



The Simultaneous Effect of Apical Resection Angle and Depth of Retrograde Cavity on Apical Microleakage via Fluid Filtration Method

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ABSTRACT

Introduction: The goal of apical surgery is to eliminate the root apex, apical lesions and promote tissue repair. In apical surgery, the root is resected at an angle of 45, 60 or 90 degree. In many cases, it is not possible to resect the root at 90-degree bevel and prepare a root-end cavity with 4-mm depth. The aim of this study was to evaluate the simultaneous effect of apical resection angle and depth of the retrograde filling with mineral trioxide aggregate (MTA) on apical microleakage. **Methods and Materials:** Root ends were resected at 45 degree, 60 degree and 90 degree bevels in 110 extracted human single root permanent teeth. For each apical surgery, root-end cavities were filled with MTA to depths of 2 mm, 3 mm and 4 mm. Root end-filled teeth were mounted in fluid filtration device. The evaluation was conducted after 24-h, 1 week, 1 month, 2 months and 3 months. Each group included 10 samples. Also 20 roots were used as positive and negative control samples, in the negatives the entire root surface was coated with 2 layers of nail varnish and positives were unfilled root-end preparation. Statistical analysis consisted of the Kruskal-Wallis test and Pairwise comparison. **Results:** There were no significant differences in apical microleakage after 24 h and 1 week in the experimental groups. In the 3rd month, samples with 90° bevel and 4-mm-thick MTA showed significant statistical differences with all samples with 45° and 60° bevels and depths of 2- and 3-mm-thick MTA ($P<0.05$). **Conclusions:** This *in vitro* study showed that when the resection angle is 90°, retrograde depth does not affect microleakage, but resection angles other than 90°, require 4 mm-retrograde depth to be sealed.

Keyword: Microleakage; Mineral Trioxide Aggregate; Retrograde Obturation; Root Resection

Introduction

Microorganisms play an important role in the development of periradicular diseases [1, 2]. The goal of nonsurgical endodontic treatment is to eliminate microorganisms and their byproducts from the root canal system, and establish an effective barrier between the root canal system and the surrounding tissues [3]. If healing in peri-radicular tissues does not occur after non-surgical endodontic treatment or it becomes impossible to implement retreatment, and in order to avoid tooth extraction, surgical endodontic treatment is necessary [4]. This treatment usually consists of raising a mucoperiosteal flap, osteotomy, root-end resection, root-end preparation, and root-end filling [5]. An ideal retrograde material should be nontoxic, non-carcinogenic, biocompatible, insoluble, and have dimensional stability and

sealing ability [6]. Different materials have been used for root-end fillings in apical surgery, such as amalgam, glass ionomer cements, zinc oxide-eugenol based materials (SuperEBA, IRM, Rickert), calcium-enriched mixture (CEM) cement [7, 8] and mineral trioxide aggregate (MTA) [9, 10]. Among all these materials, MTA has several potential clinical applications due to its superior sealing property, ability to set in the presence of blood, antibacterial effects, biocompatibility, and radiopacity [4, 11]. However, there are disadvantages when using MTA, such as the extended setting time and the difficult to handle [11, 12]. Today, MTA is the gold standard for retrograde cavities [13]. After placing MTA, initially it has mechanical retention on the canal walls, but by spreading of the particles, it establishes a chemical bond to the dentinal walls [14]. Leakage after surgical endodontic treatment is a complex subject, because many

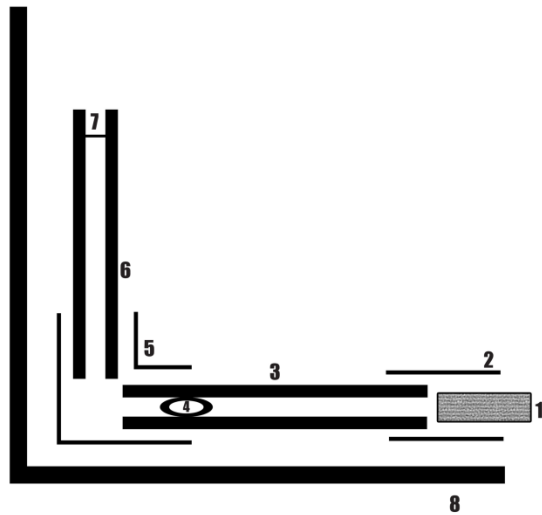


Figure 1. Schematic diagram of fluid filtration system. (1) Specimen, (2) Connector, (3) Pipette, (4) Air bubble, (5) Connector, (6) Glass tube, (7) Level of water (20 cm), (8) wooden base for fixing samples

variables might influence leakage, such as root-canal filling techniques, the physical and chemical properties of root-end filling materials used, apical root resection, root-end cavity depth and the smear layer [11].

