CPD POINTS AVAILABLE

Continuing Education credits are available on this article for subscribers by answering the questionnaire at www.dentalpractice.com.au

Maximising gingival aesthetics using lasers

By Professor Laurence J. Walsh

"Considerable interest has been directed to diode lasers as a niche tool for minor periodontal surgical procedures and troughing, as a replacement for electrosurgery and other conventional approaches."

For optimal health, function and aesthetics, the appearance and form of the gingival tissues must be free of inflammation, symmetrical (with correct heights of contour and heights of the zeniths) and be harmoniously balanced with the dentition and peri-oral tissues.[1] The gingival height of contour of the maxillary central incisors is the same as maxillary canines, with the maxillary lateral incisors being 1mm lower. When planning any veneer or crown work in the aesthetic zone, attention must be given to maximising tissue health so that a predictable aesthetic result is obtained. This requires that the preparation, temporary restoration and final restoration does not infringe the biological width, so that subsequent attachment loss through pocket formation (in thick tissue biotypes) or gingival recession (in thin tissue biotypes) does not occur. It is also necessary to avoid physical damage and chemical insult to the gingivae during tooth preparation and to employ a well-adapted and correctly contoured provisional restoration.

Careful and systematic evaluation of the baseline clinical situation will include an assessment of oral hygiene habits, periodontal attachment levels, mucogingival architecture and tissue biotype, gingival tissue thickness and consistency, papilla form, occlusion including guidance during protrusive and lateral excursions, incisor relationships and tooth mobility. This is normally supplemented with radiographs to assess crestal bone levels and crown/root ratios. From these factors, the decision regarding choice of technique can be made, with the fundamental questions being will there be infringement of the biological width and thus is resection of bone required? Once a decision is made regarding the type of procedure (Table 1), the next question is whether a conventional or laser approach will be used (Table 2). Erbium and diode lasers allow a very conservative approach to many common clinical situations, including gingivoplasty when outside the biological width (Figure 1).

Lasers have been used for periodontal surgery since the mid 1960's, with an extensive literature on the processes of tissue ablation and wound healing, as well as on surgical outcomes.[1-15] Over the past decade, considerable interest has been directed to diode lasers as a niche tool for minor periodontal surgical procedures and troughing, as a direct replacement for electrosurgery and other conventional approaches. Lasers of various types offer major advantages in terms of increased precision, invasiveness of the procedure and patient post-operative experience (Table 3).

Compared with scalpel surgery, both electrosurgery and lasers reduce or eliminate bleeding during procedures, which improve visibility of the site and reduces operating time. Lasers can be used to create open wounds which rapidly undergo sec-

Table 1. Cosmetic periodontal surgery

No change in biological width:

- Smile line correction using gingivoplasty
- Removal of excessive tissue by gingivectomy
- Debulking of gingival overgrowth

Change in biological width:

- Resective crown lengthening with bone removal
- Apically repositioned flap with bone removal

Table 2. Treatment options

Procedure	Conventional	Lasers
Gingivoplasty/ Gingivectomy	Scalpel Ceramic burs Electrosurgery Tricholoacetic acid	Diode lasers KTP and CO2 lasers Erbium (Er) lasers
Bone resection	Bone chisels Bone burs Piezosurgery	Erbium lasers

Table 3. Comparisons of 3 common modalities

	Laser	Scalpel	Electrosurge
Incisions into tissue	Yes - focussed	Yes	Yes
Recontouring	Yes - defocused	No	Yes (loop)
Need for LA	No - Erbium No - Comfortpulse Yes - other lasers	Yes	Yes
Control of haemostasis	Yes	No	Yes (mode)
Control of coagulation	Yes	No	Yes (mode)
Collateral injury to bone	No	No	Yes
Sterilizing action	Yes	No	Yes
Low bacteraemia	Yes	No	Yes
Safe near implants	Yes	Yes	No
Safe near other metals	Yes	Yes	No
Stimulates oral muscles	No	No	Yes
Low post-op pain	Yes	No	No
Fast healing of incisions	Yes	Yes	No
Fast healing of excisions	Yes	No	No

ondary intention healing. These wounds do not experience post-operative hemorrhage and show remarkable little or no post-operative pain or discomfort, because of laser sealing of nerve endings.[6-9] The surface layer created by lasing serves as a scaffold for healing and as a wound dressing. It also prevents bacterial infection of the wound surface, and seals blood vessels. Because of the latter, laser surgery reliably reduces bacterial counts in laser-treated surgical wounds and gives reduced bacteraemia. Non-contact laser methods can give zero bacteraemia, because nothing but laser energy comes in contact with tissue that might contaminate the site.[2,3]

There are a range of concerns with electrosurgery as a means of cutting or ablating tissue. The technology is inherently inefficient, requiring high powers (upwards of 350 watts) for tissue incision which a laser can achieve at 100 times lower average power. This massive difference in efficiency goes some way to explaining why diode lasers can be handheld and battery powered (Figure 2). The tissue properties change during electrosurgery as there are repeated passes of the tip, which desiccates the tissue and alters its resistance and reactance. Conduction of current in oral fluids, metallic dental materials and metal instruments is a well recognized hazard.

