Caries Detection by Quantitative Light-Induced Fluorescence

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- Case Reports: Treatment of Moderate Chronic Periodontitis; Gingivoplasty, Frenectomy, and Second-Stage Implant Recovery; Establishing a Gingival Smile Line; Treatment of Lip Hemangiomas
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Understanding Our Laser Tools
to Better Serve Our Patients

John D.B. Featherstone, MSc, PhD, San Francisco, California

J Laser Dent 2008;16(1):5

SYNOPSIS

John Featherstone, editor-in-chief, describes some of the highlights of this issue of the Journal of Laser Dentistry, illustrating how we must understand what we are doing to better serve our patients.

Last month we had articles that described how light, including laser light, can be used in everyday dental practice. The article on laser fluorescence for caries detection described just one of the novel new techniques that are becoming available. This month a review of several other techniques is presented. The bottom line is that we must understand how each of these instruments works so that we can make an assessment of what the results mean for our patients. There is no step-by-step cookbook with recipes to work from. The practitioner must be able to interpret the output to best use the information.

Many dentists who use lasers in their practice use them for ablation of dental hard tissues, for the removal of decay, and for cavity preparations. In this issue we have an applied research article that helps us understand what the erbium lasers are doing. Again, a better understanding of the tools that we have in our hands is essential for the best treatment plan and the best outcome for our patients.

The case studies are presented as examples of how to put into practice the understanding that the authors have of the lasers that they are using for the various tasks. Laser dentistry is not the only way to tackle any of these clinical problems. However, each of the cases presented demonstrates an elegant use of laser technology in clinical practice. These articles cover the use of Er:YAG, Nd:YAG, and diode lasers for primarily soft tissue applications. In every case the authors have chosen the laser that they considered, from their understanding, to be the best one for the task at hand.

We are all dental professionals, each with our own skills and experience. The common message that runs through all of the articles in this issue is that we must understand what we are doing in clinical dentistry in order to decide on the laser, or light source to use, and to interpret what is happening as we use it. Our education and experience together must guide us to do the very best that we can for the oral and general health of our patients.

In conclusion, I looked back on my editorial from the last issue and I find it worth repeating the ending statement: “We must all be continual learners and work out how to apply our learning to whatever we do each day.”

Please enjoy this issue of the journal. Feel free to e-mail me with suggestions, criticisms, or compliments at jdbf@ucsf.edu.

AUTHOR BIOGRAPHY

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 over 200 papers. He is the editor-in-chief of the Journal of Laser Dentistry.

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Supplementary Methods for Detection and Quantification of Dental Caries

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J Laser Dent 2008;16(1):6-14

INTRODUCTION
Our efforts to make the concept of caries prevention popular, and to preserve the dentition into old age are continuously successful. However, despite the dramatic decline in dental caries, particularly in industrialized countries and among children and young adults, the disease persists, albeit with highly skewed distribution. The following major changes have occurred in the pattern of the disease: progression of enamel caries is now slower, and allows preventive intervention before irreversible destruction of tooth substance. There is also a pronounced reduction in lesion development on the smooth surfaces, which are readily accessible to fluoride. Diagnostic techniques to support appropriate clinical decisions about management of the individual lesion, whether invasive therapy or a more conservative, noninvasive approach is indicated, are predominantly based on subjective interpretation of visual information: visual inspection, bitewing radiography, and the use of a dental explorer. Longitudinal monitoring of lesions has been hampered by the lack of appropriate diagnostic techniques, i.e., techniques of high sensitivity and specificity that reflect the slow lesion progression. The aim is to arrest or reverse the disease process, and to intervene before operative restorative dentistry is needed.

Objective, reliable quantitative data on the outcome of this strategy, i.e., lesion response to preventive measures, would allow flexibility in selecting intervention appropriate for the individual patient, before lesion progression reaches a stage requiring invasive therapy. Optimal dental care and treatment will increasingly involve a shift of emphasis and a change in the education and training of oral health personnel, and dental providers need to keep abreast of new approaches and technological advances for diagnosis and therapies of dental caries. In this context, there is a need for complementary methods for detection and quantification of dental caries. There are certain requirements that should be met by the methods; they have to meet all safety regulations; detect early, shallow lesions; differentiate between shallow and deep lesions; give a low proportion of false positive readings; present data in a quantitative form so that activity can be monitored; be precise so that measurements can be repeated by several operators; be cost-effective and user-friendly. Clinically applicable methods for detection of a very early phase of mineral loss and quantification of caries lesions have emerged. In this paper, some novel and commercially available caries detection methods: Fiber-Optic Transillumination, Digital Imaging Fiber-Optic Transillumination, Laser Fluorescence, Quantitative Light-induced Fluorescence, and Electronic Caries Measurement.

SYNOPSIS
This article reviews the modes of action and clinical application of novel caries detection methods including digital imaging fiber-optic transillumination, laser fluorescence, quantitative light-induced laser fluorescence, and alternating current impedance spectroscopy.

ABSTRACT
There is a need for objective instrumental caries detection methods to supplement traditional visual assessment by the clinician. These methods should be used as supplements to aid in making appropriate decisions about the clinical management of the individual lesion, such as whether to use invasive therapy or a more conservative, noninvasive approach. Objective, reliable, quantitative measures for longitudinal monitoring of lesion response to preventive measures would allow flexibility in selecting intervention appropriate to the individual patient, before lesion progression reaches a stage requiring invasive therapy. This paper reviews some novel and commercially available caries detection methods: Fiber-Optic Transillumination, Digital Imaging Fiber-Optic Transillumination, Laser Fluorescence, Quantitative Light-induced Fluorescence, and Electronic Caries Measurement.
Fluorescence, and Electronic Caries Measurement.

**THE METHODS**

**Fiber-Optic Transillumination (FOTI)**

FOTI is a technique that uses light transmission through the tooth and has been available on the market for more than 40 years, in contrast to the other more novel methods described below that have only recently been developed. FOTI is based on the theory that demineralized dental hard tissues scatter and absorb light more than sound tissue. White, cold light is transmitted from a light source through an optical fiber to a hand-piece with a thin probe that is applied to the tooth surface. Figure 1 shows the clinical FOTI setup. It detects and visualizes the caries lesions, so demineralized regions appear darker compared to the surrounding sound tissue, and the contrast between sound and carious tissue is then used for detection of lesions on occlusal, approximal, and smooth surfaces, on enamel as well as dentin. This technique relies on the human eye as the detector and is not quantitative. The majority of the FOTI studies show the same tendency as the well-performed in vitro study on occlusal surfaces by Grossman et al., which showed low sensitivity (0.39) and high specificity (0.92), i.e., the risk for false positive observations was low, and the risk for missed carious lesions was high. There is a need for training and calibration of operators, but few clinical factors influence the readings.

**Clinical perspective:** FOTI is essentially a refinement of traditional visual observation that can enhance caries detection by a trained and experienced clinician, but is not quantitative and has the same limitations as traditional visual methods for assessing lesion extent and following lesions over time.

**Digital Imaging Fiber-Optic Transillumination (DIFOTI)**

A recently marketed method based upon the same principles as FOTI is the digitized DIFOTI method. In this method the white light is delivered through an optical fiber via a specially designed handpiece that has a mirror on the opposite side of the tooth, whereby channeling the image back to a digital camera and visualizing the image on a monitor via a computer system. An ordinary computer setup with specially designed software creates a real-time image of the illuminated tooth on the computer screen. The images can be stored for later retrieval and comparative examination. Two disposable mouthpieces are available, one for proximal and one for occlusal surfaces, in an adult as well as a pediatric size. The DIFOTI method is still qualitative. Figure 2 shows a DIFOTI image of a molar occlusal surface. As can be seen tooth defects are readily visualized, such as the unusual morphology in this image. As with regular FOTI, the user’s level of experience is essential. Only limited research has so far been performed.

**Clinical perspective:** The DIFOTI technique essentially picks up surface scattering of the visualizing light and readily indicates the presence of very early carious lesions, cracks, or imperfections in the tooth surface. From a clinical perspective, however, this information is very limited in its usefulness. The method gives no indication of lesion depth, severity, or progress over time, and cannot be used in the determination of how deep the lesion is and whether surgical intervention is necessary. This problem was highlighted in the recent study by Young and Featherstone.

**Laser Fluorescence (LF)**

When a caries lesion in enamel and dentin is illuminated with red laser light ($\lambda = 655$ nm), organic molecules that have penetrated porous regions of the tooth, especially metabolites from oral bacteria, will create an infrared (IR) fluorescence. The enamel is essentially transparent to red light. The IR fluorescence is believed to originate from porphyrins and related compounds from oral bacteria. These molecules are chiefly responsible for the absorption of red light. The laser instrument, DIAGNOdent® (DD) (KaVo Dental GmbH, Biberach, Germany), is based on research by Hibst and Gall, was introduced in the late 1990s, and is today marketed in two versions. Apart from smooth and occlusal surfaces, the latest version,
the DD-pen, also aims to readily access approximal surfaces. There is as yet limited information on the usefulness of the latter device.

As described in a recent review by Hibst, red light from a 655-nm diode is transmitted through an optical fiber to a hand probe. This light beam is used to irradiate the tooth, with the red light transmitting readily through sound enamel. When the light reaches a carious lesion and interacts with appropriate organic molecules that have been absorbed into the porous structure, the light is re-emitted as invisible fluorescence in the near-infrared region. The emitted light is channelled through the handpiece to a detector and presented to the operator as a digital number on a display (0-99). A higher number indicates more fluorescence and by inference a more extensive lesion below the surface.

The first version of the LF device has shown good performance and reproducibility for detection and quantification of occlusal and smooth surface carious lesions in vitro studies, but with somewhat more contradictory results in vivo, both in the primary and permanent dentition. It has also been tried for longitudinal monitoring of the caries process, and for assessing the outcome of preventive interventions. The DD-pen (Figure 3) might be a useful additional tool in detecting approximal caries, but has so far only been evaluated in three in vitro studies. Factors that may influence the outcome of the measurements in different ways are: presence of plaque, calculus and/or staining on the tooth surface, and the degree of dehydration of tooth tissue. The system detects fluorescent organic molecules that can be present in any surface deposits, thereby readily producing false positives. For measurements on occlusal surfaces, it is also of great importance that the tip is tilted over a range of several different angles to access all relevant subsurface regions.

Clinical perspective: The LF device is a useful adjunct to traditional visual examination, especially in occlusal surfaces, for the detection of hidden lesions below the surface. However, the device detects organic molecules that have penetrated into surface deposits or subsurface porosities, such as carious lesions. It does not directly detect demineralization. Results must be interpreted with caution by understanding how the device works and how false positive readings can be misleading. The digital number displayed indicates the amount of fluorescence, which is not necessarily a measure of lesion size or depth.

