

A Comparative Evaluation of Apical Seal Associated with Ultrasonic Retrograde Cavities Filled with Bioactive Material (*In Vitro* Study)

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ABSTRACT

Background: The aim of this study was to evaluate and compare the apical microleakage around retrograde cavities prepared with ultrasonic technique and filled with (Biodentine™)

Materials and methods: 40 extracted single rooted human permanent maxillary teeth with mature apices were selected. The roots were prepared chemo-mechanically using k-files with crown-down technique and then obturated with lateral condensation gutta-percha technique. Teeth were divided into four main groups according to the cavity preparation method either manual or ultrasonic technique:

Group A (n=10): A class I retrograde cavity at root end was prepared with traditional handpeice equipped and placement of Biodentine with manual condensation.

Group B (n=10): A class I retrograde cavity at root end was prepared with Piezoelectric ultrasonic device equipped with ultrasonic tip with only manual compaction of the material.

Group C (n=10): traditional handpeice and placement of Biodentine using both manual compaction and 5 second ultrasonic activation.

Group D (n=10): Piezoelectric ultrasonic device and placement of Biodentine with both manual compaction and 5 second ultrasonic compaction. The teeth were immersed in 1% aqueous Methylene blue dye for 72 hr. Then they were sectioned longitudinally with a diamond disc and the depth of dye penetration was examined under high magnification 20X.

Results: Statistical analysis showed a highly significant difference in microleakage among the tested groups in which Piezoelectric technique has proved superiority in retrograde cavity preparation and compaction of Biodentin when dye penetration scores were compared. So microleakage was highest with cavities prepared with handpeice and manual application of retrograde material group A (2.73 ± 0.39) followed by microprepared cavities group C (1.86 ± 0.16), and it was lowest with ultrasonically-prepared cavities group B (1.09 ± 0.28) and group D (0.26 ± 0.19).

Conclusion: ultrasonic preparation produced significantly less microleakage than conventional method. Also less microleakage was observed with ultrasonic compaction of Biodentin when compared with conventional method of compaction.

Keywords: Endodontic surgery, microleakage, Biodentine, Piezoelectric ultrasonic device, retrograde cavities. (J Bagh Coll Dentistry 2016; 28(3):15-21).

INTRODUCTION

Surgical root canal therapy is an alternative treatment of apical periodontitis of endodontic origin when nonsurgical root canal treatment or retreatment fails or when nonsurgical retreatment is impossible ⁽¹⁾.

The surgical procedure is preceded by resecting an infected portion of the root apex to eradicate the periapical lesion which is the source of infection and preparing a cavity at the root end ⁽²⁾. A permanent root-end filling is then placed to provide an adequate apical seal that prevents passage of bacteria or their products from leaking root canal space into the periapical tissues ⁽³⁾.

Over many years ago, a numerous number of materials have been suggested for use as root-end fillings, including amalgam, gutta-percha, zinc

oxide eugenol cements, composite resins, glass ionomer, polycarboxylate cements, ethoxybenzoic acid (EBA) cement, and mineral trioxide aggregate (MTA).

The main prerequisites of ideal root end filling material are as follows: biocompatibility, promotion of tissue regeneration without causing inflammation, ease of handling, low solubility in tissue fluids, bonding to dental tissue, non-absorbable, dimensional stability, radio-opacity and no staining of surrounding tissues ⁽⁴⁾.

Recently, a new bioactive retrofilling material namely Biodentine™ (Septodont, France) has been developed as dentine replacement material with the aim of improving the clinical use and overcoming MTA limitations. It is primarily composed of tricalcium silicate, whereas zirconium oxide is added as a radiopacifier. Biodentine powder also contains calcium carbonate, while the liquid consists of calcium chloride, and a hydrosoluble polymer. It has been reported that Biodentine shows a reduced time setting with promising physical and biological

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properties as a dentine restorative material and was recently suggested as a pulp-capping material. Besides that, Biodentine has the potential to release calcium hydroxide when it comes in contact with physical tissue fluid enhancing the sealing ability of the material itself⁽⁵⁾.

