A comparison of Er, Cr: YSGG laser with ultrasonic preparation on the seal of retrograde cavities

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Background and aim: The aim of this in vitro study was to compare Er, Cr: YSGG laser with ultrasonic preparation on the seal of retrograde cavities.

Materials and methods: Twenty-eight maxillary anterior teeth were used in this study. After removing the crowns, the canals were prepared with the step-back technique and filled with gutta-percha. Three millimeters below the apex; each root was cut with a fissure diamond bur. The root surfaces were then covered with nail polish and three millimeters deep retrograde class I cavities were prepared, using Er, Cr: YSGG laser (group L=12 roots) or ultrasonic retro-tip (group U=12 roots). Four roots were arranged for negative and positive control groups. Retrograde cavities were then filled with mineral trioxide aggregate (MTA) and teeth were placed in 2% methylene blue dye for 72 hours. The amount of dye penetration in sagittal sections of each tooth was measured with a stereomicroscope. An independent sample t-test was used for statistical analysis.

Results: Cavities prepared with the Er, Cr: YSGG laser (1.61 ± 0.81) showed significantly less micro-leakage than those prepared with the ultrasound (2.55± 1.84) (P value =0.02).

Conclusions: Under the conditions of this research, the use of Er, Cr: YSGG laser for retrograde cavity preparation causes significantly less apical leakage and may increase the success rate of endodontic surgeries.

Key words: Er, Cr: YSGG laser • Retrograde cavities • Root end preparation • Ultrasound

Introduction

Surgical endodontic treatment is employed when the conventional root canal therapy is unsuccessful and retreatment is either impossible or useless. The main goal in apical surgery is an apical hermetic seal, such that the bacteria and their by-products do not pass through the seal. Apicoectomy and retrograde cavity preparation used to be done with burs and the success rate of this traditional apical surgery method is approximately 60% 1). Development of ultrasonic technique and its surgery tips in the last two decades raised the rate of successful endodontic surgeries to over 90% 2). However, dentin cracks and smear layers were observed after using ultrasonic retro-tips for retrograde cavity preparation and this can threaten the apical seal 3). Therefore, more efforts to find new methods in this regard are necessary. The Erbium family laser has a great capacity of ablation and its “non-contact” procedure is appropriate to prevent dentin cracks 4). In addition, it is able to remove smear layer and result in a better adaptation of retro fill material with cavity walls 5, 6). Olivera et al. showed that apicoectomy with the...
Er: YAG laser and retrograde cavity preparation with the Nd: YAG laser had the least leakage. Karlovic et al. compared the Er: YAG laser with ultrasound in the root-end cavities preparation showing that the laser group had less leakage. The Er, Cr: YSGG is a hard laser with FDA approval for both hard and soft tissue surgeries. Wallace investigated dentin cracks produced by Er, Cr: YSGG when used for root-end cavity preparation and he showed that this type of laser creates almost no cracks. The aim of this in vitro study was to compare the Er, Cr: YSGG laser with ultrasonic preparations on the seal of retrograde cavities.

Materials and methods

Twenty-eight single rooted anterior teeth with normal anatomy and curvature were used in this study. No internal or external resorption and calcification were seen on radiographs of the selected teeth. After extraction, specimens were stored in normal saline and, before starting the experiment, they were stored in 5.25% NaOCl for 2 hours, for disinfection. Soft tissues and plaque were removed from root surfaces with scaling tips and crowns were then cut at CEJ, using a diamond fissure bur; the working lengths determined to be 0.5 mm shorter than apical foramen. Visual inspection of the apical foramen was employed and 0.5 mm was subtracted. Canals were prepared with the step-back technique and file number 50 was chosen as the master apical file. Flaring was performed up to #70 file and with Gates Glidden #2, 3 and 4 and irrigation during instrumentation was done with 15 ml of 5.25% NaOCl for each tooth.

After drying the canals with paper points, they were obturated with Gutta Percha (GP) and AH26 sealer using the lateral condensation method. Then, an X-ray was taken to control the obturations. In the next step, teeth were kept in an incubator for one week (37°C and 100% humidity).

