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EVALUATION OF PUSH-OUT BOND STRENGTH OF CERASEAL BIOCERAMIC SEALER WITH DIFFERENT OBTURATION TECHNIQUES

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ABSTRACT

Aim: The aim of this study was to establish a comparison of the push-out bond strength of CeraSeal Bioceramic sealer when used with Gutta percha in single cone (SC), cold lateral compaction (CLC) and warm vertical compaction (WVC) obturation techniques.

Materials and Methods: Thirty single-rooted extracted mandibular premolars were selected and mechanically prepared using ProTaper Next rotary system till size X4. The canals were allocated into three equal groups (n=10) based upon the obturation technique as follow; Group I: Bioceramic sealer (CeraSeal) with single cone, Group II: Bioceramic sealer (CeraSeal) with cold lateral compaction technique, Group III: Bioceramic sealer (CeraSeal) with warm vertical compaction technique. Roots were sectioned transversally to a thickness of 1 mm at the middle third. Sectioned root discs were subjected to push-out test using the Universal Test Machine. The maximum load utilised at the time of dislodgment was recorded. Intergroup comparisons were carried out using one-way ANOVA followed by Tukey's post hoc test.

Results: WVC group presented the highest statistically significant mean push-out bond strength value (6.98±1.99) followed by CLC group (1.06±0.15), while the lowest value was presented in SC group (0.66±0.22) (p<0.001).

Conclusions: CeraSeal Bioceramic sealer showed higher push-out bond strength when used in WVC technique compared to single cone and lateral compaction techniques.

KEY WORDS: CeraSeal Bioceramic sealer- cold lateral compaction obturation- Push-out bond strength- Single cone obturation -Warm vertical compaction obturation

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INTRODUCTION

Achieving an adequate corono-apical seal within the root canal is considered a vital step in preventing the proliferation of residing microorganisms and avoiding bacterial infusion towards the apical third of the root [1] Many studies demonstrated that there is a direct relationship between the treatment success and root canal obturation quality [2]. Thereby, different obturation techniques have been employed to achieve the best adaptation of the obturation materials with the radicular dentine; including cold lateral compaction (CLC), warm vertical compaction (WVC), single-cone (SC) technique and others. CLC obturation technique is considered the benchmark against which other obturation techniques must be assessed[3]; however, it remains a difficult, time-consuming technique that may result in an inhomogeneous poorly adapted mass of gutta percha, with quiet large amount of sealer[4]. While, warm vertical compaction technique is considered the best technique in filling the pulp space in three dimensions [5] nevertheless, it was reported to cause weakening of the radicular dentine [6], With recent advents of root canals preparation using nickel-titanium (Ni-Ti) rotary instruments, single-cone technique became popular, it provides ease of handling, short procedure time and produce a homogenous obturation [7].

Calcium silicate-based sealers had developed rapidly in the past decade because of their biocompatibility and bioactivity [8]. These sealers have the privilege of penetrating into the dentinal tubules and interacting with the dentine moisture, creating bonds between the core filling materials and dentin, thereby, the amount of shrinkage is reduced and dimensional stability is achieved [9]. These sealers release bioactive material that can stimulate the formation of a tag-like structure between sealer and dentine. Root canal obturation using gutta percha and a calcium silicate-based sealer forms a secondary monoblock adhesion that strengthens the root structure [4]

In this study, CeraSeal (Meta Biomed Co., Ltd. Korea, Republic) which is a new Bioceramic sealer introduced to the market. It is supplied as flowable paste to be immediately applied inside the root canal. The manufacturers claim that it has a unique stability; never shrink or expand. Moreover, they claim that it has excellent sealing ability. [10].

Literature had reported that the obturation technique affects the sealer adhesion to root canal dentine [11] and that the heat emitted during the obturation process may alter the sealer properties and bond strength [12-13].The aim of the study was to compare the push-out bond strength of CeraSeal Bioceramic sealer when used with Gutta percha in single cone, cold lateral compaction and warm vertical compaction obturation techniques. The null hypothesis was that there is no significant difference in the bond strength among the test groups.

MATERIALS AND METHODS

Sample size was calculated by adopting an alpha (α) level of 0.05, a beta (β) level of 0.20; i.e. power=80%, indicated that the predicted sample size was a total of (27) samples.

Thirty freshly-extracted human mandibular premolar teeth having mature, straight, single root canals were collected from the out-patient clinic of Oral Surgery Department, Faculty of Dentistry, Cairo University. Teeth having roots with open apices, fractures or resorptive defects were excluded. Collected teeth were cleaned from soft tissues debris and calculus using hand scalers, and then washed under tap water. The selected teeth were stored in a jar filled with 10% natural buffered formalin at room temperature.