The traditional technique used to cut the root apex was usually performed with using a low-speed turbine and round bur. However, the application of piezo electric ultrasonic for root end preparations showed promising results in terms of optimal cleaning of apical tissue debris and minimally invasive technique with high efficiency. Piezoelectric device contains a crystal, when an electrical charge is applied, this crystal undergoes deformation that is converted into mechanical oscillation without producing heat^(6, 7). There are limited studies on using ultrasonic technique for root end cavity preparation and their effects on marginal adaptation of new calcium based cement material, Biodentine (Septodont, France).

The null hypothesis was tested in the current study is that the sealing ability of Biodentine on ultrasonic root end cavities is not comparable to that one prepared with traditional bur technique. This in vitro study aimed to assess and compare the sealing ability of calcium silicate based materials filled retrograde cavities prepared with two techniques of traditional bur and ultrasonic.

MATERIALS AND METHODS

Teeth selection

Forty human freshly extracted human single-rooted teeth with mature apices and straight roots were selected and teeth selection from patients aged (18-45) years. The apical 3rd of each root was examined to make sure it is free from any fracture, calcifications, resorption or cracks⁽⁸⁾. Teeth were cleaned with ultrasonics and stored in distilled water at room temperature (fig. 1).

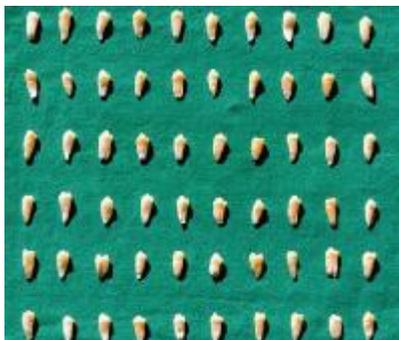


Fig. 1: The selected teeth

Preparation of specimens

Crowns were sectioned above the cemento-enamel junction to standardize the working length of the specimens of about 16 mm. The access cavities were prepared using endo round access bur #2 (Dentsply, Maillefer), the root canal patency was confirmed by passing a 10-K file (Maillefer, Ballaigues, Switzerland), The irrigant solution was 20 ml of 0.5% NaOCl for each tooth. After being cleaned and shaped, canals were dried with paper points, working length was determined. Barbed broaches were used for pulp extirpation. Then root canals were prepared with hand K- Files together with irrigation with 5 ml of freshly prepared 5.25% sodium hypochlorite (NaOCl) solution and rinsed with 3 mL of 17% ethylenediaminetetraacetic acid (EDTA) for 5 min to remove the smear layer using crown down technique, enlarging up to apical size #60 instrument and paper points were used for dryness and master cone was placed, The selected cone was fitted to ensure a snug fit apically. Lateral condensation obturation method, using finger spreaders was carried out for filling root canals⁽⁹⁾. The apical 3mm of each root was removed using high speed handpiece (W&H, Austria) and a diamond parallel sided fissure bur (Komet Dental, Austria) perpendicular to the long axis of the root under water and air spray to ensure standardization and facilitate root end cavity preparation⁽¹⁰⁾.

Retrograde cavity preparation

A round root end cavity was prepared with 3mm depth in which its shape and dimensions are standardized according to the shape of bur which was used in our study (carbide round bur #2, Komet Dental, Austria)⁽⁷⁾. For ultrasonically prepared cavities, a surgical round retro tip (surgysonic I, ES03A) with 2mm head was used for standardization of cavity. 3mm depth is considered the minimum depth of retrograde filling to establish good seal.

