

Surgical Laser Technologies' Contact ArthroProbe™ and the SLT Contact™ 1.06 μm Neodymium:YAG Laser Systems for Arthroscopic Laser Surgery



Contact Laser™ technology was developed nearly 10 years ago by Surgical Laser Technologies (SLT; Oaks, PA) as a means of accurately delivering controlled laser energy to tissue for open or endoscopic incision, excision, ablation, or coagulation. The key element of this technology is the family of Contact Laser probes, scalpels, and fibers, whose patented geometric shapes and Wavelength Conversion™ effect surface treatments modulate the thermal characteristics of the 1.06 μm neodymium:YAG laser beam to achieve a variety of therapeutic effects. Contact Laser probes and scalpels are contact tips that are used in conjunction with an assortment of fiberoptic delivery systems and several portable, multispecialty 1.06 μm neodymium:YAG lasers. Some of these contact tips are made of fused silica and others of sapphire.

Contact ArthroProbe Contact Tip

The Contact ArthroProbe for Incision is a specialized adaptation of contact delivery systems for the particular demands of arthroscopic surgery (Fig. 23-1). A single-piece 1000- μm fused silica fiberoptic is mounted in a 2.2 mm external diameter handpiece shaft. A novel application of patented technology incorporates a technical ceramic (zirconia) jacket encasing the distal tip, providing sufficient thermodynamic and mechanical support to withstand the stresses of arthroscopic laser surgery. The Contact Arthroprobe for Ablation is a unitary product comprised of a 600- μm fiber integrally attached to a large fused silica ablation probe tip that is supported by a sleeve of zirconia (Fig. 23-2).

The Contact ArthroProbe for Incision tapers to a 0.4 mm diameter distal surface, where a high, localized power density is created. With the addition of the Wavelength Conversion effect treatment, the probe is effective for tissue cutting with only a moderate degree of accom-

panying coagulation. A choice of straight and 12, 20, and 40 degree curved shafts facilitates access to all areas of joints.

The substantially larger, blunter, round, fused silica distal tip of the Contact ArthroProbe for Ablation produces its effect over a larger surface area for wide area vaporization or ablation. Shafts are available with 20 and 40 degree curves. It too has been treated to achieve Wavelength Conversion effect.

SLT Contact Laser Systems

The advent of the contact approach to laser surgery made feasible the use of 1.06 μm neodymium:YAG lasers that were more compact and versatile than the massive first generation machines, which required hard-wiring and permanent plumbing connections for cooling. Two SLT systems—the CL MD/110-40W and CL MD/DUAL Contact Lasers—provide the full power range needed for all arthroscopic or open orthopedic procedures. The CL MD/110-40W plugs into any 120 volt alternating current (VAC) outlet and delivers up to 40 watts of power; the CL MD/DUAL delivers 40 watts from a 120 VAC outlet and, interchangeably, up to 60 watts from a 220 VAC line. Each system is self-contained and weighs less than 250 pounds, meaning that both Contact Laser systems can readily be moved to any site where they are needed without wiring or plumbing restrictions. All CLMD/110 series lasers can be field-upgraded to power up to 60 watts, which is accomplished by a cost-effective module added to the customer's existing laser.

All SLT Contact Lasers have an integrated fail-safe fiber calibration port. In addition, for procedures in which coaxial cooling of Contact Laser scalpels and probes is required, a sterile fluid path and filtered path for air or CO₂ gas is provided.

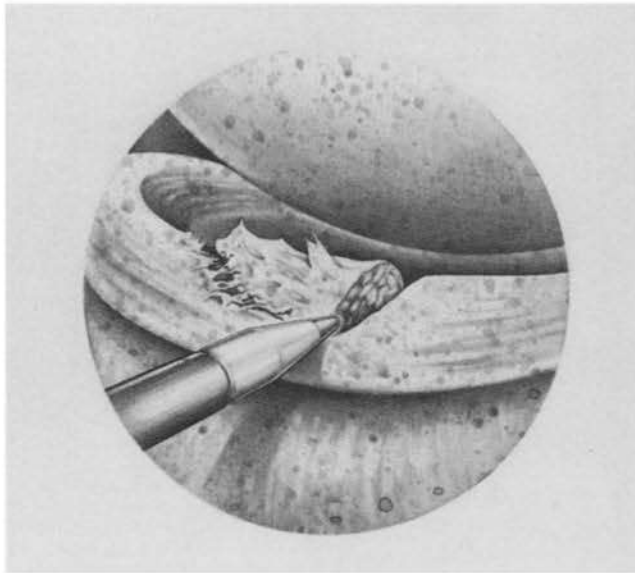


Figure 23-1. Contact ArthroProbe for Incision comprises a one-piece, 1000- μ m fiber with a proprietary technical ceramic Contact Probe tip and a handpiece for arthroscopy.

