The influence of different root canal irrigants on the push-out bond strength of AH plus and Bioceramic sealers

Alaa Mohammed Naeem [(1)], Iman Mohammed Al-Zaka [(2)]

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ABSTRACT

Background: The bond strength of endodontic sealers with dentin is a very important property for maintaining the integrity and seal of the root canal filling. The aim of this study was to evaluate and compare the effect of various irrigants (QMix, 17% EDTA and 2.5% NaOCl) on the push-out bond strength of AH plus and Bioceramic sealers.

Materials and methods: Forty eight freshly extracted maxillary first molars human teeth with striaght palatal root were used in the study. The collected samples were randomly divided into three groups of equal sample size (n=16), according to the final irrigation regimen as follows: Group (1): QMix 2 in 1, Group (2): 17% ethylenediaminetetraacetic acid, Group (3): 2.5% sodium hypochloride. All samples were instrumented using Edge file X7 rotary instrument reaching file size 40/.04 as the final master apical file. After that each group was randomly divided into two subgroups (n=8) according to the type of sealer used: AH Plus and Total Fill BC Sealer. Obturation was conducted using single cone technique with gutta percha (GP) to all experimental roots. Two-millimeter thick slices were obtained from the middle section of the root. Bond strength of sealers was measured via a universal testing machine by using stainless steel plunger. Then, the data were statistically evaluated using two-way analysis of variance (ANOVA) and post hoc test (Bonferroni's test).

Results: The push-out bond strength was significantly increased by the "irrigant" factor ($P \leq 0.05$) and by "sealer/irrigation solution" interaction ($P \leq 0.05$). Final rinse with QMix solution with BC sealer showed the highest mean value of bond strength (5.976 MPa), with a significant difference with other groups ($P \leq 0.05$), while NaOCl with AH Plus sealer showed the lowest mean value of bond strength (3.811 MPa).

Conclusion: Final irrigation of the root canals with different irrigants improved the endodontic sealer's bond strength, and QMix had a positive influence on the adhesion of BC sealer.

Keywords: AH Plus, Bioceramic sealer, QMix, push-out bond strength, irrigant. **(Received: 18/11/2020, Accepted: 15/12/2020)**

INTRODUCTION

Endodontic therapy aims to promote disinfection of root canal, prevent microorganisms from impairing periapical healing or even lead to the development of apical lesions.[(1)] It has numerous clinical steps which include not only effecient mechanical root canal instrumentation, but also irrigation with adequate disinfecting solutions for dissolving of organic and inorganic material, producing a debris free surface, and achieving a three dimensionally sealed and obturated root canal by using an ideal sealer along with gutta-percha.[(2,3)]

Generally, the root canals are shaped with hand instruments or rotary systems under a constant irrigation.[(4)] In a study of micro-CT images collected before and after shaping of the root canal, 35% or more of the root canal wall (including the isthmus) was observed to be unchanged, in any manner of the canal preparation technique. For that reason, the significance of irrigation and the complete disinfection of root canals has been verified.[(5)]

(1) Master student, Conservative Department , College of Dentistry, Mustansiriyah University, Baghdad, Iraq.
(2) Professor, Conservative Department, College of Dentistry, Mustansiriyah University, Baghdad, Iraq.
Corresponding email, alaanaeem7393@gmail.com

In addition, irrigation solutions should be assist in removal of the smear layer. The smear layer is an iatrogenic layer, generated on dentinal surfaces, primarily consist of inorganic particles of calcified tissue and organic material including bacteria, blood cells, necrotic tissue, pulp tissue and odontoblastic processes.[(2,3,6)] Therefore, removal of this layer is an essential step, as its presence prevents the penetration of root canal materials to root canal surfaces. Sodium Hypochlorite (NaOCl) is the most widely used irrigating solution, because of its an antibacterial activity and the capacity to rapidly dissolve necrotic tissue, vital tissue of the pulp, and the organic debries of dentin and biofilms. So, due to to its capacity against pathogenic organisms and pulp tissue debries, and fulfills a lot of the favorable properties that previously reported, it is considered as the irrigant of choice in endodontics.[(7)] However, since of it's inability to remove inorganic materials and dissolve the smear layer, adjunctive use of an acid or chelating agent with such properties is recommended. For complete cleaning of the root canal surfaces, it is essential to use a combination of organic and inorganic tissue dissolving agents.[(8)]