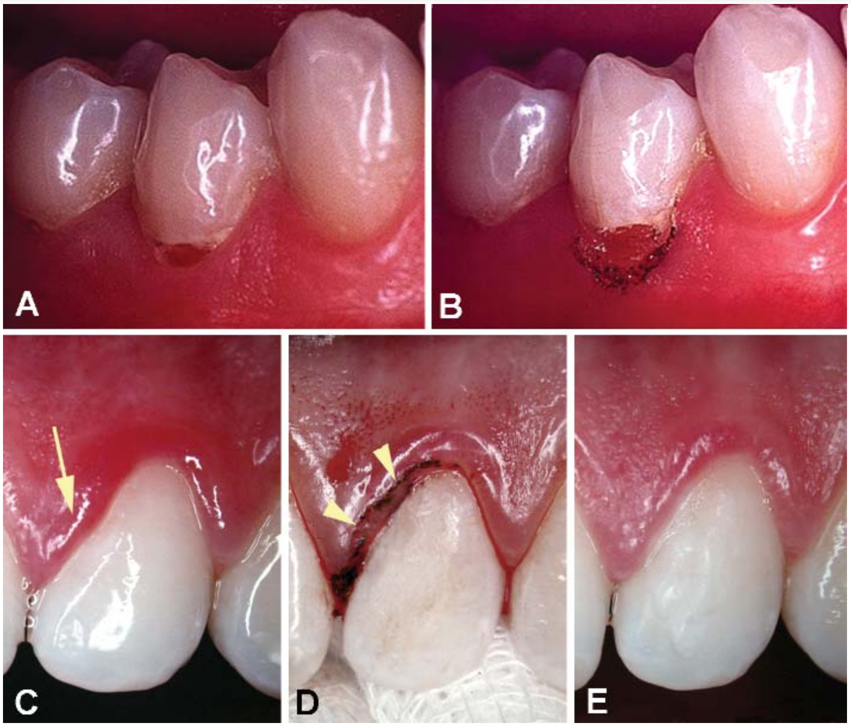

Figure 1. A and B: Laser gingivoplasty to expose cervical caries, undertaken during caries removal with an erbium laser. A is the baseline situation and B is immediately after lasing. Note the lack of bleeding; C-E: Diode laser gingivoplasty to recontour chronically inflamed tissue and expose a subgingival enamel defect (position indicated by arrow in panel C) which was restored with composite resin immediately after lasing. The lack of bleeding allows the restoration to be completed immediately. The laser cut margin is shown by the arrowheads in B. LA was administered into the papilla using a micro-injection device. C shows result after one week showing complete resolution of gingival inflammation.

Figure 2. Examples of current diode lasers. A: First generation 810 nm laser (Styla from Zap Lasers) with single patient use rigid fiber. The wireless foot control for this cordless unit is not shown. B: Second generation 980 nm (SIROLaser from Sirona). C: Third generation 940 nm cordless laser with in-built thumb activated switch for laser activation (iLase from Biolase). D: Third generation 940 nm unit (ezlase from Biolase).

Table 4. Features of diode lasers by wavelength

	810nm	940nm	980nm
Incisions in contact mode	Slow	Fast	Fast
Ablation in non-contact mode	No	Yes	Yes
Hot-tip with initiated fiber end	Yes	Yes	Yes
Coagulation in non-contact mode	No	Yes	Yes
Absorption in haemoglobin	Medium	High	Medium
Absorption in water	Very low	High	High
Ablation speed in soft tissue	Very low	High	High
Lateral thermal effect of lasing	1.0	0.14 mm	0.12 mm
Sealing arteriolar blood vessels	Medium	Very high	High
Sealing venous blood vessels	Medium	High	High
Biostimulation effect	High	Medium	Medium
Comfortpulse mode	No	Yes	No
Mains powered units	10 Watts	7 Watts	7 Watts
Cordless units	2 Watts	3 Watts	No
All-in-one handheld units	No	Yes	No
Disposable flexible tips	No	Yes	No
Fiber optic diameter (microns)	400	100-400	300-400

Most dental electrosurgery units are monopolar, which increases risk of coagulation in thin tissues such as gingiva and poses a risk of injury to deeper structures. For this reason, electrosurgery is inadvisable for incisions into or ablation of thin gingival tissue which overlies bone. In a patient with a thin biotype, channeling of current and bone necrosis is more likely to occur.

