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Keeping up with the Times
John D.B. Featherstone, MSc, PhD, San Francisco, California
J Laser Dent 2008;16(2):57

SYNOPSIS
John Featherstone, editor-in-chief, describes some of the highlights of this issue of the Journal of Laser Dentistry, and hands over to the new editor-in-chief Don Coluzzi.

This is my last issue of the Journal of Laser Dentistry as editor-in-chief. I have enjoyed the last couple of years as we changed the face of the journal. I have stepped down for personal reasons and I am pleased that Don Coluzzi has taken over for the future. The Journal will be in good hands. I would like this opportunity to thank my editorial board and the additional reviewers for all their work. Thanks too for all the efforts made by the contributors to write their articles and to conform to the rigors of peer review. Thank you for the opportunity to serve you all.

There are several articles in this issue dealing with uses of the Er:YAG laser. The laser-tissue interactions are used to enable dental procedures of various types to be performed for the benefit of the patient. I encourage you to study each of the articles so that you can better understand how these lasers work for each of the applications described. Every wavelength and every set of irradiation parameters can be used for various purposes. The task of the practitioner is to truly understand how to optimize these conditions.

The three advanced proficiency case studies provide illustrations of three different laser wavelengths, namely 810-nm diode, Er:YAG, and Nd:YAG, that can be exploited in different ways. Again the laser-tissue interactions are used to enable the final clinical outcomes.

In conclusion, I wish all who read this journal every success within the various aspects of laser dentistry. Please look to the future as new and improved lasers come on the market. Your fundamental understanding of how lasers interact with tissue is critical to your decision as to what laser to buy and what to use for which procedure. Be a continual student. Laser dentistry is a complicated activity that demands our close attention at all times.

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Dr. John D.B. Featherstone is Professor of Preventive and Restorative Dental Sciences and Interim Dean in the School of Dentistry at the University of California, San Francisco (UCSF). He has a PhD in chemistry from the University of Wellington (New Zealand). His research over the past 33 years has covered several aspects of cariology (study of tooth decay) including fluoride mechanisms of action, de- and remineralization of the teeth, apatite chemistry, salivary dysfunction, caries (tooth decay) prevention, caries risk assessment, and laser effects on dental hard tissues with emphasis on caries prevention and early caries removal. He has won numerous national and international awards including the T.H. Maiman award for research in laser dentistry from the Academy of Laser Dentistry in 2002, and the Norton Ross Award for Clinical Research from the American Dental Association in 2007. In 2005 he was honored as the first lifetime honorary member of the Academy of Laser Dentistry. Dr. Featherstone has published more than 200 papers. Through the current issue, he is the editor-in-chief of the Journal of Laser Dentistry.

Disclosure: Dr. Featherstone has no affiliation with any company that markets lasers for dentistry.
Clinical Considerations for the Use of Er:YAG Lasers in Restorative Dentistry

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INTRODUCTION
Keller and Hibst1 illustrated the potential of the Er:YAG laser for the effective ablation of dental hard tissues. As a result there followed the development and marketing of free-running pulsed, mid-infrared wavelength lasers during the mid-1990s. This offered advantages in addressing laser wavelengths that were complementary to target tissue elements, allowing clinically significant ablation rates that did not cause pulpal or collateral thermal injury using proper energy levels.2-7 The erbium YAG and erbium, chromium YSGG laser wavelengths are strongly absorbed primarily by water and to a small extent by hydroxyapatite contained in varying component ratios in hard dental tissue.8

The use of the erbium lasers in restorative dentistry can offer multiple advantages and the following 10 guidelines are offered to maximize successful outcomes:

1. Basic considerations
2. Laser-tissue interaction considerations
3. Use of coaxial water spray
4. Exceptions to using water spray
5. Cavity margin considerations
6. Acid-etch considerations
7. Avoidance of dehydration
8. Choice of composite restorative materials
9. Isolation and safety considerations
10. Miracles don’t happen!

1. Basic Considerations
So that laser-tissue interaction is therapeutically effective and efficient, it is necessary to deliver light energy of sufficient value over time to effect tissue change without causing unwanted collateral

SYNOPSIS

The authors illustrate 10 principles that govern erbium laser use on tooth structure, and three clinical case examples utilizing a specific Er:YAG laser. The authors utilize only the Er:YAG wavelength in their clinical practices.

ABSTRACT
There are two wavelengths currently available that comprise the erbium family of dental lasers. The Er:Cr:YSGG laser has an active medium of yttrium scandium gallium garnet doped with erbium and chromium ions, operates in a free-running pulsed mode at an emission wavelength of 2780 nm. The Er:YAG laser has an active medium of yttrium aluminum garnet doped with erbium ions and emits free-running pulsed laser energy at a wavelength of 2940 nm. Both wavelengths have a high absorption in water, and are appropriate for ablating oral soft tissue as well as dental hard tissue. With the latter, the rapid vaporization of interstitial water results in an explosive dislocation of target hard tissue.

Advantages of using this laser family in restorative dentistry include precision, selective ablation of target hard tissue and carious lesions, reduced collateral damage that might be due to rotary instrumentation (tactile and thermal damage), and less conductive thermal stimulation of the pulp.

Laser use in restorative dentistry is technique-sensitive, and inappropriate or poor operating parameters can result in less-than-expected results. This paper examines 10 principles of use of these erbium laser wavelengths in clinical restorative dentistry, together with a review of the literature regarding different aspects of the use of laser energy on hard tissues.

Key Words: acid etching, dental; dental bonding; dental enamel; dental pulp capping; dental veneers; dentin; dentin sensitivity; laser ablation; safety, medical device; tooth fractures

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thermal damage by conduction of excess heat into the surrounding tissues. An essential requirement is to establish a rate of interaction that is commensurate with a time frame allowing such interaction to be clinically acceptable. This is achieved through a suitable choice of incident laser energy delivered to the tissue as well as the effects of wavelength, pulse duration, repetition rate, power density, and the thermal relaxation time of the tissue; all of these factors will determine the rate (speed) of ablation of dental hard tissue.4,11

The speed of ablation is also affected by the incident angle of the delivery tip relative to the tooth and the presence of ablation products. Addressing the delivery tip parallel to the axis of the enamel prisms in order to access the interprismatic, higher-water content structure maximizes the speed of ablation. Ablation is more efficient and heat transfer is minimized when the pulse width is reduced and peak power values rise.6,12-13 In addition, the use of sharp curettes to remove gross caries can reduce laser use to an acceptable time frame.

The depth of laser ablation depends principally on the parameters utilized and is a consequence of the energy used per pulse and the number of pulses delivered. In addition, to avoid and prevent cracks or structural modifications, the tip, where present, must not touch the surface and excess energy must not be applied. The ablation threshold of human enamel has been reported14 to be in the range of 12-20 Joules/cm² and for dentin, 8-14 Joules/cm² for both the Er:YAG and Er,Cr:YSGG laser wavelengths, and each available instrument can provide this fluence. It is recommended that the clinician follow the manufacturer’s guidelines in establishing laser treatment protocols for a given laser, keeping in mind the differing operating parameters of air / water / spot size and any power losses that may occur within differing delivery systems.

2. Laser-Tissue Interaction

Considerations

In determining effective treatment the following factors may apply:

a. Target chromophores

Both Er,Cr:YSGG and Er:YAG laser wavelengths are well absorbed in water due to the broad absorption band of water around and below 3,000 nm. In addition, there is a small absorption peak at around 2,800 nm by the hydroxyl ion of hydroxyapatite mineral content of the hard tissues. Enamel, dentin, bone, cementum, and carious tissue have relatively descending mineral density and ascending water composition.

b. Mode of Interaction

Constituent water, when exposed to laser energy in this wavelength range, absorbs the light efficiently and the energy is rapidly converted to heat, resulting in a disruptive expansion of water molecules in the tissue. As such, small tissue fragments may be ejected with little or no alteration to the mineral itself. With relatively high fluences it is possible that the laser light is absorbed by the mineral as well as the water resulting in ablation of the mineral and/or disruption with some structural modification.15-17

c. Emission Mode

The emission mode of current erbium lasers is defined as free-running pulsed and the pulse durations are close to the thermal relaxation times of enamel and dentin.18

d. General Thermal Effect

The use of water-assisted mid-infrared wavelengths allows work on hard tissues with thermal rises of less than 5°C in the pulp. It is necessary to avoid an accumulation of debris at the bottom of the cavity which can lead to conductive heat damage.7,17,19-20

e. Relationship of Laser Action to Cavity Design / Restoration Retention

Laser irradiation of enamel and dentin results in a micro-cavitated surface. While this roughness might be beneficial for retention of restorative materials, unsupported enamel rods can remain, which could compromise a marginal seal. The lased dentin surface shows an absence of a smear layer.21

f. Speed of “Cutting” / Power Values

The speed of ablation is a result of the amount of incident laser energy, the pulse duration, the repetition rate, and the thermal relaxation time. In addition other factors must be considered such as the speed of the movement of the laser handpiece relative to the target tissue, the focus distance of the laser beam, the incident angle of the delivery tip relative to the tooth, and the presence of ablation products.

3. Use of Coaxial Water Spray

Studies have investigated the effects of excessive incident power and the build-up of ablation products, or their removal by means of a coaxial water spray.7,12-21 The explosive defragmentation resulting from water-assisted mid-infrared wavelengths allows much of the heat to escape from the cavity carried in the ablated particles, resulting in pulpal thermal rises of less than 5°C. The affinity of mid-infrared laser wavelengths...
Case #1
ER:YAG LASER-ASSISTED TREATMENT OF FRACTURED TEETH

PRETREATMENT
A. Outline of Case
1. Full Clinical Description
A healthy 9-year-old boy presented with three maxillary anterior teeth that were fractured due to an accident. The three broken pieces were kept in milk and the patient was brought to the dental office. The oral examination showed mixed dentition, healthy periodontium and TMJ, and the teeth were in Class I occlusion (Figure 1).

2. Radiographic Examination
Both the panoramic radiograph and the periapical radiograph showed no other abnormalities.

3. Soft Tissue Status
The soft tissue status showed good periodontal health.

4. Hard Tissue Status
Hard tissue test: Percussion was normal, with slight mobility and tenderness to touch and air spray.

5. Other Tests
Tooth vitality: All three fractured teeth tested vital with the electric pulp tester and cold testing.

B. Diagnosis and Treatment Plan
1. Provisional Diagnosis
Three upper frontal fractured teeth #7, 8, and 9.

2. Final Diagnosis
Extensive fractures close to the pulp on teeth #7, 8, and 9.

3. Treatment Plan Outline
The primary objective was to restore teeth #7, 8, and 9 using an Er:YAG laser in the following sequence:
   - Ablate the most superficial dentin; prepare the surfaces of the fractured teeth and the fragments so that they could be bonded together.
   - Reduce bacteria in areas of the tooth preparation close to the dental pulp, and attach the fragments with composite filling material.
   - Refine the composite preparation by shaping, etching, and beveling the enamel. Hybrid composite resin would then be used to both lute the fractured segments to the tooth as well as to veneer the surface of both. Subsequently, the pulpal status would be evaluated.

4. Indications for Treatment
The indications for treatment were:
To prepare adequate surface to obtain maximum area of adhesion and attach the fragments to the teeth using composite fillers. The Er:YAG laser wavelength is readily absorbed by hard tissue, therefore it is possible to more easily conserve healthy tooth structure than by using a conventional high-speed handpiece. In addition, the relative lack of tactile stimulation offered by laser treatment compared to a conventional high-speed handpiece often allows the procedure to be performed without the need for needle analgesia.

5. Contraindications for Treatment
There are no absolute contraindications for performing the procedure.

6. Precautions for Wavelength
Good visibility and low power will be necessary for careful preparation in order to avoid both thermal damage and excessive removal of tooth structure.

7. Treatment Alternatives
The treatment alternatives would have been conventional dental drills to roughen the dental surfaces; those burs could cause greater loss of hard tissue, microfractures of the tooth enamel, pulp exposure, and tenderness.

8. Informed Consent
Upon receiving a full explanation of the procedure, with associated risks, benefits, and alternatives, the patient and his parents gave consent to perform the treatment.

TREATMENT
A. Treatment Objectives Strategy
The primary objective was to use...
the Er:YAG laser to prepare the two surfaces, one of the fractured teeth and one of the fragments, for maximum adhesion without greater loss of hard tissue or microfractures and without the use of injectable dental anesthetics.

**B. Laser Operating Parameters**
An Er:YAG laser (DELight, HOYA ConBio, Fremont, Calif.) with a wavelength of 2940 nm was used with its fiber delivery system and a 600-micron quartz tip. It operates in a free-running pulsed mode with a pulse duration of 300 μsec. The laser was used at 1.0 Watt (100 mJ, 10 Hz), quartz tip 80° with air in contact mode for dentin modification, and at 3.2 Watts (160 mJ, 20 Hz), quartz tip 80° with water mist in noncontact mode for dentin ablation (Figures 2-4).

**C. Treatment Delivery Sequence**
Prior to the procedure, the patient was familiarized with the treatment sequence. Subsequently, all laser safety precautions were performed, including, but not limited to, the administering of laser safety glasses to the patient and operators, displaying laser hazard signage, and inspecting the mechanical aspects of the laser. Once safety systems were in place, the laser was test-fired to ensure proper beam function and water spray delivery. The dentin was modified in both contact and noncontact modes. With the same settings, the laser energy was directed at the mating surfaces of the fractured segments. High-volume suction was used continuously. Clearfil SE Bond (Kuraray America, Inc., New York, N.Y.) was applied to enamel and dentin surfaces and a 0.4-micron filler size composite was used as the restorative material. Finishing of the restoration was performed with coarse diamond burs, 12-blade finishing burs, and finishing discs (Figure 5).

**D. Postoperative Instructions**
The patient was told that he could resume normal activities due to the lack of numbness as a result of no injections. The parents were told to call the office if pain or any other unusual symptoms occurred.

**E. Complications**
No complications occurred during or after the procedure.

**F. Prognosis**
The prognosis was good. The patient and parents were informed that the lesions were close to the pulp so that vitality tests would have to be repeated monthly for two years.

**G. Treatment Records**
Treatment records, including the details outlined above, were included in the patient’s chart notations.

**FOLLOW-UP CARE**

**A. Assessment of Treatment Outcome**
The objectives originally set were achieved. The entire procedure was comfortably performed without the use of dental anesthesia. In addition, satisfactory esthetic results were obtained.

**B. Complications**
No complications were encountered during or after the treatment.

**C. Long-Term Results**
The long-term two-year results are in keeping with the objectives of the original treatment plan. The patient stated that he had experienced no problems with either restoration. The teeth maintained healthy vitality tests and the surfaces were sealed (Figure 6).

