Original Article

Comparative evaluation of the effect of three different obturation techniques on push-out bond strength of AH Plus Bioceramic and EndoCeramic sealers: An *in vitro* study

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Abstract

Context: Effect of three different obturation techniques on bond strength of bioceramic sealers.

Aim: This study aimed to investigate the effect of cold lateral compaction, thermafil, and thermoplasticized obturation techniques on the push-out bond strength of AH Plus Bioceramic and EndoCeramic sealers.

Settings and Design: The design of the study was an *in vitro* study.

Materials and Methods: Forty-two extracted teeth that were single-rooted and had fully developed apices were chosen, decoronated, and biomechanically prepared using rotary nickel–titanium (NiTi) instruments. Samples were divided into two groups of $n = 21$. Group 1: AH Plus Bioceramic sealer, Group 2: EndoCeramic sealer. Then, based on the obturation technique employed, each group was divided into three subgroups ($n = 7$): subgroups 1a, 2a: Cold lateral compaction; Subgroups 1b, 2b: Thermafil; and Subgroups 1c, 2c: Thermoplasticized (obtura). Using universal testing machine, slices from the middle third of the sample's root were analyzed to determine the push-out bond strength values.

Results: Compared to other groups push-out bond strength was noticeably higher for the cold lateral compaction technique with EndoCeramic sealer (Subgroup 2a), followed by the Thermafil technique with EndoCeramic sealer (Subgroup 2b).

Conclusions: In the present study, compared to heat-based obturation techniques, cold lateral compaction showed better push-out bond strength values for both sealers. EndoCeramic sealer resulted in greater push-out bond strength values than AH Plus Bioceramic sealer.

Keywords: Bioceramic sealer; cold lateral compaction technique; push-out bond strength; thermafil technique; thermoplasticized technique

INTRODUCTION

The prognosis of endodontic treatment is highly based on proper chemomechanical shaping and obturation as well. If a homogeneous, gap-free, and impermeable obturation is achieved, it reduces leakage and bacterial contamination and will form a good apical seal, which prevents reinfection of the root canal. Various endodontic sealers have been introduced, but recently, bioceramic sealers have grown in popularity because of their ability to adhere to dentine even in the presence of a hydrophilic environment. The alkaline pH of bioceramic sealers is due to the release of calcium

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ions, which causes the deposition of the hydroxyapatite layer. This could explain the biocompatibility and bioactivity of bioceramic sealers.[1]

AH Plus Bioceramic sealer (AHPB; Dentsply Sirona, Charlotte, NC) is a new premixed calcium silicate-based sealer. It is composed of 5–15 weight percent tricalcium silicate, zirconium dioxide, dimethyl sulfoxide (DMSO), and lithium carbonate. It is characterized by fast setting, high resistance to washout, and radiopaque. It is safe to use, nontoxic, and has no evidence of causing discoloration of teeth.[1]

EndoCeramic sealer (Endo Direct, USA) is presented as a preloaded syringe and is supplied with disposable single-use applicator tips. It is biocompatible, has adequate radiopacity, and has a 4-h working time and 1-h setting time.[2] A sealer's ability to adhere to tooth structure is largely dependent on its physical properties, such as film thickness, flow, alkalinity, and solubility.[3] The following are the different physical properties of AH Plus Bioceramic and EndoCeramic sealers provided by manufacturers [Table 1].[2]

Solubility is the ability of a material's constituents to deteriorate as a result of oral fluid action. It is crucial for the outcome of root canal therapy.[3] The substance will form a strong seal with dentine if it dissolves less easily in oral fluids. The wettability of the sealer is enhanced by thin film thickness and improved flow, which results in effective sealing with the dentinal wall.[3] The primary benefit of bioceramic sealers is their alkaline pH, which promotes the development of hydroxyapatite deposits on the dentine surface on reacting with oral cavity fluids.[4,5] This enhances their adhesion with dentine and increases their bioactivity.[3]

It has been demonstrated that the cold lateral condensation (CLC) technique is a highly common and clinically successful filling approach.[6,7] However, according to Emmanuel *et al*.[6] lateral compaction during final filling produced a nonhomogeneous mass of several individual gutta-percha cones that were compressed and only fused by friction and the cementing material.

