Health Science Inquiry NEWS

One Size Fits One:
Personalizing Prosthetics with 3D Printing

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3D printing is a relatively new technology, having set its roots in the late 80's to early 90's. Aptly named, 3D printing is a process where a three-dimensional object is created through the control of a computer. Public interest has recently increased due to advances in precision, repeatability and materials, resulting in a broader range of applications. For some time now, this technology has no longer been limited to only replacing external components such a bird beak, dolphin tail or human leg.

In 2015, a 22-year-old woman from the Netherlands who was suffering from increased pressure on her brain due to the thickening of her skull had her entire skull replaced with a plastic 3D custom printed implant. This surgery took 23 hours and after three months, she had regained her vision, returned to work and was entirely healthy. Later that same year, a three-year-old girl in China suffering from hydrocephalus underwent a 17 hour surgery to replace her skull with three custom printed titanium implants. This condition causes cerebrospinal fluid to accumulate in the brain cavities, causing severe pressure build-up which changes the shape of the skull. The surgery itself was a success, but the little girl will need follow up surgeries.

Last fall at the Ontario Veterinary College, veterinary surgical oncologist Dr. Michelle Oblak and her team successfully replaced approximately 70% of a dog's skull with a custom printed metal implant. This accomplishment is the first of its kind in North America and is a marked advancement in reconstructive surgery and veterinary medicine. The dog, named Patches, was a nine-year-old Dachshund afflicted with an osteochondrosarcoma tumor on her head. The tumour was so massive that it weighed down her head, pressing dangerously close to the brain and eye socket. The surgery took less than five hours, and the dog was "alert and looking around" 30 minutes after waking.

3D printing implants require an interdisciplinary approach, drawing input from several areas including medical imaging, mechanical design, materials science, computer programming and more. Every case is unique since it must consider the individual patient's anatomy and needs.

The technology has come a long way from its first inception. While some implants, such as the skull piece, are static, others can now possess functional and dynamic geometries as well. The use of this technology has a bright future for patient outcomes as well. Oblak explained that reconstructive surgeries typically take a long time. Traditional methods require time spent assessing the damage after a diseased portion of the skull is removed and shaping a titanium mesh over the spot. Imaging and 3D printing eliminates the need to create models 'on-the-fly' in the operating room, reducing patient risk.

The procedure began with a high-resolution CT scan of the tumour on Patches' head. Oblak and her team then used several different software programs to digitally remove the diseased portions of the skull and the tumour itself. Next, they modelled the 3D replacement to fit into the space and connect to the remaining bone. These plans were sent to ADEISS, a Canadian medical and dental 3D printing company, to produce the custom implant using metal. The surgery itself took about four hours, and within 30 minutes of waking up, Patches was alert and walking.

The dawn of the "Information Age" and the increasing ease of sending large image files over the Internet has bolstered the growth of 3D printing. Scientific Director of ADEISS, David Holdsworth, said he is confident in the future of 3D printing technology in medicine. "There have been dramatic advances in 3D printing in the past few years, and that applies to metal printing, as well as plastic printing (which is much more common)." Holdsworth believes the ease of 3D printing as compared to traditional manufacturing will mean that the industry will continue to expand. "The performance and cost-effectiveness of 3D metal printing has reached the point where some orthopaedic components are now manufactured by 3D printing, rather than traditional fabrication techniques," Holdsworth said. "This trend is likely to continue, and we'll see more and more 3D-printed components in the next few years."

With any growing technology, regulatory bodies must keep up in order to maintain safety standards. ADEISS requires its facility to follow a "rigorous, formal system of quality control that ensures that every aspect of the manufacturing process is done according to strict guidelines." These guidelines are set by the International Organization for Standardization.

Dr. Yara Hosein, an assistant professor at the University of Western Ontario and an expert on orthopaedic and orthodontic implants, explained that while regulations and ethics have to be maintained, public perceptions and expectations are also important. This has always been a struggle in medicine, as evidenced by movements such as anti-vaccinations or naturopathic/homeopathic practice. However, this can be prevented by educating the public on the technology behind 3D printed implants, what it is capable of and what its current challenges are.

Morla is currently an MSc. student at the University of Guelph, Ontario Veterinary College. Her passion for cancer research led her to a project that focuses on figuring out a way to radiosensitize canine mast cell cancer cells. She enjoys drawing and reading science fiction in her spare time.