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Three-Dimensional Printing in Neurosurgery: A Review of Current Indications and Applications and a Basic Methodology for Creating a Three-Dimensional Printed Model for the Neurosurgical Practice

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Abstract

Introduction

Three-dimensional (3D) printing is an affordable aid that is useful in neurosurgery. It allows for better visualization and tactile appreciation of the individual anatomy and regions of interest and therefore potentially lowers the risk of complications. There are various applications of this technology in the field of neurosurgery.

Materials and methods

In this paper, we present a basic methodology for the creation of a 3D printed model using only open-source software for medical image editing, model generation, pre-printing preparation, and analysis of the literature concerning the practical use of this methodology.

Results

The literature review on the current applications of 3D printed models in neurosurgery shows that they are mostly used for preoperative planning, surgical training, and simulation, closely followed by their use in patient-specific implants and instrumentation and medical education. Materialise^{TM} Mimics is the most frequently used commercial software for a 3D modeling for preoperative planning and surgical simulation, while the most popular open-source software for the same applications is 3D Slicer. In this paper, we present the algorithm that we employ for 3D printing using Horos^{TM}, Blender, and Cura software packages which are all free and open-source.

Conclusion

Three-dimensional printing is becoming widely available and of significance to neurosurgical practice. Currently, there are various applications of this technology that are less demanding in terms of technical knowledge and required fluency in medical imaging software. These predispositions open the field for further research on the possible use of 3D printing in neurosurgery.

Categories: Neurosurgery, Healthcare Technology
Keywords: medical education, patient-specific surgical instruments, patient-specific implants, surgical simulation, preoperative planning, 3d printing

Introduction

The field of neurosurgery has always required an excellent three-dimensional (3D) perspective. Magnetic resonance imaging (MRI) and computed tomography (CT) images have improved the preoperative planning and the visualization of spatial relations between normal anatomical structures and pathological objects. However, their main disadvantage is the lack of an additional dimension that shows finer details and correlations of the object of interest and may result in amplified errors in the planning of procedures involving critical anatomical structures [1]. Such a problem has motivated the need for 3D reconstructions of preoperative radiological data that have to be visualized in the most understandable and useful way, adjusted to the level of expertise of the surgeon and the goal of the operation. There are different types of virtual spatial visualization used for preoperative planning, including 3D software reconstructions with neuronavigation systems [2], commercial software for preoperative planning [3], open-source packages that can be adapted for preoperative planning [4,5], and physical 3D printed models derived from CT or MRI data [6,7].

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