The apical leakage is possible along the interface of filling material and the canal walls. Also, flow of substances along the open dentinal tubules at the resected root can lead to leakage *via* permeable dentin [15]. Hence, root end leakage might be affected by the angle of apical resection through number of exposed dentinal tubules [16]. This suggest that the bevel angle should be reduced and the retrograde filling should be extended to at least the coronal surface bevel to minimize the number of exposed dentinal tubules [17]. A 45 degree buccolingual bevel is an option to facilitate the insertion of retrofilling materials [18]. After root end resection, considering root length, presence or absence of intra canal post and tooth accessibility, the canal is prepared with ultrasonic up to 4 mm depths [12].

Yildirim *et al.* [11], showed that MTA thickness (3-5 mm) in the root end cavity does not affect the bacterial leakage. On the contrary, others showed that by increasing the thickness of the MTA, microleakage was reduced. Evaluations of root-end filling materials has been assessed *via* radioisotope, dye, bacteria and fluid filtration [19]. Each technique has significant limitations that might lead to errors [5]. Considering the accuracy of the fluid filtration method as well as not destroying the samples, this method was used in the present study [20].

In many cases, due to vision limitation, intra canal posts, root lengths and lack of access to the surgical site, it is not

possible to resect the root at 90 degree bevel and prepare a root end cavity with 4-mm depth [15]. Therefore, the aim of this study was to evaluate the simultaneous effect of apical resection angle and depth of the retrograde filling with MTA on apical microleakage of the root *via* fluid filtration method.

Materials and Methods

A total of 150 extracted human single root permanent teeth were collected from Dental Department of Oral and Maxillofacial Surgery, Shiraz dental school, autoclaved and stored in normal saline. Teeth with caries, calcification, and fractured root and with multiple canals were excluded. Total of 110 teeth with intact root were selected. Fourteen mm to the apical foramen of the roots were sectioned using a carbide bur in a high-speed handpiece with a cooling system. Patency of the apical foramen was determined with a size of 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Working lengths were established at 1 mm shorter than the apical foramen. Root canal preparation was carried out in all the roots by conventional technique using rotary ProTaper system; Sx, S1, S2, F1, F2, F3 and F4 (Dentsply Maillefer, Ballaigues, Switzerland). Between each file, the canals were irrigated with 2 mL of 5.25% NaOCl solution and finally rinsed by saline. The cleaned and shaped roots were dried with paper points (Endo Points Ltda., Paraíba do Sul, RJ, Brazil). Samples were randomly assigned into three experimental groups according to the angle of apical resection as following; group I, 45 degree; group II, 60 degree and group III, 90 degree. Root-end resections were made by removing 3 mm of the apex at 45°, 60° and 90° to the long axis of the root by using a standard jig with a cylindrical carbide bur (Komet, Lemgo, Germany) using a high-speed handpiece with water spray coolant. Each group samples were randomly divided into 3 subgroups according to the root-end cavity preparation as following depths; subgroup a: 2 mm, subgroup b: 3 mm and subgroup c: 4 mm, each subgroup contains 10 specimens. Class I cavities were then prepared with an ultrasonic retro tip (Gnatus, Ribeirão Preto, SP, Brazil). The depth of root-end cavities was standardized at 2 mm, 3 mm and 4 mm. All the procedures were performed under continuous irrigation. The depth of the prepared root-end cavity was checked using periodontal probe. The cavities were irrigated with 2 mL of 5.25% NaOCl solution and then 17% EDTA and, finally rinsed by saline. Next, the root-end cavities were dried with paper points. To provide an intracanal matrix to pack the root-end filling material against, a gutta-percha cone was firmly inserted into the canal leaving a root-end void of 2, 3 or 4 mm, which was confirmed by radiographs. MTA (Angelus, Londrina, PR, Brazil) was mixed according to the manufacturer's recommended proportions and

