Lasers in Implant Dentistry

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Core Message
Dental lasers can be employed during all procedures for implant dentistry. Incisions and contouring of soft tissue, along with impression procedures for restorations, can all be accomplished with any laser wavelength. When the laser is used properly, hemostasis, precision tissue removal, and increased patient comfort are some of the benefits. Certain lasers may also assist in the osseous procedures necessary to prepare the implant fixture site. In areas of peri-implant disease, lasers can remove granulomatous tissue as well as decontaminate implant surfaces and can aid in establishing a more favorable healing environment.

10.1 Introduction

Implant dentistry has become a viable and predictable treatment alternative for oral rehabilitation. Dental implants are now considered an essential component of treatment planning for edentulous areas in every dentist's armamentarium of treatment modalities. Dental lasers are slowly being integrated into clinical dental practice, and they have enabled dentists to enhance and simplify patient-centric treatment concepts.

Lasers can be used very beneficially in implant dentistry in a large variety of ways. They include all the procedures from presurgical planning to postsurgical continuing care. The different wavelengths have unique absorption characteristics and effects on dental tissues. Thus it is important to understand the characteristics of those wavelengths and their tissue interactions with peri-implant tissues.

This chapter will describe the various uses of available laser wavelengths for dental implant procedures.

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10.2 Different Laser Wavelengths Used in Implant Dentistry

The currently available dental laser wavelengths, their tissue interaction, and optimum parameters have been discussed in other chapters in this book, and the reader should consult those for further information. The following is a more focused discussion about laser use for implant dentistry.

10.2.1 Diode Lasers

The currently available dental surgical diode wavelengths are 810, 940, 980, and 1064 nm, delivered in a contact mode. They have a very small-sized footprint, resulting in good ergonomics and portability.

Wavelength	Target tissue	
810, 940, 980, 1064 nm	Hemoglobin, melanin	High absorption
	Water	None to very low absorption
	Carbonated hydroxyapatite	No absorption

The absorption in hemoglobin and melanin makes them ideally suited for soft tissue procedures [1], and the general indications for use are:

- Incision
- Excision
- Coagulation
- Hemostasis
- Debridement and detoxification of inflammatory tissue in the periodontal pocket

Specifically, diode lasers are utilized in implant dentistry for the following procedures:

- Preparation of the implant bed prior to implant placement
- Increasing the width of attached gingiva
- Incision before flap reflection
- Debridement of the socket prior to immediate implant placement
- Second-stage surgery, to uncover the implant fixture
- Creation of an emergence profile
- Adjunctive treatment of peri-implant mucositis

The infection seen in peri-implant tissue is similar to infection seen in periodontitis [2–6]. Diode lasers are also used for decontamination of diseased tissue around ailing dental implants.

In a study done by Bach et al., the laser groups had significant reduction of dark pigmented anaerobic gram-negative rods, the most relevant being *Fusobacteria*, *Prevotella*, and *Porphyromonas* species. These pathogens have been assigned a predominant role in the breakdown of the supporting periodontal tissue [7]. Hence, a diode laser is ideal for bacterial reduction, debridement of diseased soft tissue around implants, and hemostasis during implant surgery.

10.2.2 Nd:YAG Laser

Wavelength	Target tissue	
1064 nm	Hemoglobin, melanin	High absorption
	Water	No absorption
	Carbonated hydroxyapatite	No absorption

The Nd:YAG laser operates at a wavelength of 1064 nm. It is well absorbed in tissue pigments such as hemoglobin and melanin. The Nd:YAG is a free-running pulsed laser, with very short duration pulses and an emission cycle of <1% and of corresponding very high peak power per pulse (in the order of 100–1000+Watts). Thus the Nd:YAG generates high heat energy at the target tissues [8]. Nd:YAG lasers in vitro have produced undesirable results such as melting and increasing the roughness of implant surfaces. Although Nd:YAG lasers significantly decrease bacteria, they can alter implant structure along with a significant increase in temperature [9].

Romanos et al. [10] and Schwarz et al. [11] suggest that the free-running pulsed Nd:YAG laser is contraindicated for treatment of titanium implant surfaces because the high peak power, as well as the moderate reflection rate of this laser from titanium metal, easily causes melting of the metal surface. However, Gonçalves et al. [12], in an in vitro study, used an Nd:YAG laser in non-contact mode with a longer pulse duration and demonstrated no damage to these titanium surfaces.

The Nd:YAG laser is hence not ideally suited for soft tissue procedures in implant dentistry where there is a high likelihood of direct implant contact and must be used with caution by the clinician.

10.2.3 CO_2 Lasers

Wavelength	Target tissue	
9300–10,600 nm	Carbonated hydroxyapatite	Very high absorption
	Water	High absorption
	Collagen	Good absorption

Carbon dioxide (CO_2) employs photonic energy in the far-infrared spectrum (wavelength 9300–10,600 nm) and is usually delivered in a non-contact mode. Some models have extremely short pulse durations, and one instrument with a wavelength of 9.3 microns can produce a 5 microsecond pulse. Compared to any other dental wavelengths, they have the highest absorption in dental minerals, such as hydroxyapatite and calcium phosphate, and must be used with caution during periodontal soft tissue procedures in order to avoid direct contact with hard tissue. The penetration depth into soft tissue is relatively shallow (approximately 0.2–0.5 mm.). In addition to being effective against bacteria such as *Porphyromonas gingivalis* [13], the CO_2 lasers provide disinfection and bacterial reduction without any significant changes to the implant surface.

Hence, the CO_2 laser is a good option for:

- Soft tissue surgical incisions
- Disinfection and debridement of diseased tissue in pockets around implants
- Healthy clot formation
- Second-stage implant exposure
- Osseous surgery (9300 nm wavelength micropulsed instrument only)

10.2.4 Erbium Family of Lasers: Er:YAG and Er,Cr:YSGG

Wavelength	Absorption	
Er:YAG 2940 nm Er,Cr:YSGG 2780 nm	Water	Very high absorption
	Carbonated hydroxyapatite	High absorption
	Collagen	Good absorption

Erbium lasers (Er:YAG and Er,Cr:YSGG lasers) have water as a primary absorption target and mineral as a secondary target. They emit in the mid-infrared range at wavelengths of 2940 nm for Er:YAG and 2780 nm for Er,Cr:YSGG and can be delivered in a contact or non-contact mode. Similar to Nd:YAG, they have a free-running pulse emission with very short pulse durations and correspondingly high peak powers. With the very high absorption in water, their penetration depth can be as shallow as 5 microns [14]. Erbium lasers offer ablation with minimal thermal-related side effects.

As mentioned, erbium photonic energy is very well absorbed primarily by water within the enamel, dentin, bone, and soft tissue. The absorbed energy causes rapid explosive expansion of water in those tissues, resulting in ablative tissue removal. Hemostasis in soft tissue is adequate, but not nearly as effective as other wavelengths. In osseous surgery, the resulting bone surface is devoid of a smear layer and has good bleeding, without thermal damage or coagulation. Coaxial water spray is essential to prevent thermal damage and delayed postoperative healing.

The erbium lasers are useful for the following in implant dentistry:

- Raising surgical flaps.
- Debridement of surgical sites prior to immediate implant placement. Since laser surgery is bactericidal, infected implant sites can be relieved of pathogenic bacterial load and apical granulomas.
- Laser-assisted osteotomy.
- Bone harvesting and donor site preparation.
- Creation of the window in lateral sinus lift procedure.
- Uncovering of implant fixtures in second-stage surgery.
- Recontouring gingival tissue and sculpting emergence profile for prosthodontic components.
- Ablating diseased junctional epithelium.
- Removing calculus and plaque from implant surfaces without damaging the implant fixture or components.
- Treatment of peri-implantitis—debridement of soft and hard tissue.

Clinical studies by Kreisler and associates concluded that even at low energy densities, the Er:YAG laser has a high bactericidal potential on common implant surfaces. Also at these energy densities, no excessive temperature elevations or morphological implant surface alterations were detected [15].

Other authors found that Er,Cr:YSGG laser irradiation can be used successfully to decontaminate the surface of the titanium implant [16, 17].

10.2.5 Lasers for Photobiomodulation

Photobiomodulation therapy (PBM), which is also known as low level laser therapy (LLLT), has been shown to both reduce pain and accelerate healing of tissue [18]. PBM can be a useful therapy after implant fixture placement and after second-stage exposure. It should be noted that certain lasers produce a direct PBM effect, while some surgical lasers can offer similar beneficial results, although those are not true photobiomodulation. ► Chapter 7 describes the details of this phenomenon.

10.3 Laser Applications in Implant Dentistry

Dental implant procedures can be divided into three main divisions: presurgical, surgical, and postsurgical.

