Ho:YAG has a solid active medium, a crystal of chromium-sensitized yttrium-aluminum-garnet doped with holmium and thulium. Laser energy is fiberoptically delivered in free-running pulsed mode. The wavelength produced by this laser is 2120 nm, in the near-infrared, invisible, nonionizing radiation spectrum. Its absorption by water is about 100 times greater than either the Nd:YAG or 980-nm diode, and more than 100 times that of the 810-nm diode laser. As such, the Ho:YAG has many soft tissue surgical uses since soft tissue contains a large amount of water. Its optical fiber affords good access, precision and tactile feedback.

The Ho:YAG laser’s pulse rate of 5-10 Hz, or the amount of pulses of laser energy per second, is rather low compared to a typical Nd:YAG laser, and the resulting holmium incisions can be somewhat jagged-edged. Clinically, this may manifest itself only on more fibrous tissue, but the healing result would still be very acceptable.

The Ho:YAG’s optical fiber, like those of the diode and Nd:YAG lasers, needs to be cleaned and cleaved periodically during surgery. And, like the Nd:YAG and diode, the Ho:YAG fiber can be used in either contact or noncontact mode.

The hemostatic ability of the Ho:YAG is comparable to or even slightly better than that of the carbon dioxide laser, itself highly absorbed by water. In these lasers, the water component of tissue absorbs the laser energy and converts it into heat. The resulting lateral thermal diffusion coagulates adjacent capillaries, leading to good hemostasis.

In contrast, the argon, diode and Nd:YAG lasers are well absorbed by pigment in tissue and, because they are less well absorbed by water, generally penetrate more deeply into soft tissue, affording excellent coagulation and hemostasis.

The Ho:YAG’s laser’s absorbency by the mineral content of tooth structure is very low, which allows soft tissue surgery to proceed safely in close proximity to sound enamel. Since cartilage is composed of collagen and is about 75% water by weight, the holmium laser is frequently used for arthroscopic surgery of the temporomandibular joint, as well as for similar medical applications.

The Ho:YAG laser’s strong affinity for water necessitates special considerations in the manufacture of its delivery system. Holmium lasers require so-called low OH quartz fibers, fabricated under reduced water and humidity conditions, rendering an OH ion content in the glass between 1 and 5 parts per million (ppm). Conventional silica quartz fibers (such as are used with Nd:YAG lasers) typically have a high level of OH ions in the glass, around 1000 ppm. Such fibers work well for the Nd:YAG wavelength which is only weakly absorbed by water, but will not efficiently transmit the longer Ho:YAG wavelength. The special conditions under which low OH fibers are manufactured mean that a Ho:YAG laser fiber is about 25% more expensive than its high OH counterpart.

In this issue, Dr. Emile Martin presents an abbreviated series of Ho:YAG laser case studies, showcasing its capabilities as an intraoral soft tissue surgical instrument.
The Ho:YAG Dental Laser: Clinical Case Summaries

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Each of the following intraoral soft tissue surgical cases utilized a free-running pulsed Ho:YAG laser (Duopulse 2000, Excel-Quantronix). In all instances, a 400-micron diameter optical fiber was used in both contact and noncontact modes. Control panel settings were 2.0 W, 200 mJ, 10 Hz except for the laser gingivectomy case, which used 2.75 W, 275 mJ, 10 Hz. During laser operation, high-volume evacuation and water spray were used.

Case #1: Laser Gingivectomy

A 13-year-old white female, diagnosed with primary pulmonary hypertension, presented with gingival hypertrophy. Between the ages of 2 and 9, she had been taking Tegritol. She then began taking Procardia 90 mg per day. The dosage was increased to 120 mg per day for the past year. The gingival hypertrophy became evident following the introduction of orthodontic bands and brackets. Local anesthesia was administered prior to the laser procedure; duration of laser exposure was approximately 2 minutes per tooth. There were no complications during or after surgery, and healing was uneventful.