Sample Grouping:

A total of 40 teeth were randomly divided into four main groups ($n = 10$ each) according to method of root end cavity preparation either with bur or Piezoelectric ultrasonic device (ESACROM, Italy) equipped with ultrasonic retro tip, fig2:

Group A (10 teeth): A class I round retro cavity at root end with 3mm depth was prepared with right-angled low speed Handpiece (W&H, Austria) equipped with carbide round bur #2 (Komet Dental, Austria) and Biodentine, fig(2)

(Septodont, France) was placed inside retro cavity manually using small hand condenser.

Group B (10 teeth): A class I round retro cavity at root end with 3mm depth was prepared using Piezoelectric ultrasonic device (ESACROM, Italy), fig(3) equipped with diamond coated stainless steel ultrasonic surgical retro tip , fig(4) (surgysonic I, ES03A) at (30-kHz) frequency and Biodentine (Septodont, France) was placed inside retro cavity manually using small condenser.

Group C (10 teeth): A class I round retro cavity at root end with 3mm depth was prepared with right-angled low speed Handpiece (W&H, Austria) equipped with carbide round bur round bur #2 (Komet Dental, Austria) and Biodentine (Septodont, France) was placed inside retro cavity using both manual compaction and 5 second ultrasonic activation using ultrasonic condenser tip, fig (5) (surgysonic I, ES08A).

Group D (10 teeth): A class I round retro cavity at root end with 3mm depth was prepared using Piezoelectric ultrasonic device (ESACROM, Italy) equipped with diamond coated stainless steel ultrasonic surgical retro tip (surgysonic I, ES03A) at (30-kHz) frequency and Biodentine (Septodont, France) was placed inside retro cavity with both manual compaction and 5 second

ultrasonic compaction using ultrasonic condenser tip (surgysonic I, ES08A).

Microleakage study

Immediately after application of retrograde filling and setting of Biodentine which required 12 min., all the specimens were coated with two coats of nail varnish except for the apical 3mm and were allowed to dry for 24hrs. After dryness, the teeth were suspended so that only 2-3mm of the root was immersed in 1% aqueous Methylene blue dye in an incubator at 37°C for 72 hr. ⁽¹¹⁾. Then roots were washed and sectioned longitudinally with a diamond disc using a water coolant. The depth of dye penetration was examined under a stereomicroscope with magnification of 20X using a calibrated scale within the lens of optical microscope to evaluate the roots for leakage. The greatest depth of dye penetration along one of the cavity walls was taken. The depth of dye penetration was measured in millimeters ⁽¹²⁾.

Statistical analysis

Mean and Standard deviation were estimated from the sample for each study groups. Mean values were compared by one-way ANOVA / LSD test. SPSS statistical software version 18 (IBM. SPSS Inc.USA) was employed to analyze the tested groups.



Fig. 2: Biodentine (Septodont, France) capsule



Fig. 3: Piezoelectric ultrasonic device



Fig. 4: Ultrasonic surgical retro tips (surgysonic I)



Fig. 5: Ultrasonic condenser tip ES08A

RESULTS

Dye penetration method was used to compare sealing ability of material (Biodentine). Table 1

summarizes the mean values, standard deviation, standard error, minimum and maximum values for all groups:

Table 1: Descriptive statistics of microleakage of retrograde cavities in (mm)

Groups	N	Mean	S.D.	S.E.	Min.	Max.
A	10	2.37	0.39	0.12	1.8	3
B	10	1.09	0.28	0.09	0.7	1.4
C	10	1.86	0.16	0.05	1.5	2
D	10	0.26	0.19	0.06	0	0.5