The smear layer's removal power by EDTA chelating agent, makes it one of the most

commonly used in the irrigation of root canal. Therefore, it is usually used in the comparative research studies that comparing the efficacy of various irrigation solutions, as the gold standard for the removal of smear layer.[9] QMix, another irrigants which used to dissolve the smear layer and debris from the root canal surfaces, consisting of a CHX analog, EDTA as a decalcifying agent and surfactant, it is also appeared as antimicrobial irrigant.[10]

Effective endodontic treatment depends on the complete obturation of the complex root canal system with root canal filling materials that are dimensionally inert, stable and biologically compatible.[11] Due to their wettability of dentin and gutta-percha and appropriate physical properties, low solubility, dimensional stability, adequate microretention to dentin and biological performance, epoxy resin-based sealers such as AH Plus (Dentsply, USA) have been widely used in endodontic treatment.[3] The use of bioceramic material as root canal sealer has been established.[12] Total Fill BC Sealer (FKG, Switzerland) is an premixed, injectable, zero shrinkage, insoluble, radiopaque, and hydrophilic, means that it uses the moisture in the dentinal tubules to initiate and complete its setting reaction.[12]

The influence of endodontic irrigants on bond strength of various types of root canal sealers has been investigated in several studies. There is minimal evidence concerning the effects of QMix irrigation solution on the bond strength of root canal sealer. Therefore, the goal of this study is to evaluate and compare the effect of various irrigants (QMix, 17% EDTA and 2.5% NaOCl) on the push-out bond strength of both AH plus and Bioceramic sealers. The null hypothesis states that when using different irrigants, there is no difference in the bond strength of Epoxy resin and BC sealers.

MATERIALS AND METHODS

Sample selection

Forty eight freshly extracted maxillary first molars human teeth were used in the study. Soft periodental tissues on the teeth surfaces were removed immediately after the extraction manually by using a cumine, and then disinfected with 2.5 % NaOCl solution for 30 minutes.[13,14] One of the most common and efficiently used methods for sterilization and disinfection of extracted human teeth before in vitro work is by NaOCl.[14,15] The concentration used in this study (2.5% NaOCl) is within the acceptable concentrations[14] with a minimal possible effect on dentin, while the concentration used in other studies reached up to 5.25% with a longer exposure time and this could affect the dentin properties.[15] After that all disinfected samples were washed with tap water, and eventually stored in normal saline until used. The criteria for root selection were striaght palatal root, mature and centrally located apical foramen, patent apical foramen and devoid of any resorption, crack or fracture have been used in the study.

Sample preparation

To ensure standardization, the length of palatal root was determined by digital calliper and marker to 11 mm from the end of the root, after that by using diamond disc (Komet, Germany) in a straight handpiece with water coolant, the palatal root was sectioned. A size 15 K file (Dentsply Maillefer, Switzerland) was placed in the canal until it visible at the apical foramen, to ensure that the canal was patent. The working length was confirmed by subtracting 1mm from this measurement which is 10 mm. The specimens were then randomly divided into three groups (n=16) according to the final irrigation regimen as following:

Group 1: 5mL QMix 2in1 (Dentsply Tulsa Dental, Tulsa, OK) for 60 second.

Group 2: 5 mL of 17% EDTA solution (PD, Switzerland) for 60 seconds.

Group 3: 5mL of 2.5% NaOCl solution (Promida, Turkiye) for 60 seconds.

Biomechanical preparation was performed with rotary Edgefile X7 instruments (EDGEENDO, USA) according to the manufacturer's instruction using an electric speed and torque controlled endodontic motor (NSK, Japan), with the speed set to 300 rpm and a torque of 3.0 Ncm. The instrumentation was completed in crown down manner to size 40/.04 as a MAF. The canal was irrigated with 1.0 ml of 2.5% NaOCl via a sterile 30-gauge side vented needle which penetrated 2mm short of the working length. For standardization purpose, one set of the instrument was used to prepare three canals and then discarded.

Final irrigant was allowed to remain in the canal for 1 minute. After that all groups were received a (5 ml) of saline as a final flush and then dried with absorbent paper points. After that, each group was randomly divided into 2 subgroups, according to the sealer type that was used to obturate root canal (n=8):

Subgroup (A): The root canals were obturated using AH plus sealer (Dentsply Detrey GmbH, Germany).

Subgroup (B): The root canals were obturated using Total fill sealer (FKG Dentaire, Switzerland).

