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PUSH OUT BOND STRENGTH OF DIFFERENT ROOT CANAL SEALERS USED WITH THE SINGLE CONE OBTURATION TECHNIQUE: AN VITRO STUDY

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ABSTRACT

Aim: To evaluate and compare the push-out bond strength of four types of root canal sealers (zinc oxide eugenol (ZnO), AH Plus, EndoSeuence BC sealer and MTA Fillapex) used with single cone obturation.

Materials and methods: Forty extracted sound human mandibular premolars roots were chosen for this study. After de-coronation of the teeth and separation of the desired roots & preparation of the desired root pieces, they were divided into 4 groups according to the sealer used; Group1: zinc oxide eugenol (ZOE), Group2: AH Plus, Group3: EndoSeqence BC sealer and Group4: MTA Fillapex) After obturation with the single cone obturation technique, each tooth was cut into three thirds, coronal, middle and apical. Each of three mm thickness then prepared for push-out assessment using a computerized universal testing machine with a speed of 0.5 mm/min, in Apical- coronal direction until the first displacement of the filling material, and then the results were analyzed statistically.

Results: There was significant difference between the four types of materials with in favor of the Endosequence sealer (2.30 ±1.26) had the highest bond strength to the dentin walls followed by AH plus (1.70 ±1.20) while ZnO sealer had the lowest bond value (1.31 ± 0.88).

Conclusion: The sealer cement BC Sealer provided the best adhesion in all thirds of the root canal added to its bio active properties or bioinert materials is a function of their interaction with the surrounding living tissue.

Keywords: Bond strength, Root canal, obturation Technique

INTRODUCTION

Successful root canal treatment is based on diagnosis, treatment planning, knowledge of tooth anatomy and the traditional concepts of debridement, sterilization, and obturation. Adequate access and a straight-line path to the canal system allow complete irrigation, shaping, cleaning, and quality obturation. Successful obturation requires the use of materials and techniques capable of densely filling the entire root canal system and providing a fluid tight seal in order to prevent reinfection Root canal sealers fill the voids between gutta-percha points and root canal walls; for this reason, sealers are essential prevent reinfection (Kulkarni, 2017)

A variety of instruments and techniques in combination with disinfecting irrigation solutions and intracanal medications have been proposed for the chemo-mechanical preparation of infected root canals (Tziafas et al,2017)

Nickel-titanium (NiTi) instruments have become very popular in endodontic practice; the efficiency of endodontic cleaning and shaping procedures has been greatly improved, especially in the curved canals (Bonaccorso et al, 2009)

The Protaper Next system (Dentsply/Maillefer) was launched into the dental market. This system makes use of the multiple progressive taper concepts. Each file presents with an increasing and decreasing percentage tapered design on a single file concept instrument and the dentine wall, thus reducing the chance for taper lock (screw-in effect). At the same time, it also increases flexibility and cutting efficiency (Vans der and Scianamblo, 2013)

The single-cone obturation technique uses larger master cones (greater, taper) that best match the geometry of canals prepared with nickel-titanium rotary instruments. The use of these gutta-percha points does not require any accessory points or lateral condensation when the root canal is enlarged with rotary instrument (Pereira et al, 2012).

Root canal sealers along with the semi-solid

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core material, to fill voids and to seal root canals during obturation and for entombment of remaining bacteria and the filling of irregularities in the prepared canal Many types of sealers are available, which may be broadly classified into zinc oxide eugenol, calcium hydroxide, epoxy resin, glass ionomer, silicon, bioceramic and mineral trioxide aggregate based sealer. These sealers can be used in conjunction with core filling material as Gutta-percha (Balguerie et al, 2011)

AH Plus is an epoxy- resin based sealer that showed better long – term sealing ability compared to conventional sealers due to its reported expansion over time (Pawar et al,2015)

Bioceramic-based sealers have only been available for use in endodontic for the past thirty years; Calcium phosphate was first used as bioceramic restorative dental cement (LeGeros et al, 1982)

There are two major advantages associated with the use of bioceramic materials as root canal sealers. Firstly, their biocompatibility prevents rejection by the surrounding tissues. Secondly, bioceramic materials contain calcium phosphate which enhances the setting properties of bio ceramics and results in a chemical composition and crystalline structure similar to tooth and bone apatite materials (Koch and Brave, 2009).

Calcium phosphate silicate ceramic-based sealers, which can also serve as repair cements, have been introduced in endodontic (Damas et al., 2011; Zoufan et al., 2011; Nagas et al., 2012). EndoSequence BC Sealer (Brasseler USA, Savannah, GA; also previously known as iRoot SP Injectable Root Canal Sealer, Innovative BioCeramix, Inc., Vancouver, BC, Canada) and Smart paste bio (DRFP Ltd., Stamford, UK) are examples of calcium phosphate silicate ceramic based sealers (Hess et al,2011)

MTA Fillapex is a sealer that is composed of MTA, salicylate resin, natural resin, bismuth oxide, and silica (Vitti et al, 2013).

