International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Lower Jaw Reconstruction Using Prototype from Cone-Beam Computed Tomography Data

D. Yovchev[1], P. Stanimirov[2], Hr. Mihaylova[3]

[1, 3]Medical University – Sofia, Bulgaria, Faculty of Dental Medicine, Department of Imaging and Oral Diagnostic

[2]Medical University – Sofia, Bulgaria, Faculty of Dental Medicine, Department of Oral and Maxillofacial Surgery

Abstract: ***A case of reconstruction of right mandibular defect due to surgical treatment of ameloblastoma is presented. Cone-beam computed tomography (CBCT) data were used for segmentation and producing of prototype of the lower jaw using 3D printing technique. The prototype was used to shape a titanium plate in order to replace the resected bone. The aim of this work is to present and comment the possibilities for preoperative planning and virtual reconstructions using CBCT and 3D printing technology.***

Keywords: ameloblastoma, CBCT, deformity, rapid prototyping

1. Introduction

Shaping of the long titanium plates for mandibular reconstruction is not easy and it is time consuming process. Their intraoperative preparing leads to longer surgical operation and increases the cost of the intervention. Errors including not well prebended in size and shape titanium plates can influence the function, esthetics and long term prognosis of the treatment.

Using rapid prototyping technologies and contemporary imaging methods including CBCT, the achievement of models of the mandible or other anatomical objects is possible. Nearly exact copy or mirrored model of the anatomical region can be obtained. Additional changes e.g. cutting or adding parts of the object using different software tools before rapid prototyping are also possible.

The models can be used for preparation of case specific prebended titanium plates, meshes etc. before surgery.

2. Case Report

18 years old male patient with amelobalstoma of the right mandible is presented. The panoramic radiography and CBCT revealed osteolytic lesion in the right angle of the mandible (Fig 1).

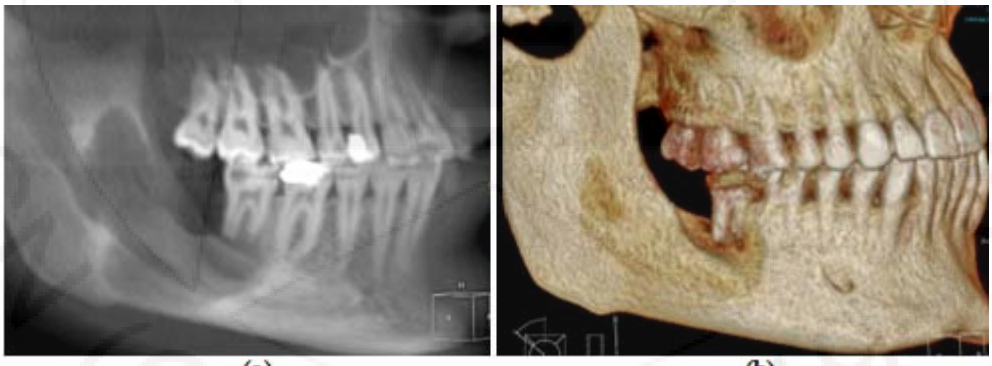

Figure 1: Preoperative CBCT. Sagittal slice (a) and 3D images (b) presenting the osteolytic defect from amelobalstoma in right mandible.

CBCT - ILUMA™, Imtec Imaging, Ardmore, OK was used. The scan was performed using a standard exposure and patient positioning protocol (120 KV, 40 s, 3.8 mA). The data were reconstructed at a voxel size of 0.3 mm and consequently were exported in DICOM.

The histopathologycal result from preoperative biopsy confirmed the diagnosis ameloblastoma. A decision to prepare a prototype of the mandible for shaping of the individual titanium plate was taken. CBCT data were imported in ILUMA V- implant ® planning software. Data were processed and mesh file (in stl) was generated. Thresholding value - 329 was used for segmentation. The mesh file was imported in 3D printer - Zprinter 450, Z Corporation, USA and the prototype was achieved (Fig 2).

Figure 2: The mandible prototype used for preparing of the titanium plate. The shape of the mandible and the bone defect of the tumor are well visible.

The surgery performed included resection of the right half of the mandible. The symmetry and reconstruction quality of the mandible after the operation was very good (Fig 3).

Figure 3: Postoperative panoramic tomography presenting the achieved symmetry.

3. Discussion

Due to possibility to reproduce nearly exactly anatomical objects the rapid prototyping has become very popular in maxillofacial surgery [1-9].

The prototypes contribute better understanding of anatomy and pathological processes. They facilitate the collaboration between the surgeon and the patient, reduce the duration and also are useful for simulation of the surgical intervention [7, 8, 10-12]. Time saving can reach up to 1 or 2 hours in cases of long surgical operations [11].

The operative strategy in ameloblastoma includes achieving histology borders without tumor cells in the resected part. That means the line of resection should be more than 1- 1.5 cm according to the radiographic border of the tumor.