The sealer was mixed according to the manufacturer's instructions. Obturation was done by single cone technique with gutta percha (Komet, Germany). All the samples were radiographed at 2 angulations (mesiodistal and buccolingual) by x-ray device (My ray, Italy) to confirm the quality of obturation. Then, the coronal accesses of the root canals were sealed with temporary filling material. The samples were stored in an incubator at 37°C and 100% humidity for 7 days to ensure complete setting of the test materials.[16]

After the storage period, the roots were embedded in clear acrylic resin, after complete curing of the acrylic mold, and by using handpiece fixed in a custom made fixing device, a 2 mm thick slice of mid-root dentin was made at 4.5-6.5 mm from anatomical apex. The cut was made horizontally with flow of cold water to minimize smearing. The thickness of each slice was checked with the aid of digital caliper and examined for any type of deformities. Then, to make sure that the load will be applied in apico-coronal direction, each slice was marked on its apical side as shown in figure (1).

Push-out bond strength test

Push-out test was carried out by applying a compressive load to the apical aspect of each slice by using a cylindrical plunger mounted on a computer software-managed Universal Testing Machine (Instron machine, Laryee, WDW-50, China). By using stainless steel plunger, which provided the most extensive coverage over the filling material without touching the canal wall, the push out test was performed. The size of the punch pin that was used 0.5 mm in diameter.

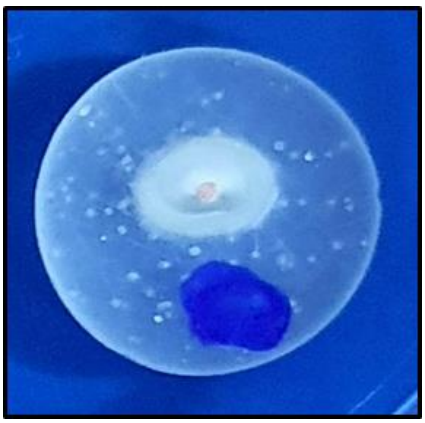

Figure 1 : Slice of mid-root dentin embedded in clear acrylic resin.

Loading was performed at a speed of 1 mm/min by a universal testing machine in an apico-coronal direction until the first dislodgment of obturating material and a sudden drop along the load deflection as shown in figure (2). The force was recorded by using data analysis software. The maximum failure load was registered in Newtons, and push-out bond strength was measured in megapascals (MPa) from force (N) divided by area (mm) of the bonded interface.[17] The area under load was measured by ½ * (circumference of coronal aspect + circumference of apical aspect) *thickness.[17,18] By using Image J software analysis program, the circumference measurements were calculated.

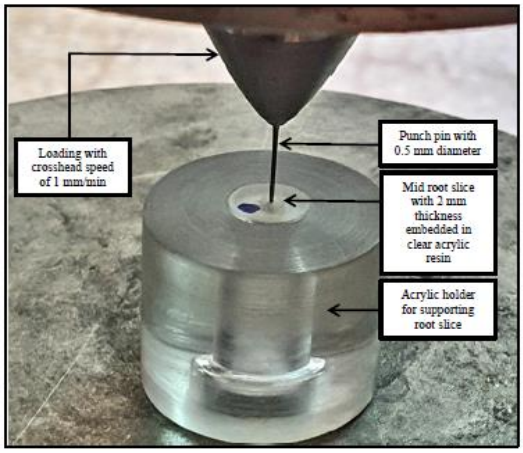

Figure 2: Push-out test process.

The mode of bond failure after push-out test was observed under light microscope (ST 60 series, China). The failures were classified as type I (adhesive failure, no residual material on the canal wall), type II (cohesive failure, material exist on entire canal wall), or type III (mixed failure, material present as patches on canal wall).[19] The data were statistically evaluated using two-way analysis of variance (ANOVA) and post hoc test (Bonferroni's test). The selected level of significance was set at a p value<0.05. Analysis was performed on IBM SPSS, ver. 25 software (IBM, New York, USA).

RESULTS

The normality of data in the present study was tested using Shapiro–Wilk test and was found to be normally distributed ($P > 0.05$). The results of mean values, minimum (Min.), maximum (Max.) and standard deviations (SD) of push-out bond strength in the middle third of root canals for two types of sealers are shown in Table (1). Two-way

ANOVA indicated that the push-out bond strength was significantly improved by the "irrigant" factor ($P \leq 0.05$) and by "sealer/irrigation solution" interaction ($P \leq 0.05$), but there was no significant difference in sealer factor Table (2).

Regarding the push out bond strength of AH Plus sealer, the bonferroni test showed no significant difference among subgroups (1A, 2A and 3A). Regarding of BC sealer, Groups 1B showed higher mean values than group 2B and 3B, and there was significant difference in push-out bond strength between subgroups (1B&2B) and (1B&3B) ($P \leq 0.05$), as shown in (Table 3).

