Er:YAG Laser-Assisted Bone and Gingival Augmentation Around Implants

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PRETREATMENT

A. Outline of Case

1. Clinical Description
A 35-year-old female patient presented with minimal attached tissue on the buccal aspect of endosseous implants at the #7 and #8 sites that had been placed more than six months earlier. The patient was undergoing prosthetic treatment and wore a tooth-supported maxillary provisional bridge (Figure 1). The referring implantologist’s report indicated that these implants were inserted at the same time of extraction of teeth #7 and #8 (immediate implantation) (Figure 2). The referring doctor noted inflammation and suppuration at the 3-month follow-up visit. He performed a nonsurgical treatment option for peri-implantitis by using antibiotics and antiseptics. He succeeded in arresting the infection process but was left with a compromised result, caused by the loss of bone and attached gingiva around the neck of the implant.

Figure 1: Photo of the patient taken by prosthodontist before treatment (7 months before referral)

Figure 2: Photo of the patient taken by the implantologist during implant insertion (6 months before referral)

The prosthodontist was uncertain about the success of the implants and the final esthetic result, so he referred the patient to our clinic to give final recommendations about removing the implants or performing bone augmentation around them.

The options of a treatment plan were discussed with both the prosthodontist and the patient, detailing the nature and potential risks of the proposed procedures. The patient was informed that the final treatment plan would be selected after uncovering the implants and checking their stability, since the implants were still submerged and their stability was uncertain.
2. Medical History
The patient was in excellent medical health with no medical concerns or history. She had no known allergies to any medications and was not taking any medication at the time. She had no history of bleeding or clotting disorders.

3. Dental History
The patient was undergoing comprehensive dental treatment including:
- Extraction of hopeless teeth
- Root canal treatment
- Endosseous implant insertion
- Replacement of old bridges and crowns in the maxilla.

4. Occlusion
The occlusion was not stable since the patient was involved in full-mouth rehabilitation for the maxillary and mandibular teeth.

5. TMJ
Examination of both temporomandibular joints, through palpation, revealed normal movements.

6. Radiographic Examination
The height of the alveolar bone and the outline of the bone crest around the implants were examined radiographically (Figure 3). Most of the mesiodistal peri-implant bone support appeared to be adequate. No periapical pathology was detected on the radiographs.

7. Soft Tissue Examination
Full-mouth periodontal probing was performed; there was no gingivitis or periodontitis. The attached gingiva was very thin on the buccal aspect of implant #7 and #8 (Figure 4). Decreasing inflammation around implants #7 and #8 was completed by the referring dentist.

There were no furcation or mobility involvements. Oral hygiene instructions were reviewed with the patient, emphasizing the importance of effective brushing twice daily and flossing once daily.

8. Hard Tissue Examination
Clinical examination revealed that teeth #2, 5, 6, 7, 8, 10, 14, 18, 19, 29, 30, and 31 were missing. All remaining maxillary teeth were under endodontic treatment with provisional crowns and bridges. Endosseous dental implants were inserted during the last six months at sites #5, 7, 8, 14, 18, 19, 29, and 30.

9. Preoperative Photography
A series of intra- and extraoral photos were taken.

10. Other Tests
No other tests were done.
B. Diagnosis and Treatment Plan

1. Provisional Diagnosis
Surgical complications including bone resorption and insufficient attached tissue in the buccal aspect of endosseous implants #7 and #8.

2. Final Diagnosis
Peri-implantitis around implants #7 and #8 caused by inadequate crestal ridge width at the time of implant placement, resulting in a knife-edge ridge of bone around the implants which was lost during the healing phase of treatment.

3. Treatment Plan
Osseous and gingival regenerative surgery around dental implants #7 and #8 was planned in two-stage surgery:
   a. The first stage included bone regeneration using a bone xenograft and a resorbable membrane. Use of an Er:YAG laser (2,940 nm) was to be applied at different settings to open the flap, remove the granulation tissues, contour the bone, and decontaminate the implant surfaces.
   b. The second stage surgery would be performed four months after the first stage, and included uncovering implants #7 and #8 with an Er:YAG laser, the placement of a connective tissue graft, accompanied by a vestibuloplasty and the deepithelization of the gingival margins of the implants.

4. Treatment Plan Outline
   a. General
Regenerative osseous and gingival surgery would be employed to promote reossosseointegration, increasing the attached gingiva on the buccal aspect of the implants, and a vestibuloplasty would be performed to remove the mobile mucosa and release the frenal attachments extending into the area of the implants.

b. Specific
Er:YAG laser-assisted regenerative osseous surgery around implants presents several advantages compared to conventional treatment methods:
   - The laser is capable of effectively removing plaque, biofilm, and granulation tissues on the implant surface without damaging their surfaces.
   - The laser is able to recontour both hard and soft tissues with minimal necrosis of surrounding tissues caused by collateral thermal damage.
   - Vestibuloplasty with the laser achieves a more sustainable result, causes minimal pain, and allows for faster and uneventful wound healing.
   - Deepithelization is easily achieved with the laser without bleeding and postoperative discomfort.

