Can You Imagine . . .

. . . breakthroughs in laser medicine that help specialists provide better care to skin, kidney, and burn patients.

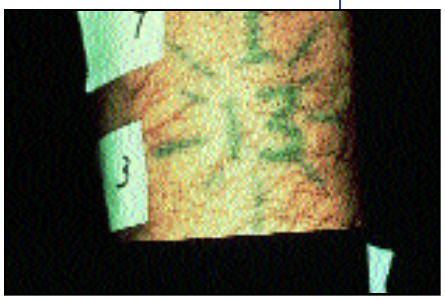
LASER R&D PROMISES NEW MEDICAL THERAPIES

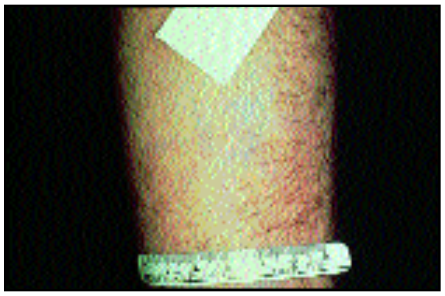
In the early years of medical laser research, doctors used single-wavelength lasers with limited dynamic properties. When the free-electron laser (FEL) was developed, it offered short pulses, high peak power, and a greater range of wavelengths. Not surprisingly, this innovation yielded a host of insights in the medical field; the Wellman Laboratories of Photomedicine (Boston, MA) is a nexus of these advances.

From 1986 to 1991, BMDO provided support to the Wellman Laboratories of Photomedicine at Massachusetts General Hospital (MGH) through the Medical Free-Electron Laser (MFEL) program. The U.S. Congress conceived the MFEL program as a means to transfer technology from military laser research to medicine. Now part of the MGH's Laser Center, Wellman Laboratories built a stellar reputation and a long list of successes in laser medicine. Their laser-related successes follow.

THROUGH ITS MFEL PROGRAM, WELLMAN LABORATORIES' RESEARCH AND TECHNOLOGY TRANSFER RESULTED IN OVER $250 MILLION IN SALES OF LASER EQUIPMENT, BOTH DOMESTICALLY AND INTERNATIONALLY.

■ **Assessing and treating burns.** In burn therapy, an infrared laser system optically determines the depth of the burn and uses a carbon dioxide laser to remove the injured tissue quickly and precisely in preparation for skin grafts. This method reduces blood loss and the imprecision of physical debridement (cutting or scraping away the tissue with surgical instruments). Wellman patented the optical diagnostic component of this technology; Sandia National Laboratories (Albuquerque, NM) and MGH are developing a therapeutic device through a Cooperative Research and Development Agreement (CRADA).





■ Laser treatment selectively and safely removes pigment from tattoos, revealing normal skin color.

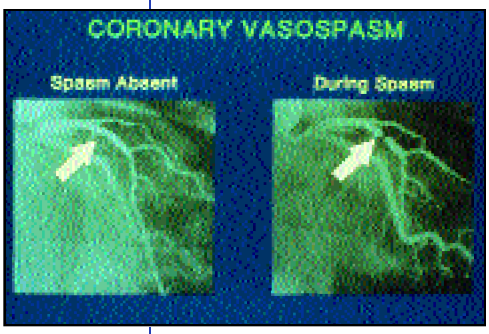
■ **Eliminating kidney stones.** The laboratory developed a laser-based lithotripsy method to eliminate kidney stones nonsurgically. Kidney stones afflict 400,000 people each year. Instead of sound waves, this method uses an intense light beam to create a shock wave in the fluid medium surrounding the stones, causing the stones to shatter. Excretion of the fragments takes place with little or no pain. Wellman Laboratories holds three patents that arose from a collaboration with a major laser company that licensed the invention, generating over $100 million in revenues.