Laser Applications in Implant Dentistry

1. The presurgical therapy utilizing a laser includes:
   - Maintaining healthy attached gingiva or increasing the width of attached gingiva prior to implant placement with procedures such as a frenectomy, vestibuloplasty, gingival grafting, or apically repositioned flap
   - Preparation of surgical site prior to implant placement
2. The laser surgical procedures consist of:
   - Disinfection of the implant site in case of immediate extraction and implant placement
   - Incision and debridement using lasers
   - Laser-assisted osteotomy
   - Sinus lift used in the creation of the window in the direct sinus lift procedure
   - Preparation of the donor site prior to bone augmentation
3. Postsurgical treatment can employ lasers for:
   - Implant fixture exposure
   - Retraction and management of tissues prior to making impressions
   - Creation of attached gingiva prior to final restoration
   - PBM therapy during healing after the implant placement for pain relief and accelerated wound healing

In addition, lasers can be used for peri-implant disease therapy.

10.4 Presurgical Procedures

10.4.1 Use of Lasers to Create Attached Gingiva or Increasing the Width of Attached Gingiva Prior to Implant Placement

One of the factors in successful implant retention in the oral cavity is the width of keratinized gingiva surrounding dental implants. The implant-mucosa interface differs from the interface between mucosa and natural teeth. These differences can contribute to the susceptibility of implants to infection. Natural teeth have a periodontal ligament supporting them which helps to defend against bacterial infection. However, dental implant lacks a periodontal ligament. In addition, Lindhe and Berlungh [18] suggested that the ability of the peri-implant mucosa to regenerate itself is limited by its compromised number of cells and poor vascularity. Also, peri-implant and periodontal tissue may differ in their resistance to bacterial infection [19–21]. Hence, the necessity of a zone of keratinized tissue adjacent to dental implants has been suggested [22]. A decreased zone of keratinized tissue could be attributed to aberrant frenal attachments or a generalized tissue pull.

The release of frenal attachments around a dental implant can alleviate any tension to the tissue around the implant site. Hence aberrant frenal attachments around an implant site must be checked for.

The surgical procedures to increase width of keratinized gingiva and achieve a stress-free and tension-free closure around implants include frenectomy and vestibuloplasty.

Figure 10.1 Frenectomy increasing the length of attached gingiva prior to implant placement

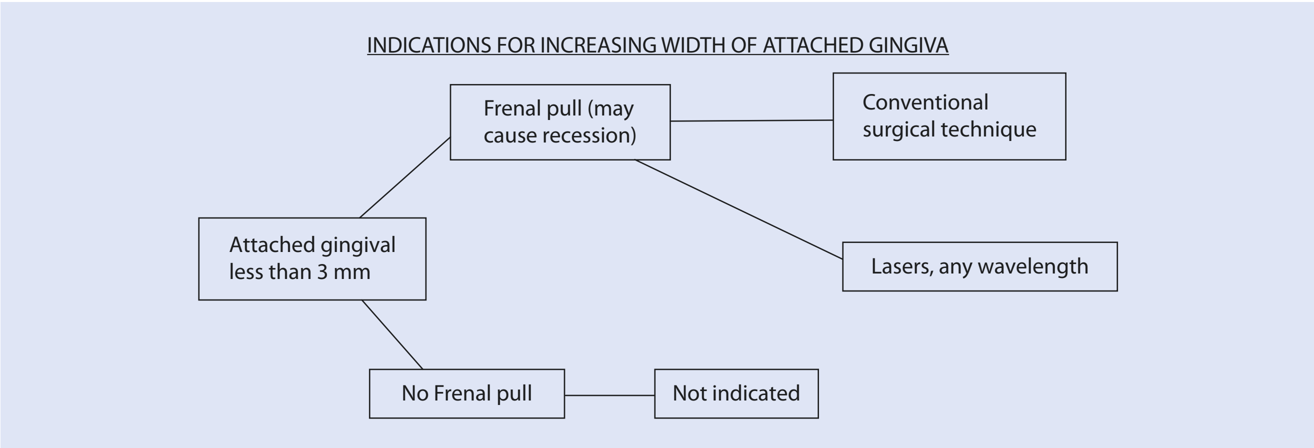


Fig. 10.1 **a** Preoperative view showing the maxillary anterior frenum insertion at the apical border of the attached gingiva. **b** A 980 nm diode laser was used with an average power of 0.7–1 W delivered with a 300-diameter micron tip. **c** Immediate postoperative view showing frenum revision and sutured extraction sites of the right central and lateral teeth. **d** Three-month postoperative view showing increased width of attached gingiva

10.4.2 Preparation of Surgical Site Prior to Implant Placement

One of the most critical aspects of implant dentistry is preoperative disinfection of the surgical site. This reduces the microbial count of the oral cavity as well as prevents any contamination of the surgical site. Traditionally this is done with antimicrobial rinses such as chlorhexidine. The emergence of bacterial resistance to antibiotics, owing to frequent doses of antibiotics, is a matter of concern. In this context, there is significant interest in the development of an alternative antimicrobial treatment modality. Lasers have excellent bactericidal properties and hence can be used successfully. The soft tissue can be disinfected more effectively with a laser than with rinsing or swabbing. The literature reports that erbium and diode wavelengths can accomplish decontamination if the photonic energy covers every square millimeter of the target surface [23, 24].

10.5 Surgical Uses

10.5.1 Decontamination of Surgical Site During Implant Placement

Decontamination of the surgical site is essential for the successful integration of immediate dental implants. The goal prior to immediate implantation is to ensure that the post extraction surgical site is free of debris and granulation tissue. The failure rate of immediate implants is higher because of pre-existing disease in the teeth and periodontal areas being replaced. Two examples are the tissues with periapical infection or periodontal disease in a molar furcation area. The protocol would be to remove gross amount of soft tissue with a curette and then use the laser to remove any visible tissue tags. The entire inner wall of the extraction socket can then be decontaminated with a laser.

All laser wavelengths are antibacterial in nature and can be used to varying degrees to disinfect the surgical site [25, 26].

The lasers can be broadly classified based on the tissue to be decontaminated, either soft or hard tissue.

Diode Lasers for Soft Tissue

Diode lasers should be used with caution near osseous tissue, since the photonic energy can scatter in soft tissue. However, when used judiciously with lower average power (approximately 1 W), they can aid in disinfecting the soft tissue site prior to grafting or implant placement. Moritz et al. studied the reduction of bacterial pathogens in periodontal pockets after irradiation with a diode laser. A comparison between the initial and the final bacterial counts revealed that irradiation with the diode laser facilitates considerable bacterial elimination, especially of *Actinobacillus actinomycetemcomitans*, from periodontal pockets [27]. It follows that diode lasers can be used with the same result on soft tissue flaps around dental implants prior to implant placement.

Nd:YAG Laser (For Soft Tissue)

The Nd:YAG laser is commonly used in periodontal therapy to incise and excise soft tissues as well as for the curettage and disinfection of periodontal pockets [28–30]. The high peak power produced by this free-running pulsed mode laser can cause deep tissue penetration. This possible thermal effect of this laser on tissues lying below the irradiated area is a matter of concern during periodontal treatment [31]. Hence caution must be exercised before using the Nd:YAG laser for decontamination of the surgical sites.

Carbon Dioxide Lasers (For Soft Tissue)

The CO_2 laser can be used for decontamination of soft tissue tags and granulation tissue. Kato et al. reported a very high reduction of *S. Sanguis* and *P. gingivalis* bacteria using the 10.6 μ CO_2 laser [32].

Erbium Family of Lasers (Soft and Hard Tissue)

Erbium lasers are antibacterial and can be used to remove both calculus and biofilm around tooth structure and implant surfaces [33, 34].

The Er:YAG laser possesses suitable characteristics for both oral soft and hard tissue ablation. Contouring and cutting of bone can be achieved with minimal damage and faster healing [35]. In addition, irradiation with the Er:YAG laser has a bactericidal effect with reduction of lipopolysaccharides [36]. These are a major component of the outer membrane of gram-negative bacteria, and they play an active role in the pathogenesis of periodontal tissue breakdown. The properties of the photonic energy from the Er,Cr:YSGG laser also verify its effectiveness for decontamination of hard and soft tissue [34].

Figure 10.2 depicts the various steps of immediate implant fixture placement while using a diode laser to disinfect the extraction site.

Figure 10.3 shows the degranulation of the peri-implant area along with disinfection of the socket with an Er,Cr:YSGG laser prior to bone grafting.

10.5.2 Incision Using Lasers

Traditionally a scalpel has been used to make an incision prior to flap opening for implant placement. Most of the commercially available dental lasers are effective in making incisions almost replacing the scalpel.