Quantitative Light-Induced Fluorescence (QLF)

The phenomenon of tooth auto fluorescence has long since been suggested to be useful as a tool for the detection of dental caries. Fluorescence is a property of some man-made and natural materials that absorb energy at certain light wavelengths and emit light at longer wavelengths. An increased porosity due to a subsurface enamel lesion, occupied by water, scatters the light either as it enters the tooth or as the fluorescence is emitted, resulting in a loss of its natural fluorescence. Consequently the demineralized area appears opaque. The strong light scattering in the lesion leads to shorter light path than in sound enamel, and the fluorescence becomes weaker. Bjelkhagen and Sundström and later de Josselin de Jong et al. developed a technique based on this optical phenomenon, making the difference in fluorescence radiance between the carious and sound tooth structure quantitative. This has been termed quantitative light-induced fluorescence (QLF).

The QLF method can readily detect lesions to a depth of approximately 500 μm on smooth and occlusal enamel surfaces. In the currently marketed systems (Inspector™ Pro, Inspektor Dental Care, Amsterdam, The Netherlands) the illumination system consists of a 50-Watt microdischarge arc lamp equipped with an optical bandpass filter with a peak intensity of 370 nm, transmitted through an optical fiber from the light source to a handpiece with a micro CCD video camera. A high-pass filter in front of the camera blocks the excitation light together with the ambient light, so
that only wavelengths above 520 nm are transmitted to the detector. Figure 4 shows the principal setup for the QLF-technique.

The preferred image is captured and saved by the operator by pressing a foot switch, and is later processed. Details about the tooth and the surface examined are set in the program, and the position and orientation of the processed image is thereafter automatically stored in a preset pattern so that when the patient comes back on recall, a contour guides the operator to the right position again. The program offers an automatic repositioning facility, which can be set at any level, and when correlation between the reference image and the real-time image is satisfactory, it can be saved automatically. The fluorescence image is first converted into a black-and-white image so that thereafter the lesion site can be reconstructed by interpolating the grey level values in the sound enamel around the lesion. The difference between measured and reconstructed values gives three quantities: \( \Delta F \) (average change in fluorescence, %), lesion area (mm\(^2\)), and \( \Delta Q \) (area x \( \Delta F \)), the latter giving a measure of the extent and severity of the lesion. Figure 5 shows the analytical part of the QLF method, as calculated by the specially designed software.

Figure 5: The analytical interface of the QLF method. The lesion is color-coded so that the operator can get a quick impression of the area and the depth.

The QLF method has been tested in several \textit{in vitro},\textit{44-46 in situ},\textit{47} and \textit{in vivo}\textit{\textit{48-53}} studies for smooth surface caries lesions. The possibility of adapting the QLF method for occlusal caries diagnosis is under investigation\textit{44-55} as well as modification for detection and quantification of secondary caries\textit{56,57} but has yet to be tested clinically. Application for quantification of dental fluorosis has also been investigated.\textit{58}

Higham \textit{et al.}\textit{60} concluded “QLF has the potential to detect, diagnose, and longitudinally monitor occlusal caries and provide useful information to the clinician with regard to the severity of the lesion and likely treatment.” Eggertsson \textit{et al.}\textit{55} reported good reproducibility of QLF methods clinically with inter- and intra-examiner reliability greater than 0.95 after training.

Factors that may influence the outcome of the measurements are: presence of plaque, calculus and/or staining,\textit{62} ambient light, daylight or office light, and the degree of dehydration of tooth tissue.\textit{63} The newly designed handpieces on the commercially available devices have largely overcome the ambient light problems. Certain errors in the capturing stage of the method, such as differences in x- or y-axis, or rotation of the image, may be adjusted during the analytical stage of the method.

The QLF method can also measure and quantify the red fluorescence (RF) from microorganisms in plaque. The RF observed in plaque can be of use when monitoring oral hygiene; removing infected dentin; detecting a leaking sealant or caries at the margin of a restoration. Two quantities are obtained, AR (average change in red fluorescence, %), and area (mm\(^2\)). So far there are a very limited number of studies performed with this feature.\textit{64}

\textbf{Clinical perspective:} The QLF system that has recently come on the market (Inspektor\textsuperscript{TM} Pro) in several countries can be used as a quantitative measure of enamel lesions in smooth surfaces. It is likely that is will also be useful for occlusal surfaces but this has yet to be proven. The sophisticated computer-driven repositioning feature enables lesion progression or arrestment to be followed over time. This system appears to be a useful adjunct to traditional visual examination.

\textbf{Electronic Caries Measurement (ECM) and Alternating Current Impedance Spectroscopy}

The ECM technique is based on the theory that sound dental hard tissue, especially the enamel, shows very high electrical resistance or impedance. Demineralized enamel becomes porous, and the pores fill with saliva, water, microorganisms, etc. The more demineralized the tissue, the lower the resistance becomes. In the impedance measurement system a circuit of a very weak alternating current is closed through the patient. From the device, a fiber leads to a probe, which is placed on the site that is to be measured.

Figure 6: Clinical use of Electronic Caries Measurement (ECM).
Figure 6 shows clinical use of an Electronic Caries Measurement device. The patient holds a ground-unit in the hand, and from the ground-unit, a fiber leads back to the device. Compressed air that is led through the probe isolates the measuring site from the surrounding saliva. The result of the measurement is presented on a display as a number between 1 and 13, and the higher the number, the deeper the lesion.

Site-specific measurements have been evaluated in a number of in vitro studies and in vivo studies. The reported sensitivity for ECM in detecting dental caries lesions of permanent premolar and molar teeth ranges from 0.93 to 0.95, and the specificity ranges from 0.53 to 0.70, in clinical studies, which gives a moderate risk for false positive readings, and a low risk of missed carious lesions. Surface-specific electrical conductance measurements have been investigated under in vitro conditions, which showed moderate sensitivity and specificity. Factors that may influence the outcome of the measurements are the degree of dehydration of tooth tissue, the degree of maturation of the enamel, and temperature variations.

Another impedance/conductance-based method is Alternating Current Impedance Spectroscopy (ACIST). It is based on the same assumptions about electrical circuits and dental hard tissues as the ECM instrument. Apart from the forward conductance (resistance values, representing continuous conduction/diffusion pathways) it also measures transverse conductance (capacitative conductance pathways). This could give more information than the ECM. A commercially manufactured impedance measurement device has recently come on the market in the United Kingdom (CarieScan™, IDMoS PLC, Dundee, United Kingdom) and is likely to reach the United States in the near future.

**Clinical perspective:** The electrical conductance or impedance measurement devices have had limited success in the past. The new ACIST system shows considerable promise as a method with good ability to detect lesions with a low level of false positives. However, the device gives a lesion/no lesion answer rather than an image, extent of the lesion, position of the lesion measure. This technique is likely to be a useful adjunct to traditional examination provided the clinician uses the information wisely in combination with other observations to determine an intervention or restorative treatment plan.

**DISCUSSION**

Quantitative dental caries detection methods may take subjective interpretations of visual, tactile, and radiographic methods to evidence-based clinical practice. A shift from traditional diagnostic methods to advanced and more sensitive methods will improve caries diagnostic routines and hence the dental care and treatment for our patients’ benefit: minimize the use of unavoidable hazards of ionizing radiation, detect caries in an early stage, obtain a more precise estimation of lesion depth and severity, reveal a dentinal lesion obscured by superimposed sound tissue, monitoring de- or remineralization, evaluate the outcome of different preventive strategies, and detect and quantify bacterial activity.

The caries detection methods reviewed in this article meet general clinical needs and although significant promise is seen in these techniques, there is not enough evidence currently available to recommend any one of them as a substitute for conventional methods. However, each of them can be valuable in its own way, as summarized above as a supplement to traditional methods. Each of the new methods reviewed brings additional information about lesions in a manner specific to the technology used.

Nevertheless, traditional methods of caries assessment, which discriminate lesions at the cavitation stage, are not always clinically appropriate, and are obsolete for clinical research requiring detection of a very early phase of mineral loss, which allow a reduction in the duration of experimental periods and the number of subjects required, saving both time and money. To develop and test a new medical technical device is a long-term commitment; it takes time, scientific research, and evidence from the time of the “first idea” to a validated commercially available device, and even though laboratory findings show strong results, caution is indicated when extrapolating these into clinical conditions.

The QLF method is today the most promising technology of those currently on the market, due to its close correlation to the enamel mineral content, but with limitations such as the inability to detect approximal (and occlusal) caries lesions, and dentinal caries. One of the upcoming methods and devices, based on different physical theories that is expected to appear on the market in the future is Optical Coherence Tomography (OCT) which can produce two- or three-dimensional images of demineralized regions in dental enamel. When a tooth with a carious lesion is illuminated with infrared light at 1310 nm, OCT technology can produce a quantitative image of the subsurface lesion to the full depth of the enamel. The OCT method is, however, still yet far from a marketed device for everyday use in the dental office.

All improvements require change, but not all change is improvement. Evidence-based care
is by definition “the conscientious, explicit, and judicious use of the current best evidence in making decisions about the care of individual patients, which includes integrating individual clinical expertise with the best available external clinical evidence.” It is therefore important to emphasize the need for clinical trials to support critical appraisal and decision making in using these techniques, by theory and empirical evidence.

In summary, there are several devices currently on the market and more to come that can be used by the clinician as valuable supplements to the traditional caries detection and assessment methods. All of the new methods require a basic understanding of how they work so that the results can be correctly interpreted for the benefit of the patient, especially to aid in the decision as to how to treat the condition of dental caries. Dr. Tranæus completed her PhD in 2002 at the Karolinska Institute, with her thesis entitled “Clinical application of QLF and DIAGNOdent – Two new methods for quantification of dental caries.” Currently, she is on a temporary 2-year assignment at SBU – The Swedish Council on Technology Assessment in Health Care. Dr. Tranæus may be contacted by e-mail at sofie.tranaeus@ofa.ki.se.

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Effect of Er,Cr:YSGG Laser on Human Dentin Collagen: A Preliminary Study

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INTRODUCTION

Since the discovery of lasers in 1960, much research has been done in order to investigate the interaction of lasers with the dental tissues.1,2 The early dental lasers for use with hard dental tissue applications often produced a charring effect. A few years ago, a Class IV Erbium Laser was cleared by the U.S. Food and Drug Administration (FDA) for use in dentistry. This type of laser (Er,Cr:YSGG) uses a crystal whose main element is erbium (a rare earth element), in addition to small portions of chromium, yttrium, scandium, gallium, and garnet. This crystal when irradiated emits a characteristic wavelength of 2780 nm that falls within the absorption band of water.3-5

One of the earlier possible explanations, proposed by the manufacturer, for the action of the Er,Cr:YSGG laser on dental hard tissues has to do with the interaction of this specific laser wavelength with the water spray of the laser handpiece. It has been suggested that when water droplets are introduced into the Er,Cr:YSGG laser beam, that the water droplets explode violently outwards, due to the energy absorption, thus creating a plasma expansion which drives the water droplets to supersonic velocity. The expression of this phenomenon is a production of a pressure of 400 MPa and velocities up to 1000 m/sec from energized water droplets.6 When this stream of water jet is striking the target, it supposedly has enough power to dislodge material but with a very accurate cutting.7 It has been suggested that water is the cutting agent; and in addition that hard dental material that is dislodged, once incorporated into the stream, could act as abrasive particles, thus increasing the efficiency of the cutting field. This abrasive water jet (AWJ) is speculated to be capable of removing hard dental tissues but without the carbonization effect associated with other types of lasers, due to its indirect action. Actually, the temperature at the operating field is reduced,8-9 something that might be expected due to the cooling effect of water.

