Evaluation of the effect of ER: YAG laser on apical microleakage (in vitro study)

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ABSTRACT

Background: Apicoectomy and retrograde filling is indicated when conventional endodontic treatment is impossible or failed to achieve apical seal. The aim of this study was to evaluate the effect of ER: YAG laser on apical microleakage.

Materials and Methods: Sixty extracted single-rooted teeth were used in this study. The roots were divided into six groups. Group 1: apicoectomy by fissure bur, and apical cavities prepared by round bur, then cavities were filled with MTA. Group 2: the roots preparations and fillings were the same as group 1, then the apical areas were treated by Er:YAG Laser. Group 3: apicoectomy by fissure bur, and apical cavities prepared by ultrasound retrotip and cavities were filled with MTA. Group 4: the roots preparations and fillings were the same as group 3, then the apical areas were treated by Er:YAG Laser. Group 5: the roots obturation with gutta percha, then the apices were resected using Er:YAG Laser. Group 6: the roots apices were resected with Er:YAG Laser, then the canals were obturates with gutta percha. Apical microleakage was measured by methylene blue dye penetration technique.

Results: Significant difference between the groups. Group 1 shows the best apical seal, while group 5 shows the worse apical sealing ability.

Conclusion: Apicoectomy by bur is better than apicoectomy by laser, and apical cavity prepared by bur is better than prepared by US. The use of ER: YAG laser in apicoectomy is preferred to be done before obturation of the root canal with gutta percha.

Keywords: Apicoectomy, microleakage, ultrasound, ER: YAG laser. (J Bagh Coll Dentistry 2013; 25(4):66-71).

INTRODUCTION

The modes of treatment of non vital tooth should be either: extraction if the tooth is un useful and un restorable or treated by root canal therapy (RCT) if the tooth is restorable and there is some evidence that small periapical cystic lesion may resolve following successful RCT, however in some cases there are failure of RCT or there are some obstacles to do RCT, so endodontic Surgery (apicoectomy) is indicated. Endodontic surgery can be defined as the surgical procedure that aims to treat complications unsolved by conventional RCT [(1)].

Apicoectomy means the amputation or resection of the root apex and curettage of the periapical lesion by surgical operation. There are two types of apicoectomy: conventional apicoectomy and retrograde apicoectomy. Retrograde apicoectomy is indicated in some cases where there are obstacles to do conventional apicoectomy as in case the root canal can't be adequately cleansed and filled via the pulp chamber due to presence of pulp stone, calcified root canal, imperfect obturates root canal, fractured reamer, or the affected tooth is covered by a crown or a bridge [(2)].

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Also root-end resection may be the treatment of choice for teeth in which adequate nonsurgical retreatment had failed to eliminate existing periapical pathosis. Thus, following the apical resection, efforts should be made to seal the root-ends and prevent apical microleakage [(3)].

In recent years there have been important innovations in the practice of endodontic surgery, these included; advances in diagnostic imaging, surgical technique, visibility of the surgical field in particular the introduction of the surgical microscope providing better and sharper visualization, introduction of laser, guided tissue regeneration and advances in retrograde filling materials [(4)].

The permeability of dentin exposed by apicoectomy is one of the causes of endodontic surgery failure because microleakage and bacterial contamination trigger inflammation [(5)]. Pécora, et al. reported that dentin permeability decreased when smear layer was found close to the apical third of the root canal. In contrast, the removal of smear layer after apicoectomy using rotary instruments is beneficial because it promotes cementum deposition on the exposed dental surface and favors tissue repair [(6)]. According to Gagliani, et al., apical microleakage increases at increased resection angles because a larger number of dentinal tubules are sectioned and exposed. Less dye penetration is found when apicoectomy is performed at 90 degrees because the apical delta is more fully removed in perpendicular resections [7].

