Original Research

Effect of Waterlase laser retrograde root-end cavity preparation on the integrity of root apices of extracted teeth as demonstrated by light microscopy

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Abstract
Most endodontists use ultrasonic instruments for retrograde root-end cavity preparation even though they have been found to produce cracks. In this laboratory study, thirty-six randomly chosen roots had root-end cavity preparations made with the Waterlase laser and only one questionable intra-canal crack was found. It was concluded that the Waterlase laser when used to make endodontic root-end cavity preparations produces either no cracks, or a very low percentage (2.8%) of cracks.

Introduction
Most endodontists consider ultrasonics as the method of choice for retrograde root-end cavity preparation. Several authors have found ultrasonic root-end cavity preparation produces cracks and/or chipping. (Table 1).

The Biolase Waterlase (Biolase @ Technology, Inc. San Clemente, CA, USA) Er-Cr:YSGG (Erbium, Chromium: Yttrium, Scandium, Gallium and Garnet) pulsed laser has been found to be useful in endodontic surgery for root-end resection, root-end cavity preparation, haemostasis, and sterilization of the root apex and surrounding tissue. For restorative procedures, laser use has increased patient acceptance related to pain, vibrations, whine of the drill, micro-fractures and heat production (15). This laser cuts hard tissue with highly energised water particles and soft tissue directly with laser energy. (15) Preliminary studies looking at the safety and efficacy of using the ErCr:YSGG laser found it to be a proficient instrument in cutting bone. (16) FDA approval for apicoectomy surgery was granted on 12 February 2002 and flap surgery on 3 February 2003. Gouw-Soares (17) demonstrated the Er:YAG (Erbium:Yttrium-Aluminium Garnet), Ga-Al-As (Gallium Aluminium Arsenide) and Nd:YAG (Neodymium: Yttrium-Aluminium Garnet) lasers, when used in combination for performing an apicoectomy, produced heat which may lead to cracking. Root-end cavity preparation should be three millimetres in depth and the resection angle should be zero (18,19).

The purpose of this study was to determine if root-end preparations at a depth of three millimetres in resected roots at a zero angle performed by the Waterlase laser produce cracks and/or chipping. To the author’s knowledge there is no published data on the use of the Waterlase laser for this purpose.

Materials and methods
Seventeen extracted teeth, comprising eight mandibular molars, five maxillary molars, three bicuspid and one central incisor were chosen at random for a total of thirty-six root apices.

The teeth were stored in 0.9% sodium chloride and 1% sodium hypochlorite solution to preserve and inhibit microbial growth. All the teeth apices were preoperatively evaluated by two independent investigators with a fibre-optic translucent light source for a time period not exceeding 2 min using a Fisher stereomicroscope (FSM) at ×40 magnification and a Global Surgical Microscope (GSM) at ×12 magnification with digital photographs being taken at this time (20).
A three millimetre root-end resection was made on each root apex perpendicular to the long axis using a carbide bur in a high speed hand piece with water using GSM at ×12 magnification (21). The resected root apex was again examined for cracks and photographed as above. Following root resection, the teeth were immediately placed in a solution of 0.004% aqueous methylene blue dye in distilled water (2). Forty-eight hours following immersion, two investigators independently examined the specimens using the FSM ×40 magnification and photographed them with the GSM at ×12 magnification (Fig. 1).

The teeth were immediately returned to the storage unit and immersed in 0.004% methylene blue solution. The total preparation time for each root was less than 2 min. The teeth were then re-examined under the FSM at ×40 magnification with transillumination by two independent investigators.

**Results**

The 36 roots were evaluated before resection with the GSM ×12 magnification and the FSM at ×40 magnification by two independent investigators using transillumination for under 2 min and no cracks were identified. Digital photographs with GSM at ×12 magnification illustrated no cracks.

The root-ends were evaluated after resection as would be done in a clinical surgical situation, and no cracks were evident using the GSM at ×12 magnification. Forty-eight hours following immersion in 0.004% methylene blue dye, two investigators independently examined the resected root ends with the FSM at ×40 magnification and the GSM at ×12 magnification, and once again no cracks were found.

During the root-end preparation in handling the specimens with gloved hands no detectable heat was produced in the specimens, thus enhancing chances for no cracks being produced. Sample specimens before and after root-end preparation are shown in Figures 1–3.

The teeth were re-examined under the FSM at ×40 magnification using transillumination by two independent investigators. One questionable intracanal crack was observed in one root-end preparation (that is, in 2.8% of specimens).