Decoronation was performed using low-speed diamond disk (Dica, Dendia, USA.) under copious amount of coolant to standardize the root length at 16 mm ± 1. Working length of each canal was established by letting the tip of 10K-file (Dentsply,Maillefer, Ballaigues, Switzerland) to be visible at the apical foramen, then withdrawn and the length obtained was recorded as working length after subtracting 1 mm. The thirty roots were mechanically instrumented using rotary nickel titanium ProTaper NEXT files (Dentsply, Maillefer, Ballaigues, Switzerland) in brushing motion with rotational speed of 300 rpm/ torque 2.0-5.2 operated in X-Smart Plus electric motor, till size X4 file(40/0.06), irrigation of the root canals was carried out by applying 3 mL of 5.25% Sodium hypochlorite (NaOCl) between each file followed by using1 mL of 17% Ethylenediamine Tetraacetic Acid (EDTA) (MD-cleanser, Meta Biomed) to remove the smear layer, then 5 mL distilled water was used as a final rinse. Paper points were used to dry the canals. Samples were randomly distributed into three equal groups (n=10) according to the obturation technique used as follow;

Group I: Root canals were obturated using Protaper Next matching single gutta percha cone corresponding to file (X4) (Dentsply-Maillefer, Ballaigues, Switzerland) & CeraSeal Bioceramic sealer by using single cone technique (SC). CeraSeal was applied into the canal with the provided syringe tip. The syringe was slowly pushed into the canal to fill it, and then pulled out of the canal. The gutta percha point was then introduced into the canal and seared off at the orifice level followed by vertical light packing with a plugger. The excess sealer was removed by water-soaked cotton pellets.

Group II: Root canals were obturated using Protaper Next matching gutta percha cones (X4) &CeraSeal Bioceramic sealer gutta percha in cold lateral compaction technique (CLC). The sealer was applied as in the previous technique, then the master cone was slowly introduced to the canal. A stainless-steel finger spreader (Dentsply Tulsa) size 25 and accessory gutta-percha points (Diadent, North Fraser Way, Burnaby, BC, Canada) completed the CLC obturation technique. Finally, gutta percha points were seared off at the orifice level followed by vertical light packing with a plugger.

Group III: Root canals were obturated using Protaper Next matching gutta percha cones (X4) & CeraSeal Bioceramic sealer gutta percha in warm vertical compaction technique (WVC). After sealer application as in the previous techniques, the master cone was inserted in the canal then a heated plugger was introduced to cut off the master cone leaving the apical part (4 mm). Calamus (Dentsply Tulsa) was used to backfill the canal by setting at 200 °C; the needle was positioned ahead of the apical gutta-percha for 5 s before injection. The expelled gutta percha forced the needle in a coronal direction toward the canal orifice, then a plugger was used to compact the gutta-percha at the orifice level.

Root canal orifices were sealed with glass ionomer cement (Fuji, GC, Tokyo, Japan). Roots were stored at 37°C and 100% humidity in an incubator for 1 week to confirm complete setting of the root canal sealers

Push-out bond strength Test

All the roots were vertically positioned and fixed in chemically cured acrylic resin. Roots was sectioned in a horizontal plane perpendicular to the long axis to obtain a 1 mm slice from the middle third of each root using low speed precision diamond saw (IsoMet 4000, Buehler USA), 8-inch diameter and 0.6 mm thickness rotating at speed of 2500 rpm under water cooling with feeding rate of 10 mm/min. Each specimen thickness was measured with +/−0.02 mm accuracy using digital caliper (Mituyoyo, Japan). Each root slice was marked on its coronal side to ensure proper orientation of the slices.

Each root slice was mounted in a custom-made metallic block that had a circular cavity in the middle to enable displacement of the filling material. The specimens were then subjected to compressive loading with a 0.5 mm diameter blunt stainless-steel plunger at cross-head speed of 1 mm/min using a 500N load cell till debonding. The plunger tip was situated to touch the filling only without stressing the radicular dentin. The plunger was mounted on a universal testing machine (Instron-model

3345-England) and computer software Bluehill 3 version 3.3 was recorded the data.

The maximum load utilised on the tested materials was recorded in Newton (N) at the time of dislodgment by a computer and converted to mega pascal (MPa).

