3D Modeling and Printing Technologies in Neurosurgery

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Dear Editor,

Three-dimensional (3D) printing technology introduced by Charles Hull in 1986 (Figure 1) [1]. Recently it has gradually penetrated into the field of clinical medicine and it has been used to various medical applications, as creating accurate models of individual patient anatomy for patient education, as visual aids during surgery and for surgery training / planning, and as patient specific phantoms [1]. This letter aims to highlight the merits new technology of 3D-printing to create patient-specific solutions for neurosurgery defects, and this generated great interest in the development of new technologies and new education. In addition, spine surgeons, orthopedics, neurosurgeons and researchers are appearing on the letter. 3D-printing technologies provide clinicians, engineers, researchers and may be used in rehabilitation, reconstruction and regeneration. In rehabilitation, it can be used to create prostheses to replace or cover damaged tissues. Reconstruction, through neurosurgery, can also applied to create custom cutting guides, fixation devices, practice models and implanted medical devices to improve patient results. Regeneration of tissue attempts to replace defects with biological materials [1-2].

Up to now, the 3D-printing has not been widely applied in neurosurgery, and there are few related reports. However, now there are 3D-printing implants, 3D-printing models for surgical practice, 3D-printing bone replacements, even 3D-printing human tissue. It has shown promise for uses for neurosurgical education, medical evaluation, and surgical planning as cerebral aneurysm and spinal disease by the fabrication of physical models of complex parts of the human anatomy [1,3-4]. 3D-printing technology offers the unique capability to create practical neurosurgical scenarios without the inherent risks of patient care in practical and residency training. It enables learners to make errors in decision-making process and technique without catastrophically negative consequences [3]. This technology will advance through loosely coordinated progress in three parts: printing methods, software to design and print, and materials used in printing. It is believed that 3D-printing continue to expand their abilities, reduce cost, increase

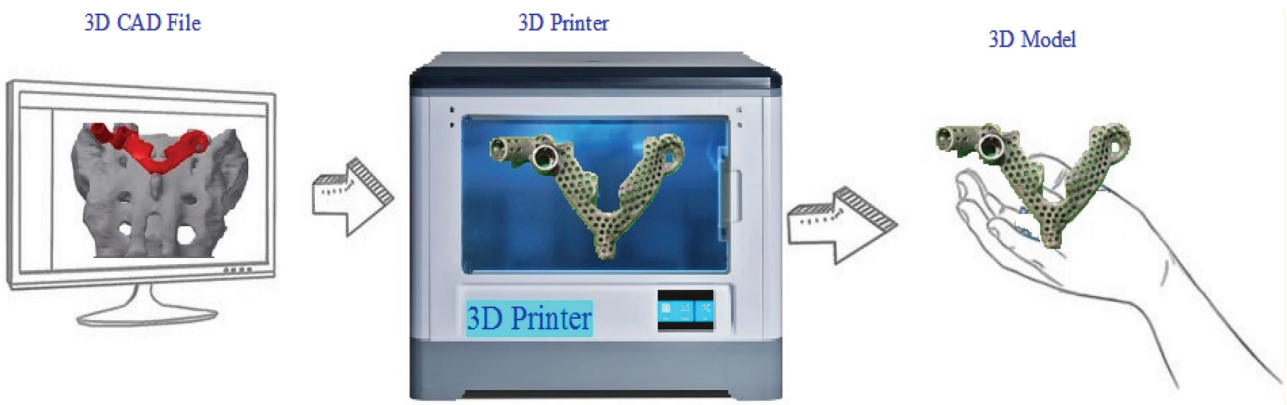

Figure 1. Schematic of 3D modeling and printing technologies. a) 3D CAD File: 3D printable models can be produced with a computer-aided design (CAD) package, via a 3D scanner, or by a plain digital camera and photogrammetry software; b) 3D Printer: 3D printing or additive manufacturing is a method of making three dimensional solid objects from a digital file; and c) 3D Model: 3D Model is ready for use.

speed, and use a wider range of printable materials [1]. In addition, recent advances in 3D-printing technology may lead to immediate improvements to clinician' design for applied in neurosurgery [2-3]. However, randomized controlled studies, technology standardization, neurosurgery models and equipment, customized implants and prosthetics, and validating of technique as imaging, using 3D printed models remain scarce. In addition, future work will include enhancing the simulacrum to include all of the areas of neurosurgery and spine, developing techniques, implementing 3D-printing in neurosurgery education as development of printing devices that permit rapid onsite printing in the teaching hospital, and validating the overall simulator as a tool for cultivating neurosurgical skill [3].

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