Light's Answer To Ultrasound

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You have a tiny wound on your hand that doesn't heal, a bad burn on your chest – or an injured retina. Your doctor cannot tell how serious the injuries are below the surface. He needs tissue samples. That means using a scalpel, which again equals pain, perhaps even a risk. Soon there may be hope for an improved and totally harmless method to peer under the surface of the skin: light.

For some time, doctors have had good techniques for seeing what goes on inside our bodies. Xrays, magnetic fields and sound waves are terrific techniques on their separate fields. However, they all have their weaknesses – especially when it comes to creating a satisfying image of what is happening right below the skin.

X-rays cannot reveal the early stages of skin cancer. Magnetic fields do not show how deep the injuries are under a burn. And sound wave measurement of our eyes cannot reproduce the structures because the resolution is too poor. But light waves may offer an alternative approach. The body contains a number of structures that offer good contrasts when photographed with light.

For a long time, researchers have wondered how light waves can enter the body and exit again in a functional way. Now they appear to on the verge of a solution: a new imaging technique in medical diagnostics, called Optical Coherence Tomography (OCT).

Painless And Harmless

Say you have a wound on your arm that needs a more detailed examination. With an OCT device, you would put your arm under the machine and a beam of white light would be emitted towards your wound. The light is reflected and collected by a detector that translates the information into images. The images are displayed on a computer screen. They show the structure of your skin, and a trained eye will be able to distinguish damaged tissue from healthy tissue. This scenario still lies in the future.

The device exists, but it is not yet ready for clinical use. Most of our knowledge about OCT is still confined to research laboratories worldwide. Several researchers are focusing on measuring tissue structures, while Trude Stoeren, a research fellow at University of Trondheim (NTNU), is working on collecting information about the tissues' special characteristics.

"In Trondheim we are researching the use of OCT in photodynamic cancer therapy. This method is already being used. Our technology could improve this method," says the physicist.

Photodynamic therapy has yielded good results in the treatment of skin cancer. First, an ointment containing light-sensitive substances is rubbed on the skin, and after a while a lamp is directed towards the area. When the substance is exposed to light, oxygen is released and kills all cancer cells in the area. One of the challenges thus far has been to determine exactly when to illuminate the substances.

The substances are gradually absorbed by the skin, and they must be in the right location with respect to the cancer tumour to be effective. This is where OCT comes into the picture. Ms Støren is in her laboratory sending rays of white light down into lumps of jelly with added colour. This allows her to test how the light rays should be set, the quality of images they provide at varying depths and the strength of the radiation needed to provide the images she wants. However, skin layers diffuse light differently, making them far more complicated to photograph. But Trude Støren will not stop before she succeeds.

New Ranges Of Application

OCT does not provide sharp and detailed images deeper than a few millimetres, and is therefore best suited to photograph tissues in the upper layers of the skin. However, the technique holds a trump card in its hand: Light can easily be transmitted to clinical imaging devices such as microscopes, fibre optic endoscopes, catheters and needles. This quality presents a whole new world in which doctors can examine everything from blood veins to bladders. Trude Støren concludes: -The excitement of researching new methods is that totally new application may appear.

Optical Coherence Tomography

A focused beam of white light is sent through a beam splitter. The light is divided into two beams, with one beam directed to a reference mirror and the other to the sample being studied – such as your skin. Both are reflected back to the beam splitter, which sends them to a detector where they interfere with each other. The detector signal is collected by a computer, which then translates the information into pictures that can be interpreted.

Skin layers have different thicknesses. When light waves are sent through the skin, they are reflected differently, depending upon the tissue type. The reference mirror acts to control how deeply into the tissue the light travels. When the light wave has traveled to a depth equivalent to the depth set by the reference mirror, the detector reacts and sends a signal to the computer. The computer collects signals from different depths and combines them to make a two-dimensional image of the skin.

OCT technology was adapted from a technique originally used to find faults in optical fibres. Medical research began studying OCT in the early 1990s. SINTEF Trondheim has conducted research with OCT since 1995, and Trude Støren, a PhD student at NTNU, has worked with it since 1997.

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