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Case #2: Laser Papilloma Removal

A 22-year-old black male presented with a pedunculated lesion in the midline of the maxillary lip. The lesion manifested with a pink, cauliflower-like appearance. The patient’s chief complaint was that the tissue “gets in his way.” He was in good health, had a history of cigarette smoking, and was allergic to erythromycin. The clinical diagnosis was a papilloma, probably of viral origin. The Ho:YAG laser was used to excise the lesion without complication, with good hemostasis, and with uneventful healing.

According to the pathology report, multiple sections showed parakeratotic, acanthotic, papillary stratified squamous epithelium exhibiting scattered binucleated cells and numerous vacuolated cells within the upper spinous layer. The underlying fibrous stroma contained markedly dilated capillary channels. Scattered lymphocytes were also seen.
Case #3: Laser Lingual Frenectomy

A 49-year-old white male presented for lingual frenectomy. His medical condition was negative for this procedure, although he had a history of codeine allergy and mitral valve prolapse without regurgitation. No anesthesia was used. There were no complications and healing was uneventful.

Case #4: Laser-Assisted Mucocele Removal

A 77-year-old white female presented with a slight enlargement in the mucosa of the right lip. Clinical diagnosis was a mucocele. It was not painful although it did get in her way from time to time. There were no medical contraindications to performing this procedure. The Ho:YAG laser was used initially to open the tissue covering the mucocele. The mucocele was then undermined with a scalpel, removed, and sent for histological analysis. The particular laser model used also incorporated a free-running pulsed, fiberoptic-delivered Nd:YAG laser which was used in both contact and non-contact mode to promote hemostasis. Nd:YAG control panel settings were 2.0 W, 100 mJ, 20 Hz. Surgery proceeded without complication and healing was uneventful.

The pathology report indicated that the mucosa contained abundant minor salivary gland components. Gland lobules showed marked interstitial chronic inflammation and areas of ductal dilation. Segments of the fibrous tissue showed lakes of amorphous mucoid coagulum which contained foam macrophages. This had the appearance of mucocele formation.
Case #5: Laser Fibroma Removal

A 51-year-old white female presented in good health. Her chief complaint was chronic cheek biting of the right cheek. Clinical examination revealed a firm, pink, raised lesion on the right buccal mucosa. Surgery and postoperative healing proceeded uneventfully. Excised tissue was sent to the laboratory for evaluation.

The pathology report indicated an elevated fibrous nodule, surfaced partially by stratified squamous epithelium. Compacted collagen bundles were associated with some blood-filled capillaries. There were bands of striated muscle at the specimen base. Edges exhibited heat artifact.

As indicated in the introduction, the Ho:YAG laser wavelength is approximately 100 times more highly absorbed by water than either the Nd:YAG or diode lasers. As shown in the three accompanying photographs, the appearances of immediate postoperative wounds in three clinically similar laser procedures (excisional biopsies) performed by different practitioners on different patients show some of the differences in tissue absorption.

The holmium excision exhibits an outer layer, up to 1 mm wide, of surface ablation of the water component of the tissue. Neither of the other two wavelengths, Nd:YAG or diode, shows that same wound edge. Furthermore, the Nd:YAG and diode surgical sites show a greater depth of cut, partially owing to their relatively deeper soft tissue penetration. Although not shown here, all three laser wounds healed uneventfully and without complications. The clinicians elected not to use sutures in order to minimize the formation of scar tissue. Healing occurred by secondary intention.

Comparing Laser Wounds

Donald J. Coluzzi, DDS

Dr. Martin is a graduate of Temple Dental School. He has earned a Mastership in the Academy of General Dentistry, a Fellowship in the American Academy of Implant Dentistry and is a Diplomate of the American Board of Oral Implantology. Dr. Martin has attained Educator Status in the Academy of Laser Dentistry's Laser Certification Program and is attending the St. Joseph's Hospital General Practice Residency program in Syracuse, New York where he lectures on implants and lasers. He is the current president of the American Academy of Implant Dentistry and serves on the Academy of Laser Dentistry's Board of Directors. Dr. Martin has previously given demonstration training courses for the Excel Quantronix Corporation. He is a principal in a group dental practice in Syracuse, New York.