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Quantum Detection of Tooth Decay

A new laser device designed to detect the earliest stages of tooth decay could help dentists stop cavities in their tracks.

By Tyler Hamilton

A newly developed laser device that uses thermal radiation and light waves to detect tiny, subsurface lesions in teeth could potentially unseat x-rays as the diagnostic standard in dental care.

Researchers at the University of Toronto's Centre for Advanced Diffusion Wave Studies say that the technology can spot lesions as small as 50 microns in between teeth, one of the most difficult spaces to spot cavities, and up to 5 millimeters below the surface of a tooth. This is well outside the boundaries of x-ray detection without exposing the patient to radiation. The researchers built a clinical prototype of the device this month and plan to begin clinical tests next year.

Dentistry, which has long lived by the "drill, fill, and bill" approach to dental care, is gradually shifting to a model focused on early detection and oral-disease prevention. Most new detection technologies on the market or in the lab attempt to image the teeth using light, including such methods as optical coherence tomography and light-induced fluorescence. Such products, while more effective than x-rays, have their own limitations.

"Light by itself cannot do it because it scatters too much," says Andreas Mandelis, a professor of mechanical, industrial, and electrical engineering at the University of Toronto who codeveloped the new laser device.

Mandelis, an expert in the use of thermophotonics to detect defects in metals, semiconductors, and other crystal structures, realized seven years ago while visiting the dentist that subsurface defects in tooth enamel, such as demineralization, could be detected using the same approach. Loss of mineral content is a precursor to cavity development.

Mandelis's dentist, Stephen Abrams, lamented that the dental profession treated decay, or "caries," at the wrong end of the spectrum--when large, noticeable cavities had already formed. The two joined forces and began conducting research into diagnostic alternatives.

"The analogy we use is gangrene," says Abrams, now chief executive of Quantum Dental Technologies, a startup founded by him and Mandelis to commercialize the laser device. "When do you want to treat gangrene: when you have to lob off a limb, or when you catch it early? Dentistry figures it's been doing a great job, but what we've

been doing is chopping off limbs all these years."

Their device works by focusing pulses of laser light on the tooth, causing it to glow and release heat. The wavelengths of light and heat emitted from the tooth are captured by an infrared detector, offering detailed information about the tooth's condition, including the presence of hidden lesions and signs of early demineralization of enamel.

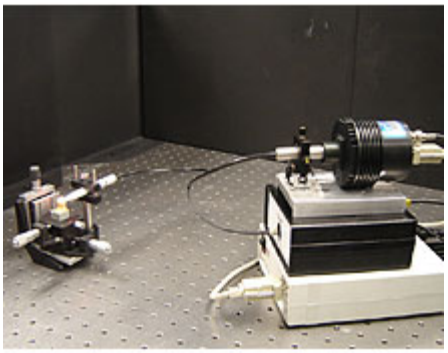
By pulsing near-infrared light at different frequencies, the device can also explore different depths under the enamel. For example, a lower frequency of 5 hertz would allow a deep probe because it gives the heat enough time to radiate back to the surface, while 1,000 hertz would be a relatively shallow probe. Throughout the whole process, the temperature of the tooth rises by two ºC.

Detecting the earliest signs of decay could bring big changes to dentistry. "You need to lose about 30 percent of the mineral before you begin to see it on an x-ray; that's why these new technologies are so exciting," says Christopher Fox, executive director of the International Association for Dental Research, based in Alexandria, Virginia, and a 20-year industry veteran. "If we can detect early mineral loss, we have different intervention technologies we can use to prevent getting to that drill and fill point."

Fox calls Quantum's approach "very interesting" but says that x-rays will always be needed to assess periodontal health, such as the deterioration of bone structure around the teeth.

Still, Abrams says that the device could dramatically reduce the use of x-rays. In one study, published in the journal *Caries Research*, 52 human teeth were subjected to a range of tests--including radiographs, visual inspection, and laser-induced fluorescence--that looked at tooth decay on biting surfaces. Quantum's system caught "very early lesions" in enamel about 80 percent of the time. Its sensitivity was 33 percent higher than laser fluorescence and 2.8 times higher than a radiograph. Abrams says studies that focus on areas between the teeth and subsurface are ongoing, and he expects that the sensitivity compared with laser fluorescence will be much higher.

Researchers plan to spend the next 15 months engineering a version of the device small enough to be used in dentists' offices, with the first clinical prototype likely to be introduced in the summer of 2008, followed by a clinical trial.



Testing teeth: Researchers at the University of Toronto have just assembled a clinical prototype of a new laser device (shown above) that measures thermal and light frequencies to detect early signs of decay below a tooth's surface, where demineralization is difficult to spot with x-ray technology. The optical pen beams heat-emitting infrared light onto a tooth's surface, and sensors within the pen measure heat and light waves that bounce back. Certain wave patterns can reveal loss of mineral content in a tooth, a sign of early decay that can lead to troublesome cavities.
Credit: Quantum Technologies