### Table 1 Ultrasonic and bur root-end preparation in vitro

<table>
<thead>
<tr>
<th>Paper</th>
<th>Type of instrument</th>
<th>Frequency of cracks</th>
<th>Assessment</th>
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</thead>
<tbody>
<tr>
<td>Abedi et al. (1)</td>
<td>Fissure bur and ultrasonic</td>
<td>Significantly more cracks with ultrasonic versus bur</td>
<td>SEM</td>
</tr>
<tr>
<td>Layton et al. (2)</td>
<td>Ultrasonic low and high</td>
<td>More than 40% demonstrated cracks</td>
<td>Dye and microscope</td>
</tr>
<tr>
<td>Frank et al. (3)</td>
<td>Bur slow and high speed, sonic ultrasonic medium and high</td>
<td>10–50% of teeth</td>
<td>Dye and microscope</td>
</tr>
<tr>
<td>Lloyd et al. (4)</td>
<td>Sonic and bur</td>
<td>Sonic 10–15%</td>
<td>SEM</td>
</tr>
<tr>
<td>Beiling et al. (5)</td>
<td>Ultrasonic</td>
<td>5–10%</td>
<td>SEM</td>
</tr>
<tr>
<td>Min et al. (6)</td>
<td>Bur, ultrasonic</td>
<td>Bur 10%, ultrasonic 100%</td>
<td>Confocal microscopy</td>
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<td>Brent et al. (7)</td>
<td>Ultrasonic</td>
<td>20–25%</td>
<td>SEM</td>
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<tr>
<td>Morgan and Marshall (8)</td>
<td>Ultrasonic</td>
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<td>Gray et al. (9)</td>
<td>Bur and ultrasonic</td>
<td>Bur 0%</td>
<td>SEM</td>
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<tr>
<td>Rainwater et al. (10)</td>
<td>Bur and ultrasonic</td>
<td>Ultrasonic 7%</td>
<td>Microscope</td>
</tr>
<tr>
<td>Peters et al. (11)</td>
<td>Ultrasonic</td>
<td>1%</td>
<td>SEM</td>
</tr>
<tr>
<td>Gondim et al. (12)</td>
<td>Sonic, ultrasonic</td>
<td>18–80%</td>
<td>SEM</td>
</tr>
<tr>
<td>Ishikawa et al. (13)</td>
<td>Ultrasonic</td>
<td>10–20%</td>
<td>SEM</td>
</tr>
<tr>
<td>Khabbaz et al. (14)</td>
<td>Bur, sonic, ultrasonic</td>
<td>7–20%</td>
<td>Video microscope</td>
</tr>
</tbody>
</table>

SEM, standard error of the mean.
Discussion and conclusion

Pulsed ErCr: YSGG laser energy can be used to prepare root-ends for an apical seal. It is the energised water molecules that do most of the cutting and thus it was found that the roots remained very cool to the touch during preparation, as has been noted for osseous tissue (22). No cracks were noted pre-treatment. The digital photographs with the GSM at ×12 magnification were studied and no cracks were observed. It is important to note that this is the magnification typically used during clinical surgical procedures. Scanning electron microscopy examination would have been useful for closer inspection of the samples. The canals were left un-instrumented as there was no significant difference in the incidence of root cracks when canals were obturated or unobturated (6). Three millimetres of the root apices were removed with a high-speed fissure bur and water under the GSM at ×12 magnification to simulate clinical conditions and no cracks were observed. The root-end preparations were prepared to a depth of three millimetres with the Waterlase laser using laser settings recommended by the manufacturer. There were again no cracks observed during or immediately after the procedure.

The thickness of remaining dentine is not of such a concern with the laser preparation, as it would be with ultrasonic or rotary instruments, because there is no vibration or pressure exerted during root-end preparation that may produce cracks. Methylene blue plus transillumination with magnification was used to detect dentinal cracks as

Figure 1 Pre- and post-preparation specimens.

Figure 2 Pre- and post-preparation specimens.
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recommended by Wright et al. (23). After 24 h in the methylene blue dye, the teeth were again evaluated and photographed with the GSM ×12 magnification. They were again subjected to transillumination and FSM at ×40 magnification and evaluated for under 2 min. Only one questionable intracanal crack was found. This may have initially been present but could not be detected until the root-end preparation was completed.

Connective tissue changes that occurs in response to other laser root surgery would not occur with the Waterlase as it is the energised water that does the cutting, not the laser. At present, no apical preparation laser micro-handpiece is available but such an instrument is under development. Teeth in situ, regardless of the method of root-end preparation, do not exhibit a lesser tendency towards cracking than extracted teeth (12).

Based on this laboratory study, the Waterlase laser does not produce a clinically relevant rate of cracking when used to make endodontic root-end preparations. The next step is to use this laser in root-end preparations under clinical conditions with the GSM and to record the results with digital photographs.

Acknowledgement

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References


Figure 3 Pre- and post-preparation specimens.