Currently, Thermafil is developed using a gutta-percha layer surrounding a radiopaque plastic core (carrier), which is heated to form a thermoplastic material. For Thermafil obturation, manufacturers recommend using NiTi rotary systems and the corresponding thermoplasticized Gutta-percha coated carrier systems. The manufacturing process of obturators complies with ISO file sizes and changeable tapered NiTi rotary files. These techniques can result in a homogeneous mass with a higher Gutta-percha to-sealer ratio in the root canal.[8,9]

In order to improve gutta-percha'erhomogeneity, three-dimensional obturation, and surface flexibility, thermoplastic obturation procedures were developed. One of the more modern techniques that employ thermoplasticized gutta-percha is Obtura III Max, an injectable, heated gutta-percha therapy. It has a higher three-dimensional adaptability to the canal system and is said to be better than lateral condensation.[10]

Both bond strength and sealer characteristics may be impacted by the heat generated during this operation.[11] If there is strong adhesive contact between sealer and gutta-percha; and sealer and radicular dentine, endodontic therapy will be more successful.

The adhesive ability of an endodontic sealer can be assessed by seeing how well it bonds to dentine. It has been noted that the obturation methods have an impact on the endodontic sealer adhesion to root canal dentine.[12]

Research on the impact of obturation techniques using bioceramic sealers is still limited. The AH Plus Bioceramic and EndoCeramic sealers are new. The impact of obturation techniques on these sealers has not been the subject of many investigations. This study assessed the impact of three different obturation techniques (i.e., cold lateral compaction, thermafil, and thermoplasticized techniques) on the push-out bond strength of two sealers, i.e., AH Plus Bioceramic and EndoCeramic sealers.

MATERIALS AND METHODS

Sample preparation

The sample size was determined using G*Power software (latest ver. 3.1.9.7; Heinrich-Heine-Universitat Dusseldorf, Dusseldorf, Germany) the effect size was 0.8, the power was 0.80, and the α-error was 0.05. Obtained sample size was 42 ($n = 42$).

A diamond disc on a straight handpiece was used to decoronate the crowns of 42 recently extracted single-rooted, human mandibular teeth at the cementoenamel junction level. Nickel–titanium (NiTi) rotary instruments were utilized for cleaning and shaping. The irrigation of the canals was carried out using 5 ml

Table 1: Physical properties of AH Plus Bioceramic and EndoCeramic sealers

Brand	Set time (min)	pH	Solubility (%)	Flow (mm)	Film thickness (ers)
EndoCeramic sealer (ENDO DIRECT, USA)	60	11.5	1.0	23.4	26
AHPB; Dentsply Sirona, Charlotte, NC	120harl	12	1.4	21.3	35

AHPB: AH Plus Bioceramic

of 5.25% sodium hypochlorite (NaOCl) (Vishal Dentocare Pvt Ltd., Ahmedabad, Gujarat) for 1 min, 5 ml of 17% ethylenediaminetetraacetic acid (Waldent Alchem) for 1 min and 10 ml of distilled water. Depending on the sealer used, samples were divided into two groups of $n = 21$.

- Group 1 ($n = 21$): AH Plus Bioceramic sealer
- Group 2 ($n = 21$): EndoCeramic sealer and according to the obturation technique used, they were further divided into six subgroups of $n = 7$
- Subgroup 1a ($n = 7$): Cold lateral compaction technique with AH Plus Bioceramic sealer
- Subgroup 1b ($n = 7$): Thermafil technique with AH Plus Bioceramic sealer
- Subgroup 1c ($n = 7$): Thermoplasticized technique with AH Plus Bioceramic sealer
- Subgroup 2a ($n = 7$): Cold lateral compaction technique with EndoCeramic sealer
- Subgroup 2b ($n = 7$): Thermafil technique with EndoCeramic sealer
- Subgroup 2c ($n = 7$): Thermoplasticized technique with EndoCeramic sealer.

