by diane martindale

Laser beams make a play to replace the scalpel, the dental drill, and the X ray

Dentistry by Laser Light

WHEN DENTIST RICHARD HANSEN GOES AFTER A CAVITY OR CLEANS A ROOT CANAL, HIS patients barely hear a thing. Instead of a whiny turbine drill, he uses a flash of laser light to blast away bits of dentin and enamel. Hansen, director of the Center for Advanced Dentistry in Fullerton, California, is convinced that the laser is the dental tool of the future—precise, inherently sterile, less painful, and perhaps less damaging to teeth. Above all, he says, it puts the person in the chair at ease: "What patients like most, of course, is that the laser is silent."

For now, this is still a rare luxury. Just 3.5 percent of the 7,553 dentists recently surveyed by the American Dental Association use lasers for surgical procedures. The steep cost and limited applications of early dental lasers have left many of them skeptical. But the tide is turning, as designs have improved and the Food and Drug Administration has certified lasers for more applications. In 1990 the agency allowed laser cutting of soft tissue such as gums. In 1997 the FDA approved lasers that remove tooth decay and earlier this year gave the thumbs up to laser treatments for root canals and other hard-tissue procedures. Meanwhile, engineers are striving to transform the laser into an all-purpose dental tool, useful for everything from treating gum disease to finding cavities before they surface.

Still, lasers require a hefty investment in equipment and training. Biolase Technology of San Clemente, California, the largest manufacturer of dental lasers in the United States, charges $49,900 for its top-of-the-line Waterlase system. That's a tough sell in a market where most dentists are accustomed to working with drills that use $1.50 tungsten-carbide bits. To make matters worse, lasers suitable for cutting gums are generally not useful for nicking away at cavities, and vice versa, because of the physics of how lasers do their job.

A dental laser shines a powerful beam through a fiber-optic cable connected to a hand piece resembling a standard drill. The beam emerges from the tip, shining onto the tooth or gums. Water molecules there absorb the energy from the beam and convert it into heat that cuts or abrades. But the best way to impart energy to the water molecules depends on the type of tissue. The infrared beam from an erbium laser is absorbed efficiently by the tooth but poorly by the gums. The blue-green light of an argon laser reacts more efficiently with hemoglobin, so it cuts gums effectively and helps halt bleeding. Different jobs, therefore, call for different lasers.

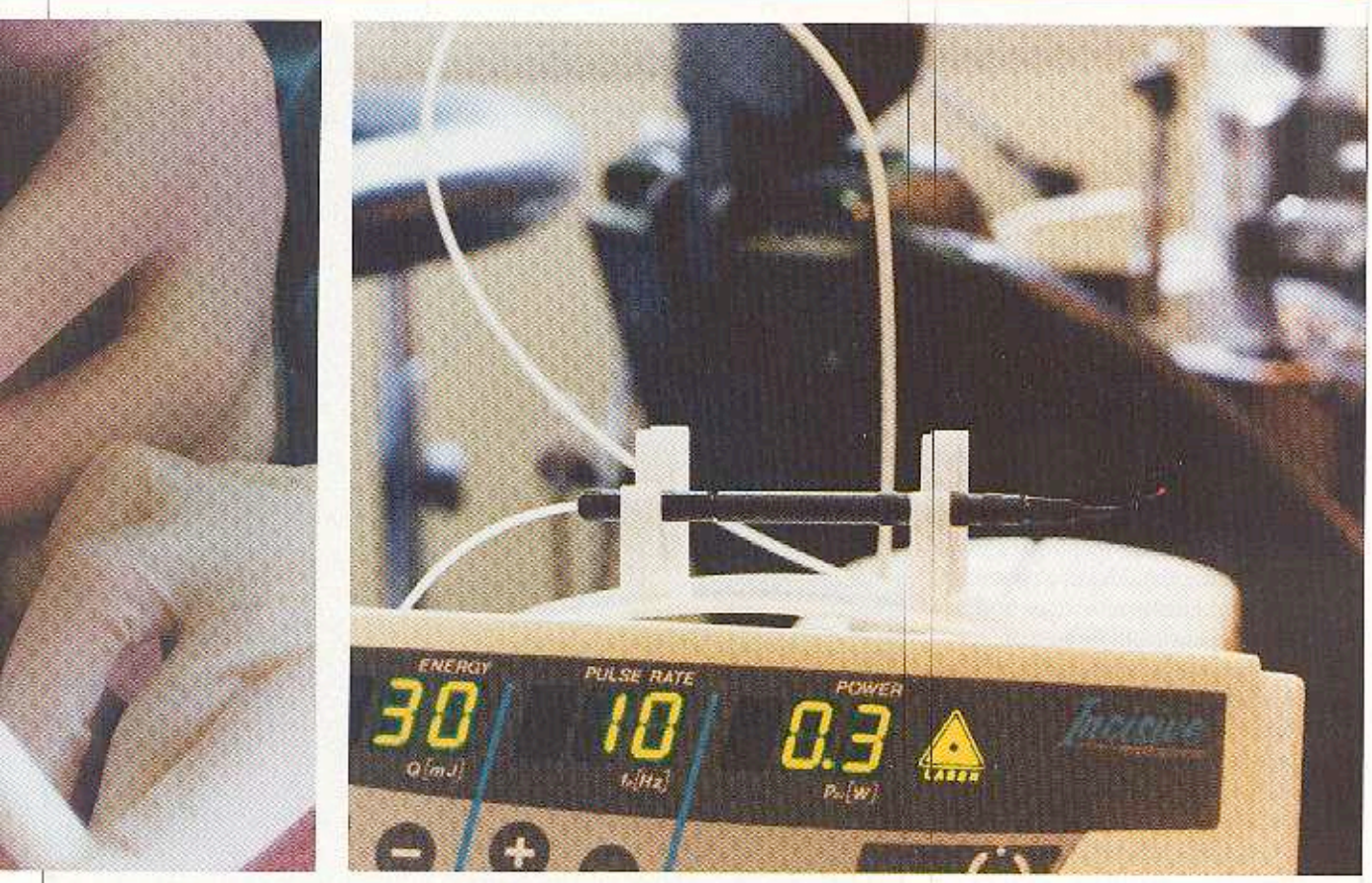
Biolase has already developed one solution. The company's Waterlase machine does not shoot a laser directly onto the tooth or gums. Instead, the beam energizes a spray of water droplets, which blasts the surface and scours away diseased or decayed tissue. This technique addresses concerns that shining a laser directly on a tooth can generate enough heat to harm the enamel. Earlier this year the FDA sanctioned Waterlase for both soft- and hard-tissue work in root canals and jaw surgery. Keith Murray, a laser physicist at NASA's Langley Research Center in Hampton, Virginia, is working on a more elegant approach. He has designed an adjustable laser that can switch instantly between soft-tissue and hard-tissue wavelengths.

