

3D Printing Role in Oral and Maxillofacial Surgery Current and Future Trends

Joseph Krajekian*

Diplomate of American Board of Oral & Maxillofacial Surgeon, USA

Submission: July 26, 2016 Published: August 31, 2016

*Corresponding author: Joseph Krajekian, Diplomate of American Board of Oral & Maxillofacial Surgeon and Dentistry at the Cleveland Clinic, Case Western School of Dental Medicine, USA.

Abstract

The application of three-dimensional (3D) printing enables virtual simulation surgery with tremendous details. Data is usually obtained from detailed computed tomography (CT) scan and the creation of material objects from digital images by depositing layers into 3D structures. That can be used for training, education, surgical planning and prosthetic reconstruction. We report on two patients with complex reconstructive option in maxillofacial surgery where 3D technology was utilized to analyze the tumor size, location, and extension more precisely which drastically aids in better preoperative planning. Another case was for fabrication of custom 3D pure titanium TMJ joint for reconstruction with optimal fit and function.

Keywords: 3D Printing; Personalized medicine; Personalized surgery; Virtual surgery; Customized prosthesis; Medical models; Custom TMJ; Titanium TMJ implant; Scleroderma

Introduction

Medical applications for 3-D printing are expanding rapidly and are expected to revolutionize health care. 3-D printing is currently \$700 million industry with only 11 million (1.6%) being invested in medical applications. In the next 10 years it is expected that 3-D printing will grow to \$8.9 billion industry and 1.9 (26%) billion is projected to be spend in medical applications.

Medical uses for 3-D printing can be categorized into three segments.

- Bioprinting tissue and organ;
- Creation of customized prosthetics, implantable devices and medical models
- Pharmaceutical drug dosage forms delivery and discovery.

Most reconstructive surgeons are familiar with Charles Hull invention of 3-D printing “stereo lithography” in the early 1980’s. 3-D printing has since evolved and been applied in medicine since the early 2000s. The first applications were used in dental implants and custom prosthetic devices. Since then it’s applications have significantly grown and most recent published reviews describe the use of 3-D printing to produce bone, ears, trachea, blood vessels, tissue organs as well as novel dosage form for pharmaceuticals by personalizing drug printing fabrication at point of care while taking into account patient age, gender, race and clinic response.

In this article we will focus on creation of customize prosthesis, implantable devices and anatomical models within the oral maxillofacial surgery practice [1].

Case 1 - Custom 3D pure titanium TMJ prosthesis



Figure 1: Pre-op anatomy with anterior open bite secondary to bilateral mandible fracture.



Figure 2: Limitation of stock TMJ prostheses.



Figure 3: Custom 3D printing prostheses with optimal

64 year old female with history of scleroderma has developed a spontaneous pathologic fracture of her mandibular angle bilaterally over 3 years ago. As a result, she developed significant anterior open bite (Figure 1) with inability to chew food requiring parental feeding for nutrition. She has seen multiple surgeons within the US who have not been able to assist her in her reconstructive needs due to the complexity and surgical limitations. After CT evaluation and virtually ideal occlusion alignment patient seem to have had significant bone resorption bilaterally. Patient also does not have enough proximal condylar head to allow any fixation. Additionally, a stock Total TMJ prosthesis would not be able to reach the distal segment of the mandible bilaterally after it is properly alignment (Figure 2). The only option left is to create custom 3D temporomandibular joint replacement pure titanium, as she exhibited sensitivity to nickel (Figure 3). Currently Biomet custom joint are not FDA approved in the United States however through the compassionate use program we have been able to secure approval from the FDA to custom make the implant to this the patient. Without the 3D printing option for the custom prostheses this patient would continue to suffer and live a life with significant compromised quality of life [2].

Case 2- Custom 3D Titanium Crib

34 year old male with destructive lesion in mandible that was identified as a myxoma after biopsy of his right mandible. Surgical plan was made to undergo partial mandibulectomy with adequate margin. After conversation with the patient we decided to reconstruct with custom 3D printing titanium plate with crib containment. This allows for corticocancellous bone graft from anterior iliac crest with bone marrow aspirate concentrate (BMAC) and platelet rich plasma (PRP). BMAC is a minimally invasive procedure used to collect bone marrow from the patient's own body (autologous) and concentrates it to the optimal level while keeping all cell types, including adult stem cells, mesenchymal cells and bone morphogenic protein signal. While PRP acts are a stimulator for bone and soft tissue healing via several growth factors enhancing bone maturity and consolidation [3]. This 3D plate allows the patient to obtain optimal cosmetic outcome as we are able mimic the pre-existing contours, width and height of bone making dental implant rehabilitation easier and more predictable (Figure 4-7).

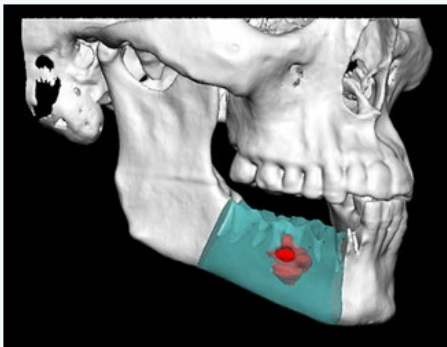


Figure 4: Tumor identification (red) with adequate margin (blue).

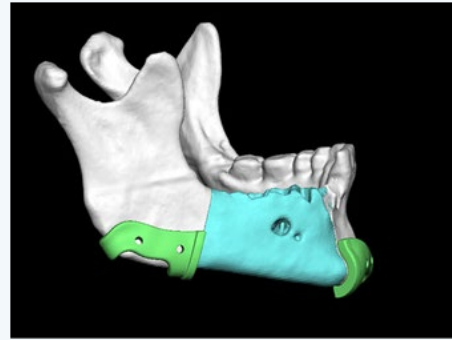


Figure 5: 3D printed resection guide (green).

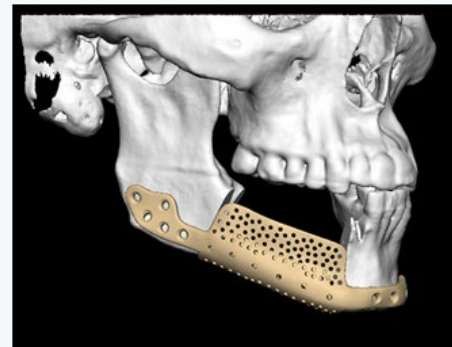


Figure 6: 3D custom printed titanium plate with crib containment for the bone graft (yellow).



Figure 7: 3D custom printed titanium plate with optimal contours and adaptation to patient native bone.

Conclusion

Despite advances 3-D printing there are significant barriers and controversies. Some of which are unrealistic expectation in particularly regarding tissue/organ printed, safety and security issues, and regulatory approvals. Regardless of the challenges 3-D printing is expected to play an important role in the trend towards personalized medicine and revolutionize healthcare. It is through the vision and collaborative support that allows us to service these complex cases.

References

1. (2013) Science and society: Experts warn against bans on 3D printing. *Science* 342(6157): 439.

2. C Lee Ventola (2014) Medical Applications for 3D Printing: Current and Projected Uses. *PT* 39(10): 704-711.
3. F Rengier, A Mehndiratta, H von Tengg-Kobligk, C M Zechmann, R Unterhinninghofen, et al. (2010) 3D printing based on imaging data: review of medical applications. *Int J Comput Assist Radiol Surg* 5(4): 335-341.