Removal of the last three millimeters of the root eliminate most of the apical deltas, isthmuses, and other canal irregularities, which are usually present at that specific area of the root canal system. Consequently, the microorganisms harbored in these canals are removed, preventing the seepage of their byproducts to the periapical tissues. Carbide burs mounted on high-speed hand-pieces provide adequate smooth surfaces for root-end resections. However, little is known if the type of bur used or the degree of smoothness after root-end resection would have a significant impact on the clinical outcome of surgical endodontic. Root-end resection performed with high energy laser result in ablation of the exposed dentinal tubules, which may decrease microleakage, and increase the resistance to root resorption. The absence of vibration during the root-end resection with lasers may also prevent loss of adaptation between the gutta-percha and the canal wall [3]. Gouw-Soares, et al. conducted a study with human teeth with apicoectomies performed with burs, Er:YAG laser or CO2 laser. The use of lasers resulted in smoother surfaces and more homogeneous dentin fusion and recrystallization, which occluded tubules and decreased permeability [8]. Paghdiwala found that thermal ablation with Er:YAG laser can cause the dissolution of mineral components and fusion of amorphous particles, without crystallization, which results in a clean and smooth surface. The advantages of this type of laser over burs are: better visibility; accurate apical resection; no contact; removal of lesion in a shorter time by vaporization; haemostasis; no vibration or discomfort and minimal pain; and less bacterial risk of trauma to adjacent tissues [9]. Grgurevic, et al. tested different Er:YAG laser parameters for apicoectomy, and they concluded that even high-energy lasers are safe when used under water-air refrigeration [10].

Apicoectomy combined with retrograde filling is one of the most widely performed endodontic surgical procedures. The ideal root-end cavity preparation can be described as at least 3-5 mm deep class-I cavity, with walls parallel to the long axis of the root. This regularly shaped cavity should incorporate the root canal anatomy and should retain the retrograde filling material. The apical cavity may prepare by bur or by ultrasound (US) retrotips. The use of US-activated tips for root-end cavity preparation improves this procedure since less removal of bone tissue is required to gain proper access to the apical region. Also, the resected apical segment can be smaller and less angulated [1]. In addition, ultrasonically prepared root-end cavities can be more conservative than bur-prepared cavities, involving both the canal and the isthmus, allowing better adaptation of the retrofilling material and consequently improving the apical seal. Both non-coated stainless steel and diamond-coated retrotips can be used for root-end cavity preparation [1,7,11,12].

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. Several retrofilling materials have been studied, such as dental amalgam, zinc oxide and eugenol-based cements (IRM and Super-EBA), Sealer 26 and mineral trioxide aggregate (MTA) [13]. MTA has demonstrated advantages as sealing, marginal adaptation and possibility of use in the presence of humidity. MTA presents excellent biological property; however, its sandy consistence makes it difficult to handle [13-15].

Mineral Trioxide Aggregate (MTA) is a material developed in Loma Linda University, USA and represents a significant improvement over other materials used as a root- end filling materials, it is the first restorative material that allows for the overgrowth of cementum and it may facilitate the regeneration of periodontal ligament. MTA is cement composed of tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferrite and calcium sulfate and bismuth oxide. It is very alkaline and hydrophilic requires moisture to set making dryness not necessary, it is mixed with sterile water to make a sandy consistency [16].

MATERIALS AND METHODS

Sixty extracted single-rooted teeth with single canal were used in this study. The roots used in this study were straight without curvature, free from cracks and fracture examined by magnification lens (X10). The calculus and debris were removed from root surface by periodontal curette, then the teeth were decoronated using a diamond disk bur, and the remaining lengths of the selected roots were 16 mm as a standard root length. The exact working length was established by passing size 10 stainless steel file until it’s tip was just out of the apical foramen and then by subtracting one mm from the measured length. The roots were instrumented with stainless steel files and the final size was 40 using conventional technique.

Sodium hypochlorite was used for root canal irrigation after each file. Then the roots were dried with paper points and finally each root was obturates with gutta percha master apical cone size 40 and accessory gutta percha cone by lateral condensation and use endofill as a sealer, and the coronal access cavity was filled with a temporary filling.

