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TECHNIQUES

Surgical laser therapy for periodontal and peri-implant disease

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Abstract
Dental lasers have numerous applications for periodontal and peri-implant disease therapy which include surgical procedures of soft tissue and osseous structures. Surgical intervention is necessary to aid in correction of the clinical attachment level and pocket depths that did not respond adequately to the initial therapy.

Keywords Laser · Surgical periodontal therapy · Surgical peri-implant therapy · Flapless surgery · Periodontitis · Peri-implantitis

Quick reference/description

Careful planning of the treatment of periodontal and peri-implant diseases is essential, based on a comprehensive examination and diagnosis. After the completion of initial (nonsurgical) therapy and evaluation, surgical intervention may be necessary which can be enhanced using dental lasers. The properties of precision, thorough

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decontamination/detoxification, and improved visibility during debridement are advantageous for a favorable treatment outcome. Moreover, bone ablation using lasers is useful for improving periodontal and peri-implant therapy. However, it is crucial to prevent thermal damage during laser therapy for optimal wound healing.

Indications

- In moderate to severe periodontitis or peri-implantitis with large bone defects.
- In peri-implant mucositis or the early stages of peri-implantitis.
- In periodontitis or peri-implantitis cases that are unresponsive or only partially responsive to initial non-surgical therapy.

Materials/instruments

- Diode laser system
- Nd:YAG laser system
- Erbium laser systems
- CO_2 laser systems
- Periodontal probe
- Piezo-ultrasonics
- Conventional scaling instruments
- Saline
- Bone graft materials
- Membranes
- Sutures

Procedure

After completion of initial non-surgical therapy, regular assessments and maintenance follow-ups are crucial. Complete debridement and detoxification of periodontal or peri-implant pockets can be difficult due to several factors ranging from anatomically complex defects to patient's inability in maintaining good oral hygiene. Additionally, the pocket depth reduction and the resultant clinical attachment level following initial therapy can be inadequate for optimum periodontal health. Hence, surgical periodontal therapy may be required. The laser delivery system has a small diameter tip with delicate shape that facilitates access to the furcation and to infrabony pockets (Table 1).

Surgical therapy can be performed via a flapless approach or via a more conventional approach by reflecting and subsequent repositioning of a flap.

Table 1 Wavelengths used in surgical therapy

Laser type	Nominal wavelength (nm)	Periodontal tissue target for laser photonic energy used in surgical therapy	Precautions
Diode	445, 810, 940, 980, 1064	Incision and excision of gingival tissue along with very good hemostasis. Good absorption in pigmented tissue and hemoglobin, and in sites of acute inflammation	Prolonged contact with dark colored calculus, root surface and bone tissue should be avoided in gingival surgery or granulation tissue debridement While using low average power irradiation for peri-implantitis, no implant surface damage is seen
Nd:YAG	1064	Incision and excision of gingival tissue along with very good hemostasis. Good absorption in pigmented tissue and hemoglobin, and in sites of acute inflammation	Prolonged contact with dark colored calculus, root surface and bone tissue should be avoided in gingival surgery or granulation tissue debridement For treating peri-implantitis, the laser beam should be parallel to the long axis of the implant fixture for minimal interaction
Er,Cr:YSGG, Er:YAG	2780, 2940	Excellent incision and excision of soft tissue with minimal depth of cut due to the very high absorption in the tissue's water content. Good hemostasis. Excellent cutting and shaving of bone tissue	Water spray should be used for calculus removal, osseous surgery, and soft tissue surgery Low average power should be used near the implant fixture in peri-implantitis
CO_2	9300, 10,600	Excellent incision and excision of soft tissue due to the high absorption in the tissue's water content. Very good hemostasis. Excellent cutting and shaving of bone tissue (9300 nm wavelength ONLY)	Water spray should be used for calculus removal and for osseous surgery at 9300 nm Low average power should be used near the implant fixture in peri-implantitis. Care should be taken to minimize reflection from the metal implant toward surrounding tissues

Flapless periodontal and peri-implant surgery

Currently, two flapless techniques are available for surgical periodontal therapy. These techniques are minimally invasive; however, there can be limitations due to restricted access to the diseased periodontium around the tooth root or the implant. One of these techniques is a laser-assisted new attachment procedure (LANAP®), which uses a proprietary Nd:YAG tool. The other technique is a laser-assisted comprehensive pocket treatment (LCPT), which employs an erbium laser.

