

ORCIDJong-Woo Choi: orcid.org/0000-0001-8047-9821Woo Shik Jeong: orcid.org/0000-0002-5923-0383

Use of 3D Printing Model for the Management of Fibrous Dysplasia: Preliminary Case Study

Jong-Woo Choi, M.D., Ph.D., M.M.M., Woo Shik Jeong, M.D.

Department of Plastic and Reconstructive Surgery, College of Medicine, Ulsan University, Asan Medical Center, Seoul, Korea

Fibrous dysplasia is a relatively rare disease but the management would be quite challenging. Because this is not a malignant tumor, the preservation of the facial contour and the various functions seems to be important in treatment planning. Until now the facial bone reconstruction with autogenous bone would be the standard. Although the autogenous bone would be the ideal one for facial bone reconstruction, donor site morbidity would be the inevitable problem in many cases. Meanwhile, various types of allogenic and alloplastic materials have been also used. However, facial bone reconstruction with many alloplastic material have produced no less complications including infection, exposure, and delayed wound healing. Because the 3D printing technique evolved so fast that 3D printed titanium implant were possible recently.

The aim of this trial is to try to restore the original maxillary anatomy as possible using the 3D printing model, based on the mirrored three dimensional CT images based on the computer simulation. Preoperative computed tomography (CT) data were processed for the patient and a rapid prototyping (RP) model was produced. At the same time, the uninjured side was mirrored and superimposed onto the traumatized side, to create a mirror-image of the RP model. And we molded Titanium mesh to reconstruct three-dimensional maxillary structure during the operation. This prefabricated Titanium-mesh implant was then inserted onto the defected maxilla and fixed.

Three dimensional printing technique of titanium material based on the computer simulation turned out to be successful in this patient. Individualized approach for each patient could be an ideal way to restore the facial bone.

Key Words Fibrous dysplasia · Three-dimensional surgery · Maxilla reconstruction · Pre-surgical simulation · Three-dimensional simulation · 3D printing · Titanium mesh.

Received: June 14, 2016 / **Revised:** June 15, 2016 / **Accepted:** June 16, 2016

Address for correspondence: Jong-Woo Choi, M.D., Ph.D., M.M.M.

Department of Plastic and Reconstructive Surgery, Seoul Asan Medical Center, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea

Tel: 82-2-3010-3604, **Fax:** 82-2-476-7471, **E-mail:** pschoi@amc.seoul.kr

Introduction

Fibrous dysplasia is quite rare disease and there are some controversies in terms of the etiology and management. As the fibrous dysplasia is known to involve the craniofacial skeleton extensively, we should encounter the many difficulties in order to choose the right decision for the management of the fibrous dysplasia (1-3). Especially, given the nature of the benign tumor, we should preserve the original function and facial aesthetics as well. This fact tends to make the surgery itself diffi-

cult. We should restore the original anatomy while minimizing the functional problems. In fibrous dysplasia, the normal bony structures is known to be deformed into the fibrotic tissue. It can be classified into two categories such as the monostotic and polyostotic types. As the polyostotic type of fibrous dysplasia is frequently extended upto the skull base, the complete resection is often impossible. On the contrary, the monostotic type of fibrous dysplasia has a potential for the complete resection (4-6). However, in spite of the monostotic type, the complete restoration of the original bony anatomy is not easy. The three dimen-

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

sional bony structures make the simple autogenous bone graft work not well. Therefore, we tried to reconstruct the three dimensional structures based on the mirror image guided 3D printing model. As the monostotic type of fibrous dysplasia generally involves the ipsilateral side only, we thought the utilization of the contralateral side could be used for the template. Based on this mirror imaged 3D printing model, the molding work of the titanium mesh was made. I am reporting this case preliminarily.

Case Report

27 years old female patient presented the protrusion on the left malar area 5 years ago. CT scan including the general laboratory tests were done. 3D CT scan revealed us the fibrous dysplasia was involving the left maxilla and zygomatic bone. Simplant(simplant pro, Materials[®], Belgium) software was used for the three dimensional analysis (Fig. 1).