The predominant mode of failure in AH-Plus group was mixed failure (both adhesive and cohesive failure), while cohesive failure was the most frequent type in BC group.

Table 1: Descriptive statistics of push-out bond strength (MPa) for all groups.

Groups	Subgroups	N.	Mean	±SD	Min.	Max.
Group 1 QMix	Subgroup 1A (QMix&AH)	8	4.705	0.986	3.388	6.
	Subgroup 1B (QMix&BC)	8	5.976	1.214	4.518	7.906
Group 2 EDTA	Subgroup 2A (EDTA&AH)	8	5.129	1.810	2.259	7.153
	Subgroup 2B (EDTA&BC)	8	4.094	1.214	2.259	6.400
Group 3 NaOCl	Subgroup 3A (NaOCl&AH)	8	3.811	0.840	2.635	5.271
	Subgroup 3B (NaOCl&BC)	8	4.000	0.875	2.635	5.271

Table 2: Two way ANOVA test between-subjects affect the bond strength.

Source	Type III Sum of Squares	df	Mean Square	F	P-value	Sig.
Irrigant	16.482	2	8.241	5.700	0.006	S**
Sealer	0.239	1	0.239	0.165	0.686	NS*
Irrigant*Sealer	10.650	2	5.325	3.653	0.034	S**
Error	60.724	42	1.446			
Total	1112.497	48				
Corrected Total	88.095	47				

$P > 0.05$: Non significant (NS)* $P \leq 0.05$: Significant (S)**

Table 3: Statistical test of the effect of irrigants*sealers interaction on the push-out bond strength with pairwise comparisons using Bonferroni test

Sealers	Irrigants	Mean difference	Std. Error	P-value	Sig.
Subgroup A (AH Plus)	QMix*EDTA (1A*2A)	0.424	0.601	1.000	N.S.*
	QMix*NaOCl (1A*3A)	0.894	0.601	0.433	N.S.*
	EDTA*NaOCl (2A*3A)	1.318	0.601	0.102	N.S.*
Subgroup B (BC sealer)	QMix*EDTA (1B*2B)	1.882	0.601	0.010	S.**
	QMix*NaOCl (1B*3B)	1.977	0.601	0.006	S.**
	EDTA*NaOCl (2B*3B)	0.094	0.601	1.000	N.S.*

P > 0.05: Non significant (NS)* *P* ≤ 0.05: Significant (S)**

DISCUSSION

Adhesion of endodontic sealers to root canal dentin resist filling dislocation either by frictional retention or micromechanical adhesion and maintains the integrity of sealer-dentin interface.[20] The push-out bond test was used because is reproducible and can be interpreted easily. With the advantage that it enables root canal sealers to be tested even with low bond strength, and it is more effective.[21]

The push-out test method for bond strength testing generates fractures parallel to the dentin-sealer interface[22,23], thereby producing more clinically accurate and effective results that better represent a sealer's bond strength. The greater the bond strength of an endodontic sealant to radicular dentin, the greater the integrity of sealer-dentin interface.[24]

In this study, 2 mm thick segment was used, in order to prevent premature debonding and was only taken from the middle portion of the roots, because these areas usually have more favorable conditions for adhesion of root canal sealers than the apical portion, also since the radicular dentin is not uniform and its tubular density decreases from coronal to apical region. In addition, during the chemomechanical preparation, the prepared wall surface of root canal can differ widely.[16,20,25]

Due to its superior properties, such as dimensional stability, low solubility, better wettability of dentin and gutta-percha and good sealing ability, the epoxy resin-based AH Plus sealer was selected as a reference for comparison in the present study and dealt with as a gold standard.[3,26,27]

Regarding obturation techniques, the single cone obturation technique was used in this study with AH plus and Bioceramic sealers by using matching gutta-percha cones, due to the introduction of new rotary files with different and variable tapering, gutta-percha cones manufactured to have the same tip size and taper as the corresponding rotary systems. Also the single cone obturation technique, that was used in this study with AH plus and Bioceramic sealers, was in accordance with previous studies.[28,29]

