Chapter 82
The Added Value of 3D Imaging and 3D Printing in Head and Neck Surgeries

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ABSTRACT

3D imaging and 3D printing are two methods that have been proven very useful in medicine. The objective of 3D medical imaging is to recreate the static and functional anatomy of the inner body. The development of computational systems for image processing and multidimensional monitoring of medical data is important for diagnosis and treatment planning. The technique of 3D printing has enabled the materialization of anatomical models and surgical splints using medical imaging data. The methods of 3D imaging and 3D printing have been utilized in various medical fields such as neuroimaging, neurosurgery, dentistry, otolaryngology and facial plastic surgery. This review aims to evaluate the use of 3D imaging and 3D printing techniques in head and neck surgery and concludes that these technologies have revolutionized medicine. However, improvements in healthcare systems and further research still have to be made to establish their use in everyday medical practices.

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INTRODUCTION

The use of three-dimensional (3D) medical imaging and printing methods has become more prevalent over the past few decades, contributing significantly to the promotion of personalized healthcare. These methods have been proven significant for diagnosis and treatment regarding the particularly challenging area of the head and neck, which involves complex anatomy in a small space.

Imaging methods are based on the interaction of various energy forms with materials and focus on the interpretation of these interactions. Most imaging systems provide two-dimensional (2D) slices of the objects of interest, but can also produce 3D images of them through tomographic reconstruction. 3D imaging, in particular, is a methodology that overcomes the limitations of 2D Imaging, increasing the efficiency of diagnosis and treatment. Many diagnosis and treatment plans are currently mainly based on the interpretation of medical images, which makes the development of reliable computational systems for medical image processing essential (Junn et al., 2020).

3D printing is a fabrication process in which sequential layers are usually added on top of each other to form a variety of geometric shapes, a process known as additive manufacturing. 3D printers are controlled by a computer that reads digital model data given by computer-aided design (CAD) software or a computed tomography (C.T.) scanner. The broad use of 3D printing techniques in the medical field stems from the ability of this method to prepare patient-specific devices (Al-Dulimi et al., 2020; Eshkalak et al., 2020).

This paper aims to review and evaluate the use of 3D Imaging and printing techniques in medical operations focusing on the head and neck area, such as neurology, dentistry, facial plastic surgery and brain cancer. The basic principles, as well as the applications of 3D Imaging and 3D printing in a variety of medical areas, are presented.

3D IMAGING IN THE MEDICAL FIELD

Medical Imaging is as a group of methods that focus on the noninvasive generation of images derived by the interaction of energy with biological tissue. Some of the most prevalent medical imaging techniques are computed tomography (C.T.), magnetic resonance imaging (MRI), and ultrasound imaging (U.I.). C.T. is a computerized x-ray imaging procedure in which a narrow beam of x-rays is aimed at a patient and quickly rotated around the body, producing signals that are processed computationally, generating cross-sectional image slices of the body, which are called tomographic images. A 3D image of the patient can be created by stacking the successive 2D slices. MRI is a technique that is based on a magnetic field and computer-generated radio waves to produce detailed images of the organs and tissues of the human body. A 3D M.R. image is created by joining together the 2D M.R. slices. U.I. is based on the application of sound waves instead of radiation, and 3D U.S. images can be generated with the volume rendering of ultrasound data (Junn et al., 2020).

Image reconstruction refers to the process of generating axial images from non-invasively acquired projection data. A set of 3D voxels represents objects, and every projection group is a 2D layout, also called a projection image. Image reconstruction algorithms can be outlined as simple back projection, filtered back projection and iterative reconstruction algorithms. The goal of these algorithms is to solve the inverse Radon transform to estimate the image to be reconstructed using the projection data. These methods are mainly implemented in 2D but can be extended in three dimensions. Ideally, a large