Er:YAG Laser-Assisted Flapless Esthetic Crown Lengthening

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PRETREATMENT

A. Outline of Case

1. Clinical Description

A 29-year-old female patient presented with the chief complaint of a gummy smile and requested esthetic improvement of her smile. She had previously undergone orthodontic treatment followed by gingivectomy. Examination showed increased gingival display on smiling. It was apparent that the golden proportion of the eight upper anterior teeth, size and length on the centrals, axial inclinations, gradation, gingival symmetry, contour, and zenith were not as esthetically pleasing as the patient desired (Figure 1).

![Preoperative anterior view showing excessive display of gingival tissue and tooth asymmetry when smiling](image)

The treatment plan involved esthetic crown lengthening around several anterior teeth followed by prosthetic procedures.

The patient was informed in detail of the nature and potential risks of the proposed closed- and open-flap procedures, and informed consent was reviewed and signed.
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. There was no history of bleeding or clotting disorders.

3. **Dental History**
   The patient had undergone orthodontic treatment to correct a deep overbite relationship as well as to correct a midline discrepancy. She had existing composite restorations that were placed in an effort to close the proximal spaces after long orthodontic treatment.

4. **Occlusion**
   Intraoral examination revealed a Class I deep-bite occlusion. The patient had a 2-mm overjet and a 60% overbite.

5. **Temporomandibular Joint**
   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 were examined in the radiographs, and no periodontal bone loss was noticed. The crown-to-root ratios on the treatment teeth were favorable. No periapical pathology was detected on the radiographs (Figure 2).

![Figure 2: Radiographic examination](image)

7. **Soft Tissue Examination**
   Periodontal examination showed abundant keratinized tissue and there were no changes in color and texture of the soft marginal tissue. Bleeding on probing had been registered on teeth #2, 3, 5, 12, 13, 14, 15, 17, 18, 23, 24, 25, 26, 27, 29, 30, and 31. Full-mouth periodontal probing (Figures 3-4) was utilized to determine tissue and bone topography and showed normal sulcus depth around all the examined teeth with no attachment loss. The patient was diagnosed as plaque-induced gingivitis that was modified by localized tooth-related factors (dental restorations). Bone sounding was done for upper anterior teeth to determine biologic width; the tip of the probe was forced through the supra-alveolar connective tissue to make contact with the bone, and the distance...
from the cementoenamel junction to the bone level was assessed in mm. There was no furcation or mobility involvement. Oral hygiene instructions were reviewed with the patient, with emphasis on the importance of effective brushing twice daily and flossing once daily.
8. Hard Tissue Examination
Clinical examination revealed that 4 first premolars had been extracted for the orthodontic treatment goal. In addition, excess spacing was present following orthodontic treatment. There were some amalgams and composite fillings but no sign of any major carious lesions. No mobility was noted in any teeth. Radiographic examination showed favorable crown-to-root ratios on all teeth without alveolar bone loss.

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

10. Other Tests
Smile analysis: The dentolabial gingival relationship had been registered to analyze the patient smile. There was excessive display of the maxillary gingiva (on full smile, the patient presented 5-6 mm of gingival display at the maxillary centrals, and the patient had a crown size discrepancy between the 2 maxillary centrals and a mild case of altered passive eruption (Figures 5-7). Tooth size and proportion were found to be undesirable with a width-to-length ratio that was greater than 90% for the maxillary centrals. Impressions for study models were made. The desired symmetrical gingival contour, zenith positions, and ideal tooth dimensions were drawn in the buccal aspect of the anterior maxillary teeth on the diagnostic cast. The stone cast with diagnostic wax-up was used to manufacture the soft acetate template.

B. Diagnosis and Treatment Plan

1. Provisional Diagnosis
The patient exhibited a high smile line with excessive asymmetrical gingival display and short anterior maxillary teeth with excess spacing.

