

Full Length Research Paper

Sealing ability comparison of mineral trioxide aggregate in root-end cavities prepared with ultrasonic and Er,Cr:YSGG laser

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The aim of this study was to compare apical microleakage subsequent to filling of root-end cavities, prepared by either ultrasonic or erbium, chromium:yttrium, scandium, gallium, garnet (Er,Cr:YSGG) laser, with mineral trioxide aggregate (MTA). Microleakage following root-end filling has a direct effect on the outcome of surgical endodontic treatment; therefore, any procedure contributing to adequate sealing of the apical part of the root should be performed. Forty eight human maxillary anterior teeth were selected for this study. After cleaning, shaping and obturation of teeth with gutta-percha and AH26 sealer, 3 mm of the root ends were resected perpendicular to the long axis of roots. The teeth were randomly divided into two experimental (n=20) and two control (n=4) groups. Root-end cavities were prepared by ultrasonic and Er,Cr:YSGG laser (parameters: 4 W, 55% water and 65% air) methods. A protein leakage model was used for evaluation. Data were analyzed using one-way analysis of variance (ANOVA) and a post hoc Tukey test at $p < 0.05$. The mean values of protein microleakage in the laser and ultrasonic groups were 0.0340 ± 0.0053 and 0.0495 ± 0.0276 mg/mL, respectively, with statistically significant differences between the groups ($p < 0.001$). Based on the results of this study, sealing ability of MTA in root-end cavities prepared with Er,Cr:YSGG laser was better than that in cavities prepared with conventional ultrasonic technique.

Key words: Apical surgery, dental lasers, MTA, root filling materials, ultrasonic.

INTRODUCTION

Apical surgery is usually performed in an attempt to eliminate problems that persist after non-surgical endodontic treatment. This procedure is considered a therapeutic alternative for teeth with calcified or perforated root canals, non-removable pins and broken instruments, ledge formation, and for root canals with a stable bacterial colonization that does not respond to

conventional endodontic treatment (Tronstad et al., 1990; Johnson et al., 2011; Xu et al., 2009). The purpose of this procedure is to eliminate diseased tissues and ensure proper root canal sealing, preventing leakage and penetration of bacteria and toxins from the tooth towards surrounding tissues (Fernandez-Yanez Sanchez et al., 2008). The traditional method to prepare root-end cavities comprises the use of burs. However, various root-end cavity preparation techniques have been introduced, which entail the use of ultrasonic instruments and lasers (Karlovic et al., 2005; Leco Berrocal et al., 2007; Walivaara et al., 2009). The advantages of ultrasonic preparation are their smaller dimensions and improved access to the resected root-end cavity (Carr 1997). However, its use produces cracks on root canal walls

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Abbreviations: MTA, Mineral trioxide aggregate; Er,Cr:YSGG, erbium, chromium:yttrium, scandium, gallium, garnet.

(Gutmann et al., 1994; Saunders et al., 1994; Wuchenich et al., 1994; Abedi et al., 1995; Frank et al., 1996; Layton et al., 1996). Nowadays, laser technology is being used in all fields of dentistry, particularly in endodontics. High-power lasers, if used properly with optimal settings for the target tissue, yield favorable results, including a decrease in dentine permeability (Aranha et al., 2005), cavity preparation without vibration (Aoki et al., 1998) and improvements in disinfection ability during root canal cleaning and shaping (Gordon et al., 2007; Wang et al., 2007). erbium, chromium:yttrium, scandium, gallium, garnet (Er,Cr:YSGG) laser with a wavelength of 2.78 μm has been demonstrated to be more efficacious than ultrasonic instruments in retrograde preparations in terms of less crack formation on root canal walls (Wallace, 2006), improved bactericidal activity (Gordon et al., 2007), and effective removal of the smear layer and debris (Schoop et al., 2007). The laser preserves the integrity of root-end cavities better than ultrasonic devices from the standpoint of chipping (Rahimi et al., 2010).

Different methods have been used for evaluation of the sealing ability of root-end filling materials, including dye penetration, glucose penetration, fluid filtration and protein leakage (Valois and Costa 2004; Shahi et al., 2009). Each technique has been questioned and has its own advantages and disadvantages (Matloff et al., 1982; Kersten and Moorer, 1989; Valois and Costa, 2004). Bacterial size is bigger than protein particles; therefore, bacterial leakage sometimes stops and in these situations, the leakage of smaller protein particles takes place. Although dye has smaller particles than albumin, dye leakage studies evaluate the leakage in one plane; however, protein leakage technique enables the estimation of root-end filling microleakage in all the planes as well as simulation of clinical situation (Bradford, 1976; Valois and Costa, 2004; De Bruyne et al., 2005; Verissimo and do Vale, 2006).

