

In vitro study to compare the sealing ability of a hydroxyapatite endodontic sealer with other sealers (Quantitative Measurement)

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ABSTRACT

This study is designed to compare and evaluate the sealing ability of a new Iraqi hydroxyapatite-containing endodontic sealer and other sealers using spectrophotometric system as a quantitative measurement of the volume of dye penetration into root canals. Fifty single-rooted extracted human teeth were used.

Step-back technique was used to flare and enlarge the canals, the teeth were divided into five groups according to the type of sealer used :Group I: Zinc oxide eugenol cement sealer, Group II: ZOE + hydroxyapatite (Iraqi), Group III: Glass ionomer cement sealer, Group IV: GIC + hydroxyapatite (Iraqi), Group V: Calcium phosphate cement + zinc oxide (Wach's cement).

All groups were immersed in methylene blue dye for one week then dissolved in 50% nitric acid and filtered then centrifuged. The leakage was assessed quantitatively using a spectrophotometric system. The results showed that calcium phosphate cement + zinc oxide, (Wach's cement) had the lowest mean of dye leakage, followed by glass ionomer cement sealer, then glass ionomer cement sealer + hydroxyapatite, while ZOE had the highest mean of dye penetration into the filled root canal. The newly developed Iraqi hydroxyapatite containing endodontic sealer was as effective as the other tested sealers concerning apical microleakage.

Key Words: Sealer, hydroxyapatite, zinc oxide eugenol.

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الخلاصة

أجريت هذه الدراسة لمقارنة قابلية الختم لمادة الختم المحتوية على الهيدروكسي أبيتايت $Ca_{10}(PO_4)_6(OH)_2$ ومواد الختم الأخرى باستخدام جهاز الطيف الضوئي لقياس كمية صبغة الميثيلين الزرقاء الداخلة إلى قناة جذر السن.

يتكون النموذج المستخدم لهذه الدراسة من (٥٠) سنناً دائماً ذي قناة جذرية مستقيمة واحدة، تم قطع الجزء التاجي لكل الأسنان، ووسّعت ذروة السن لحجم (٢٥) لغرض تثبيت القياسات لجميع الأسنان، وقد حُضرت القنوات بطريقة التوسيع باستخدام نوع (K-file) وطريقة (Step-back action)، غُسلت القنوات بمادة المحلول الملحي الفسيولوجي (Normal saline solution)؛ بعد ذلك قُسمت الأسنان إلى خمس مجموعات، في كل مجموعة (١٠) نماذج استناداً لنوع مادة الختم المستخدمة في حشو القنوات وكما يلي: (١) أكسيد الزنك والأيوجينول (ZOE)؛ (٢) أكسيد الزنك والأيوجينول + الهيدروكسي أبيتايت $(Ca_{10}(PO_4)_6(OH)_2)$ ؛ (٣) سمّنت الأيونومير الزجاجي (Glass ionomer cement)؛ (٤) سمّنت الأيونومير الزجاجي + الهيدروكسي أبيتايت $(Ca_{10}(PO_4)_6(OH)_2)$ ؛ و (٥) سمّنت فوسفات الكالسيوم + أكسيد الزنك (سمّنت الوجيز) (Wach's cement).

غُطّي سطح كل جذر بطبقات متعددة من مادة شمع اللصق ماعداً (١) ملم القريبة من الذروة، ثم غُمرت النماذج بمحلول يحتوي على (٢%) مل من صبغة الميثيلين الزرقاء لمدة أسبوع ووضعت في حاضنة (Incubator) بدرجة حرارة (٣٧°) مئوية؛ بعد ذلك أذيب كل نموذج في (٢) مل من حامض النتريك المركز بنسبة (٥٠%) كمادة مذيبيّة؛ يَرشّح المحلول الناتج، بعدها يُقاس تركيز الصبغة النافذة إلى قناة جذر السن.

أظهرت النتائج أن الصبغة قد دخلت إلى قنوات الجذر كافةً ولكل المجاميع المُختبِرة. أظهرت مجموعة سمّنت فوسفات الكالسيوم + أكسيد الزنك (سمّنت الوجيز) أقل نفوذية إلى قناة جذر السن، تلتها مجموعة سمّنت الأيونومير الزجاجي ومن ثم مجموعة مادة الختم المحتوية على الهيدروكسي أبيتايت، وكانت أعلى نفوذية في مجموعة أكسيد الزنك والأيوجينول.

INTRODUCTION

The preservation of endodontically treated tooth in a healthy state is achieved by proper diagnosis, biomechanical preparation and obturation⁽¹⁾. The emphasis on filling canals in three dimensions stresses the importance

of placing a sealer in the canals to the apex of the tooth, with the solid core forcing the sealer into any irregularities or accessory canals⁽²⁾.

Many studies⁽³⁻⁵⁾ had stated that all root canal sealers leak to some extent, there is probably a critical level of leakage that is unacceptable for healing, and therefore, results in endodontic failure.