2. Final Diagnosis
Altered passive eruption of maxillary teeth.
3. Treatment Plan

Flapless esthetic crown lengthening procedure utilizing an Er:YAG laser followed by esthetic restorative procedures to improve the overall esthetics of the patient’s smile. This crown lengthening procedure was planned to be done completely by Er:YAG laser in accordance with the following clinical needs:

a. Buccal gingivectomy with a papillae preservation approach from tooth #4 to #13 to achieve these goals:

- 2 mm gingival display at full smiling
- Gingival zenith located distal to the long axis of the tooth on the labial surface of the maxillary central incisors and canines
- Gingival height of contour to ideally follow the contour of the upper lip
- Height of contour of the central incisors symmetrical and at a level coincident with the maxillary canines
- An 80% length-to-width ratio of the maxillary central incisors

b. Flapless osteotomy and bone contouring of teeth #4 to #13 where there was adequate attached gingiva and less than 3 mm of tissue coronal to the bone crest to establish a healthy biologic dimension of the dentogingival complex (biologic width) that may prevent postoperative recession or open embrasure spaces.

4. Treatment Plan Outline

a. General

The treatment plan involved an esthetic crown lengthening procedure that allowed for the surgical repositioning of the gingival margin in order to obtain an esthetic smile and create a symmetrical and harmonious relationship between the gingival architecture and the positions of the maxillary teeth. The second phase of treatment addressed the fabrication of provisional restorations to reestablish the correct incisal edge position that harmonized with the esthetic needs of the patient.

b. Specific

The ability of the Er:YAG laser to cut both hard and soft tissues creates the opportunity for a minimally invasive flapless crown lengthening approach that:

- Allows for faster uneventful wound healing and eliminates irregular tissue positioning due to tension in the tissue that occurs when a flap is reflected and sutured
- Prevents collateral tissue damage that could occur with conventional methods, as the erbium laser is end-cutting
- Minimizes necrosis of surrounding tissues caused by collateral thermal damage.

5. Indications and Contraindications

a. Indications

Treatment: Esthetic crown lengthening that includes gingivectomy and osseous recontouring is indicated to resolve altered passive eruption where repositioning the gingival margin will result in exposure of the osseous crest or the violation of biologic width.

Laser: For minor biologic width and esthetic gingival corrections, a flapless osteotomy procedure is performed through the gingival sulcus using an Er:YAG laser without the longer healing time required for open crown lengthening surgeries. To do this, it is imperative to meet the precise indications: to have an adequate width of keratinized tissue and a bone crest not considered thick (thin and intermediate tissue biotypes). One-stage flapless crown lengthening is less traumatic for gingival tissues and shortens the total treatment time.

The Er:YAG laser’s 2940-nm wavelength is well absorbed by water, a chromophore of soft and hard tissues. In this case, a pulsed Er:YAG laser can cut and ablate tissue with excellent surgical precision and minimal collateral effects resulting in decreased tissue damage, causing less inflammation, less postoperative discomfort, and thus enhanced healing. The concept of minimally invasive dentistry can be achieved by choosing laser treatment.
b. Contraindications
Treatment: The absolute contraindication would be present if the patient were suffering from serious illnesses of the hematogenic system. Osseotomy becomes a liability when the stability of the treated dentition may be affected.

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

6. Precautions
- The specific absorption of this wavelength is in water which is present in both hard and soft tissue. The clinician must be careful to avoid possible damage to adjacent root surface tissue by moving the laser tip carefully and positioning it almost parallel to the root surface.
- It is appropriate to use minimal power and proper technique, minimizing the risk of collateral tissue damage.
- Laser energy leaving the fiber vaporizes biological tissue and amalgam restorations; therefore the clinician must be aware of this potential danger.
- Since the primary laser-tissue interaction is thermal, care must be taken to avoid excessive heat build-up in the sulcus, especially when using higher energy for osseous contouring. Proper irrigation and water cooling must be carefully managed.
- The “blind” approach to bone surgery may cause bone craters which may become a risk for developing an area of chronic inflammation or even periodontal disease.