Under the condition of this study the final rinse with Qmix root canal irrigant showed the highest mean of push-out bond strength. This result could be explained by the presence of surfactant in the Qmix solution. Surfactants decrease surface tension and improve wettability, thereby enhancing the flow rate of the irrigating solution, effectively removing the smear layer and increasing the root canal sealer's ability to penetrate the dentinal tubules.[30,31] Also, Assis et al., found that CHX in the Qmix solution increases the free surface energy of dentin and reduce the contact angle of endodontic sealers.[32] The result of this study, that found the final rinse

of the root canal with Qmix solution showed the highest mean of push-out bond strength, was in agreement with the finding of Gündoğar et al.[33] When comparing the mean value of push-out bond strength of the Qmix with EDTA group, there was no significant difference between them. These results in agreement with (Leal et al. ; Bayram et al. ; Keerthana et al.).[16,34,35] Previous researches concerning the effectiveness of smear layer removal, that using protocols of NaOCl during preparation and as a final rinse EDTA or QMix, found similar smear layer and debris removal capacities. Therefore, indicating the same extension of sealer penetration into the dentinal tubules, so justifying the similar findings of push-out bond strength of the current study.[28,36,37,38] However, other studies concluded that QMix was better than 17% EDTA.[33,39,40]

The lowest mean of push-out bond strength was found in NaOCl group, and there was a highly significant difference shown between QMix group and NaOCl group. This may be attributed to the nature of NaOCl root canal irrigant, which can only remove the organic portion of the smear layer and cannot dissolve the inorganic materials.[37] This results agree with (Banode et al. ; Keerthana et al. ; Gündoğar et al.), they concluded that due to NaOCl was used as irrigation solution, the lowest mean value of smear layer removal and bond strength was gained. [33,35,41]

For AH Plus sealer, this study showed that there was no significant difference in the push out bond strength of AH Plus sealer after using different irrigation solutions (QMix, 17% EDTA, NaOCl). Obviously, AH Plus has high dislodgement resistance and the use of chelating solutions, and NaOCl has a positive effect on AH Plus' push-out bond strength. So due to the removal of the smear layer and debris by using irrigation solutions that lead to complete exposure of the amino groups of the dentinal collagen, therefore, this may increase the number of covalent bonds between the epoxy resin and amino groups, resulting in a stronger bond of AH Plus to root canal dentin. This result in agreement with the results of other studies.[16,19,28,34,42,43]

Regarding the BC sealer, after using different irrigation solutions (QMix, 17% EDTA, NaOCl), this study showed that the removal of the smear layer by using Qmix solution as a final rinse improved the bond strength of BC sealer compared to other irrigation solutions. Two reasons could be attributed to the bond strength of the sealer, firstly: smear layer removal procedures by QMix solution allow the penetration of sealer into the dentinal tubules and this may increase the dentin bond strength of sealer as well as an improved seal, secondly: the suggested mechanism of the sealer's bonding. Thus, because of the hydroxyapatite which represent the main component of dentin, and has a hydroxyl group, and due to the setting reaction of the Total Fill BC Sealer, which is bioceramic-based sealer, that begins by absorbing water from the dentinal tubules, and after this reaction, calcium silicate hydrogel and hydroxyapatite compound are formed. The calcium silicate hydrogel chemically binds to the hydroxyapatite through the hydroxyl groups and this follows a continuous crystal growth process, producing a strong chemical bond with the dentin. Additionally, during the setting reaction of bioceramic-based sealers, these sealers are able to flow through dentinal tubules without any shrinkage.[12,44,45]

The bond strength of BC sealer in Group (II), that using EDTA solution as a final rinse, was lowest as compared to Group (I) that using Qmix solution as a final rinse, this may be due to effect of EDTA on apatite that formed during setting reaction of the sealer. Lee et al., studied adverse effects of EDTA on hydration and micro hardness of MTA and found that after chemomechanical preparation, the residual EDTA left behind in root canal dentin continue to chelate calcium ions released from MTA during hydration, thus interfering with the hydrated products precipitation.[46] Also Govindaraju et al., demonstrated that the compressive strength of tricalcium silicate cements was decreased by using EDTA as irrigation solution to remove the debris.[47] This result in agreement with the results of other studies who stated that after final irrigation of the root canals with Qmix solution and as compared with EDTA and NaOCl solutions, the bond strength of BC sealer was improved.[33] However, this result disagree with Bayram et al., who found that there was a similar effects of Qmix and 17%EDTA on the bond strength of BC root canal sealer.[16] This disagreement may be related to evaluated the adhesion resistance of sealers in the absence of gutta-percha and the methods that used for the irrigation in their study.