5. Indications and Contraindications
   a. Indications
Treatment: In cases of bone loss around an implant related to peri-implantitis, biomechanical stresses, and overheating of the bone where the implant is still stable and the bone loss is not too severe, the implant can often be treated and saved.
   - Debridement and regenerative osseous surgery is the treatment of choice, accompanied by attempted mechanical removal of all diseased tissue from around the implant, removal of as many bacteria as possible, administration of antibiotics, and application of bone-grafting material in an attempt to regenerate the peri-implant hard tissues.
A free connective tissue graft is used to increase the width and thickness of the attached gingiva to improve esthetics, and make the gingival margin bind better around the implants.

A vestibuloplasty is indicated to ensure the presence of adequate vestibular depth around the implants which is important for oral hygiene and to prevent mechanical tension on the neck of the implant.

Deepithelization of the gingival margins of the implant with a laser may enhance connective attachment around the implant neck by slowing epithelium growth.

Laser: The pulsed Er:YAG laser can cut and ablate tissues with excellent surgical precision and minimal collateral effects resulting in decreased tissue damage and thus faster healing. Implant surface debridement and decontamination are obtained effectively and safely with the Er:YAG laser compared to plastic curettes. With its wavelength of 2,940 nm and associated maximum water absorption, the Er:YAG laser effectively removes biofilm from the implant surface without damage.

b. Contraindications
Treatment: Absolute contraindication would be present if the patient were suffering from serious illnesses of the hematogenic system. Implant mobility is another contraindication for this treatment.

Laser: Lasers are safe to use if the user adheres to protocols, so there was no known contraindication for the chosen wavelength in this case.

6. Precautions
- The clinician must be careful to avoid possible damage to adjacent root surfaces.
- It is appropriate to use minimal power and proper technique, minimizing the risk of collateral tissue and implant surface damage.
- Laser energy vaporizes biological tissue and amalgam restorations; therefore the clinician must be aware of this potential danger.
- Perpendicular aiming of laser beam is to be avoided to minimize laser reflection from implant surfaces to the operator and adjacent tissues.
- Direct laser irradiation of the implant over an extended period is to be avoided so as not to impair the implant/bone surface through overheating.
- During a vestibuloplasty it is important to make sure that the laser is guided parallel to the bone in order to avoid unwanted side effects such as thermal collateral damage or unintentional bone ablation.

7. Treatment Alternatives
Treatment planning in a complex implant case can be confusing because of the many different surgical and restorative approaches to solve the same problem. The possible alternative treatment for this patient could be:

a. Removal of old implants #7 and #8, with a bone augmentation procedure by the conventional approach of augmenting the ridge first and placing the implant(s) after six months of healing.

b. Removal of old implants #7 and #8, with simultaneous implant placement with a bone augmentation approach in which bone grafting is done at same time as implant placement.

c. Use of plastic therapeutic instruments for implant surface debridement and topical citric acid or tetracycline after debridement as substitute for the laser.
Depending on the situation, the removal of infected implants and a two-stage bone augmentation technique of the alveolar ridge are more advantageous than other approaches in achieving esthetic results with better predictability. This is due to the fact that gingival morphology follows the shape of the underlying bone, and it is difficult to build esthetically acceptable gingiva in areas with vertically deficient supporting bone. For financial reasons and the number of treatments, the patient chose to keep the affected implants after the proposed treatment. The prosthodontist supported the patient preference especially since the patient had a low smile line which hid the vertical tissue loss around the implant and expected asymmetry of gingival contour with adjacent teeth.

### 8. Informed Consent
Following discussion of the relative risks/benefits and treatment alternatives with the patient and prosthodontist, the Er:YAG laser-assisted regenerative tissue surgery in a two-stage procedure was decided. Written consent was signed by the patient and prosthodontist.

### TREATMENT

#### A. Treatment Objectives

Improve the functional and esthetic longevity of dental implants through:

- Regeneration of subsequent bone in the buccal aspect of dental implants #7 and #8.
- Establishing a healthy gingival contour around implants. This can be done through the widening of attached gingiva to enhance plaque removal around the gingival margin, reduce inflammation, and improve esthetics.