**D. Long-Term Prognosis**
Although the restoration of the treated teeth shows good integrity and function, the long-term prognosis is dependent upon proper correct closure maintenance and the patient’s oral lifestyle.
for water allows for selective ablation, whereby greater absorption takes place in demineralized tissue richer in organic material and with a higher percentage of water; this allows some protection of the sound underlying tissue with a reduced penetration of the beam. The accumulation of ablation debris within a deep cavity can lead to “superheating” which can lead to conductive heat damage. Without water use, laser light may be absorbed by the mineral and the crystals themselves may be heated above their melting point.

Furthermore, any lack of water can lead to cracks in enamel or can result in melting of dentin with consequent flat adhesion surfaces. Thus negative effects for the enamel mean possible marginal leakage, and for the dentin possible non-adhesion of the completed restoration.

4. Exceptions to Using Water Spray
There are two clinical situations the restorative dentist might encounter which can be treated with lasers without the simultaneous use of a coaxial water spray:

a. Desensitizing Technique
This technique must be done without water and without contact with the tooth, for a short time only and with low power (using low Hz and low mJ).26

b. Pulp Capping
This technique must be carried out without water but with air cooling, and the tip must touch the surface for only a few seconds.27

5. Cavity Margin Considerations
A succession of studies has identified the fragility of laser-irradiated enamel, relative to the stability of the postrestoration margins. Studies have proposed an approach of combined laser-irradiation, acid-etch techniques to overcome such potential problems. Laser irradiation of enamel is not a valid alternative to acid-etching pretreatment for resin composite materials adhesion.

Irrespective, there may well remain the need to remove grossly overhanging and unsupported enamel with a rotary bur, in order to either expedite cavity preparation or provide a stable postrestoration margin.28-33

6. Acid-Etch Considerations
While the surface produced by the laser is similar to the conventionally prepared, etched enamel surface, it still requires acid etching to obtain an equivalent

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conventional high-speed handpiece often allows the procedure to be performed without the need for needle analgesia.

5. CONTRAINDICATIONS FOR TREATMENT
There are no absolute contraindications for performing the procedure.

6. PRECAUTIONS FOR WAVELENGTH
Adequate water spray must be maintained as the procedure is being performed. Good visibility and low power will be necessary for careful preparation in order to avoid both thermal damage and excessive removal of tooth structure.

7. TREATMENT ALTERNATIVES
The treatment alternatives would have been conventional dental drills to roughen the dental surfaces; those burs could cause greater loss of hard tissue and increase of pulp temperature.

8. INFORMED CONSENT
Upon receiving a full explanation of the procedure, with associated risks, benefits, and alternatives, the patient gave consent to perform the treatment.

TREATMENT
A. Treatment Objectives Strategy
The primary objective was to use the Er:YAG laser to prepare the two surfaces for maximum adhesion without greater loss of hard tissue or microfractures and without the use of injectable dental anesthetics.

B. Laser Operating Parameters
An Er:YAG laser (DELight, HOYA ConBio, Fremont, Calif.) with a wavelength of 2940 nm was used with its fiber delivery system and a 600-micron quartz tip. It operates in a free-running pulsed mode with a pulse duration of 300 μ sec. The laser was used at 0.65 Watt (65 mJ, 10 Hz) quartz tip 30° with water mist in noncontact mode.

Figure 8: The final preparations after using the laser and burs

Figure 9: Immediate postoperative view showing final restorations

D. Postoperative Instructions
The patient was told that she could resume normal activities due to the lack of numbness. The patient was also told to call the office if pain or any other unusual symptoms occurred.

E. Complications
No complications occurred during or after the procedure.

F. Prognosis
The prognosis was good.

G. Treatment Records
Treatment records, including the details outlined above, were included in the patient’s chart notations.

FOLLOW-UP CARE
A. Assessment of Treatment Outcome
The objectives originally set were achieved. The entire procedure was comfortably performed without the use of dental anesthetic. In addition, satisfactory aesthetic results were obtained.

B. Complications
No complications were encountered during and after the treatment.

C. Long-Term Results
The long-term results were considered to be excellent and in keeping with the objectives of the original treatment plan. The patient stated that she had experienced no problems. The teeth maintained healthy vitality tests.

D. Long-Term Prognosis
Although the restoration of the treated teeth shows good integrity and function, the long-term prognosis is dependent upon proper correct closure maintenance and the patient’s oral lifestyle.
bond strength. Laser irradiation of enamel is not a valid alternative to acid-etching pretreatment for resin composite materials adhesion.28-40

7. Avoidance of Dehydration of Dentin
As stated above, laser ablation of dentin does not produce a smear layer so this layer cannot impede adhesion to laser-irradiated surfaces. Nevertheless when the erbium lasers are used, there is a selective ablation of organic tissue so that after acid-etching and laser conditioning of dentin there is less collagen left to be exposed and consequently to be hybridized. The weakest point with laser-treated dentin is the region immediately below the dentin layer infiltrated by resin.28 A study by Ceballos and colleagues37 using transmission electron microscopy showed a 3-4 nm altered dentin subsurface, with collagen fibrils without cross-banding and fused together, and elimination of interfibrillar space. Thus a bonding system must be used to ensure restoration retention.38

8. Choice of Composite Restorative Materials
The choice of composite materials must be made on the basis of the depth and width of dentin craters, and the use of composite nano- or micro-fillers is fundamental to the proper restoration of laser-ablated cavities. Whenever possible, the use of a first layer of composite flow is advisable.

Studies have shown that the seal at enamel margins in Er:YAG laser-irradiated preparations depends on the resin composite formulation of the corresponding adhesive.39-40

9. Isolation and Safety Considerations
Studies have shown that the Er:YAG laser demonstrates bactericidal potential for dentin.31-42 A rubber dam isolation technique

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Case #3
ER:YAG LASER-ASSISTED TREATMENT OF AN ENAMEL DEFECT

PRETREATMENT
A. Outline of Case
1. FULL CLINICAL DESCRIPTION
A healthy 56-year-old male presented with an enamel defect of tooth #7 (Figure 11). The oral examination showed healthy periodontium and TMJ, and the teeth were in Class I occlusion.

2. RADIOGRAPHIC EXAMINATION
The radiographic exam showed no periapical lesions.

3. SOFT TISSUE STATUS
The soft tissue status showed good periodontal health.

4. HARD TISSUE STATUS
Hard tissue test: Percussion was normal, with no mobility or tenderness to touch and air spray.

5. OTHER TESTS
Tooth vitality: The tooth tested vital with the electric pulp tester and cold testing.

B. Diagnosis and Treatment Plan
1. PROVISIONAL DIAGNOSIS
Tooth #7 with an enamel defect.

2. FINAL DIAGNOSIS
Vital tooth #7 with an enamel defect.

3. TREATMENT PLAN OUTLINE
The primary objective was to restore tooth #7 using an Er:YAG laser in the following sequence:
• Prepare the cavities of the tooth
• Decontaminate bacteria in the treated surfaces.

Another objective was to prepare the margins using a bur to remove unsupported enamel and smooth the surface, and then to restore the cavities with hybrid composite resin.

4. INDICATIONS FOR TREATMENT
The indications for treatment were: to prepare an adequate surface to obtain maximum area of adhesion and restore the cavities with hybrid composite resin. The Er:YAG laser wavelength is readily absorbed by hard tissue, therefore it is possible to more easily conserve healthy tooth structure than by using a conventional high-speed handpiece. In addition, the relative lack of tactile stimulation offered by laser treatment compared to a conventional high-speed handpiece often allows the procedure to be performed without the need for needle analgesia.

5. CONTRAINDICATIONS FOR TREATMENT
There are no absolute contraindications for performing the procedure.

6. PRECAUTIONS FOR WAVELENGTH
Adequate water spray must be maintained as the procedure is being performed. Good visibility and low power will be necessary for careful preparation in order to avoid both thermal damage and excessive removal of tooth structure.

7. TREATMENT ALTERNATIVES
The treatment alternatives would have been conventional dental drills to roughen the dental surfaces; those burs could cause greater loss of hard tissue,
microfractures of the tooth enamel, and tenderness.

8. Informed Consent
Upon receiving a full explanation of the procedure, with associated risks, benefits, and alternatives, the patient gave consent to perform the treatment.

TREATMENT
A. Treatment Objectives Strategy
The primary objective was to use the Er:YAG laser to prepare the surfaces of the cavities in order to obtain the maximum adhesion without greater loss of hard tissue or microfractures and without the use of injectable dental anesthetics.

B. Laser Operating Parameters
An Er:YAG laser (DELight, HOYA ConBio, Fremont, Calif.) with a wavelength of 2940 nm was used with its fiber delivery system and a 600-micron quartz tip. It operates in a free-running pulsed mode with a pulse duration of 300 μsec. The laser was used at 5 Watts (200 mJ, 25 Hz), quartz tip 80° with water mist in noncontact mode for enamel ablation, and at 3.2 Watts (160 mJ, 20 Hz), quartz tip 80° with water mist in noncontact mode for dentin ablation.

C. Treatment Delivery Sequence
Prior to the procedure, the patient was familiarized with the treatment sequence. Subsequently, all laser safety precautions were performed, including, but not limited to, the administering of laser safety glasses to the patient and operators, displaying laser hazard signage, and inspecting the mechanical aspects of the laser. Once safety systems were in place, the laser was test-fired to ensure proper beam function and water spray delivery. After enamel and dentin ablation was completed (Figure 12), a bur was used to

Figure 12: View of preparation after laser use

remove unsupported enamel and refine the margins of the preparation. High-volume suction was used continuously. The preparation was then etched with phosphoric acid. Figure 13 shows the completed etched preparation.

Figure 13: View of preparation after bur use and acid etching

Clearfil SE Bond (Kuraray America, Inc., New York, N.Y.) was applied to enamel and dentin surfaces and a nano-composite Adonis (Sweden & Martina S.p.A., Due Carrare-Padova, Italy) was used as the restorative material. Finishing of the restoration was performed with coarse diamond burs, 12-blade finishing burs, and finishing discs (Figure 14).

D. Postoperative Instructions
The patient was told that he could resume normal activities due to the lack of numbness as a result of no injections. The patient was told to call the office if pain or any other unusual symptoms occurred.

E. Complications
No complications occurred during or after the procedure.

F. Prognosis
The prognosis was good.

G. Treatment Records
Treatment records, including the details outlined above, were included in the patient’s chart notations.

FOLLOW-UP CARE
A. Assessment of Treatment Outcome
The objectives originally set were achieved. The entire procedure was performed with success without the use of dental anesthetics. In addiction, satisfactory aesthetic results were obtained.

B. Complications
No complications were encountered during or after the treatment.

C. Long-Term Results
The long-term results are in keeping with the objectives of the original treatment plan. The patient stated that he had experienced no problems with the restoration. The tooth maintained healthy vitality tests.

D. Long-Term Prognosis
Although the restoration of the treated tooth shows good integrity and function, the long-term prognosis is dependent upon proper correct closure maintenance and the patient’s oral lifestyle.
must be used in every procedure to maintain the decontamination provided by the laser. As illustrated in Figure 10, safety measures should include the use of:
- wavelength- and device-specific protection glasses for the doctor, the assistant, and patient
- appropriate face masks to avoid plume aspiration
- high-speed evacuation of plume and debris
- nonreflecting instruments
- magnification to better visualize and control the dentist’s work.

10. Miracles Don’t Happen!
Finally, it should be remembered that lasers are not magic wands — a lot can be done with lasers, but the dentist’s knowledge and experience take precedence over the tools. An accurate diagnosis is the only basis to offer the patient the correct therapy which must be carried out with due expertise.

AUTHOR BIOGRAPHIES
Dr. Prof. Giuseppe Iaria qualified in Medicine and Surgery at University of Milan in 1984. His postgraduate dental qualifications — Dentist and Orthodontist — were obtained at the University of Milan in 1987 and 1989 with the highest marks. During the Sixth International Conference of the Academy of Laser Dentistry in Palm Springs, California in February 1999, he achieved his certificate of Master of the Academy of Laser Dentistry. On October 22, 2000 he obtained the certification of Dental Laser Educator at the University of California San Francisco. In 2001, the publishing house UTET published his text entitled The Lasers in Dentistry and Oral Surgery. On April 16, 2004 he was certified with the International Society for Lasers in Dentistry. Currently Dr. Prof. Iaria is a member of the Science and Research Committee of the Academy of Laser Dentistry. He serves as a referee and editorial board member for several international dental journals and has held consultancies with many international laser companies. He participated as a speaker at important national and international conferences and has conducted several courses on the use of lasers in dentistry.

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Dr. Steven Parker studied dentistry at University College Hospital Medical School, University of London, UK and graduated in 1974. He maintains a Private Practice in Harrogate, UK. He holds Fellowship and Diplomate status with the International Congress of Oral Implantologists.

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**Editor’s Note:** USA clinicians are advised that no erbium laser has been cleared by the U.S. Food and Drug Administration for the desensitization, pulp capping, and decontamination procedures and bactericidal properties identified in this article.
Peri-Implantitis Therapy with an Er:YAG Laser

Avi Reyhanian, DDS, Natanya, Israel
Donald J. Coluzzi, DDS, Portola Valley, California

Introduction

Osseointegrated dental implants have become a routinely recommended procedure in the clinical practice of dentistry.\(^1\)\(^-\)\(^4\) Although they can be highly successful restorations, implant failure can and does still occur.\(^5\)\(^-\)\(^8\) Among the many complications possible in the procedure, one of the more common postoperative ones is peri-implant disease and, within this category, peri-implantitis.\(^9\)

Three major factors contribute to the failure and complications of implants:

1. Patient-related factors
2. Iatrogenic (doctor/team) factors
3. Surgical equipment / manufacturer problems.

Patient and iatrogenic factors are more prevalent than implant manufacturing problems.

Implant complications are divided into two main categories: Intraoperative and postoperative.\(^9\)

Peri-implantitis is a postoperative complication.

Biofilms form on all hard, nonshedding surfaces in a fluid system, i.e., both on teeth and on oral implants. As a result of the bacterial challenge, the host responds by mounting a defense mechanism leading to inflammation of the soft tissue. In the implantomucosal unit this inflammation is termed “mucositis” which may develop into “peri-implantitis.”\(^9\)

Peri-implantitis is an inflammatory reaction that is associated with the presence of a submarginal biofilm, with advanced breakdown of soft and hard tissue surrounding the endosseous implant: loss of the bony support of the implant.\(^10\)

The etiology of the disease is conditioned by the status of the tissue surrounding the implant, design of the implant, degree of roughness, poor alignment of implant components, external morphology, and excessive mechanical load.\(^10\)

There are two major factors that, separately or combined, contribute to the formation of peri-implantitis:

1. Bacterial exposure, especially gram-negative and anaerobic species\(^11\)\(^-\)\(^12\)
2. Overload.\(^13\)\(^-\)\(^14\)

Clinical signs and diagnosis include: Bleeding on probing, purulence, bone loss, pocketing, dull sound on percussion, peri-implant radiolucent mobility of the implant, fistula, and changes of color in the gingiva and/or the mucosa.\(^10\)

Treatment involves either implant removal, especially if the fixture is mobile, or therapy, usually involving surgery and debridement techniques.