Laser-assisted new attachment procedure (LANAP®)

The LANAP® is a single session treatment, which comprises a specific step (Fig. 1). Following pocket depth verification, selective removal of the pocket's epithelial lining is done using a laser instrument. Conventional scaling instruments are used to debride the root surfaces followed by blunt dissection at the bone crest. The laser device helps to achieve hemostasis after debridement. The fibrin clot from the hemostasis facilitates approximation of the gingival tissue to the tooth. After soft tissue approximation, occlusal adjustments are done along with delivery of postoperative instructions.

This procedure has been shown to create new cementum, connective tissue attachment and alveolar bone. When proper parameters for pocket irradiation are followed, the Nd:YAG wavelength (1064 nm) is usually considered safe. However, special attention should be paid to prevent thermal damage to underlying tissues as the photonic energy has deep tissue penetrability. The LANAP® protocol can be used for the treatment of moderate periodontitis (Fig. 2).

Laser-assisted peri-implantitis protocol, termed as LAPIP™ is given by the same company for treatment of peri-implant disease. It uses reduced laser emission to apply less average power around the implant structure. The laser fiber is directed parallel to the long axis of the fixture as much as possible. This is done to prevent absorption of photonic energy by the metal, which will reduce overheating and minimize any reflected photons off the surface.

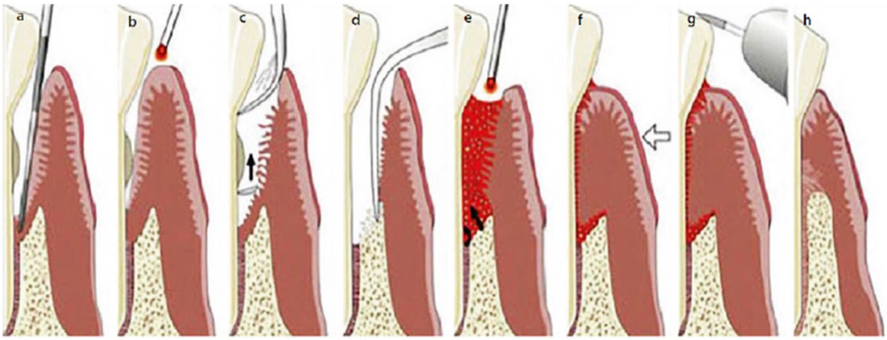

Fig. 1 Graphic depiction of LANAP® using pulsed Nd:YAG laser. **a** Bone sounding to determine pocket depth. **b** Under local anesthesia, a 360 µm optic fiber delivers 3.6–4.0 W average power at a pulse duration of 100–150 µs to selectively remove the diseased pocket epithelial lining, denature pathologic proteins and create bacterial antisepsis. **c** Root surface accretions are removed with piezo ultrasonics and conventional instruments. **d** Blunt dissection with a conventional dental instrument is used to modify bone contour at the alveolar crest and perform intra marrow penetration to gain access to stem cells and growth factors. **e** Using the same fiber with a pulse duration of 55–650 µs, hemostasis is achieved by forming a thick, stable fibrin clot, activating growth factors and upregulating gene expression. **f** The gingival tissue is pressed toward the tooth for approximation. **g** Occlusal adjustments are performed to eliminate improper contacts and to allow passive eruption. **h** Predicted healing in an environment conducive for true regeneration of cementum, periodontal ligament, and alveolar bone (LANAP® is a patented and registered trademark of Millennium Dental Technologies, Inc., Cerritos, Calif., USA) (Graphic reproduced with permission from Millennium Dental Technologies)

Laser-assisted comprehensive pocket therapy (LCPT)

