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Case Report

A case of 3D mirror and printing technology in the aid of resection and reconstruction of an adult mandibular ameloblastoma

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Abstract: Purpose: We introduce a new method with the help of 3D printing technology to complete mandibular ameloblastoma resection and reconstruction surgery with vascularized fibula grafting. This can reduce the difficulty of the operation to great extent, and make the operation more satisfactory. Methods: One patient with mandibular ameloblastoma underwent CT scan, and the CT data was transferred to mimic software 17.0 for 3D reconstruction. A mirror image of the mandible was generated by the mirror tool of the software. The pathological model and mirror image model were then printed by 3D printing machine. According to the models, preoperative planning, designing of vascularized fibula, pre-curving of the titanium plate, and simulation of the operation were completed. Results: The operation was completed smoothly and safely. The facial appearance was symmetrical and satisfactory, and the mandible function was satisfactory. Conclusion: The operation of mandibular ameloblastoma is very difficult. 3D printing technology assisted mandibular ameloblastoma surgery can reduce the difficulty of the operation greatly, optimize pre-operation planning, and provide individualized treatment. It is an effective guarantee for satisfactory results from the operation.

Keywords: 3D printing technology, mirror image model, mandibular ameloblastoma, bone graft reconstruction

Introduction

The operation of mandibular ameloblastoma is challenging. Only experienced surgeons can do it. However, even for experienced surgeons, ensuring that each operation is completed safely and successfully is difficult [1]. When the mandible has a large swelling tumor, the operation is more difficult. This is because reconstruction of the titanium plate cannot be shaped according to the lateral surface of the mandible. The only way is that after the mandible cut off, the titanium plate is roughly shaped according to the experience of the surgeon [2, 3]. During the operation, it is not only necessary to bend the titanium plate repeatedly, which often results in prolonged operation time and stress fatigue, those results in postoperative loosening and potential breakage of the titanium plate. Such an operation like this is also difficult to guarantee the symmetry and beauty of the opposite side of the patient.

In this case report, the mandibular tumor was quite rarely large, and the bone was swelling and damaged incredibly. Therefore, the difficulty of using a conventional surgical method was not beyound conceivable. Therefore, we used 3D printing technology and mirror image technology to assist in the resection and reconstruction of mandibular tumor. In particular, a mirror image model for mandibular reconstruction was designed by mirror technology. Preoperative bending and shaping of the titanium plate was done with the mirror image model before operation. This prevented the bending and shaping process of the titanium plate during the operation. It could also effectively avoid the damage to the plate caused by repeated bending and shaping during the operation, and reduce the possibility of the fracture of the plate, and eventually save the operation time and reduce the difficulty of the operation greatly. It also ensures the facial symmetry of the patient and meets the patient's requirements for beauty.

Figure 1. The preoperative facial appearance of the patient.

Case report

The patient was a 54 years old female. She had swelling of the lower right side of face for 19 years. The physical examination was done when she came into the Affiliated Hospital of Yan'an University. There was maxillofacial asymmetry, obvious swelling of the lower right half of the lower jaw. The local skin color was normal and neither skin rash, hyperemia, nor high skin temperature. Swelling on the surface of the bulge was seen (**Figure 1**). Most of the right temporomandibular bone bulges could be touched. Some can touch the ping-pong sensation without touching pain. The bulge at the right mandibular angle was obvious and the sac could be touched. Bilateral temporomandibular joint movement was consistent. There was no restriction when patient opened the mouth. Upper and lower jaw occlusal relationship is normal. CT scan of the mandibular was done and there was a big space occupying on the right mandibular. A three dimensional model of the mandible was reconstructed by importing the CT scan data of mandible into the 3D printing software--mimics software 17.0, and the mandibular ameloblastoma model of 1:1 scale was printed out (**Figure 2A**, **2B**). A three dimensional model of the ipsilateral aspect is designed using the unique 3D mirror image technology of the software. This model was based on the prototype of the healthy side. The mirror image model of 1:1 scale was printed out (**Figure 3A**, **3B**). The length of vascularized fibula, which was used to graft, was predicted by the comparison of the models. After completing the preoperative preparation, surgery of mandibular tumor resection and osteotomy, vascularized fibular graft, and titanium plate reconstruction was performed under general anesthesia (**Figure 4A**, **4B**). The operation was smooth and safe. The three dimensional reconstruction of CT scan after operation showed that the mandibular bony reconstruction was in a good position (**Figure 5A**, **5B**). Facial symmetry was normal, as well as the occlusal relationship between the upper and lower jaw (**Figure 6**).

Discussion

The operation of mandibular ameloblastoma should not only accurately construct the anatomical marks of the lower face and the relationship of the jaws, but also restore the physiological functions of chewing, including swallowing, language breathing, and so on [4]. The appearance of the patient's facial appearance must also be considered. So, the surgery is not only a repair process, but also has important aesthetic considerations. Meanwhile, the best aesthetic effect of mandibular reconstruction also guarantees the recovery of the best function, because the function and shape are based on the anatomy of the jaws [5]. The defects of surgical methods for the repair of mandibular with both aesthetic and functional features have been the hotspots of maxillofacial surgeons.

