Open wide and say 'zap'

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A group of researchers in Australia and Taiwan has developed a new way to analyze the health of human teeth using lasers. As described in the latest issue of *Optics Express,*, by measuring how the surface of a tooth responds to laser-generated ultrasound, they can evaluate the mineral content of tooth enamel -- the semi-translucent outer layer of a tooth that protects the underlying dentin.

This is the first time anyone has been able to non-destructively measure the elasticity of human teeth, creating a method that can be used to assess oral health and predict emerging dental problems, such as tooth decay and cavities.

"The ultimate goal is to come up with a quick, efficient, cost-effective, and non-destructive way to evaluate the mineralization of human dental enamel," says David Hsiao-Chuan Wang, a graduate student at the University of Sydney in Australia and first author on the paper in Optics Express. Wang and his advisor Simon Fleming, a physics professor at the University of Sydney's Institute of Photonics and Optical Science, collaborated on the study with dental researchers at the University of Sydney and ultrasonic evaluation researchers at National Cheng Kung University in Tainan City, Taiwan.

Stronger than bone, enamel is the hardest and the most mineralized substance of the human body -- one of the reasons why human teeth can survive for centuries after a person has died. It envelops teeth in a protective layer that shields the underlying dentin from decay.

Throughout a person's lifetime, enamel constantly undergoes a cycle of mineral loss and restoration, in which healthy teeth maintain a high mineral content. If the balance between mineral loss and gain is lost, however, teeth can develop areas of softened enamel -- known as carious lesions -- which are precursors to cavities and permanently damaged teeth.

Enamel demineralization is caused by bad oral hygiene. Not brushing, for instance, can lead to the build-up of dental plaques, and bacteria in these plaques will absorb sugars and other carbohydrates a person chews and produce acids that will dissolve the minerals in tooth enamel.

Quantifying the mineral content of tooth enamel can help dentists determine the location and the severity of developing dental lesions. Existing methods for evaluating enamel are limited, however. Dentists can visually assess the teeth, but dental lesions can be hard to spot in certain parts of the mouth because they are obscured by dental plaque, saliva, or the structure of a tooth itself. Dentists can use sharp instruments to probe the enamel, but this can be destructive to the teeth and gums. X-ray scans can reveal dental lesions, but they give no information on the level of mineralization.

For research purposes, "nano-indentation" is commonly used for gaining information on the elasticity of tooth enamel -- a measure of its mineral content -- but nano-indentation destroys the measured regions of the enamel in the process and is only used to look at extracted teeth.

What Wang, Fleming, and their colleagues wanted to do was to develop a clinical method that would give as much information as nano-indentation and could be used to assess tooth enamel in actual patients while being completely non-destructive. So they developed a way to measure the elasticity of tooth enamel by adapting laser ultrasonic surface wave velocity dispersion, a method similar to what industrial

engineers use to evaluate the integrity of thin films and metals.

The method uses short duration laser pulses to excite ultrasonic waves that propagate along the surface and penetrate only a small distance into a tooth. The velocity of these waves is influenced by the elastic properties of the enamel on a tooth, and by detecting the ultrasonic waves with fiber optics at various points, they can determine the enamel's elasticity, which is directly related to its mineralization.

In their *Optics Express* article, Wang, Fleming, and their colleagues showed that they could use this technique on extracted human teeth. They have not yet tested the technique on a living person's teeth, and it will likely take several years before any eventual device is ready for use in the dentist's office.

More information: "Laser Ultrasonic Surface Wave Dispersion Technique for Non-destructive Evaluation of Human Dental Enamel," Hsiao-Chuan Wang et al., *Optics Express*.

Source: Optical Society of America (news : web)