Erbium lasers with wavelengths of 2780 nm or 2940 nm are used for laser-assisted comprehensive pocket therapy (LCPT). These lasers are commonly used for calculus and soft tissue removal. Moreover, they are also indicated for contouring bone tissues. Hence, both wavelengths are useful for debridement of granulation tissue as well as osseous defects in moderate to deep periodontal pockets, depending on the ease of access (Fig. 3). After evaluating the pocket anatomy, root surface debridement is done using hand instrumentation and laser. After that, the diseased epithelial and connective tissue of the gingival pocket lining and the diseased bony tissue are removed by curette and laser.

The main aim of the treatment is thorough decontamination of the entire pocket and enhancement of bleeding from the osseous surface. The set parameters do not have an impact on the hemostasis in the bone. In contrast, the procedure should facilitate bleeding to enhance tissue regeneration. Low-level laser penetration into the surrounding tissues can have some biostimulatory effects. Laser ablation of the external gingival tissue is performed at the pocket entrance. Removal of the epithelium and occasionally a connective tissue layer are done. This small dimension gingivectomy, automatically decreases the pocket depth. Epithelial migration into the pocket is delayed by the exposure of connective tissue, which allows reestablishment of the clinical attachment. This results in some gingival recession; however, it allows effective pocket healing.

The last step of the protocol includes ensuring adequate coagulation to seal the pocket entrance. It is done using the erbium laser in a non-contact mode without water spray. For example, an Er:YAG (2940 nm) laser can be used for LCPT in

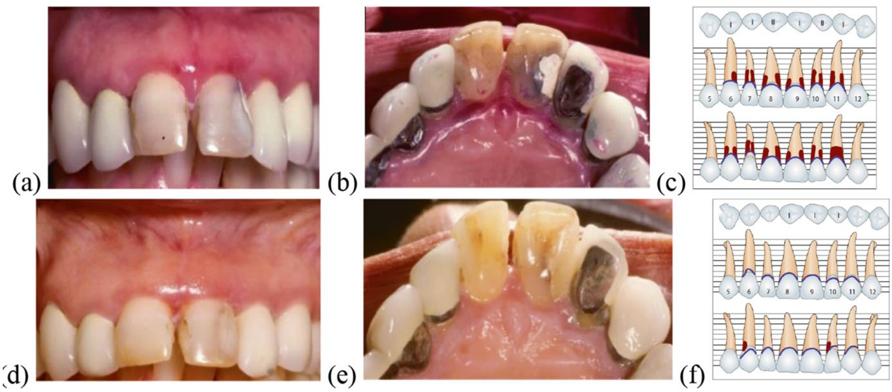

Fig. 2 **a**, **b** Clinical view of a patient's anterior facial and lingual region with moderate-severe periodontitis (probing depths 4–8 mm) and trauma from occlusion. **c** Pretreatment periodontal probe chart showing pockets and mobility on all anterior teeth. Each horizontal line represents a 2 mm increment, and the red markings indicate bleeding on probing. Mobility is indicated with Roman numerals on the incisal view at the top of the chart. The patient was treated with the LANAP® protocol. **d**, **e** 3-Year postoperative facial and lingual view showing reduction in inflammation. **f** 3-Year postoperative periodontal probe chart showing marked decrease in pocket depth and mobility (Clinical case courtesy Dr. Raymond Yukna)