The quality of the seal obtained with convention sealers is quite far from being perfect. like its inability to strengthen root, as it does not adhere to dentin, inability to control microleakage, and the solubility of sealer makes prognosis dilemmatic and un-assuring (Bouillaguet et al, 2008), So, the purpose of the article is to evaluate and compare the quality of sealing and adhesion to dental walls of the root canal of different root canal sealers including conventional, adhesive and new bioceramic sealer to be used with the simple cone obturation. As the new trend in endodontic is to simplify the obturation procedures and getting benefits from bioactive properties of new bioceramic materials to promote the healing.

METHOD OF THE STUDY

1-Sample selection

Fourty extracted human single root lower premolars were included in this study. Teeth were examined visually under stereomicroscope and radiographically by taking P.A radiograph. And the teeth with the curvature, fracture, incomplete apex, resorption and any bifurcating canals, ribbon-shaped canal, or extreme calcifications canals were excluded from this study (patni et al, 2016)

Storage of the samples was in 0.1% aqueous thymol solution (Dultra et al, 2006)

2-Sample Preparation:

Selected teeth was cleaned by using hand scaler to remove any soft tissues or calculus deposits on their root surfaces then thoroughly washed under running water, to facilitate instrumentation, the coronal portions of all teeth were removed with water-cooled, slow speed double-faced diamond dis leaving the remaining root segment of 12 mm long to standardize the length of all specimens (Uzunoglu et al, 2015)

A custom made square ring was used to receive the root segment which was centered inside the aluminum squares (10 mm diameter and 12 mm height), with guided coronal side turned downward and fixed to a glass plate by adhesive and the acrylic resin was poured into the square until it planed with the apex of the root. After setting of the acrylic resin, the acrylic block was removed from the square (Al-Mezouri et al, 2013)

3-Root canal instrumentation

The working length was determined by inserting a K-file# 15 into the canal until it was just visible at the apical foramen at 10x magnification; then 1 mm was subtracted from this measurement (Celikten et al, 2016)

X-smart Endo motor (Dentsply Maillefer) was utilized for preparation of the canals with speed and torque adjusted according to manufacturer recommendation. The ProTtaper Next files used in the sequence as per manufacturer's instructions ProTaper Next X1(0.17/0.04), X2(0.25/0.06) and X3 (0.30mm tip with 7% taper) (at a rotational speed of 200 rpm and 200-g/cm torque with a brushing motion (Chandrasekhar et al,2016)

Two mL of 2.5% NaOCl was used between each instrument carried up to the apical 3 mm with 27gauge disposable endodontic needle tips that will be placed in to the canal. Following instrumentation, root canals was irrigated with EDTA 17% to remove the smear layer. Finally, the root canals was flushed with 3m L of saline solution and dried with size X3 paper point (Celikten et al, 2016) .

4- Root canal obturation:

The instrumented roots were divided randomly in to four groups (10 roots each):

Group 1: Zinc oxide eugenol sealer was mixed according to the manufacturer's directions and was introduced into the canal using a lentulo-spiral size 3 (Mani, Paste carriers, Japan) which was kept 3mm to 4mm short of the working length. This process was repeated twice to ensure that an adequate amount of sealer will placed in each canal. The master gutta-percha point size X3 was coated with sealer and place in the canal to the full working length (Patni et al, 2016)

Group 2: MTA FillApex sealer was mixed by using a self-mixing tip attached to a syringe and was introduced into the canal using a lentulo-spiral followed by the gutta percha point insertion (Madhuri et al, 2016)

Group 3: Endosequence Sealer premixed Bioceramic sealer is placed into the canal with the provided syringe tip up to two- third of the canal, using backfill technique to optimally fill the canal. Then X3 gutta percha point is slowly inserted into the working length (Madhuri et al, 2016)

Group 4: AH plus sealer was mixed according to the manufacturer's directions and was introduced into the canal using a lentulo-spiral size 3 followed by the placement of single mater cone gutta percha (yap et al, 2017)

=The excess gatta percha in all samples was removed with a heat carrier and the remaining gatta percha was vertically compacted by plugger at the canal orifice. All obturated roots of all groups, root were store in incubator at 37 ^{O}C at 100% humidity for 5 days to ensure the sealer is set (Balguerie et al, 2011)

Push out bond strength test

Each root was divided into three thirds, coronal, middle and apical.