Subgroup 1a and 2a: Cold lateral compaction technique

Samples were dried with paper points and then bioceramic sealers were injected into root canal and the suitable master cone was carefully inserted up to working length. Subsequently, fine accessory gutta-percha cones and a stainless-steel finger spreader were used to perform cold lateral compaction technique. In the end, cones were seared off at the orifice level.[6]

Subgroup 1b and 2b: Thermafil technique (Carrier-based technique)

The bioceramic sealers were inserted into the canal system using an intracanal tip and any excess sealer was removed with a master cone. Thermaprep plus oven's obturator holder (Dentsply Sirona) was fitted with a Thermafil obturator size 30, which was selected. After pushing the holder down, the oven's temperature was changed according to the size of the obturator. After oven's signal, obturator was removed and inserted into the canal with firm apical pressure without bending or twisting. While stabilizing the handle with the index finger, sear the shaft with a round bur at the canal orifice and access opening was then sealed with Cavit G (Ammdent).[6]

Subgroup 1c and 2c: Thermoplasticized technique (Obtura III Max)

The manufacturer's instructions were followed for setting up Obtura III Max system (Endo-Tech, Canada). With a file size #20, the bioceramic sealers were inserted into the canal in an anticlockwise rotation. The thermoplasticized gutta-percha was injected following its heating to 185°1 in the delivery system. Initially, the needle was placed in an apical direction 2–5 mm from the working length until it was bound to the canal wall. The softened gutta-percha in the apical area was vertically compressed using a hand plugger and then remaining root canal was then backfilled until the gutta-percha was visible.

For each sample, sections with a thickness of 2 mm were obtained from the middle third of the root surface using a microtome [Figure 1]. The push-out bond strength of each sample was then assessed using universal testing machine [Figure 2]. The obtained data were subjected to statistical analysis.

Statistical analysis

The SPSS version 21(Statistical Package for Social Science, IBM Corporation Ltd., Armonk, New York, USA), was used to analyze data. Kruskal–Wallis test was used for intragroup comparison, and an unpaired *t*-test was used for the intergroup comparison of the mean push-out bond strength using two different sealers.

RESULTS

Results showed that mean push-out bond strength values were higher for Group 2 compared to Group 1. The mean push-out bond strength value was highest for subgroup 2a and least for subgroup 1c. The inter-group comparison was made where the descending order for the mean push-out bond strength value shows: Subgroup 2a (3.1971) > subroup1a (1.1186) ($P = 0.030^*$); subgroup 2b (1.9114) > subgroup 1b (0.5000)($P = 0.019^*$); subgroup 2c (0.4100) > subgroup 1c (0.2814) ($P = 0.436$). Table 2 and Figure 3 depict the intergroup comparison, where Group 2 exhibits a higher push-out bond strength than Group 1, irrespective of the obturation technique. Mean push-out bond strength values were significantly higher for subgroup 2a than subgroup 1a and also for subgroup 2b than subgroup 1b, whereas for subgroup 2c and subgroup 1c, the difference was not statistically significant.

