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Computergestützte Herstellung einer Negativform zur präoperativen Formung einer Schädeldachplastik aus PMMA-Kunststoff

Computer aided generated mold used as a template for preoperative implant fabrication in cranioplasty

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Introduction

Trauma, calvarian tumors, infected craniotomy bone flaps and defects following decompressive surgery are the main reasons for large cranial defects. The main indication for reconstruction of these defects are cosmetic reasons and/or protection against mechanical impact. The intraoperative free-hand modeling of skull implants turns out, in particular with very large defects, as cosmetically and technically difficult.

Methods

We report a technique of rapid prototyping for custom reconstruction of large cranial defects using Fused Deposition Modeling, which is based on routine radiographic diagnostics and can rapidly provide implants at a fraction of the costs for commercially available custom implants. A thermoplastic material extruded as a wire is used by a 3D-plotter to reconstruct the bony skull defect based on CT data. Using a CAD-technique a negative mold of the defect is reconstructed, which can be created based on pre-craniektomy CT-data or be recreated by an approximation of a mirrored image of the unaffected contralateral side. The negative mold is used to form a conventional PMMA-reconstruction, which can be sterilized by irradiation.

This technique has been used to reconstruct entire neurocraniums based on 1mm spiral CT images and data sets. Comparison of anthropological measurements of human skulls and rapidid prototyping generated solid models demonstrated an absolute mean deviation of +/- 0,79 mm.
Bone defects from patients after craniectomy using routine diagnostic data sets were reconstructed using the same technique. In a cadaver specimen a surgical craniecotomy was performed and a negative mold of the defect that was built using Fuded Deposition Modeling. The mold was based on the pre-operative imaging data takining into account the modified mirror image of the contralateral side using "free hand" CAD assisted design. Furthermore a positive FDM – model was built. Different PMMA-implants were built using a negativ mold. In addidion laboratory fabricated implants were built
by means of a wax pattern formed on the FDM model in order to form a properly contoured shape. The wax pattern than was invested in gypsum and wax was removed. The resulting mold then was used for PMMA implant fabrication.
The different implants were radiographically imaged and the reconstructions were compared to the pre-operative images by an overlay technique. The stability of shapes and the mechanical stability of the PMMA implants was analyzed after different sterilization techniques.

Results

Our results demonstrate that FDM generated negative mold based on clinical routine CT data provides a rapid and highly accurate method of custom implants of skull defect reconstructions which because it is based on routine data and commercially available hardware components and inexpensive consumables is a cost-effective alternative to industrially produced implants. The implant fabrication can be performed preoperatively by the operating surgeon.