The roots were divided into six groups randomly (10 roots for each group):

Group 1: the apex of the root was resected for 3mm length at 90 ^{0} to the long axis of the root using high-speed hand piece and a diamond fissure bur under water cooling, and root-end cavity prepared with contra-angle low speed hand piece and a stainless steel round bur size 1 (cutting end 1mm in diameter) for 2mm depth and the cavity was filled with MTA which was mixed according to manufacturer instruction.

Group 2: the root preparation and fillings are the same as group I. Then the apical area was treated by Er:YAG Laser (160 mJ, 10 Hz), just surface treatment by laser without further resection from the apex by laser.

Group 3: Apicoectomy for 3 mm length at 90 ^{0} to the long axis of the root using high-speed hand piece and a diamond fissure bur under water cooling, and the root-end cavity prepared by using US unit (P-max, Satelec France) with retrotip S12, 7D for 2mm depth and filled with MTA.

Group 4: the root preparation and fillings are the same as group 3. Then the apical area was treated by Er:YAG Laser (160 mJ, 10 Hz), just surface treatment by laser without further resection from the apex by laser.

Group 5: after the roots obturation with gutta percha master apical cone size 40 and accessory gutta percha and use endofill as a sealer, in this group there is no preparation and filling of the root-end cavity. The apex of the each root was resected for 3mm length at 90 ^{0} to the long axis of the root using Er:YAG Laser (450 mJ, 6 Hz) under water cooling.

Group 6: after instrumentation of the root canal, the root apex was resected for 3mm length with Er:YAG Laser (450 mJ, 6 Hz), then the roots were obturates with gutta percha master cone size 40 and accessory gutta percha, and the excess gutta percha were cut with a hot ash from the coronal and apical parts. In this group also there was no preparation and filling of the root-end cavity.

The sixty roots were stored for 7 days in humid atmosphere and 37 ^{0}C for setting of the fillings. Finally all the roots were painted with a two layers of nail varnish except 2mm from the apex, and then the roots were immersed in 2% methylene blue dye which was used as leakage indicator in an incubator for 48 hours. After that each root was washed with running tab water for about one minute. Longitudinal grooves were made on both sides of each root without penetrating the walls of the pulp by using a fine diamond disc bur under water cooling and then split the root into two halves by using chisel and mallet to finish the longitudinal root sectioning.

The gutta percha and MTA filling was removed from the sectioned roots and the apical linear dye penetration (apical leakage) was measured by using stereomicroscope (X40) magnification with calibrated grid. The maximum apical dye leakage was measured from the tip of the root end to the deepest point where the dye was apparent in both separated halves of the root (figure1).Three readings to measure each sample for apical leakage and the mean value was the documented reading.

Analysis of variance (ANOVA) test was performed to test the difference between the mean of dye penetration among the six groups. Statistical significance was evaluated as follows:

If p-value > 0.05 = No statistically a significant difference.

If p-value < 0.05 = statistically significant difference.

If p-value < 0.01 = statistically a highly significant difference.

The least significant difference (LSD) was used to test between groups

RESULTS

The descriptive statistics (mean values and standard deviation with the minimum and maximum values) are presented in Table 1 and Figure 2.

Analysis of variance (ANOVA) test was performed to test the difference between the mean of dye penetration among the six experimental groups. Statistical difference was found significant ($P<0.05$) among the experimental groups (table 2).

The Least Significant Difference (LSD) test was used for multiple comparisons between the six experimental groups which show variations between non-significant, significant and highly significant (table 3).