7. Treatment Alternatives
The possible alternative treatment for this patient could be:
- Mucoperiosteal flap with ostectomy using conventional instruments, i.e., scalpel and high-speed rotary instruments
- Osseous crown lengthening by Er:YAG laser and open-flap technique
- Two-stage procedure, which requires flaps, ostectomy, and repositioning 4 to 6 weeks after gingivectomy.

8. Informed Consent
The relative risks/benefits and treatment alternatives were discussed with the patient. She preferred the flapless laser treatment option and provided verbal informed consent which was documented.

TREATMENT

A. Treatment Objectives
Improve the overall esthetics of the patient’s smile through:
- Minimizing the excessive display of gingival tissue on smiling
- Establishing a healthy biologic dimension of the dentogingival complex (biologic width) as an adjunct to esthetic restorative procedures to correct the width-to-length ratio of the maxillary anterior teeth.
- Minimal extension porcelain veneers were planned as a restorative option to correct the dental esthetic parameters.

B. Laser Operating Parameters
The laser chosen 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. Marking the gingival contour: 80 mJ/pulse, 10 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 for each tooth was 5 seconds.
2. Gingivectomy: 100 mJ/pulse, 20 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 for each tooth was 30 seconds.

3. Intrasulcular soft tissue ablation and osteotomy of bone crest: 300 mJ/pulse, 6 Hz, with maximum water and air. Laser handpiece P2061 with quartz prism (exit surface 0.4 x 1.65 mm) in near-contact mode. Total estimated exposure duration for each tooth was 1 minute.

4. Bone recontouring and smoothening: 180 mJ/pulse, 10 Hz, with maximum water and air. Laser handpiece P2061 with cylindrical fiber (1.1 mm diameter, circular flat) in contact mode. This tip was chosen because of the shallow depth of penetration. Total estimated exposure duration for each tooth was 30 seconds.

C. Preliminary to Patient Treatment

Prior to the treatment, the following safety precautions were utilized:

- Infection control guidelines were respected for environment, patient, and dental staff.
- A safe environment was maintained by restricting operating room access to persons 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

After cleaning of the preparation site and disinfection with chlorhexidine, a topical anesthetic (benzocaine) was placed from tooth areas #5 to #12, followed by local anesthesia (articaine HCl 4% and adrenaline 1:200 000, Ubistesin™, 3M™ ESPE™, Seefeld, Germany).

- The level of the alveolar crest was determined by bone sounding prior to any considerations regarding esthetic crown lengthening.
- Since the gingival margin levels were already determined, the fabricated soft acetate template was used as a guide to mark the planned gingival contour of the area to be treated by using the Er:YAG laser at low power (0.8 W) perpendicular to the gingival tissue following the margins of the surgical template (Figure 8).
  - With the laser tip almost parallel to the root surface, the soft tissue was cut in a sweeping motion from the mesial to distal level just coronal to the desired points using 2 W average power. Then the soft tissue was beveled to the marked points. Lasing began with the central incisors after the ideal symmetry, contour, and zenith were established; the right side was completed, followed by the left side (Figures 9 and 11).
  - After contouring of the free gingival margin, a periodontal probe was placed into the sulcus to the level of the bone around each tooth. Bone sounding measured the biological zone (Figure 10). All 8 front teeth had compromised biological width and needed osteotomy.
  - The intrasulcular soft tissue was ablated down to the bone crest to form a pouch using the prism tip that was applied parallel with the long axis of the tooth and the long exit surface of the tip in a mesiodistal direction. The laser was then used to remove bone, with the tip held adjacent to the tooth and “walked” across the affected area; the tip was advanced apically to its full 3-mm marked length to satisfy biologic width requirements. The average power was 1.8 W and air and water irrigation were applied. The papillae were left intact. During bone ablation, superimposing several pulse rows was applied rather than working down to the desired depth. This method has the advantage that unintentional cutting can be avoided and it helps to create a more even osseous margin (Figures 12-13).
  - Following the osteotomy, the crestal portion of the labial cortical plate was recontoured and smoothed. The laser was set at 10 pulses per second, 1.8 W average power with air and water irrigation. The 1.1-mm cylindrical tip was moved laterally from mesial to distal in a
sweeping motion, following the cementoenamel junction contours through the sulcus to a depth of 3 mm from the new free gingival margin. It is important to note that with both of these movements, the tip of the laser was in contact with the bony crest and care was taken to insert the laser tip parallel to the root surface to avoid cementum ablation (Figure 14).