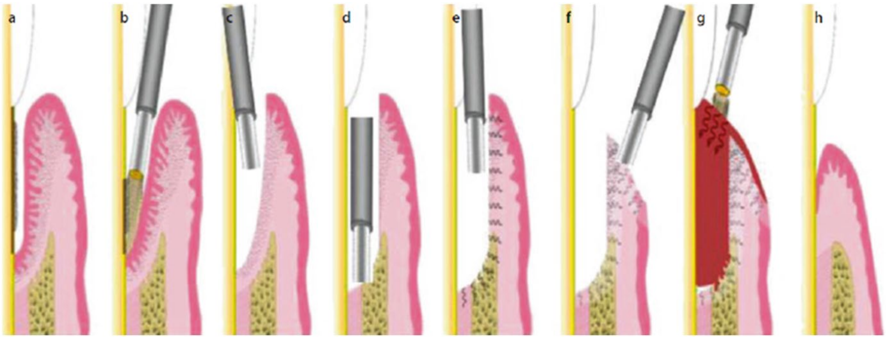

Fig. 3 Graphic depiction of LCPT using an Er:YAG laser. **a** Assessment of pocket depth. **b** Subgingival calculus is removed with conventional instrumentation and laser (along with a water spray) to decontaminate and detoxify the diseased root surface. **c** The curette and laser are also used to remove the diseased epithelial and connective tissue lining of the pocket. **d** Bone defect is also debrided by laser with a water spray to promote bleeding from the bone and the resulting healthy tissue. **e** Some of the laser irradiation can offer biostimulation to the surrounding intrasulcular tissue. **f** The outer epithelium and some connective tissue are removed to delay epithelial migration in the healing pocket. The gingivectomy produces some gingival recession. **g** The laser is used in a noncontact mode without a water spray to ensure hemostasis and form a stable blood clot to protect the pocket entrance along with stimulation of the periodontium's outer surface. **h** New attachment and pocket depth reduction (Graphic modified from Aoki et al. (reference #2) with permission © copyright 2015 John Wiley and Sons A/S)

treating deep pockets and an infrabony defect (Fig. 3). At a 1-year postoperative follow-up, new attachment and bone healing can be seen radiographically (Fig. 4). This same protocol can also be utilized for the treatment of peri-implant mucositis or the early stages of peri-implantitis.

Osseous periodontal surgery using a flap

One of the major periodontal surgeries is osseous surgery. In these procedures, bone is reshaped, recontoured or removed. Optimal bone anatomy will aid in establishing and maintaining physiologic gingival architecture, clinical attachment and shallow pockets, which are crucial for long-term periodontal tissue stability.

Both the Er:YAG (2940 nm) and Er,Cr:YSGG (2780 nm) wavelengths are effective in bone tissue ablation with minimal thermal damage. Moreover, the healing evaluation of the lasers performing an osteotomy is comparable to conventional instrumentation and can be beneficial for improved outcomes.

The delivery of an appropriate laser wavelength via a small diameter tip can provide better access and more precision than mechanical tools. Commonly, conventional surgical instruments need a larger area of access as compared to laser instruments, which have its irradiation restricted to the tip providing more precision.

In defects that cannot be appropriately contoured, bone grafting procedures with proper membranes can be implemented. The laser device generates minimal thermal damage that results in a new bone surface without a smear layer and with good vascularity to facilitate bone augmentation.