Other researchers are bypassing the difficulties of laser drilling and concentrating on soft-tissue applications, where lasers offer some significant benefits. Lasers cauterize incisions, reducing bleeding and infection, sealing off nerve endings, and minimizing postoperative pain. Brian Wilson, a biophysicist at the University of Toronto, is expanding the repertoire of soft-tissue lasers to include applications for severe gum disease, which affects 5 to 20 percent of all Americans, especially teenagers and young adults.

Normally, dentists clean out infections between the teeth and gums by making an incision and inserting pellets of antibiotics. Instead, Wilson proposes using lasers and other light sources for photodynamic therapy, originally developed in cancer treatments. The dentist would inject the infected parts of the gums with a dye molecule that remains inert until illuminated with a laser or other light source. Once energized, the dye forms singlet oxygen, a reactive molecule that kills bacteria.

While patients appreciate the quiet, lasers have other appealing qualities to dentists. The intense beams of light sterilize tissue as they go. They can speed up tooth whitening. And lasers help make dentistry more precise, for instance, by allowing very controlled tooth bonding.

PHOTOGRAPH BY AMY ECKERT



Alan Goldstein, a dentist in New York City, uses a pulsed laser (left) to perform soft-tissue work such as reshaping gums. A guiding red laser beam marks the invisible surgical beam. Digital controls (right) regulate the power and frequency of each pulse.

"This process does away with complicated, painful surgery. Also, the dye is not an antibiotic, so I don't believe bacteria will become resistant," Wilson says. In a recent lab test, photodynamic therapy killed 99.9 percent of *Pseudomonas gingivalis*—one of the bacteria that cause gingivitis—in 10 minutes. Clinical trials are scheduled for later this year.

Lasers might also be useful for diagnoses. "With fluoride treatments and other improvements, we rarely see big gaping holes in people's teeth," says Andreas Mandelis, an applied physicist working on lasers at the University of Toronto. These days, most patients show up having only tiny pits in their tooth enamel. Dentists can halt these nascent caries with a polymer bonding agent, but only if they can spot the damage. In 2000, KaVo, a medical-imaging company in Germany, began selling a simple decay detector in the United States that supplements conventional X rays and the dentist's sharp explorer probe. Called Diagnodent, the $2,800 machine illuminates the tooth with a low-power red laser and measures whether the enamel glows, or luminesces, in response—a sign of bacterial degradation. About 5,500 units are in use in this country.

Diagnodent can distinguish between stains and incipient cavities, but it cannot locate decay more than about one-tenth of an inch into the tooth, because laser light is easily scattered. Mandelis and Toronto dentist Stephen Abrams are developing a more effective laser-luminescence cavity detector by looking at thermal effects as well. Their technique uses a longer-wavelength infrared laser beam, which heats the tooth in addition to making it glow. Heat does not scatter as readily as light, so the thermal energy can penetrate through the enamel, exposing changes in composition. An infrared detector measures how the heat travels through the tooth while a light sensor picks up the fluorescent signal. The combined information allows a three-dimensional look at the tooth. "It is more accurate than dental X rays, without the side effects," Abrams says. Mandelis's group has experimented on only extracted teeth, but he expects a commercial device to be available in about five years.

What will the world of tooth care look like then? Some dentists wonder how much will have changed. "Lasers are not the panacea that has been presented in the media. It's a new and potentially promising technology that will need several years of research and improvements before I'll feel confident using it on my patients," says Jerry Gordon, a dentist in Bensalem, Pennsylvania. But Richard Hansen thinks laser precision will spark a revolution. "What we've done in the last few years with lasers is to prevent the need for root canals," he says. "Soon we may be able to eliminate most adult dentistry entirely."