Most root canal cements are basically composed of ZOE modified by additives for greater opacity, strength, setting and adhesion⁽⁶⁾. Practically all ZOE sealer cements are cytotoxic and invoke an inflammatory response in connective tissue, ZOE is a chemotactic when tested in the Boyden chamber, the response can be long lasting since inflammation will persist until the excess eugenol or ZOE cement particles are absorbed by macrophages⁽⁷⁾.

Glass ionomer cements (GIC) are based on the hardening reaction that occurs between particular species of ion-leachable glasses and the aqueous solutions of polyacrylic acids. GIC bond chemically to dentin and hydroxyapatite of enamel and releases fluoride ions⁽⁸⁾.

In a study done by Wu Min Ka et al.⁽⁹⁾, it was pointed that after condensation ketac-endo leaked less than AH-26 and found that without condensation, the amount of leakage of two sealers were similar.

Wach's sealer contains powder (calcium phosphate, zinc oxide, bismuth subnitrate, bismuth subiodide and heavy magnesium oxide) and liquid (oil of clove and Canada balsam). Because of its low level of tissue irritation and limited lubricating characteristics, this sealer is desirable when there is the possibility of over extension beyond the confines of the root canal^(10, 11).

Several root canal sealers are composed of either hydroxyapatite or tricalcium phosphate (TCP) which appear to be biocompatible with both bone and soft tissues^(12, 13). In 1996, a new sealer containing hydroxyapatite has recently been developed. Hydroxyapatite is assumed to influence apical healing, but its composite structure may also affect the cement's sealing ability⁽¹⁴⁾.

The purpose of this study was to compare and evaluate the sealing ability of a new hydroxyapatite-containing endodontic sealer with other different types of sealers using spectrophotometric system.

MATERIALS AND METHODS

Fifty single-rooted extracted human teeth with straight canals, were used in this study; all teeth had mature apices. The coronal portion of teeth were removed at the cemento-enamel junction in order to eliminate the variables in the access preparation. Canal patency was determined by passing a no. 10 file through the apical foramen 1 to 2 mm. The pulpal tissue was removed by barbed broaches. The working length was measured, each root canal was serially prepared to a minimal size of a 45 k-file at the apical seat and the rest of the canal was flared to a no. 70 k-file using conventional step-back technique. The patency of the apical foramen was maintained by passing the tip of a no. 15 k-file through the foramen. Recapitulation with the master apical file was done after each file size.

One ml. of normal saline was used between file sizes for irrigation and each canal was finally irrigated with 5 ml. of normal saline solution and dried with absorbent paper points.

The teeth were divided into five equal groups according to the type of endodontic sealer used in obturation; which were: I) ZOE sealer*, II) hydroxyapatite (Iraqi) + ZOE cement sealer, III) glass ionomer cement sealer**, IV) hydroxyapatite (Iraqi) + GIC sealer, and V) Wach's cement (calcium phosphate cement sealer + zincoxide)*** (figure 1).

All canals were obturated with the lateral condensation of gutta-percha, and selected type of endodontic sealer for each group (figure 2). The roots of all teeth were coated with many layers of sticky except one mm. apically, then immersed in 2% methylene blue dye**** for one week, after that the teeth were cleaned out, and each tooth was dissolved in (2) ml. of 50% nitric acid as a decalcifying agent for 48 hours (figure 3). The resulting solution was filtered and centrifuged at 4000 – 6000 rpm. The solution was analyzed using a spectrophotometer device***** , and the collected data were analyzed statistically using ANOVA test and student t-test.

* Dorifill, Dorident, Austria.

**Endion, Voco, Germany.

***Alpha dental products C., USA.

****Bucket Bot Corp., Switzerland.

*****Pye Unicom, England.

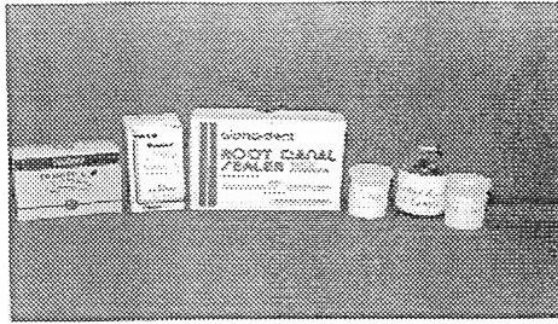


Figure (1): The five types of sealers tested



Figure (2): Flared technique allows for deep penetration of the spreader within 1-2 mm of the working length when master cone fitted snugly

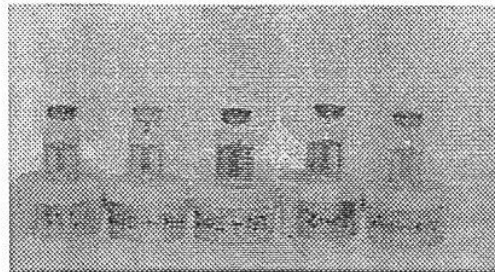


Figure (3): A comparison of the solutions obtained after decalcification of the samples in the five experimental groups

RESULTS

A summary of the statistical analysis is shown in table (1). Analysis of variance (ANOVA) test was performed to test the differences between the means of volumetric leakage among the five experimental groups; a statistical significant difference was found among all the experimental groups ($P < 0.05$). the results of ANOVA test are seen in table (2).