Mineral trioxide aggregate (MTA) was introduced at the Loma Linda University (Lee et al., 1993) for the repair of perforations. Gradually, it has gained several applications in the clinic, including pulp capping, treatment of root resorption and immature apices (apexogenesis/apexification), pulpotomy, repair of root perforations and root-end filling (Torabinejad and Chivian, 1999; Samiee et al., 2010). As a root-end filling material, MTA provides better sealing ability and thereby less leakage than other retrograde filling materials (Torabinejad et al., 1993; Tang et al., 2002).

The aim of this study was to compare sealing ability of MTA as a retrofilling material in root-end cavities prepared by Er,Cr:YSGG laser and ultrasonic retrotip, using a protein leakage model.

MATERIALS AND METHODS

Tooth selection and sample preparation

forty eight single-rooted human incisors with straight roots and well-

developed apices, which had been extracted for periodontal or orthodontic reasons, were selected for the purpose of this study and stored in chloramine T solution. The teeth were evaluated under a stereomicroscope and by radiographic imaging. The teeth with caries, cracks, resorption, fractures, morphologic anomalies, and open apices were excluded from the study. The outer surface of the roots was mechanically cleaned by a curette and an ultrasonic cleaner under water spray, and kept in saline solution until used for the purpose of the study. The teeth were decoronated so that the root lengths were about 12 ± 1 mm. Working length was measured using a #15 K-type file (Mani, Utsunomiya, Japan) 1 mm short of the apical foramen. The root canals were prepared up to master apical file #40 using step-back technique and the shaping of middle and coronal thirds was carried out by Gates Glidden burs sizes 1 to 3 (Mani, Utsunomiya, Japan) and also RaCe rotary size 40/0.10 taper instrument (FKG, La-Chaux De Fonds, Switzerland). During root canal preparation, 2 mL of 2.5% NaOCl solution (Taj corp., Tehran, Iran) was used as irrigation solution. All the canals were obturated with gutta-percha (Aria Dent, Tehran, Iran) and AH26 sealer (Dentsply, Konstanz, Germany) using the lateral compaction technique. The roots were stored at 37°C and 100% relative humidity for 48 h. After that period, the apical 3 mm of each specimen was resected perpendicular to the long axis of the root with a diamond bur (D&Z, Darmstadt, Germany) under continuous water and air spray.

Root-end cavity preparation and filling

The resected roots were randomly divided into two control groups (n=4) and two experimental groups (n=20), according to the root-end cavity preparation technique: ultrasonic or laser. In the ultrasonic group and two specimens of the positive control group, the cavity preparation was performed by ultrasonic apical surgery retrotip and ultrasonic unit (Spartan Ultrasonic, Fenton, Missouri, USA) at a frequency of 32 kHz and medium intensity. An intermittent pressure with in-and-out motion was used to prepare the class I cavities 3 mm deep and 1 mm wide. Finally, a circumferential motion was used to complete the preparation.

In the laser group and the other two specimens of the positive control group, the root-end cavities with the above-mentioned properties were prepared with Er,Cr:YSGG laser (Waterlase MD Laser, BioLase Technology Inc, San Clement, CA, USA) and G6 tips (Parameters: 4 W, 55% water and 65% air) according to manufacturer's instructions.

The cavities were irrigated and dried with sterile paper points. The specimens of the two experimental groups were filled with white ProRoot MTA (Dentsply, Tulsa Dental, OK, USA). The ProRoot MTA was mixed according to manufacturer's instructions on a sterile glass slab and retrofilling was completed by a small condenser (Kerr Hawe, Orange, CA, USA). The excess material was removed with a sterile cotton pellet. Four positive control group specimens were not filled with retrofilling material. The samples were kept at 37°C and 100% relative humidity for 48 h. All the experimental and positive control specimens were covered by two layers of nail varnish except for the apical and coronal surfaces. In the negative control specimens, all the root surfaces were covered by two layers of nail varnish. Then the samples were allowed to dry for 30 min. All the preparations were performed by one operator.