The sectioning of root was made by using Microtome. Four cut was made horizontally to obtain three sections (apical, middle, and coronal) of 3 mm in thickness, three sections was obtained (1.5), (4.5), and (7.5) mm from true anatomical apex. Each study group of (10) roots was provided a total of (30) test specimens. Push-out test was performed by applying a compressive load to the apical aspect of each slice via a cylindrical plunger mounted on Universal Testing Machine. The obturated area of the section at each level was measured from the apical side to determine the size of punch pin (Jainaen et al, 2007).

Three different sizes of punch pins was used, 0.7 mm diameter for the coronal slices, 0.55 mm diameter for the middle slices and 0.4 mm diameter for the apical slices. The punch pins should provide almost complete coverage over the main cone without touching the canal wall and sealer. The root filling in each section will be subjected to loading using a universal testing machine at a speed of 0.5 mm / min in an apical-coronal direction until the first dislodgment of obturating material and a sudden drop along the load deflection (fig.1) The maximum failure load was recorded in Newton (N) and is going to be used to calculate the push-out bond strength in mega-pascals (MPa) according to the following formula:

$$MPa = \frac{Maximum\ load}{Adhesion\ area\ of\ the\ root\ canal\ filling\ material\ (mm^2)}$$

The adhesion surface area of each section calculated as (Ersahan and Aydin, 2010):

Lateral surface area$= \pi(R_1 + R_2)s$

$$= \pi(R_1 + R_2)\sqrt{(R_1 - R_2)^2 + h^2}$$

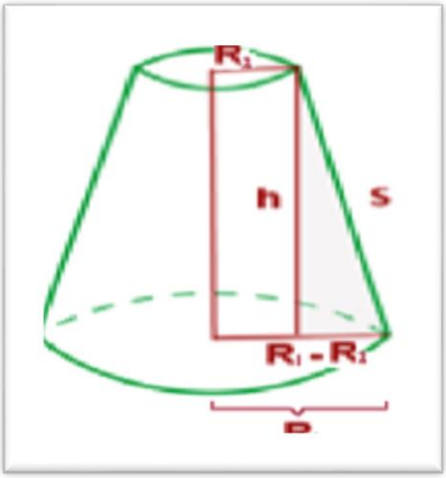

Fig. (1): Schematic drawing of the sample section (Al-Mezouri et al, 2013)
The results obtained from the push out test were analyzed statistically

RESULTS

The table 1 shows that Endosequence sealer (2.30 ±1.26) had the highest bond strength to the dentin walls followed by AH plus (1.70 ±1.20) followed by MTA fillapex while ZnO sealer had the lowest bond value (1.31 ± 0.88).

By using ANOVA test (table 1) also showed that there is significant difference in the push out bond strength between the tested groups (≤0.05).

The table 2 shows that there is no significant difference between the Endosequence sealer and AH plus sealer but there is significant difference between the Endosequence sealer and the other sealers (MTA and ZnO)

From the table 2 also shows that there is no significant differences between the AH plus sealer and (MTA, ZnO) sealer.

Table (1): Comparison of mean values of overall root canal sealer made by different root canals sealers

Descriptive						
Sealers	**n**	**Mean ± SD**	**SE**	**95% CI for Mean**	**Range**	**P-value**
Zinc oxide	30	1.31 ± 0.88	0.16	0.99-1.64	0.48-3.31	0.006
MTA	30	1.48 ±1.11	0.20	1.06-1.90	0.45-4.93	
Endosequence	30	2.30 ±1.26	0.23	1.83-2.77	0.43-4.51	
AH pulse	30	1.70 ±1.20	0.22	1.25-2.14	0.46-4.14	

One-way ANOVA was performed for statistical analyses.

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Table (2): Multiple comparison of overall root canal dentinal made among different root canals sealers

Multiple Comparisons

Dependent Variable: mean values of overall root canal sealers

Bonferroni

(I) Study Groups	(J) Study Groups	Mean Difference (I-J)	Std. Error	P-Value	95% Confidence Interval	
					Lower Bound	Upper Bound
Zinc oxide	MTA	-0.17	0.29	1.000	-0.95	0.61
	Endosequence	-0.98*	0.29	**0.006**	-1.76	-0.21
	AH Plus	-0.38	0.29	1.000	-1.16	0.39
MTA	Zinc oxide	0.17	0.29	1.000	-0.61	0.95
	Endosequence	-0.82*	0.29	**0.034**	-1.60	-0.04
	AH Plus	-0.22	0.29	1.000	-0.99	0.56
Endosequence	Zinc oxide	0.98*	0.29	**0.006**	0.21	1.76
	MTA	0.82*	0.29	**0.034**	0.04	1.60
	AH Plus	0.60	0.29	0.240	-0.18	1.38
AH Plus	Zinc oxide	0.38	0.29	1.000	-0.39	1.16
	MTA	0.22	0.29	1.000	-0.56	0.99
	Endosequence	-0.60	0.29	0.240	-1.38	0.18

***.** The mean difference is significant at the 0.05 level.

Bonferroni correction was performed for multiple comparison of overall root canal dentinal made among different root canals sealers.