Conventional approaches include:

- Systemic administration of antibiotics
- Removal of supragingival bacterial plaque
- Removal of granulation tissue with plastic curettes
- Debridement of the exposed surface by using mechanical brushing, air powder abrasives, citric acid, disinfectants like chlorhexidine or topical tetracycline, plaque inhibitor like delmopinol, or low-intensity ultraviolet radiation
- Removal of the peri-implant pocket
- Regeneration of peri-implant hard tissue by means of guided tissue regeneration
- Plaque control and oral hygiene.

The Use of the Er:YAG Laser in Treatment of Peri-implantitis

The Er:YAG laser interacts with both hard and soft dental tissues,
and thus can be effectively utilized for both surgery and debridement of the infected implant area. 
- The laser can make crestal, intrasulcular, or vertical release incisions in raising a flap. The Er:YAG laser produces a wet incision (some bleeding) as opposed to the dry incision (no bleeding) produced by other soft tissue lasers.15
- The laser easily vaporizes any existing granulation tissue, with a lower risk of overheating the bone than those posed by the current diode or CO2 lasers.16-17 The Er:YAG laser wavelength’s excellent ability to effectively ablate soft tissue without producing major thermal side-effects to adjacent tissue has been demonstrated in numerous studies.18-20
- The implant surface can be debrided by lasing directly on the implant’s exposed screws with a low-energy setting. Both the target tissue and implant surface are disinfected without damage.21-25
- Ablating the bone with the Er:YAG laser also ablates necrotic bone, as well as contours and reshapes the surrounding osseous tissue.26-28
- The laser is bactericidal.29-30

CASE STUDY
This case describes treatment of peri-implantitis with an Er:YAG laser.

PRETREATMENT
A. Outline of Case
1. Clinical Examination
A 51-year old male presented with no medical abnormalities. The patient presented by referral four months after having implants inserted in the location of the lower left and right lateral incisors.

2. Soft- and Hard-Tissue Examination
Periodontal probing showed generalized 4 mm pockets with bleeding. The patient had very ineffective oral hygiene, and does not brush or floss at all; consequently, all teeth were covered with plaque. Both of the implants were nonsubmerged with abutments present. The lower right implant presented a labial fistula, the probing of which led to the apical end of the implant (Figures 1 and 2). The left implant presented without complications. The remaining soft tissue was within normal limits.

3. Radiographic Examination
Panoramic and periapical X-rays showed a large radiolucency area surrounding about 70% of the right implant, implying massive bone loss (Figure 3).

4. Mobility Tests
The infected implant was stable with no mobility.

B. Diagnosis and Treatment Plan
1. Provisional and Final Diagnosis
Advanced peri-implantitis with massive bone loss around the implant.

TREATMENT
A. Laser Operating Parameters
An intrasulcular incision was made with an Er:YAG laser (OpusDuo™ AquaLite™, Lumenis Ltd., Yokneam, Israel) (2940 nm), using...
a 200-micron sapphire tip in contact mode with a water spray. The power setting for the incision was 450 mJ / 20 PPS (9 Watts) (Figure 4).

B. Treatment Delivery Sequence
The intrasulcular incision was performed from the distal side of the right cuspid to the mesial side of the left implant. Then a vertical incision for release was performed at the mesial of the left implant and a buccal flap was lifted (Figure 5). The defect was probed to determine the extent of the lesion (Figure 6). The infection had engulfed the buccal side and lingual side toward the apex of the implant, with massive loss of bone and a great deal of granulation tissue, as shown in Figure 7.

The granulation tissue was ablated with the laser in noncontact mode using a 1300-micron sapphire tip and a power setting of 700 mJ / 12 PPS (8.4 Watts) with a water spray (Figure 8). Since the buccal bone had not resorbed, direct observation was impossible, making it difficult to ablate the granulation tissue inside and around the implant. Therefore a small window of the buccal bone was removed with the same laser parameters to gain direct access to the lesion. After removal of the infected soft tissue (Figure 9), the laser beam was aimed at the surface of the exposed screws in a low-energy setting of 150 mJ / 20 PPS (3 Watts), for debridement. The next step was to ablate necrotic bone, and to shape and recontour the defect. The site was filled with a xenograft bone substitute (Bio-Oss®, Geistlich Pharma AG Biomaterials Division, Wolhusen, Germany) (Figure 10) and then covered with an absorbent bilayer membrane (Bio-Gide®, Geistlich Pharma AG Biomaterials Division) (Figure 11). The flap was sutured (silk 3-0), with particular attention paid to primary closure of the flap (Figure 12). An immediate postoperative radiograph is shown in Figure 13.

C. Postoperative Instructions
The patient was prescribed clindamycin 150 mg x 50 tabs to avoid infection. He was also given
ibuprofen 800 mg x 15 tabs for pain. He was instructed to rinse with chlorhexidine 0.2%, starting the next day, for 2 weeks 3 times a day and was advised to maintain good oral hygiene.

**FOLLOW-UP CARE**

**A. Assessment of Treatment Outcome**

The patient was called the next day, and he reported moderate pain and moderate swelling. He also said that there was no tissue bleeding and the site was closed. At 10 days postoperative, the patient returned for inspection and removal of sutures (Figure 14). The patient returned four days later and the suture points had healed (Figure 15). The swelling had resolved, there were no signs of fistula, and healing was progressing well. After six weeks the soft tissue was completely healed without complications. The soft issue was healing over the bone and there were no bony projections observed under the soft tissue.

**B. Prognosis**

The prognosis is good. The two-month postoperative views and radiograph show good healing (Figures 16-18). It will be essential for the patient to maintain good oral hygiene. It is important to note that the lack of mobility of the infected implant is very important for guided tissue regeneration to be successful.

**Conclusion**

The Er:YAG laser can be employed for debridement of implant surfaces as well as regenerative osseous surgery, and has been proven to be effective and safe. The use of this laser wavelength for these procedures presents many advantages vs. conventional methods, such as reducing pathogens and patient discomfort. This laser has become an invaluable tool for many procedures by simplifying treatment and offering patients faster, less stressful oral therapy with enhanced outcomes.

**AUTHOR BIOGRAPHIES**

Dr. Avi Reyhanian graduated from the University of Bucharest, Romania in 1988. He then participated in a fellowship program at the Oral & Maxillofacial Department, Rambam Hospital in Israel. He is a member of the academic staff at the Institute of Advanced Dental Education in Haifa, Israel and he currently practices general dentistry and oral surgery in Natanya, Israel. Dr. Reyhanian’s practice has employed dental lasers since early 2002; he currently uses Er:YAG (2940 nm),

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**Figure 13: Immediate postoperative radiograph**

**Figure 14: Ten days postoperative, sutures just removed**

**Figure 15: Two weeks postoperative, suture areas healed**

**Figure 16: Two-month postoperative view of treated implant**

**Figure 17: Two-month postoperative view of surgical area**

**Figure 18: Two-month postoperative radiograph**
CO₂ (10,600 nm), and diode (830 nm) lasers in his practice. He is a member of the Academy of Laser Dentistry and the Israel Society of Dental Implantology. Dr. Reyhanian presents lectures in Israel, Europe, USA, and Asia on the topic of dental lasers, and has published several articles. Dr. Reyhanian may be contacted by e-mail at avi5000rey@gmail.com.

Disclosure: Dr. Coluzzi is an occasional presenter and trainer for Hoya ConBio, and receives an honorarium for that service.

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Dr. Donald Coluzzi, a 1970 graduate of the University of California San Francisco School of Dentistry, is an associate clinical professor in the Department of Preventive and Restorative Dental Sciences at the University of California San Francisco School of Dentistry. A charter member and past President of the Academy of Laser Dentistry, he has used dental lasers since early 1991. He has Advanced Proficiency in Nd:YAG and Er:YAG laser wavelengths. He is the 1999 recipient of the Leon Goldman Award for Clinical Excellence and the 2006 Distinguished Service Award for Clinical Excellence and Treatment of the edentulous jaw. Int J Oral Surg 1981;10(6):387-416.

Dr. Reyhanian is a member of the academic staff at the Institute of Advanced Dental Education in Haifa, Israel, and is a consultant to the Lumenis Company.

Disclosure: Dr. Reyhanian is a consultant to the Lumenis Company.

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Dr. Donald Coluzzi, a 1970 graduate of the University of California San Francisco School of Dentistry, is an associate clinical professor in the Department of Preventive and Restorative Dental Sciences at the University of California San Francisco School of Dentistry. A charter member and past President of the Academy of Laser Dentistry, he has used dental lasers since early 1991. He has Advanced Proficiency in Nd:YAG and Er:YAG laser wavelengths. He is the 1999 recipient of the Leon Goldman Award for Clinical Excellence and the 2006 Distinguished Service Award from the Academy of Laser Dentistry, and is a Fellow of the American College of Dentists. Dr. Coluzzi has presented about lasers worldwide, co-authored two books, and published several peer-reviewed articles.

Disclosure: Dr. Coluzzi is an occasional presenter and trainer for Hoya ConBio, and receives an honorarium for that service.

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Use of an Er:YAG Laser for Pulpotomies in Vital and Nonvital Primary Teeth

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SYNOPSIS

A protocol for performing a primary tooth pulpotomy utilizing an Er:YAG laser is described. Radiographic histories of several clinical cases are also shown.

INTRODUCTION

Primary teeth that have the pulp tissue exposed due to caries, mechanical removal of carious tissue, or as a preventive procedure on severely abraded teeth require the completion of a pulpotomy. The American Academy of Pediatric Dentistry defines a pulpotomy as when the coronal pulp is amputated, and the remaining vital radicular pulp tissue surface is treated with a medicament such as formocresol or ferric sulfate or with electrocautery to preserve the radicular pulp’s health. Mineral trioxide aggregate (MTA) has also been used as pulp dressing agent for pulp therapy treatment. A pulpotomy is defined as a root canal procedure for pulp tissue that is irreversibly infected or necrotic due to caries or trauma. The objective of either procedure is to maintain the tooth or teeth involved – functionally and painlessly – without pathology until the primary tooth normally exfoliates upon eruption of the underlying permanent tooth or until the tooth is adequately developed for the root canal completion.

Lasers are an effective alternative for treating pulps with the additional benefits of providing pulp therapy without the need to introduce chemicals into children’s systems. It has been demonstrated that small amounts of formocresol may be absorbed and distributed throughout the child’s body within minutes of its use at the pulpotomy site. Pulpotomy is one of the clinical indications for use of the Er:YAG laser (2940 nm), which is useful in treating both vital and nonvital primary teeth where a pulpotomy is required to maintain the primary tooth until it is ready to exfoliate. In addition, successful treatment can delay the need to extract a nonvital primary tooth until a space maintainer can be inserted.

CLINICAL CASE SUMMARIES

This report presents a series of clinical cases of treating primary teeth, using the Er:YAG laser for pulpotomies in primary teeth.

PRETREATMENT

The teeth included in this report were performed on children who had medical histories completed by their parents which the indicated the children were healthy. Pulpotomies in the report are selected examples of more than 4,000 pulp treatments necessitated by traumatic injuries, mechanical or caries exposure, or in teeth determined to be nonvital due to caries or trauma. Cases represent examples of teeth treated with an Er:YAG laser in 2002 or later, with follow-up radiographs extending from 2 months to 5 years post-treatment. In anterior pulp therapy cases, the pulp therapy treatment was completed on children as young as 8 months of age. These cases represented children suffering from nursing bottle dental caries or who had traumatized the upper anterior teeth which resulted in the teeth becoming nonvital. In the posterior teeth, children had treatment as early as 16 months on first primary molar teeth and as early as 24 months for second primary molar teeth which had erupted prior to the normal eruption time of 36 months.

Radiographic Documentation

Examples in this report were chosen from those cases where the child was able to accept the taking of dental radiographs prior to beginning the treatment.

ABSTRACT

Pulp therapy for vital and nonvital primary teeth usually involves the use of chemical agents, such as formocresol, or electrocautery. This article reviews the results of using the Er:YAG laser to achieve similar results. Clinical and radiographic evidence indicates that using the Er:YAG laser results in safe, successful treatment of pulpotomies in primary teeth, similar to the successful treatment of other modalities.

Key Words: amoxicillin; dental pulp exposure; electrocautery; formocresol; radiography, dental; root canal irrigants; zinc oxide-eugenol cement
**TREATMENT**

**A. Treatment Objectives**
Provide successful pulp therapy using the Er:YAG laser as an alternative to chemical or electrosurgical methods.

**B. Laser Operating Parameters**
Either of two Er:YAG lasers were used for treatment: The DELight® or VersaWave® (HOYA ConBio, Fremont, Calif.) or the PowerLase® AT (Fotona d.d., Ljubljana, Slovenia, distributed in the United States by Lares Research, Chico, Calif.).

1. **DELight and VersaWave Settings**
   - Wavelength: 2940 nm
   - Repetition rate: 30 Hz
   - Energy per pulse: 55 mJ
   - Water spray: 20 cc per minute
   - Delivery system: Flexible fiber
   - Emission mode: Free-running pulsed
   - Tip size: 600-µm 80-degree quartz tip
   - Pulse duration: 300 microseconds
   - Average power: 1.65 Watts
   - Total time per treatment: 15 seconds repeated three times

2. **PowerLase AT Setting**
   - Wavelength: 2940 nm
   - Repetition rate: 80 Hz
   - Energy per pulse: 20 mJ
   - Water spray set to 6
   - Air set to 3
   - Delivery system: Articulated arm
   - Emission mode: Free-running pulsed
   - Tip size: 800-µm sapphire tip in 90-degree handpiece
   - Pulse duration: SP or 300 microseconds
   - Average power: 1.60 Watts
   - Total time per treatment: 15 seconds repeated three times

In all but one of the following cases, HOYA ConBio’s DELight or VersaWave Er:YAG laser was used to perform the pulpotomy. Case #5 used the PowerLase AT Er:YAG laser.

**C. Treatment Delivery Sequence**
For all children appropriate laser safety glasses were placed on the child, either goggles for infants and young children, or regular safety glasses. Appropriate glasses were worn by all auxiliary personal and operating dentists. All procedures were completed through a dental operating microscope fitted with the appropriate 2970-nm laser filters. All required office safety protocols were followed.

Where patient cooperation was adequate, either rubber dam, Isolite™ tooth isolation (Isolite Systems, Santa Barbara, Calif.), or

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<th>Case #1: Traumatic injury to tooth #E, nonvital pulpotomy, patient age 3 years old at initial treatment</th>
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<td>Figure 5: Pretreatment, January 9, 2003</td>
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simple tooth isolation using cotton rolls were used for the procedure. Depending on the child’s age, level of cooperation, and condition of the tooth, local anesthesia was usually required for vital teeth. There are instances when using the laser that children did allow for the use of the laser without the need for local anesthesia.

High-volume evacuation was used in all instances.

Analgesia (articaine 1:100,000 epinephrine) was used when appropriate.

