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Evaluating the effects of different protocols applied to resected root end on apical

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Objective: This study aimed to investigate the effects of different protocols applied to the resected root end on apical sealing.

Methods: In this study, 35 permanent lower premolars were chemomechanically prepared and obturated. Three mm of the root end was resected, and a 3-mm retro cavity was prepared using an erbium, chromium: yttrium-scandium-gallium-garnet (Er, Cr: YSGG) laser. The roots were randomly divided into four groups according to the protocol applied: group 1 (control group): no treatment was performed (n=5), group 2: Biodentine sealing (n=10), group 3: Biodentine sealing + Er, Cr: YSGG application, and group 4: only Er, Cr: YSGG application. The fluid filtration model was tested. The results were evaluated using one-way analysis of variance.

Results: All groups showed leakage. No statistically significant difference was found between the groups ($p \leq 0.05$). The largest leak average was observed in group 1 (0.000373640±0.000135817 Lp) and the smallest leak (0.000270134±0.000136416 Lp) in group 3.

Conclusion: The protocols applied did not completely prevent leakage of the resected root end; however, the use of Biodentine and the Er, Cr: YSGG laser led to less leakage.

Keywords: Apical leakage; Biodentine; chromium; endodontics; erbium; yttrium-scandium-gallium-garnet laser.

Surgical endodontic treatment (SET) is considered when nonsurgical treatment (NSET) is impossible or unanswered. Root-end resection, apical cavity preparation, and apical seal are recommended for successful SET.[1] Root-end resection with no bevel is recommended because a bevel causes more opened dentinal tubules and apical permeability.[1,2] Apical cavity preparation is considered as a class I cavity with 3 mm depth and parallel walls.[3] To make an apical cavity, a microhandpiece with rotating burs, ultrasonic device with special tips, and different lasers can be used. Ultrasonic tips allow to open smaller and deeper cavities, cuts with no bevel, and facilitates better preparation of root canals with abnormal anatomic structure;[4] however, on the other hand, they cause more microcracks, leading to failure of SET.[5] Er, Cr: YSGG lasers have been used in the preparation of apical cavity because of the following advantages: less microcracks,[6] less dentin permeability,[7] no vibration,[8] and disinfection.[9]

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Smear layer removal and melting and solidification of root canal dentin walls are important to develop apical sealing. To remove smear layer, different types of laser are recommended.[7,10,11]

After the preparation of root-end cavity, obturation of the cavity with a biocompatible, impermeable material is recommended. Biodentine is one of these materials with an appropriate setting time and good handling.[12] Biodentine is a calcium silicate-based MTA-like material that has a short setting time. Biodentine powder consists of tricalcium silicate, calcium carbonate (filler), and zirconium dioxide (radiopacifier). Biodentine liquid contains calcium chloride (setting accelerator), super plasticizer, and water.[13] According to the manufacturer, Biodentine can be used for pulp capping, pulpotomy, apexification, root perforation, internal and external resorption, and also as a root-end filling material in periapical surgery. Biodentine is found to be biocompatible and inductive for odontoblasts.[14]

Er, Cr: YSGG laser has some advantages such as different settings can cause different results on root canal dentin,[15,16] According to Gholami et al. (2011), Er, Cr: YSGG laser is the second choice of treatment for dentin hypersensitivity because of its ability to occlude dentinal tubules.[17] In this study, similar to dentine hypersensitivity treatment levels, our pilot study levels (unpublished data) had been used to occlude dentinal tubules. The aim of this study was to investigate the effects of low level Er, Cr: YSGG laser application on the apical area of the root on the leakage with the fluid filtration model.

Materials and methods

Thirty-five human single-rooted lower premolar teeth stored until use in thymol solution to prevent bacterial growth were used. Each single-rooted tooth was cleaned and crowns were separated from the cementoenamel junction. Instrumentation of the roots was performed with a crown-down technique using WaveOne nickel–titanium rotary instruments (Dentsply-Maillefer, U.S.A). The canals were rinsed with 10 mL 5% sodium hypochlorite in between instrumentation and 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) as the final rinse. The roots were filled using the cold lateral condensation method. The apical 3 mm of each instrumented root was resected 90° to the longitudinal axis of the root. The roots were randomly divided into four groups according to the protocols applied.

Group 1 (control group): No treatment was performed (n=5).

Group 2: Er, Cr: YSGG, 3-mm retro cavity was prepared using Er, Cr: YSGG (i Plus, Biolase, U.S.A) laser (Fig. 1) (MZ5 tip, 3.5 W, 100% water, 100% air, 20 Hz, H mode), and the cavity was filled with Biodentine (Septodont, France) (n=10) (Fig. 2).

Fig. 1. Biodentine.

Group 3: Er, Cr: YSGG, 3-mm retro cavity was prepared using Er, Cr: YSGG (MZ5 tip, 3.5 W, 100% water, 100% air, 20 Hz, H mode), and the cavity was filled with Biodentine. The dentinal tubules were melted using Er, Cr: YSGG laser (MZ6 tip, 0.50 W, 0% water, 0% air, 20 Hz, H mode) (n=10).