The value detected was divided by the adhesion surface area of the filling material as follow:

Push-out bond strength (MPa) = Maximum load (N) / Adhesion area (mm^2)

Adhesion area= 2Πrh

Π = 3.14.

r = Root canal radius in millimetres

h = Root dentin specimen thickness in millimetres

Values were recorded, tabulated for each group and the mean and standard deviation values were calculated for each group in each test

Statistical analysis

Data were explored for normality by checking the data distribution, calculating the mean and median values by using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data were presented as mean and standard deviation (SD) values after showing parametric distribution. Levene's test showed homogeneity of variances. Tukey's post hoc test was used after One way-ANOVA to present the intergroup comparisons. The significance level was set at P ≤0.05 within all tests. Statistical analysis was performed with IBM® SPSS® Statistics Version 26 for Windows.

RESULTS

Mean and standard deviation (SD) values for push-out bond strength (Mpa) in different groups are presented in table (1) and figures (1,2)

The mean values of push-out bond strength measured in different groups showed significant difference (p<0.001). WVC group showed the highest mean value (6.98±1.99) followed by CLC group (1.06±0.15), while the lowest value was presented in SC group (0.66±0.22). Pairwise comparisons showed that WVC had a significantly higher value than CLC and SC groups (p<0.001).

TABLE (1): Mean and standard deviation (SD) values for push-out bond strength (Mpa) in different groups

Push-out bond strength (Mean±SD)			p-value
Single Cone Group	Cold Lateral compaction Group	Warm Vertical Compaction Group	
$0.66{\pm}0.22^{B}$	$1.06{\pm}0.15^{B}$	$6.98{\pm}1.99^{A}$	<0.001*

Different upper superscript letters indicate a statistically significant difference within the same horizontal row and vertical column respectively *; significant (p ≤ 0.05) ns; non-significant (p>0.05)

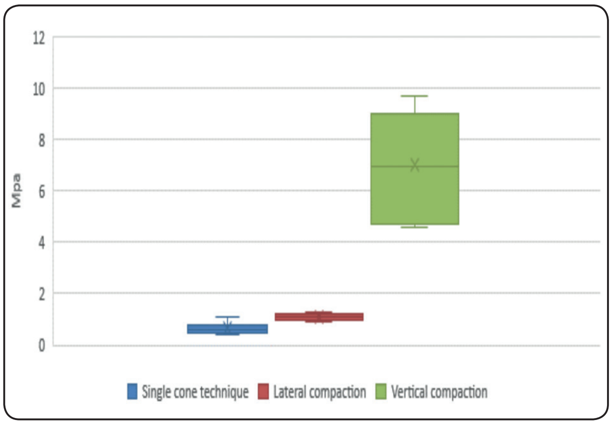

Fig. (1): Box plot of the push-out bond strength values in different groups

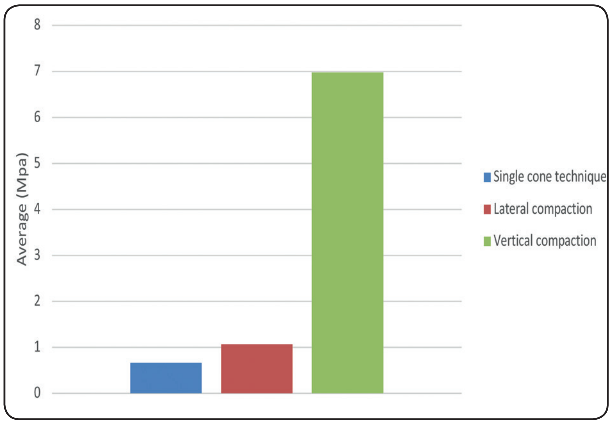

Fig. (2): Bar chart showing average push-out bond strength values in different groups

DISCUSSION

The root canal seal mainly depends on the adhesion of the obturating materials to the canal walls in both static and dynamic situations. In a static situation; it prevents the fluid percolation between the filling material and the canal wall, consequently preventing the accumulation of microorganisms and stagnant tissue fluids which causes periapical disease. In a dynamic situation, it enhances the filling dislodgement resistance [14]. The use of sealers has been considered mandatory, because of the poor adhesiveness of gutta-percha to root canal walls. The main function of endodontic sealers is to create a bond between the obturation material and the canal walls, thus improving the tooth fracture resistance. That's why there has been a continuous improvement in the root canal sealers.

Many methods have been used for assessing the adhesion potentials of different obturating materials, though none of them has been widely accepted [15]. Nevertheless, the bond strength test is considered the most effective method. In the present study, the push-out testing method was employed, since the results of this test have been shown to be effective and reproducible, which allows evaluation of the root canal sealers even when with low bond strength values. Though, this test does not match the clinical situation, and lacks the ability to display the relationship between the bond strength and the clinical success, yet, it displays significant information by comparing various obturation techniques [16].

