ORIGINAL RESEARCH

Assessment of the Dentinal Surface Adaptation Efficacy of Different Obturation Systems with Bioceramic Sealer: A Scanning Electron Microscope Study

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Abstract

Aim: Aim of this study was to evaluate the dentinal surface adaptation effectiveness of different obturation methods with bioceramic sealer.

Materials and methods: Sixty recently removed human permanent premolars of the mandible having a solitary, straight as well as completely produced root were chosen on the basis of clinical/radiographic evaluation. The coronal parts of the premolars were subjected to sectioning at the cementoenamel junction (CEJ) with the aid of a water-cooled diamond disk. The regular access opening was done, following which the working length was visually estimated by deducting 1 mm from the length of a 10 size K-file (Dentsply, OK, USA) at the apex. Subsequent to preparing the radicular canal, the premolar specimens were randomly allocated to one of the following three groups. Group I: Lateral compaction (LC) technique; group II: Warm vertical compaction (WVC) technique; and group III: Thermafil obturation technique. Following obturation, the samples were subjected to sectioning in the horizontal direction at three dissimilar points as follows: First at the cervical third, then at the middle, and at the apical third employing a minitom under water irrigation to put off overheating. Internal spaces amid the radicular dentin as well as the obturating agents were appraised with the use of a scanning electron microscope (SEM).

Results: Intragroup analysis showed that higher gaps were noted at the coronal level (2.30 ± 0.04), in pursuit by middle part (1.12 ± 0.02) and apical third (0.70 ± 0.02) for the LC method. With the WVC procedure, higher gaps were situated in the coronal level (1.96 ± 0.07), again in pursuit by middle part (1.02 ± 0.02) and apical third (0.86 ± 0.04). Even with the Thermafil obturation method, higher gaps were noted at the coronal level (0.92 ± 0.10), in pursuit by middle part (0.67 ± 0.05) and apical third (0.57 ± 0.01). No statistically significant difference was noted within the group. Upon intergroup comparative assessment of dentinal surface adaptation with dissimilar obturation systems at coronal, middle and apical thirds, there was a statistically noteworthy disparity amid the groups (p <0.001).

Conclusion: This research arrived at a conclusion that the most superior dentinal adaptation of bioceramic sealer was procured when the Thermafil obturation method was employed for obturating the root canals compared to the WVC technique as well as the LC technique.

Clinical significance: Numerous endodontic substances have been promoted for obturating the root canal areas. Majority of the methods use a core substance, in addition to a sealer. Despite the type of core agent, a sealer indispensable to each technique offers a fluid-tight sealing. The oral physicians' comprehension of the characteristics of the endodontic sealer plus method used, enhances the therapeutic effect.

Keywords: Bioceramic sealer, Dentinal adaptation, Obturation systems, Scanning electron microscope.

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Introduction

Attaining a complete sealing of the whole radicular canal organization in all three dimensions, after shaping and cleaning the same, is the ultimate aim of a successful radicular canal obturating procedure. Accomplishment of the same is influenced profoundly by both the endodontic sealant and apt gutta-percha (GP) compacting along the radicular canals. Intimately adapting the radicular canal restoration along the margins of the walls of the canal is essential to avoid gap creation amid the radicular canal walls as well as the radicular restoration.[1] Gap creation amid the radicular restoration as well as the walls of the dentin could allow re-contamination and infection of the root canal structure, causing a failure of the root canal treatment. Hence, a hermitic seal of the root canal is obligatory for avoiding microbial migration inside the radicular canal structure.[2]

Attaining a "hermetic seal" is frequently indicated as a key objective in endodontic treatment. As per acknowledged definitions, the term "hermetic" indicates a seal against the exit or access of air or prepared air-tight through fusion/sealing. Nevertheless, root canal sealing is frequently assessed for fluid outflow—a consideration employed to categorize obturation agents as well as the method. The seepage may happen either in

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the apical or coronal direction. In some way, the term "hermetic" has found entrance to endodontic taxonomy in a manner possibly comparable to development of an air-tight sealing.[3]

