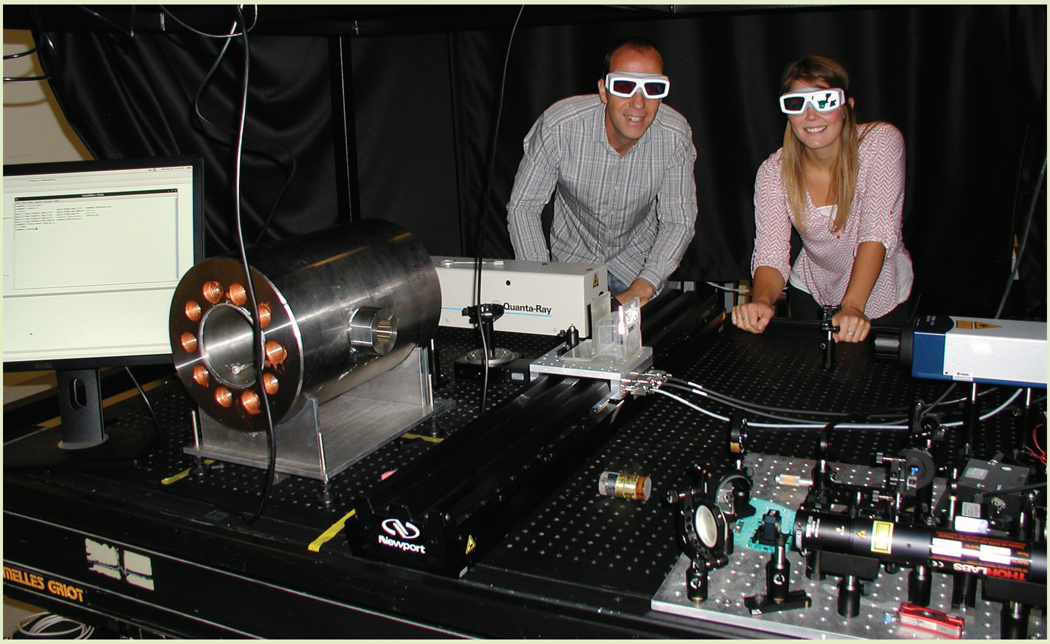
# Earthquake Methods Inspire New Medical Imaging Technique

Inspired by the techniques geophysicists use to reveal structures beneath the Earth's surface, Dodd-Walls Centre Ph.D. student Jami Johnson has developed a non-invasive medical imaging technique which promises a new way to screen for risk of strokes. Using both laser-ultrasound and photoacoustic imaging, the technique works by sending tiny pulses of laser light into the body which cause tiny vibrational 'quakes' in the tissue. These 'quakes' generate sound waves that can be detected to reconstruct an image of the tissue structure. In this way Jami was able to image a human carotid artery to detect signs of calcification, which is a major cause of strokes, the second leading cause of death in the world.

One of the most compelling aspects of this project is the diversity of expertise that came combined to find a solution. In the Physical Acoustics Lab at The University of Auckland where Jami did her research, similar techniques are used to monitor Auckland's volcanoes, measure the ripeness of fruit and probe the Southern Alpine Fault. The group has a unique set of skills and knowledge to understand all these systems. Jami's supervisor, Dodd-Walls Centre Principal Investigator Kasper van Wijk, has a background in geophysics and one of her main collaborators was an expert in computational seismology and imaging Associate Professor Jeffrey Shragge, from the Colorado School of Mines.




Dodd-Walls Centre Ph.D. student Jami Johnson *(right)* and Dodd-Walls Centre Principal Investigator Kasper van Wijk *(left)* working together in the laboratory.

“The medical and seismic imaging fields are analogous in many ways,” Jami explains. “Photoacoustic fields can be thought of as mini-earthquakes created inside of an artery, whereas we create laser-ultrasonic fields at the surface of the skin, just like seismologists create man-made explosions at the surface of the earth. The scale is vastly different, but the physics is essentially the same.

Jeff and Jami developed algorithms to reconstruct images of the biological tissue from the sound waves being measured.

To relate this knowledge to the peculiarities of the medical context, Jami worked with Associate Professor Mervyn Merrilees, an expert in medical imaging from The University of Auckland Faculty of Medical and Health Sciences.

“We spoke with Mervyn at the beginning of my PhD,” Jami explains, “because we knew that imaging arteries was the end goal for my project. He had the know-how for obtaining samples, ethics approval, and validating our imaging results with methods that are accepted in the medical community.”

One of the triumphs of Jami’s research was finding a way to overcome a major limitation in photoacoustic imaging known as “reflection artefacts”. This is when the sound waves bounce around within the tissue and cause unwanted fuzz or clutter in the images. Once again, it was a collaboration with geophysicists that helped solve the problem. Jami was struggling with reflection artefacts in her images when Dr. Joost van der Neut, an expert in seismic imaging from Delft University of Technology in the Netherlands came to visit their lab. Along with his colleague Kees Wapenaar, Joost worked with Jami to develop a method to predict what the artefacts would be and then remove them from the data. They use ultrasound to identify the bouncing sound waves and then are able to remove the problematic waves from the data. Not only does the method they developed solve a problem in medical imaging, it also suggests a new approach to solve long-standing problems in seismology.

The method Jami and her team have developed fills a gap in current medical imaging technology. Unlike x-rays it is harmless to tissue. It penetrates deeper into the body than other optical techniques and enables higher resolution than ultrasound. It also requires no contact with the skin to operate. During her Ph.D. Jami worked with a US-based expert in non-destructive testing, James Caron, to develop instrumentation that would operate without contact.

Not only could the technique be used to screen for strokes, it could also be used to help guide surgeons and doctors to accurately insert needles or operate. Currently ultrasound is used for such applications, but the need for the ultrasound probe to be in contact with the skin and moved manually restricts its uses.

Throughout her project, the Dodd-Walls Centre supported Jami by providing travel funding to visit her collaborators and attend conferences to present her work. The collaborations she established strengthened research links across the world. Having finished her Ph.D. Jami is now continuing her research in medical imaging at Sorbonne Université in Paris working with her new team to develop ultrasound techniques to see behind bone. She continues to collaborate with Kasper and the medical school in Auckland on advancing biomedical imaging techniques with photoacoustics.

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