The advantages of using the laser versus the scalpel are numerous. A laser incision cannot spread infection, and there is also no subsequent cascade of inflammation. The laser's use also seals off the lymphatic and blood vessels. There is also a clinically measurable reduction in pain swelling and other postoperative complications. If the swelling is

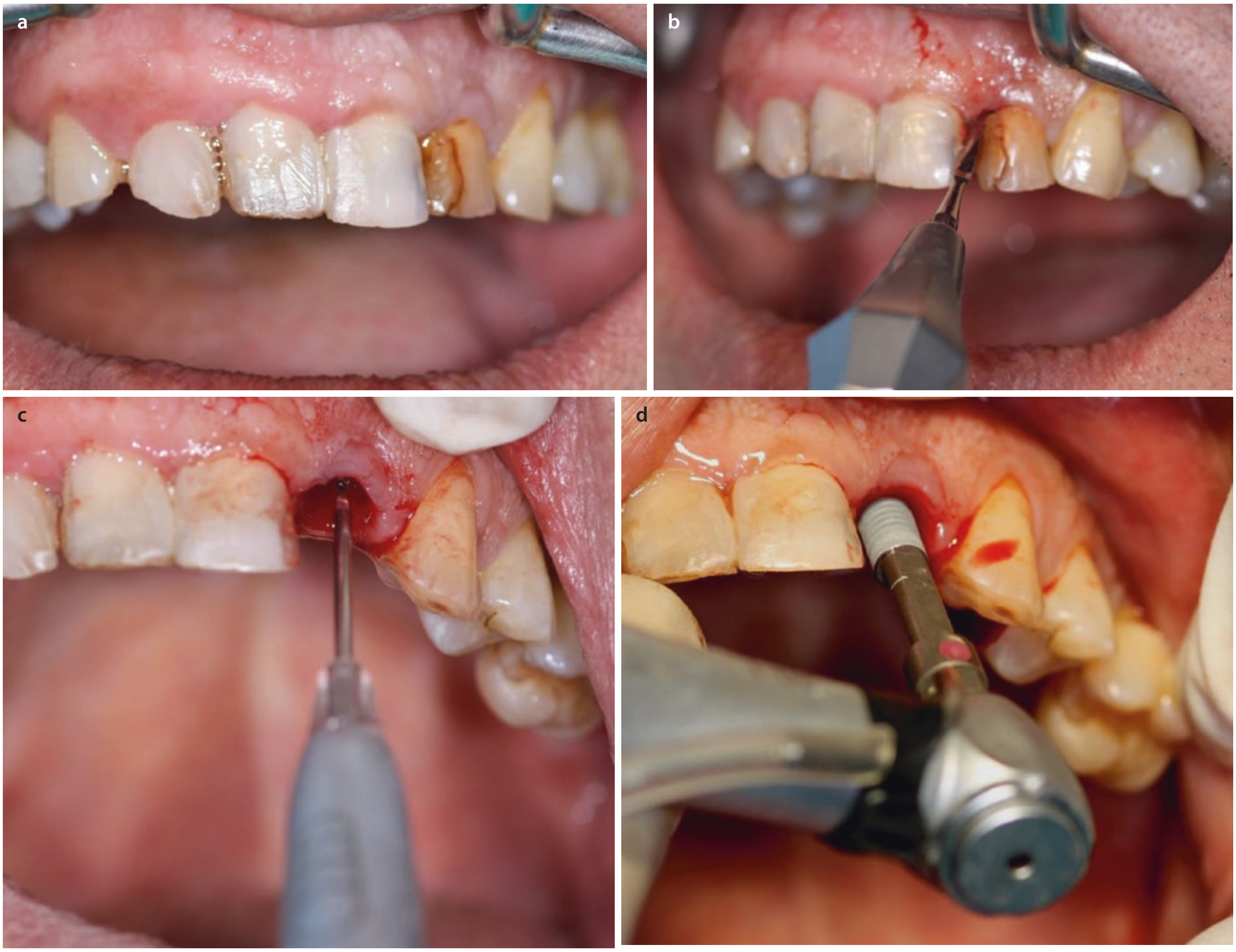


Fig. 10.2 **a** Preoperative view of maxillary anterior segment. The upper left lateral incisor will be replaced with an implant crown. **b** A periosteal elevator is carefully positioned for an atraumatic extraction. **c** A 940 nm diode laser with an average power of 1 W delivered with a 300-diameter micron tip is used for disinfection of the extraction socket. **d** The implant fixture is being placed in the decontaminated osteotomy

reduced, sutures will not pull through the tissue and are less likely to come undone. There is a reduced need of postoperative pain medication and antibiotics. Laser incisions have only a few myofibroblasts that are injured compared to scalpel incision. Hence there is superior tissue healing and a more precise control of depth of tissue damage [37, 38].

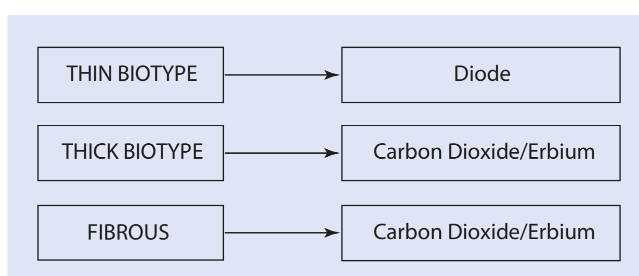
The choice of laser is determined by the existing thickness of the soft tissue. Thicker tissues can be challenging to incise with the diode wavelengths and would require more efficient cutting, which CO_2 and the erbium family can provide.

One of the most important advantages of the laser is the decreased bleeding. For patients taking anticoagulant therapy such as aspirin, clopidogrel, and warfarin, a laser incision should be the ideal choice. The diode, Nd:YAG, and CO_2 instruments provide excellent hemostasis, whereas erbium lasers do not control bleeding as efficiently as the other wavelengths. Unobstructed vision, excellent hemostasis, and efficient cutting through all tissue biotypes make CO_2 lasers most suitable for these procedures [39].

To conclude laser incisions are precise, disinfecting, and provide the operator with a clear field of vision. Due to excellent hemostasis, they additionally provide favorable healing with minimal inflammation.

Decision Chart for Laser Incision

The laser wavelength selection is based on the soft tissue characteristics.