3D object was reconstituted based on the CT DICOM file. Then, mirroring technique (Mimics Z software: Materialize, Leuven, Belgium) was applied and we could obtain the 3D computer simulation modeling files.

Based on this computer modeling process, the 3D printing model was reconstructed using the 3D printer. This 3D printing model was prepared for the surgery and treated to the sterile condition.

At first, the buccomucosal approach was done for the exposure of the zygomaticomaxillary area. Then the lesions of the fibrous dysplasia were eliminated using the saw and burr. As the fibrous dysplasia in this patient was diagnosed with the monostotic type, the goal of the surgery was the complete resection and reconstruction of the maxilla and zygoma. In addition, the extended transconjunctival approach was done for the exposure for the resection of the protruding mass on the orbital floor. During the surgery, the titanium mesh was molded according to the 3D printing model prepared in advance.

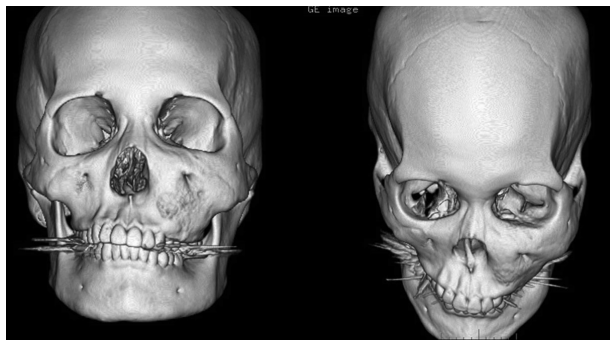


Fig. 1. Preoperative 3D CT images. Fibrous dysplasia is manifested in the left maxilla and zygomatic area.

Then it was transferred to the patient's defect area and fixated with microscrews. The postoperative periods didn't have unusual findings and the patient was discharged at postoperative 4 days. The follow up 3D CT scan at 3days and 6 month after the surgery have shown that there were no recurrence and the overall reconstruction contour was satisfactory (Fig. 2).

Discussion

Fibrous dysplasia is mostly treated with two methods. First one is the shaving. And the other is the resection of the lesion as much as possible. Although the shaving technique seems to be less invasive, it could be indicated to the cases where the overall the lesions is not severe. Sometimes it is indicated to the cases where the complete resection is impossible as the lesion is too extensive. On the contrary, the resection can be applied to the monostotic types usually. It could minimize the recurrence but the reconstruction could be very challenging (7-11).

With regards to the reconstruction, the autogenous bone graft would be the most common method. However, the autogenous bone graft might make the donor site morbidity and has a limitation to reconstruct the complex bony defects like the zygomaticomaxillary area. Therefore, the various bone alloplastic materials mimicking the autogenous bone have been used frequently. In spite of the advantages of the alloplastic materials such as the hydroxyapatite, these materials might cause the postoperative complications including the infection,

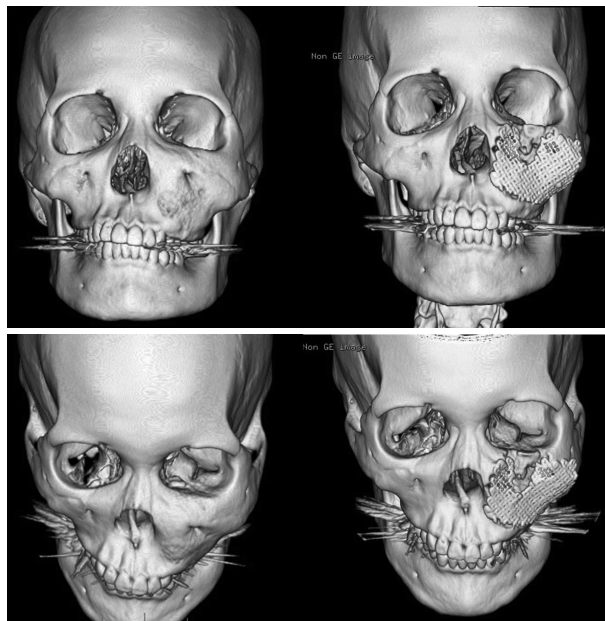


Fig. 2. Pre and postoperative 3D CT images. The left maxilla and the part of the zygoma were reconstructed with titanium mesh after the subtotal resection of the lesions.

exposure and delayed wound healing.