D. Treatment Procedure

Access to the pulp chamber was achieved either through the use of high-speed dental handpiece, slow-speed dental handpiece, or the Er:YAG laser set to enamel ablation settings (DELight and Versawave at 15 Hz / 120-400 mJ, or the PowerLase AT at 15-20 Hz / 125-300 mJ). Local anesthesia was used where indicated. Once the chamber was opened, the laser tip was placed into the chamber using the above settings for approximately 15 seconds. In most instances, this was repeated three times. If hemostasis was not achieved, the process was repeated one more time or until adequate hemostasis was achieved.

The chamber was then filled using zinc oxide eugenol cement and the appropriate restoration was placed.

E. Postoperative Instructions

Parents were instructed to call the office if any problems such as swelling or pain occurred.

FOLLOW-UP CARE

A. Assessment of Treatment Outcome

Children were seen at normal six-month preventive maintenance visits and appropriate clinical and radiographic evaluations were completed as needed.

B. Complications

In certain teeth radiographic evaluation revealed internal root resorption, however, the teeth remained clinically stable. The failure rate associated with the use of the laser appears to be similar to teeth treated using formocresol.
Conclusion
The clinical cases described include assessment up to 5 years postoperatively, and demonstrate the effectiveness of the Er:YAG laser for performing pulpotomies on primary teeth. Successful outcomes are evident both clinically and radiographically.

**AUTHOR BIOGRAPHY**
Dr. Lawrence Kotlow maintains a private practice in pediatric dentistry and has been providing lectures and discussion concerning the use of Er:YAG lasers in pediatric dentistry for more than 7 years. He is a graduate of SUNY Buffalo Dental School and is a Board Certified specialist in pediatric dentistry. He received his pediatric training at the Children’s Hospital in Cincinnati, Ohio. He has Advanced Proficiency in the Er:YAG laser and Standard Proficiency in the diode and Nd:YAG lasers from the Academy of Laser Dentistry. He contributed the chapter on erbium laser and pediatric dentistry for the October 2004 Dental Clinics of North America and has published more than 25 articles concerning pediatric dentistry and laser dentistry as well as lectured internationally. He has served on the board of directors for the Academy of Laser Dentistry.

Dr. Kotlow may be contacted by e-mail at lkotlow@aol.com.

**Disclosure:** Dr. Kotlow has presented educational seminars on pediatric dentistry and lasers for Hoya ConBio.
He consults and provides professional guidance in development of products for many laser- and technology-associated manufacturers such as Isolite, Schick, and Lares Research and various laser safety glass manufacturers. For his professional speaking engagements or product input he receives an honorarium or new products to evaluate.

REFERENCES
As featured in the previous two issues, the three most recent recipients of the ALD Advanced Proficiency are Charles Hoopingarner, DDS; Steven Parker, BDS, LDS, RCS, MFGDP; and Mary Lynn Smith, RDH.

Dr. Hoopingarner treats a patient who desired a more aesthetic smile without restorations. To accomplish that objective, he performed a maxillary anterior frenectomy together with soft and hard tissue crown lengthening utilizing a closed flap technique for the removal and recontour of the osseous crest tissues. Using an Er:YAG laser, he contours the periodontal tissues to ensure an adequate biologic width.

Dr. Parker utilizes an 810-nm diode laser to remove hyperplastic gingival tissues in preparation for a new fixed bridge. The diode wavelength is an excellent choice for this procedure since it has very little interaction with tooth structure while offering precision of tissue removal and excellent hemostasis.

Ms. Smith treats a patient with chronic generalized periodontitis, using the Nd:YAG laser after scaling with conventional instrumentation was completed. The photographs feature two specific tooth areas during initial therapy and follow-up evaluation appointments. This laser wavelength (1064 nm) is indicated for the removal of the diseased epithelial lining of the periodontal pocket, and thus can be a good addition to the protocol for the initial treatment of the disease. She also uses this instrument for the treatment of aphthous ulcers, another indication for use.

These three cases show how various treatments can employ different laser wavelengths with successful results.

**Soft Tissue Gingivoplasty, Osseous Recontouring / Crown Lengthening, and Frenectomy Using an Er:YAG Laser**
Charles R. Hoopingarner, DDS
Houston, Texas

**Use of an 810-nm Diode Laser in a Gingivoplasty Procedure Associated with Restorative Dental Care**
Steven Parker, BDS, LDS RCS, MFGDP
Harrogate, North Yorks, Great Britain

**Nd:YAG Laser-Assisted Treatment of Moderate Chronic Periodontitis and Nd:YAG Laser Treatment of Two Aphthous Ulcerative Lesions**
Mary Lynn Smith, RDH
McPherson, Kansas
Soft Tissue Gingivoplasty, Osseous Recontouring / Crown Lengthening, and Frenectomy Using an Er:YAG Laser

Charles R. Hoopingarner, DDS, Houston, Texas

J Laser Dent 2008;16(2):81-86

SYNOPSIS
This article describes soft and hard tissue crown lengthening and a maxillary frenectomy that were all performed with an Er:YAG laser.

PRETREATMENT
A. Outline of Case
1. Full Clinical Description
A 24-year-old white female was referred for evaluation and treatment of excessive maxillary gingival display with no medical limitations to treatment. She had vital signs within normal limits (blood pressure 110/78, pulse 70). She was allergic to codeine and was taking Lexapro® 10 mg once daily, Topamax® 10 mg at bedtime, and Estrostep®. The patient had completed an endodontic obturation and crown on tooth #14. Teeth #3, 29, and 30 had occlusal resin restorations. She had a Class I occlusion which had been orthodontically treated and was missing four first bicuspid. Probing depths were 2-3 mm in all areas, as shown in the periodontal chart, Figure 1.

Her chief complaint was an unaesthetic gingival presentation in the maxillary anterior region. She stated she “had a gummy smile and her lip comes up too far.” Figures 2 and 3 depict the full smile and a close-up of the anterior region of her smile.

2. Radiographic Examination
A panoramic radiograph and decay-detecting radiographs were evaluated, revealing a normal bone contour, and no caries or osseous defects (Figure 4). There was no interproximal decay present.

3. Soft Tissue Status
Oral cancer screening was negative. There was a high frenum attachment in the maxillary midline. There was also slight blunting of the papillae, and generalized marginal gingivitis in the posterior segments. Oral hygiene was fair at best. The anterior segment was characterized by excessive gingival display. The upper lip was highly active, traveling 15 mm from rest to full smile.

Figure 1: Preoperative periodontal chart
Figure 2: Preoperative full smile
Figure 3: Preoperative full anterior view
Figure 4: Preoperative panoramic radiograph
4. Hard tissue Status
There was no caries detected and no indication for vitality testing.

5. Other Tests
There was modest physiologic tooth wear and faceting present. No mobility or fremitus was observed. There was no muscle or joint tenderness, joint sounds, or limitations in range of motion present. Smile evaluation revealed excessive gingival display and a width-to-length ratio of 92%. The gingival extension on the maxillary centrals was at the same level as that of the canines.

B. Diagnosis and Treatment Plan
1. Provisional Diagnosis
Mild generalized chronic gingivitis, excessive gingival display, incisally positioned maxillary midline frenum (relative to the desired tissue level). It was believed this would allow tension to be expressed in the area of the gingival margin after completing the gingival and osseous recontouring. Final individual biologic width was determined at the time of surgery.

2. Final Diagnosis
Mild generalized chronic gingivitis, excessive gingival display, incisally positioned maxillary midline frenum placing tension on the gingival apparatus, lack of sustainable biologic width or attachment subsequent to soft tissue recontour.

3. Treatment Plan Outline
Because a soft tissue revision alone would have left an inadequate periodontal attachment apparatus, gingival and osseous recontouring with the Er:YAG laser would allow for ideal aesthetic width-to-length ratio for the incisors and preservation of the biologic width. Revision of maxillary frenum attachment with the Er:YAG laser is indicated to prevent excessive tension at the gingival margin. Oral hygiene review and motivation, along with scheduled dental prophylaxis were part of the treatment plan.

4. Indications for Treatment
Indications for gingival recontouring are largely aesthetic. However it was felt that over the life of the dentition that the hyperplastic tissue would be a contributing factor to diminished periodontal health in the anterior segment. Osseous recontouring was necessary to maintain the patient’s individual biologic width. Frenum revision was indicated to prevent apical migration of the gingival margin. For this procedure, the Er:YAG laser’s 2940-nm wavelength allowed the advantage of decreased healing time with minimal patient discomfort. The Er:YAG also has the advantage of being able to be utilized for both soft tissue ablation and osseous recontouring for biologic width maintenance and scoring the periosteum. With a complete understanding of biologic width/gingival attachment mechanics, final gingival position is very predictable using the Er:YAG laser. Scoring of the periosteum is easily accomplished during the frenum revision.

5. Contraindications
There were no contraindications for treatment. However there are many precautions which must be observed.

6. Precautions for Wavelength
Standard safety precautions for laser operation should be strictly adhered to. As this wavelength readily interacts with both hard and soft tissue, care must be taken to avoid excessive tissue removal and in particular premature osseous ablation when using the laser without cooling water spray. Care must also be taken to avoid interaction with the tooth itself by properly angling the tip or leaving a thin tissue layer over the tooth prior to removal with a hand instrument. Adequate water spray must be used during the osseous phase. Care must be taken to avoid tissue emphysema by turning the cooling air off or down to an appropriate level and using digital pressure to compress the tissue at the mucogingival border. Care in treatment planning must be exercised to leave an adequate dimensional band of gingival tissue to prevent mucogingival dehiscence, to leave the cemento-enamel junction subgingival, and to maintain a healthy, adequate biologic width.

7. Treatment Alternatives
Conventional periodontal surgical procedures with subsequent increase in healing time and maxillary impaction as a LaForte osteotomy are treatment alternatives. No treatment was another alternative.

8. Informed Consent
After a full explanation and questions answering, a written informed consent was obtained for both surgical procedures.

TREATMENT
A. Treatment Objectives
Strategy
The gingival tissue will be contoured with an Er:YAG laser to allow for ideal width-to-length ratio (77.5%) of the central incisors, establish proper soft tissue heights from canine to canine, establish proper tissue scallop/zenith on each individual tooth from #6 to #11 while establishing an attachment distance consistent with the patient’s individual biologic width. This will require osseous recontouring to support the attachment at the desired levels. The frenum attachment will be shortened, eliminating tension on the gingival margin, and the periosteum will be scored to prevent reattachment. The Er:YAG laser has the advantage of being able to be utilized for soft tissue ablation, osseous recontouring for biologic width maintenance, and scoring of the periosteum. The
central incisors were 8.5 mm wide. This condition would support a length of 11.3 mm and would mean removal of 2.1 mm of soft tissue. This procedure would not expose the cementoenamel junction (CEJ) but would leave only 1.9 mm for attachment and sulcus. As this violates the concept of individual biologic width, the osseous crest needs to be recontoured to a level 1.1 mm apical to the presenting position to satisfy the patient's individual biologic width needs.

B. Laser Operating Parameters
Laser: Er:YAG (DELight, HOYA ConBio, Fremont, Calif.):
- Delivery system: Fiber-optic system with varying quartz tips: 600-micron for initial tissue ablation, 400-micron for osseous recontouring, a 400-micron straight soft tissue tip, and 1200 x 300-micron chisel tip for tissue and osseous beveling and smoothing
- Wavelength: 2940 nm
- Mode: Free-running pulsed
- Pulse width: 300 microseconds
- Power: 1.5 Watts (30 Hz and 50 mJ)
- Beam Diameter: Varied, 400 to 600 microns used as focused and defocused patterns
- Repetition rate: 30 Hz
- Continuous air (reduced pressure) and water spray for osseous procedures and air only for soft tissue

Laser settings:
- Soft tissue ablation: 30 Hz and 50 mJ, air cooling and no water
- Osseous recontouring and scoring of periosteum: 30 Hz and 50 mJ with air and water spray and decreased air volume

C. Treatment Delivery Sequence
Pretreatment: The operatory was secured and the laser warning sign was posted. The laser unit was properly placed and connected to the air supply. Safety glasses with 4+ optical density for the 2940-nm laser wavelength that met ANSI standards Z136.1 and Z136.3 were used. All shiny reflective objects were removed from the operative area. The operatory was set up and supplied according to the standard for a surgical procedure. Charting and radiographs were visible to the operator. The procedure was reviewed in the morning report meeting. Prior to administration of anesthesia, the treatment was reviewed with the patient and informed consent was confirmed. The patient was properly draped and 3.8 cc Septocaine™ 4% 1:200,000 epinephrine was distributed by infiltration in the maxillary anterior segment. Eye protection was placed on the patient as well as the operator and assistant. The laser was test-fired in a safe direction. A width-to-length measurement was confirmed and the ideal length was established, as shown in Figures 5 and 6.

Since there was more than 2 mm of attached gingival tissue apical to the intended finish line, the limiting factor became the position of the CEJ. This was assessed by probing and marked with stab punctures. Crestal bone was identified by probing and marked, as shown in Figure 7. The refined intended gingival finish line was appreciated and indicated with tissue-marking ink.

The laser was set with a straight soft tissue quartz tip at an energy setting of 50 mJ and repetition rate of 30 Hz. The gingival tissues were ablated to the desired level without the use of water spray (Figure 8). This was done using longitudinally directed noncontact strokes until the desired amount of tissue was ablated; care was taken not to score the tooth itself and not to approach

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Figure 5: Preoperative width
Figure 6: Preoperative target length
Figure 7: Preoperative crestal bone level
Figure 8: Initial laser ablation of tissue
Figure 9: Tissue beveling under way
the osseous crest too closely. As shown in Figure 9, the tissue was beveled with a chisel tip while establishing the proper alignment and zenith placement at the same time. All teeth in the segment were treated in this manner. The frenum was revised with longitudinal noncontact strokes that were directed around larger vessels until all fibrous bands had been ablated, as shown in Figure 10. This was accomplished with a straight soft tissue tip at 30 Hz and 50 mJ of energy with no water spray and decreased cooling air. The effectiveness of the revision was checked by confirming there was no tension on the gingival tissue when elevating the upper lip. With the addition of water spray, the periosteum was scored to the level of the bone using horizontal light contact strokes and a chisel tip (Figure 11). To avoid tissue emphysema, the cooling air was decreased appropriately and digital pressure was applied around the operated area. The immediate postoperative view of the soft tissue surgery is shown in Figure 12.

The biologic width was reassessed by projecting the patient’s individual biologic width onto the tissue (Figure 13). The osseous tissue was contoured using a 400-micron tip at 30 Hz and 50 mJ with adequate water spray and decreased air flow. The protective sleeve on the tip was marked at 3 mm and used as a depth guide during the procedure (Figure 14). Care was taken to avoid tissue emphysema by compressing the tissue with digital manipulation. The bone was then beveled with the chisel tip in a noncontact defocused mode with water spray and decreased cooling air. Recontouring was extended interproximally through to the palatal surface; moreover, the distance between the contact area and the osseous papilla crest did not exceed 4.5 mm. The periodontal probe was then used to confirm the new biologic width (Figure 15) and an immediate postoperative view of the completed laser surgery is shown in Figure 16.

