-C sealer (Group 2) and Activ GP with Activ GP sealer (Group 3) used as obturation materials. However, Statistically significant differences ($P < 0.05$) were seen in the apical sealing ability between Guttapercha with Bio-C sealer (Group 1) and Activ GP with Bio-C sealer (Group 2), Activ GP with Activ GP sealer (Group 3) used as obturation materials.

Table 2: Tukey's post-hoc test for Inter-group comparison

Inter-group Comparison	Tukey's post-hoc test P value
Group 1 *vs* Group 2	0.068
Group 1 *vs* Group 3	0.001
Group 1 *vs* Group 4	0.001
Group 1 *vs* Group 5	0.001
Group 2 *vs* Group 3	0.176
Group 2 *vs* Group 4	0.001
Group 2 *vs* Group 5	0.022
Group 3 *vs* Group 4	0.176
Group 3 *vs* Group 5	0.89
Group 4 *vs* Group 5	0.639

Graph 1: Mean values of the Apical dye penetration/dye leakage among the tested groups



DISCUSSION

One of the main objectives of root canal obturation is to prevent recontamination of the root canal system by preventing the ingress of microorganisms and fluids. Different methods were used to measure the apical sealing ability of root canal filling materials including; dye penetration, dye extraction and fluid infiltration.[11] The dye penetration method was used in this in-vitro study because of its following advantages; it is easy, fast, does not require sophisticated materials and considered as an indicator of the potential for leakage.[12] Passive dye penetration method was used in this in-vitro study, as the positive control group specimens showed the validity of this method in their extent of dye penetration.

It is recognized that gutta-percha does not provide the idealistic bonding to root canal dentin, so several studies are conducted to find alternative materials for creating an apical seal that is tight and sustaining to the root structure mechanically. Especially when gutta-percha was used as obturation material with conventional root canal sealers, there is a gap that exists between the gutta-percha and sealer and also between sealer and root canal dentin surface through which bacteria and fluids can pass.[13,14]

Bioceramic, a term introduced for an important subset of biomaterials; includes materials that can be classified as bioinert, bioactive or biodegradable according to its interaction with the surrounding tissues. Bio-C sealer is a Calcium silicate based Bioceramic sealer. The setting reaction of Bio-C sealer results in the precipitation of calcium phosphate, which encourages bioactivity and tissue growth. Since calcium silicate sets by reacting with water provided by tissue fluids and is stable in water or humid conditions, sealers based on calcium silicate have also been announced as hydraulic sealers.[15]

In the present in-vitro study, Group 1; Specimens obturated with gutta-percha coated with Bio-C sealer in single-cone technique, showed the maximum apical sealing ability with the least dye penetration (Mean value 0.4) compared to the specimens in which root canal filling was done using Activ GP with Bio-C sealer(Group 2) and Activ GP with Activ GP sealer(Group 3). This can be attributed to the properties of Bio-C sealer, tubular diffusion of the sealer particles into the dentinal tubules resulting in infiltration of the mineral content of a strong alkaline sealer into the inter-tubular radicular dentin, producing a mineral infiltration zone after denaturing the collagen fibres and formation of hydroxyapatite in the presence of dentin's moisture.[16]

There has been an effort to develop new obturation materials such as Activ GP for providing a better seal of the root canal system as "Monoblock" (a solid mass of obturation material) that adheres and bonds to the root canal dentin. Group 2; specimens obturated with Activ GP coated with Bio-C sealer showed optimal apical sealing ability with moderate dye penetration (Mean value 1.0). However, there was statistically significant difference in dye leakage between the specimens of Group 1 and Group 2. Group 3; specimens obturated with Activ GP coated with Activ GP sealer showed poor apical sealing ability with more dye penetration (Mean value 1.5).

In endodontics, the role of adhesive systems inside the root canal space remains controversial, because of the limitations of bonding to radicular dentin, as several factors negatively affect the adhesion of resin-based obturation materials; The anatomy of the root canal is more irregular with lateral canals, a decreasing number of dentinal tubules in the apical area of root and furthermore, the apical canal wall is partially covered with calcified appositions.[17,18] The root canal system has an unfavourable geometry for resin bonding since Configuration factor or C-Factor might be 100:1 with virtually every dentin wall has an opposing wall with minimal unbonded surfaces.[7] Another limitation of dentin bonding is deterioration of the resin bond with time due to functional forces or incompleteness of resin infiltration into the demineralised dentin which leads to fluid movement between the hybrid layer and unaffected dentin.[7] The more dye leakage through Activ GP system (Activ GP with

Activ GP sealer) as obturation material in the present study was in accordance with Horsted-Bindslev P et al[19] who also attributed the failure of Activ GP system in preventing dye leakage to the polymerization shrinkage of the glass ionomer sealer (Activ GP sealer) and the debonding of the ActiV GP cone with its sealer as a result of non-homogeneous coating of fillers on its cones.

The ActiV GP - Sealer system uses a single-cone technique in which the master cone closely corresponds to the geometry of NiTi rotary files used for canal instrumentation, thus there may be a thicker layer of

sealer at the interfacial area between root canal dentin and Activ GP.[13] It has been demonstrated that a thicker layer of root canal sealer negatively influences the sealing ability, resulting in voids due to shrinkage upon setting reaction.[20]

There has been conflicting data regarding the sealing ability of Activ GP system as obturation material, Monticelli et al[21] found that there was no difference in leakage between teeth obturated with Gutta-percha/AH Plus sealer and Activ GP/GI sealer (Activ GP sealer) using a fluid filtration model. However, when S. mutans was used in a bacterial leakage model, it was found that single-cone obturation with Activ GP/GI sealer (Activ GP sealer) resulted in significantly more leakage compared with GP/AH Plus sealer.[22] Within the parameters of the present in-vitro study, it did not appear that a complete seal occurred for any of the root canal obturation systems tested.

CONCLUSION

Within the limitations of this study it was found that; Gutta-percha coated with Bio-C sealer as root canal obturation material showed the maximum apical sealing ability compared to Activ GP with Bio-C sealer and Activ GP with Activ GP sealer. Activ GP with Activ GP sealer as root canal obturation material exhibited least or poor apical sealing ability. However, further in-vivo studies are recommended to confirm and correlate the findings of this in-vitro study to a clinical scenario.

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