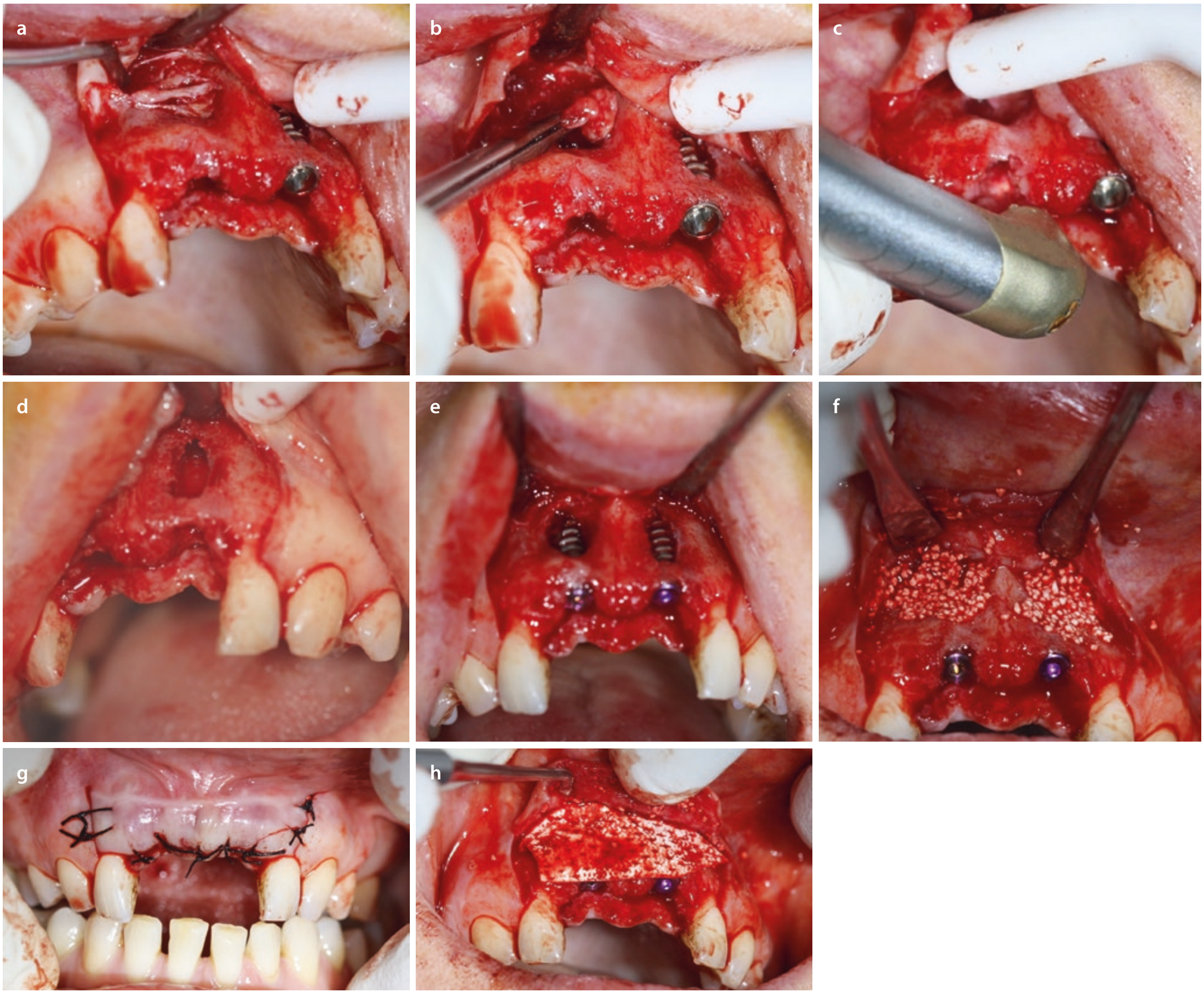


Fig. 10.3 **a** Perioperative view of maxillary anterior area, while a curette is used to access infected granulation tissue. **b** The curette removes the diseased tissue segments. **c** An Er,Cr:YSGG laser is used at an average power of 2.5 W with the parameters: 50 Hz H mode, air 20%, and water 20% delivered with a MT4 tip. **d** Photo showing the site after degranulation and disinfection are complete. Note the vascularity and the sound osseous surface. **e** The implant fixtures are inserted. **f** Bone grafting material in place and is covered with a membrane **g**, **h**. The immediate postoperative view with the flap repositioned and sutured

Figure 10.4 demonstrates an Er,Cr:YSGG laser flap incision for implant placement.

Note

If the patient is on anticoagulant medication, the diode and Nd:YAG lasers are ideal choices for the incision.

10.5.3 Laser Use in Osteotomy for Implant Placement

The current standard protocol for osteotomy site involves the use of burs which are either internally or externally irrigated and are operated at an adjusted speed in order to minimize thermal temperature rise in the hard tissue [40]. They allow for implants to be tapped or torqued into position with a torque wrench or a 20:1 reduction handpiece. The osteotomy of bony structures is sometimes challenging, since thin and fragile bone segments of the maxilla and mandible are prone to fracture due to massive contact pressure and vibration caused by mechanical instruments. A laser osteotomy offers a viable and beneficial alternative.

As noted above, both erbium laser wavelengths (Er:YAG at 2940 nm and Er,Cr:YSGG at 2780 nm) are efficient for dental hard tissue ablation. Studies on healing of laser-ablated

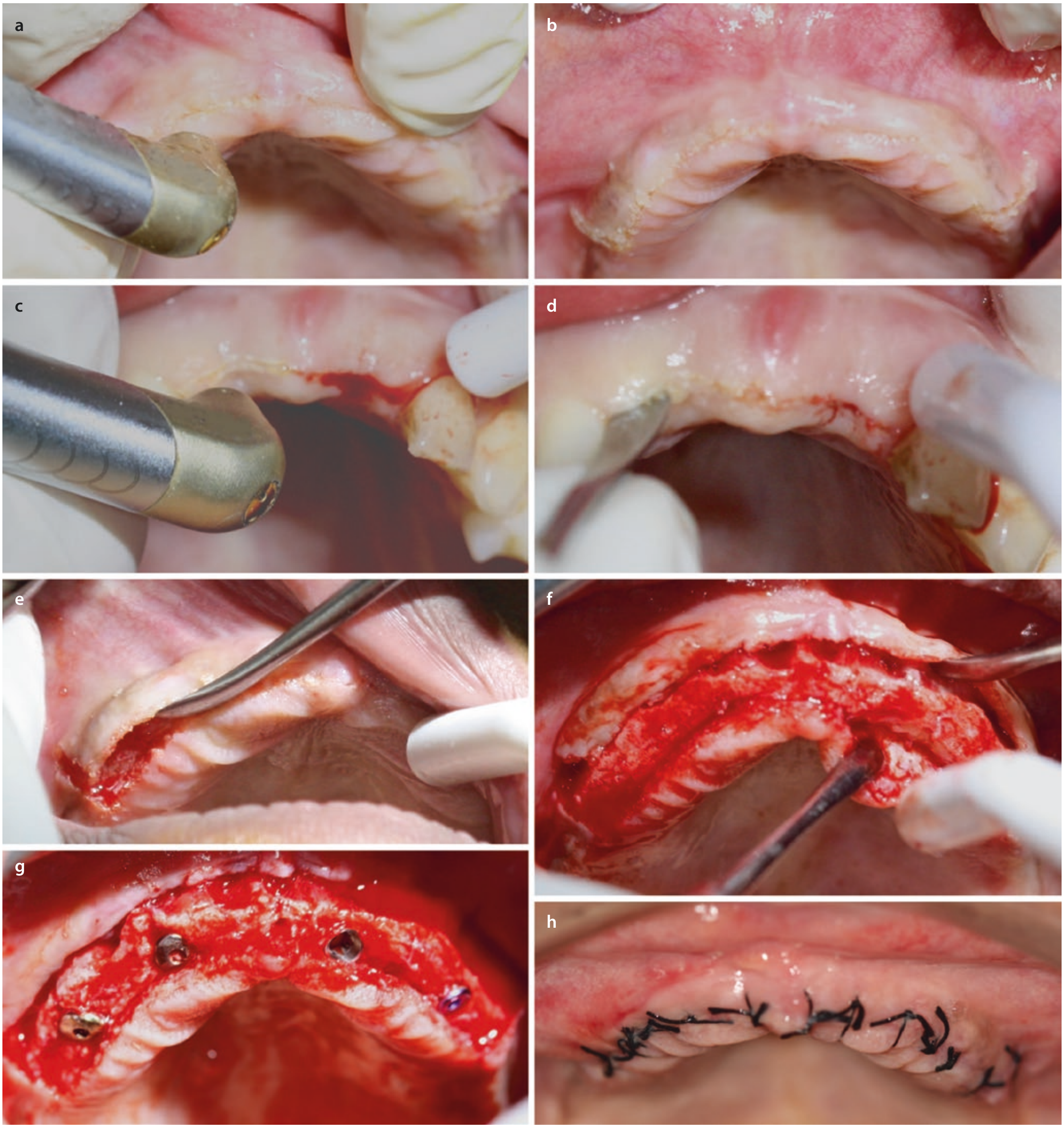


Fig. 10.4 **a** An Er,Cr:YSGG laser is used at an average power of 2.75 W with parameters of 75 Hz delivered through a 75 Hz H mode, air 20%, and water 20% delivered through a MT4 tip. **b** The incision produced with the laser shows favorable tissue interaction with excellent hemostasis. **c**–**e** A periosteal elevator is used to reflect the flap. **f** The edentulous ridge is exposed. **g** The implant fixtures are placed. **h** Immediate postoperative view of the flap repositioned. The edges of the laser incision were easily approximated and sutures were placed.

bone support the argument that the postoperative reduction in effects such as physical trauma, tissue heating, and bacterial contamination may lead to uncomplicated healing, when compared to conventional use of a surgical bur for osteotomy [41–43].

Microanalysis of the surface of the bone ablated using lasers shows little evidence of thermal damage, with a minimal char layer 20–30 μm in depth [44, 45]. Moreover, some animal studies have shown favorable osseous healing with laser use [46, 47].

Further Reading

Maybe some comment on BIC studies:
References missing!!

And effect of PBM on bone:
Sasaki et al. [76]
Bouvet-Gerbettaz et al. [77]
Dörtbudak et al. [78]

Drawbacks and Future of Lasers in Osteotomy

Generally, the application of laser systems is very advantageous when it offers new and beneficial therapeutic possibilities in contrast to commonly accepted conventional methods [48–50]. The healing advantages however are overshadowed by three major drawbacks currently:

1. The time required is lengthy, much more than when traditional instruments are used.
2. There is a lack of calibration for the size of the fixture.
3. There is a lack of control of the depth of the osteotomy.

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In addition, producing a predictable cylindrical laser cavity without the use of a surgical template is not feasible, especially in the apical end of the implant preparation. This is due to deviations in the laser beam angulations.