Even though there exist numerous methods for obturating radicular canals, the hunt for superior methodologies is ongoing. The LC is incredibly efficient as it precincts the radicular canal restoration within the radicular apex. A number of publications recommend that LC does not seal the spaces proficiently and leads to emptiness or spaces owing to the non-homogeneous transference of the sealing agents.[4]

Plasticizing the restorative agent through application of heat and then carrying the same within the radicular canal with the aid of hot pluggers is the basis of WVC methodology. Following compaction of the obturation in the radicular apical part, the crown part is backfilled. The advantage of this technique is that the plasticized restorative agent adapts soundly to the radicular canal irregularities and isthmuses that leads to intense compaction with a superior sealing at every radicular canal access portal.[5] Thermafil obturation method that integrates the application of thermal/frictional warmth for plasticizing the GP, permits superior adaptation to walls of the root canal, advanced level of uniformity and offers most favorable apical as well as coronal seal.[6]

In addition to the method of compaction, sealing agents play a critical role in achieving a hermetic sealing of the radicular canals. The basic principle of a sealant is to aid in sealing off the gaps amid lateral cones as well as the GP center across the walls of the canal. Lately formulated calcium silicate-based bioceramic sealing agents are greatly preferred as they have the capacity of calcium discharge as well as are bioactive. Penetration of sealer cement into dentinal tubules of root dentin is assessed by different factors, such as smear layer elimination, dentin permeability, and obturation method. Therefore, it is critical to evaluate the adaptation of sealers to the root dentin during different obturation techniques. But research is scarce in evaluating the influence of different obturation methods on the adaptation of bioceramic sealers. Thus, this research was performed to evaluate the dentinal surface adaptation effectiveness of different obturation systems with bioceramic sealing agents employing a SEM.

Materials and Methods

Selection of Samples

This *in vitro* research was performed in the department of conservative dentistry and endodontics, Buddha Institute of Dental Sciences and Hospital, Patna, India. Sixty human permanent mandibular premolars and which were removed for orthodontic reasons were included. Tooth with solitary, straight as well as completely produced root was chosen on the basis of clinical/radiographic evaluation. Exclusion criteria were premolars having an open apex, cracks/defects from resorption. A pre-treatment radiograph was made to leave out the premolars having internal resorption or calcifications. Each sample was subjected to storage in 10% ethyl alcohol solution till the tooth preparation was finished. Organic debris on the exterior of the radicular parts was detached by immersing the samples in 1% NaOCl solution for 4 days prior to initiating the research.

Sample Size Calculation

Calculation of the sample was done by using the following formula:

$$n = \frac{Z^2_{1-(\alpha/2)}}{d^2}$$

where $Z_{1-(\alpha/2)}$ was a constant and its value for two-sided test is 1.96 for 95%, n was the total required sample size, and d was absolute precision 20% = 0.2.

Preparation of Samples

The coronal parts of the premolars were subjected to sectioning at the CEJ with the aid of a water-cooled diamond disk. Regular access opening was done, following which the working length was visually estimated by deducting 1 mm from the length of a 10 size K-file (Dentsply, OK, USA) at the apex. The mid as well as coronal one-third was prepared employing size 2–4 Gates Glidden drills (Mani Inc., Tochigi, Japan) through a low-speed hand piece. The radicular canals were subjected to irrigation with 1 mL of 5.25% NaOCl subsequent to each file instrumentation of the canals. Whether the apical foramen is patent or not was established with size 10–15 K-files (Dentsply). Biomechanical preparation was performed using MTwo Ni-Ti files and a 35/0.04 master apical file. After the radicular canal preparation, the smear layer was eliminated and the canals were subjected to irrigation with 10 mL of 17% ethylenediaminetetraacetic acid (EDTA) (Septodont, Cedex, France) for 60 seconds and 10 mL of 5.25% NaOCl. Irrigation was performed with a syringe with a 23-gauge needle. To conclude, the radicular canals were subjected to flushing with 3 mL of distilled water and subsequently dried using paper points.