The predominant mode of failure for AH Plus group was mixed failure (both adhesive and cohesive failure), this finding is in agreement with (Aranda-Garcia et al. ; Leal et al.) that they observed the predominant failure mode of AH Plus sealer was mixed failure.[28,34] While, the

predominant mode of failure for BC group was cohesive failure, this finding is in agreement with (Shokouhinejad et al. ; Bayram et al.) that they revealed the mode of failure for BC sealer was mainly cohesive.[16,43] This result could be attributed to bioactivity of BC sealer, since BC sealers bond to root dentin and allows ions exchange where the minerals of BC sealer permeate the dentin,[48] and make a mineral infiltration zone at the sealer-dentin interface that may result in lower gap formation compared to AH Plus sealer.[49,50,51] Also, Han & Okiji stated that inside the dentinal tubules, BC sealer forms a tag-like structure that may be responsible for the sealing capacity and dentin bonding of the sealer.[52]

One of the limitations of this study was that it assessed only the bond strength of resin based and bioceramic based sealers under influence of different irrigation protocols, and adhesion is only one property of the endodontic sealer quality. There is another property for future studies such as studying the effect of different irrigation protocols on the penetration depth of different sealers.

CONCLUSION

Within the limitations of this sutdy, it can be concluded that the irrigation solution type plays an important role in the adhesion of endodontic sealers. Irrigation with QMix compared with EDTA and NaOCl irrigation solutions as a final irrigant produces a higher push-out bond strength of BC sealer to radicular dentin, while QMix, EDTA and NaOCl showed no significant difference on the push-out bond strength of AH plus sealer to radicular dentin.

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المستخلص:

الخلفية: تعتبر قوة الترابط بين معاجين الحشو اللبية مع العاج خاصية مهمة للغاية.كان الهدف من هذه الدراسة هو تقييم ومقارنة تأثير مختلف أنواع الري (QMix، EDTA٪17 و NaOCl ٪2.5) على قوة الارتباط والانفصال للخارج لمعاجين حشو الاقنية الجذرية التالية (AH plus و Bioceramic).

المواد والطرق العمل: استخدمت في الدراسة ثمانية وأربعون سن بشري طاحن اولي للفك العلوي مستخرج حديثًا مع جذر حنكي مستقيم. تم تقسيم العينات التي تم جمعها بشكل عشوائي إلى ثلاث مجموعات متساوية في حجم العينة (ستة عشر جذرا في كل مجموعة) ، وفقًا لنظام الري النهائي على النحو التالي:

المجموعة الاولى: ري نهائي بمحلول QMix،

المجموعة الثانية: ري نهائي بمحلول EDTA بتركيز 17٪،

المجموعة الثالثة: ري نهائي بمحلول هايبوكلورات الصوديوم وبتركيز 2.5 ٪.

تم تجهيز جميع العينات باستخدام أداة (Edge file X7) الدوارة التي تصل إلى حجم 40 / 0,04. بعد ذلك تم تقسيم كل مجموعة بشكل عشوائي إلى مجموعتين فرعيتين (ثمانية جذور في كل مجموعة فرعية) ، وفقًا لنوع معجون الحشو المستخدم: (AH Plus و Total Fill BC). تم سد القناة الجذرية باستخدام تقنية المخروط الفردي باستخدام (gutta perch) لجميع الجذور التجريبية. تم الحصول على شرائح بسمك 2 مم من القسم الأوسط من الجذر. تم قياس قوة الارتباط لماجين الحشو عبر آلة اختبار عالمية باستخدام مكبس من الفولاذ المقاوم للصدأ. بعد ذلك ، تم تقييم البيانات إحصائيًا باستخدام تحليل التباين ثنائي الاتجاه (ANOVA) والاختبار اللاحق (اختبار Bonferroni).

النتائج: اظهرت النتائج تأثر قوة الارتباط معنويا بعامل "الري" والتفاعل "معجون الحشو / محلول الري". أظهر الري النهائي بمحلول (QMix) باستخدام معجون الحشو (Bioceramic) أعلى متوسط قوة ارتباط ، مع وجود فرق معنوي مع المجموعات الأخرى. بينما أظهر الري النهائي بمحلول هايبوكلورات الصوديوم و باستخدام معجون الحشو (AH Plus) أقل متوسط قوة الرابطة.

الاستنتاجات: نستنتج من ذلك ان الري النهائي لقنوات الجذر بأستخدام مواد الري المختلفة يؤثر على قوة ارتباط معاجين حشو الاقنية الجذرية ، وكان لمحلول الري (Qmix) تأثير إيجابي على قوة ارتباط معجون الحشو (Bioceramic).