Surgical Treatment of Spinal Lesions with the Aid of 3D Printed Models

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Introduction

• 3D printing (Additive Manufacturing (AM)) represents a process in which products are built on a layer-by-layer basis using series of cross-sectional slices. The advantage of 3D printing for rapid manufacturing is to create quickly and cost effectively tailor-made products and unique configurations.

• However, the use of 3D printing in neurosurgery is recently still rare one of the major application is, to create models for surgical planning, practicing and teaching.

• The aim of this article is to present a newly developed application of 3D printing in preoperative planning of spinal surgeries.
Methods

• The 3D models for printing was generated from preoperative high resolution CT scans, and CT-angiographs.

• We used a dedicated software to generate three dimensional models (stereollitography, STL) from DICOM images.
Methods

• Professional 3D printing software (Simplify3D; [http://www.simplify3d.com](http://www.simplify3d.com)) was used for processing the model.

• We corrected the manifold errors and „sliced” the objects into series of thin layers to produce a G-code file containing instructions tailored to the 3D printer.
Methods

• In fused deposition modeling (FDM), or fused filament fabrication (FFF) the model or part is produced by extruding small beads of material which harden immediately to form layers.

• The polymer we used is polylactic acid (PLA), which is a biodegradable thermoplastic aliphatic polyester derived from renewable resources. The melting temperature is 173–178 °C.

• For printing we used a dual headed desktop 3D printer device (MakerBot Replicator 2X; MakerBot Europe GmbH & Co. KG Motorstraße 45, D-70499, Stuttgart). This device has a 100 microns layer resolution, which is more than enough for our project.
Results

• We operated 13 patients with various pathologic disorders, located at the craniospinal region (C0-C5).

• 8 patients had malignant metastatic tumors, while 5 had different C1 and/or C2 vertebral fractures.
Results

• In all cases we produced a real sized, three dimensional model of the bony parts of the affected region (occipital bone and the C1 to C3 vertebras) with the most important vessels (vertebral arteries).

• Those models were 3D printed to investigate the pathological distortions, and do measurements for the implantations (e.g.: C1 lateral mass screw or custom made titanium mesh).

• The overall processing time of the model was around two hours. Printing a real sized, realistic monochrome model of the affected region of the bony parts of the spine with vertebral arteries takes about six to eight hours.
Results

• The application of 3D printing in neurosurgery promises a number of innovations and its utility is diverse.

• 3D objects are valuable for diagnosis, preoperative planning and intraoperative navigation by using actual imaging data of patients to create a realistic model.

• These objects provide sufficient insight in anatomical relationship between pathology and its environment, especially when it is unclear on computer visualization.

• In addition, the technology is beneficial in medical prosthesis designing. It allows surgeons to create tailor-made prosthetics that fit to patient’s requirements.
Discussion

• Our article focuses on the utility of 3D printing in preoperative planning. Our objects represent cases of malignant metastatic tumors and complex fractures of the upper cervical spine. In extended processes, treatment may be difficult and 3D models can help in preoperative planning of fixations.