A wide range of lasers can be used for soft tissue surgery, with the erbium lasers offering both anaesthesia-free hard tissue cutting (tooth structure and bone) as well as anaesthesia-free soft tissue surgery. This is possible because of the unique analgesic effect created by the laser pulses and the conduction of these effects through both bone and soft tissue.[11,13,14] Lasers offer improved surgical versatility over all the conventional treatments, because they can be used to vaporize soft tissue through excisional or excisional approaches, as well as to coagulate it. Electrosurgery is not useful for vaporization (ablation) over an extended area because of accumulating thermal injury to soft tissues and underlying bone. Many lasers can be used to treat tissue in a contact or non-contact mode, whereas electrosurgery must always be used in a contact mode for safety reasons. Lasers do not pose a risk of thermal injury to teeth with metallic restorations, or to the bone adjacent to implants.[4,5,12] Lasers do not rely on the flow of electrical current and thus do not pose a risk to patients with older (unshielded) pacemakers, nor do they cause neuromuscular stimulation.

Generational change

There are three distinct generations of diode lasers and each has particular features which reflect the way the wavelength interacts with key tissue components such as haemoglobin, water and melanin. The latter is found in small amounts in oral tissues, while haemoglobin is abundant because of the high vascularity of gingival tissues and the enhancement of this vascular bed during inflammation.[2,15] Various attributes of the three generations of diode lasers are shown in Table 4, which demonstrates that there are in fact many differences between them. Interestingly, the third generation systems have an ontogeny (development time) of some 24 years, compared to 15 years for the first generation and 10 years for the second generation.

The first generation diode laser technology uses the 810-830 nm wavelength range. This offers strong coagulation because of a wide zone of collateral thermal influence on soft tissue. The major absorbing agents at this wavelength are melanin and to a much less extent, haemoglobin (Figure 3). These lasers must be used in contact to ablate soft tissue and do this at a slow rate, being much better suited for coagulation. This first generation technology is often used in continuous wave mode, which enhances the lateral thermal changes. If pulse modes are used, the pulse durations are typically long and exceed the thermal relaxation time of the tissues. Lasers operating at 810 nm are usually mains powered benchtop units and deliver their energy through a glass fiber, which must be cleaved after each use. One recent system uses a disposable tip and is battery powered (Figure 2A).

The second generation diode laser technology uses the longer 980 nm wavelength, which corresponds with an harmonic within the infrared absorption spectrum of water. Lasers operating at this wavelength absorb best in deoxygenated (venous) blood, then in oxygenated blood and then in water. Lasers operating in this wavelength also use a glass fiber to deliver the energy to the tissues and are mains powered (Figure 2B).

The third generation diode laser technology employs the 940 nm wavelength which absorbs strongly into both haemoglobin and water. This wavelength corresponds to the peak absorption for oxygenated (arterial) blood in this region of the spectrum and also has higher absorption into deoxygenated (venous) blood than 810 or 980 nm diode lasers, giving this laser type outstanding ability to control bleeding. At the same time, the 940 nm wavelength has strong water absorption, giving tissue cutting at a rate similar to a 980 nm laser, but with better control of bleeding.

A 940 nm laser can be used to coagulate, cut or ablate soft tissue, in a contact mode for enhanced surgical precision and tactile feedback, or in a non-contact mode. Pulsed modes such as Comfortpulse™ have been developed which allow a range of soft tissue procedures to be completed without injected local anaesthesia. This is possible by using very short pulse durations (such as 50-100 microseconds) which are shorter than both the thermal relaxation time of soft tissue and the receptor range for nociceptor pain responses. Common 940 nm laser systems use a permanent reinforced fiber with single patient use disposable tips, rather than relying on the user to cleave the fiber after each use. This reduces variability caused by errors in the efficiency of cleaving, saves time and is preferred from an infection control standpoint. Both mains powered and battery powered (fully hands free, marker pen size) units are now available in the third generation systems (Figure 2C and 2D).

