Immediate Implant Placement Into Infected Sites: Bacterial Studies of the Hydroacoustic Effects of the YSGG Laser

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This article describes the use of an erbium laser to use photoacoustics to reduce the bacteria in osteotomy sites that were infected by apical pathology. The author shows reduced bacterial counts by performing bacterial cultures following laser treatment. Swabs were taken after the extraction of the tooth and then after the laser was placed into the osteotomy site. The results showed a noticeable reduction of bacteria and no traces of virulent bacteria.

Key Words: Er,Cr:YSGG laser, photoacoustic effect, infection, biofilm, detoxify, Bacteroides species, Bacteroides forsythus, periradicular, root fractures, internal resorption, photomodulation

INTRODUCTION

This article describes the use of the erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser (Biolase Technology, Irvine, Calif) to disinfect an osteotomy site infected with bacteria from a failed root canal. Traditional methods for dealing with infected potential implant sites have involved treatments performed in stages. The first stage, which takes place within the extraction of the involved tooth, entails curetting the infected site and placing a graft material of choice to maintain the ridge. Subsequent healing may take up to 4 months. Stage two is planning the proposed implant treatment. For this, computerized tomography is performed to give a 3-dimensional visualization as well as create a surgical guide for ideal implant placement. Stage three is the proper placement of the implant in the most functional and esthetic location. Oftentimes a 6-month healing period is necessary to assure integration of the implant fixture. Stage four involves progressively loading the implant to complete the treatment; this fourth stage may take an additional 3 months.

Oftentimes, patients find it difficult to deal with the prolonged treatment time required for the traditional treatment protocol. Patients and clinicians would benefit from a treatment protocol that decreased treatment time from 9 months to 3 months. This author discusses how to complete treatment in less time by successfully disinfecting infected sites with bacteria that could otherwise cause failure of the implant.

Background

The number of pathogens left in an infected osteotomy site is dependent upon the ability to debride the area or to disrupt bacterial counts in the osteotomy. Debridement refers to the elimination of bacteria and their
related irritants from the osteotomy space by means of copious irrigation via syringe and/or with internally irrigated drills during the preparation of the osteotomy site. The procedure is similar to dentinal walls during an endodontic treatment. In combination with a reagent, alveolar cortical bone debris forms what is termed mud. Alveolar mud potentially harbors remnants of bacteria and their related irritants.¹

Recently, significant interest in biofilms and in their role in endodontics has developed. A biofilm is a structured community of bacteria enclosed within a protective, sticky polysaccharide matrix that adheres to root canal surfaces. Further, biofilm fragments have been observed to disrupt, drift, and reattach to any surface. On external surface, these biofilms are referred to as plaque.²,³ Logically, 3-dimensional cleaning procedures should be directed towards disrupting any given biofilm and breaking up this matrix, moving the infected mass into solution so that it can be eliminated from the osteotomy site. It is the opinion of the author that among related factors, the hydroacoustic phenomenon has the greatest effect on this disinfection. Compounding the challenge of killing microorganisms is their ability to lodge within anatomically complex spaces.³

Novaes and Novaes report that immediate implant placement for replacement of teeth with periapical lesions can be successful if certain preoperative and postoperative measures are carried out.⁴ Such measures include the administration of antibiotics, meticulous cleaning, and alveolar debridement prior to the surgical procedure.⁵ It has been shown that chemical means can only kill bacteria at a 100 μm level. But, with laser technology, particularly the use of hydroacoustic effects, bacteria can be killed at a level greater than 1000 μm.⁶ Concurrently, a regional acceleratory phenomenon can be initiated.⁷

The Er,Cr:YSGG laser is a US Food and Drug Administration–approved laser system for cleaning, shaping, and enlarging root canals. It is also used in osseous apical and periodontal surgery. The YSGG laser can remove calcified hard tissue by emitting a beam of infrared energy at 2.78 μm that works in combination with water spray. This laser has assisted in accelerating healing, decreasing postoperative pain, and increasing bone to implant contact.⁸

The effect on implant dentistry with laser energy is the usage of radiation and water to act as a means to destroy bacteria. The energy produced is an explosion of water energy. Research performed at Temple University has revealed the effects of this energy.⁹ Within a confined space, the laser was able to reduce significantly the bacteria present after laser energy was emitted.¹⁰ Reports by Crispi et al¹¹ have shown that use of energy from erbium lasers can debride the root surface without damaging the walls.

The purpose of this article is to show in 10 case reports, that the level of bacterial reduction of osteotomy sites via hydroacoustic energy is reduced. These case reports are to provide evidence for what has been clinically observed. The author did not receive remuneration from any company to provide these case reports.

