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Quantum canary detects tooth decay fast

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A new system will enable dentists to examine patients' teeth noninvasively and identify problems earlier. While visual and radiographic examination have helped dental surgeons detect tooth decay in the past, they have done so only after the lesions in the teeth have become large enough to consume much of the enamel that surrounds them. For that reason, treatment has tended to involve detecting the disease in a specific tooth after the event and then placing a dental filling in it to fix the problem.

Now, researchers at Toronto, Canada-based Quantum Dental Technologies have developed the Canary system, which, they claim, will enable the advent of the disease to be caught at a much earlier stage, allowing preventative treatment to be taken long before fillings are required.

According to Dr Stephen Abrams, president and co-founder of Quantum Dental Technologies, the system allows dental professionals to examine the teeth of patients non-invasively and to monitor the development of caries lesions over time. It can detect decay on smooth enamel surfaces, root surfaces, biting surfaces, between teeth and around existing amalgam or composite fillings.

The handset is no larger or heavier than a dental drill

The Canary system comprises a handheld device, a companion console and a display that work together to deliver dental surgeons with what the company calls a ’Canary number’, which provides an indication of the amount of attention that needs to be paid to each tooth that has been examined. The handset itself, which is no larger or heavier than a dental drill, generates a low-power near-infrared pulsating laser light that is used to scan teeth for the presence of tooth decay. As the laser light is shone onto a tooth, it is both absorbed and radiated back in two forms: light and heat.

’By simultaneously measuring the luminescence of the reflected light and the heat created by the absorption of the laser energy by the tooth, the system is then able to provide a user with information on the presence and extent of tooth decay both at its surface and to a depth of 5mm below it,’ said Abrams.

A scan using the Canary system takes five seconds

More specifically, the new system combines what is known as laser photo-thermal radiometry (PTR) and modulated luminescence (LUM) technologies to detect caries, or the formation of cavities in the teeth by the action of bacteria.
Early mineral loss from a tooth causes small changes in its structure, which creates a more porous, less dense structure. This affects the location, rate and transport of the generated heat and fluorescence throughout it, and hence by measuring these parameters, the system can determine the extent of decay in a particular tooth.

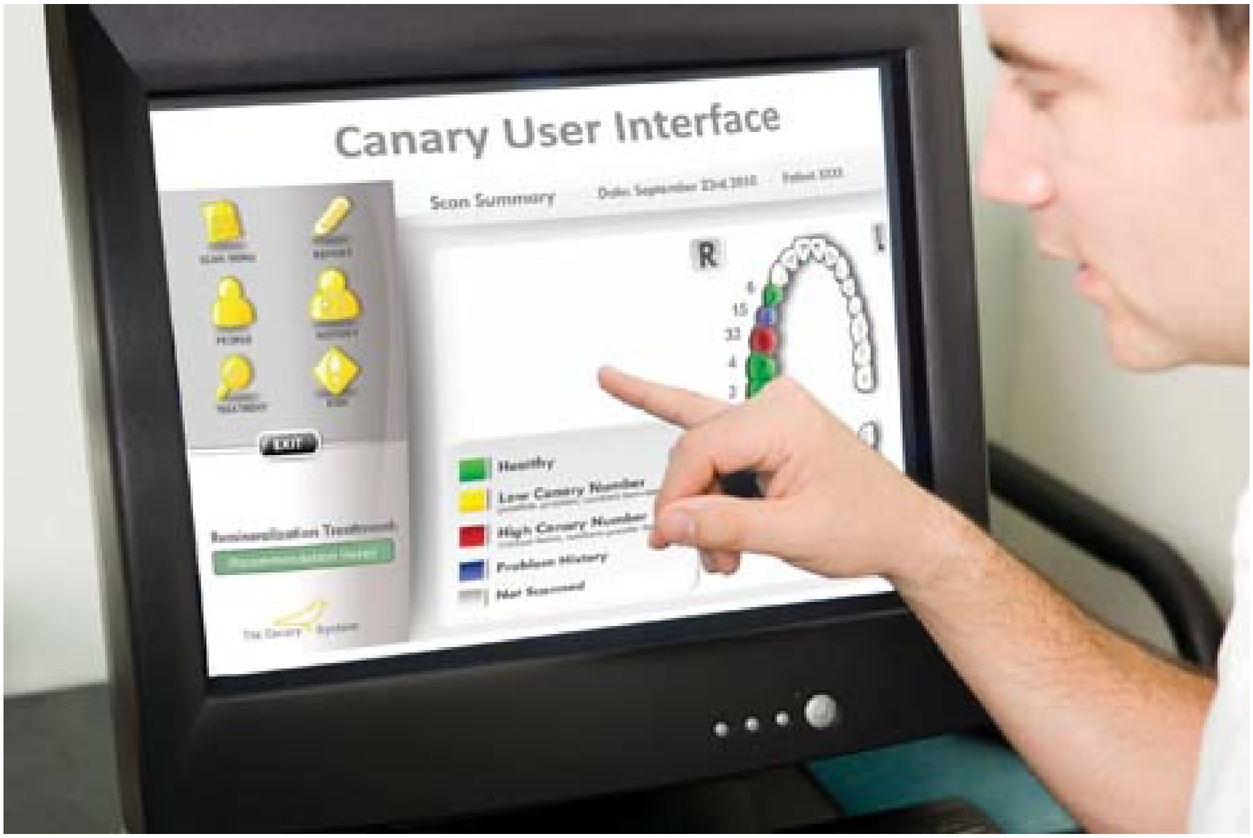
Both the luminescence and the photo-thermal signals reflected from a specific tooth sport an amplitude and phase component. While the amplitude is the size of the signal generated from the tooth, the phase represents the delay of the signal from the time the laser light is absorbed to its collection by the detectors in the probe. Hence the probe effectively collects four sets of data to quantify the amount of demineralisation of a tooth.