Due to the crucial lack of depth control, laser osteotomy is still assessed to be inferior to other bone cutting techniques that utilize high-speed drills or piezoelectric devices. Even though the contact-free mode is highly beneficial for arbitrarily cut geometries, the lack of a tactile feedback is a striking restriction. Therefore, achieving accurate bone removal depth is difficult. Only visual inspection and intermittent application of gauges enable the surgeon to assess and guarantee a certain amount of tissue volume ablation and depth.

Research is currently focused on making laser osteotomy more accurate. A recent approach is concentrated on the creation of defined geometries by navigated laser ablation based on volumetric three-dimensional (3-D) data [51–53]. A different approach was described by Rupprecht et al. [54, 55] using a special feedback system to control laser drilling of cortical bone with an Er:YAG laser under water spray cooling.

Certainly, the combined therapy of conventional bur osteotomy site preparation and laser irradiation within the osseous tissue can be of benefit.

With further developments like special miniature laser systems, depth control feedback systems, and robotic guidance, new clinical indications and applications will undoubtedly arise. The current rate and intensity of research will soon propel the use of laser implant placement osteotomy as a routine procedure.

10.5.4 Laser Sinus Lift for the Creation of a Window in Direct Sinus Lifts

Two serious limiting factors in the placement of implants in the posterior maxilla are the anatomical shape and location of the maxillary sinus and quantity of bone. To ensure successful implant placement in the posterior region, a minimum of 6–8 mm of sound bone structure is mandatory.

Additionally bone density in the posterior maxilla is often poor, which could lead to complications during implant fixation. To improve placement outcomes, maxillary sinus lift surgery was developed as a method to increase the amount of bone available for the implant. This has now become a routine surgery to address deficient maxillary posterior bone.

The different methods for a sinus lift procedure include:

- Lateral window technique
- Crestal core elevation
- Osteotome technique (Summers technique)
- Balloon sinus elevation

The lateral window sinus lift is a direct sinus lift procedure which allows for direct visualization and accurate bone placement. Also, tearing of the membrane can be easily treated, minimizing contamination of the graft during healing.

The lateral approach involves a modified Caldwell-Luc operation to gain access to the sinus cavity. A bony window is created in the lateral maxillary wall; the Schneiderian membrane is elevated, and bone grafting material which may be a combination of autogenous bone and allograft is placed between the membrane and the maxilla. An absorbable collagen membrane may sometimes be placed between the bone graft and the membrane as well as over the bony window to prevent the graft from migrating.

The surgical instruments conventionally used to perform sinus grafting are rotary handpieces [56, 57]. In the past decade, piezoelectric-ultrasonic devices have replaced rotary instruments because of the reduced risk of membrane rupture [58].

The development of Er:YAG and Er,Cr:YSGG wavelengths has enabled bone ablation to be carried out with minimal adjacent damage. The use of erbium lasers in dentoalveloar surgery represents a less traumatic experience for the patient when compared to the intense vibration of the slow-speed surgical bur. However, to prevent overheating of the bone, it is important to maintain a sufficient coaxial water spray.

In the maxilla, the speed of the laser ablation is comparable with that of the bur due to the cancellous structure of the osseous tissue. However, it is important to set appropriate power settings to minimize blood spatter and to reduce the stall out effect caused by bone shavings that may have gathered at the tip or near the laser orifice.

Procedure

A full thickness flap must be raised, and the outline of the bony window must be predetermined. After the location for the window has been identified, a bony window corticotomy is initiated by placement of the laser beam at 30–45-degree angulations to the cortical surface in a non-contact mode (with 0.5–1 mm distance from the target tissue). Lasing should be performed with slow movements until the darkness of the underlying Schneiderian sinus cavity is visualized. Ablation should be stopped after completing the predetermined window border decortications; and, at that point, there should be only a few very thin bony bridges remaining on top of the membrane.

The rest of the surgery is completed following conventional surgical procedures.

The Schneiderian membrane must be kept intact so it can help to contain the graft material as well as to prevent migrations of the graft particles in the sinus cavity. If the membrane is cut and damaged, the graft material may become infected and lead to a failed sinus lift procedure.

There still are technical drawbacks in the unrestricted use of lasers in lateral access osteotomy. One major drawback is the missing depth control which can cause significant destruction of the membrane. Therefore, case selection is important for the use of lasers in osteotomy procedures.

Figure 10.5 depicts the creation of a window with an Er,Cr:YSGG laser in a direct sinus lift procedure.

10.5.5 Laser Use for Bone Removal for Autogenous Augmentation

For some bone augmentation procedures, native osseous material can be harvested from the patient. This is termed an autogenous bone graft. There are some possible sites for obtaining this material, and one example is from a torus. The erbium lasers are ideal for this procedure, and the

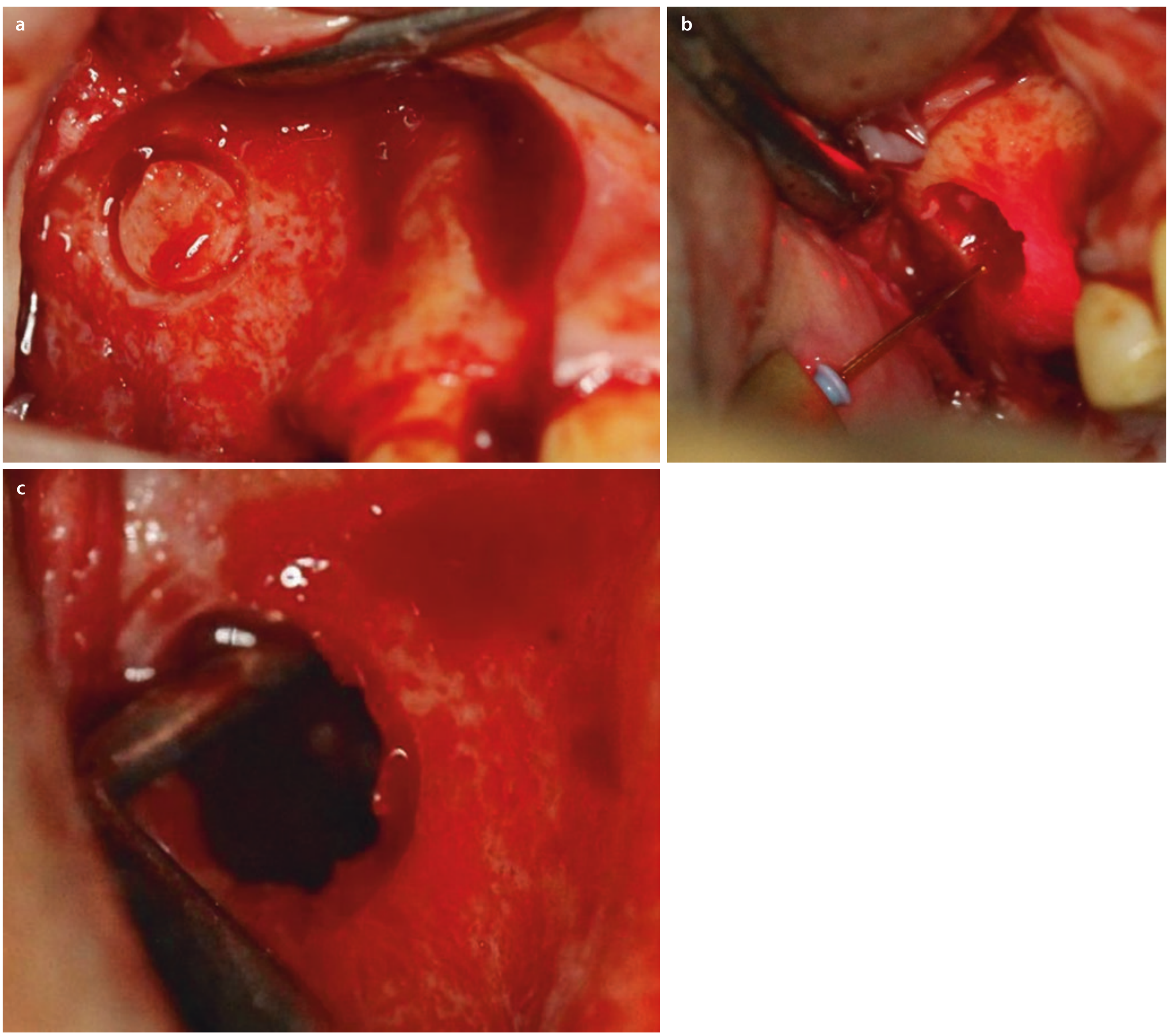


Fig. 10.5 **a** Preoperative view of the area where the direct sinus lift will be performed. **b** The Er,Cr:YSGG laser is used at an average power of 6 W with the following parameters: 25 Hz H mode, air 80%, and water 80% delivered with an MZ6 tip. The corticotomy proceeds with slow movements of the laser tip. **c** The membrane is then gently elevated

procedure is similar to an osteotomy, described in ▶ Sect. 10.5.3. ◘ Figure 10.6 demonstrates how the laser is utilized.