However, it has recently been proposed that the action of the Er,Cr:YSGG laser is similar to the Er:YAG, since their wavelengths are similar (2780 nm for the
Er:YAG, 2940 nm for the Er,Cr:YSSG), both falling within the water absorption band. Accordingly they have similar absorption parameters in the hard dental tissues.\textsuperscript{10}

The most recent explanation for its action is the interaction of this specific laser wavelength with hydrated dentin. Since this wavelength is absorbed very well by the water content of dentin and also by the hydroxyapatite mineral, the water is heated and finally vaporized; the vapors remain inside the dental tissues until the pressure building up in the dental hard tissues is enough to disrupt their integration, causing micro-explosions, thereby ejecting dentin particles (water-induced ablation).\textsuperscript{11}

In cavity preparations made by dental burs, bonding of resin to enamel is achieved via micromechanical retention on the roughened surface, whereas the retention to dentin is based mainly on the hybrid layer formation and to a lesser degree to the micromechanical retention offered by the resin tags embedded in dentin.\textsuperscript{12-13}

In cavities prepared by Er,Cr:YSGG lasers, the associated microroughness on both enamel and dentin does not require a change of approach to resin bonding to the enamel. However, the resulting alteration of collagen may lead to the formation of an inferior hybrid layer zone due to incomplete penetration of the collagen fibrils by the hydrophilic primers and resin monomers.\textsuperscript{14} In this case, the resin-dentin bond is favored by resin tag formation.\textsuperscript{15}

The objective of this work was to investigate the possible alterations of human dentin proteins (mainly collagen) following irradiation by an Er,Cr:YSGG laser under different clinically relevant settings. These changes in dentin could affect the hybrid layer formation and the subsequent dentin bonding to resin composite restorative materials.

### MATERIALS AND METHODS

Fifteen standardized dentin sections (each 2 mm thick) were prepared from sound human molars that had been stored in sterile saline, until they were used. From each tooth, a single disc was obtained by using a low-speed saw (IsoMet\textsuperscript{®}, Buehler Ltd., Lake Bluff, Ill., USA) under tap water cooling. The cutting plane was parallel to the occlusal surface of the tooth and in most cases the sections did not interfere with the pulp horns. A groove was made on one side of each section, dividing the surface into two parts. Finally the sections were randomly distributed into three groups.

In groups A and B, one half of each section surface was treated with the settings suggested by the manufacturer for treating dentin and enamel respectively. Settings and calculated energy densities are shown in Table 1. Groups A and C were irradiated at 88 J/cm\textsuperscript{2}, and Group B at 150 J/cm\textsuperscript{2}.

In group C, half of the surface was treated with dentin-treating laser irradiation settings and then both halves (the whole surface) were etched for 15 seconds with 37% phosphoric acid (Enamel Prep Etching Gel, Ivoclar Vivadent A.G., Schaan, Liechtenstein) applied by a disposable brush. This procedure was repeated on all five sections of group C, simulating the etching procedure that usually takes place before the use of composite resin filling materials along with the use of priming and bonding agents.

The main question was: Do all or any of these procedures affect...
dentin collagen, and to what extent? The chosen method for monitoring was the use of 5% ninhydrin solution. Ninhydrin \([2, 2\text{-dihydroxy-1H-indene-1, 3(2H)-dione or } 2,2\text{-dihydroxy-1,3-indanedione}]\) (Merck & Co, Inc., Whitehouse Station, N.J., USA) comes as a monohydrate molecule, forming pale yellow prisms that freely dissolve in water, producing a yellow-colored solution.\(^{16}\) When used as a reagent, upon the presence of free \(\alpha\)-amino acids and carboxyl groups (which in this case come from human dentin proteins, mainly collagen), it yields a blue-reddish color. The degree of coloration is not only a qualitative method but it can also become a semi-quantitative one with the use of a spectroscope. Thus, changes can be precisely detected and measured, compared to a control of a given substrate.\(^{16}\)

After all procedures were completed, according to the protocol, all sections were embedded in 5% aqueous ninhydrin solution for 3 hours. Then all sections were examined by light microscopy (50X up to 1000X magnification) and photographs were taken.

**RESULTS**

All control areas of groups A and B, plus the back side of all sections (groups A, B, and C), had the same appearance: deep blue-reddish color, demonstrating that after dentin was cut with a diamond saw, free \(\alpha\)-amino and carboxyl groups were exposed, originating mainly from the dentin collagen (Figure 1).

In the laser-irradiated area of group A macroscopically, the treated area looked pitted (Figure 2). At 100X (Figure 3) and 200X magnification (Figure 4), small circular craters were observed, which were white centrally, and surrounded by deep blue rings. At higher magnification (500X), the dentin surface was observed to be roughened (Figure 5), and at 1000X magnification appeared to be smear layer-free (Figure 6).

In the laser-irradiated area of group B, macroscopically, a generally roughened dentin with no coloration was observed (Figure 7). At higher magnification (500X), the surface appeared aggressively roughened compared to the treated area of group A, but the surface was smear layer-free (Figure 8).

In the sections of group C, both
the etched-only and the irradiated/etched areas appeared similar in coloration: not as densely colored as the control area (Figure 9). In the areas that were both laser-irradiated and etched (500X), the surface appeared to be like the laser irradiation-only group, only much smoother, with the residuals of the etching procedure apparent in some areas (Figure 10).

DISCUSSION
Earlier studies with other types of lasers showed carbonizations along with crack lines due to thermal effects during the treatment of dental hard tissues. The erbium laser energy is primarily absorbed by the water molecules, converted into kinetic energy, resulting in no carbonization of the irradiated surface and no thermal damage to pulp with clinically relevant energy levels.

In this study, the observation that the treated dentin surfaces were smear layer-free was in agreement with other studies. Collagen alteration was directly related to the energy level used. At the higher energy level studied, more alteration of collagen was observed. Collagen alterations were similarly observed on the surfaces following etching. Other studies that examined the alteration of dentin collagen after acid etching reported a denaturation of collagen, a removal of peptides, changes in collagen conformation in situ, and a collapse of the fibrils. This dentin surface change, prior to bonding agent application, did not seem to negatively affect the formation of a sound hybrid layer. In our study the condition of collagen fibrils of acid-etched or laser-treated dentin was not tested. More research is needed to evaluate the morphological and structural changes of the remaining collagen and the quality of the resulting hybrid layer after the use of this laser under the clinically relevant parameters used.

When the lower energy settings were used, the creation of each crater was the effect of internal explosion of vapors inside the dentin. It looked as though in the center of each crater, along with the dentin removal, there was an area that was free from α-amino and carboxyl groups, while at the periphery there were remains of collagen. This could be explained by the Gaussian profile distribution of the pulse energy. At the higher power settings the treated dentin surface appeared to be collagen-free, and cracked hydroxyapatite crystals remained, giving a rough surface appearance. This roughened surface might not need additional acid etching to achieve a good bond with composite resin filling systems, although other studies showed that acid etching,
following erbium laser irradiation, should not be omitted.\textsuperscript{14, 22-23}  
On the laser-irradiated and etched area there were two observations of particular interest. First, the color was identical to the color of the etched-only surface. Obviously, the laser-irradiated surface was affected by acid etching. The acid removed the free $\alpha$-amino and carboxyl group zone and the cracked hydroxyapatite crystal structures, exposing the collagen underneath toward the surface. The second finding agrees with this hypothesis because under magnification the laser-irradiated and etched surfaces appeared smoother when compared to the laser treatment-only surface, meaning that the acid demineralized the hydroxyapatite crystals that roughened the surface. The question is whether or not this micromechanical roughness following laser treatment is stable and stiff enough for better adhesion. Additional studies are needed to answer these questions.

Since there was no difference on the opposite sides of treated and control areas, it was assumed that both energy levels (88 and 150 J/cm$^2$) were safe for the pulp tissue when there is a 2 mm dentinal wall thickness. These findings are in accordance with the findings of other researchers.\textsuperscript{24}

**CONCLUSION**

The Er,Cr:YSGG laser, when used on dental hard tissues, may be slow to answer these questions. Energy levels (88 and 150 J/cm$^2$) were safe for the pulp tissue when there is a 2 mm dentinal wall thickness. These findings are in accordance with the findings of other researchers.\textsuperscript{24}

The Er,Cr:YSGG laser is used for cavity preparation, the remaining surface is smear layer-free.

**AUTHOR BIOGRAPHIES**

Dr. Eleftherios-Terry Farmakis completed his Undergraduate and Postgraduate studies (MDSc and PhD) in Dentistry at the University of Athens, Greece. He specialized in Endodontics and is a member of Greek Endodontic Society (EEE), American Association of Endodontists (AAE), and International Association for Dental Research (IADR). He has several fields of interest, and one of them is lasers in dentistry. Dr. Farmakis can be reached at elefarm@dent.uoa.gr.

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Dr. Evangelos Kontakiotis received both his dental degree and his PhD diploma from the Dental School, University of Athens, Greece, where he serves as an Assistant Professor in the Department of Endodontics. He has published more than 80 articles, some of which are in the laser field.

Dr. Nikos Kouvelas received his dental degree and PhD from the Dental School, University of Athens, Greece and completed his Pediatric Dentistry specialty in Toronto, Canada. Dr. Kouvelas is an Assistant Professor in the Department of Pediatric Dentistry, Dental School, University of Athens, Greece, and is a member of ESOLA.

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The research was presented at the 1st Congress of European Society for Oral Laser Application (ESOLA) May 2001, Vienna, Austria.

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Advanced Proficiency Case Studies

Charles Hoopingarner, DDS; Steven Parker, BDS, LDS, RCS, MFGDP; and Mary Lynn Smith, RDH were the three most recent recipients of Advanced Proficiency during the Academy of Laser Dentistry’s 2007 Annual Conference in Nashville, Tennessee. This issue of the Journal will continue to feature cases from these clinicians.

Ms. Smith treats a patient with chronic generalized periodontitis. Her therapy includes the adjunctive use of an Nd:YAG laser after scaling is completed with conventional instrumentation. The 1064-nm wavelength 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.

Dr. Parker presents two cases utilizing an 810-nm diode laser. The first case involves soft tissue crown lengthening, uncovering two implant fixtures, and a frenectomy, in preparation for a final fixed bridge. The second case depicts a patient who presents with multiple hemorrhagic lesions caused by trauma on the lower lip. In both treatment plans, the diode laser offers excellent hemostatic assistance during the procedures.