■ **Removing undesirable skin features.** Wellman Laboratories introduced laser treatments for nonscarring removal of tattoos, portwine stain birthmarks, pigmented moles, and vascular lesions of the skin. Before this type of laser therapy, there was no effective way to achieve satisfactory outcomes with these conditions. Wellman Laboratories continues to work on the system, optimizing and reducing costs of laser delivery systems and applying selective treatments to other organs besides the skin. A Wellman Laboratories' report estimates that 300,000 patients have been treated with this therapy, generating $250 million in business revenues. In cosmetic surgery, for example, laser removal of "spider veins" on the face and legs is growing in popularity. MGH filed a patent application in 1991 for laser removal of skin lesions and tattoos and licensed the technology. Laser products for dermatologic use are on the market and MGH receives royalties.

■ **Shining new light on cancer and arthritis.** Wellman Laboratories also studied and advanced photodynamic therapy (PDT) of various cancers. Rheumatoid arthritis (RA) may also be amenable to treatment by PDT. Degenerative changes associated with RA are treated by injecting photoactive drugs into the synovial fluid that surrounds an RA-affected joint, then irradiating it with a low-powered laser source. For PDT of cancers, MGH filed a total of eight patent applications. A CRADA with Lawrence Livermore National Laboratory (Livermore, CA) resulted from these studies. Two patents that cover the device and method of use have been awarded for PDT of dysfunctional uterine bleeding. Wellman Laboratories

licensed the inventions to a medical start-up company. Wellman Laboratories is collaborating with two companies to establish research programs for drug development for this application. These treatments are in development, and Wellman Laboratories is also working with a recent FDA-approved compound for the treatment of late-stage esophageal cancer.

■ Reducing brain damage. In hemorrhagic stroke or head injuries, arteries in the brain respond to bleeding by contracting (vasospasm), thereby shutting off the blood supply to areas in the brain. This protective mechanism causes even more damage by depriving the injured brain of needed oxygen. A short-lived, low-powered laser pulse instantly reverses vasospasm, re-establishing blood flow to the stroke-affected area and possibly reducing brain damage. Wellman Laboratories estimates that 800,000 persons each year are impaired by head trauma and brain hemorrhage. Wellman Laboratories designed a laser catheter system that threads into cerebral arteries to deliver laser light. Undergoing testing, this system may be in clinical use within the next one to two years. A Wellman Laboratories' report estimates the cost benefit of early intervention and effective therapy of early stroke at about $3 billion, in terms of lifetime dependency.



■ A short pulse of laser light can instantly reverse arterial spasm, restoring critical blood flow to the heart muscle.

For laser-induced vasodilation of cerebral arteries, MGH filed two patents and is in licensing negotiations. For preventing coronary artery narrowing with a PDT agent (such as chloroaluminum phthalocyanine) MGH filed two additional patents and is negotiating a license. This treatment is not yet clinically available.

According to Lynn Osborn at MGH and market analysis by Arthur D. Little and Co. in Cambridge, Massachusetts, the MFEL program's research and technology transfer resulted in over $250 million in sales of laser equipment, both domestically and internationally. This figure does not include the cost savings resulting from decreased hospital stays or from more rapid patient recovery and return to work.

ABOUT THE TECHNOLOGY

The FEL employs high-frequency electromagnetic fields to control and accelerate bursts of electrons, causing the particles to emit coherent light. Because the characteristic wavelength of the emitted light depends on the properties of the excitation fields, rather than on the intrinsic properties of the medium being excited, FEL emissions are continuously tunable over some range of operation. This behavior contrasts with other lasing mechanisms, which produce one of several discrete wavelengths available for that particular laser material. The continuously variable wavelength feature makes the FEL extremely valuable as a research tool to explore the effect of wavelength on any laser-based process or effect.

During BMDO development of FELs for high-power applications, interest arose in applying these advancements to the then-new field of photonics in medicine. Laser treatments had already shown promise for several skin therapies, surgical cutting, and selective tumor ablation. BMDO established the MFEL program to research and refine these processes and to explore new medical applications, such as PDT. The program's intent was not to develop FELs for medical uses, but to find the best laser operating conditions (wavelength, pulse shape, intensity) for a given therapeutic outcome, and then to use that knowledge to determine the best laser source for the application.