All root surfaces were covered with sticky wax and 2 layers of nail polish and a three millimeter root-end resection was made on each root perpendicular to the long axis of the root using a diamond fissure bur on a high speed headpiece with water spray. Specimens were then randomly divided into two experimental groups of 12 teeth and two control groups of 2 teeth. In group L, after removing about 3 mm of GP from the end of the canals with a heated instrument, retrograde class I cavities were prepared by G6 tip of Er, Cr: YSGG laser (Biolase technologies San Clemente, California, USA) wavelength 2.78 micrometers, frequency 20 Hz, pulse duration 140 microseconds, E/P=150 MJ/P, P=3 W, water 55%, air 65%, (as suggested by the manufacturer for dentin cavity preparation). All of the class I root-end preparations were etched down to a depth of 3 mm and approximately 1.5 mm in diameter, as confirmed with a periodontal probe. All cavities were prepared by the same person.

The root was kept moist during preparation while the energized water molecules did the cutting. In group U, the root-end class I cavities with the same depth and diameter were prepared using E 31 D retro tip on an ultrasonic unit (Endo-mate-NSK). The same person prepared all the cavities using intermittent pressure with in-and-out motion until preparation was completed to a depth to 3 mm. Finally the tip was moved circumferentially to complete the preparation. All retrograde cavities in both groups were filled with MTA (pro Root MTA- Tulsa Dental). An MTA gun was used to transfer the MTA to the cavities and then, it was condensed and burnished. In the positive control group, retrograde cavities were kept empty and in the negative control group, retrograde cavities were filled with sticky wax. To check retrograde fillings, X-rays were taken of the teeth in both groups. All teeth were then put in 2% methylene blue dye for 72 hours and after that they were washed under running water for 5 minutes and then dried out. The roots were grooved on the buccal and lingual surfaces using diamond discs. They were then split into two sections with the tip of a spatula. Dye penetration was measured linearly to its farthest extent within the root-end cavity using an Olympus dissecting stereo Microscope (Optical Co. LTD model: SZX/1//B 200/Japan).

Results

The extent of dye penetration in millimeters, the mean and the standard deviation for each group are listed in Table 1. Because one sample Kolmogorov-Smirnov

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td>12</td>
<td>1.61</td>
<td>±0.81</td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>12</td>
<td>2.55</td>
<td>±1.84</td>
</tr>
<tr>
<td>Positive control group</td>
<td>2</td>
<td>4.68</td>
<td>±0.1</td>
</tr>
<tr>
<td>Negative control group</td>
<td>2</td>
<td>0</td>
<td>-</td>
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test showed normal distribution of data, an independent sample t-test was used for statistical analysis. Results showed that the laser group (1.61±0.81) had significantly less leakage than the ultrasonic group (2.55±1.84) (P=0.02). Positive and negative control groups showed maximum and no leakage, respectively.

**Discussion**

Apical seal after endodontic surgery can be affected by the angle of the root cutting, the procedure of root end cavity preparation and the retrograde filling material. Cutting the root perpendicularly to its long axis exposes less dentinal tubules and will cause less leakage. However, this will limit access to the end of the root. Piezoelectric ultrasonic devices can overcome this limitation because they can yield a class I retrograde cavity three millimeters deep with parallel walls. Their main disadvantages are the high incidence of dentinal cracks and also production of smear layers on the dentinal walls during cavity preparation.

Khabbaz et al. compared bur, sonic and ultrasonic for the root-end cavity preparation and showed 7-20% cracks with ultrasonic tips. According to SEM evaluation of Ishikawa et al., root-end cavity preparation with ultrasonic tips caused 10-20% cracks. It has also been shown that, while burs created 10% microcracks, ultrasonic caused 60-80% microcracks when used for root-end cavity preparation. Layton et al. in 1996 used ultrasonic in low and high power settings and demonstrated more than 40% cracks.

Recent introduction of lasers and their applications has attracted the attention of researchers to solve the above mentioned problems by its utilization. Due to lack of vibration and lower risk of traumatizing the surrounding tissues, lasers do not produce dentinal crack. They also produce no smear layer and bring about a better adaptation of retrofill material with cavity walls.