There are different techniques for further reconstruction and one of them includes usage of titanium plate implant. It can be prepared before or during the operation. In the presented case rapid prototype of the mandible for preoperative shaping of the plate was used. Possible errors could occur. They can be related to post processing CBCT data, rapid prototyping process, prebending of the plate or intraoperative change of the initial surgical plan.

4. Conclusion

Rapid prototypes are useful for achieving good functional and esthetic results in cases when resection of mandible is indicated. Additionally they reduce the duration of the surgery and respectively minimalize the intraoperative risk of complications. Usage of CBCT data instead of widely popular MDCT leads to lower radiation dose.

References

[1] Chow B.K., J.K. Chow. Applications of office-based three-dimensional technologies including cone-beam computed tomography and rapid prototyping in the management of maxillofacial trauma-literature review and a case report. Hong Kong Dent J 2009, 6, 93-97.

[2] Chow LK, LK Cheung. The Usefulness of Stereomodels in Maxillofacial Surgical Management,. J Oral Maxillofac Surg 2007, 65, 2260-2268.
[3] Cohen A., A. Laviv, P. Berman, R. Nashef, J. Abu-Tair. Mandibular reconstruction using stereolithographic 3-dimensional printing modeling technology. Oral surgery, Oral medicine, Oral pathology, Oral radiology and Endodontology, 2009, 108, 661-666.
[4] Keightley AJ, DL Cross, RA McKerlie, L Brocklebank. Autotransplantation of an immature premolar, with the aid of cone beam CT and computer-aided prototyping: a case report. Dent Traumatol. 2010 ; 26(2):195-199.
[5] Kim SH, YS Choi, EH Hwang, KR Chung, YA Kook, G.Nelson. Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. Am J Orthod Dentofacial Orthop. 2007, 131(4), 82-89.
[6] Lambrecht J. Th., DC Berndt, R. Schumacher, M. Zehnder. Generation of three-dimensional prototype models based on cone beam computed tomography. International Journal of Computer Assisted Radiology and Surgery. 2009, 4 (2), 175-180.
[7] Lambrecht JT, DC Berndt, AM Christensen, M. Zehnder. Haptic model fabrication for undergraduate and postgraduate teaching. Int J Oral Maxillofac Surg. 2010, 39(12), 1226-1229.
[8] Rengier F., A. Mehndiratta, H. Tengg-Kobligk, C.M. Zechmann,R Unterhinninghofen, HU Kauczor, FL Giesel. 3D printing based on imaging data: review of medical applications Int J Comput Assist Radiol Surg. 2010, 5(4), 335-41.
[9] Singare S, L Dichen, L Bingheng, L Yanpu, G Zhenyu, L Yaxiong. Design and fabrication of custom mandible titanium tray based on rapid prototyping.Med Eng Phys. 2004;26(8):671-6.
[10] Ibrahim D, TL Broilo, C Heitz, M Gerhardt de Oliveira, HW de Oliveira, SMW Nobre, JHG Dos Santos Filho, DN Silva. Dimensional error of selective laser sintering, three-dimensional printing and Poly Jet models in the reproduction of mandibular anatomy.Journal of Cranio-Maxillofacial Surgery, 2009, 37, 167-173.
[11] Salgueiro MI., M.R. Stevens. Experience with the use of prebent plates for the reconstruction of mandibular defects. Craniomaxillofac Trauma Reconstr. 2010; 3(4): 201–208.
[12] Vescan A. D., H.Chan, Daly M., J. I. Witterick, J.C. Irish, J.H. Siewerdsen. C-arm Cone Beam CT Guidance of Sinus and Skull Base Surgery: Quantitative Surgical Performance Evaluation and Development of a Novel High-Fidelity Phantom. Progress in biomedical optics and imaging, ISSN : 1605-7422. 2009; 10; 37; 1-10.

Author Profile

Assistant Professor **Dr Dimitar Yovchev,** PhD, Medical University-Sofia, , Bulgaria, Faculty of Dental Medicine, Department of Imaging and Oral Diagnostic. He has experience more than 14 years in the field of diagnostic imaging. His main interests are in cone beam computed tomography and rapid prototyping, ultrasound and plain x ray diagnostic in maxillofacial region.

Associate Professor **Pavel Stanimirov,** PhD, Medical University – Sofia, Bulgaria, Faculty of Dental Medicine, Department of Oral and Maxillofacial surgery. His main scientific interests are in field of oncology.

Associate Professor **Dr Hristina Mihaylova** PhD, Medical University-Sofia, Bulgaria, Faculty of Dental Medicine, Department of Imaging and Oral Diagnostics. She has experience more than 20 years in the field of diagnostic Imaging. Her main interests are in the area of diseases of maxillo-facial region.