In this study, three different obturation techniques were employed: the single cone technique (SC) where a tapered gutta-percha cone matching the prepared canal shape was used. This technique is known to be simple and fast, although in some studies it showed inadequate obturation in oval root canals [17], Lateral compaction technique which provides adequate apical seal. Warm vertical compaction (WVC) was used because it showed a better filling ability of canal irregularities as well as lateral canals [18]

In the present study, CeraSeal Bioceramic sealer was utilized as one of the Bioceramic sealers recently introduced to the market. This BC sealer forms chemical bond with dentine through production of hydroxyapatite during setting by the "mineral infiltration zone", which is inferred to its micromechanical interaction nature. It utilizes moisture present in the dentinal tubules to complete its setting reaction without shrinkage producing a gap-free interface between the obturation materials and dentin. [19]. Moreover, it diffuses easily into the dentinal tubules which results in good adaptation and hermetic seal [20].

In our study, the mean bond strength value of the SC group was not significantly different from CLC group ($p>0.05$). This finding could be attributed to the bioactivity of Ceraseal Bioceramic sealer, its hydrophilic nature and the low contact angle it produces when touches the canal walls causes the sealer to cover the canal walls, providing good adaptation and ample hermetic seal [21]. Jeong et al. [22] reported the ability of calcium silicate-based sealers to penetrate the dentinal tubules without the compaction forces frequently applied with different obturation techniques. Recent Scanning electron microscopy study reported that Bioceramic sealer presented an enhanced adaptability to the canal walls than AH Plus sealer [23],

There had been contradictory results regarding the SC obturation technique, on one hand Nagas et al, [4] stated that the SC technique with an 0.06 taper master cone shows higher bond strength values when compared to CLC technique. On the other hand, McMichen et al reported that the SC obturation technique showed an inadequate adaptation of large master cones to the canal walls due to lack of sustained pressure with variable and irregular canal morphologies together with increased sealer thickness and voids [24]. However, these contradictory results could be attributed to different methodologies between the two studies.

However, the results of this study came in accordance with Mokhtari et al. [25] who attributed the high bond strength values showed by the CLC obturation technique to; compaction pressure upon using finger spreader to create a space that allows application of accessory cones which provides better contact at the sealer/ dentin interface, reduces the voids in the sealer and fills the root canal irregularities through applying accessory cones, thereby reducing the sealer thickness and improving retention[26].

Results of the study showed that WVC had a significantly higher push-out bond strength values when compared to CLC and SC groups ($p<0.001$). The results showed that the obturation technique plays an important role on the bond strength of the obturating materials to the canal walls which makes the null-hypothesis rejected.

Though, Camilleri reported that heat produced during WVC obturation technique affects the physical properties of calcium silicate-based sealer not chemical properties of Bioceramic sealer [13]. Likewise, DeLong et al [11] demonstrated that the WVC technique established the weakest bond strength among different obturation techniques when using TotalFill BC sealer groups however, the difference was not significant.

Our findings were in accordance with Gade et al. [27] who reported thaton using Endosequence sealer in WVC obturation technique, higher bond strength values were reported than when used in CLC obturation. Kaya *et al.* [28], illustrated that the push-out bond strength was not affected by the warm obturation techniques. Likewise, Al-Hiyasat et al [29] reported that the obturation techniques did not influence the bond strength of TotalFill BC sealer significantly. Different results could be related to different incubation periods, since the bond strength of Bioceramic sealer improves with time as stated by Yap et al [30]

A concern would be raised that this in-vitro study is not the same as the in-vivo studies where the tooth is located in its socket surrounded with periodontal ligaments and maintaining the body temperature which may affect the sealer properties particularly in the WVC technique. However, a previous study reported that the body temperature had no impact on the properties of the Bioceramic sealer [13]. Another study used Raman spectroscopy to explore the effect of heat on the properties of calcium-silicate based sealers and stated that heat application had no effect on their chemical composition, regardless of either the temperature or the duration. Those findings were correlated to the chemical composition of the sealer, since hydrated calcium silicate is made of an inorganic matrix of calcium silicate hydrate encompassing unreacted silicate granules with water-filled microspaces. Upon heat application, water desorption occurs causing microstructural changes and weight loss of the cement. Nevertheless, moisture obtained from the root canal system can compensate for the water loss during the setting reaction [31].

Overall, in the present study, better results were obtained with warm vertical compaction technique. However, clinical implications of endodontic sealers / filling techniques should be assessed also in terms of sealing ability using different methods and evaluated using micro-CT to provide different perspectives.

CONCLUSION

Within the limitation of this study, it could be concluded that CeraSeal Bioceramic sealer showed favorable bond strength values when used in WVC technique. Further studies are required to confirm the findings of the current study.

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