Group 4: Only the dentinal tubules were melted using Er, Cr: YSGG laser (MZ6 tip, 0.50 W, 0% water, 0% air, 20 Hz, H mode) (n=10).

Fig. 2. Er, Cr: YSGG laser (MZ5 tip, 3.5 W, 100% water, 100% air, 20 Hz, H mode) was used to open retro cavity and to occlude dentinal tubules (MZ6 tip, 0.50 W, 0% water, 0% air, 20 Hz, H mode).

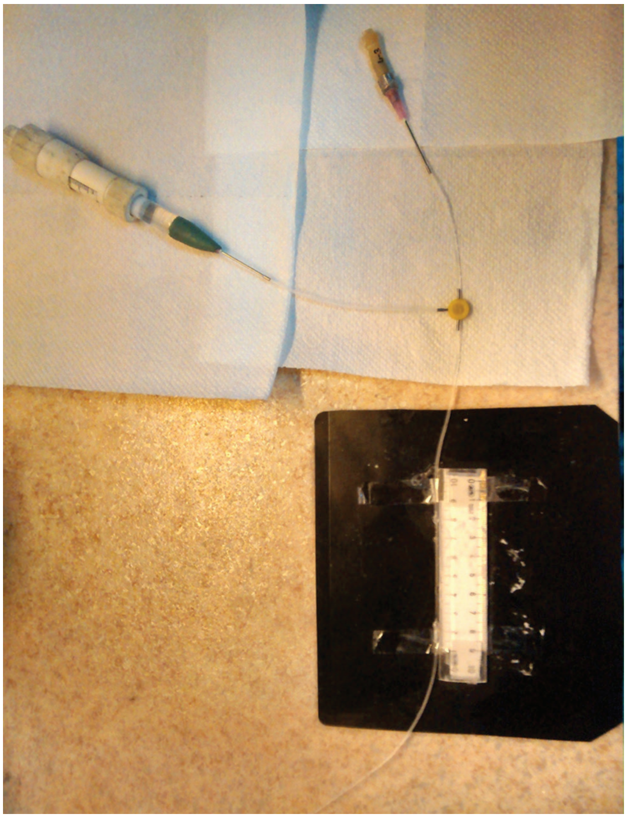

Fig. 3. Fluid filtration test.

To investigate apical leakage, the test method of fluid filtration, as reported by Pashley and Depew, was used.[18] The plastic tube was attached to the prepared specimens with fast-setting cyanoacrylate adhesive (Pattex, Henkel). Then, this plastic tube was connected to the fluid filtration apparatus. Another tube was connected to the micropipette. In this tube, an air bubble was created with a micro-syringe. All tubes, pipettes, and syringes were filled with distilled water under a pressure of 1 atmosphere with O2 gas. Apical sealing was measured by the mobilization of this air bubble in the glass capillary system under constant pressure. The movement of the air bubble was recorded every 3 min. The mean value of four measurements was averaged, and the amount of the fluid passing through the root was calculated in L/min (Fig. 3). The results were evaluated using one-way ANOVA.

Results

Apical leakage was observed in all groups. No statistically significant difference was found among the groups. The highest apical leakage was found in group 1 and the lowest one in group 3. The results of the quantitative evaluation of the apical leakage properties of the four groups are shown in Table 1.

Discussion

Studies have shown that even after root canal treatment, microorganisms can still survive in root canals.[19] It is also known that these microorganisms require nutrients to survive. Because of the importance of sealing of the root canals, studies on apical and coronal sealing have been an ongoing research topic in endodontics. The purpose of this study was to investigate the effects of different protocols on apical sealing. This study investigated whether there was any advantage of melting the root-end dentinal tubules with the Er, Cr: YSGG laser after using Biodentine as a root-end filling material or whether only melting the root-end with Er, Cr: YSGG laser was sufficient.

When nonsurgical root canal treatment fails or is impossible, surgical root canal treatment can be performed. In endodontic surgery, the amount of resection of the root-end and the angle of resection are two of the important steps. Although the anatomy of the roots is complex, approximately 75% of accessory and lateral canals are located in the apical 3 mm of the root.[3] Because of this, resection of the apical 3 mm of the root end is recommended to reduce residual etiologic factors (such as irritants, microorganisms, and anatomical formations that can lead to leaks). For simpler preparation of the root-end cavity, elimination of the anatomic ramifications is recommended; for decreasing the number of dentinal tubules present between the surgical site and the root canals, perpendicular root resection is recommended.[20–22] Beveled root-end resection increases the risk of apical microleakage.[20] So, in the present study, perpendicular root-end resection of the apical 3 mm of the roots was performed for simulation of ideal clinical condition.