Dr. Hoopingarner treats a patient who desired a more esthetic smile. The treatment plan includes soft tissue crown lengthening, closed flap osseous crest removal, and a maxillary frenectomy — all of which will reestablish a favorable biologic width after the periodontal tissues are modified. He uses an Er:YAG laser for all of the surgical procedures, demonstrating that wavelength’s ability to precisely contour both hard and soft oral tissue.

The excellent results shown in these four cases demonstrate how different laser wavelengths can be successfully utilized by the competent practitioner.
CLINICAL CASE

Nd:YAG Laser-Assisted Treatment of Moderate Chronic Periodontitis

Mary Lynn Smith, RDH; McPherson, Kansas


SYNOPSIS
This article describes treatment of chronic generalized periodontitis including adjunctive use of an Nd:YAG laser.

PRETREATMENT

A. Diagnostic Tests
1. Full Clinical Description
A 58-year-old Caucasian male presented for routine dental prophylaxis (Figure 1). He expressed no chief complaints. His last dental visit was seven months prior. There were previously diagnosed periodontal and restorative concerns. During the hygiene appointment, the health history was reviewed and tissues visually screened for signs of oral cancer. Comprehensive restorative, periodontal, and radiographic exams were completed. Micro-ultrasonic scaling, biofilm removal, and coronal polishing were performed as well. The patient was educated concerning his oral health and probable progression of untreated disease.

The health history revealed he had experienced shortness of breath occasionally, seasonal allergies, episodes of anxiety, and arthritis. The patient was not taking any medications other than over-the-counter pain relievers when needed. He has been treated for anemia and asthma in the past. A recent cardiovascular system evaluation revealed good health. There were no contraindications to treatment. Occlusion was Angle’s Class I on the right, while on the left it was a super Class I. He experienced fatigue in the TMJ with prolonged joint stress. The moderate-to-severe wear pattern of incisal edges indicated probable bruxism. He was missing teeth #1, 8, 16, 17, and 32. Teeth #7 and 9 had drifted mesially. Teeth #4, 14, and 30 were treated endodontically and restored with porcelain-fused-to-metal (PFM) crowns. Tooth #13 had root canal therapy but was left with a large filling, no crown, and was compromised with a mesial fracture. Amalgam fillings were present in teeth #5, 15, and 18.

Tooth #15 had a fractured filling with mesial decay. Decay was noted on the distal aspect of tooth #18.

The patient had been monitored by an oral surgeon since 2002 when a squamous dentigerous cyst with reactive granulomatous inflammation in the right mandible near the TMJ was removed.

Radiographs revealed distal decay on tooth #18. Caries on the mesial aspect of tooth #15 was not detected radiographically. Generalized moderate horizontal bone loss in the posterior was noted.

2. Radiographic Examination
A panoramic radiograph was taken 2 years prior (Figure 2). A radiographic full-mouth series was taken to assess current bone loss and possible caries (Figure 3a). Additional radiographs were taken of the area distal to tooth #31, where a cystic structure was noted (Figure 3b). Tooth #24 exhibited a widened periodontal ligament most likely due to occlusal trauma. Radiographs revealed distal decay on tooth #18. Caries on the mesial aspect of tooth #15 was not detected radiographically.

Generalized moderate horizontal bone loss in the posterior was noted.

3. Soft Tissue Status
The gingiva was inflamed from plaque and calculus located above and below the gingival margin. A complete six-point periodontal...
Smith probing was performed with 5 mm as the greatest pocket depth. Generalized bleeding was evident and moderate subgingival calculus present. Recession of 1 to 2 mm was noted on teeth #3, 5, 6, 11, 12, 13, and 20 buccal and #14, 24, and 26 lingual. Class I furcation involvements are noted on buccal surfaces of teeth #2, 15, 18, 19, and 31, and the lingual surface of #30. No mobility was detected. Figure 4 shows the preoperative probe chart. The examination revealed generalized chronic periodontitis. An oral cancer screening revealed a 4-mm venous lake lower lip left of the midline and an amalgam tattoo on attached mucosa distolingual to tooth #14.

4. Hard Tissue Status
- Occlusion classification was Angle’s Class I on the right and super Class I on the left with severe crowding of lower anterior teeth (Figure 5)
- Missing teeth were #1, 8, 16, 17, and 32
- Mesial drifting noted on teeth #7 and 9
- Attrition noted on teeth #6, 7, 9, 10, 11, 13, 20, 21, 22, 23, 24, 25, and 27
- Significant fracture noted on tooth #15 amalgam and #13M tooth structure
- Endodontically treated teeth #4, 13, 14, and 30; all other teeth vital
- Decay noted on teeth #15M, 18D
- Existing restorations: PFM crowns on teeth #4, 14, 30; amalgam fillings on teeth #5, 15, 18; composite fillings on teeth #13, 15, and 18

5. Other Tests
- TMJ fatigue is experienced with prolonged joint stress.

B. Diagnosis and Treatment Plan
1. Diagnoses
- Provisional diagnosis: Generalized chronic periodontitis
- Doctor’s final diagnosis:
  - Soft tissue: Moderate generalized chronic periodontitis
  - Hard Tissue: Teeth #15MOBL and 18DOB caries
  - Parafunction with excessive wear of anterior teeth
  - Cyst in the right mandible is being monitored by oral surgeon, currently considered nonprogressing and nonpathogenic.

2. Treatment Plan Outline
a. Restorative treatment to include:
   - tooth #13 crown; #15 caries removal and crown or four-surface filling; #18 caries
removal and a three-surface filling.
• an appliance to prevent further attrition from bruxing is indicated. Referral to oral surgeon for follow-up on cyst.
• possible long-term plans include extracting tooth #24 or 25 (depending on prognosis) to re-align teeth orthodontically, and replace tooth #8 with a three-unit bridge or implant.

b. Active phase-I periodontal infection therapy to include four 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
• micro-ultrasonic 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
• micro-ultrasonic 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
• micro-ultrasonic instrumentation for full-mouth bacterial decontamination
• coronal polishing
• laser decontamination of unresolved areas
• intraoral photos
• 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 are 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
Restorative treatment: Caries removal from teeth #15 and 18 with composite restorations of #15 on the MOBL surfaces and #18 on the DOB surfaces. A referral to an oral surgeon was made for follow-up on the cyst. Other restorative needs were discussed and will be treated in phases at the completion of periodontal therapy.

B. Periodontal Treatment Objective
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 provide the patient with customized education in specific daily plaque management techniques, ensuring maximum rehabilitation of the tissues.
Beginning with the most infected teeth, each appointment will address quadrants 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 quadrant 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. Instrumentation with the ultrasonic is concentrated on the cervical area of tooth structure and the fiber was calibrated to 1 mm less than the previous application. This continues the reduction of bacterial load and enhances the body’s healing response.

C. Laser Operating Parameters
A free-running pulsed Nd:YAG laser (PulseMaster 600 IQ, 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 approximately 40 seconds per site; for superficial coagulation, the settings were 100 mJ and 20 Hz, with an average power of 2.0 Watts for approximately 20 seconds per site. The total laser emission time for the four sessions of periodontal infection therapy was 76 minutes.

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

- review of health history
- plaque management assessment and instruction
- anesthetic consisted of topical administered at the gingival margin and subgingival areas. A compounded preparation called TAC (20% lidocaine, 4% tetracaine, and 2% phenylephrine, was applied
- micro-ultrasonic and hand-instrument debridement of root surfaces
- laser decontamination and superficial coagulation of pocket epithelium
- postoperative care instructions given
- pre- and postoperative photographs.

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.

Quadrants were addressed in each therapeutic appointment. Examples of initial treatment are shown in the following figures:
Figure 8a shows the initial pocket on the distolinguinal of tooth #3; 8b shows the laser treatment; and 8c shows the immediate postoperative completion of coagulation. Figure 9a shows the initial pocket...
E. Postoperative Instructions
Postoperative instructions were given verbally and in 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 recommended for a week. Subgingival flossing was 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 had no complications during or after the laser treatments. At the conclusion of the first therapeutic appointment, he requested 400 mg of ibuprofen for possible jaw discomfort postoperatively. No pain reliever was needed after other appointments.

G. Prognosis
Prognosis is good as long as he conforms to good oral hygiene and recommended intervals for professional supportive maintenance visits. An appliance to prevent further attrition and possibly relieve excessive occlusal stresses related to bruxism is indicated. Restorative treatment planning prioritizes caries removal and restoration of teeth #15 and 18; then, a crown on tooth #13, which was previously treated endodontically, to prevent breakage or tooth loss.

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, 20 weeks, and 8 months following the initial laser therapy. He was not compliant with recommended intervals for therapy care. Periodontal charts show comparative data of the initial state to 20 weeks post-therapy as well as eight months post-therapy. Significant improvement is noted as 92% reduced hemorrhaging sites and 77% reduced periodontal sites.

The one-week examination revealed that the tissues were healing and the patient’s skill in plaque management was improving. Figure 10a shows the one-week view of tooth #3 and 10b shows tooth #19.

Six week post-therapy re-infection assessment appointment was missed due to work-related issues.

Twenty-week post-therapy appointment:
The patient is becoming more compliant with the recommended interval for professional care and is maintaining improved plaque control. Tissues are exhibiting signs of improved health such as
decreased probing depths, decreased bleeding on probing, normal tissue coloration and texture, and normal mobility. This appointment included:
• health history review
• 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
• micro-ultrasonic 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, 1.8 Watts average power, delivered with a 400-micron contact fiber for 7 minutes total emission time. Oral hygiene instructions were reviewed. There was a 92% decrease in hemorrhaging, 77% decrease in periodontal sites, and 77% fewer teeth with pocketing.

Figure 12a shows the 20-week probing of tooth #3 and 12b shows tooth #19.

Eight-month post-therapy appointment:
The patient reported very high stress since the last appointment and decreased consistency in daily plaque management routine. Periodontal chartings compare initial, 20-week and 8-month data. There was a slight increase noted, but reasonable results were maintained. The 8-month therapeutic appointment included:
• health history review
• oral cancer screening
• six-point pocket and hemorrhaging periodontal charting (Figure 13)
• assessment of the patient’s plaque management, refining techniques and continuing motivation for thorough daily care
• micro-ultrasonic 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, 60 mJ, average power of 1.8 Watts. Emission time totaled 8 minutes. Long-term follow-up is illustrated: Figure 14a shows the probing of tooth #3 and 14b shows tooth #19.

B. Complications
The patient had no complications related to laser treatments either during or after therapy. He had no soft or hard tissue damage. He was pleased with the results from the laser.

C. Long-Term Results
Caries removal from teeth #15 and 18 with composite restorations of #15 on the MOBL surfaces and #18 on the DOB surfaces were completed following periodontal infection therapy.