Protein leakage test

The apparatus used to evaluate protein leakage was prepared by using a 10 mL glass vial with a rubber stopper and a cylinder as previously described (Valois and Costa, 2004). Initially, a heated instrument was used to make a hole through the center of each rubber stopper. Each root was inserted into the hole so that its

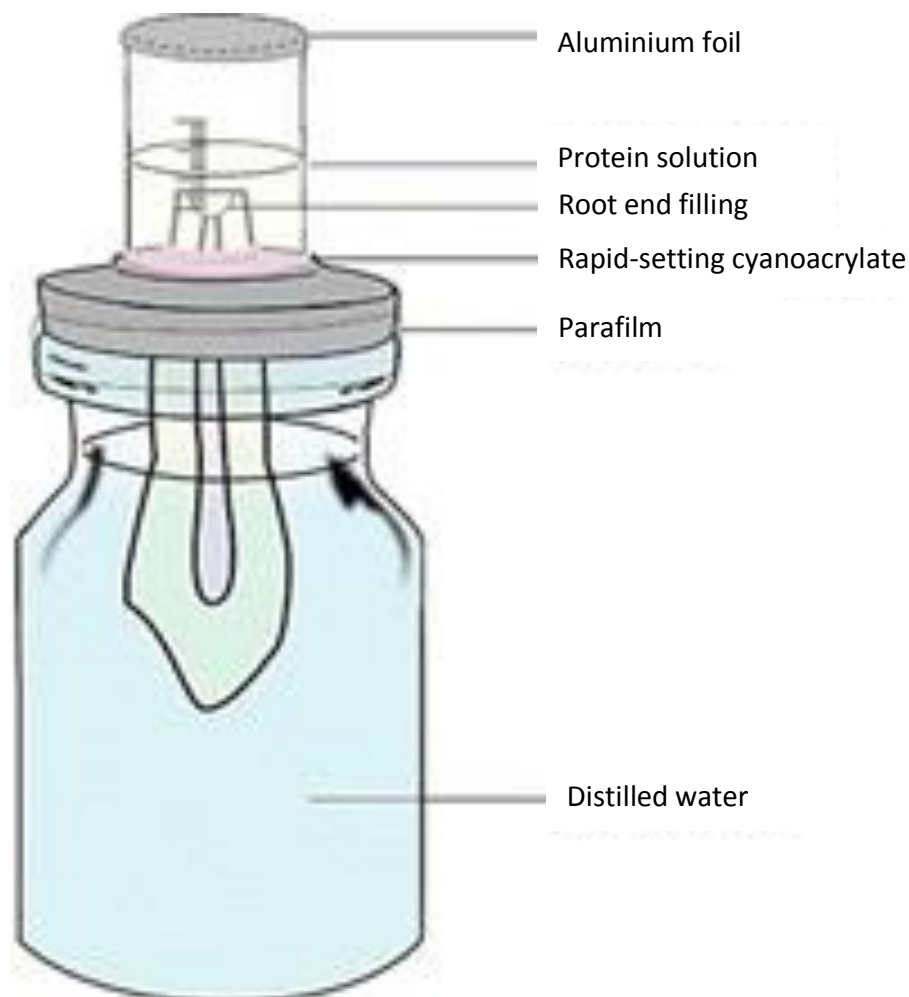


Figure 1. Schematic picture of protein microleakage apparatus.

apical end was outside the vial and its coronal part within the vial. Fast-setting cyanoacrylate paste was used to seal the gaps between the root and the stopper. Plastic cylinders were then adapted to the external surface of stoppers to create a reservoir around the apical ends of the root. The glass vials were filled with 9.5 mL of distilled water so that the coronal surface of each root was immersed in the solution. The reservoir of the apparatus was filled with 1 mL of 22% bovine serum albumin (BSA) solution (Sigma Chemical Co, St Laurs, MO, USA) and coated with an aluminium foil. The whole apparatus was stored at 37°C and 100% relative humidity during the 60-day experimental period. During this time, the water in the glass vial was refreshed and the protein solution of the reservoir was replenished daily (Figure 1). In order to measure leaked protein, 100 µl of the water inside glass vials (test solution) was transferred into Eppendorf test tubes. Then, 1 mL of the Bradford protein reagent (Sigma Chemical Co, St Laurs, MO, USA) was pipetted into the test tube and the contents were mixed. This was repeated each day for 60 days or until color conversion was observed. Yellow color conversion of the protein reagent was taken to be indicative of apical microleakage. Protein concentration was quantified with an UV spectrophotometer (GENESYS 10 UV Spectrophotometer, Genesys 10, Madison, USA). The measurement is based on observation of maximum observance for an acidic solution of reagent (Coomassie Brilliant Blue, G-250 Bio-

Rad Corporation, Life Science Group, CA, USA) within a range of 465 to 595 nm of binding to protein occurrence.