◘ Figure 10.6 depicts use of an Er,Cr:YSGG laser to harvest bone for an autogenous augmentation procedure.

10.6 Postsurgical Laser Utilization

10.6.1 Second-Stage Implant Surgery

The second-stage implant surgery involves uncovering the implant cover screw to facilitate and evaluate the site for

◘ **Fig. 10.6** **a** The preoperative view of a torus that will be excised. **b** A flap is reflected to expose the extent of the osseous structure. **c** The Er,Cr:YSGG laser is used at an average power of 6 W with the following parameters: 25 Hz H mode, air 80%, and water 50% delivered with an MZ6 tip. The laser excision proceeds with minimal thermal damage to the bone while preserving its vascularity. **d** The osseous segment is removed and the site is closed **e** and **f**. The harvested bone segment is measured and treated abutment placement. Conventional modes for second-stage implant recovery include scalpel blade, tissue punch, and electrocautery, although the latter has since been contraindicated.

The efficiency and visual advantages of using the laser are unsurpassed in second-stage implant recovery and are now becoming routine. The benefits include precision, hemostasis (which may vary depending on the wavelength), and immediate postoperative protection through a coagulum surface [59, 60]. In addition, there is a reduced need for anesthesia.

Procedure

It is essential to accurately assess the position of the implant site relative to the edentulous ridge. This may be done through radiographs, model mapping, and using natural landmarks. Exposure of the cover screws allows an impression to be taken from which the prosthodontic infrastructure can be made.

Local anesthetic may or may not be used, depending on patient and operator preference. Some analysis of the form, thickness, and vascularity of the tissue should be made, which will define the choice of laser wavelength and the operating parameters. The photothermal tissue interaction will be dependent on those two factors [61].

A small cone of tissue must be removed till near contact with the screw is made. From this, the tissue opening must be extended to the diameter of the cover screw. Typical laser average power values should be in the range of 1–1.5 W. All wavelengths work well, although studies offer contraindications for Nd:YAG [62, 63]. Although the diode lasers are very popular for this procedure, it is not the ideal choice if the tissue is thicker than 1–2 mm or the implant is deeply submerged. As mentioned, the CO_2 laser is efficient in removing thicker tissue.

On some occasions, there is an inadequate amount of gingival tissue surrounding the integrated implant. Similar to the presurgical scenario described above, lasers can create additional attached gingiva by performing a vestibuloplasty or frenectomy.

If bone has formed over the implant, the choice of laser wavelengths is more limited. The CO_2 laser could affect a thin layer of bone and facilitate removal of the bone with a hand instrument [39]. Generally speaking, the erbium lasers will ablate osseous tissue very efficiently and will safely accomplish the uncovering process.

Figure 10.7 shows the Er,Cr:YSGG laser uncovering the implant fixture and contouring the gingiva to establish the emergence profile.

Figure 10.8 depicts an inadequate zone of attached gingiva surrounding the integrated implants. The Er,Cr:YSGG laser performs a frenectomy and contours the vestibular tissue to create additional attached gingiva.

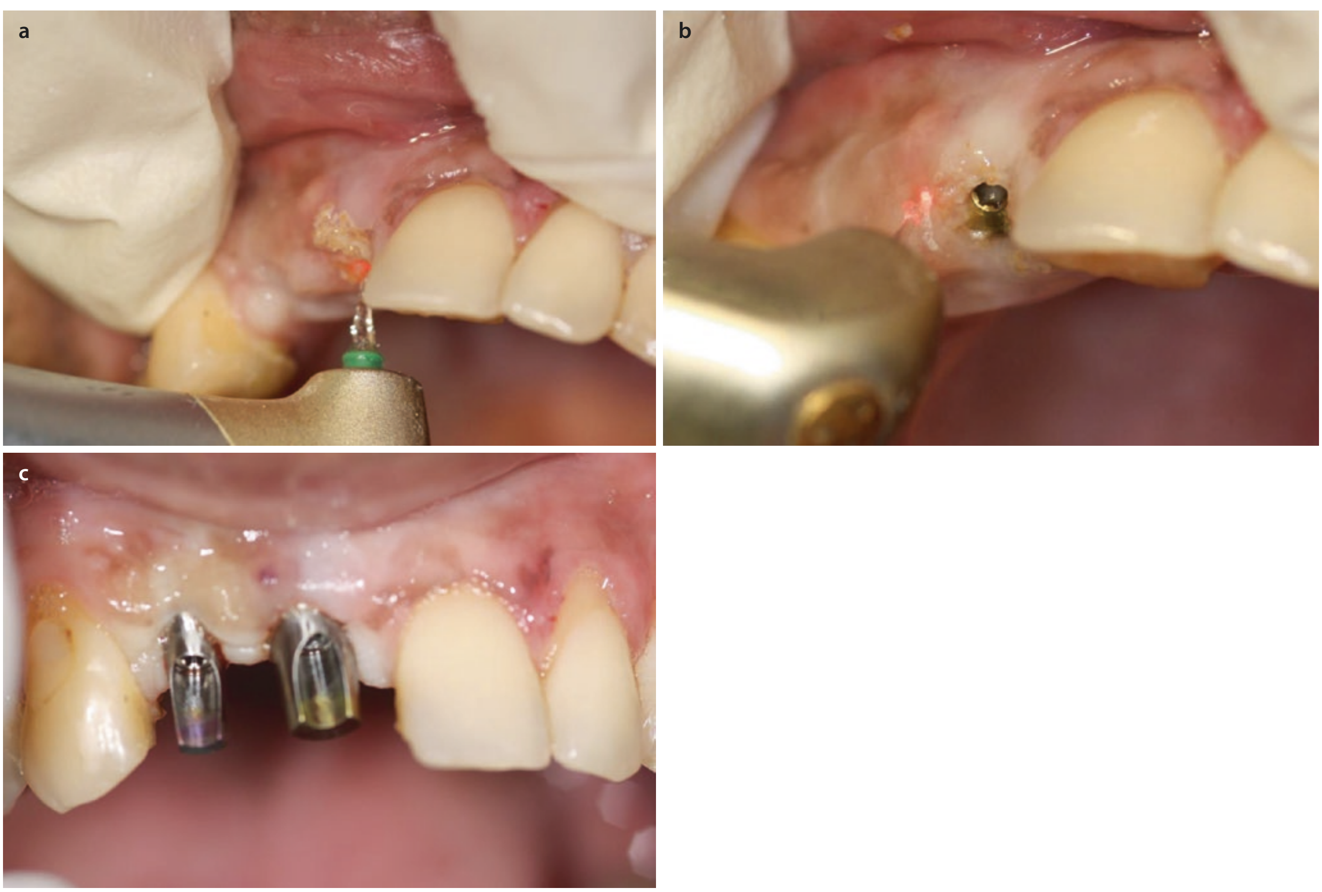


Fig. 10.7 **a** The Er,Cr:YSGG laser is used at an average power of 2.75 W with the following parameters: 75 Hz S mode, air 20%, and water 40% delivered with an MZ5 tip. An incision is made through the tissue at the location of the implant fixtures in the upper right incisor area. **b** The laser is used to contour the gingiva to establish an emergence profile. **c** The abutments are placed. Note the healthy tissue tone and sculpting, which will contribute to the success of the final restoration