At 20 weeks post-therapy there was marked improvement. At 8 months post-therapy, the lower anterior required additional therapy but the molar areas were maintaining improved health. The 8-month periodontal charting compared to his initial state shows improvements of 83% in hemorrhaging, 70% in perio sites, and 59% of teeth affected (Table 1). Figures 15a and 15b show the comparison of tissues initially and at 8 months post-therapy.

D. Long-Term Prognosis
Although the intervals between therapeutic appointments were not optimal, good results were realized and a good prognosis exists. Good oral hygiene and 12-week supportive therapy must continue. An electric toothbrush with small
heads for greater cleaning efficiency, particularly in the crowded lower anterior region, would be beneficial to the patient’s oral health. If restorative plans are not carried out, periodontal issues may persist due to crowding on the lower and further shifting of the upper teeth. It is critical to reinforce that periodontal disease is site-specific and episodic in nature. It is not cured but maintained through appropriate daily care and recommended professional care.

Following customized recommendations will ensure the best results. Tooth #13 has a guarded prognosis if it is not restored with a crown. An appliance to prevent further attrition and provide relief from excessive occlusal forces related to bruxing would preserve the dentition and temporomandibular joint from unnecessary cumulative damage. The oral surgeon gave a good prognosis regarding the site of the previous cyst, stating it was nonprogressing and nonpathogenic. Long-term plans to extract tooth #24 or 25 (depending on prognosis) and re-align anterior teeth orthodontically, as well as replace tooth #8 with a bridge or implant, will be discussed at a later time.

**AUTHOR BIOGRAPHY**
Mary Lynn Smith is a registered dental hygienist, working clinically for more than 12 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.

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**Table 1: Results of Laser-Assisted Therapy**

<table>
<thead>
<tr>
<th>Treatment Assessment Interval</th>
<th>Number of Sites with Bleeding on Probing</th>
<th>Number of Sites with Periodontal Pockets 4 mm or Greater</th>
<th>Number of Teeth with Beyond-Normal Periodontal Pocketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning</td>
<td>48</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>20 Weeks</td>
<td>4</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>8 Months</td>
<td>8</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Rate of Improvement After 6 Months</td>
<td>83%</td>
<td>70%</td>
<td>59%</td>
</tr>
</tbody>
</table>

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**Figure 15a: Preoperative full smile at presentation**

**Figure 15b: Eight-month postoperative full smile**

**Figure 15:** Comparison views.
Use of an 810-nm Diode Laser in a Combined Gingivoplasty, Frenectomy, and Second-Stage Implant Recovery Procedure

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Editorial Note: Although the photographic images are overexposed, they do show well the points made in the article and captions.

SYNOPSIS

Multiple procedures using a diode laser are described prior to placement of a fixed bridge.

PRETREATMENT

A. Outline of Case

1. Full Clinical Description

A 78-year-old male patient attended for a routine examination (Figure 1). He had been a regular patient of the practice during a three-year period and had received only examination and hygiene maintenance at six-monthly intervals. At his current visit, he expressed a need to evaluate the possibility of replacing his existing upper and lower cast chrome-cobalt partial dentures with fixed prostheses. He was advised that treatment would involve the provision fixed bridgework in three quadrants, with additional support through implant-retained abutments in the upper left quadrant.

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 occlusion, with normal Frankfort and maxillary (FMP) angle.

3. TMJ

Examination of both temporomandibular joints, through palpation and radiograph, revealed normal structure and movements. Opening / closing and excursive movements of the mandible revealed no abnormality. With the dentures in place, there was group function of posterior quadrants on both sides. This was noted for duplication in the new prostheses.

4. Radiographic Examination

Panoramic (Figure 2) and periapical radiographs were taken to establish both dental and alveolar bone status prior to treatment. 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. It was noted that there was sufficient alveolar bone in the edentulous upper left region, to allow the placement of dental implants (Figure 4). There was visual evidence of retained root fragments associated with extractions in both maxillary molar regions.

Figure 1: Preoperative view at presentation

Figure 2: Preoperative panoramic radiograph showing several implant fixtures fully osseointegrated

Figure 3: Preoperative periapical radiograph of tooth #9
5. Soft Tissue Status

**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. The loss of teeth in the upper left quadrant had resulted in some loss of postextraction keratinized gingival tissue. This was of concern in the bicuspid region, where there was a low frenal attachment, as shown in Figure 5.

**Gingival soft tissues:** All natural tooth sites were examined with a periodontal probe and findings recorded, as shown in Figure 6. Of specific relevance to the treatment provided, there was some false pocketing at tooth #9, with recorded depths of 3 mm on mesial, distal, and facial aspects. Generally, the attached gingiva appeared thickened, yet healthy in appearance (Figure 7). Such hypertrophic change may have been due to antihypertensive medication and did not merit any further intervention. The general level of oral hygiene was considered good with signs of calculus deposits only on teeth #22, 23, and 26.

6. Hard Tissue Status
At the time of initial active-treatment assessment, the following teeth were charted as missing:
- Upper jaw: #1, 3, 4, 7, 10, 11, 12, 13, 14, and 16.
- Lower jaw: #17, 19, 20, 27, 28, 29, 30, and 32.
- Tooth #9 had been restored with a porcelain-fused-to-metal (PFM) crown, and teeth #2, 5, 18, and 31 restored with amalgam. There was evidence of caries distally at tooth #18. The PFM crown at tooth #9 had been re-cemented several times and this may have been due in part to a short clinical crown height.
- **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 presenting oral condition and the proposed treatment plan, it was considered that no further tests were appropriate.

B. Diagnosis and Treatment Plan

1. Provisional Diagnosis
Treatment for this patient to fully restore his dentition in accordance with his preferences would involve several stages, including implant placement and fixed bridgework.

2. Final Diagnosis
Laser-assisted treatment could be assigned in accordance with the following clinical needs:

   a. **Gingivoplasty at tooth #9** to remove hyperplastic tissue and achieve some crown-lengthening. The disparity in gingival levels with tooth #8 was acceptable to the patient and the amount of bone and gingival tissue removal required to achieve a balanced appearance was considered prejudicial to the long-term survivability of tooth #9.

   b. **Second-stage recovery of implants placed in the upper left cuspid, bicuspid, and molar regions.**

   c. **Lateral frenectomy of low attachment of buccinator fibers to preserve attached gingiva associated with the bicuspid implant.**

The final diagnosis reflected the observations and needs outlined above.

3. Treatment Plan Outline

   General: Three dental implants would be placed in the upper left quadrant, as part-support for fixed bridgework. In addition, bridgework would be provided in the other three posterior quadrants.

   Specific: In order to facilitate optimal soft tissue profiles for both natural and implant abutments in the upper left quadrant, it was
decided to use an 810-nm diode laser to remove hyperplastic gingival tissue associated with tooth #9, to effect second-stage recovery of the implants, and to carry out a relieving frenectomy at the lateral frenal attachment of superficial buccinators fibers.

4. Indication and Contraindications

**INDICATIONS**

**Treatment:** In all 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 of tooth and implant sites. In addition, an optimal definition of a stable gingival margin at tooth #9 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 interactions in surgical procedures are predominately 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 keratinized and nonkeratinized 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 situation of a well-fitting partial denture. However, in view of the patient’s wishes, this alternative was abandoned. Consequently, 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 connective tissue attachment, 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** – lip line height, etc. in placement of the final gingival contour. Is the patient accepting of the contour, should it match the adjacent teeth, does the lip hide it anyway, and so on.

**Laser:** Any surgery using laser energy carries some risk of tissue damage and this possibility 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, as well as 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.

**Gingivoplasty:** 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.

**Second-Stage Implant**

**Recovery:** Care should be exercised to accurately locate the position of the implant. Tissue ablation should proceed slowly and with care to remove any char. Wherever possible, direct contact with the cover screw or any surrounding crestal bone should be avoided.

**Lateral Frenectomy:** Tissue resection during laser incision will assist the ability to resect using minimal power parameters. In addition, the laser fiber tip should be angled as near possible, parallel to the alveolar bone, to avoid damage to the hard tissue and periodontium.

6. Treatment Alternatives

Alternative methods for soft tissue incision would include a scalpel, electrosurgery, and soft tissue punch for implant sites.

7. Informed Consent

The treatment plan was fully explained to the patient and all associated risks 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

1. **Laser:**
   - A diode laser (DioLase ST, American Dental Technologies, Corpus Christi, Texas) was used. The operating features are as follows:
     - **Wavelength:** 810 nm
     - **Co-axial aiming beam:** Diode Class I laser 630-680 nm, 3 mW
Emission mode: Continuous wave (CW) with supplementary gated CW, single 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.

2. Laser settings:
- Gingivoplasty / second-stage implant recovery: 1.4 W CW / contact mode. Time taken per site: 1-2 minutes.
- Lateral frenectomy: 1.7 W CW / contact mode. Time taken: 1-2 minutes.

C. Treatment Delivery Sequence

1. 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. 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 that 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.
- Patient seated: review treatment plan and informed consent.
- Safety: place eye protection, patient first followed by operating personnel.

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

**Gingivoplasty tooth #9:** Laser power setting: 1.4 Watts CW. The soft tissue pocket was explored with a periodontal probe. The laser fiber was lightly initiated using articulating paper and, perpendicular to the surface, a series of points were developed on the labial gingiva to outline the incision line (Figure 8). With a light contact of the fiber with 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, as shown in Figure 9. The final excess tissue removal was achieved with a sharp curette, as shown in Figure 10. In this way, direct contact with the underlying tooth was avoided.

**Second-Stage Implant:** Laser power setting: 1.4 Watts CW. At each site, the location of the cover screw was identified with an explorer. With the fiber freshly cleaved and lightly initiated, a circular incision was developed in the overlying keratinized gingiva. This was gradually deepened, with care to avoid the build-up of char, until the cover screw was uncovered. Excess tissue was removed to completely expose the extent of the screw and healing caps were placed (Figures 11-13).
Lateral Frenectomy: Laser power setting: 1.7 Watts CW. The buccal tissue was placed under tension to identify the profile of the muscle fiber insertion. The optic fiber was freshly cleaved and lightly initiated. With the fiber held perpendicular to the tissue surface and parallel to the alveolus at 2-3 mm away from fixed gingival tissue, an initial incision was performed. With the tissue under tension, the incision was developed to a depth where superficial muscle fibers were parted, as shown in Figure 14, and no blanching or movement of gingival tissue was observed. Care was taken to avoid char build-up in the tissue or on the fiber tip and the incision was restricted to achieve the surgical objective (Figure 15).

At this time, adjunctive treatment including implant healing cap placement was carried out and the denture adjusted to allow correct seating.

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 should 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 and softening and hydration of loose tissue at the frenectomy site at 3-5 days post-operation. The patient would be reviewed at one week and light toothbrushing commenced at the tooth site. 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. The healing was progressing well, as shown in Figures 16 and 17. At two weeks, the healing caps were removed to inspect the tissue contour around the implants, and the contours were excellent (Figures 18-20). The gingivoplasty site resolved rapidly at two weeks and the frenectomy site gradually healed during four weeks after surgery. The implant abutments (Figure 21) and the telescoping thimble on tooth #9 (Figure 22) were fitted during this time. Shortly thereafter, the final prosthesis was delivered, as shown in Figure 23.