#### B. Laser Operating Parameters

The instrument of choice was an Er:YAG laser (K.E.Y. Laser, KaVo Dental GmbH, Biberach, Germany) with the following operating features:

- Wavelength: 2940 nm
- Pulse energy: 80 to 600 mJ
- Pulse frequency: 2 to 30 Hz
- Pulse Width: 250 µs
- Average Power: 0.16 to 7.8 W
- Emission mode: Free-running pulse
- Delivery system: Flexible quartz-silica optical fiber with an additional rigid quartz or sapphire tip
- Tip diameter: Disposable 400-micron width, lengths either 6 mm or 18 mm

Specific laser operating parameters for this treatment were:

1. The flap incision: 100 mJ/pulse, 25 Hz, with air, no water. Laser handpiece 2062 with fiber insert size 50/10 (0.47 mm diameter and 10 mm length) in contact mode. Total estimated exposure duration was 2 minutes.

2. Vaporization of granulation tissue and bone recontouring: 120 mJ/pulse, 20 Hz, with maximum water and air. Laser handpiece P2061 with cylindrical fiber (1.1 mm diameter, circular flat exit surface) in near-contact mode, as close as possible to the target without direct contact. Total estimated exposure duration was 2 minutes.
3. Implant debridement and decontamination: 100 mJ/pulse, 10 Hz, with maximum water and air. Laser handpiece 2061 and cylindrical fiber (1.1 mm diameter, circular round exit surface) in noncontact (defocused) mode, at least 5 mm from the target tissue. Total estimated exposure duration was 1 minute.

4. Vestibuloplasty: 300 mJ/pulse, 15 Hz, with air, no water. Laser handpiece 2062 with fiber insert size 50/10 in contact mode. Total estimated exposure duration was 2 minutes.

5. Deepithelization: 140 mJ/pulse, 6 Hz, with air, no water. Laser handpiece 2060 in noncontact mode, at least 5 mm from the target tissue. Total estimated exposure duration was 1 minute.

C. Preliminary to Patient Treatment
Prior to the treatment, the following safety precautions were implemented:

- Infection control guidelines were respected for the environment, patient, and dental staff.
- A safe environment was maintained by restricting operating room access to persons not involved in the treatment, posting warning signs, and minimizing highly reflective surfaces.
- All instruments were pre-dispensed prior to treatment commencing. High-volume evacuation was used.
- The patient and all staff members working in the above-mentioned safety controlled area wore protective glasses specific for the laser.
- The laser was first test-fired outside of the patient’s mouth. The patient was then seated and appropriate safety equipment was utilized.

D. Treatment Delivery Sequence
First Stage Surgery

1. After cleansing the preparation site and disinfection with chlorhexidine, a topical anesthetic (benzocaine) was placed from tooth areas #6 to #9, followed by local anesthesia (articaine HCl 4% and adrenaline 1:200,000, Ubistesin™, 3M™ ESPE™, Seefeld, Germany).

2. The implants were accessed with an appropriate laser incision. The procedure was started with a vertical incision for release with handpiece E 2062 and fiber (50/10). The incision was performed on the mesial aspect of tooth #9, followed by a crestal incision on the alveolar ridge, to the mesial of tooth #4. Down-pressure on the tissue was avoided so as to protect the tissue and prevent the fiber from adhering to it. The energy used for the incision was 100 mJ per pulse at 25 Hz. Average power: 2.5 W, in contact mode without water irrigation. It was noted that at site #8 there was bone loss to the sixth thread on the buccal aspect, and at site #7 the implant body was transparent through thin buccal bone (Figure 5).

![Figure 5: View after raising the flap shows bone loss to the sixth thread of implant #8 and very thin buccal bone of implant #7](image-url)
3. Once the implant and the surrounding bone were exposed, the diseased tissue was vaporized by the laser using the 1.1 mm cylindrical tip, 2.4 W average power with air and water irrigation. The tip of the laser was in contact with the bony crest and maximum water spray cooling was applied to avoid thermal damage. By ablating a thin layer of bone, a new, healthy bone surface was achieved and necrotic bone was removed.

4. After the treated site was cleaned by ablating tissue and blood on the threads, the implant surface was decontaminated using a cylinder tip (1.1 mm) with the tip almost parallel to the implant surface, 1 W average power with air and water irrigation (Figure 6).

5. The bone defects around the implant #7 and #8 were filled with anorganic bovine-derived bone mineral matrix (NuOss™, Collagen Matrix, Inc., Franklin Lakes, N.J., USA) and resorbable collagen membrane (RCM6™, Collagen Matrix, Inc., Franklin Lakes, N.J., USA) which was fixed in place with titanium pins (Figures 7 and 8).

6. Sutures were applied using 4-0 silk, and primary closure was achieved. A provisional fixed bridge was placed during the healing period (Figure 9).
Second Stage Surgery

1. After 4 months of healing time (Figure 10), implants #7 and #8 were uncovered again with the same two first steps mentioned above.

2. The titanium pins were removed. Bone regeneration was noted on both implants and all implant threads were covered (Figure 11).

