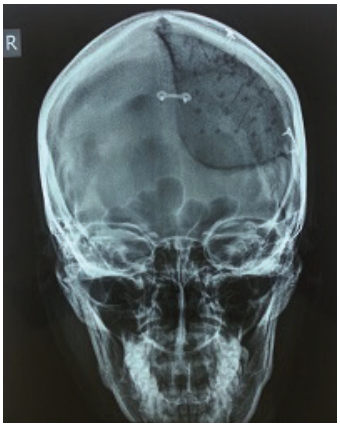
A Better Mold for Cranioplasties

3D PRINTING ENABLES FASTER, CHEAPER, MORE PREDICTABLE OUTCOMES

"Before 3D printing, the surgeon had to shape the bone cement implant by hand. The aesthetic results were poor, the operation lasted longer and the outcome was less sure. With 3D printing, the outcome is much better because the implant is tailored to an individual's CT scan."

– Miodrag Katalenic, University of Zagreb

CASE STUDY



A 23-year old woman's successful cranioplasty using 3D printing technology.

A MEDICAL CHALLENGE

A 23-year-old woman presented at the University Hospital Osijek, Croatia, department of neurosurgery, with a benign change in the bones of her skull. The deformed part of the skull was on her forehead, and highly visible. In addition to needing to remove part of the diseased bone, doctors determined that it was also necessary to address the woman's cosmetic defects in order to reduce the psychological consequences of the surgery.

Traditionally, this procedure, a cranioplasty, required surgeons to tailor polymethyl-methacrylate (PMMA) bone cement implants to the patient's skull using silicone molds. But these molds often have poor aesthetic results, long production times and high costs. Additionally, the operation would be lengthy and the final outcome was not guaranteed.

Additive Technology Offers Hope

This patient, and many others, have benefitted from the additive technology of 3D printing. Since 2013, faculty at the University of Zagreb's Centre for Additive Technologies (CATeh), have experimented with various 3D printed materials for medical purposes.

3D printers have allowed CATeh to expand its knowledge and research in the field in medicine. "The Stratasys Objet350 Connex3™ multi-material technology has enabled better, faster and cheaper production of PMMA implants for cranioplasties, tailored specifically to the patient from a 3D printed mold," said Professor Mladen Sercer, head of Chair of Polymer Processing at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

3D printed mold with bone prosthetic.

3D Printing a Cranial Mold

Cranial surgeries such as this woman's, require high precision and accuracy of the implant as well as compactness of the material in order to ensure successful sterilization of the mold. 3D prototyping models enable the hospital to remove any faults in the mold design in the early phases, before surgery.

"3D printing enables faster product development and easier communication with patients. This aids in early detection of faults and problems which makes the whole process faster and more economical," said Sercer.

The first step is converting a patient's CT scan into a virtual 3D image. This prototype is 3D printed to check for an exact fit of the implant by measuring it against the bone cavity in the patient's skull. Only once the exact measurements are confirmed is the mold filled with a low-viscosity PMMA, or bone cement, to create the actual prosthesis.

Surgeon trimming bone cement after successful removal from a 3D printed mold.

3D printing technology has also solved another production challenge in prosthetic molds. The exothermic, or heat-generating properties of the polymerization stage in the cooling process of the bone cement, can make it difficult to find a material that can be easily separated from the mold. "Traditional research methods in polymer processing would not be able to achieve the results we achieve with the 3D printed mold," said Miodrag Katalenic, Chair of Polymer Processing at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

Beyond the Cranioplasty

The university continues to push the boundaries of implementing additive technologies. To date, 13 surgeries have been done using 3D printing technology. In addition to cranioplasties, the university hospital has also performed reconstruction of the vertebrae and half of the jaw.

"Additive technology gives bone cement (PMMA), a proven material, a new life and greater application because with 3D printing it is now possible to easily and accurately create the complex shapes required for custom implants," said Katalenic. How was the outcome of the 23-year old cranioplasty patient? "The patient is very pleased with the results of her operation," said Sercer.

CATeh was founded with the goal of becoming the leading regional center for research, development and implementation of additive technologies connecting science and industry. The university now offers an elective course, “Modern Additive Manufacturing,” in an effort to ready students across multiple disciplines in the technological possibilities of 3D printing.

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