When the near-infrared light hits the tooth enamel and dentine, it is partly converted into heat and raises the temperature of the tooth by about 1°C. Once its temperature rises, the tooth emits infrared radiation. A near-infrared detector on the probe then captures the amplitude and phase of the thermal radiation emitted throughout a depth below the tooth’s surface, which change depending on the state of the tooth.

’In teeth with caries, the generated heat is confined to the subsurface region, where the majority of the mineral loss takes place, and as a result a larger amplitude signal and phase delay is observed as most of the heat is concentrated to a much smaller area closer to the tooth surface than an otherwise sound tooth,’ said Abrams.

The luminescence from the tooth is measured by a photo-detector also mounted on the probe. Similar to other purely light-based techniques on the market, the scattering of the light limits its ability to penetrate deeper inside a tooth and therefore is highly influenced by surface features.

However, unlike current systems that employ a continuous luminescence, the designers of the Canary system elected to deploy an ac luminescence technique instead. Because this signal decays according to the degree of demineralisation of the tooth enamel, it carries information about the integrity of the tooth that can be measured.



The system supplies a Canary number to teeth that are scanned

’The integrity of the tooth surface can be mapped by means of scanning the laser across the tooth surface. By using modulated frequencies that are compatible with the luminescence decay rate, we can highlight both demineralised and healthy areas of the tooth, which is where the ac luminescence technique has an advantage over continuous luminescence techniques,’ said Abrams.

The handheld probe on the Canary system not only encapsulates the infrared laser, as well as the infrared and luminescence detectors, it also sports an intra-oral camera so that real-time video and still images of the tooth surface can also be captured along with the data regarding the health of the tooth. The image data can be used by dental practitioners to provide a visual indicator of the state of the tooth, as well as used as a basis from which to compare any subsequent visual changes that might occur to the tooth over time.

The handheld probe is connected to a main console, which is responsible for controlling the operation of the system. Inside the console, a dedicated data-acquisition module captures the response signals from the sensors and the camera on the probe, while an analogue output module generates sinusoidal signals to modulate the low-power laser on the probe.

After acquiring the response signals from the probe, software lock-in amplifier algorithms running on a PC-based system then compute the amplitude and phase of both the PTR and LUM signals. The data is then analysed and a Canary number is generated from them providing the dental surgeon with an indication of the amount of tooth decay on each of the teeth that have been scanned. A scan takes five seconds and the tooth surface does not have to be completely dry, making it easy to incorporate into dental practice.

To assist dentists with their work, the Canary system tooth decay detection program also sports a text-to-voice synthesiser. As a user scans each tooth surface, the system audibly announces the Canary number, allowing dentists to continue to work without constant reference to the monitor, while prompting patients to enquire about the meaning of the number, the location of the decay and their treatment options.

Reports from the Canary system are displayed on the interactive, touch-screen monitor where an oral healthcare provider can review them with a patient. Patient reports include an odontogram, incorporating Canary numbers and colour coding for the teeth examined. The highest Canary number for each tooth is displayed, allowing the patient and dentist to monitor the outcome of any treatment. The patient report also includes the recommendations for home and office treatment, and timing of the next visit.