3. The flap was extended palatally to harvest a free connective tissue graft. Healing abutments were inserted for both implants, then the soft tissue graft was sutured around the neck of the implants with a resorbable suture (5-0 PGA coated). Then the wound was closed with silk sutures to allow transgingival healing of the implants (Figures 12 and 13).

4. Vestibuloplasty was performed to ensure presence of adequate vestibular depth around the implants. The Er:YAG laser was applied in a contact mode with fiber 50/10 and 4.5 W average power. The vestibular periosteal wound was left to heal by secondary intention (Figure 14).
5. Deepithelization of gingival margins was achieved by a 2060 laser handpiece, 0.84 W average power in defocused mode (10 mm away from gingival tissue) (Figures 15 and 16).

G. Prognosis
The prognosis was very good during the postoperative period.

H. Treatment Records
All procedural details were entered in the patient’s treatment notes, along with the consent forms, radiographs, and chartings.

FOLLOW-UP CARE

A. Assessment of Treatment
The patient was first assessed at one week, and then at one month after each stage of surgery. This case was followed for 16 months. All through the follow-up care, there was no sign of any complications related to the laser treatments. The recovery was relatively uneventful.

During the first three days following each surgical session, the patient reported moderate pain and moderate swelling. There was no tissue bleeding and the site remained closed, and the flap showed signs of attachment and was healing nicely. At 1 week postoperative, the patient returned for inspection and removal of sutures; the swelling had resolved and the patient no longer had complaints of pain (Figure 17).

E. Postoperative Instructions
After both surgical phases, verbal and written postoperative instructions were given to the patient. No gingival pack was applied in either stage. The patient was placed on clavulanic acid (Augmentin 1 g) one tab every 12 hours for 7 days; ibuprofen (600 mg) one tab every eight hours for three days, and chlorhexidine rinse twice a day for 10 days. The patient was evaluated postoperatively at 3 and 10 days.

F. Complications
The patient had no complications during either surgical phase.

Figure 15: View of laser deepithelization procedure by defocused mode

Figure 16: View immediately following second stage surgery

Figure 17: One week postoperative view
One month after second-stage surgery (implant exposure), the soft tissue was completely healed (Figure 18), and there were no reported complications, no recession, no bleeding, and no implant mobility. Six months after the start of treatment, the full-mouth rehabilitation was completed by the prosthodontist with ceramic crowns on the teeth and implants. The radiographs confirmed improved bone levels surrounding the implants with no evidence of bony defects (Figure 19).

**Figure 18:** One-month postoperative view demonstrating tissue healing. Note increasing width and thickness of attached gingiva with adequate vestibular depth

**Figure 19:** Radiograph taken at 6-month postoperative interval showing improvement in bone level

Healing assessment at the 9- and 16-month appointments showed that the patient had excellent healing and improved tissue color, contour, and consistency. Gingival tissue was well attached and gingival margins were stable (Figures 20 and 21).

**Figure 20:** View after 9 months of uneventful healing. Note the healthy gingival contour around implants

**Figure 21:** Postoperative photograph at 16 months shows excellent healing around implants #7 and #8. Note the improved vestibule depth and stability of attached gingiva

**B. Complications**
There were no significant postoperative complications. As expected, severe ridge deficiency resulted in a long implant-supported fixed restoration. The prosthodontist used pink porcelain to mask the increased length of the crowns. As anticipated, the patient’s low lip smile line hid this compromised esthetic result.
C. Long-Term Results
The long-term results were felt to be good at the 16-month recall visit, the soft tissue remained healthy, and no gingival or bone recession was observed. The tissue healing remained relatively the same through the postoperative period. The final reconstruction demonstrated a functional and esthetic outcome. The results were satisfactory to the patient and the clinician.

D. Long-Term Prognosis
The use of an Er:YAG laser in regenerative osseous surgery around implants presents several advantages over conventional treatment, with no complications and with high patient and clinician satisfaction and confidence.

AUTHOR BIOGRAPHY

Walid Altayeb received his dental degree from the Faculty of Dentistry, Damascus University in 1998, and completed his Master of Science in Periodontics in 2004 and Doctorate of Philosophy in Periodontics in 2007. He is a Fellow and Master of the Academy of Laser Dentistry. He has served as lecturer in the Department of Periodontics, Damascus University. He has participated in many conferences in the Middle East, Spain, and USA as speaker in the fields of periodontal medicine and laser dentistry. Dr. Altayeb has achieved an advanced level of knowledge about the application of lasers in dental science and patient treatment (Advanced Proficiency certificates from the Academy of Laser Dentistry in 980-nm diode and 2940-nm Er:YAG lasers). He is currently Chair of the ALD affiliate study club in Qatar and is working in private as a periodontist and implantologist in Madina Dental Center, Doha. Dr. Altayeb may be contacted by e-mail at dreltayeb@hotmail.com.

Disclosure: Dr. Walid Altayeb has no financial arrangements with any corporate organization related to this article.