The biologic width measurement was confirmed at 3 mm from the osseous crest to the intended final free gingival margin.

D. Postoperative Instructions
The patient was told to avoid foods warmer than room temperature for 48 hours and then begin hot saline mouth rinses. The area was to be cleaned with hydrogen peroxide on cotton tip applicators for the first 48 hours. After the first postoperative visit, the patient was cleared for normal hygiene procedures which included nonsulcular brushing with an ultrasoft brush dipped in hot water and gentle flossing. Emergency care contact numbers were given. Over-the-counter ibuprofen was suggested if necessary.
E. Complications
No complications arose during the procedure or during the recovery stage.

F. Prognosis
Because of the exact planning, there is an excellent prognosis for the tissue to remain at the expected level. The scoring of the peristomeum raises the prognosis for frenum stability to excellent.

G. Treatment Records
The treatment record reflects the treatment described including estimated exposure times totaling 26 minutes.

FOLLOW-UP CARE

A. Assessment of Treatment Outcome
The patient was assessed at 4 days, 2 weeks, 6 weeks, and 10 weeks and returned to a semi-annual recare program in our office. At 48 hours there was some edema around the frenectomy site. Lip manipulation produced discomfort but there were no static tissue pain reports. The tissues, while erythematous, showed no sign of infection and healing appeared to be progressing nicely. At 2 weeks there were no complications and the tissues were healing uneventfully (Figure 17). Oral hygiene, however, was inadequate. General oral hygiene protocol was reinforced and a polish and flossing was performed.

At one month the tissue still appeared inflamed (Figure 18). There were significant plaque and accretions present. Hygiene was again stressed and a mild cleaning of the area was done.

At two months the tissues were within normal limits and appeared to have stabilized.

Figure 19 shows a close-up of the frenum and some of the anterior tissue, and Figure 20 is the smile view.

The patient was seen at 6 months and again at 1 year. As hygiene had improved, the tissues looked healthy, the tissue length was being maintained, and the frenum attachment was taut and showed no signs of migration. Figure 21 shows a one-year postoperative close-up view of the tissue, and Figure 22 shows a one-year postoperative view of the smile.

B. Complications
No complications were appreciated during the procedure. The inadequate oral hygiene compliance led to a prolonged inflammation and final healing was delayed. The marginal gingival tissue at the zenith of teeth #6 and 12 at first appeared to be below the CEJ. By accurately placing the bone level relative to the CEJ and because the patient’s individual biologic width had been properly assessed, the final tissue height was coronal to the CEJ.

C. Long-Term Results
The patient has maintained a healthy aesthetic gingival display. While there continues to be plaque-induced inflammation, the periodontal attachment mechanism is healthy.

D. Long-Term Prognosis
In order for this state of health to be maintained, the patient’s oral hygiene must continue to improve and she must maintain periodic recare evaluations. If these improvements are maintained there is a very good long-term prognosis.
AUTHOR BIOGRAPHY
Dr. Charles Hoopingarner attended the University of Texas Health Science Center at Houston (UTHSCH) Dental Branch, graduating with a DDS in 1973. He has maintained a private practice in Houston, Texas since 1973. He was an adjunct associate professor in anatomical sciences at UTHSCH Dental Branch for 11 years. Currently he is adjunct clinical faculty in the Restorative Dentistry Department at UTHSCH and has been a clinical instructor at the Las Vegas Institute for Advanced Dental Studies since 1997, teaching Advanced Anterior Aesthetics and Comprehensive Aesthetic Reconstruction and Laser Dentistry. Dr. Hoopingarner is a member of the Academy of Laser Dentistry (ALD) and has used dental lasers of various wavelengths as integral parts of his patient care delivery system for the last 10 years. He holds Advanced and Standard Proficiency certification from the ALD and has lectured internationally on the safety and use of laser technology in the dental practice. He may be contacted by e-mail at choop@swbell.net.

Disclosure: Dr. Hoopingarner has no direct financial or ownership positions with commercial companies relative to this case presentation. He has received honoraria and expenses from HOYA ConBio to present material on laser dentistry.
Use of an 810-nm Diode Laser in a Gingivoplasty Procedure Associated with Restorative Dental Care

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J Laser Dent 2008;16(2):87-92

SYNOPSIS
This article describes removal of hyperplastic gingival tissues prior to placing a new fixed bridge. An 810-nm diode laser was used.

PRETREATMENT
A. Outline of Case
1. Full Clinical Description
A 44-year-old female presented for her routine examination. She expressed a wish to review and update the presentation of the restorations in the upper right dental quadrant. The existing three-unit fixed bridgework had been provided many years previously and had functioned well. However, due to the passage of time and possible changes in the gingival condition, there had been some recession and loss of contour in the soft tissue margins at the bridge abutment teeth (Figure 1). During the previous 25 years, the patient had attended regularly for inspection and routine treatment, including prophylaxis and occasional restorative procedures.

MEDICAL HISTORY
The patient was in general good health. She had not received any medical treatment or medication for significant conditions.

DENTAL HISTORY
The patient had been a patient of the Practice since 1984. She was originally a nervous patient who was reluctant to undergo treatment and had consequently allowed significant deterioration in both hard and soft tissue status. She had previously received some simple orthodontic treatment. Since that early time, confidence in dental treatment had improved and reparative procedures had been carried out as required.

2. Occlusion
During examination of the dental arches in occlusion and the underlying skeletal landmarks, it was noted that the patient had a Class I dental relationship; the Frankfort Mandibular Plane (FMP) angle appeared slightly lower than normal and the adult skeletal relationship was a moderate Class III. The path of closure was normal and overbite and overjet values were considered both positive and within normal limits.

3. TMJ
Examination of both temporomandibular joints, through palpation and radiograph, revealed normal structure and movements. Opening / closing and excursion movements of the mandible revealed no abnormality.

4. Radiographic Examination
Panoral and periapical radiographs were taken to establish both dental and alveolar bone status prior to treatment (Figure 2). These views were repeated at stages during the treatment, as required. With the exception of dental findings listed below, there was no sign of hard tissue pathology in either jaw or TMJ regions.

5. Soft Tissue Examination
General oral soft tissue:
Examination of all soft tissue structures revealed no abnormality. All tissues appeared normal in appearance and dorsal and ventral tongue surfaces, together with tongue movements, were within normal expectations.

Gingival soft tissues: All natural tooth sites were examined with a periodontal probe and findings recorded. Of specific relevance to the treatment provided, there was some false pocketing at tooth sites #3 and 6, with recorded depths of 3 mm on mesial, distal, and facial aspects. In addition, the contour of the gingival tissue at these tooth sites was rather flat and detracted from what might be an ideal (Figures 3-4). Generally, the attached gingiva appeared of normal thickness, with little evidence of inflammation. The
general level of oral hygiene was considered good, with the patient having attended for regular hygiene appointments.

6. Hard Tissue Status
At the time of initial active-treatment assessment, the following teeth were charted as missing:
- Upper jaw: #1, 4, 6, 12, 16.
- Lower jaw: #17, 32.

All four wisdom teeth had been removed following pericoronitis and teeth #6 and 12 through orthodontic treatment. Tooth #4 had been lost due to fracture and infection, leaving a one-unit edentulous space.

There was a fixed / fixed porcelain-fused-to-metal (PFM) bridge to replace tooth #4, using teeth #3 and 6 as abutments. Teeth #28, 29 and 30 had been restored with PFM full veneer crowns. The remaining restored teeth had received a combination of amalgam and composite restorations.

Tooth vitality test: All teeth tested vital to ethyl chloride.

Mobility: There was no mobility recorded at any natural tooth site.

Percussion: Percussion testing of all tooth sites revealed no hyperesthesia.

7. Other Tests
Pertinent to the proposed treatment, no other tests were considered necessary.

B. Diagnosis and Treatment Plan
1. Provisional Diagnosis
Treatment for this patient to replace the existing bridge in accordance with her preferences would involve removal of the existing bridge. With regard to laser-assisted therapy, it was considered appropriate that some soft tissue manipulation would be required around the abutment teeth.

3. Treatment Plan Outline
a. General: The existing bridge in the upper right posterior region would be removed and associated correction of crown margins carried out. A new PFM bridge would be fabricated and fitted.

b. Specific: In order to achieve some slight crown-lengthening and facilitate optimal soft tissue profiles, it was decided to use an 810-nm diode laser to remove hyperplastic gingival tissue associated with teeth #3 and 6.

4. Indication and Contraindications
INDICATIONS
Treatment: In the areas of soft tissue management within this treatment plan there is an ideal in achieving hemostasis, consistent with the need to provide access for hard tissue treatment and early abutment preparation. In addition, an optimal definition of a stable gingival margin at teeth #3 and 6 would allow early placement of a permanent coronal restoration. A further indication would include the delivery of soft tissue surgery that provides minimal postoperative discomfort and complication for the patient. The use of a suitable laser wavelength would seek to meet these requirements.

Laser: It is recognized that all laser-tissue interaction in surgical procedures is predominantly photothermal in nature. The conversion of incident laser light energy into heat will lead to primary and, through local conduction, secondary heat effects that would allow soft tissue surgery to be carried out through tissue ablation with a supportive hemostasis. As such, the use of laser energy to effect soft tissue surgery is justified.

Wavelength: The predominant chromophores of the hyperplastic keratinized gingival tissue in this case are melanin (tissue pigment), hemoglobin, and intracellular water. In addition, the prime needs
of treatment would be to achieve tissue ablation with hemostasis, indicating the optimum need for using a near-infrared wavelength, such as the 810-nm diode laser.

**CONTRAINDICATIONS**

_Treatment:_ The only absolute contraindication to treatment in this case would be to accept the original clinical presentation, which would be at variance with the patient’s wishes. Consequently, in view of the need to provide optimal retention for the crowns and maximize aesthetics, soft tissue manipulation is mandatory and there can be few if any contraindications for treatment. In addition, further considerations apply:

- **a. Biologic width** (i.e., the sum of the gingival crest, connective tissue, epithelial attachment, and sulcular depth relative to the osseous crest) must be determined and considered when recontouring the periodontium with a subsequent placement of a restoration.

- **b. Aesthetic considerations,** including lip line height and other factors, must be taken into account in placement of the final gingival contour: Is the patient accepting of the contour, should it match the adjacent teeth, does the lip hide the contour anyway, and so on.

_Laser:_ Any surgery using laser energy carries some risk of tissue damage and must be borne in mind.

_Wavelength:_ The choice of a longer wavelength would offer a more superficial level of tissue ablation.

5. **Precautions**

The benefit of hemostasis offered by near-infrared laser wavelengths is accepted. In comparison to the Nd:YAG laser, the depth of penetration of the 810-nm diode wavelength in oral soft tissue is less, which would reduce the risk of collateral thermal damage. Nonetheless, the use of minimum power parameters, time intervals to allow thermal relaxation, and control of carbonization of the tissue and optic fiber, would all reduce the risk of primary and secondary thermal damage.

_Gingivectomy:_ Whenever periodontal contouring and tissue removal is undertaken in association with natural teeth, attention must be given to the preservation of the biological width. In addition, preservation of a stable result is dependent on good patient home care. Further, it is essential that the internal and external contours of the periodontal attachment apparatus are mapped out, so that possible laser damage to the periosteum, bone, periodontal attachment, and root cementum can be avoided. Final tissue cleavage using a sharp curette and the placement of suitable material into the pocket can help to protect delicate nontarget tissue.

6. **Treatment Alternatives**

Alternative methods for soft tissue incision would include a scalpel or electrosurgery.

7. **Informed Consent**

The treatment plan was fully explained to the patient and all associated risks were outlined. A written consent form was signed by the patient in the presence of a witness. The consent form was retained in the treatment notes.

**TREATMENT**

A. **Treatment Objectives**

The objective of this treatment would be to effectively remove or resect soft tissue at each of the treatment sites with the 810-nm diode laser with minimal peri- and postoperative complications.

B. **Laser Operating Parameters**

_Laser:_

- A diode laser (DioLase ST, American Dental Technologies, Corpus Christi, Texas, USA) was used. The operating features are as follows:
  - **Wavelength:** 810 nm
  - **Co-axial aiming beam:** Diode Class I laser 630-680nm, 3 mW
  - **Emission mode:** Continuous Wave (CW) with supplementary Gated CW, single pulse or repetitive single pulse
  - **Maximum power output:** 12.0 Watts
  - **Delivery system:** Quartz fiber-optic (320-µm diameter) with conduit handpiece and disposable cannula tip
  - **Beam diameter:** 320 µm.

_Laser settings:_

- Gingivoplasty: 1.4 Watts CW / contact mode. Time taken per site: 1-2 minutes.

**C. Treatment Delivery Sequence**

_Preliminary to patient treatment_

- Secure operating room, define controlled area, and place proper laser warning signs
- Set up laser and test proper laser operation
- Test-fire laser, employing all safety measures, using minimum power settings and directing beam onto articulating paper.
- The objective is to ensure correct laser operation, patency of delivery system, and emission of cutting and aiming beams. In addition, the fiber tip can be inspected to ensure a proper cleave has been carried out and the spot size is uniform
- Dispense supplies, and arrange equipment and sterile instruments
- Review patient information (charting, X-rays, etc.)
- Patients seated: Review treatment plan and informed consent
- Safety: Place eye protection, patient first followed by operating personnel.

_Treatment sequence_

Individual treatment sites were isolated and infiltration local anaesthetic (2% lignocaine 1:80,000 adrenaline) was administered.

_Gingivoplasty teeth #3 and 6:_

Laser power setting: 1.4 Watts CW.
The soft tissue pocket at each tooth site was explored with a periodontal probe to establish internal architecture. The laser fiber was lightly initiated using articulating paper and, with the fiber held perpendicular to the surface, a series of points were developed on the labial gingiva to outline the incision line. With a light contact of the fiber with the tissue, the incision line was developed, with minimum depth. Any char on the tissue or fiber tip was removed with damp gauze. Successive sweeps of the fiber allowed precise tissue cleavage to be carried out (Figures 5-8), to a point where final excess tissue removal could be achieved with a sharp curette. In this way, direct contact with the underlying tooth was avoided. Final adjustments were carried out to refine the emergence profile of the buccal gingival tissues.

D. Postoperative Instructions
The surgical sites were shown to the patient and their appearance was explained. A chlorhexidine mouthwash was prescribed and the patient instructed to carefully apply this with cotton wool, avoiding disturbance of the coagulum; this was to be carried out three times daily during the five-day postoperative period. The patient was advised that the appearance of the treatment sites would change, with detachment of the coagulum at fixed gingival sites at 3-5 days post-operation. The patient would be reviewed at one week and light toothbrushing was to be commenced at that time. Postoperative analgesia was prescribed for use as required. There were considered no limitations on eating or drinking. The patient was instructed to call should any problem occur and was called by phone after 24 hours.