Subsequent appointments at weekly intervals allowed regular review of the tissue. The soft tissue sites were therefore regularly reviewed initially and at three months, six months, and one year. Figure 24 shows excellent gingival health and minimal pocket depth around tooth #9 and identical findings existed around the three implants, as shown in Figures 25-27. In all cases, the healing was as expected and normal oral function was maintained. Tooth #9 was vitality-tested and a positive response recorded. Figure 28 shows the six-month postoperative view, and Figure 29 depicts a panoramic radiograph at that same interval. The 10-month probing chart, shown in Figure 30, exhibits good periodontal health.

The one-year postoperative view of the prosthesis is shown in Figure 31. At one year, the tissue tone is excellent and the physiologic contour shows very good adaptation to the abutments. Periodontal probings of the implant abutments, shown in Figures 32-34, demonstrate excellent tissue attachment. Radiographs at one year also confirm the health and fit of the restorations (Figures 35-37).
B. Complications
No long-term complications were observed. Some concern was expressed that the amount of attached gingiva adjacent to the frenectomy site might compromise the health and function of the implant cuff, but this tissue has remained stable and normal in appearance.

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. He 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 is in 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 in 2000. He is an ALD-Recognized Standard Proficiency Course Provider. He has held consultancies with multiple laser companies and has presented courses, lectures, and workshops worldwide. He has authored numerous articles on the use of lasers in dentistry, including a chapter “The Use of Lasers in Fixed Prosthodontics” in the October 2004 Dental Clinics of North America. Dr. Parker was the 2005 President of the Academy of Laser Dentistry. Dr. Parker may be contacted by e-mail at thewholetooth@easynet.co.uk.

Disclosure: Dr. Parker has no current affiliations with any company.
Establishing a Maintainable Esthetic Gingival Smile Line with an Er:YAG Laser

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SYNOPSIS
This article describes aesthetic crown lengthening involving both soft and hard tissue.

PRETREATMENT
A. Outline of Case
1. Full Clinical Description
A 31-year-old black female presented with no significant medical conditions or limitations to treatment. Her vital signs were within normal limits (blood pressure 100/70, pulse 67). She had no known allergies and was taking no medications. The patient had small occlusal restorations on teeth #30 and 19. She had a resin-based crown on tooth #8, which was placed approximately 8 years prior to the examination date. Teeth #16 and 17 were impacted with no oral communication. The teeth were in Class I dental occlusion. Her chief complaint was an unaesthetic gingival presentation in the maxillary anterior region. She stated that her “crown was too short” (Figure 1).

2. Radiographic Examination
A panoramic radiograph and decay-detecting radiographs were evaluated, revealing a normal bone contour and impaction of teeth #16 and #17. No interproximal carious lesions were present. A periapical film of tooth #8 is shown in Figure 2.

3. Soft Tissue Status
Oral cancer screening was negative. Probing depths were 2-3 mm in all but the molar areas (Figure 3). She had 3-4 mm depths in the upper right and upper left molar areas. There was a high fibrous frenum attachment in the maxillary midline. There was slight blunting of the papillae in general and generalized marginal gingivitis in the posterior segments. The anterior segment was characterized by excessive fibrous gingival display.

4. Hard Tissue Status
There were no carious lesions detected and no direct indication for vitality testing except for tooth #8 which tested vital. There was no mobility or fremitis.

5. Other Tests
There was modest tooth wear and faceting present. There was no muscle or joint tenderness, joint sounds, or limitations in range of motion present. Smile evaluation revealed excessive gingival display.

Figure 1: Preoperative full smile
Figure 2: Periapical radiograph of tooth #8
Figure 3: Preoperative charting showing minimal pocket depths in anterior areas
and a width-to-length ratio of 110%. The gingival extension on the maxillary centrals was significantly more incisal than that of the canines.

B. Diagnosis and Treatment Plan
1. Provisional Diagnosis
Mild generalized chronic gingivitis, excessive gingival display, gingival hyperplasia adjacent to teeth #7-10, incisally positioned maxillary midline frenum which could possibly put tension on the gingival tissues if the gingival margin were raised to the planned level.

2. Final Diagnosis
Mild generalized chronic gingivitis, excessive gingival display, gingival hyperplasia adjacent to teeth #7-10, incisally positioned maxillary midline frenum which placed tension on the gingival margin. Additionally, the existing resin crown restoration on tooth #8 was found to be defective. After contouring the gingiva appropriately there was an inadequate attachment width present resulting in a violation of the biologic width.

3. Treatment Plan Outline
The objective was to perform gingival and osseous recontouring with an Er:YAG laser to allow for ideal aesthetic width-to-length ratio throughout the maxillary anterior segment. The laser would also be used to revise the maxillary frenum attachment. Therapy for gingivitis is to consist of oral hygiene review and motivation, dental prophylaxis, and follow-up fine scale and polish. Tooth #8 will be restored with a modified pressed ceramic crown.

4. Indications for Treatment
Indications for gingival recontouring are largely aesthetic. However, it was felt that over the life of the dentition the hyperplastic tissue would be a contributing factor to decreased periodontal health in the anterior segment. The esthetic contouring will be achieved by both gingival sculpting and osseous removal. Frenum revision was indicated to prevent apical migration of the gingival margin on teeth #8 and #9. Although for financial reasons the restoration was done as a second-stage procedure, the Er:YAG laser would have allowed for immediate restorative treatment. Compared to conventional modalities, this wavelength has the advantage of decreased healing time with minimal patient discomfort. The Er:YAG laser is also beneficial since it can be utilized for both soft tissue ablation and osseous recontouring for biologic width maintenance. Final gingival position is very predictable using this laser and scoring of the periodontium is easily accomplished during the frenum revision.

5. Contraindications
There were no contraindications for treatment. However, care in treatment planning must be exercised to leave an adequate dimensional band of gingival tissue to prevent mucogingival dehiscence.

6. Precautions for Wavelength
Six precautions for Er:YAG 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. In particular, care must be taken to avoid premature osseous ablation when using the laser without cooling water spray. This may be done by directing the light energy perpendicular to the tooth during soft tissue removal until the tissue can be easily removed by hand instrumentation or sequentially removing some osseous tissue prior to completion of the final soft tissue contours. Another alternative is to use a water spray when applying laser energy to the soft tissue when it may be possible to encounter osseous tissue. Adequate water spray must be used during the osseous phase. The angle of energy application is also critical in avoiding the tooth itself. Care must be used to avoid interacting with tooth structure. Care must be taken to avoid 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.

7. Treatment Alternatives
Conventional periodontal surgical procedures with subsequent healing time prior to restoration would be treatment alternatives. No treatment was also an alternative.

8. Informed Consent
After a discussion of risks and possible complications, written informed consent was obtained for both the surgical and restorative procedures.

TREATMENT
A. Treatment Objectives
Strategy
The periodontal tissue of the maxillary anterior teeth will be recontoured with an Er:YAG laser to establish proper soft tissue heights and proper tissue scallop and zenith of the individual teeth. To establish an attachment distance consistent with the patient’s biologic width, osseous recontouring will be performed, and the frenum attachment will be revised along with scoring the periodontium to prevent reattachment.

In order to achieve the aesthetic goals, the gingival tissues must be contoured from tooth #6 across to #11, leaving the cuspids and centrals at the same level and the lateral incisor 0.5 mm incisal to that level. To achieve a 77.5% width-to-length ratio, it would be necessary to remove 4.5 mm of gingival tissue. Since there was adequate gingival tissue present, the limiting factors were the location of the cemento-enamel junction (CEJ) (which should not be exposed) and the position of the osseous crest. Probing indicated the osseous crest to be 5 mm apical to the gingival margin. To maintain the patient’s individual attachment width of 1.75 mm (connective tissue...
attachment and epithelial attachment) and allow for 1 mm of sulcus depth, osseous recontouring was necessary. The gingival revision is performed and then the osseous tissue is recontoured to a level 2.75 mm apical to the intended free margin of the gingiva. The Er:YAG laser has the advantage of being able to utilize for both soft tissue ablation and osseous recontouring for biologic width maintenance and scoring the periosteum. The restoration on tooth #8 was replaced as a secondary procedure.

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, and 1200 x 300-micron chisel tip for tissue and osseous 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 using light contact and defocused pattern
- Repetition rate: 30 Hz
- Continuous air only for soft tissue surgery; reduced volume of water spray for osseous procedure

Laser settings:
- Soft tissue ablation: 30 Hz and 50 mJ, air cooling and no water
- Frenum revision, 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 an 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. 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 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.

Figure 4a shows the caliper used for width-to-length measurement. After calculation, the periodontal probe was placed at the desired new tooth length, as depicted in Figure 4b. 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 subsequently marked, as shown in Figure 5. The refined intended gingival finish line was appreciated and indicated with tissue-marking ink.

The laser was set with a chisel-shaped quartz tip at an energy setting of 50 mJ and repetition rate of 30 Hz. The gingival tissues were then ablated to the level of this marking without the use of water spray, as seen in Figure 6. This was done using axially directed noncontact strokes until the desired amount of tissue was ablated, while stopping short of scoring the tooth itself. The tissue was beveled (Figure 7). The bulk of the tissue was then removed by instrumentation, and the final tissue contour was performed with the laser, paying close attention to establishing the proper alignment and zenith placement. All teeth in the segment were treated in this manner, and Figure 8 shows the immediate soft tissue surgical result.

Next, the distance to the crestal bone was probed (Figure 9). The intended biologic width was reestablished by projecting the patient’s individual biologic width
Hoopingarner

onto the tissue and confirming adequate gingiva remained to complete the osseous recontouring.

The osseous tissue in this case was contoured using a 400-micron tip at 30 Hz and 50 mJ with adequate water spray. The protective sleeve on the tip was measured at 3 mm and used as a depth guide during the procedure, as shown in Figure 10. (Tips lacking a convenient sleeve length can be marked with a stopper or ink for reference.) Care was taken to avoid emphysema by compressing the tissue with digital manipulation and decreasing the cooling air pressure. The bone was then beveled with the chisel tip in a noncontact defocused mode with water spray (Figure 11).

Care was taken to extend the recontouring interproximally and through to the palatal surface. The contact-area-to-osseous-papilla-crest distance was not allowed to exceed the 4.5 mm level.

Figure 12 depicts the biologic width measurement, which was confirmed at 2.75 mm from the osseous crest to the intended final free gingival margin. The immediate postoperative view of the final tissue contouring is shown in Figure 13.

