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Generative design offers solution to patient-specific knee implants

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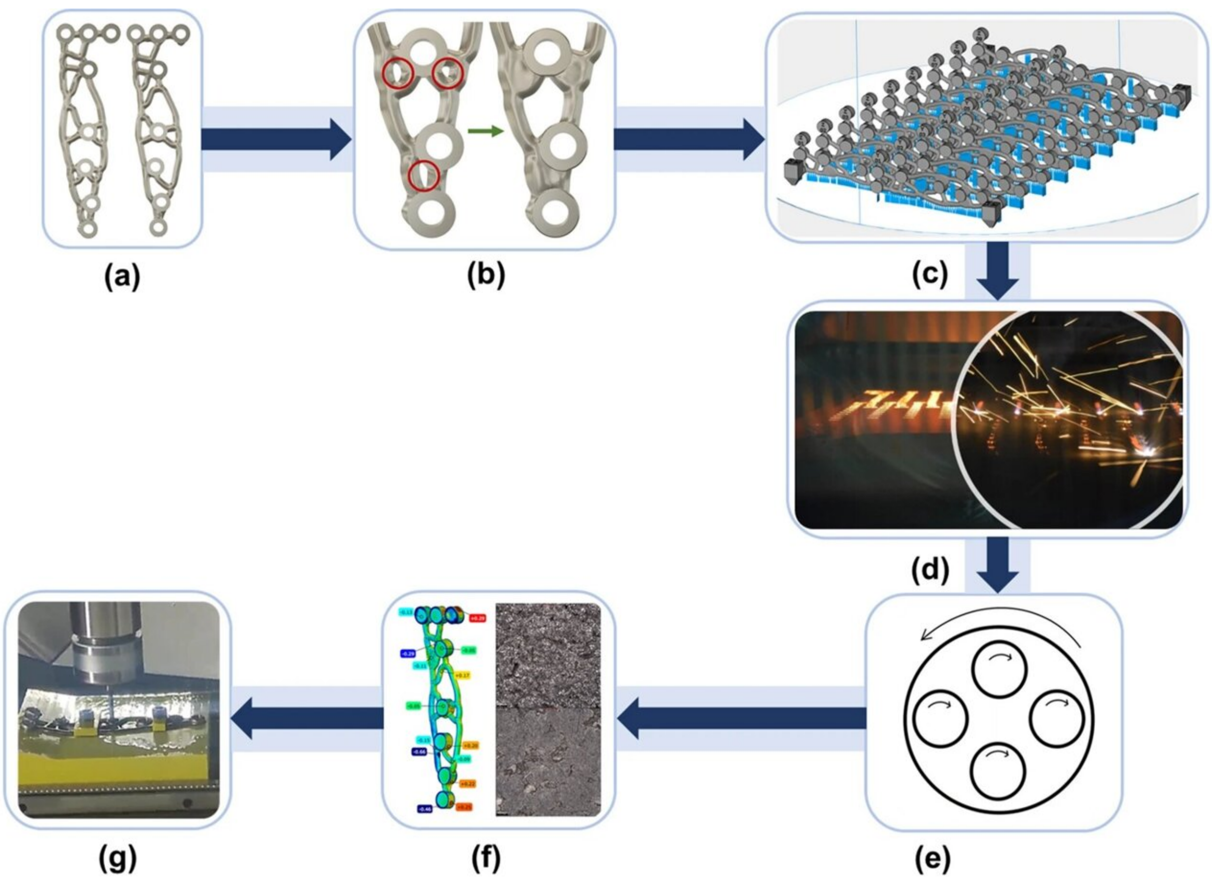

G-DfAM workflow for HTO plate fixations, a GD HTO plate conceptual designs, b design optimization of GD plate conceptual designs, c PBF-EB build preparation, d PBF-EB manufacture of Ti-6Al-4 V plates, e mass finishing, f optical surface inspection, g CNC machining of plate holes and threads. Credit: *Progress in Additive Manufacturing* (2022). DOI: 10.1007/s40964-022-00342-2

An advanced design technique, used to develop components for aerospace and automotive industries, has been harnessed in the production of bespoke medical devices.

Researchers at the University of Birmingham, working in partnership with design software specialists Autodesk, Manufacturing Technology Center (The UK National Center for Additive Manufacturing), and the University Hospitals Birmingham have used a technique called Generative Design to produce a knee implant that can be used to treat osteoarthritis.

A proof-of-concept paper describing the comprehensive workflow of detailed design and advanced manufacturing processes for a generatively designed patient-specific bone fixation device has been published in *Progress in Additive Manufacturing*.

Generative design uses artificial intelligence (AI) and machine learning to design parts that can be manufactured to be absolutely optimal for their intended use. For an aircraft or a car, for example, this might be a component that is both lighter and stronger, leading to increased fuel efficiency and lower CO_2 emissions. This study is the first known application of Generative Design to a biomedical implantable device.

There are several advantages to being able to use this technology in medical applications. For example, current knee implants for treating knee arthritis are manufactured in a limited number of shapes and sizes.

Although new 3D printing techniques are starting to be employed to make implants designed to an individual patient's shape, this doesn't take into account the constraints imposed by surgical planning, as well as the patient's weight or activity levels. These are important elements to understand how a patient's anatomy and a knee implant will interact and are crucial to the implant design and post-surgical rehabilitation.

Generative design allows the implants to be biomechanically specific, so the implant is tailored to the load it will be bearing. This also allows the end product to be lighter, less prominent and minimally invasive, which means the patient will heal more quickly and is also less likely to need revision surgery.

In the new study, the researchers set out how the design produced by Autodesk's software can be manufactured and processed into a functional prototype, including how much of the process can be automated.

Postgraduate and lead researcher, Mr Sanjeevan Kanagalingam, of the University of Birmingham, says that "the 'one-size-fits-all' approach used in knee surgery to treat osteoarthritis can result in major complications, primarily due to overengineered implant designs and therefore limits surgical adoption and patient outcomes."

"This AI integrated design interface allows us to configure tailored surgical planning parameters and take personal biomechanical information into account, and synergistically combine it with the embedded manufacturing intelligence to model medical-grade titanium implants that are specific to each patient."

Principal Investigator and Senior Lecturer, Dr. Lauren Thomas-Seale, also at the University of Birmingham, added that "the combination of the academic, industrial and clinical knowledge of team working on this project, and the vast design space offered by Generative Design, has yielded implant designs beyond anything that has been seen before."

"Such an approach, noting the diversity of the project team, has enabled the development of a design process which can take into account the many differences between patients, for example the variation between male and female body mass."

The next steps will be to mechanically test the devices to see how much they bend and flex under loads. If successful, the team will eventually move on to clinical testing.

Kanagalingam concluded that "this generative design approach not only increases the patient-specificity of bone fixations but also serve as a novel, versatile framework in the design of load-bearing patient-specific implants for the hips, shoulders and maxillofacial surgeries."

More information: Sanjeevan Kanagalingam et al, Detailed design for additive manufacturing and post processing of generatively designed high tibial osteotomy fixation plates, *Progress in Additive Manufacturing* (2022). DOI: 10.1007/s40964-022-00342-2

Provided by University of Birmingham