Group I: Lateral Compaction Technique

A calibrated sealer [BioRoot RCS (Septodont, Saint-Maur-des-Fossés Cedex, France)] coated master GP size of 35/.04 (Dentsply Maillefer, Switzerland) was chosen. By using finger-spreader size of #30, the GP cone was pushed to single side, and additional GP cones were placed towards the spreader space after its elimination. This process was continuously performed until the spreader did not further penetrate past 3 mm of the canal orifice.

Group II: Warm Vertical Compaction Technique

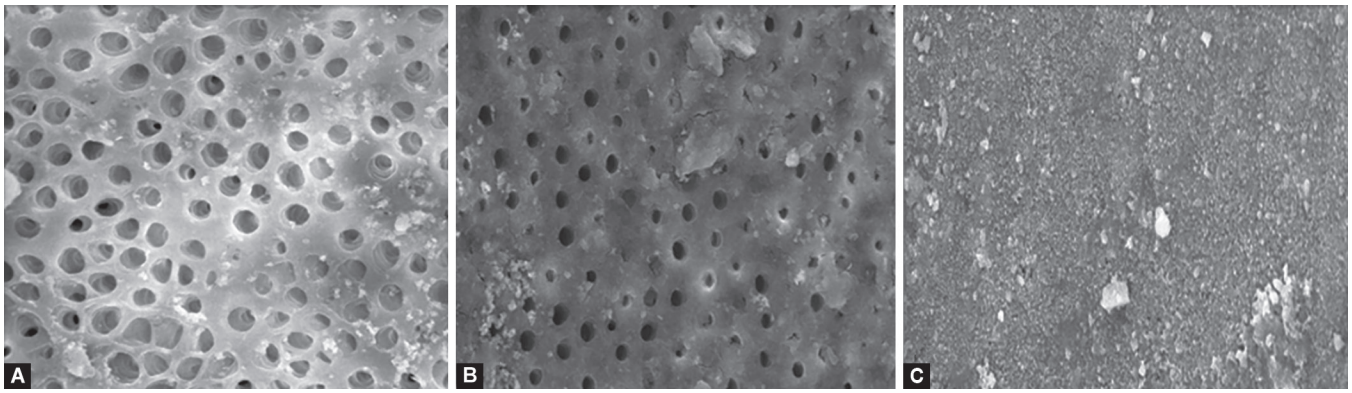
After ensuring fit of master GP cone size of 35/0.04 with sealer, suitable pluggers (System B™ plugger) that pierces 5–7 mm short of working length were taken. The obturation unit considered for heat source was attuned to 200°C, and the hot prefitted plugger was employed to compact the GP at the apical 4 mm. Backfilling of the radicular canal was performed up to a mm beneath the CEJ.

Group III: Thermafil Obturation Technique

Size 35/0.04 Thermafil verifier was utilized to ensure the size of the canal and therefore, the accurate Thermafil obturator. The Thermafil plastic obturator was subjected to heating in a Thermaprep Oven for thirty seconds as per the manufacturer's recommendations. Rigid apical pressure was employed to introduce the Thermafil obturator to the working length. A round diamond bur in a turbine handpiece was utilized to cut the plastic shaft at 1–2 mm inside the access cavity as well as the surplus GP was eliminated with an instrument.

Evaluation under Scanning Electron Microscope

After the storage time, the premolars were subjected to sectioning in the horizontal direction at the following three dissimilar points: First at the cervical third, then the middle and the apical third employing a minitom under water irrigation to put off overheating. A 1-mm thick segment from each third was arranged. Sandpaper was employed to eradicate damaged or distorted surface material. Then the specimens were positioned with silver paste on metallic stubs, gold covered with a sputtering structure below vacuum



Figs 1A to C: The SEM images of (A) LC technique; (B) WVC technique; and (C) Thermafil obturation technique

Table 1: Mean and standard deviation of three different obturation systems with sealer

Obturation systems	*n*	*Mean ± SD (μm)*
Group I: Lateral compaction technique	20	4.12 ± 0.08
Group II: Warm vertical compaction technique	20	3.84 ± 0.13
Group III: Thermafil obturation technique	20	2.16 ± 0.16

desiccation, and after that the internal spaces amid the radicular dentin and the obturating agents (at three dissimilar randomly chosen points of every root sample) were subjected to test with a SEM, at voltage of 10–30 kV. After that, photomicrographs were procured at 1,000× magnification (Fig. 1). Internal spaces at three randomly chosen points in every root sample and at three diverse levels (apical, middle, and coronal) were calculated, and the mean (micron) was predicted.