E. Complications
Complications that can be expected following laser soft tissue surgery can include pain, tissue swelling and deformation, bleeding, and infection. In this case, no such complications were encountered.

F. Prognosis
Laser-assisted soft tissue procedures, employing correct power parameters and technique generally have a very good prognosis. It was felt that in this case a similar outcome could be expected.

G. Treatment Records
All procedural details, both generally and specifically with reference to the laser use, were entered in
the patient’s treatment notes, along with the consent details, radiographs, and chartings. As such, the treatment records would reflect the treatment outlined above.

**FOLLOW-UP CARE**  
**A. Assessment of Treatment Outcome**  
The patient was reviewed at one week (Figure 9), with successive treatment sessions thereafter at weekly intervals (Figures 10-13), to complete the bridge preparation. The soft tissue sites were therefore regularly reviewed initially and at 3 months (Figures 14-17), 6 months (Figures 18-21), and 1 year. The gingivoplasty incisions resolved rapidly during the initial two-week period and the tissue assumed a healthy appearance. The healing was as expected and normal oral function was maintained. The teeth were checked for stability, vitality was tested, and a positive response recorded.

**B. Complications**  
No long-term complications were observed. The postsurgical site tissue remained stable and normal in appearance. With the placement of provisional and final coronal restorations, it was possible to support the tissue and allow correct toothbrushing.

**C. Long-Term Results**  
The long-term results are in keeping with the objectives of the original treatment plan. The restorative phases of treatment were satisfactorily completed and the patient was very satisfied with the outcome.

**D. Long-Term Prognosis**  
The long-term prognosis of the treatment provided should be considered as good. The patient continues to maintain good oral hygiene and attends for assessment as required. She is pleased with the aesthetic and functional result obtained.

**AUTHOR BIOGRAPHY**  
Dr. Steven Parker studied dentistry at University College Hospital Medical School, University of London, UK and graduated in 1974. He maintains a Private Practice in Harrogate, UK. He holds Fellowship and Diplomate status with the International Congress of Oral Implantologists.

Dr. Parker has been involved in the use of lasers in dentistry since 1990. Prior to joining the Academy of Laser Dentistry in 1993, he was President of the British Dental Laser Association. He joined the Board of Directors of the Academy in 1996 and became chair of the International Relations Committee.
From 1999 through 2004, he was chair of the Committee for Proficiency Recognition and co-editor of *Wavelengths*, the former journal of the Academy of Laser Dentistry. He was awarded the Leon Goldman award for Excellence in Clinical Laser Dentistry by the Academy in 1998. In addition, Dr. Parker holds Advanced Proficiency status in multiple laser wavelengths and completed the Academy Educator Course at the University of California San Francisco.

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**Disclosure:** Dr. Parker has no current commercial affiliation.
Nd:YAG Laser-Assisted Treatment of Moderate Chronic Periodontitis and Nd:YAG Laser Treatment of Two Aphthous Ulcerative Lesions

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**SYNOPSIS**

This article describes treatment of chronic generalized periodontitis and aphthous ulcers using an Nd:YAG laser adjunctively.

**PRETREATMENT**

**A. Diagnostic Tests**

1. **Full Clinical Description**

A 78-year-old Caucasian male presented for dental prophylaxis and periodic examination (Figure 1). He had no chief complaint and no pain. His last dental visit was for emergency restorative treatment two months prior.

During his hygiene appointment, his health history was reviewed and tissues were visually screened for signs of oral cancer. Comprehensive restorative, periodontal, and radiographic examinations were completed. Micro-ultrasonic scaling, biofilm removal, and coronal polishing were performed as well. He elected to purchase an electric toothbrush at this appointment. The patient was educated concerning his oral health and probable progression of untreated disease.

He was in reasonably good health with an existing heart murmur but needed no premedication. He reported high blood pressure, managed with 25 mg of Toprol-XL®, seasonal allergies, past occurrences of a gastric ulcer, blood transfusion, and shingles. There were no contraindications to dental treatment.

The dental history revealed an Angle’s Class II occlusion with a severe overbite. He had limited maximum opening and experiences fatigue but no pain in the temporomandibular joints (TMJ). Teeth #1, 16, 17, 20, and 32 were missing, #19 had drifted mesially, and the lower anterior teeth were crowded. Significant fractures within tooth structure were noted on teeth #18 and 19. Tooth #2 had been treated endodontically and had been restored with a precious metal crown. Tooth #3 also had a precious metal crown, #5 a porcelain-fused-to-metal (PFM) crown, and #14, 30, and 31 nonprecious metal crowns. Tooth #4 had a composite filling and #13, 15, 18, 19, 28, and 29 had amalgam fillings. Loss of tooth structure was noted on buccal surfaces of teeth #4, 6, 11, 12, 21, 22, 28, and 29 and lingual surfaces of #6 through 11 and 22 through 27; posterior occlusal surfaces of #12, 19, 21, 28, and 29; and incisal edges of teeth #8, 9, 22, 23, 24, 25, 26, and 27. Exostoses were present on the facial aspect of teeth #23 through 26 but no lingual tori were present. Periodontal findings included: tissues were inflamed and irritated with the presence of moderate-to-heavy plaque and calculus. Periodontal pocketing ranged from 2-7 mm. Purulent exudate was noted on tooth #25MF. Gingival recession of 1-3 mm was present on almost half the teeth. There was no mobility.

2. **Radiographic Examination**

A panoramic radiograph (Figure 2) and 4 vertical bitewings were taken at the initial hygiene visit. Three months later the patient presented for periodontal therapy and 14 additional periapical radiographs were taken to clarify areas of bone loss (Figure 3). Radiographs revealed moderate-to-severe horizontal bone loss in the posterior and between teeth #24 and 25. Areas of particular periodontal concern were teeth #2, 14, 15, 24, and 25. No carious lesions were detected on pretreatment radiographs.

3. **Soft Tissue Status**

Tissues appeared inflamed and irritated with the presence of moderate-to-heavy plaque and calculus. A complete six-point periodontal probing was performed with 7 mm as the greatest pocket depth.
Out of 27 teeth present, 20 teeth exhibited signs of periodontal disease. Generalized bleeding was evident and moderate subgingival calculus present. Recessions of 1-3 mm were noted on teeth #7, 8, 9, 10, 24, 25, and 26 linguually, and #4, 6, 11, 12, 13, 15, 18, 19, 21, 22, 28, and 31 facially. No mobility was present. Class I furcation involvements were noted on teeth #2ML, 14DL, 15ML, 18B, 19B, and 31B. The initial periodontal probing chart is shown in Figure 4. Oral cancer screening was within normal limits.

4. Hard Tissue Status
- Occlusion classification was Angle’s Class II, bilateral with severe overbite.
- Missing teeth were #1, 16, 17, 20, and 32; #19 had drifted mesially.
- Lower anterior teeth were crowded.
- Teeth #18 and 19 had significant fractures.
- All teeth were vital except #2, which had been treated endodontically, and restored with a precious metal crown.
- Other restorations included PFM crown in tooth #5; nonprecious crowns in #14, 30, and 31; composite fillings in #4; amalgam fillings in #13, 15, 18, 19, 28, and 29.
- Loss of cervical tooth structure was noted on the buccal aspect of teeth #4, 6, 11, 12, 21, 22, 28, and 29, and on the lingual aspect of #6, 7, 8, 9, 10, 11, 22, 23, 24, 25, 26, and 27.
- Wear facets were noted on posterior occlusal surfaces of teeth #12, 19, 21, 28, and 29.
- Attrition was noted on the incisal edges of teeth #8, 9, 22, 23, 24, 25, 26, and 27 (Figure 5).
- Exostoses were noted facially inferior to teeth #23-26.

5. Other Tests
TMJ: The patient had a limited opening of 27 mm with a Shimbashi (vertical measurement of occlusion) of 9 mm. There was no pain associated with function, but fatigue was reported.

B. Diagnosis and Treatment Plan
1. Diagnosis
Provisional diagnosis included chronic periodontitis.

The doctor’s final diagnosis stated: Severe generalized chronic periodontitis with poor prognosis of teeth #24 and 25; mildly symptomatic temporomandibular joint dysfunction (TMD); generalized loss of tooth structure related to the patient’s occlusal relationship and function; teeth #18 and 19 had significant fractures, weakening the teeth.

2. Treatment Plan Outline
a. Restorative treatment to include:
- Manage possible inflammation of TMJ during treatment by frequent jaw rest and shorter appointments as the patient indicates.
- Restorative treatment to include rebuilding patient’s occlusion or using an appliance to open the bite and preserve tooth structure. Restore teeth #18 and 19 with crowns.
b. Active phase I periodontal infection therapy to include five periodontal infection therapy appointments, one hour each and scheduled approximately a week apart:
- assessment of patient’s plaque management, refining techniques and continuing motivation for thorough daily care
- full-mouth microultrasonic instrumentation and hand instrumentation for biofilm and calculus removal
- laser soft tissue decontamination and superficial coagulation
- intraoral photographs

c. Six-week post-therapy re-infection assessment appointment to include:
- one appointment for 30 minutes
- health history review
- visual evaluation of tissue rehabilitation
- assessment of patient’s plaque management, refining techniques and continuing motivation for thorough daily care
- intraoral photographs
- microultrasonic biofilm removal at gingival third of tooth
- probing and sulcular instrumentation is avoided in order to allow undisturbed maturation of connective tissue at the base of the pocket

d. Twelve-week post-therapy appointment to include:
- health history review
- oral cancer screening
- periodontal charting to assess rehabilitation
- assessment of patient’s plaque management, refining techniques and continuing motivation for thorough daily care
- microultrasonic instrumentation for full-mouth bacterial decontamination
- coronal polishing
- laser decontamination of unresolved areas
- determination of recare interval

3. Indications for Treatment
Treatment is indicated to halt the periodontal destruction and rehabilitate the affected tissues. Periodontal infection therapy must include removal of biofilm and calculus from the root surfaces through scaling. The Nd:YAG laser furthers decontamination of the pocket by addressing the periodontal pocket wall. The 1,064-nm laser wavelength is highly absorbed in melanin and hemoglobin. Both of these chromophores are present in inflammatory tissue. Laser-tissue interaction reduces pathogens in the pocket and coagulates hemorrhaging sites, assisting the body’s healing response. This laser enhances the body’s healing process by reducing bacterial counts and achieving superficial coagulation.

4. Contraindications for Therapy and Precautions
There were no contraindications for this patient to receive laser-assisted treatment of periodontal disease with the Nd:YAG laser. Laser safety precautions were followed for protection of the patient and clinician.

The energy from the Nd:YAG laser must be directed toward the soft tissue and away from the tooth and bone.

5. Treatment Alternatives
- No treatment and progression of disease, eventual tooth loss and systemic impact
- Conventional scaling and root planing
- Placement of localized antimicrobials or antibiotics with possible reactions
- Periodontal surgery

6. Informed Consent
After being educated in the progression of untreated periodontal disease and treatment options, the patient gave verbal and written consent to proceed with the planned therapy. This is documented in the patient’s record.

TREATMENT
A. Restorative Treatment
Objective
Since there were no active carious lesions, recommendations were discussed and treatment was planned in phases at the completion of phase I periodontal therapy.

B. Treatment Objectives
The treatment objectives are to halt the destruction of the periodontium due to disease processes. Laser-assisted periodontal treatment will reduce bacterial load in the periodontal pocket wall, eliminating the related inflammatory response by the body. The Nd:YAG laser wavelength is well absorbed in pigmented and hemoglobin-rich inflamed tissue. Signs of healing, such as decreased probing depths, elimination of hemorrhaging, and normal tissue coloration and texture, are desired. The appointments are designed to allow the patient-customized education in specific daily plaque management techniques, ensuring maximum rehabilitation of the tissues. Beginning with the most infected teeth, each appointment will address two to four teeth for debridement of root surfaces through scaling followed by tissue decontamination and superficial coagulation through lasing. At the subsequent appointment, approximately 7 to 10 days later, a different group of teeth will be debrided and tissues lased. The previously treated area will be revisited for ultrasonic biofilm removal from tooth surfaces and laser decontamination of tissues. This continues the reduction of bacterial load and enhances the body’s healing response.

Instrumentation with the ultrasonic device is concentrated on the cervical area of tooth structure and the fiber was calibrated to 1 mm less than the previous application. These procedures allow reinforcement of behavior modification in daily plaque management.
C. Laser Operating Parameters
A free-running pulsed Nd:YAG laser (PulseMaster 600IQ, American Dental Technologies, Corpus Christi, Texas) with a 1064-nm emission wavelength was used with a 400-micron contact fiber. For bacterial reduction, the laser parameters were 30 mJ and 60 Hz, average power of 1.8 Watts; for superficial coagulation, the settings were 100 mJ and 20 Hz, with an average power of 2.0 Watts. The total laser emission time for the six sessions of periodontal infection therapy was 75 minutes.

D. Treatment Delivery Sequence
The treatment delivery sequence at each therapeutic appointment included:

- review of health history
- plaque management assessment and instruction
- anesthetic as needed:
  - topical anesthetic administered at the gingival margin and subgingivally. A compounded preparation called TAC (20% lidocaine, 4% tetracaine, and 2% phenylephrine) was applied
  - local anesthetic of 2% lidocaine with epinephrine 1:100,000 was administered for more profound anesthesia
  - infiltration with 4% articaine with epinephrine 1:100,000 was administered when a full block was not necessary
- microultrasonic and hand instrument debridement of root surfaces
- laser decontamination and superficial coagulation of pocket epithelium
- postoperative care instructions given.
- Laser safety measures included:
  - wearing 1,064-nm laser wavelength protective eyewear by all operatory personnel
  - use of 0.1-micron filtration masks
  - environment secured to limit access
  - laser-in-use warning sign placed
  - reflective surfaces minimized
  - high-volume evacuation utilized to control plume and cool the tissue.

Chart documentation included laser and wavelength used, fiber size and type, operating parameters, and emission time.

The laser fiber was cleaved and the laser test-fired. The fiber was calibrated to 1 mm less than the pocket depth (Figure 6). With the fiber remaining in constant contact with the internal pocket tissue and in constant motion, treatment began at the top of the pocket and progressed apically, moving the fiber vertically and horizontally until the calibrated depth was reached. The fiber was always directed away from the root surface and toward the target tissue. Accumulated debris was wiped from the fiber and a proper cleave maintained (Figure 7). The amount of lasing time was influenced by tissue interaction, extent of disease, and depth of the pocket. When fresh bleeding was visible, the laser procedure was deemed complete for that site. High-volume suction was present to eliminate the plume and cool the tissue.

Two to four teeth were treated during the therapeutic appointments. Examples are shown in Figures 8 and 9. Figure 8a shows the initial pocket on the mesiobuccal of tooth #31; 8b shows the laser treatment; and 8c shows the immediate postoperative completion of treatment. Figure 9a shows the initial pocket on the mesiobuccal of tooth #15; 9b shows the laser treatment; and 9c shows the immediate postoperative completion of treatment.