- After the bone had been resected, the possible roughing and irregularities created on the bone surface by the erbium laser were smoothed with a hand bone file and Gracey curettes (Figures 15-16).

Figure 8: With the surgical guide in place, the proposed gingival margin was transferred to the patient’s tissues by using the Er:YAG laser at low power

Figure 9: A periodontal probe was used to measure the planned correction in the cervico-incisal direction to ensure the esthetic width-to-length aspect was followed. An acceptable starting point for the central incisors was 11 mm in length

Figure 10: Following laser-mediated gingivectomy, bone sounding revealed the osseous crest at the newly positioned gingival margin. Osseous resection was therefore required to create space for the biologic width

Figure 11: View after completion of the gingivectomy

Figure 12: The Er:YAG laser’s quartz tip was calibrated at 3 mm advanced apically

Figure 13: Er:YAG laser quartz laser tip was 3 mm in length advanced apically
Sutures were not necessary because the papillae were still attached. Wet gauze was used to apply pressure over the surgical site for 3 to 5 minutes until a thin clot formed under the tissue. The tissue was then sealed with oral tissue adhesive (PeriAcryl®90, GluStitch, Delta, British Columbia, Canada) (Figures 17-18).

**E. Postoperative Instructions**

Verbal and written postoperative instructions were given to the patient. These included warm salt water rinses, 400 mg ibuprofen as needed, chlorhexidine gluconate 0.12% rinses twice daily. The patient was instructed to use a soft cotton applicator and 3% hydrogen peroxide twice daily to gently cleanse the areas. She was cautioned to avoid crunchy and hard foods in the first week and resume normal hygiene practices in 4 to 7 days.

The patient was scheduled to return after 1 week, 1 month, and 3 months. Esthetic restorative treatment was scheduled after 3 months from the surgery date.
F. Complications
The patient had no significant complications during the procedure. The gingival margins were swollen for about 1 week. The patient complained of mild spontaneous pain during the first 3 days which was resolved by ibuprofen (400 mg / three times daily). No other complications were reported.

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 post-operation (Figure 19), then at 3 months (Figure 20), 6 months (Figures 21-24), and 9 months (Figure 25-26). All through the follow-up care, there was no sign of any complication related to the laser treatments. The recovery was relatively uneventful.
Gingival swelling and redness were noticed at the 1-week recall without bleeding or infection. The gingiva was completely healthy at the 1-month recall. The healing at the crown lengthening site was satisfactory, in that there was no swelling or bleeding.

The porcelain laminate veneers were placed after three months. Healing assessment photographs of the area after 3, 6, and 9 months showed complete healing without complications, well-attached gingival tissue, and stable gingival margins. The cone-beam computed tomography after 9 months did not reveal any bony defect over the surgical area (Figures 27-29).
C. Long-Term Results

The long-term results were felt to be good with continued six-month recall visits. The soft tissue remained healthy and no gum or bone recession was observed. The tissue healing remained relatively the same through the postoperative period. The patient, who was having esthetic problems for years, found herself in a much better position after a relatively short laser treatment.

D. Long-Term Prognosis

With the patient having a better understanding of dental conditions and improved home care, the long-term prognosis for laser-assisted crown lengthening was excellent. Laser-assisted flapless crown lengthening was more predictable than other methods, less traumatic with a shortened healing time, and overall a positive experience for the patient who achieved her desired results.

B. Complications

No long-term complications were observed. The patient will be seen annually for recalls to monitor any hygiene issues.