Table 1: Descriptive statistic of dye penetration

Groups	Mean	SD	Min	Max
Group1	0.156	0.0078	0.05	0.25
Group2	0.597	0.02985	0.1	1.8
Group3	0.314	0.0157	0.12	0.8
Group4	0.735	0.03675	0.1	1.55
Group5	5.55	0.2775	4.5	7.5
Group6	0.38	0.019	0.2	0.5

Table 2: ANOVA test between groups

Between groups	F-test	P-value	Sig
	2.284	0.046	S

Figure 1: The dye penetration in split roots

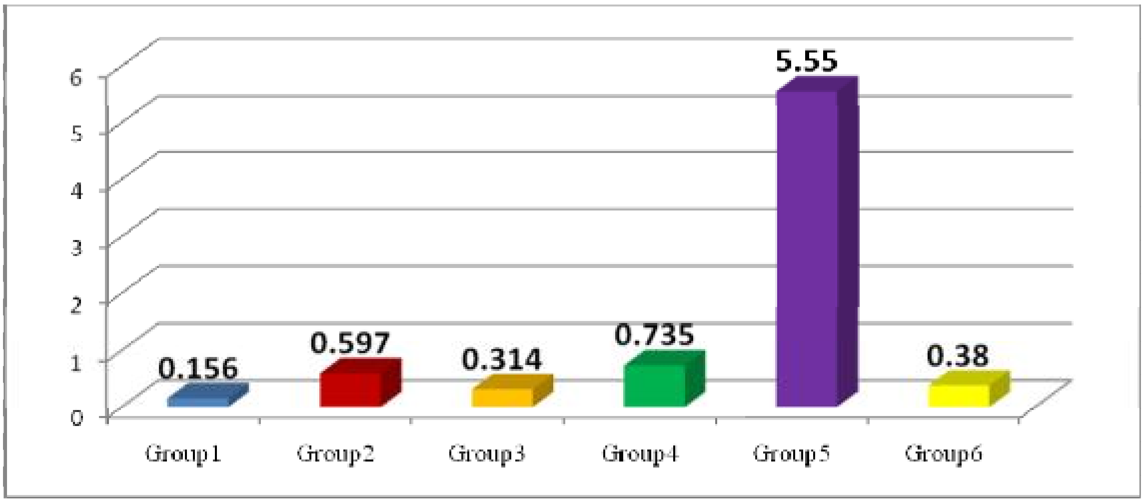

Figure 2: Bar chart for tested groups

Table 3: Least significant difference (LSD)

Groups	P-value	Sig
G1&G2	P<0.05	S
G1&G3	P>0.05	NS
G1&G4	P<0.05	S
G1&G5	P<0.01	HS
G1&G6	P>0.05	NS
G2&G3	P>0.05	NS
G2&G4	P>0.05	NS
G2&G5	P<0.01	HS
G2&G6	P>0.05	NS
G3&G4	P<0.05	S
G3&G5	P<0.01	HS
G3&G6	P>0.05	NS
G4&G5	P<0.01	HS
G4&G6	P<0.05	S
G5&G6	P<0.01	HS

DISCUSSION

The selected roots for this study were straight, with standardized length, and apical foramen were completed and without resorption. In this study, three millimeters was resected from the apex, and the cutting was perpendicular to the long axis of the root because as mentioned by other studies; the removal of the last three millimeters of the root eliminate most of the apical deltas, isthmuses, and other canal irregularities, which are usually present at that specific area of the root canal system. Consequently, the microorganisms harbored in these canals are removed, preventing the seepage of their byproducts to the periapical tissues [1,3,7,17].

The class I cavity preparation to accommodate the apical filling material were 2 mm depth and have parallel walls to achieve effective sealing as mentioned by other studies [13,17] .

The use of ultrasound tips provides more adequate access to the apical end of the root canal. Therefore, resections may be performed perpendicular to the long axis of the tooth, which preserves structure and decreases the number of sectioned dentinal tubules [15,18,19]. The ultra sonic retrotip S12, 7D was used, the length of the active part of the tip was 2mm.

MTA filling was used in this study that it does not require a dry field, easy to handle, apply and remove excess, has good biocompatibility, results in less apical microleakage in endodontic surgeries, has excellent marginal adaptation to the walls of the cavity, and requires little force for condensation [12,19].