**Microbiological aspects**

Anaerobic infections are caused by a mixture of organisms. *Bacteroides* species can inhabit tooth periapical lesions,¹² while being encapsulated in a polysaccharide that promotes its virulence, survival, and importance in mixed infections. *Bacteroides forsythus* has been shown to persist in asymptomatic periapical endodontic lesions and may survive in bone in an encapsulated form after extraction and subsequently infect an implant.¹³,¹⁴ Interestingly, as much as 50% of an endodontic infection is caused by bacteria that have not yet been identified.¹⁵ These bacteria may be left intraosseously after
extraction and subsequently colonize an implant site.

Bacteria isolated in these case reports include *Porphyromonas gingivalis*, *Prevotella intermedia*, beta-hemolytic streptococci, *Campylobacter-Wolinella*, *Capnocytophaga* species, *Fusobacterium*, *Peptostreptococcus microns*, enteric gram-negative rods, *Enterococcus* species, *Prevotella melaninogenica*, and nonpigmented *Prevotella*. After extraction of the infected tooth, specimens were collected with a sterile swab and immediately placed into containers (Figure 4). A local microbiology lab (Sanford Laboratories, Sioux Falls, SD) compared counts of both cultures.

**Figure 1.** Case #1 cone beam computerized tomography showing infection apically for tooth #21.

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**Cases**

The cases were chosen by radiographic visualization of pathology (Figure 1). The remainder of this article discusses the cases used to provide evidence that hydroacoustic effects do indeed damage bacteria and thereby decrease bacterial counts, in turn allowing clinicians to immediately seat an implant with high rates of success.

Ten patients (7 men and 3 women), ranging between 43 and 61 years of age and having root fractures, failed apicoectomy, incomplete root canal fill, and internal resorption all needing extractions, were selected for implant replacement immediately after extraction. Inclusion criteria for the procedure entailed presence of bone for implant stabilization, chronic infection or inflammation in the treatment area, and systemic pathologies that contraindicated bone healing around implants with traditional concepts. Patients who smoked or lacked primary stability were also excluded.
Treatment

In each patient, the intra-arch relationship was evaluated using diagnostic casts. Periapical and panoramic radiographs, periodontal probings, temporomandibular evaluation, cone beam computerized tomography (reformatted to SimPlant software; Materialise, Glen Burnie, Md), SurgiGuide (Materialise) fabrication, and facebow (Panadent, Grand Terrace, Calif) were performed, and clinical photos were taken.

Preparation for surgery was done under standard of care. The patients rinsed with 0.12% chlorhexidine gluconate oral rinse (Peridex, 3M ESPE Dental Products, St Paul, Minn) for 30 seconds. Venipuncture was accomplished in either the right antecubital fossa or dorsum of the hand. Intravenous sedation was performed to induce a conscious sedation state. The drugs utilized included diphenhydramine (Baxter Health, Deerfield, Ill) (25 mg), nalbuphine (Hospira, Lake Forest, Ill) (range 2.5 mg to 10 mg), midazolam (Hospira) (range 4 mg to 8 mg), and, in a few cases, fentanyl (Hospira) (range 25 μg to 75 μg) as well. Upon completion of sedation, 1 g of cefazolin (Hospira) or 150 mg of clindamycin (Pharmacia & Upjohn, New York, NY) and 8 mg of dexamethasone sodium phosphate (American Regent, Shirley, NY) were administered intravenously. Forty milligrams of methylprednisolone (Pharmacia & Upjohn) was administered, intramuscularly, in the triceps. A local anesthetic of 36 mg of lidocaine (10 μg of epinephrine) and 9 mg of bupivacaine (9 μg of epinephrine) was administered as well. The analgesic was 10 mg of hydrocodone bitartrate and 750 mg of acetaminophen (Watson Pharmaceuticals, Corona, Calif) every 4–6 hours as needed for dental pain was also prescribed postoperatively.

The teeth were extracted as atraumatically as possible using periotomes, proximaters (Karl Schumacher, Southampton, Penn), physic forceps (Golden Misch, Detroit, Mich), and forceps. SurgiGuide (Materialise) (Figure 2) was used to place the implant in the most ideal position, beginning with a 1.5 pilot drill, followed by 2.0 and internal drills to complete the osteotomy sites. Waterlase MD (Biolase Technology) was then utilized, with an MZ-4 tip inserted into the osteotomy at the apex and then fired at 0.5 Watts 7 water/14 air 20 Hz (Figure 3), in a clockwise fashion moving coronally. The tip was in contact with the walls of the osteotomy. Approximately 1 minute was spent detoxifying the osteotomy site. Most of the 60 seconds was spent in the area with the greatest concentration of infection. At this point, the second swab (Figure 4) collected specimens so as to obtain a bacterial count from which to evaluate whether the laser treatment reduced bacterial counts.

PepGen P-15 Flow (DENTSPLY Friadent, Mannheim, Germany) (a putty grafting material) was used on the facial (buccal) of the osteotomy, while filling the apical aspect of the osteotomy was carefully avoided. Filling the void would allow the graft material to flow into areas between the osteotomy and the implant body, as the implant was seated. The osteotomy site was underprepped for enhanced initial stability. As the threads of this implant are self-tapping and easily seat with moderate pressure, the bases of each implant were seated at the alveolar bone crest without difficulty.