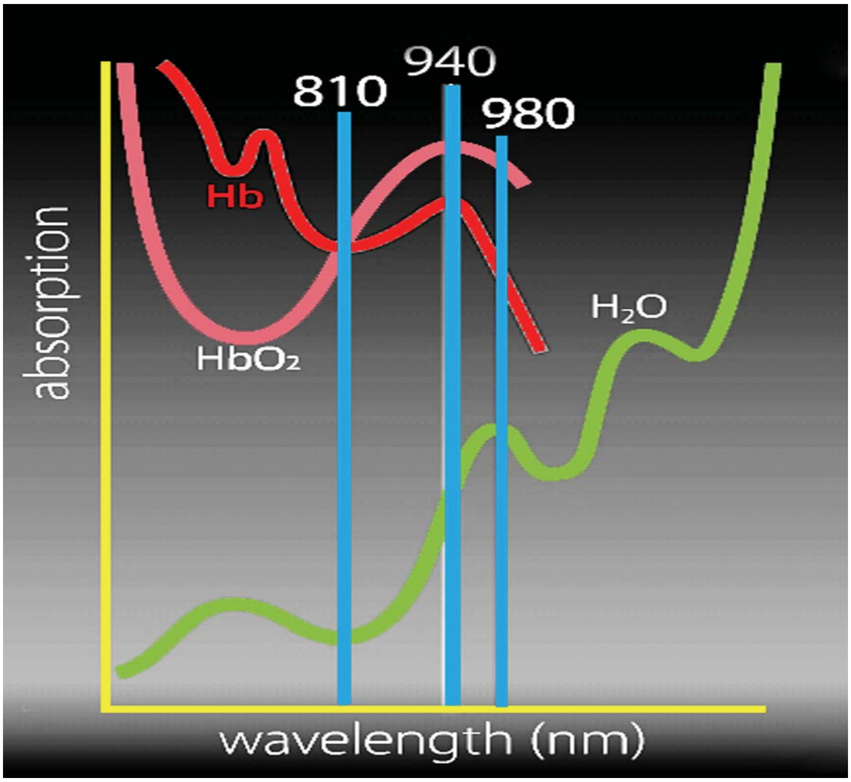

Figure 3. Absorption of major diode laser wavelengths according to wavelength in the near infrared range, for de-oxygenated haemoglobin (Hb) in venous blood, oxygenated haemoglobin (HbO2) in arterial blood, and water.

Diode lasers are becoming more widely used as alternatives to electrosurgery systems and retraction cords and this trend is set to continue in the future. Recent research opens additional applications for these lasers for a range of periodontal and endodontic procedures beyond those illustrated herein.

References

1. Walsh LJ. Cosmetic dentistry - Dealing with hard and soft tissue problems. Brisbane: Knowledge Books and Software, 2003.
2. Moritz A, Beer F, Verheyen P, Wernisch J, Schoop U, Blum R, Walsh LJ. Oral Laser Application. Berlin: Quintessence, 2006.
3. Walsh LJ. Soft tissue management in periodontics using a carbon dioxide surgical laser. Periodontology 1992; 13:13-19.
4. Walsh LJ. The use of lasers in implantology: an overview. Journal of Oral Implantology 1992; 18:335-340.
5. Walsh LJ. Applications of carbon dioxide surgical lasers in periodontology and implantology. Postgraduate Dentist 1994; 4:50-54.
6. Walsh LJ. Utilization of a carbon dioxide laser for periodontal surgery: a three year longitudinal study. Periodontology 1995; 16: 3-7.
7. Walsh LJ. The clinical challege of laser use in periodontics. Periodontology 1996; 17: 66-72.
8. Walsh LJ, L'Estrange PR, Seymour GJ. High magnification in situ viewing of wound healing in oral mucosa. Australian Dental Journal 1996; 41:75-79.
9. Walsh LJ, Ivanovski S. Cosmetic management of gingival fibromatosis by laser recontouring. Periodontology 1997; 18: 3-6.
10. Walsh LJ. Emerging applications for lasers in implantology. Periodontology 2002; 23:8-15.
11. Walsh LJ. The current status of laser applications in dentistry. Australian Dental Journal 2003;48:146-155.
12. Walsh LJ. The role of lasers in implant dentistry. Australasian Dental Practice 2007;18:138-140.
13. Walsh LJ. Erbium dental lasers and bone modification. Australasian Dental Practice 2008;19:104-106.
14. Walsh LJ. Laser analgesia with pulsed infrared lasers: theory and practice. Journal of Oral Laser Applications 2008; 8:1-10.
15. Walsh LJ. Dental lasers: Some basic principles. Postgraduate Dentist 1994; 4:26-29.

About the author

Professor Laurence J. Walsh is the technology editor of Australasian Dental Practice magazine. He is also a noted commentator on and user of new technologies and is the Head of The University of Queensland School of Dentistry.