Statistical analysis

Data were analyzed using one-way ANOVA. In case of significant differences between the groups, a post hoc Tukey test was used. Statistical significance was set at 5%.

RESULTS

All the positive control specimens showed BSA leakage during the first 24 h. In the negative control specimens, the absorption amount was zero at day 60 of the experimental period and BSA leakage did not occur. The mean values of protein microleakage in the laser and ultrasonic groups were 0.0340 ± 0.0053 and 0.0495 ± 0.02276 mg/mL, respectively. One-way ANOVA and post hoc Tukey test for comparison of mean differences indicated that the differences between the two groups

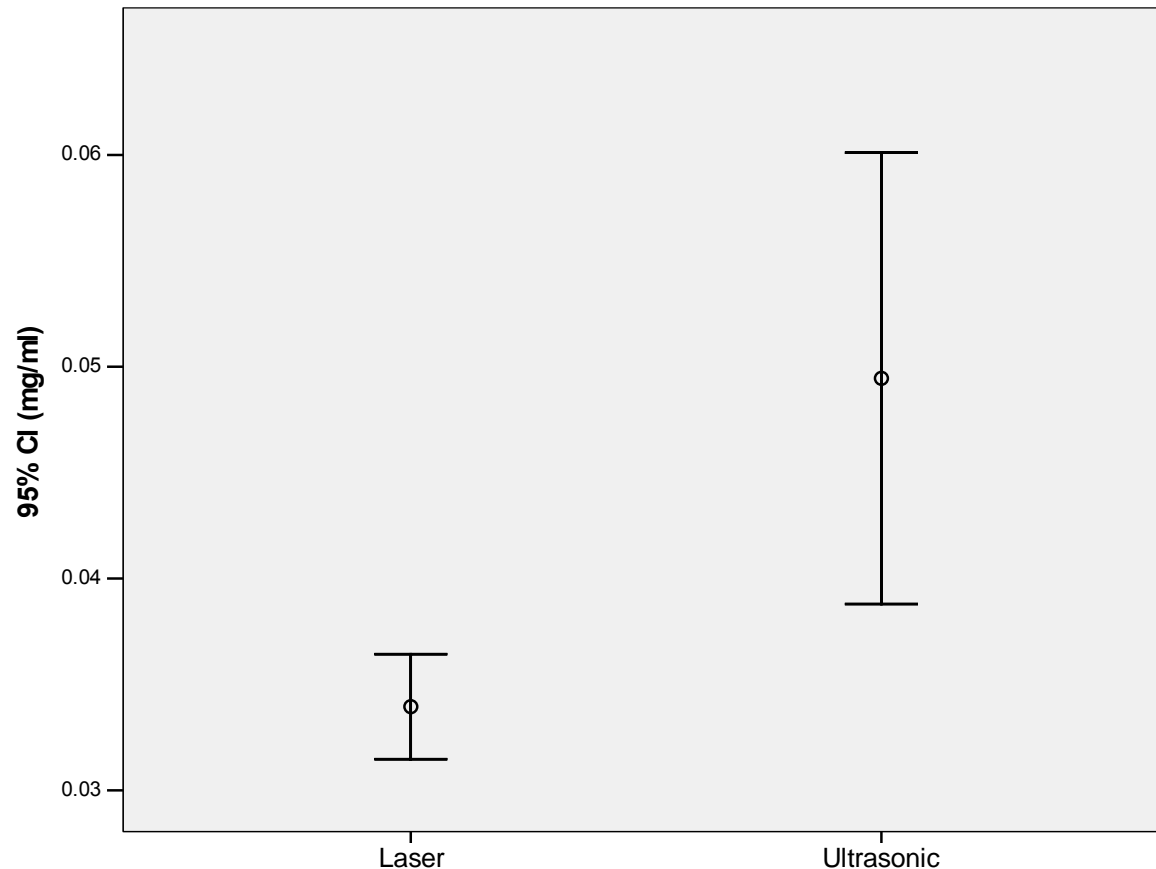


Figure 2. Comparative analysis of protein microleakage in the laser and ultrasonic groups.

were statistically significant ($p < 0.001$) and the microleakage amount in the laser group was significantly less than that in the ultrasonic group (Figure 2).