Figure 1: Sectioning the samples using microtome

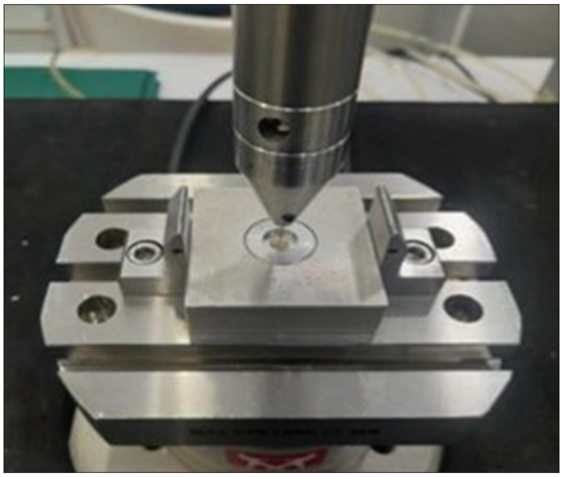

Figure 2: Push-out bond strength test using universal testing machine

Table 2: Inter group comparative analysis of mean push-out bond strength, standard deviation and overall significance between two groups (unpaired *t*-test)

Obturation technique	Sealer	*n*	Mean	SD	*t*	*P*
CLC group	AHPB sealer	7	1.1186	1.05550	−2.463	0.030*
	EndoCeramic sealer	7	3.1971	1.96734		
Thermafil group	AHPB sealer	7	0.5000	0.30849	−2.714	0.019*
	EndoCeramic sealer	7	1.9114	1.34083		
Obtura group	AHPB sealer	7	0.2814	0.23533	−0.805	0.436
	EndoCeramic sealer	7	0.4100	0.35090		

*Statistically significant. SD: Standard deviation, AHPB: AH Plus Bioceramic, CLC: Cold lateral condensation

DISCUSSION

Root canal seal mainly depends on the adhesion of the obturating materials to canal walls in both static and dynamic situations, in static situation it prevents the fluid percolation between the filling material and canal wall, whereas, in a dynamic situation, it enhances the filling dislodgement resistance.[13,14] Adhesion potential of various obturating materials has been assessed with different techniques, but none of them have gained widespread acceptance. Nonetheless, the bond strength test is still thought to be the best approach.[14] Hydraulic materials based on calcium silicates solidify in the presence of moisture or water.[15] They have the capacity to produce hydroxyapatite layers, which cause dentine to mineralize.[3,15,16]

Bioceramic sealers are hydrophilic with low contact angle, spread easily in root canals, and provide good adaptation.[17] They have excellent biocompatibility, dimensional stability, and bioactive potential that stand out compared to conventional root canal sealers. They have shown to be advantageous in this regard, as they can create a tight seal and promote tissue regeneration.[18] One major disadvantage with bioceramic sealers is the difficulty in removing them from the root canal once they are set for retreatment or postplacement.[18]

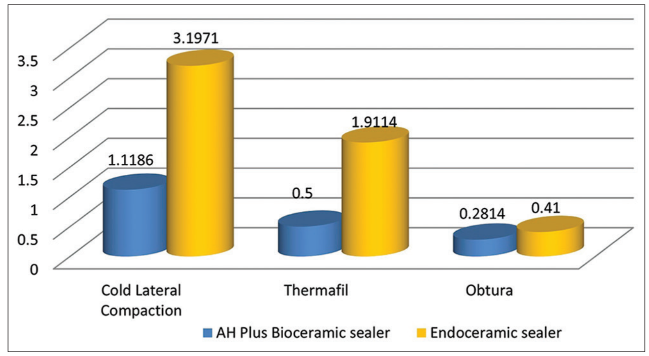

Figure 3: Bar graph showing mean push-out bond strength of two sealers using three different obturation techniques

EndoCeramic sealer showed the highest push-out bond strength compared to AH Plus Bioceramic sealer irrespective of the obturation technique used, the difference is significant in cold lateral compaction, Thermafil techniques but not with obtura. Sealer's ability to adhere to tooth structure is largely dependent on its physical properties like flow (23.4 mm for EndoCeramic and 21.3 mm for AH Plus Bioceramic), film thickness (26 µm for EndoCeramic and 35 µm for AH Plus Bioceramic), alkalinity (pH of 11.5 for EndoCeramic and 12 for AH Plus Bioceramic) and solubility (1% for EndoCeramic and 1.4% for AH Plus Bioceramic) which might have contributed for higher bond strength for EndoCeramic sealer compared to AH Plus Bioceramic sealer.[1-3] Sanz *et al*.[3] stated that if the sealer's solubility is less, it will be less dissolved in oral fluids and have better bonding and longevity. Furthermore, low viscous sealers lead to a thin film, causing more wettability and better penetration into dentinal tubules, which enhances bond strength.[3]