Er:YAG laser has different energies for both cutting (450 mJ, 6 HZ) and surface treatment (160 mJ, 10 HZ).

Several in vitro studies for the assessment of microleakage were reported using staining, scanning electron microscope, bacterial activity, and many other chemical agents. Dye penetration techniques still remain one of the commonest methods to test sealing ability of restorative materials. Methylene blue is a commonly used dye, it was found that its leakage is comparable with that of the small bacterial product of similar molecular size [16].

In the present study apical penetration of methylene blue dye at different rates was found in all evaluated specimens.

Group 1 had the lowest rates of dye penetration 0.156 mm when compared with the other groups, the apex was resected with diamond bur which provides adequate smooth surfaces for root-end resections, and this is in agreement with other studies. However, little is known if the type of bur used or the degree of smoothness after root-end resection would have a significant impact on the clinical outcome of surgical endodontic [3].

Group 1also reveals a significant difference with group 2 and group 4 ($p < 0.05$), this might be due to the laser energy which was used for root apex surface treatment which leads to more microleakage, this is in agreement with Pashley, et al., who used different laser energies 11, 113 or 556 J/cm2. The two lowest laser energy levels increased permeability, whereas the highest produced a fully glazed surface that occluded dentinal tubules [20]. Such findings were confirmed by Kimura, et al., who visualized areas of melted dentin under scanning electron microscopy, with partial occlusion of dentinal tubules and no cracks, fractures or thermal damage to adjacent structures or the pulp [18].

Group 1had a less dye penetration than group 3 and group 6 but the difference is not statistically significant ($p > 0.05$), according to this results it is preferred to do retrofilling after apicoectomy and this study shows the apical cavity preparation by bur shows better results from cavities prepared by US, this might be due to the US produces microcracks in the root, compromising the seal and leading to treatment failure, this is in agreement with other studies [7,16].

Group 2 had more dye penetration than group 3 but the difference was not statistically significant, this might be due to the effect of laser surface treatment which increases the microleakage.

Group 2 had less dye penetration than group 4 but also the difference is not significant, this might be due to the use of US and laser in group 4 which increases the microcracks by US and microleakage by laser.

Group 2 had more dye penetration than group 6 but the difference is not significant, this also might be due to the effect of laser surface treatment.

Group 3 shows significant difference with group 4, this also due to the use of laser for surface treatment in group 4.

Group 3 shows no significant difference with group 6, this is due to the use of US in this group. Group 4 shows significant difference with group 6, also due to the use of US in cavity preparation in group 4, which might also due to the same reason as between group1 and group 2.

In group 5 there were high statistical significant differences with other groups, after cutting of the root apices with ER:YAG laser affects the adaptation of the gutta-percha filling material to the root canal walls due to the rapid increase of temperature generated by laser applied to the gutta-percha and root canal sealer, and the apical seal area were removed. so this cause more shrinkage and thermal damage of the gutta percha which affect the adaptation of the gutta percha with root canal surfaces and this increase the rate of apical leakage in this group.

Group 6 had low rate of dye penetration 0.38 when compared with groups 2 and group 4. Root-end resection performed with laser result in ablation of the exposed dentinal tubules, which may decrease microleakage, and increase the resistance to root resorption [3]. Gouw-Soares, et al, conducted a study with human teeth with apicoectomies performed with burs, Er:YAG laser or CO2 laser. The use of lasers resulted in smoother surfaces and more homogeneous dentin fusion and recrystallization, which occluded tubules and decreased permeability [8]. Paghdiwala found that thermal ablation with Er:YAG laser can cause the dissolution of mineral components and fusion of amorphous particles, without crystallization, which results in a clean and smooth surface [9].

As a conclusion; apicoectomy with class1 apical cavity preparation by bur was better than apical cavity prepared by US. Retrograde filling after apicoectomy was preferred because of better results than without retrograde filling. The use of ER: YAG laser in apicoectomy is preferred to be done before obturation of the root canal with gutta percha.

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