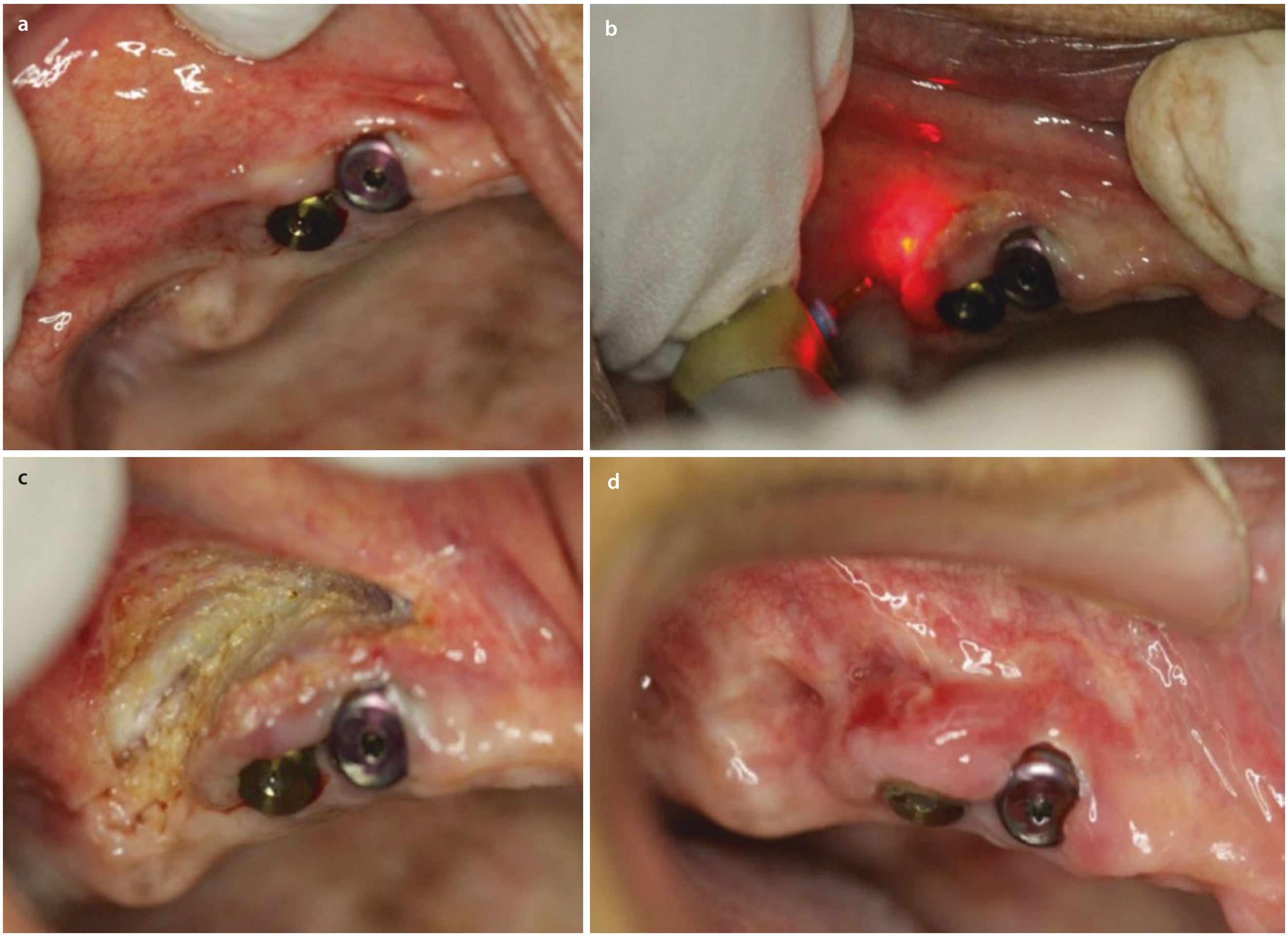
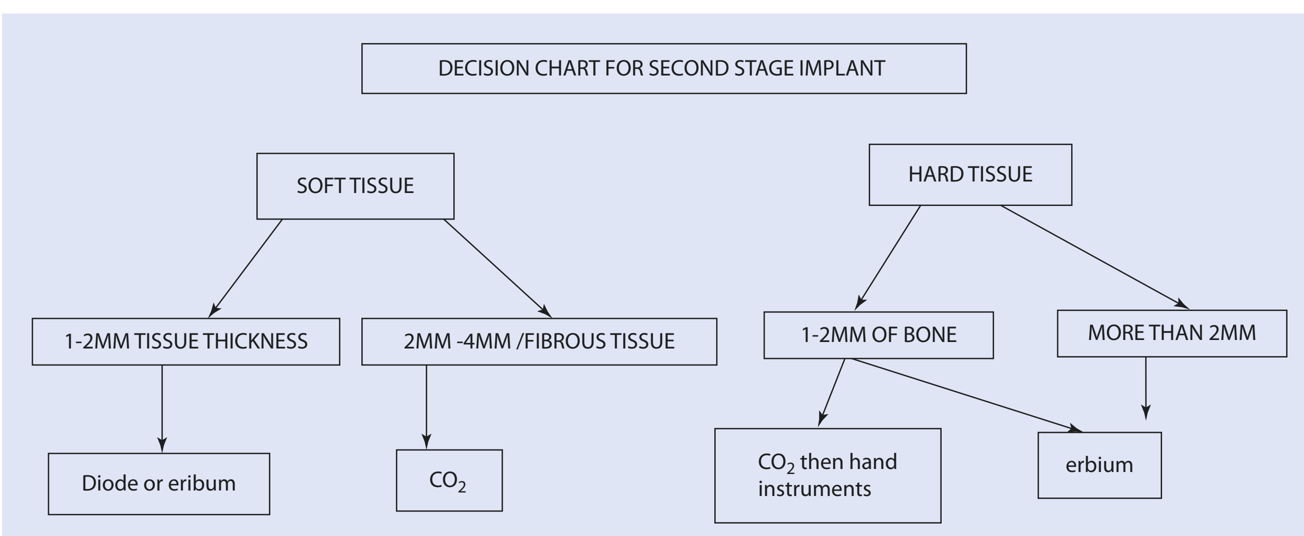


Fig. 10.8 **a** Preoperative view of integrated abutments with healing screws with a thin amount of surrounding gingival tissue with a frenum insertion. **b** The Er,Cr:YSGG laser is used at an average power of 2.75 W with the following parameters: 50 Hz S mode, air 20%, and water 40% delivered with an MZ5 tip to revise the frenum and increase the vestibular depth. **c** Immediate postoperative view shows the apical extension of the surgery. Note the excellent hemostasis. **d** A 15-day postoperative photo shows creation of a large zone of attached gingiva in the healing tissue



10.6.2 Laser Troughing Prior to Impression

In implant dentistry, the margin of the abutment may be subgingival in some instances. To prepare the gingival tissues for an accurate impression for the final restoration, a «sulcus» or space must be created; and the procedure is often referred to as troughing.

For non-implant restorative procedures, this is accomplished with retraction cords, the scalpel, or electrosurgery. Electrosurgery is contraindicated around implants, but retraction cord or a scalpel is an option. However, the retraction cord technique is time-consuming with potential to injure the gingiva as well as to cause postoperative discomfort. Use of a scalpel may result in reduction in the width of attached gingival postoperatively and also some amount of postoperative discomfort.

In contrast to conventional techniques, laser troughing allows for clear clean visualization of gingival margins. Most lasers are excellent coagulation devices with minimal to no bleeding. Lasers usually require 30–60 s to achieve retraction which does not rebound because lasers remove the internal epithelial lining of the gingival sulcus. Also another advantage of laser troughing is that it promotes the ideal environment for current impression scanning devices. All of the currently available wavelengths can perform this procedure; however, Nd:YAG should be used with caution next to an implant fixture.

◘ Figure 10.9 demonstrates how the Er,Cr:YSGG laser is used for gingival troughing around an immediately loaded implant and the crown preparations on the adjacent teeth.

◘ Figure 10.10 shows how a diode laser is used for troughing the gingiva around the implant abutments.

◘ **Fig. 10.9** **a** Preoperative view of the anterior maxillary area. The upper left central incisor will be extracted and replaced with an immediately loaded implant. **b** The implant fixture is placed. **c** A zircon abutment is attached to the fixture. **d** The Er,Cr:YSGG laser is used at an average power of 2 W with the following parameters: 100 Hz H mode, air 10%, and water 10% delivered with an MZ5 tip to trough the gingiva around the abutment and the prepared teeth. **e** The immediate postoperative view with excellent tissue contour

Fig. 10.10 **a** The preoperative view of abutments on the maxillary right anterior incisors. **b** and **c** A 940 nm diode laser is used with an average power of 0.7–1 W delivered through a 200-diameter micron tip. The photonic energy creates a «sulcus» while uncovering the margin of the abutment. **d** The immediate postoperative photo shows a clean, dry field for the impression. Note the excellent bleeding control afforded by the laser. **e** 1 week postoperative healing

10.6.3 Photobiomodulation

As mentioned, photobiomodulation (PBM) offers clinical benefits for reducing pain and inflammation while stimulating wound healing [18]. It would therefore follow that PBM would be very useful after surgical implant procedures. Many in vivo studies of animal models with implants and laser therapy have demonstrated their efficacy [10, 64, 65]. At present, protocols and dosing parameters are needed for clinical dentistry applications [66].

10.7 Peri-implant Disease

Dental implants are now becoming the most widely and commonly used treatment modality to replace missing teeth. However, even after successful osseointegration, dental implants can also lose supportive bone [67, 68]. There are various causes related to early and late implant failure.