Statistical Analysis

The data was assessed employing Statistical Package for the Social Sciences (SPSS), version 20.0 (IBM SPSS Corp., Armonk, NY, USA). The Kruskal–Wallis test was utilized for the entire group judgment at each level. Statistical significance was set at $p < 0.05$.

Results

The mean internal space of three dissimilar obturating methods with the sealer is depicted in Table 1. A mean gap of 4.12 ± 0.08 was noted with the LC method, 3.84 ± 0.13 with the WVC procedure and 2.16 ± 0.with the Thermafil obturation method.

Table 2 exhibits the intragroup comparative assessment of dentinal surface adaptation with diverse obturation techniques at coronal, middle as well as apical thirds. Higher gaps were noted at the coronal level (2.30 ± 0.04), in pursuit by middle part (1.12 ± 0.02) and apical third (0.70 ± 0.02) for the LC method. With the WVC procedure, higher gaps were situated in the coronal level (1.96 ± 0.07), again in pursuit by middle part (1.02 ± 0.02) and apical third (0.86 ± 0.04). Even with the Thermafil obturation method, higher gaps were noted at the coronal level (0.92 ± 0.10), in pursuit by middle part (0.67 ± 0.05) and apical third (0.57 ± 0.01). No statistically significant difference was noted within the group ($p > 0.05$).

Table 3 delineates the inter group comparative assessment of dentinal surface adaptation with diverse obturation methods at coronal, middle and apical thirds. On judgment amid the groups higher gaps were noted with the method of LC at coronal (2.30 ± 0.04) as well as middle third (1.12 ± 0.02), higher gaps were and at apical third with WVC method (0.86 ± 0.04). The Thermafil obturation procedure exhibited the lowest gaps at all of the three points. There were a statistically significant differences amid the groups ($p < 0.001$).

Discussion

A mixed use of a core substance and a sealing agent is the traditional practice employed in endodontic obturation these days. Owing to deficient adhesion capability in GP, sealers were developed to conquer this drawback. High-quality sealing capacity is an essential prerequisite of root canal obturating agents. A bond of the sealing agent with dentin by mechanical retention or chemical linkage or together is significant in maintaining a tight seal among the either following therapy against microbial seepage. In addition, it is vital to endure stresses created by function or from consecutive treatments as post-preparation or coronal filling procedure.[7]

In this study, mandibular permanent premolars having a single-canal were selected because of the wide frequency between extracted teeth. Additionally, application of only one kind of tooth can help to increase the similarity between the samples. Various procedures have been recommended as well as assessed, majority suggesting the employment of GP as the core agent along with sealers of a dissimilar constitution to plug the residual spaces amid the individual GP systems and also amid the GP and radicular canal wall. Diverse sealer compositions have been extensively researched and tested, as concerns their mechanical and biological characteristics, mirroring the existing conviction that the suitable choice of a sealer and its clinical presentation may affect, at least slightly, the result of root canal treatment.[8]

In this research, bioceramic sealer (BioRoot RCS) was used. BioRoot RCS employed in this research constituted a tricalcium silicate sealer that offers a good provision for tissue curing by dentinal hydroxyapatite mineralization. This also additionally promotes radicular canal sealing, with their outstanding bioactive characteristics.[9] Al-Haddad et al.[10] inferred that BioRoot RCS enhances the quantity of calcium from calcium phosphate crystals when it interacts with a physiologic solution. Owing to such biological benefits of BioRoot RCS vs other types of sealers, its infiltration plus adaptation ability was assessed with dissimilar obturation methods.

In this research, Thermafil obturation procedure exhibited superior dentinal adaptation vs the WVC process and LC method.