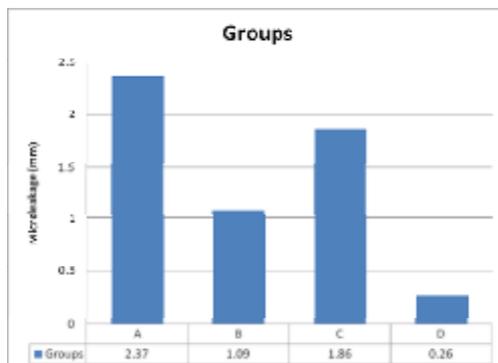


Figure 6: mean values of apical microleakage in (mm) of the tested groups

All techniques used for root end preparation had shown a degree of microleakage. The overall comparison of the mean gap at the dentin-retrograde filling material inter-face values of the four tested groups has shown that ultrasonically-prepared cavities had less microleakage than micro prepared cavities, so microleakage was highest with apical cavities prepared with handpiece and manual application of retrograde material group A (2.73±0.39) followed by

microprepared cavities but with both manual and ultrasonic compaction of (Biodentin) group C (1.86±0.16), and it was lowest with ultrasonically-prepared cavities with or without ultrasonic compaction group B (1.09±0.28) and group D (0.26±0.19).

In order to identify the presence of statistical significant difference among groups, One way ANOVA test was carried on.

Table 2: One way ANOVA test to show the statistical difference of dye penetration between groups

ANOVA	Sum of Squares	d.f.	Mean Square	F-test	p-value
Between Groups	25.481	3	8.494	115.038	0.000
Within Groups	2.658	36	0.074		(HS)
Total	28.139	39			*

***Highly significant at level P<0.001.**

The revealed ANOVA results had shown highly significant influence (P< 0.001) of method of apical cavity preparation and compaction method of retrograde filling on the amount of microleakage or dye penetration.

Because a significant difference was found, least significant difference (LSD) test was done to analyze the data to show the difference in microleakage between different groups (table 3).

Table 3: LSD test to compare the microleakage between each pair of tested groups

Groups	Mean Difference	p-value	
A	B	1.28	0.000 (HS)*
	C	0.51	0.002 (HS)*
	D	2.11	0.000 (HS)*
B	C	-0.77	0.000 (HS)*
	D	0.83	0.000 (HS)*
C	D	1.60	0.000 (HS)*

***Highly significant at level P<0.001.**

These investigations had shown that there was a highly significant difference ($P < 0.001$) between each pair of tested groups when dye penetration values were compared.

DISCUSSION

Microleakage has been defined as the passage of bacteria, ions, molecules, fluids or chemical substances between the root structure and the applied restorative material and is one of the major factors influencing the longevity of the dental restoration and it has been reported to cause failure of endodontic treatment^(13, 14).

Surgical approach is commonly indicated in situations such as persistence of periapical pathology, overfilled canals, ledges, canal obstructions, separated instruments, apical transportations and perforations. The goals of periradicular surgery are to gain access to the affected area by root end resection, followed by insertion of a root end filling material which aims to create a biocompatible seal that stimulates regeneration of the periodontium. It is an important conservative treatment and an extension of endodontic therapy whose purpose is to preserve the tooth⁽¹⁵⁾.

Several techniques have been used for assessment of apical seal, however, dye penetration techniques still remain one of the commonest methods to test sealing ability of restorative materials which is simple and safe (methylene blue, fuchsin, rhodamine B, fluorescent dyes). These materials are able to prevent the leakage of small molecules (tracer solutions) equals 1.2nm^2 which equals 120 \AA^2 , this particle size is less than that of the bacterial one⁽¹⁶⁾.

One of the pre-requisites for the success of surgical endodontics relies on selection of root end filling material. In recent years many materials have been used for root-end fillings in endodontic surgery. Biodentine has received crescent interest as a retrograde material with promising results in which it is a new material based on calcium silicate technology and water chemistry. The powder contains dicalcium silicate, tricalcium silicate, calcium carbonate, iron oxide, and zirconium oxide filler. Liquid consists of calcium chloride which is acting as accelerator and a polymer which is acting as a water reducing agent⁽⁵⁾.

Pawar et al⁽¹⁷⁾ successfully treated a large periapical lesion using Biodentine as retrofilled material in their 18 months follow-up case study. When Biodentine comes in contact with dentine it leads to the formation of tag-like structures alongside an interfacial layer called the “mineral

infiltration zone,” where the alkaline caustic effect of calcium silicate cements hydration products degrades the collagenous component of interfacial dentine.