Peri-implant diseases are one of the most common reasons for implant failure. These infectious diseases are defined as inflammatory lesions of the surrounding peri-implant tissues and include two different entities: peri-implant mucositis and peri-implantitis. *Peri-implant mucositis* describes an inflammatory lesion that resides in the mucosa, while *peri-implantitis* also affects the supporting bone.

10.7.1 Diagnosis of Peri-implant Disease

Peri-implant mucositis may be identified clinically by redness and swelling of the soft tissue, but bleeding on probing is currently recognized as the important feature. In peri-implantitis, the mucosal lesion is often associated with suppuration and deepened pockets, but always accompanied by loss of supporting marginal bone [69].

Several studies demonstrate the tendency for implants to develop peri-implant disease. The range of 10–50% has been reported up to 10 years after placement [70]. Based on the Consensus Report of the Sixth European Workshop in Periodontology, Lindhe and Meyle reported an incidence of mucositis of up to 80% and of peri-implantitis between 28 and 56% [71]. Zitzmann et al. quantified the incidence of the development of peri-implantitis in patients with a history of periodontitis almost six times higher than in patients with no history of periodontal inflammation [72].

The visual signs of peri-implantitis include:

- Increased probing pocket depth
- Suppuration from the pocket
- Draining fistulous tract
- Peri-implant mucosal swelling/hyperplasia
- Radiographic evidence of bone loss such as crater bone formation

The microflora that cause peri-implantitis are similar to those that cause periodontal infection [73, 74].

- *Aggregatibacter actinomycetemcomitans*
- *Porphyromonas gingivalis*
- *Bacteroides forsythus*
- *Prevotella intermedia*
- *Peptostreptococcus micros*
- *Fusobacterium nucleatum*

10.7.2 Peri-implantitis Can Be Further Classified into Early and Late Peri-implantitis: A Consequence of Early Disease Usually Is Incomplete Osseointegration, While Late Disease Is a Possible Failure of an Existing Implant and Its Restoration

Early peri-implantitis can be caused by any or all of the following:

- Improper preparation of the recipient site which results in undue hard tissue damage such as necrosis of bone
- Bacterial contamination and extensive inflammation of the wound that may delay healing of the soft and hard tissues
- Improper mechanical stability of the implant following its insertion
- Premature loading of the implant
- Cementation residues between abutment and prosthesis

Late peri-implantitis can be a result of any or all of the following:

- Excessive load force from poor design or malocclusion
- Chronic infection in the tissue
- Poor oral hygiene
- Lack of keratinized gingival tissue
- Patient's systemic factors, such as diabetes

10.7.3 Treatment of Peri-implant Disease

Firstly the clinician must assess whether the peri-implantitis is treatable. Twenty five years ago, two terms were applied to help in this decision. The ailing implant has bone loss that could respond to regeneration therapy. The ailing implant has progressing osseous defects with mobility and peri-implant radiolucency. Any implant which is mobile has failed. This must be removed [75].

The conventional treatment for peri-implant disease can be divided into a nonsurgical and a surgical approach. ▶ Chapter 14 discusses the role of all available laser wavelengths for adjunctive and standalone treatment. Peri-implant mucositis would respond well to nonsurgical therapy, and surgical procedures would be necessary for treatment of peri-implantitis.

The nonsurgical approach includes scaling and polishing debridement and adjunctive locally applied antimicrobial photodynamic therapy.

The surgical protocol involves raising a flap and surgical debridement. Application of antimicrobial agents, local and systemic antibiotics, air or abrasive polishing, guided tissue regeneration, or a combination using tetracycline, citric acid, and guided tissue regeneration can also be performed.

◘ Figure 10.11 demonstrates how the Er,Cr:YSGG laser can be used adjunctively for treatment of peri-implantitis around ailing implants.

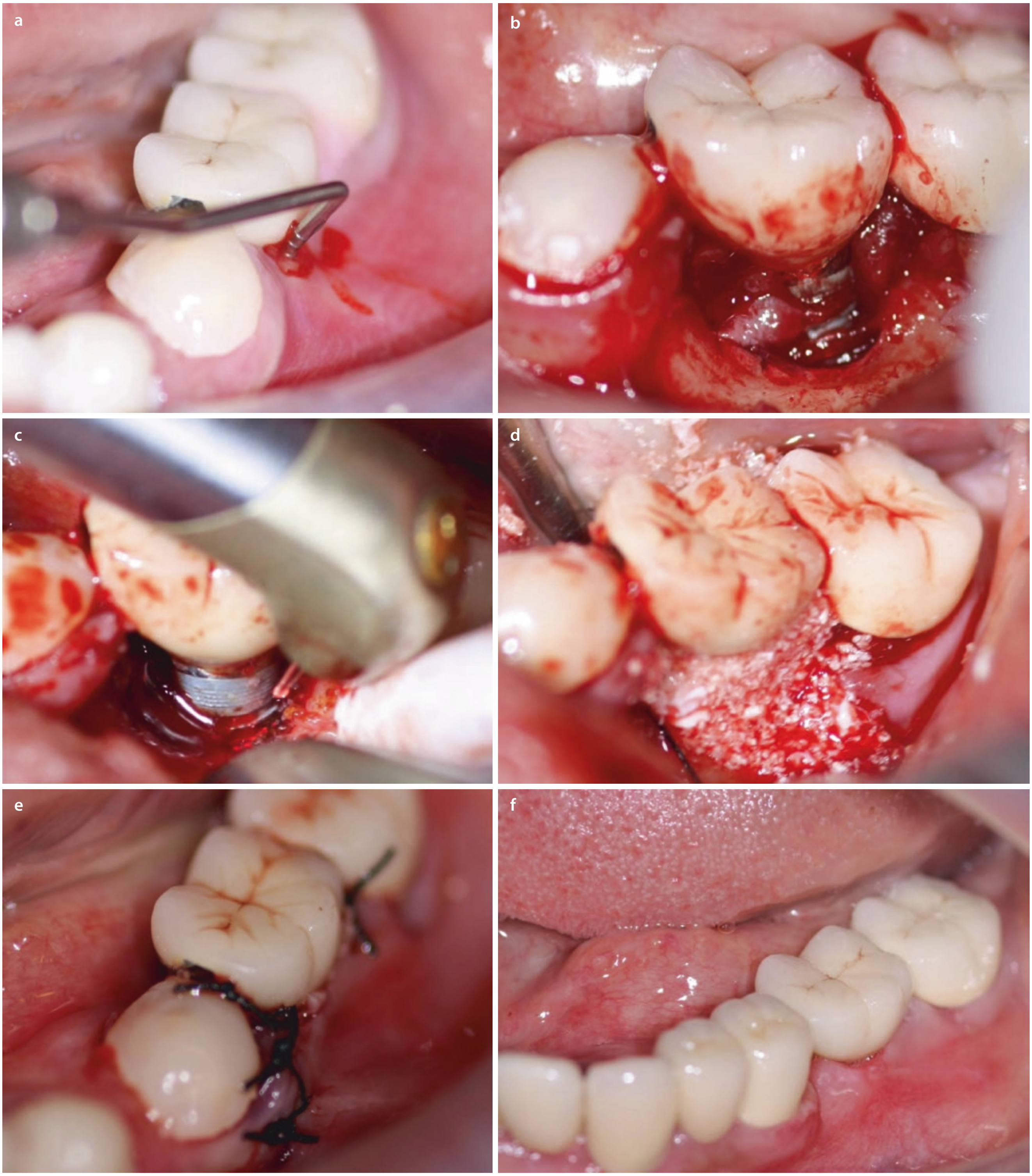


Fig. 10.11 **a** Photo of bleeding and inflammation in a deep pocket surrounding the lower left molar implant crown. A diagnosis of peri-implantitis was established. **b** A flap was reflected and a large amount of granulation tissue is present around the implant fixture. **c** The Er,Cr:YSGG laser is used at an average power of 2.75 W with the following parameters: 75 Hz H mode, air 20%, and water 40% delivered with an MZ5 tip is used to remove the granulation tissue from the implant threads and offer disinfection of the site. **d** Bone graft material is placed in the site. **e** The flap is sutured in place. **f** A 15-day postoperative photo that shows good tissue healing and resolution of the peri-implantitis is expected

Conclusion

As has been described, lasers are useful in all aspects of implant dentistry from preoperative to postoperative applications. As more research and further long-term longitudinal studies are conducted, the results should confirm the effectiveness of various wavelengths.

Lasers in dentistry have significantly enhanced the concept of patient centered care, and this is especially true of their use in implant dentistry. Laser-assisted treatments result in less pain, swelling, and inflammation as compared to conventional treatments. This has afforded more comfort and therefore increases patient acceptance. The clinician who desires excellent patient care with implant dentistry should include lasers in the dental armamentarium.

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