The frenum was then revised with longitudinal noncontact strokes that were directed around larger vessels until all fibrous bands had been ablated. This was accomplished using a chisel tip with no water spray at 30 Hz and 50 mJ of energy. The effectiveness of the revision was checked by confirming that there was no tension present on the gingival tissue when elevating the upper lip. The tip was then rotated 90 degrees and with the addition of water spray the periosteum was scored to the level of the bone using horizontal light contact strokes, as shown in Figure 14. Again, care was taken to avoid emphysema by reducing the cooling air and applying digital pressure around the operated area. Figure 15 illustrates the completed frenum revision.
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 non-sulcular brushing with an ultrasonic brush dipped in hot water and gentle flossing. Emergency care contact numbers were given. No analgesics were prescribed and the patient was instructed to take over-the-counter ibuprofen if necessary.

E. Complications
No complications arose during surgery or recovery.

F: Prognosis
Due to the extent of the tissue bulk removed, some variation in tissue position may occur and require slight soft tissue revision. This was particularly expected in the area of the poorly contoured crown on tooth #8. The overall prognosis was very good for tissue health maintenance and esthetic acceptance.

G: Treatment Records
The treatment record reflects the treatment described including estimated exposure times totaling 37 minutes and postoperative instructions.

FOLLOW-UP CARE
A. Assessment of Treatment Outcome
The patient was assessed at 4 days, 2 weeks, 6 weeks, and 10 weeks and has returned to a semiannual recare program in our office. At 48 hours there were no pain reports and the tissues, while reddened, showed no sign of infection. Healing appeared to be progressing nicely. The 4-day postoperative view is shown in Figure 16.

At two weeks (Figure 17) there were no complications. Oral hygiene was excellent. Expectedly, the tissue was rebounding on the undercontoured tooth #8. This was remedied at 6 weeks with the restoration of proper contour and emergence profile.

Tooth #8 was prepared and a provisional restoration was placed using a BIS-GMA resin. A Lucite®-reinforced pressed ceramic material, IPS Empress® (Ivoclar Vivadent Inc., Amherst, N.Y.), with cut-back and refractory porcelain correction was fabricated and cemented at 10 weeks.

B. Complications
No complications were appreciated. No analgesic medication was necessary. While there was the expected immediate postoperative tenderness, there was no infection. Since the patient followed instructions and did no sulcular brushing for one week, the reattachment was not impeded.

C. Long-Term Results
At 6 months (Figure 18) the tissues were maintaining a good level of health. The patient had maintained a healthy aesthetic gingival display and there were no further changes to gingival contour once the definitive restoration was placed. Figure 19 shows an 18-month postoperative view, with the tissues stable. At 21 months, radiographs depict a healthy periodontium (Figure 20); the intended tooth length was maintained and there was a 1 mm sulcus present, as shown in Figure 21.
D. Long-Term Prognosis
The patient has now been seen on re-care evaluation for nearly two years and has shown no sign of inflammation, regression, or recurrence of the hyperplasia. Sulcus depth has remained constant at 1 mm. While there is a color variation where the incisal extent of the frenum was not revised, there has been no reattachment incisal to the scored periosteum. There is an excellent prognosis for continued health and aesthetics.

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 the Treatment of Multiple Hemangiomata of the Lip

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SYNOPSIS

The use of a diode laser for dealing with multiple hemorrhagic lesions is described.

PRETREATMENT

A. Outline of Case

1. Full Clinical Description

A 68-year-old female patient attended for treatment including the provision of dentin-bonded crowns at several tooth sites. At examination, it was noted that there were several discrete pigmented lesions of the right lower lip, which appeared to be blood-filled. Otherwise, the appearance and function of the lip was normal.

MEDICAL HISTORY

The patient was in general good health. She had been receiving hormone replacement therapy for many years and had recently been prescribed statins for hypercholesterolemia, which was maintained within normal limits.

DENTAL HISTORY

The patient had been a regular and well-motivated attendee of the practice during many years. Teeth #1, 12, 16, 17, 19, 28, 29, and 30 had been lost, with the latter three being replaced by a fixed bridge (Figure 1). Her general oral health was good, with no caries, and the periodontal condition was satisfactory. The lesions on the right lower lip had appeared during a period of several months. Although considered unsightly, they did not arouse any concern for the patient.

2. Occlusion

The patient had an increased overbite at 5 mm and slightly retroclined upper incisors, although these had been cosmetically enhanced by crowning. Her molar relationship, together with the incisal appearance, was consistent with a Class II division 2 occlusion.

3. TMJ

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

4. Radiographic Examination

The presentation and scope for treatment of the lip lesions did not warrant any radiographic investigation.

5. Soft Tissue Examination

General oral soft tissue: Examination of all oral 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. Regional lymph node palpation was normal.

Specific: The appearance of the pigmented lesions on the lip was consistent with some traumatic etiology. There was no associated pulse on palpation, nor was there...
any emptying of each lesion on pressure, such findings being consistent with a cavernous hemangioma. As such, each lesion was discrete, with a nonpedunculated base and a thin epithelial cover (Figures 2-3).

6. Hard Tissue Status
Further to the comments above, the general hard tissue status was good, with multiple full-veneer crown restorations that were satisfactory.

7. Other Tests
In view of the age of the patient and presentation of the lesions, it was felt prudent to contact the patient's general medical practitioner. Although no tests specific to this proposed oral treatment were arranged, systemic conditions such as any blood dyscrasias were eliminated through her recent treatment of hypercholesterolemia and there was no report of any skin ecchymosis, suggestive of blood vessel fragility. It was concluded that the lip lesions were due to isolated capillary dilatation and probably traumatic in origin. Further questioning of the patient did not reveal any contributory factors such as lip-biting.

B. Diagnosis and Treatment Plan
1. Provisional Diagnosis
A provisional diagnosis was made of unsightly multiple raised hemorrhagic lesions of the lower lip.

2. Final Diagnosis
Following the investigations outlined above, it was felt that these lesions were isolated hemangioma of possible traumatic origin. Laser-assisted treatment could be assigned in accordance with the need to excise these unsightly lesions with minimal tissue disruption or postoperative complication.

3. Treatment Plan Outline
It was felt that, with the use of a laser wavelength that would maximize the interaction with blood pigments, these lesions could be excised and contributory capillary supply sealed to prevent recurrence. In view of the need to anticipate unforeseen bleeding, it was felt prudent to administer an adrenaline-enhanced local anaesthetic, and to have hemostat instruments in case of hemorrhage.

4. Indication and Contraindications

**INDICATIONS**

**Treatment:** In all areas of soft tissue management within this treatment plan there is an ideal in achieving hemostasis, consistent with the need to provide unhindered access to the surgical site. The appearance of these lesions was cosmetically distracting and potentially hazardous due to the inherent fragility. 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 are predominately 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 in this case are melanin (tissue pigment) and hemoglobin. In addition, the prime needs of treatment would be to achieve tissue ablation with hemostasis, indicating the optimal 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 situation. However, in view of the recent etiology and a presumed wish to prevent further exaggeration, together with the presumed improvement in function and aesthetics, such inaction could not be justified.

**Laser:** Any surgery using laser energy carries some risk of tissue damage and this possibility must be borne in mind.

**Wavelength:** The choice of a longer wavelength would offer a more superficial level of tissue ablation. However, in view of the need for hemostasis, longer wavelengths would require greater power parameters in order to induce conductive heat effects and this may prove damaging. Other near-infrared or visible wavelengths such as Nd:YAG (1064 nm) or KTP (532 nm) would prove suitable for such surgery, subject to correct power parameters.

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 laser wavelength in oral soft tissue is less, which would reduce the risk of collateral thermal damage. Nonetheless, the use of minimum power parameters, and 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.

General precautions applicable to the use of the 810-nm diode laser wavelength would include the need to observe caution in continuous-wave laser energy delivery. Sufficient interaction to ablate structural components may not be sufficient to provide hemostasis, and power required to achieve control of blood flow may be injurious to
surrounding soft tissue. Consequently, the ability to accurately deliver laser energy through an optic fiber can do much to prevent unwanted tissue exposure. In addition, during such procedures as this, there will be a rapid accumulation of denatured proteinaceous material onto the fiber tip and care must be exercised to remove such accumulations in order to minimize carbonization of debris. Further care should be exercised to avoid the temptation of using the optic fiber as a scalpel; it is essential that, although in contact with the tissue, the fiber be used solely as the conduit of laser energy and therefore play no part in the incision of tissue through mechanical force.

Specific precautions relate to the precise delivery of laser energy to isolated soft tissue sites; wherever possible, nontarget tissue should be protected through the placement of damp gauze and positioning of a high-speed suction tube in the line of the laser beam. In addition, no reflective surfaces such as a mouth mirror should be used. The target lesion should be placed under tension, using tissue forceps to facilitate incision using minimal power parameters. Points of excessive bleeding should be treated with increased power, sufficient to induce coagulation without causing collateral damage.

6. Treatment Alternatives
Alternative methods for soft tissue incision would include a scalpel with possible associated suture placement or electrosurgery.

7. Informed Consent
The treatment plan was fully explained to the patient and all associated risks 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 an 810-nm diode laser, with minimal peri- and postoperative complications.

B. Laser Operating Parameters
- 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 630-680 nm, 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:
  - Excision of hemangioma: 1.7 Watts. Selective coagulation of bleeding points: 2.0 Watts.
  - Time taken per site: 1-2 minutes, with intervals. Total time taken: 6 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.
- Patient 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 adrenalin) was administered. The laser was programmed to deliver 1.7 Watts CW and the laser fiber was lightly initiated using articulating paper. Each lesion was treated in turn; using tissue forceps; each lesion was placed under tension.
under tension and the fiber tip applied to the base. The laser energy was delivered to the tissue in a brush stroke to initiate an incision, with the fiber tip in contact mode with the tissue (Figure 4). This was developed to expose half of the lesion base. At this time, due to breach of the epithelium, some bleeding occurred which was controlled by increasing the power output to 2.0 Watts and applying the fiber tip within the bleeding site (Figures 5-6). With the absorption of energy, there was evidence of coagulation of the blood (Figures 7-8). Once controlled, the coagulum was wiped clear with a damp gauze and the process continued until a flat surface was obtained and the lesion excised, using a reverted 1.7 Watts setting. Finally, the fiber was cleaned and applied in a noncontact mode, 1-2 mm away from the surface, to define a protective coagulum (Figure 9). The process was repeated for the other treatment sites (Figures 10-11).

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 would change, with detachment of the coagulum and softening and hydration of the tissue at 3-5 days postoperation. The patient would be reviewed at one week. 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. 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, with successive examination thereafter at one month, three months, and six months (Figures 12-15). In all cases, the healing was as expected and normal lip function was maintained.

B. Complications
No long-term complications were observed.

C. Long-Term Results
The long-term results are in keeping with the objectives of the original treatment. The patient was very satisfied with the outcome. No further lesions appeared.

D. Long-Term Prognosis
The long-term prognosis of the treatment provided should be considered as good. The original etiology remained speculative.