Han and Okiji et al⁽¹⁸⁾ showed that calcium and silicon ion uptake into dentin leading the formation of tag-like structures in Biodentine. An interesting feature of Biodentine is the product packaging in a new pre-dosed capsule formulation for use in a mixing device largely improve the physical properties and better handling including sealing ability of the material also the modified powder composition and the addition of setting accelerators and softeners has an advantage of fast setting time (12 min) thereby sealing the interface earlier to avoid further leakage to take place so there is a lower risk of bacterial contamination⁽⁸⁾.

The development of ultrasonic retrotips has revolutionized root end therapy, improving the surgical procedure with better access to the root end⁽¹⁹⁾.

Piezoelectric units have some advantages compared with earlier magnetostrictive units because they offer more cycles per second, 40 versus 24 kHz. The tips of these units work in a linear, “piston-like” motion, which is ideal for surgical endodontics when creating a preparation for a retrograde filling. Also it produces less heat when compared to magnetostrictive unit.

The introduction of the ultrasonic tips has many advantages over the conventional bur preparation. The cavities prepared are conservative and precise because the cavity will be along the long axis of the root thus causing minimal destruction to the morphology of the canal also lessens the risk of lateral perforation. Furthermore, the geometry of the retrotip design does not require a beveled root-end resection for surgical access, thus decreasing the number of exposed dentinal tubules and minimizing apical leakage while cavities prepared with the conventional slow speed handpiece result in more exposure of dentinal tubules and formation of considerable amount of debris and smear layer which are permeable to fluids and toxins thus preventing the intimate contact of the material to the cavity walls⁽⁶⁾.

This may be the reason for less microleakage observed in our study with cavities prepared with ultrasonic retrotips when we compared it with those prepared with conventional bur. This result is also accordance to study by Harikaran et al⁽¹²⁾ who explained the result to the different surface irregularities produced by the two methods in which surfaces prepared with carbide burs are known to be less rough than those prepared with diamond-coated ultrasonic tips. A rougher and

hence more irregular surface offers a greater contact surface area, improving the retention and stability of the filling material reducing the risk of interface gaps and the resulting microleakage. Pragna et al⁽²⁰⁾ found no significant difference between ultrasonic and conventional method, While results by Salwan et al⁽¹⁶⁾ disagrees with our study wherein they found better performance of slow speed handpeice compared to ultrasonics and attributed that result to the assumption of possible microfractures, cracks and surface changes of the cavity walls after ultrasonic preparation which were seen by many authors to be significantly more than those seen in cavities prepared by burs^(21,22).

The retrofilling materials are inserted into the retrograde cavity aiming to provide apical sealing and to prevent microorganism penetration, decreasing the leakage of irritating agents in the material/canal's wall interface and contributing to periapical repair and preventing surgical treatment failure⁽⁵⁾.

Condenser tip ultrasonically activated can be utilized for placement of retrograde filling materials. The results of our study demonstrated that the use of ultrasound for Biodentin compaction inside retrograde cavity resulted in significantly less microleakage when compared with manual compaction. This is in agreement with Roberta et al⁽²³⁾ in which they attributed it to the assumption that the ultrasonic vibration made a higher performance of the condenser during the compaction procedure because it helped in better distribution and density of the material inside the retrograde cavity improving the flow, settling and compaction of the material to root end dentinal walls with fewer voids.

According to the results of this study, the null hypothesis rejected as Biodentine placed on ultrasonic root end cavities is comparable to that one prepared by traditional bur technique.

Within the limitations of this study, the following conclusions were drawn:

1. Statistically highly significant differences were found comparing the results of ultrasonic retrotip preparation versus conventional bur preparation in which ultrasonics produced significantly less leakage and better seal.
2. Ultrasonic compaction of Biodentine was superior to manual compaction in terms of microleakage and apical seal, in the overall comparisons.

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