A microprocessor control unit leads operators through system setup. Power, pulse duration and other parameters are selected and confirmed on the LED panel on the top of the laser. Delivery systems connect to a fiber launch port on the right rear surface of the laser adjacent to the gas/fluid cartridge slot and the fiber management mast, which can, if desired, route the fiberoptic overhead, out of the way.

Physical Principles and Tissue Effects

All thermal lasers create their therapeutic effects through the transformation of light energy into thermal energy at or within the tissue. With the conventional, noncontact mode of delivery, the nature of this transformation is determined entirely by the laser wavelength, power density (which in turn is a combination of the total output power and the spot size), and the optical and thermodynamic properties of the tissue.

Contact Laser technology, in contrast, provides a means of uncoupling the tissue effect from the laser wavelength. It is accomplished by what is referred to as Wavelength Conversion effect treatments. Infrared energy-absorbing surface treatments titrate the relative amounts of light and thermal energy emitted from the Contact Laser scalpel, probe, or fiber to provide the desired thermal profile in the tissue. The native 1.06 μ m neodymium:YAG wavelength emitted from a bare, untreated fiber penetrates several millimeters into most soft tissue, which is useful for deep coagulation but unsuitable for more controlled hemostasis, ablation, or cutting. Shaped fibers without surface treatments emit the native wavelength

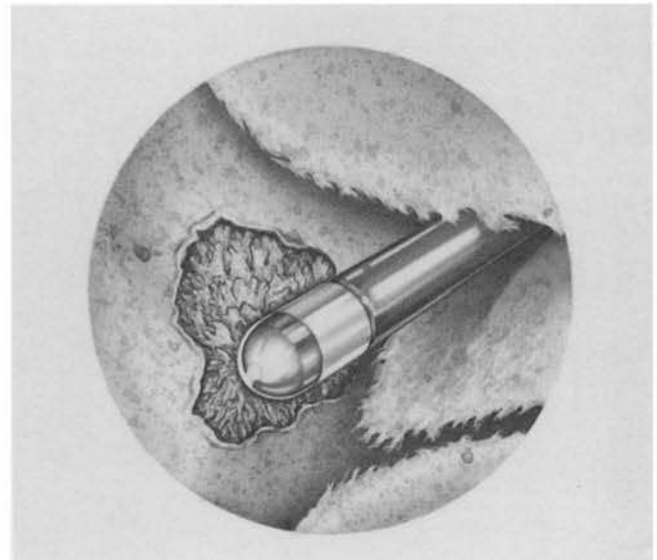


Figure 23-2. Contact ArthroProbe for Ablation.

until the tip becomes fouled or deformed, after which they combine light with thermal effects, though in an unpredictable and changing ratio.

An appropriate surface treatment (i.e., an infrared-absorbing substance), on the other hand, can transform predetermined amounts of the 1.06 μ m neodymium:YAG light energy into heat at the probe or fiber surface to provide an intense thermal effect at the tissue surface with little radiant energy penetration, comparable to the therapeutic result with the 10.6 μ m CO₂ laser (Fig. 23-3). Lesser amounts of surface treatment create other effects, thereby adjusting the thermal profile in a controlled, reliable way to create the desired temperature gradient within tissue.