DISCUSSION

Successful root canal treatment depends on the thorough debridement of the root canal system, the elimination of pathogenic organisms and finally the complete sealing of the canal space to prevent ingress of bacteria from the oral environment and spread to the periapical tissue (Sundqvist et al,1998) The physical properties necessary for this function include adaptation and adhesion of the filling material to the root canal wall, because gutta-percha does not directly bond to the dentine surface. Ideally, the sealer should be capable of producing a bond between core material and dentine wall.

New root canal sealers are constantly being developed in an attempt to provide all of the favorable properties. Recently, a new bioceramic root canal sealer, EndoSequence BC sealer (Brasseler USA, Savannah, Georgia; also known as iRoot SP, Innovative Bioceramix, Vancouver, Canada), has been introduced to the market (Zhang et al,2009) It is described by the manufacturer to be an injectable, premixed, hydrophilic, radiopaque, insoluble, and aluminum free material based on a calcium silicate composition. The BC sealer is composed of calcium silicates, calcium phosphate monobasic, calcium hydroxide, and zirconium oxide

(Zhang et al, 2010) showed that iRoot SP is equivalent to AH Plus sealer in apical sealing ability. Furthermore, it has been demonstrated that iRoot SP and Endosequence BC sealer are significantly less toxic than AH Plus (Zoufan et al, 2011) iRoot SP has also been shown to be effective against Enterococcus faecalis (Zhang et al, 2009)

Other study has shown that BC sealer eliminated all bacteria within two minutes of contact. The authors explained that its potent antibacterial effect might be a combination of its high pH, hydrophilic nature and active dissemination of calcium hydroxide (Zhang et al,2009) The hardening of the sealing occurs in a three or four hour’s lapse, which gives the handler enough time to use it in surgical and non-surgical applications (Carneiro et al,2012)

In the present study, the push out bond bond strength test was used to evaluate and compare the bonding property of the tested root canal sealers.

Endosequence BC sealer showed a higher bond strength as compared to other groups because of its true self-adhesive nature, which forms a chemical bond (through production of hydroxyapatite during setting) with dentin (Zhang et al,2009) Also it is hydrophilic, posseses low contact angle allowing it to spread easily over the canal walls providing adaptation and good hermetic.

The result of the study do correlate with the study of (Ghoneirn et al., 2011; Candeiro et al., 2012) (Carrillo Varguez et al., 2016) who claimed that the highest bond strength of BC could be explained by the combined effect of the chemical and mechanical bonding of the BC sealer to dentin wall (formation of hydroxyapatite during the setting) as well as the chemical sssignificantly increased push out bond strength of BC sealer)

The result of the study disagree with (Shokouhinejad et al,2013) evaluated that the bond strength of EndoSequence BC Sealer compared to AH Plus in the presence and absence of a smear layer, finding that the dislocation resistance of EndoSequence BC Sealer was equal to that of AH Plus and with no significant effect on the smear layer.

The result of the study also disagree with the study of (Varguez et al, 2016) who claimed that the AH Plus sealer significantly higher bond strength than Endosequence BC sealer sealer when used with cold lateral compaction. The higher bond strength obtained with AH Plus may be associated with its ability to react with any exposed amino groups in collagen to form covalent bonds between the resin and collagen upon opening of the epoxide ring (Samara- et al, 2014) Epoxy-based resin sealer penetrates deeper into the dentinal tubules due to its flowability and long-term polymerization time, which might contribute to enhancing the mechanical interlocking between the sealer and dentin. Thus, a very low shrinkage while setting and long-term dimensional stability shown by AHPlus might also contribute to its observed bond strength.

The result of the study also showed that the MTA Fillapex it achieved lower adhesion than the AH-Plus, the result is do correlate with the study of (Sonmez et al, 2013) who claimed that the AH Plus had greater adhesion than MTA Fillapex, because its chemical composition could also affect its binding capacity (Samara-Baechtold et al, 2014). A recent study found that the reason of the non-adherence of the MTA Fillapex is the formation of apatite on its own surface (cement sealant) so the low binding was attributed to the dentinal tubules.

The present study showed that the bio-ceramic sealer used in article have very good bonding properties and adaptation to the dentinal walls making them promising material to be used as alternative root canal sealers adding to their biocompatibility and bioactivity specially in cases that require tissue regeneration, therefore, the use of bio -ceramics in clinical endodontic significantly helps to achieve goal of better quality endodontic performed in a more predictable fashion.

CONCLUSION

The sealer cement Endosequence proved to be the material with better adhesion in all thirds of the root canal being significantly more noticeable in the apical third.

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