The student t-test results are compiled in table (3), this test was done to compare the leakage between each pair of tested groups. The results of comparison between each pair groups showed significant differences except between group I and group II and between group III versus group IV (figure 4).

Table (1): Summary of the statistical analysis

Group	Type of Sealer	No. of Teeth	Max. leakage	Min. leakage	Mean	S.D
I	ZOE	10	0.264	0.116	0.188	0.046
II	ZOE + HA	10	0.241	0.112	0.175	0.039
III	GIC	10	0.172	0.084	0.121	0.027
IV	GIC + HA	10	0.183	0.082	0.127	0.036
V	(Wach's cement)	10	0.088	0.068	0.079	0.007

Table (2): ANOVA test results

Source of Variation	S.S	d.f	M = $\frac{S.S}{d.f}$	F-value
Between groups	0.079	4	0.019	17.909
Within groups	0.051	45	0.001	
Total	0.130	49		

d.f = degree of freedom; S.S = Sum of squares; M.S = Mean of squares.

Table (3): Results of student t-test

Comparison Groups	t-value	Significance
I vs. II	0.693	N.S
I vs. III	4.025	S
I vs. IV	3.337	S
I vs. V	7.524	S
II vs. III	3.640	S
II vs. IV	2.882	S
II vs. V	7.764	S
III vs. IV	-0.433	N.S
III vs. V	4.884	S
IV vs. V	4.229	S

S = Significant; N.S = Not significant.

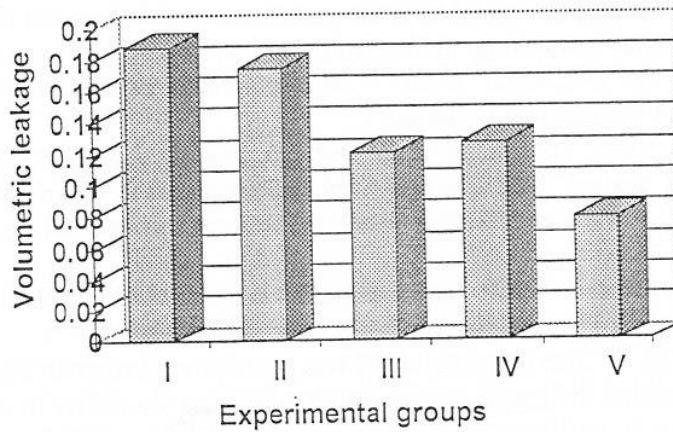


Figure (4): Bar chart graph to compare the mean leakage (volumetric measurement) for the five experimental groups

DISCUSSION

Three main factors could affect the final results in endodontic therapy when microleakage is considered; first, sealer material; second, final canal configuration; third, technique of obliteration.

Flared technique allowed deeper penetration of the endodontic root canal spreader and irrigant needle to facilitate the lateral condensation of gutta-percha⁽¹⁵⁾.

Materials used to determine the leakage are usually dyes such as methylene blue dye. In this study the actual volume of dye leakage into the root canal system was calculated by using spectrophotometric analysis; this method provides a direct quantitative measurement of the material leaking into the radicular space or spaces⁽¹⁶⁾. There is a lack of correlation between linear dye penetration and the actual volumetric leakage since linear value may represent a thin spike of leakage⁽¹⁷⁾.

Root canal sealers are intended to permanently fill inevitable voids between solid root canal filling and the root canal wall. In this study all experimental sealers leaked, but some leaked more than others, which may be due to differences in sealers dissolution⁽¹¹⁾.

A new Iraqi sealer that contain hydroxyapatite has been developed and used. In the present study, the mean of volumetric leakage of hydroxyapatite containing endodontic sealer is not significantly different from other endodontic sealers that doesn't contain hydroxyapatite in their composition. The addition of (HA) to the endodontic sealer does not have in adverse effect on the sealing ability of root canal sealer; the same results were reported by Gambarini *et al.*⁽¹⁴⁾, who found that the additive did not adversely affect the sealing properties.

In this study ZOE cement showed significantly more leakage than other types of sealers. This fact might be explained due to the inability to bond to the dentinal tissue. Also it could be due to porosities found in ZOE sealer⁽¹¹⁾.

Wach's cement sealer was statistically better than GIC in reduction of apical leakage, the same finding was documented by Pittford⁽¹⁸⁾.

Ray *et al.*⁽¹⁹⁾ also found that GIC was superior to Grossman's sealer. They explained that finding due to the fact that GIC has the ability to adhere tightly to dentin, in addition the solubility and disintegration of GIC are very low in comparison with other sealers.

CONCLUSIONS

1. The newly developed Iraqi hydroxyapatite-containing endodontic sealer was as effective as the other tested sealers concerning apical microleakage.
2. CPC cement + ZO (Wach's cement) has significantly less apical leakage than other tested sealers.
3. An adhesive, glass ionomer cement sealer showed significantly less dye penetration than ZOE cement sealer.
4. Dye penetration was significantly more with the ZOE cement sealer.

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