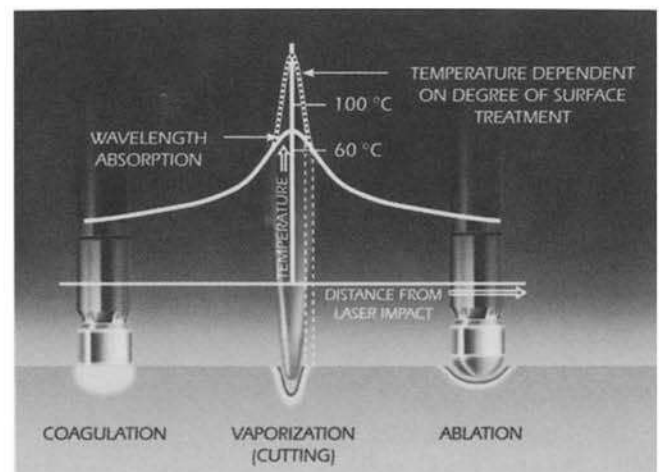


Figure 23-3. Changes in temperature gradient and tissue effect by Wavelength Conversion effect treatments.

Subconjunctival THC:YAG (“Holmium”) Laser Thermal Sclerostomy Ab Externo: A One-year Report

Background: Laser sclerostomy can be performed in a less-invasive manner than standard filtering surgery. Longer wavelengths in the infrared range have water-absorptive characteristics that facilitate perforation of the sclera. The goal was to perform laser sclerostomy ab externo to avoid intraocular instrumentation and minimize conjunctival trauma.

Methods: A thulium, holmium, chromium-doped:YAG (THC:YAG) crystal laser was used to create thermal sclerostomies in 49 glaucomatous eyes of 46 patients. The laser is a long-pulsed (300- μ second), compact, self-contained, solid-state laser operating in the near infrared (2.1 μ m). Energy was delivered via a specially designed 22-gauge (712- μ m) optic probe that emits energy at a right angle to the long axis of the fiber. Pulse energies of 80 to 120 mJ were used. Total energy levels to produce full-thickness sclerostomies ranged from 1.4 to 7.2 J

Subconjunctival 5-fluorouracil (5-FU) injections were administered in 46 eyes. Success was defined as an intraocular pressure (IOP) of less than or equal to 22 mmHg with or without medications. For eyes in which preoperative IOP was less than or equal to 22 mmHg, success was defined as a decrease in IOP of greater than or equal to 30%.

Results: Estimated probability of success allowing for one retreatment was 0.75 at 6 months and 0.68 at 12 months. Mean IOP of successful cases was 13.3 mm Hg at both 6 and 12 months. Twelve cases failed within the initial 6 months, and two additional cases failed by 12 months.

Conclusion: THC:YAG (“holmium”) laser thermal sclerostomy is an alternative to other full-thickness filtration procedures. Further evaluation and understanding will define its ultimate role in glaucoma management.

Sunrise sLASE 210 Surgical Holmium:YAG Laser for Arthroscopic Laser Surgery



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The sLASE 210 Laser system is a pulsed thulium-holmium-chromium-doped YAG (THC:YAG) solid-state laser that emits energy at a wavelength of $2.1\ \mu\text{m}$ (Fig. 22-1). This wavelength is relatively new as a therapeutic energy source, but because of its unique effects on tissue the $2.1\ \mu\text{m}$ holmium:YAG laser has rapidly developed into a user-friendly clinical tool with a growing number of surgical applications.

The current sLASE 210 product line consists of the sLASE 210 (10 watts), and sLASE 210 PLUS (20 watts). Each of these lasers has different features designed to meet specific clinical requirements. Unlike scientific lasers, the sLASE 210 is a clinical device that includes a highly sophisticated combination of software and hardware elements to ensure reliable, safe operation to the user and patient. Furthermore, because the laser is only one of many sophisticated instruments used in the operating room, it is designed to be as user-friendly as possible.

The design also takes into consideration the rigorous environment of the operating theater and the need for compactness and transportability. The following information provides detailed information about the internal and external components and how the sLASE 210 holmium:YAG laser works.

Internal Systems

The sLASE 210 system utilizes a metal frame design to which internal subassemblies and discrete components are fastened. Despite the numerous mechanical systems incorporated within, the internal design is compact, minimizing the size of the complete laser system as much as possible. Because there is both high voltage and water systems found within, care has been taken to isolate the two conditions, for the unlikely event of a water leak. The major subassemblies of the internal system consist of the laser

head assembly, high voltage power supply, cooling system, low voltage power supply, and sLASE 210 control system.