The ideal root-end cavity is described as a class I cav-

Table 1. Quantitative evaluation of apical leakage properties of four groups

	n	Average Leakage Properties	SD
Group 1 (control group)	5	$3.7336x10^{-4}$	$1.358x10^{-4}$
Group 2 (Er, Cr; YSGG+Biodentine)	10	$3.717x10^{-4}$	$3.746x10^{-4}$
Group 3 (Er, Cr; YSGG+Biodentine + Er, Cr; YSGG)	10	$2.701x10^{-4}$	$1.364x10^{-4}$
Group 4 (Er, Cr; YSGG)	10	$3.034x10^{-4}$	$1.614x10^{-4}$

Values are means±SD. P=0.05 significant level. Letter shows statistically differences.

ity with 3 mm depth and parallel to the long axis of the root.[3] A microhandpiece with rotating burs, ultrasonic device with special tips, and different lasers can be used for preparing a root-end cavity. Ideal cavity preparation cannot be easily done using only a microhandpiece with rotating burs. With the advanced technology, ultrasonic tips have made it easier to work. Although nowadays usually ultrasonic tips are being used for this purpose, root fractures and microcracks caused by ultrasonic tips have been reported.[5] After using lasers for hard tissue removal in periradicular surgery, some advantages of Er, Cr: YSGG laser such as occurrence of less microcracks,[6] less dentin permeability,[7] no vibration,[8] and disinfection[9] were reported. Studies that attempted to determine which power values of Er, Cr: YSGG laser are most appropriate for endodontic surgery recommended different values.[23] In a current study, 3.5 W has been reported as the minimum effective power.[24] So, in this study, 3.5 W was used.

There are various widely used root-end filling materials such as mineral trioxide aggregate (MTA), super EBA (Harry J. Bos- worth Co., Skokie, IL), IRM (LD Caulk Co., Milford, DE), Biodentine (Septodont, Saint Maur des Fossés, France), etc.[25] In vitro studies about sealing ability and biocompatibility have reported that MTA is superior to other commonly used materials.[26–28] MTA is a preferable material for endodontic surgery with some properties such as well-seal ability,[29] bioactivity,[30] and osteogenic potential;[31] however, it also has some disadvantages such as difficulties in manipulation and long setting time. So, for finding different materials, researches are being continued.[32]

Biodentine is a calcium silicate-based MTA-like material that has a short setting time and good handling.[12] A current study found that Biodentine causes lesser microleakage than MTA when used as a retrograde filling material.[33] In this study, using Biodentine as a root-end filling material decreased the apical leakage; however, no statistically significant difference was found.

There are many methodologies introduced for assessing apical leakage in endodontic treatments. Usually, in vitro studies measure microleakage by inserting a tracer into the root canals such as dyes, bacteria, or isotopes. Dye penetration method has been widely used because of its simplicity and lower cost,[34] but the small size of the dye molecules can cause overestimation of leakage. So, the validity and reliability of this technique is questionable.[35] The bacterial microleakage method is the most suitable method for assessing microleakage as it is the best simulation of clinical conditions.[36]

Fluid filtration is a different method described for assessing apical microleakage. In this technique, the aim is to provide a closed circuit filled with liquid. A pressure provider, T tube, and sample are attached to the system. By attaching the sample to a capillary tube, the system can be closed. With the help of T tube, a bubble must be created, and with pressure, liquid should be pushed into the sample. The movement of the bubble in a specific period gives the movement of the liquid so the amount of leakage (μl/min).[37] Nondestructive process, quantitative and reproductive test results make this technique preferable.[38,39] It was reported that because of the different pressure value, experiment time, bubble size or capillary tube diameter could change the test results, this technique was not standardized.[40] Despite the reported disadvantages, many studies have used this method. In a current study, Moradi et al. (2015) compared two techniques, bacterial microleakage and fluid filtration, and a correlation between this two techniques was shown.[41] They also argued that some other contrast studies showed different results, but the differences could be able to occur with the differences about the test variables such as using oxygen gas or helium gas as a pressure provider. They suggested using oxygen gas for pressure because constant pressure can be provided as in contrast of using helium gas. There are no current studies about the sealing ability of apical procedures used by us. So, this precursor study was performed by us with the aim to conduct advanced studies. In this study, fluid filtration technique was preferred because of simpler use, lower cost, and reproducible and quantitative results. To obtain standardization, oxygen gas was used, length of the specimen was kept same, and one investigator was used for all the tests, and every measurement was performed four times and the mean scores were calculated and used in this study, as recommended in the literature.[42,43]

Using Er, Cr: YSGG laser did not cause a statistically significant difference in the present study in agreement with that by Onay et al. (2014) who presented that root-end filling materials' sealing ability was not influenced by Er, Cr: YSGG laser.[44] But Paghdiwala (1991) discovered that the thermal ablation of the Er: YAG laser can lead to dissolution of mineral components and melting of amorphous particles without crystallization and a clean and smooth surface; thus, apical microleakage can be prevented.[45] Methodological differences can cause this contrast.

Conclusion

Based on current findings of this in vitro study, neither is Er, Cr: YSGG laser treatment is necessary nor does it influence the apical microleakage when compared with Biodentine. We found that in all apical protocols tested in this study, apical microleakage was shown, but the combined use of Biodentine and Er, Cr: YSGG laser resulted in successful apical sealing. Further investigations are needed to determine the efficacy of different laser types and different settings of lasers for apical sealing.

Conflict of interest: None declared.

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