E. Postoperative Instructions
Postoperative instructions were given in verbal and written form. The patient was instructed to avoid (for the first 24 hours) acidic, rough, or crunchy foods. Normal eating could resume following that period. Avoidance of seeds, husks, and other foods that may lodge between the gingiva and tooth was
Smith recommended for a week. The patient opted to purchase an electric toothbrush. Instructions and technique for use were explained. Subgingival flossing and the electric toothbrush were to be avoided for several days. All other areas were to be cleaned as usual. If discomfort were to occur, the patient was instructed to use warm salt water rinses and over-the-counter pain medication. The patient was informed that the most important aspect of the therapy was the healing process and minimizing plaque at the gingival margin was critical in preventing re-infection.

**F. Complications**
The patient experienced tenderness the evening following appointments where more instrumentation was required, particularly in the teeth #24-25 area. He also experienced sensitivity to temperature changes in this area. A 5% neutral sodium fluoride varnish was applied to exposed root surfaces to prevent root caries and desensitize, and a 1.1% neutral sodium fluoride dentifrice was prescribed for daily use. Adequate rest was allowed during therapy to minimize issues with the TMJ and the patient tolerated treatment well. There were no other complications during or after the laser treatments.

**G. Prognosis**
Prognosis is fair to good overall as long as he conforms to good oral hygiene and recommended intervals for professional supportive maintenance visits. Continued monitoring of teeth #24 and 25 will be necessary. Restorative treatment for teeth #18 and 19 is the next priority in treatment. The patient is undecided about an occlusal appliance.

**H. Documentation**
All treatment and related information was recorded in the patient’s treatment record.

**FOLLOW-UP CARE**

**A. Assessment of Treatment Outcomes**
The patient was assessed at 1 week, 6 weeks, 12 weeks, and 6 months following active phase-I periodontal infection therapy. The patient was educated about the importance of his oral hygiene and encouraged to continue with a thorough daily routine.

The one-week examination revealed that the tissues were healing. Plaque management needed further refinement.

The six-week post-therapy re-infection assessment appointment:
Patient has improved plaque management and tissues were becoming healthier. This appointment included:
• health history review
• visual evaluation of tissue rehabilitation
• assessment of patient’s plaque management, refining techniques and continuing motivation for thorough daily care
• intraoral photographs
• microultrasonic biofilm removal at gingival third of tooth.

As mentioned previously, probing and sulcular instrumentation was avoided in order to allow undisturbed maturation of connective tissue at the base of the pocket. Figures 10a and 10b show the six-week view of teeth #31 and 15, respectively.

**The twelve-week post-therapy appointment**
Overall, a marked improvement in periodontal health was seen. The patient presented with irritation and flaking of skin at the corner of the mouth. Nystatin cream was prescribed for probable fungal infection. This appointment included:
• health history review

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**Figure 9a:** Initial mesiobuccal pocket probing of tooth #15 with exudates

**Figure 9b:** Laser treatment of pocket

**Figure 9c:** Immediate postoperative view

**Figure 10a:** Six-week postoperative view of tooth #31

**Figure 10b:** Six-week postoperative view of tooth #15

**Figure 10c:** Immediate postoperative view
oral cancer screening
six-point pocket and hemorrhaging periodontal charting to assess rehabilitation (Figure 11)
assessment of the patient’s plaque management, refining techniques and continuing motivation for thorough daily care
microultrasonic instrumentation for full-mouth bacterial decontamination and hand instrumentation as needed
coronal polishing
laser decontamination of appropriate areas
determination of recare interval at 12 weeks.

The previously mentioned Nd:YAG laser was used with a setting of 30 mJ and 60 Hz, a 1.8 Watts average power, delivered with a 400-micron contact fiber for 17 minutes total emission time. Oral hygiene instructions were reviewed: Continue use of daily fluoride as for caries prevention. A 12-week supportive periodontal therapy appointment was scheduled. This short-term follow-up is illustrated in Figure 12a for tooth #31 and Figure 12b for tooth #15.

The six-month post-therapy appointment:
The patient was continuing to improve the efficiency and consistency of plaque removal. The fungal infection on the left corner of mouth had completely resolved. Teeth #24 and 25 had no exudate or mobility and tissues were healthier, however they remain an area of particular concern. The six-month therapeutic appointment included:
• health history review
• oral cancer screening
• six-point pocket and hemorrhaging periodontal charting
• assessment of the patient’s plaque management, refining techniques and continuing motivation for thorough daily care
• microultrasonic instrumentation for full-mouth bacterial decontamination and hand instrumentation as needed
• coronal polishing
• laser decontamination of appropriate areas.

The previously mentioned Nd:YAG laser was used with a 400-micron fiber, with parameters of 30 Hz, 60mJ, average power of
CLINICAL CASE

1.8 Watts for decontamination. Hemostatic assistance was accomplished with 100 mJ, 20 Hz, average power of 2.0 Watts applied to sites of tooth #14, 24, and 25 due to increased inflammation. Emission time totaled 15 minutes. Long-term follow-up is illustrated in Figures 14a and 14b, depicting tooth #31 and #15, respectively.

B. Complications
The patient had no soft or hard tissue damage. He experienced sensitivity on the root surfaces of teeth #24 and 25 most likely due to the removal of heavy calculus and recession which occurred with tissue resolution. He was pleased with the results from the laser.

C. Long-Term Results
At 12 weeks post-therapy there was marked improvement. Hemorrhaging sites improved by 76% and number of perio sites by 55%. At 6 months post-therapy, tissues showed continued resolution with 92% less hemorrhaging and 62% fewer perio sites. For comparison, the initial pre-therapy view is shown in Figure 15 and the six-month postoperative view of the improved anterior periodontal health is seen in Figure 16.

D. Long-Term Prognosis
Prognosis is fair to good overall as long as the patient conforms to good oral hygiene and recommended intervals for professional supportive maintenance visits. More phase I active periodontal infection therapy may be indicated for persistent areas, including teeth #24-25. If health declines, adjustment of maintenance interval and possible adjunctive use of a locally delivered antimicrobial such as Arestin® (OraPharma, Inc., Warminster, Pa.) may be considered. If there is acute and rapidly progressing disease, surgical intervention or extraction may be indicated. Restoration of teeth #18 and 19 is the next treatment recommendation; however, the ideal treatment would be to restore the lost vertical dimension of occlusion. The patient does not wish that treatment at this time. He is considering an occlusal splint or bruxism appliance, which is highly recommended to preserve tooth structure and to reduce occlusal forces. Those forces may exacerbate his periodontal condition.

E. Additional Treatment Notes
At the second therapeutic appointment, the patient presented with a

<table>
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<th>Table 1: Results of Laser-Assisted Periodontal Therapy</th>
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<td>Treatment Assessment Interval</td>
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<td>Beginning</td>
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<td>12 Weeks</td>
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<td>6 Months</td>
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<td>Rate of Improvement After 6 Months</td>
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Figure 14a: Six-month postoperative probing of tooth #31

Figure 14b: Six-month postoperative probing of tooth #15

Figure 15: Initial preoperative anterior view at presentation

Figure 16: Six-month postoperative full smile

Figure 17: Aphthous ulcerative lesion on left posterior palatal area
1.5-mm diameter aphthous lesion left of the midline on the soft palate (Figure 17). On the third therapeutic appointment a 2.0-mm diameter lesion was present just right of the midline on the soft palate. Consent was given to treat the lesions with the laser. The lesions were treated one time each in noncontact mode with the same laser (Nd:YAG) as periodontal therapy was being provided. The lesion was irradiated with a 400-micron fiber for 30 seconds then given tissue rest for 30 seconds between each of the following settings: 60 mJ, 10 Hz, 0.6 average Watt; 80 mJ, 10 Hz, 0.8 average Watt; 60 mJ, 20 Hz, 1.2 average Watts; 80 mJ, 20 Hz, 1.6 average Watts. Total emission time was 2 minutes. Laser safety precautions were observed including safety eyewear and high-volume evacuation. Postoperative evaluation at one week showed near-resolution of the first lesion. At one-week postoperative for the second lesion and two weeks for the first lesion, both lesions had completely resolved (Figure 18).

Figure 18: Two-week postoperative view of entire palate

AUTHOR BIOGRAPHY
Mary Lynn Smith is a registered dental hygienist, working clinically for more than 14 years. She achieved her Standard Proficiency in the Nd:YAG (1,064-nm) and diode (810-nm) wavelengths in 2003, and completed her Advanced Proficiency in the Nd:YAG in 2007. Mary Lynn has contributed to the dental community through articles and speaking to fellow hygienists on care of implants, periodontal therapies, and laser-assisted hygiene techniques and principles. She currently resides in McPherson, Kansas and is employed by Dr. Jon Julian, DDS. Mrs. Smith may be contacted by e-mail at mlsrdh@swbell.net.

Disclosure: Mrs. Smith has no commercial relationships relative to this case presentation.
In her case study of laser treatment of moderate chronic periodontitis and aphthous lesions (93-100), Mary Lynn Smith uses an Nd:YAG laser in noncontact mode at four separate settings in 30-second intervals at each setting to help in the resolution of the aphthous lesions. Her report complements the successful findings of numerous other published accounts in the laser literature.

While the etiology of aphthous ulcers and related conditions is uncertain, evidence indicates that aphthous ulcers are related to a focal immune dysfunction. A variety of factors or situations may predispose the patient to their manifestation, possibly playing a triggering or modifying role: infection, systemic disease, immunological factors, or a physical or chemical agent; hormonal alterations; stress, trauma, food allergy; nutritional factors such as hypovitaminosis (especially deficiency in B vitamins or vitamin C), iron-deficiency anemia; foods such as chocolate, coffee, peanuts, eggs, cereals, almonds, strawberries, cheese, tomatoes, gluten; cheek biting, mouth breathing, jagged teeth, orthodontic appliances, ill-fitting dentures, or nursing bottles with nipples that are hard or too long; xerostomia; radiation; excessive use of alcohol, tobacco, hot foods, highly acidic foods, spices, or ingredients in toothpaste, mouthwash, candy, chewing gum (especially if made from chicle), dyes, lipstick; occupational exposure to dyes, heavy metals, acid fumes, or metal and mineral dust; the use of drugs such as cytotoxic cancer chemotherapy drugs, gold salts, iodides, and barbiturates; and antiviral medications in human immunodeficiency virus (HIV)-positive patients.

As discussed previously in the research abstracts of the Academy’s publication Wavelengths (1998;6(2):12-13), successful treatment of aphthous ulcers with argon, helium-neon, low-level diode, Nd:YAG, and carbon dioxide lasers has been reported. In most published cases of aphthous ulcer treatment conducted via laser, the procedure is conducted in noncontact mode with low energy settings and limited to very specific durations of exposure, resulting in little or no visible surface change (such as a slight drying or shrinkage) to the lesion. (In contrast, Sklar used an Er:YAG laser in noncontact mode to ablate the lesions.) Patients generally report immediate relief of the pain during treatment and noneventful healing post-treatment when such protocols are followed. No or diminished recurrence of the lesions is the norm.

In most instances, anesthesia is not used so as to enable patient feedback regarding discomfort. If at any time discomfort is elicited, typically the laser energy output in decreased or the working distance between the handpiece and target tissue is increased. The treatment area is also cooled by holding the high-volume evacuation system a few millimeters away.

Sharon-Buller and colleagues report their results when using the carbon dioxide laser (without anesthesia) for treatment of ulcerative lesions: “Pain relief is rapid and long-term. In our experience, the recurrence rate of aphthosis at the same site after laser treatment is negligible.”

Colvard and Kuo found similar results when they used a carbon dioxide laser (with anesthesia): Laser therapy reduced or eliminated the pain and inflammation with normal wound healing.

Fekrazad and fellows relate their findings with an Nd:YAG laser: Pain relief and rapid recovery. They also state that no side effects were detected.

Whether or not healing time is actually reduced after laser treatment is not definitive. As Parkins and colleagues indicate below in their Nd:YAG laser study, patients’ perception that healing time is reduced may actually be due to the comfortable post-treatment course.

The notion of no side effects being encountered with laser treatment is not insignificant when compared to the alternative conventional therapy with medication, especially in patients with HIV infection. As Convissar points out, “The advantages of laser treatment over systemic pharmacological intervention include avoidance of the deleterious interactions with other medications and the side effects of the medications themselves.”

Below, Zand and colleagues describe their treatment results using a CO2 laser, as do Sarver and Yanosky with a diode laser.

For U.S. readers, certain Er,Cr:YSGG, carbon dioxide, Nd:YAG, diode, Er:YAG, and frequency-doubled Nd:YAG lasers have been cleared by the U.S. Food and Drug Administration for aphthous ulcer treatment.
As always, clinicians are advised to review the specific indications for use of their lasers and to review their operator manuals for guidance on operating parameters before attempting similar techniques on their patients.

REFERENCES

Previously herpes labialis and recurrent aphthous ulcers have not been successfully treated. A preliminary study with a pulsed Nd:YAG laser evaluated the results with a protocol of four-minute noncontact exposures for both types of lesions – 8 patients with aphthous ulcers and 14 with herpes labialis. … Most patients experienced relief of symptoms. Some mild discomfort occurred during treatment. The most notable sensation was of warmth. The cooling action of high-velocity suction was helpful in reducing the patient’s response. Continuous motion of the laser fiber was helpful. A momentary pause as a rotational pattern is reversed should be avoided. Most patients tolerated the treatment well and indicated that the sensations were minor compared to the discomfort of the lesions. In no case was local anesthesia required.

Although no visible plume was produced during laser treatment, it could be a cause for concern. Especially with a herpetic lesion, viral particles could be present within the plume. A mask of small size is advised at all times. Future research culturing the plume as it is withdrawn in the suction stream would be informative. Since no tissue alteration is visible there may be less liberation of the virus than would occur with an invasive technique. The progress of herpes lesion was halted and aphthous lesions became desensitized. Aphthous ulcers can be treated with an Nd:YAG laser to reduce or eliminate the discomfort. Several subjects that were treated during the early prodromal stage did report that the lesion was aborted. Ulcer formation usually was averted. When the lesion had progressed to an ulcerated state before treatment, the desensitization of exposed nerve endings was probably responsible for the dramatic improvement. The lasting duration of the pain elimination, usually until healing was complete, was judged a favorable outcome. Healing time is probably not appreciably altered. Patients are more comfortable and notice the area less. Herpes labialis treated with an Nd:YAG laser takes an altered disease course. Most patients achieve initial comfort. Early treatment during the prodromal period usually reverses the development and aborts ulcer formation. Satellite vesicles and acute discomfort do not evolve. Recurrences are reduced for most patients; and during the experimental period a significant number did not experience any additional herpes lesions. With those who eventually did have another lesion it tended to be at another location, and less severe.