AUTHOR BIOGRAPHY
Dr. Steven Parker studied dentistry at University College Hospital Medical School, University of London, UK and graduated in 1974. He is in 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 in 2000. He is an ALD-Recognized Standard Proficiency Course Provider. He has held consultancies with multiple laser companies and has presented courses, lectures, and workshops worldwide. He has authored numerous articles on the use of lasers in dentistry, including a chapter “The Use of Lasers in Fixed Prosthodontics” in the October 2004 Dental Clinics of North America. Dr. Parker was the 2005 President of the Academy of Laser Dentistry. Dr. Parker may be contacted by e-mail at thewholetooth@easy.net.co.uk.

Disclosure: Dr. Parker has no current affiliations with any company.

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**Editor’s Note:** The following three abstracts are offered as topics of current interest. Readers are invited to submit to the editor inquiries concerning laser-related scientific topics for possible inclusion in future issues. We’ll scan the literature and present relevant abstracts.

**LASER TREATMENT OF VASCULAR LESIONS OF THE LIP**

In his case study involving hemangiomas of the lip (43-47), Dr. Steven Parker utilizes an 810-nm diode laser with power settings between 1.7 and 2.0 Watts in continuous wave and gated pulsed modes to effect successful treatment.

Relatively few reports of lip hemangioma treatment via laser appear in the dental literature per se. Case reports by Imai and colleagues (who used an Nd:YAG laser at unspecified operating parameters) and Sun (who utilized an argon laser at 1.25 Watts in pulsed mode) are notable examples. Rice and Kotlow describe treatment of venous lake of the lip, another type of vascular lesion; both practitioners used an 810-nm diode laser – Rice at 1.0 Watt continuous wave, and Kotlow at 0.6 Watt continuous wave.

Most reported instances of laser-assisted treatment of hemangiomas and other vascular lesions of the lips appear in the dermatologic, plastic surgery, and oral surgery literature. There, researchers and clinicians identify a variety of lasers, including 488- and 514.5-nm argon, 577-nm flashlamp-pumped dye, 578.2-nm copper vapor, 1064-nm Nd:YAG, and 10.6-μm carbon dioxide. Each author describes the rationale for wavelength choice, generally based on a particular laser’s interaction with the primary chromophores of interest in these cases, oxyhemoglobin and melanin; a laser’s relative depth of penetration into tissue; and its photocoagulative or hemostatic capability.

A considerable portion of the published literature is devoted to treating such lesions in infants and children. Based on a classification of hemangiomas and vascular malformations formulated by Mulliken and Glowacki, Vesnaver and Dovšak note that hemangiomas tend to develop after birth, grow during the first year of life, and then gradually involute; in contrast, vascular lesions are usually noted at birth, grow as the body matures, and tend not to regress. Knowledge and diagnosis of the different types of lesions affect the selection of preferred treatment, whether administered to pediatric or adult patients.

Various authors outline the variety of treatment modalities for treating vascular lesions of the lip: conventional surgery, embolization, oral corticosteroid therapy, cryosurgery, electrodesiccation, electrocautery, intralesional injection of fibrosing agents, administration of interferon, laser-assisted surgery. Each has its advantages and drawbacks, and a careful study of the underlying characteristics and indications for use is warranted.

Bradley and Vesnaver and Dovšak review some of the precautions to consider when using Nd:YAG lasers in treating vascular lesions, although these considerations may well apply to other laser wavelengths, particularly those exhibiting deeper penetration and those used at higher powers:

- Avoid perforating the mucosa covering the lesion or damaging the skin surface to avoid scarring
- Keep the laser tip moving to avoid overexposing a given area and minimize damage to nerves
- Use care when performing laser treatment near salivary glands to lessen the risk of post-treatment stenosis
- Consider simultaneous cooling of the skin surface to decrease skin damage.

Attention to proper laser technique and precautions is always advisable. Vesnaver and Dovšak noted minor complications in some patients: One involved deep necrosis of lip tissue which healed uneventfully once the necrotic tissue was removed and the wound sutured in layers. Another experienced mild, transient paresthesia of the right half of the lower lip after photocoagulation of a small lesion in the right lower oral vestibulum; sensory recovery took two weeks. It bears mentioning that these investigators used 8 to 12 Watts of Nd:YAG laser power at 35-55 Hz to perform their treatments – far higher power levels than dental practitioners typically employ. In the oral surgical field, treatment of large, cavernous lip hemangiomas using lasers of even higher power is not uncommon.

Van Doorne and colleagues state that while complications of laser treatment of lip lesions are unusual, they may include skin atrophy, transient hyperpigmentation, slight depression of the skin, and scarring.

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provide satisfactory cosmesis and lip function in most cases.
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

THE CO2 LASER IN THE TREATMENT OF CAVERNOUS HAEMANGIOMA OF THE LOWER LIP: A CASE REPORT

Toshio Ohshiro, MD
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A case is reported of a 14-year-old girl who had a large cavernous haemangioma and haemangioma simplex of the lower lip. Although a few reports of such a haemangioma and the operation for it can be found in the literature, the blood loss problem and the final cosmesis leave much to be desired. We excised the tumour in two stages using the CO2 laser, retaining full function and obtaining good configuration of the affected part. The suitability of the CO2 laser for this procedure, because of its haemostatic effect, was noted. The importance of both the physiological and psychological problems of such a patient were treated by applying our total treatment concept.

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ULCERATED HEMANGIOMAS: CLINICAL CHARACTERISTICS AND RESPONSE TO THERAPY

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Background: Hemangiomas represent the most common benign tumor of infancy, with ulceration its most frequent complication. Objective: Our purpose was to review our experience with this challenging problem by evaluating the clinical features, management, and therapeutic responses of ulcerated hemangiomas. Methods: A retrospective analysis of ulcerated hemangiomas at the University of California, San Francisco outpatient pediatric dermatology clinics and Oakland Children’s Hospital from 1987 to 1997 was performed. Results: The medical records of 60 patients were examined. Forty-nine female and 11 male patients were seen with a female/male ratio of 4.5:1. The majority of ulcerated hemangiomas were of the plaque type (n = 50; 83%) and relatively large; 47 (78%) were larger than 6 cm². The perineum was the single most frequently involved site, affected in 20 cases (33%). Topical antibiotics, barrier creams, and bio-occlusive dressings were used in most cases. Systemic antibiotics were used in 26 cases (43%) for overt or presumed infection. Systemic corticosteroids were used in 21 children (37%), 5 of whom did not show a response. Intralesional triamcinolone was used in 7 cases (12%), with 4 showing definite improvement. The flashlamp pulsed-dye laser was the modality used in 22 children (37%), 11 (50%) of whom showed definite improvement, 4 (18%) who showed no significant response, and 1 (5%) who showed definite worsening. Interferon alfa-2a was required in 5 patients (8%), all of whom showed improvement without appreciable neurologic side effects. Immediate surgical excision was required in only 2 cases (3%). Pain control with oral acetaminophen, acetaminophen with codeine, and topical 2.5% lidocaine ointment was effective in managing the pain of lip and perineal hemangiomas, with no side effects noted. Conclusion: No one uniformly effective treatment modality was found, and frequently several were used concurrently. The decision to use specific therapies was dependent on the age of the patient, as well as the location, size, and stage of growth or involution of the hemangioma. Our approach to management included 4 major areas: local wound care, management of infection, specific therapeutic modalities (systemic and intralesional corticosteroids, flashlamp pulsed-dye laser, and interferon alfa-2a), and pain management.

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TREATMENT OF VASCULAR LESIONS IN THE HEAD AND NECK USING Nd:YAG LASER

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Introduction: Vascular lesions in the head and neck region, including both haemangiomas and vascular malformations, are common and many different treatment modalities have been used for their removal. In the past decade, the Nd:YAG laser has emerged as a new mode of treatment for vascular lesions, and the purpose of this paper was to determine its clinical value. Patients and Methods: A prospective study was conducted in 111 patients with vascular lesions in the head and neck region. They were treated with the Nd:YAG laser by photocoagulation. Of these, 96 had small lesions, with surface diameters of less than 3 x 3 cm², and 5 had large lesions, with surface diameters of more than 3 x 3 cm². The patients were all followed up carefully until complete healing was recorded, along with any complications. Results: In both groups of patients, tissue sloughing occurred within 2-3 days. Healing time in small lesions was 2-3 weeks, and in large lesions 3-4 weeks. Three patients with small lesions and one patient with a large lesion experienced minor complications. Conclusion: The Nd:YAG laser is a safe and effective tool for treating vascular lesions.

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- **Ana Trillouros, DDS, Private Practice, NY** will present “Practical Caries Management in the Laser Dentistry Office”. Dr. Trillouros will describe how to successfully implement diagnostics and caries management into the laser dentistry office.
- **Tord Lundgren, Prof. of Periodontology, University of Florida at Gainesville, FL** will present “Minimally Invasive Periodontal Treatment” shed light on the aspects of minimal invasive periodontal treatment (The Scandinavian School).
- **Peter Pang, DDS, Private Practice, Santa Rosa, CA** will present an overview and clinical aspects of “Lasers in Periodontal Treatment”.
- **Jeanne Godett, RDH, Sacramento, CA** will present an additional counterpoint to these two presentations in the Hygiene Forum.

- **Brian Houston, DDS, Private Practice, Prosthodontist** will emphasize the esthetic aspects and rules for placing implants from a Prosthodontist’s clinical view in “The Esthetics of Implant Placement – The Prosthodontic View”.
- **Steven P.A. Parker, BDS, LDS RCS, Private Practice, United Kingdom** will present “Lasers in Implantology – Placing, Uncovering, and Treatment of Periimplantitis”.
- **Adam Stabholz, Prof. of Endodontics, University of Jerusalem**, will take a critical look at “The Practical Use of Lasers in Endodontics” and will give guidance for the clinical use of lasers in endodontics.

Partial listing: subject to change

Social Events and Tours
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- **Wednesday, April 9:**
  - 7:30 pm – 9:00 pm: Welcome Reception and Exhibits Preview
  - **Fees:** None
- **Thursday, April 10:**
  - 8:30 am – 3:00 pm: Wild Animal Park
  - **Fees:** $95 adults (12+)
  - $75 children (3-11)
- **Friday, April 11:**
  - 10:00 am – 1:30 pm: Luncheon at the famous Hotel del Coronado
  - **Fees:** $68.00 per person
- **Friday, April 11:**
  - 3:00 pm – 7:30 pm: ALD2008 Sailing Regatta (34 footers with captain)
  - **Fees:** $105.00 per person
- **Saturday, April 12:**
  - 9:00 am – 2:00 pm: San Diego Trolley, Amphibious Seal Vehicle Tour of San Diego, the Harbor, & Old Town Mission and Shopping
  - **Fees:** $75.00 per person
- **Saturday, April 12:**
  - 7:00 pm – midnight: President’s Awards Ceremony, Dinner Dance and Rock n Roll Party
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  - Wednesday, April 9, 2008 – 7:30 am – 5:30 pm
- **Standard Proficiency**
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