Several studies have shown that usage of lasers in endodontic surgeries reduces the leakage compared with burs and ultrasonic tips. Stabholz et al. in 1992 showed that the usage of the Nd: YAG laser after preparation of retrograde cavities caused less dentinal leakage in the cavities. In 1993 Paghdiwala et al. used the Er: YAG laser for apicoectomy of roots and showed by SEM observation that this laser reduces dentin permeability. Olivera et al. showed that apicoectomy with the Er: YSGG laser followed by dentinal surface irradiation and retrograde cavity preparation with the Nd: YAG laser reduced the dentinal permeability. In 2005, Francischone et al. showed that the apicoectomy with the Er: YAG laser, using either ZOE or sealer 26 as retrograde filling material, causes less leakage than burs and ZOE as retrograde filling material.

Bader's research covered a 4-year study reporting 320 cases in which endodontic surgery was performed. Either microbur or ultrasonic for preparation of retrograde cavities were used and half of the cases in each group were then treated with a CO2 laser: the conclusion was that, regardless of technique, the CO2 laser did not improve the healing process. This laser produces scars due to thermal damage causing delayed healing. Arisu et al. irradiated retrograde cavity surfaces with a Nd: YAG laser and assessed morphology and permeability of the apical dentin surface and the results showed that the usage of India ink with the Nd: YAG laser enhanced the amount of melting and recrystalization of dentin. They also showed that radiation and initiator increased the leakage. The Nd: YAG laser, however, seals dentinal tubules and cannot create a micro-retentive surface. Bader and Arisu used different kinds of lasers than the present study. Neither of the previous two studies used lasers for retrograde cavity preparation while this study used the Er, Cr: YSGG laser for retrograde cavity preparation.

The Er, Cr: YSGG laser has been found to be a proficient instrument in cutting hard tissues like bone and dentin. Contrary to other lasers used in endodontic surgeries the Er, Cr: YSGG laser prevents any changes in connective tissues. This laser cuts hard tissues with highly energized water particles and therefore produces the least thermal damage.

Batista et al. evaluated the time required and quality of retrograde cavity preparation using ultrasonic or the Er, Cr: YSGG laser. The Er, Cr: YSGG showed the highest mean time for preparation of the root end cavities while fractures in the root surface occurred with the use of EMS ultrasonic retro tips. Ultrasonic groups (CVD and EMS ultrasonic retro tips) showed better scores for quality of preparation than Er, Cr: YSGG and probably the presence of root filling materials in the Batista study may influence the efficacy and time of laser use. Therefore, we removed 3 mm of gutta-percha from the ends of the canals before laser application with a heated instrumentation as recommended by Abedi.

The Er, Cr: YSGG laser also produces a micro-retentive surface due to the irregular intertubular dentin surface which may increase the mechanical bond between retrofill material and dentinal walls.
MTA is the material of choice for retrograde-filling; it is easy to use and its sealing ability is not influenced by bleeding and moisture \(^{20}\); for this, MTA demonstrated superior marginal adaptation and biocompatibility over other materials \(^{21, 22}\).

The next step for experimentation would be “in vivo” studies on animals and humans. Lietzau et al. examined the effectiveness of an Er: YAG laser used in conjunction with a dental operation microscope for apicoectomy, in comparison with the traditional surgical procedure and they showed that the use of Er: YAG laser as adjuvant tool in periapical surgery, with additional control by an operation microscope, displays significantly better results in terms of postoperative healing, in comparison with the conventional surgical treatment \(^{23}\). Obviously usage of lasers in the mouth would be easier with the development of a laser micro-surgery hand piece which we look forward to utilize.

**Conclusion**

Under the conditions of the present study the use of Er, Cr: YSGG for retrograde cavity preparation may increase the success rate of endodontic surgeries.

**References**


[Acknowledgements]
According to the fact that dentin cracks and smear layers were observed after using ultrasonic retrotips for retrograde cavity preparation, we thought that Erbium family laser might be a suitable alternative for ultrasonic devices. Therefore, we decided to compare Er, Cr; YSGG laser with ultrasonic preparation on the seal of retrograde cavities. This article has not been published, nor has it been submitted for publication, elsewhere. The authors have no conflict of interest, financial or otherwise, regarding any aspect of the subject matter of the article.