Table 2: Intragroup comparison of dentinal surface adaptation with different obturation systems at coronal, middle, and apical levels

Obturation systems	*Coronal (Mean ± SD)*	*Middle (Mean ± SD)*	*Apical (Mean ± SD)*	*K analysis of variance (ANOVA) value*	*p-value*
Group I: LC technique	2.30 ± 0.04	1.12 ± 0.02	0.70 ± 0.02	24.24	0.065
Group II: WVC technique	1.96 ± 0.07	1.02 ± 0.02	0.86 ± 0.04	22.48	0.058
Group III: Thermafil obturation technique	0.92 ± 0.10	0.67 ± 0.05	0.57 ± 0.01	21.08	0.052

Table 3: Intergroup comparison of dentinal surface adaptation with different obturation systems at coronal, middle and apical levels

Obturation systems	*Coronal (Mean ± SD)*	*Middle (Mean ± SD)*	*Apical (Mean ± SD)*
Group I: LC technique	2.30 ± 0.04	1.12 ± 0.02	0.70 ± 0.02
Group II: WVC technique	1.96 ± 0.07	1.02 ± 0.02	0.86 ± 0.04
Group III: Thermafil obturation technique	0.92 ± 0.10	0.67 ± 0.05	0.57 ± 0.01
K ANOVA value	26.52	25.28	24.38
p-value	0.001	0.001	0.001

The lateral compaction procedure is a frequently used obturating technique. According to the studies by Gordon et al.[11] and Xu et al.,[12] LC procedure is the prototype in opposition to which novel systems are judged. In this research, although the GP density was noted to be quite reasonable, there were apparent empty spaces. Also, spreader zones were evident in cross-sections.

Warm vertical condensation procedure should cause plasticizing of the GP in the area apical to the heat carrier. Through this, it can be inferred that by warm vertical condensation, the superiority of GP adaptation to the walls of the apical radicular canal differs and the presence of an adequate quantity of GP in the apical canal as well as appropriate heating are vital in attaining better adaptation in the root canals having largely differing diameters. Venturi et al.[13] concluded that manifold heating exhibits greater amount of GP contraction. It is likely that GP subjected to heating merely flows and extends about the pluggers rather than being pushed forcefully in to the irregular areas. This could give explanation why warm vertical condensation exhibited higher voids of GP filled regions vs the Thermafil procedure.

Warm vertical compaction exhibited the lowest quantity of voids vs the LC technique. Likewise, in the research performed by Farias et al.[4] and Basavanna et al.,[14] LC technique depicted reduced adaptation with higher gaps. Inferior consequences for lateral condensation method vs the remainder cohorts were documented in preceding researches owing to gap creation, spreader area, and non-existence of surface division of sealer adaptation to walls of the root canals. Also, a research by Arikatla et al.[15] elucidates that the LC method produce a non-consistent flow of sealer beside the root canal wall, which could lead to emergence of greater interfacial gaps. Similarly, the results of the present study also correlate with findings of Athkuri et al.[16] study wherein WVC has provided the highest percentage of root-filled area compared to LC and techniques.

The group obturated using Thermafil system at the apical part exhibited the most excellent consequences. Thermafil specimens depicted a higher uniform mass consisting of GP plus the plastic carrier. Likewise, Samadi et al.[17] elucidate that Thermafil obturators are bendable plastic carriers layered with alpha phase GP whilst extruder of element obturating component comprises the beta phase GP. Alpha phase GP exhibit little melting temperature as well as high-quality adhesiveness, while the beta phase GP have greater melting points and lack adhesive characteristics. Therefore, the probability of shrinkage of thermoplasticized GP as utilized in Thermafil must be lower than element obturation unit. It has outstanding viscosity, fluidity as well as increased adhesiveness duplicating the root superiorly with lower spaces.

The limitation of this research is that solely those teeth having straight canals were employed. Curved canals may be complicated to work upon and may make difficult the appropriate radicular canal cleansing. Thus, additional investigation pertaining to the depth of infiltration and 3D-sealing of the obturation techniques could be researched in curved radicular canals as well as in teeth with multiple roots for enhanced clinical evaluation.

Conclusion

This research arrived at a conclusion that the most superior dentinal adaptation of bioceramic sealer was procured when the Thermafil obturation method was employed for obturating the root canals compared to the WVC technique as well as the LC technique.

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