In each case, impressions were taken for the completion of custom post and crown to be seated in 3 months (Figure 5). YSGG laser therapy was then put into practice to stimulate the keratinized tissue (Figure 6) around the implant site because the author has found this procedure to stimulate tissue growth and thus prevent shrinkage. Photomodulation (LaserSmile, Biolase Technology) was performed under pulsed mode operation, with 1.5 Watts grated for 30 seconds. Photomodulation (Figure 7) allows cells to quickly repair themselves and reduces hista-
mine release\textsuperscript{17} by energizing the mitochondria within the cells.

**Results**

Healing progressed uneventfully in all 10 cases. Incisors and bicuspid were temporized out of function and placed in immediate load. Healing caps were placed upon molars, allowing them to heal nonloaded for 3 months. The implants were tested in all cases after the 3-month healing period with Periotest (readings from $-7$ to $-1$; Medizintechnik Guide, Modautal, Germany) to determine whether implants had osseointegrated. All 10 cases were successful and have been in function for a year or more over the course of this study. Nine of the 10 cases demonstrated a noticeable reduction in anaerobic bacteria, and specific virulent types were not seen in the cultures.
One case revealed no change in bacterial count, but in this case, the starting culture also had minimal amounts of bacteria (Table).

The use of laser technology has shown to have a significant effect upon areas of infected sites. Hydroacoustic effects are often said to be very effective in preventing bacterial growth. Further studies have shown that this type of laser energy denatures endotoxins by effectively cleaving molecules. Bacteria and their endotoxins are the agents that trigger periodontal disease, and as such, are key targets for laser therapy.

**CONCLUSION**

Based on the 10 cases presented, it can be inferred that this technique provides an immediate means of placing dental implants within an infected site following the aforementioned laser treatments.

Using traditional methods, these cases would have taken 3 times longer for completion than those attained with this laser-assisted technique.

It is hoped that this article will stimulate new thinking concerning the placement of dental implants into infected extraction sites. A larger prospective study should be performed to confirm the efficacy of this suggested treatment form. Patients wish to avoid the social embarrassment that accompanies staging performed via traditional methods. The use of this suggested technique would allow the patient and dentist to benefit from decreased treatment time.

**TABLE**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age, y</th>
<th>Sex</th>
<th>Tooth</th>
<th>Indication</th>
<th>XIVE Implant, Diameter, mm</th>
<th>Anaerobic Postosteotomy Readings</th>
<th>Suc/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55</td>
<td>Male</td>
<td>21</td>
<td>Apical pathology</td>
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<td>Few amounts of oral flora</td>
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<tr>
<td>2</td>
<td>43</td>
<td>Male</td>
<td>30</td>
<td>Fractured root, apical pathology</td>
<td>XIVE 5.5</td>
<td>Reduction of bacteria level</td>
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<tr>
<td>3</td>
<td>46</td>
<td>Female</td>
<td>13</td>
<td>Incomplete RCT, apical pathology</td>
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<td>Significant reduction of bacterial counts</td>
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<tr>
<td>4</td>
<td>49</td>
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<td>10</td>
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<td>XIVE 3.8</td>
<td>No change</td>
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<tr>
<td>5</td>
<td>61</td>
<td>Female</td>
<td>9</td>
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<td>XIVE 4.5</td>
<td>Reduction of bacterial counts</td>
<td>Suc</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>Male</td>
<td>8</td>
<td>Vertical fracture, apical pathology</td>
<td>XIVE 4.5</td>
<td>No bacterial counts found</td>
<td>Suc</td>
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<tr>
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<td>47</td>
<td>Male</td>
<td>19</td>
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<td>XIVE 4.5</td>
<td>No virulent bacteria, small amounts of normal bacteria</td>
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<tr>
<td>8</td>
<td>50</td>
<td>Female</td>
<td>25</td>
<td>Internal resorption</td>
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<td>Significant reduction in bacteria, no virulent bacteria</td>
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<td>57</td>
<td>Male</td>
<td>10</td>
<td>Failed apico</td>
<td>XIVE 4.5</td>
<td>No virulent bacteria, even with <em>Peptostreptococcus</em></td>
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</tr>
<tr>
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<td>43</td>
<td>Male</td>
<td>12</td>
<td>Vertical fracture, apical pathology</td>
<td>XIVE 4.5</td>
<td>No anaerobic bacteria found</td>
<td>Suc</td>
</tr>
</tbody>
</table>

*RCT indicates incomplete root canal; apico, apicoectomy; Suc/Fail, success or failure of the implant.*
ABBREVIATIONS

Er,Cr:YSGG: erbium, chromium: yttrium-scandium-gallium-garnet

REFERENCES