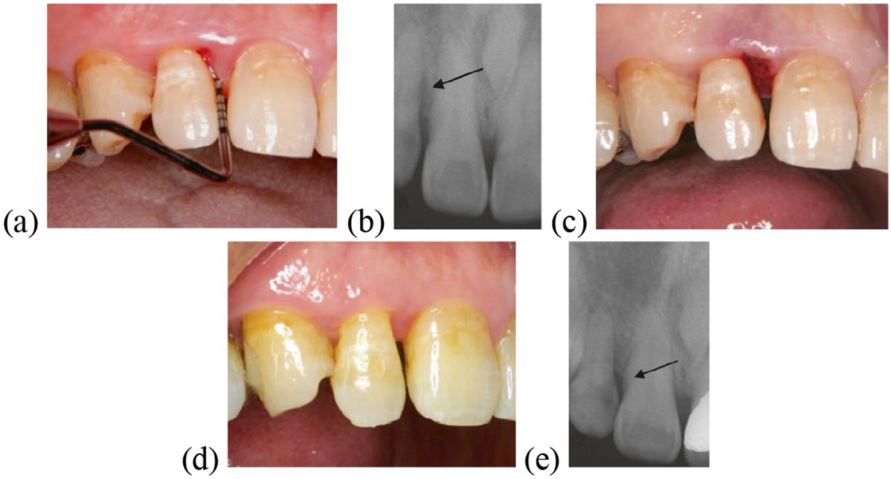

Fig. 4 **a** Deep pockets present on the lateral incisor with one of them measuring 8 mm with bleeding on probing. **b** Radiograph showing vertical bony defect (black arrow). **c** Immediate postoperative view showing a stable blood clot. The Er:YAG laser was used with a 600 µm curved tip at 1.0 W average power (50 mJ/pulse at 20 Hz) with a water spray to remove inflamed soft tissue in the pocket along with a curette to debride the root surface. The inner epithelial wall and the bone defect were also debrided. The outer epithelium was recontoured without a water spray to delay gingival down growth and a stable blood clot was formed. **d** 1-Year postoperative view showing good healing with 2 mm probing pocket depth with a slight loss of the gingival papilla. **e** Radiograph confirming the filled bone defect (black arrow) (Graphic modified from Mizutani et al. (reference #3) with permission © copyright 2016 John Wiley and Sons A/S)

For example, in case of a 9-mm-deep pocket on the distal aspect of a mandibular right cuspid, an Er:YAG laser was used for open flap surgery (Fig. 5). The pocket did not heal following initial non-surgical therapy. Hence, a flap was elevated, and the Er:YAG laser was used for removal of granulation tissue and debridement of the root surface. The bone defect was also debrided. The flap's inner surface was also debrided with irradiation followed by placement of sutures. Clinical attachment gain and marked pocket depth reduction was seen postoperatively.

Another example is that of an 11 mm pocket on the mesial aspect of a maxillary right first premolar that did not respond to initial therapy, which was treated with an open flap procedure using the Er,Cr:YSGG laser (Fig. 6). After elevating the flap, the erbium laser was utilized to debride the pocket epithelium, the root surface and the bone defect. The flap was then sutured into place. A follow-up evaluation showed reduction in pocket depth and gain in clinical attachment with minimal gingival recession.

Surgical therapy for peri-implantitis

The main aim for the treatment of peri-implantitis is debridement and disinfection of the implant surfaces and the diseased tissues around implant fixtures. Generally, laser wavelengths like the diode, erbium and carbon dioxide laser systems do not

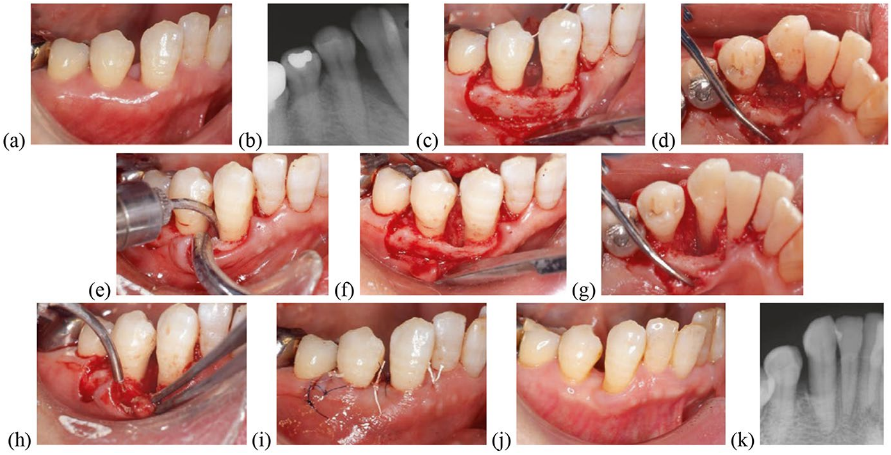

Fig. 5 **a**, **b** After initial therapy, a 9 mm pocket with bleeding on probing remains on the distal of the mandibular right cuspid. **c**, **d** Elevation of a flap with the granulation tissue filling the pocket when viewed from the buccal and lingual aspects. **e** An Er:YAG laser is used with an 80° curved, 600 μ-diameter tip at 1.2 W average power (40 mJ per pulse at 30 Hz) with a saline water spray for debridement. **f**, **g** Clean vertical bone defect with no thermal damage from the laser energy. **h** The laser is used with the same parameters to decontaminate and stimulate gingival flap tissue. **i** Suturing the flap in place. **j** 8-Year postoperative view showing healthy gingival tissue with some recession. A 7 mm pocket depth reduction with 5 mm of clinical attachment gain. **k** 8-Year postoperative radiograph (Case photos and details modified from Aoki et al. (reference #2) with permission © copyright 2015 John Wiley and Sons A/S)

