Photoacoustic Imaging and Diffuse Reflectance Spectroscopy – Non-invasive Imaging Techniques to Reduce the Need for Surgery

Surgery in vulnerable parts of the body poses clinical challenges that can place the patient at risk. This is especially the case when removing tumors from around the eyes. In addition, it is vital to ensure that there is sufficient blood supply to the affected area after surgery. Professor Malin Malmsjö at the Department of Ophthalmology is looking into the use of new diagnostic tools with the potential to improve surgical procedures and increase the safety of the patient. In collaboration with researchers at the Faculty of Engineering, Malin is hoping to reduce the extent of surgery and optimize tissue reconstruction.

Malin’s research group has hitherto focused on detailed studies of microvascular blood flow during surgery, and has used a number of commercially available laser-based techniques such as laser Doppler velocimetry and laser speckle contrast imaging. During the past two years ago, Malin’s group has been working on the application of a novel technique, diffuse reflectance spectroscopy (DRS) in clinical tumor surgery; a technique that was developed by Nina Reistad at the Department of Physics.

In addition, a photoacoustic imaging (PAI) system was recently acquired, thanks to a generous grant from the Lundberg Foundation, and has just been installed at Malin’s bio-imaging laboratory, next to the operating theatres at the Eye Clinic. So far, the PAI technique has been developed primarily through experimental animal research. Malin is now one of the first researchers in the world to implement this technique in the clinic. The project is being carried out in close collaboration with other clinical specialties, in particular dermatology, rheumatology and pathology. To ensure a sound scientific platform, an interdisciplinary team has been established with the research group of Magnus Cinthio at the Department of Biomedical Engineering. Apart from clinical bioimaging activities, Malin’s research group also performs experimental surgery on pigs, as well as histological and cellular and molecular biological analysis at the Biomedical Center (BMC) in Lund.

So how does PAI work? PAI utilizes a combination of laser light and high-frequency ultrasound to provide real-time imaging of tissue. Photoacoustics provides not only anatomical and functional images in real time, but also molecular images of the tissue, by combining laser light and high-frequency ultrasound. Nanosecond-pulsed laser light illuminates the tissue. This light is absorbed and causes “thermoelastic expansion”, which creates sound waves that are detected in an ultrasonic receiver. The signals are then processed to create 3-dimensional ultrasonic and photoacoustic images with high resolution.
The PAI and DRS techniques are now being tested and developed for optimization of tumor surgery and to provide a means of non-invasive diagnosis of giant cell arteritis.

Regarding tumor surgery, we are developing the techniques for the non-invasive diagnosis of infiltrative basal cell carcinomas, lentigo maligna and malignant melanoma. When a skin tumor is surgically removed, it is analyzed histologically to ensure that all the cancer cells have been removed. The aim of this new technique to delineate the tumor before surgery, instead of after surgery. In the case of melanoma, we hope to be able to determine the depth of the tumor, and thus obtain a measure of how invasive it is. This will be used to help decide whether lymph node biopsy is necessary.

Regarding giant cell arteritis, we also want to be able to detect the lesions non-invasively. The temporal artery supplies blood to the head and the brain. Giant cell arteritis is an inflammatory condition that often affects part of this artery or its branches. The condition is characterized by a number of symptoms, including headache, fever, weight loss and stiff aching muscles. In rare cases, giant cell arteritis can cause extremely serious complications such as blindness, stroke or heart attack, which may lead to death. However, the risk of developing these complications is reduced by treatment. Today, giant cell arteritis can only be diagnosed by removing a section of the artery (biopsy) and analyzing it. This procedure is not without risk, and in rare cases can lead to neurological damage and facial paralysis. We hope to develop a method of diagnosing giant cell arteritis using image analysis, making it unnecessary to surgically remove part of the artery in the future.

Taken together, we hope to be able to reduce the number of operations required in the removal of skin tumors, and to completely remove the need for temporal artery biopsies, both of which would improve the safety and care of patients.