Laser Head Assembly

The laser head assembly includes the $2.1\ \mu\text{m}$ holmium:YAG laser resonator, a 3-mW helium-neon gas laser, a series of optical beam steerers and combiners, mechanical safety shutters and apertures. Because all of the optical components are located here, its precise optical alignments are preserved by isolating the entire assembly from mechanical vibration or shock with a proprietary shock absorber. The laser head assembly is connected to the high voltage network, and because of the tremendous heat generated during the laser excitation process the $2.1\ \mu\text{m}$ holmium:YAG laser head is water-cooled by the internal cooling system.

The helium-neon laser is a small, low power gas laser with a visible wavelength (red: $0.633\ \mu\text{m}$). This laser's output beam is combined optically with the $2.1\ \mu\text{m}$ holmium:YAG beam path and is delivered concentrically through the delivery system to act as an aiming reference for the surgeon. The helium-neon laser energy is low, so there is no tissue effect caused by the red beam.

Most of the laser head assembly components interface in some manner with the central processor unit as part of the normal operating process and safety protection. In many cases certain monitors are redundant, particularly with respect to safety systems. Parameters that are monitored are the laser head power level, safety shutter position and timing, and many others too numerous to discuss in this chapter. In essence, this complex network ensures that the laser is properly set up for operation, is off when it should be, turns on when it should and at the correct power level, and is delivered to the treatment site



Figure 22-1. sLASE 210 laser system.

for the proper time interval. Any hazardous operating condition detected by the sLASE safety monitors causes immediate disabling of the laser system and instant interruption of all laser energy transmission if lasing is in progress during the fault. Noncatastrophic faults may or may not disable laser operation, depending on the nature and severity of the abnormal condition.

High Voltage Power Supply

To provide the energy necessary to excite the solid-state 2.1 μm holmium:YAG laser rod, a high voltage supply network is required. This network consists of several sub-components that provide a specific type of pulse energy to the laser head to properly excite the laser rod. This operation is described more thoroughly later.

Cooling System

The sLASE 210 cooling system is comprised of a heat exchanger, water pump, fan, water reservoir, and flow switch. The sole use of the cooling system is to dissipate the excess heat away from the 2.1 μm holmium:YAG laser resonator. A unique feature of the sLASE 210 (twenty watt) system is the option of using the self-contained heat-

to-air exchanger, or connecting an external cooling source for maximum efficiency. External cooling may be provided by a stand-alone chiller system that is provided or an external cooling supply such as tap water. Connection of external cooling to the sLASE console is facilitated by two quick disconnect water fittings.

Low Voltage Power Supply

The low voltage power supply provides all of the power necessary for the logic circuits in the system and does not exceed 25 volts. This assembly also performs as the primary interface between the processor unit and all of the various sensors and detectors throughout the system.

Control System

The heart of the sLASE 210 control system is the controller board, which contains the 8085 microprocessor, digital input/output ports, control panel and display interfaces, and circuits for power monitor and interlocks. All of the sLASE 210 system's programming is contained on an EPROM and nonvolatile RAM. The control system also utilizes "watchdog" technology to ensure proper CPU performance (e.g., direct current voltage level, logic timing). If for any reason the watchdog circuit detects an unsuitable condition, the laser is disabled.

External Systems

The external components of the sLASE 210 are those that are required to allow the user to set up, operate, and control the laser. The main features are the control panel and display, emergency off switch, external power detector system, fiberoptic interface system, on/off keyswitch, remote interlock system, footswitch system, circuit breakers, and power cable. All of these features are accessible by the user and must be understood for proper and safe use of the laser system.

Control Panel and Display

The primary user interface is the control panel. Located on the top of the laser console for good visibility, the control panel keypads allows the user to select system status (Standby, Aim, Ready), treatment power level, a fiber calibration routine, pulse repetition rate, exposure time, and Repeat mode. The user can also access stored data pertaining to total pulses delivered, total joules delivered, and total time of exposure. The system continuously accrues all of the values after the laser has been powered up until the reset touchpad is pressed or the system is shut down. A special feature of the sLASE 210 is the ability to operate and continuously monitor the total number of joules delivered for those procedures that require careful monitoring of the total energy transmitted to tissue.