damage the implant surfaces. Care should be taken while using the laser instruments as high average power settings can produce heat on the peri-implant tissues or directly impact the titanium fixture. Hence, proper parameters and approaches should be implemented during the surgery.

After decontaminating the implant and debriding the surrounding tissues, proper bone augmentation materials and membranes can be inserted in the defect to facilitate regeneration. Good bone vascularity is crucial and can be achieved by using appropriate laser parameters. The use of lasers should benefit bone healing after surgery along with a biocompatible implant fixture.

The Er,Cr:YSGG laser can be used effectively for peri-implantitis therapy (Fig. 7). After flap reflection, granulation tissue was found in the bone defect, and the hard and soft tissues in the area were debrided with the laser. Placement of a bone graft and a membrane were followed by suturing the flap in place. Restoration of periodontal health was observed at a 6-month follow-up.

Severe peri-implantitis can also be treated using an Er:YAG laser (Fig. 8). In this case, a large per-implant defect is present in the maxillary left cuspid and bicuspid with bleeding and suppuration and pocket depths of 8–12 mm. After a surgical flap was raised, the Er:YAG laser was used for debridement. Bone graft material was placed, the laser performed hemostasis, and the flap was sutured. The one year

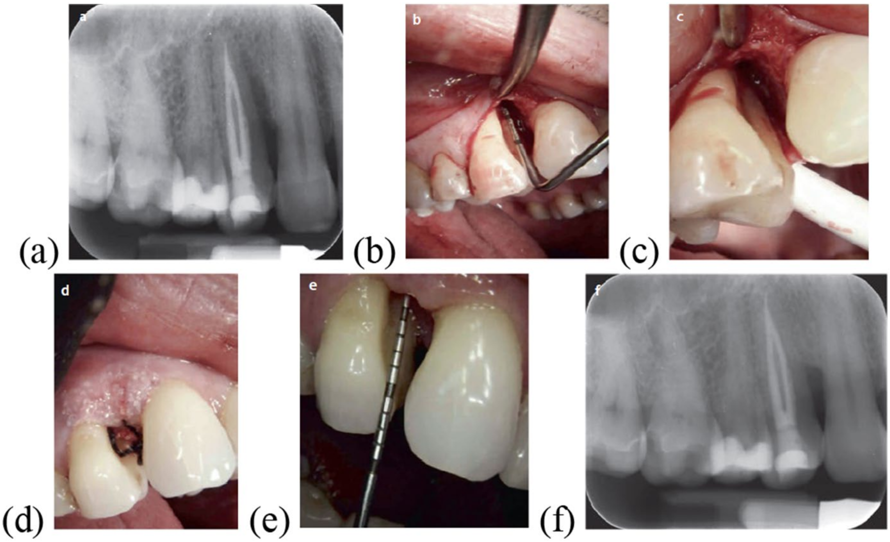

Fig. 6 **a** Radiograph showing 11 mm pocket on the mesial aspect of the maxillary first premolar remaining after initial therapy. **b** After removal of subgingival calculus with ultrasonic instruments, a flap is raised, and the bone defect is explored with a periodontal probe. **c** Immediate postoperative view of the debrided infrabony pocket. An Er,Cr:YSGG laser was used with a 600-μ-diameter contact tip. To remove granulation tissue from the hard and soft tissues, an average power of 1.5 W (50 mJ, 30 Hz) was used with 50% air and 40% water spray in the short pulse mode. The smear layer was also removed from the root surface and bone tissue with an average power of 0.75 W (15 mJ, 50 Hz) with 50% water and 40% air. **d** The sutured flap. **e** 8-Month postoperative view showing good reattachment with slight gingival recession. **f** 8-Month postoperative radiograph showing a more stable periodontal condition with bone regeneration (Clinical case courtesy of Dr. Rana Al-Falaki)

clinical follow up shows healthy periodontium and subsequent radiographs of 1, 2 and 3 years confirms that the original osseous defect was successfully repaired.