placed into the root-end with MTA carrier (Maillefer Dentsply, Baillagues, Switzerland), and applied within the prepared cavity with the endodontic plugger (Maillefer Dentsply, Baillagues, Switzerland). This application was maintained until the retrograde cavity was totally filled. After removing the intra-canal barrier, radiographs were taken in buccolingual and mesiodistal directions to evaluate the quality and depth of the retro-end fillings. If retrograde filling was not confirmed in terms of length or density, the sample were excluded and replaced by another. After removing the intra-canal barrier, samples were stored in an incubator at 37° C in 100% humidity for 48 h.

Total of 20 roots were used as positive and negative control samples. For the 10 negative control samples, the entire root surface was coated with 2 layers of nail varnish after filling the root-end preparation with red rope wax. Positive control samples consisted of 10 teeth unfilled root-end preparation.

The fluid filtration method with some alterations was used to evaluate microleakage [21]. The fluid filtration contains two micropipettes that are perpendicular to each other. The amount of liquid emission was measured by evaluating the air bubble movement in the micropipette. The apical portions of the samples were attached into the horizontal micropipette *via* waterproof glue. All pipettes were filled with distilled water. The height of water in the vertical pipette was adjusted at 20 cm and an air bubble was created with syringe at the beginning of horizontal micropipette. The amount of bubble's movement was determined in 5 periods as following; 24 h, 1 week, 1 month, 2 months and 3 months (Figure 1). The rate of microleakage was calculated based on the following formula for each time interval.

Rate of microleakage=Fluid filtration of each time interval (μL)/Time of interval (min)

Statistical analyses

Statistical analysis consisted of the Kruskal-Wallis test. The SPSS

software (Ver. 18.0 for Windows; SPSS, Chicago, IL, USA) was used. The level of statistical significance was set at 0.05 for all statistical analyses. Pairwise comparison was done to compare groups with each other.

Results

The specimens in the positive-control group exhibited microleakage, showed significantly more apical microleakage within minutes after the beginning of the experiment. However, in the negative-control group, there were no evidence of microleakage throughout the experiment. Table 1 shows microleakage of the experimented samples within the mentioned periods. The highest and lowest microleakage belonged to group II and III.

There were no significant differences in apical microleakage after 24 h and 1 week in all of the experimental groups. In the 1-month interval, samples with 60° bevel in different depths showed significant higher microleakage than samples with 90° bevel and depth of 4 mm ($P<0.01$). In the 2nd and 3rd months, samples with 90° bevel and 4-mm-thick MTA showed significant statistical differences with all samples with 45° and 60° bevels and depths of 2- and 3-mm-thick MTA ($P<0.00$).

Discussion

Leakage after apical surgery is complicated and might be affected by many variables, such as root canal filling technique, physical and chemical properties of root end filling material, apical root resection angle, root end cavity thickness and the smear layer [11]. Present study showed that perpendicular root resection with highest depth of MTA is significantly affect the microleakage, which is consistent with similar investigations [22, 23].

Table 1. Mean (SD) values of microleakage (μL) obtained in each group

Groups	Subgroups	24 h	1 Week	1 Month	2 Months	3 Months
I (45°)	2 mm ^(a)	4.8 (0.3)	1.2 (0.08)	0.5 (0.01)	0.3 (0.01) ^a	0.4 (0.006) ^{ab}
	3 mm ^(b)	4.2 (0.5)	1 (0.06)	0.5 (0.01)	0.3 (0.01) ^a	0.4 (0.006) ^a
	4 mm ^(c)	3.2 (0.4)	0.7 (0.08)	0.4 (0.02)	0.3 (0.009)	0.3 (0.006)
II (60°)	2 mm ^(a)	4.9 (0.4)	1.5 (0.07)	0.5 (0.01) ^a	0.4 (0.009) ^{ab}	0.4 (0.006) ^a
	3 mm ^(b)	4.7 (0.4)	1.1 (0.08)	0.5 (0.02) ^a	0.4 (0.008) ^a	0.4 (0.005) ^a
	4 mm ^(c)	4 (0.4)	1(0.08)	0.5 (0.02) ^a	0.3 (0.01) ^a	0.3 (0.006)
III (90°)	2 mm ^(a)	4.2 (0.3)	1.2 (0.08)	0.5 (0.02)	0.2 (0.005)	0.3 (0.006)
	3 mm ^(b)	3.4 (0.4)	1.1 (0.05)	0.5 (0.01)	0.3 (0.009) ^B	0.3 (0.005) ^B
	4 mm ^(c)	3.2 (0.3)	1 (0.06)	0.4 (0.01) ^A	0.2 (0.009) ^A	0.3 (0.006) ^A