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RESEARCH ABSTRACTS

RELIEVING PAIN IN MINOR APHTHOUS STOMATITIS BY A SINGLE SESSION OF NON-THermal CARBON DIOXIDE LASER IRRADIATION

Nasrin Zand,1 Leila Ataie-Fashtami,1 Gholamreza Esmaeeli Djavid,1 Mohsen Fateh,1 Mohammad-Reza Alinaghizadeh,2 Seyyed-Mostafa Fatemi,1 Fateme Arbarbi-Kalati3

1Iranian Center for Medical Laser (ICML), Academic Center for Education, Culture and Research (ACECR), Tehran, Iran
2Research Center of Science and Technology in Medicine (RCSTIM), Medical Sciences/University of Tehran, Tehran, Iran
3Tabriz University of Medical Sciences, Tabriz, Iran

This randomized controlled clinical trial was designed to evaluate the efficacy of single-session, nonthermal, carbon dioxide (CO2) laser irradiation in relieving the pain of minor recurrent aphthous stomatitis (miRAS) as a prototype of painful oral ulcers. Fifteen patients, each with two discrete aphthous ulcers, were included. One of the ulcers was randomly allocated to be treated with CO2 laser (1 W of power in de-focused continuous mode) and the other one served as a placebo. Before laser irradiation, a layer of transparent, non-anesthetic gel was placed on both the laser lesions and the placebo lesions. The patients were requested to grade their pain on a visual analog scale up to 96 h postoperatively. The reduction in pain scores was significantly greater in the laser group than in the placebo group. The procedure itself was not painful, so anesthesia was not required. Powermetry revealed the CO2 laser power to be 2-5 mW after passing through the gel, which caused no significant temperature rise or any visual effect of damage to the oral mucosa. Our results showed that a low-intensity, nonthermal, single-session of CO2 laser irradiation reduced pain in miRAS immediately and dramatically, with no visible side effects.

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PRINCIPLES OF COSMETIC DENTISTRY IN ORTHODONTICS: PART 3. LASER TREATMENTS FOR TOOTH ERUPTION AND SOFT TISSUE PROBLEMS

David M. Sarver
Mark Yanosky

Vestavia Hills, Alabama


One of the clinical orthodontist’s biggest occupational stress factors is the constant pressure from patients and their parents to finish treatment. Many predictable factors must work together for treatment to run on schedule, including patient cooperation and timeliness of appointments. But unanticipated impediments, such as tooth eruption problems and certain soft tissue characteristics, can prolong treatment. This purpose of the article is to describe how we use a diode soft tissue laser to solve many clinical and cosmetic problems. One of the most uncomfortable experiences for orthodontic patients is the formation of aphthous ulcers. In the past, we have offered salt water rinses, various anesthetic and palliative mouth rinses, and, in particularly persistent and painful lesions, a prescription rinse of tetracycline and topical anesthetic. Some of these solutions help to varying degrees, but often they only make the situation tolerable. The diode laser offers a potential solution. The recommended technique involves using the laser on a very low-wattage setting, out of contact with the lesion (a distance of 1-2 mm), visualizing a spot large enough to cover the entire lesion. The laser is activated for 30 seconds, and in our experience, the patient reports an immediate elimination of pain. The aphthous ulcer will generally heal and disappear approximately 1 day after laser treatment, compared with 10 to 14 days for an untreated lesion to heal.

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The Journal of Laser Dentistry’s Continuing Dental Education Program offers readers an opportunity to earn one CE self-instructional credit for each of three articles in this issue. Read the specified articles and then select the most correct answer to each of the questions. If you correctly answer 7 of the 10 questions on each test (for a score of 70%), you earn one credit hour for each test. Answer forms must be completed as directed in the instructions; otherwise, they will not be processed.

This program is developed by representatives of the Academy of Laser Dentistry’s Science and Research committee and is provided as a benefit to ALD members at no additional charge. Nonmembers are also eligible to participate for a $20 administrative fee per issue. Answers to this exercise will be published in a future issue.

Please photocopy and complete the registration form as well as the answer sheet and evaluation form on pages 108-109 for each test and mail them (along with the $20 administrative fee if you are not an ALD member) to:

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You will be notified by mail of your test score(s) and the number of credits awarded. You must then forward the information to your state dental board or agency for licensure purposes. Individuals who score less than 70% will receive a letter.

Answers to these tests are due on or before December 31, 2008.

Please call the Academy of Laser Dentistry (954) 346-3776 if you have any questions about this program.
Educational Objectives

Upon successful completion of this module, you will be able to:

- Describe the fundamental characteristics of the erbium lasers as used in dentistry.
- Specify 10 guidelines for maximizing successful clinical restorative dentistry utilizing an erbium laser.
- Identify the rationale for using erbium lasers for the effective ablation of tooth structure.
- Describe typical treatment plans and clinical protocols involved in the use of erbium lasers in restorative dentistry.
- Evaluate the expected successful treatment outcomes in clinical cases where erbium lasers are used in restorative dentistry.

Test Questions

1. The use of laser energy in the ablation of dental hard tissue is an example of:
   a. photochemical interaction
   b. photothermal interaction
   c. photobiomodulation
   d. photogenic interaction

2. Several factors contribute to the efficient erbium laser ablation of dental hard tissue. Among these are the:
   a. laser's delivery system
   b. power density at the ablation site
   c. type of anesthesia used on the patient
   d. amount of preconditioning of the laser tip

3. The principal laser wavelengths used in tooth preparation are Er:YAG and Er,Cr:YSGG. Their respective wavelengths are:
   a. 2,100 nm and 2,780 nm
   b. 2,100 nm and 2,940 nm
   c. 2,780 nm and 2,940 nm
   d. 2,940 nm and 9,600 nm

4. The erbium laser wavelengths have a:
   a. high absorption by water
   b. low absorption by water
   c. very high absorption by hydroxyapatite
   d. very low absorption by collagen

5. The surface of dentin after exposure to either Er:YAG or Er,Cr:YSGG laser irradiation has the following characteristics:
   a. a smear layer and closed tubules
   b. a smear layer and open tubules
   c. absence of a smear layer
   d. presence of carbonization

6. A co-axial water spray during erbium laser preparation of enamel and dentin is necessary because the spray:
   a. serves to aim the laser beam at the target
   b. cools the laser tip
   c. aids in desensitizing the tooth structure
   d. helps to disperse debris and ablation products

7. Erbium laser irradiation of enamel and dentin results in a micro-cavitated surface. This surface:
   a. should be desensitized to avoid pulpal damage
   b. is ideal for bonding composite resin
   c. requires additional acid-etch techniques to minimize early marginal breakdown of the composite restoration
   d. should be protected with a cavity liner prior to restoration

8. Each of the following is a safety consideration when using erbium laser wavelengths EXCEPT one. Which one is this EXCEPTION?
   a. wavelength- and device-specific protection glasses for the doctor, the assistant, and patient to prevent eye damage
   b. appropriate face-masks to avoid plume aspiration
   c. high-speed evacuation of plume and debris to remove potentially harmful combustion byproducts
   d. encasement of the laser tip in a wavelength-specific shield to minimize unwanted beam diversion

9. Which of the following statements is true? Erbium laser energy:
   a. has greater absorption in demineralized tooth structure than in healthy tooth structure
   b. is so efficiently absorbed that no debris accumulates in a deep preparation
   c. has greater absorption in healthy tooth structure than in demineralized tooth structure
   d. does not cause any thermal rise in the target tissue

10. Studies of the pulpal temperature rise when using erbium lasers confirm the following:
    a. temperature rise is rapid with each pulse and care should be taken to avoid damage
    b. pulpal temperature rise is within 5 degrees Celsius above normal
    c. pulpal temperature rise is approximately the same as with an air turbine
    d. erbium laser wavelengths induce photobiomodulation which keeps the temperature rise within normal limits
Educational Objectives
Upon successful completion of this module, you will be able to:
- State the definition and etiology of peri-implantitis.
- Describe the various alternatives for treatment of peri-implantitis.
- Identify the rationale for using an Er:YAG laser for treatment of peri-implantitis.
- Specify the treatment protocol for and expected successful result of Er:YAG laser treatment of peri-implantitis.

Test Questions
1. Which of the following statements is true? Peri-implantitis:
   a. manifests as an inflammation of the structures surrounding an implant fixture
   b. is a disease of soft tissue destruction only
   c. has clinical signs similar to a carious lesion
   d. cannot be treated with a laser

2. One of the major factors contributing to peri-implantitis is the:
   a. design and shape of the implant fixture
   b. specific tooth that is being replaced by the implant
   c. amount of bacterial exposure to the implant
   d. length of time that the implant has been allowed to osseo-integrate

3. The development of peri-implantitis can occur because of:
   a. the quantity of bone surrounding the area where the implant is to be placed
   b. the initial depth of the osteotomy
   c. the thermal trauma to the periodontium during the osteotomy

4. Clinical signs of peri-implantitis include:
   a. marginal discrepancy of the restoration
   b. bleeding or purulence from the gingival tissue
   c. loosening of the restoration from the abutment
   d. fracture of the mechanical connection between the restoration and the abutment

5. Which of the following is a therapeutic treatment of peri-implantitis?
   a. removal of the implant fixture and restoration
   b. occlusal adjustment of the restoration
   c. removal of the granulation tissue with plastic curettes
   d. supragingival prophylaxis with pumice

6. The Er:YAG laser can be used for the treatment of peri-implantitis because this device:
   a. is highly absorbed by the metallic surface of the implant fixture
   b. can reshape the body of the implant fixture
   c. produces very high temperatures in the osseous tissue
   d. can vaporize the existing inflammatory granulation tissue

7. The Er:YAG laser can be used for dental osseous surgical procedures because it:
   a. instantly provides coagulation of the osseous tissue
   b. will remove only healthy osseous tissue and not the inflammatory material
   c. is effective in removing necrotic and healthy osseous tissue

8. The Er:YAG laser can be used directly on the implant surface because it:
   a. has no damaging effect on the implant screw areas at low energy settings
   b. can be used to remove some of the screw threads
   c. will recrystallize the metallic surface of the implant to harden it
   d. will not disturb the biofilm that adheres to the implant

9. According to the peri-implantitis treatment plan described in the article, the Er:YAG laser will be used for:
   a. carving the occlusal surface of the implant restoration
   b. making a pilot hole for the osteotomy
   c. preparing the donor gingival graft site
   d. ablating the soft and hard tissue in the periodontal defect

10. According to the peri-implantitis treatment sequence described in this article:
    a. a free gingival graft was placed over ablated soft tissue
    b. a xenograft bone substitute material was placed into the cleaned defect
    c. the soft granulation tissue was removed with hand instruments
    d. the implant fixture was removed
ACADEMY OF LASER DENTISTRY • SELF-INSTRUCTION PROGRAM NO. 1623

Use of an Er:YAG Laser for Pulpotomies in Vital and Nonvital Primary Teeth

Lawrence Kotlow, DDS

Educational Objectives

Upon successful completion of this module, you will be able to:

• State the definition and clinical rationale for performing a pulpotomy on pediatric teeth.
• Describe the protocol for the use of an Er:YAG laser in performing a pulpotomy on pediatric teeth.
• Assess the expected long-term treatment outcomes in clinical cases where an Er:YAG laser is used to perform pulpotomies.

Test Questions

1. Lasers are an effective alternative for treating pulps in pediatric teeth without the need to:
   a. use local anesthetics
   b. use tooth isolation
   c. introduce chemicals
   d. sedate the patient

2. A pulpotomy is defined as:
   a. the removal of the coronal pulp of a tooth
   b. the removal of very deep dentinal caries
   c. a root canal procedure for pulp tissue that is irreversibly infected or necrotic due to caries or trauma
   d. placement of calcium hydroxide paste on the healthy dentin

3. A concern when using formocresol for pulpotomy treatment of primary teeth is that:
   a. formocresol may be absorbed and distributed throughout the child's body within minutes of its use at the pulpotomy site
   b. the child may have extreme pain immediately after the tooth is treated
   c. the child may complain of a burning sensation after the tooth is treated
   d. formocresol may get on and discolor the child's skin if the child moves

4. When a laser is utilized to perform a pulpotomy, which of the following statements applies?
   a. the laser should not be used on children under the age of one year
   b. the laser should not be used on permanent teeth
   c. the laser treatment's success is similar to that achieved with chemical pulp therapy
   d. a carbon dioxide laser is the preferred wavelength for a laser pulp treatment

5. Which of the following is true for Er:YAG laser pulpotomy treatment? The laser:
   a. should be used with the tip placed 5 mm from the pulp chamber
   b. can be utilized for a pulpotomy as an alternative to electrosurgical therapy
   c. is always used to remove tooth structure for access to the pulp chamber
   d. is always used without any local anesthetic

6. When the Er:YAG laser is used for pulp therapy, which of the following applies?
   a. only the child patient requires laser safety glasses
   b. everyone within the operating area is required to use laser safety glasses
   c. no one in the operating area requires laser safety glasses, since the Er:YAG laser is harmless to the eyes
   d. only the dentist is required to use laser glasses since the child's mouth is so small the laser beam stays within the child's oral cavity

7. A successful pulpotomy on a primary tooth should last:
   a. one year
   b. five years
   c. ten years
   d. until the permanent tooth normally erupts

8. As indicated in the published case study, successful pulpotomy therapy using the Er:YAG laser requires a power setting of approximately:
   a. 4 Watts
   b. 6 Watts
   c. 0.75 Watt
   d. 1.65 Watts

9. Which of following is required when using the Er:YAG laser for a pulpotomy on a pediatric patient?
   a. high-volume evacuation
   b. premedication for the patient
   c. use of loupes or a microscope
   d. presence of the patient’s parent in the operatory

10. The Er:YAG laser can be used to treat:
    a. only posterior primary and permanent teeth
    b. only anterior primary teeth
    c. only vital teeth
    d. both vital and nonvital primary teeth
ANSWER SHEET FOR TEST 1621

Clinical Considerations for the Use of Er:YAG Lasers in Restorative Dentistry
Giuseppe Iaria, Dr. Prof. Med. Dent., Steven P.A. Parker, BDS, LDS RCS, MGGDP

Subject Code: 250

Place an X in the box corresponding to the answer you believe is most correct.

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Program Evaluation — Test 1621

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Usefulness of content
Benefit to your clinical practice
Quality of manuscript
Usefulness of references
Quality of illustrations
Relevance of illustrations

Poor = 1 to Excellent = 5

Please evaluate this article.
**ANSWER SHEET FOR TEST 1622**  
Peri-Implantitis Therapy with an Er:YAG Laser  
*Avi Reyhanian, DDS, and Donald J. Coluzzi, DDS*  
**Subject Code:** 690

Place an X in the box corresponding to the answer you believe is most correct.

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Please list future CE topic preferences:  
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**ANSWER SHEET FOR TEST 1623**  
Use of an Er:YAG Laser for Pulpotomies in Vital and Nonvital Primary Teeth  
*Lawrence Kotlow, DDS*  
**Subject Code:** 430

Place an X in the box corresponding to the answer you believe is most correct.

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