Pitfalls and complications

- All available wavelengths of dental lasers are indicated for soft tissue surgery but only the Er,Cr:YSGG, Er:YAG, and the 9300 nm carbon dioxide lasers can perform hard tissue procedures such as calculus removal and osseous contouring.
- The clinician should be very familiar with the operation and tissue interaction of the chosen laser for the procedure to minimize damage to the surrounding healthy tissue. Safe and effective treatment parameters and techniques are described in the operating manual of each device.
- During osseous procedures, a water spray or saline spray should be used to avoid temperature rise in the periodontium.

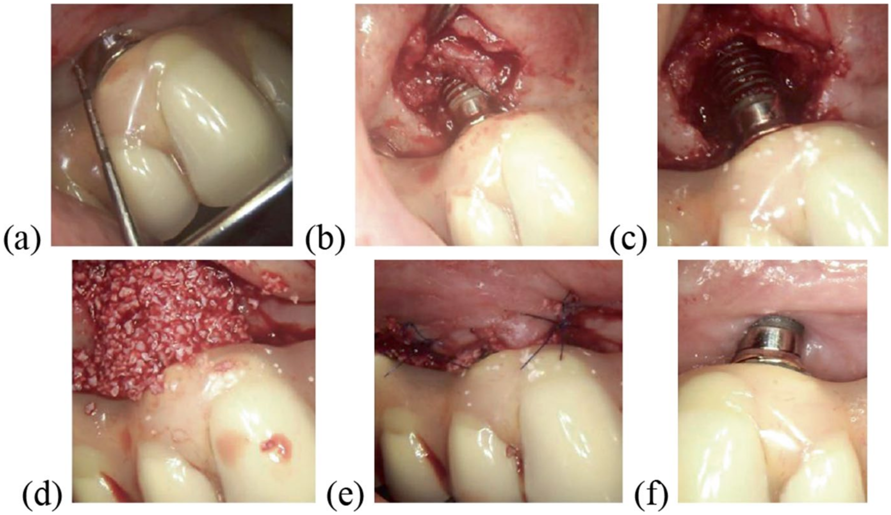

Fig. 7 **a** Preoperative view of peri-implantitis around a maxillary posterior implant with an 8-mm pocket. **b** After reflecting the flap, the extent of the defect can be seen filled with granulation tissue. **c** Immediate postoperative view following debridement therapy. An Er,Cr:YSGG laser was used with a 600-μ-diameter contact tip. The granulation tissue was removed from the hard and soft tissues with an average power of 2.0 W (66 mJ, 30 Hz) with 70% water and 50% air, angling the tip away from the implant surface. The implant was debrided at an average power of 1.25 W (25 mJ, 50 Hz) with 70% water and 50% air. The flap's internal surface was decontaminated at an average power of 0.75 W (15 mJ, 50 Hz) with 50% water and 40% air. Note the good vascularity of the bone tissue. **d** Immediate placement of bone grafting material to cover the defect. **e** The flap is sutured in place. **f** 6-Month postoperative view of the healed periodontium (Clinical case courtesy of Dr. Rana Al-Falaki)

- All calculus and other hard accretions must be removed from the root/implant surface prior to the placement of diode, Nd:YAG, or 10600 nm carbon dioxide laser energy to debride the periodontal granulation tissue. Prolonged contact with the root surface and osseous tissue must be avoided.
- Low average power should be used during irradiation of an implant surface.
- Certain protocols, such as LANAP®, are specific to the manufacturers, who provide training for those protocols.
- The gingivectomy performed in the LCPT protocol occasionally results in some amount of gingival recession.
- The use of dental lasers for the treatment of periodontal and peri-implant diseases has produced many published citations with advocates and proponents. The clinician should take advantage of the available literature to learn more about the benefits and limitations.

