Research shows how to improve the bond between implants and bone

4 July 2018, by Colleen Macpherson

Xiaoyue Wang (sitting), former student Vicky Vuong, and Grandfield load a sample into the focused ion beam microscope at the Canadian Centre for Electron Microscopy. This is the instrument used to prepare the thin sample for imaging at the CLS. Credit: Kathryn Grandfield

Research carried out recently at the Canadian Light Source (CLS) in Saskatoon has revealed promising information about how to build a better dental implant, one that integrates more readily with bone to reduce the risk of failure.

"There are millions of dental and orthopedic implants placed every year in North America and a certain number of them always fail, even in healthy people with healthy bone," said Kathryn Grandfield, assistant professor in the Department of Materials Science and Engineering at McMaster University in Hamilton.

A dental implant restores function after a tooth is lost or removed. It is usually a screw shaped implant that is placed in the jaw bone and acts as the tooth roots, while an artificial tooth is placed on top. The implant portion is the artificial root that holds an artificial tooth in place.

Grandfield led a study that showed altering the surface of a titanium implant improved its connection to the surrounding bone. It is a finding that may well be applicable to other kinds of metal implants, including engineered knees and hips, and even plates used to secure bone fractures.

About three million people in North America receive dental implants annually. While the failure rate is only one to two percent, "one or two percent of three million is a lot," she said. Orthopedic implants fail up to five per cent of the time within the first 10 years; the expected life of these devices is about 20 to 25 years, she added.

"What we're trying to discover is why they fail, and why the implants that are successful work. Our goal is to understand the bone-implant interface in order to improve the design of implants."

Grandfield's research team, which included post-doctoral fellow Xiaoyue Wang and McMaster colleague Adam Hitchcock from the Department of Chemistry and Chemical Biology. The team members used the soft X-ray spectromicroscopy beamline at the CLS as well as facilities at the Canadian Centre for Electron Microscopy in Hamilton to examine a failed dental implant that had to be removed, along with a small amount of surrounding bone, from a patient. Prior to implantation, a laser beam was used to alter the implant, to roughen the surface, creating what looked like "little volcanoes" on the surface. After removal from the patient, the point of connection between bone and metal was then carefully studied to understand how the implant behaved.

"What we found was that the surface modification changed the chemistry of the implant. The modification created an oxide layer, but not a bad oxide layer like rust but a better, more beneficial layer that helps integrate with bone material."

The research results were published in *Advanced*

Materials Interfaces in May, ensuring the findings are available "to implant companies interested in using nanotechnology to change the structure of the implants they produce," said Grandfield.

The next steps in the research will be to apply the surface modification technique to other types of implants "to be able to understand fully how they function." Grandfield added the research done at the CLS involved healthy bone "so I'd be really interested in seeing the response when bone is a bit more compromised by age or disease, like osteoporosis. We need to find the best surface modifications … because the technology we have today to treat patients with healthier bone may not be sufficient with compromised bone."

More information: Xiaoyue Wang et al. Biomineralization at Titanium Revealed by Correlative 4D Tomographic and Spectroscopic Methods, *Advanced Materials Interfaces* (2018). DOI: 10.1002/admi.201800262

Provided by Canadian Light Source