DISCUSSION

In endodontic surgery, root-end cavity preparation followed by appropriate retrofilling is necessary to prevent leakage of irritants from the root canal system into periradicular tissues (Winik et al., 2006). The vast majority of root-end cavity preparation-related failures are attributed to irregular cavity configuration in vestibulo-oral dimension, inability to prepare deep and parallel cavity walls and creation of cracks during cavity preparation (Dorn and Gartner, 1990). In addition, a well-adapted filling material in a properly prepared root-end cavity is a vital factor in the success of surgical retreatment procedure (Karlovic et al., 2005).

Since there is no published data about the effectiveness of MTA in root-end cavities prepared by Er,Cr:YSGG laser and conventional ultrasonic method with multi-plan protein microleakage evaluation, in the present study ProRoot MTA (as a golden standard of retrofilling materials) and Er,Cr:YSGG laser were used.

The laser output power was 4 W; the tip was 600 μm in diameter, with 55% water and 65% air similar to the technique used by Wallace (2006). The amount of microleakage in the Er,Cr:YSGG laser group was significantly less than that in the ultrasonic group, which might be attributed to the fact that Er,Cr:YSGG laser is highly absorbed by water, resulting in micro-explosions of the water in dentine, which removes the smear layer. Therefore, irradiation with this laser increases the number of open dentinal tubules and allows the sealing agent to penetrate into these tubules and create the tags that decrease microleakage (Ishizaki et al., 2004; de Groot et al., 2009). In addition, laser irradiation creates an irregular intertubular surface and almost free of cracks, which increases the mechanical bond between the dentine and the root-end filling material (Winik et al., 2006; Rahimi et al., 2010).

Gouw-Soares et al. (2004) reported that the samples prepared with erbium:yttrium, aluminum, and garnet (Er:YAG) laser presented clean surfaces, without the smear layer, but roughly compatible to the ablated dentine and without evidence of dentinal tubules. Leonardi et al. (2010) in a dye leakage study assessed the apical sealing of dentinal tubules after root-end surface cutting with Er:YAG and Nd:YAG lasers. The

results of this study demonstrated that the use of the Er:YAG laser resulted in superior dentinal tubule sealing in comparison with neodymium-doped yttrium aluminium garnet (Nd:YAG) application. Karlovic et al. (2005) compared the sealing effectiveness of Er:YAG laser to the ultrasonic device in the preparation of similar retrograde cavities using different retrograde filling materials. The results show that cavities prepared with Er:YAG laser had significantly lower microleakage for all the materials tested.

In another study, Batista et al. (2009) evaluated the time required and the quality of retrograde cavity preparations using ultrasonic devices or Er, Cr:YSGG laser. The Waterlase Laser showed the highest mean time for preparation of root-end cavities. Fractures in the cavosurface angle occurred only in the ultrasonic group. Ultrasonic samples showed better scores for quality of preparation than Er,Cr:YSGG. Çalışkan et al. (2010) assessed the apical microleakage of composite-filled root-end cavities prepared by Er,Cr:YSGG laser. The results demonstrate that microleakage of composite-filled root-end cavities, prepared by Er,Cr:YSGG laser, was significantly more than those prepared by conventional methods. On the contrary, Kocak et al. (2010) compared the sealing efficacy of retrograde cavity preparations prepared and filled with different equipment and materials. In their study, low-speed burs, ultrasonic devices or Er,Cr:YSGG laser devices were used for cavity preparations. According to the results of their fluid filtration microleakage study, the cavities prepared with Er,Cr:YSGG laser demonstrated significantly lower microleakage in all the filling materials.

In spite of controversial findings of above-mentioned studies, the results of the present protein microleakage study show that microleakage of the root-end cavities prepared by Er,Cr:YSGG laser was less than those prepared by ultrasonic retrotip. Within the limitations of this in vitro study, it seems that sealing ability of MTA in preparation with Er,Cr:YSGG laser was better than conventional ultrasonic root-end preparation.

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