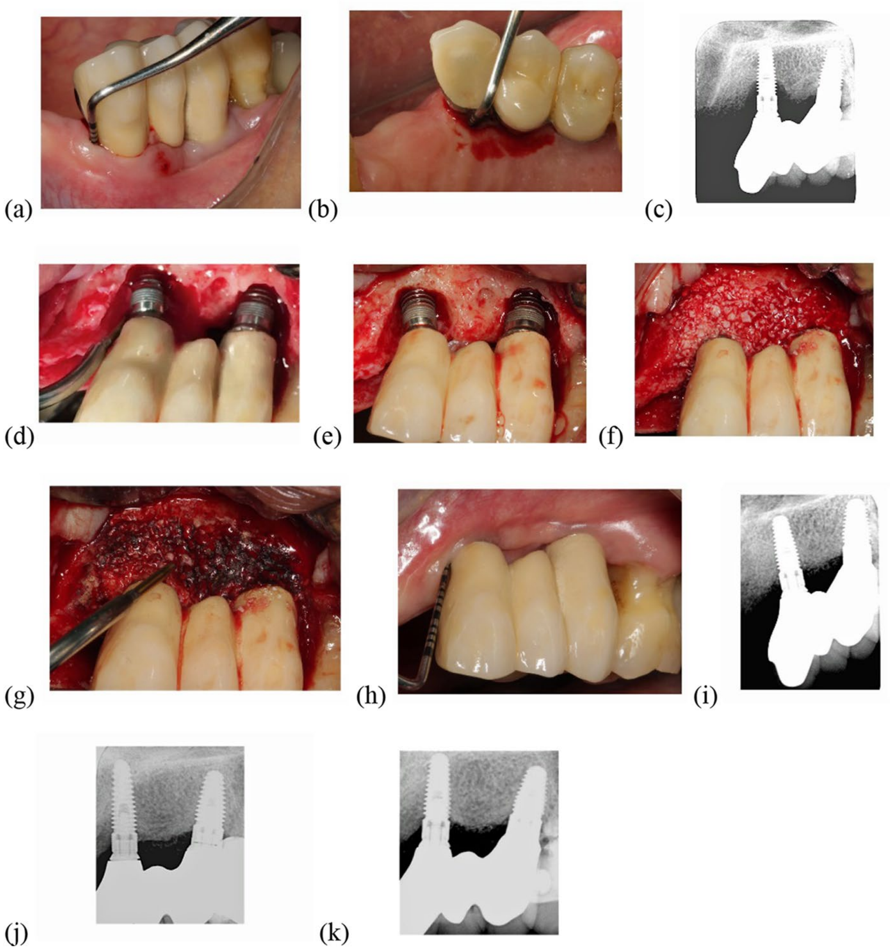

Fig. 8 **a**, **b** Preoperative view of 8–12 mm pocket depths around the maxillary left cuspid, part of a 3-unit implant supported fixed prosthesis. **c** Preoperative radiograph of the area shows a significant infrabony defect. **d** The Er:YAG laser was used at 20 Hz and 50 mJ/pulse with a water spray in near contact mode to remove granulation tissue and debride the implant surface. **e** No thermal damage was observed on the implant surface or the osseous structures. **f** Bovine bone graft material (InterOss) was grafted into the bony defects. **g** The laser was used without water spray in a non-contact mode to produce a clot, and the flap was sutured back into position. **h** One-year postoperative view shows some gingival recession but otherwise healthy tissue. **i** One-year postoperative radiograph shows the complete repair of the previous osseous defects. **j** Two-year postoperative radiograph. **k** Three year postoperative radiograph (Graphic modified from Lin et al. (reference #5) with permission © copyright 2019 Elsevier A/S)

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