On the contrary, the titanium material is known to have very good biocompatibility and has been actually used for more than 30 years in craniofacial surgery (12). Of course, given the nature of the titanium materials, it also has a possibility of the exposure or infection especially after the radiation therapy.

That's the reason why I thought the titanium reconstruction would be ideal for the fibrous dysplasia. As the fibrous dysplasia is the benign tumor mostly, it does not require the postoperative radiation therapy. I hypothesized the disadvantages like this could be minimized when we applied to the reconstruction of the fibrous dysplasia. In addition, I also hypothesized that, compared to the reconstruction with the autogenous materials, the recurrence of the fibrous dysplasia could be minimized.

The shape of the facial skeleton is different according to the each individual, race and sex. The shape of the zygoma and maxilla would be different as well. The individualized application in terms of the reconstruction should be done. Therefore the reconstruction based on the 3D printing model would be ideal. Especially the zygomaticomaxillary area has a unique three dimensional structure, this prefabricated titanium mesh based on the 3D modeling could maximize the benefit. But, the problem is how to imagine the original anatomy prior to the lesional invasion. The solution exists on the contralateral side. The mirroring technique enabled us to reconstruct the original anatomical structures based on the contralateral uninvolved side. The outcome of this case has shown us this is reasonable approach. The 3D printer is known to have the bias the less than 2 mm, it worked quite well.

Conclusion

It is our opinion that the model surgery and the application

of the prebent titanium mesh implant to the defect of the zygomaticomaxillary area could be an good alternative and might replace the traditional surgery technique. Especially this approach could be a reliable when we encounter the need of reconstruction for the benign tumor resection.

References

1. Godse AS, Shrotriya SP, Vaid NS. Fibrous dysplasia of the maxilla. *J Pediatr Surg* 2009;44(4):849-851
2. Espinosa JM, Elizalde A, Aquerreta JD, Alcalde J, Zubieta JL. Fibrous dysplasia of the maxilla. *Ann Otol Rhinol Laryngol* 1998; 107(2):175-177
3. Muralidhar M, Sohoni S, Raghavan MR. Monostotic fibrous dysplasia of maxilla. *J Indian Med Assoc* 1987;85(9):273-274, 277
4. el-Khashab M, Abaza NA, Fahim MS. Monostotic fibrous dysplasia of the maxilla: report of case. *J Oral Surg.* 1966;24(2):158-161
5. Fusconi M, Conte M, Pagliarella M, De Vincentis C, De Virgilio A, Benincasa AT, et al. Fibrous dysplasia of the maxilla: diagnostic reliability of the study image. Literature review. *J Neurol Surg B Skull Base* 2013;74(6):364-368
6. Kirtane MV, Mehta RV, Dewoolkar VV, Karnik PP. Monostotic fibrous dysplasia or ossifying fibroma of the maxilla. Case report. *Dent Dialogue* 1974;1(2):21-24
7. Eachempati P, Aggarwal H, Shenoy V, Baliga M. Multidisciplinary approach for management of a patient with fibrous dysplasia of maxilla. *BMJ Case Rep* 2015;2015.
8. Shinbirev NA. [Intraoral resection of the maxilla for fibrous dysplasia]. *Zh Ushn Nos Gorl Bolezn* 1970;30(3):99-102
9. Strom CG, Miller T. Fibrous dysplasia of the maxilla. *Trans Pac Coast Otoophthalmol Soc Annu Meet* 1975;56:187-193
10. Ward PH, Alley C, Owen R. Monostotic fibrous dysplasia of the maxilla. *Laryngoscope* 1969;79(7):1295-1306
11. Whatley TG, Brown PC 2nd, Frew AL Jr. Polyostotic fibrous dysplasia involving the maxilla and mandible: report of case. *J Oral Surg* 1979;37(2):117-119
12. Mokal NJ, Desai MF. Titanium mesh reconstruction of orbital roof fracture with traumatic encephalocele: a case report and review of literature. *Craniofacial Trauma Reconstr* 2012;5(1):11-18