FingerKIt (Fraunhofer IAPT)

Ceramic and Titanium implant variants developed in the FingerKIt project

Through FingerKIt, the prospect of restoring the mobility of impaired finger joints can become a reality for patients. «

Dr.-Ing. Philipp Imgrund
Fraunhofer IAPT

Patient-specific implants made by AM – a new treatment perspective for impaired finger joints

Remobilization of finger joints through AI-based reconstruction

Patient-specific implants promise a high accuracy of fit and thus better functionality and durability than conventional implants. Furthermore, individualization is a great opportunity for areas in which the possibilities of implant fitting and remobilization are still insufficient, e.g. for small joints such as finger joints.

In the internal Fraunhofer project FigerKIt, an autonomous process chain in the production of patient-specific implants has been developed for the first time, from design and production to certification-compliant testing. With Fraunhofer IAPT, IKTS, ITEM, IWM and MEVIS, five institutes were working on this joint project. The potential of metal binder jetting for the production of high-precision components comes to bear in the manufacture of the fi igree finger implants.

Development of shape models from imaging data

Based on clinical 2D X-Ray scans and 3D CT-scans, Fraunhofer MEVIS developed a method to generate a 3D shape model of the fingers, which is the starting point for the implant design process. The goal was to use only 2D X-Ray data in order to reduce time, cost and patient risk by avoiding the necessity of CT scans.

AI-based design automation of personalized implants

At Fraunhofer IAPT, developing a suitable design of the implants and automating the design process was addressed. Based on X-Ray data and predefined requirements from the shape models, an algorithm has been trained to generate the patient-specific implant design fully automatically. One main asset is the integration of fi igree automatically generated TPMS structures in the shaft for reliable osseointegration, providing a firm fit and preventing implant loosening.

At Fraunhofer IWM, the biomechanical parameterization of the implant design was performed based on simulations. This allows for optimized simulations and the generation of a model for reliability prediction. Additionally, different concepts for certification-compliant testing of the mechanical properties of small artificial joints were evaluated.

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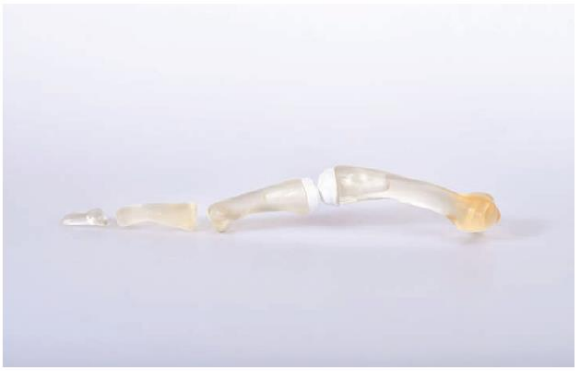


Finger model with integrated ceramic implants

Additive and near-net-shape production

In addition to developing the designs, Fraunhofer IAPT has also adapted the metal binder jetting technology for a titanium alloy for precise manufacturing of the fi igree implants. Appropriate printing and sintering parameters have been developed to assure reproducible quality and biocompatibility. In parallel, Fraunhofer IKTS has developed an additive manufacturing process chain for complex silicon nitride implants with triply periodic minimal surface (TPMS) structures, high density and good biocompatibility. Additionally, slip cast alumina-toughened zirconia (ATZ) prototypes feature an osseointegrative macro/micro surface texturing of the stem. Due to near-net-shape manufacturing, no further hard machining is necessary, except for the articulating surface. The high quality of the microstructure results in mechanical properties that far exceed the loads that occur in the implanted state.

Biocompatibility testing and regulatory documentation

Fraunhofer ITEM was in charge of the biocompatibility testing and development of a novel push-out test method for verification of the bone ingrowth into the implant. In addition, ITEM developed a full regulatory ISO 13485-conform documentation for the patient-adapted implant.

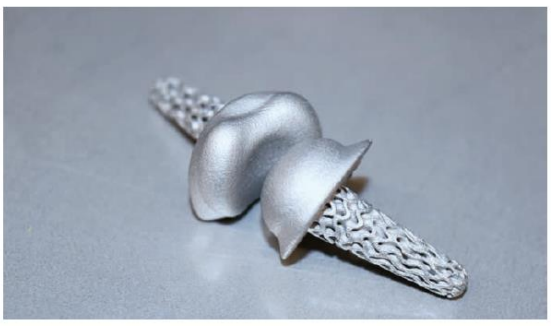
Outlook:

In follow-up projects, the partners seek to establish a proof of concept for manufacturing of AI generated individual small joint implants made of ceramics or titanium in collaboration with industry, standardization bodies and hospitals, in order to established patient specific finger joint implants in the market. Moreover, the work flow may be transferred to other small patient-specific implants.

Key results of the FingerKit project

- 3D shape models derived from 2D X-Ray data for simplified defect imaging
- Biomechanical simulation and reliability prediction of the 3D-printed implants
- Automated implant design process based on 3D imaging data of the defects
- AM processes for implants made of Titanium, oxide and nitride ceramics
- Biological and mechanical characterization and full regulatory documentation

Titanium implant with TPMS structured shaft for enhanced osseointegration



More information at the FhG forum:

Donnerstag, 16. Mai 2024

10:35 - 11:05

CongressCenter, Panoramasaal, 3 OG

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