Capital and small letters indicate statistically significant difference between the groups in each column ($P<0.05$). Columns without letters do not have statistically significant differences

The main purpose of root end filling material after root end resection and preparation is to establish an effective barrier between root canal and the periapical tissues [5, 22]. MTA yields better results than amalgam, super-EBA, IRM in leakage, marginal adaptation and scanning electron microscopy studies. Researchers have suggested different apical depth of MTA (2-5 mm) as retrograde material [5]. Thus fluid filtration technique and MTA retrograde were used in the present study.

Studies have shown different ideal root-end preparation depth in apical surgery. Torabinejad *et al.* [24], have declared that 3- to 4-mm thickness of MTA as retrograde is efficient. Also Kim *et al.*, showed that retrograde depth of 3-mm or more was ideal. In agreement with the present study, Volois *et al.* [5], stated that 4-mm-thick MTA was sufficient and had superior significance to 3-mm-thick MTA [5]. In addition, they showed no significant differences between leakage of 2- and 3-mm thick MTA as retrograde, which is in line with this study [5].

Yildirim *et al.* [11], showed that there was no statistically significant differences between the two cavity thickness (3 and 5) regarding bacterial microleakage. Lamb *et al.* [25], evaluated apical sealing ability of MTA different thickness, and showed that root resection did not affect the MTA sealing ability, when at least 3 mm of the material remained. Four-millimeter thickness of apical plug was assigned, which was in line with Hachmeister *et al.* [26]. Also current study showed that in 4 mm-thick MTA retro-filled teeth, angle of resection does not matter, which might be due to the seal ability of 4-mm-thick MTA.

Another variable that affect microleakage after apical surgery is the bevel angle of apical resection. Among all techniques of retrofilling, the 90° buccolingual bevel 3 mm from the apex, exposes lower dentinal tubules and prepares effective removal of ramifications [15]. The 45° or 60° buccolingual bevel is another option to simplify retrograde insertion that can be suggested when access to the surgical site is not adequate. However, these bevel angles increase the apical leakage due to extending exposed permeable dentinal tubules [18, 27].

Post *et al.* and Garip *et al.* [28, 29], have shown that angle of apical resection does not affect the microleakage, which is in accordance with the current study.

Also, Saunders *et al.* [30], showed that presence or absence of smear layer might affect microleakage. Researches indicated that absence of smear layer might improve sealing ability of apical surgeries [31]. However, Yildirim *et al.* [11], showed that removing the smear layer does not affect apical microleakage. So that, in the present study to omit the effect of smear layer, it was removed with 17% EDTA.

Apart from reason of microleakage, studies reported different quantities of microleakage degree, which might be due to different measuring methods. Furthermore, some studies did not use gutta-percha or sealer in the root canal space to omit other variables affecting microleakage [28].

In the present study, after 3-months follow-up of samples microleakage, showed that in 4 mm-thick MTA retro-filled teeth, angle of resection does not matter. Besides, in 90° resection angle, 2- and 3-mm retro-fill MTA were also acceptable.

Considering the result of the present study, in apical surgery cases with long intra-canal posts or in case of short roots, 2-mm-thick MTA as retro-fill with 90° bevel angle resection is acceptable.

Conclusion

This study shows that, when the resection angle is 90°, retrograde depth does not affect microleakage, but resections other than 90°, requires 4 mm-retrograde depth to be sealed.

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Conflict of Interest: 'None declared'.

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