The cold lateral compaction technique showed the highest bond strength, followed by the Thermafil technique and the least by the thermoplasticized obturation technique. This could be due to using a spreader to apply lateral and apical compaction pressure, making space for the insertion of accessory cones, which enhances dentin-sealer contact, reduces voids, and fills in abnormalities in root canals. Mokhtari *et al*.[19] also stated that the CLC obturation technique demonstrated higher bond strength values in their study for the aforementioned factors. Zaki *et al*.[20] stated that cold lateral compaction showed the highest bond strength due to the application of pressure through placing accessory cones, which might cause reduced sealer thickness, improving sealer adaptability and bond strength.[3] Since all sealers have thixotropic and pseudoplastic properties, during lateral compaction, the viscosity of the sealers decreases and their flow increases, which causes better penetration of sealer into dentinal tubules, which might have contributed for its higher push-out bond strength.[21]

Thermafil group showed reduced bond strength compared to lateral compaction due to increase in temperature, which accelerates the setting of tricalcium silicate-based materials this finding has also been reported for industrial Portland cement used in concrete.[22] A similar change in the flow of bioceramic sealers was noted in the study by Camilleri[23] when the temperature was adjusted from 25°2 to 140°1. Qu *et al*.[24] showed a decrease in the sealer flow after heating and it is assumed that heat may accelerate the hydration and hydroxyapatite formation reactions of bioceramic sealers affecting its physical properties.

Levitan *et al*.[25] suggested that the length of fill may be difficult to control using Thermafil and is dependent on the rate of insertion. Furthermore, studies have shown a higher incidence of sealer extrusion in carrier-based obturation techniques than lateral compaction.[26] Another disadvantage may be gutta-percha getting stripped off from the carrier in curved and elliptical canals, which was reported in a study done by Ruchi Gupta *et al*.[27] However, the Thermafil group showed higher push-out bond strength compared to that of obtura, which is achieved by the combination of the heating process and the carrier facilitating the insertion of filling material and exerting pressure along the root canal walls.[28]

Thermoplasticized obturation technique showed the least bond strength in the present study. Rodrigues Cândido Lopes *et al*.[11] demonstrated a significant decrease in bioceramic sealer flow due to dehydration and breakdown of thermoplasticized polyethylene glycol, which reduces its bond strength. Putrianti *et al*.[10] stated that heat produced during thermoplasticized compaction alters sealer's film particles, decreases the setting time, affecting the bond strength.

In a study done by Falakaloglu and Gundogar,[29] obtura showed the least bond strength due to shrinkage of thermoplasticized gutta-percha on cooling, this increases stress concentration on the sealer, affecting its bond strength. DeLong *et al*.[30] stated that lower bond strength in the obtura group might be due to the usage of a heat source that caused the mechanical removal of sealer during downpacking. Similarly, in this study, the lowest bond strength obtained by the thermoplasticized technique might be due to the above reasons.

The sealers used in this study are new and there are few studies that have reported on the impact of obturation techniques on these sealers, which makes the comparison difficult. Further research on these sealers is required.

CONCLUSIONS

In the present study, the cold lateral compaction technique produced better results than the heat-based obturation techniques, i.e., Thermafil and thermoplasticized techniques. Of the sealers utilized, the EndoCeramic sealer showed the highest push-out bond strength values than AH Plus Bioceramic sealer.

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Conflicts of interest
There are no conflicts of interest.

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