In 1989, Hidalgo et al. [6] reported for the first time the reconstruction of the mandible with vascularized fibular graft. At present, this method has become the first choice for repairing large mandibular defects [7-9]. The operation of small tumors in the mandible can be radiated along the lateral surface of the mandible before the mandible is cut and removed, and the reconstructed titanium plate for internal fixation is shaped. This will ensure that the maxillary and maxillofacial occlusal relationship and maxillofacial morphology can be accurately restored after mandibular osteotomy and

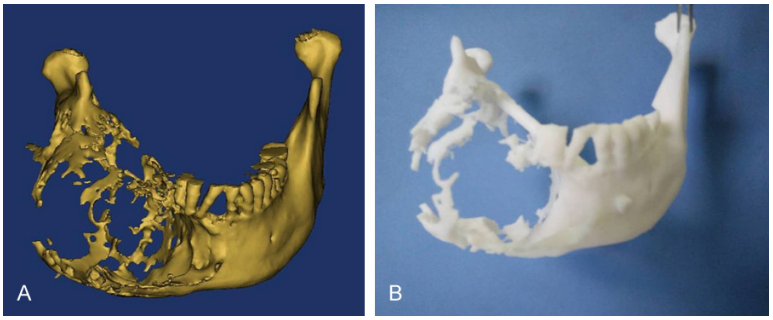

Figure 2. Three-dimensional reconstruction model of preoperative mandibular ameloblastoma was performed using Mimics software 17.0 (A). 3D printing mandibular ameloblastoma model of 1:1 scale was printed preoperatively (B).

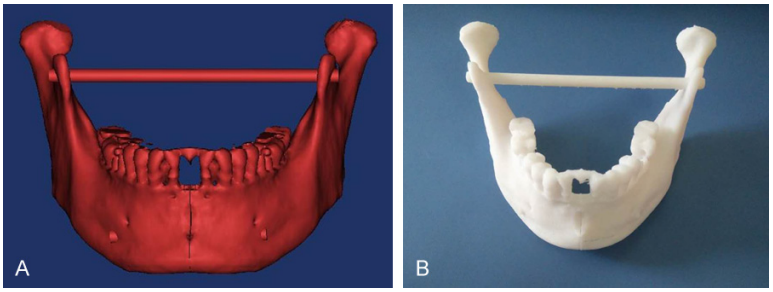

Figure 3. Three-dimensional mirror image model of mandible was performed in Mimics software 17.0 at preoperative (A). 3D printing mirror image mandibular model of 1:1 scale was printed preoperatively (B).

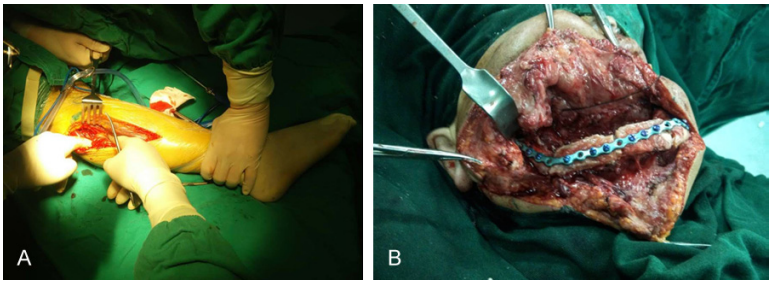

Figure 4. Vascularized fibula was intraoperatively cut off according to the design (A). According to the preoperative design, vascularized fibula was segmented and reconstructed with titanium plate to complete mandibular reconstruction at intraoperative (B).

bone graft repaired [10]. However, in the case of mandibular tumors with extensive lesions and outward expansion of the cortical bone, a large part of the defect remains after resection. The original jaw mark has been seriously damaged, so it is difficult to determine its original anatomy and morphology. In general, the outcome of surgery depends largely on the experience of the surgeon, so it is subjective and lacks accuracy [8, 11]. Repeated bending and shaping of the titanium plate during operation can cause stress fatigue. Furthermore, the shape of the fibula is different from that of the mandible. So it always takes a lot of time to repair the bone flap. After autogenous bone graft, although the continuity of the mandible was restored, the shape of the alveolus could not be recovered well. Because the bone quantity and shape was restricted, reconstruction of the oral cavity was affected, and it was difficult to achieve the beautiful appearance of facial symmetry [12, 13]. Therefore, it has been a hot topic in the field of maxillofacial surgery to reduce the difficulty of operation, shorten the time of operation, improve the precision of the operation, and achieve a symmetrical and beautiful facial appearance and satisfactory oral function.

The combination of 3D printing technology and medicine is a significant progress in medical history. 3D printing technology can optimize preoperative planning, provide individualized and precise treatment, and reduce the difficulty of operation and improve the safety of operation [14]. Stoker et al. [15] first applied the 3D printing model to craniofacial surgery. It was the first time that 3D printing technology was combined with craniofacial surgery. D'Urso et al. [16] subsequently verified that the 3D printing model has good accuracy, which helps surgeons intuitively design and simulate surgery on the model.

In this case, the lateral cortical bone of the mandible has been significantly swelled and deformed by the ameloblastoma. Therefore, depending on the conventional surgical meth-

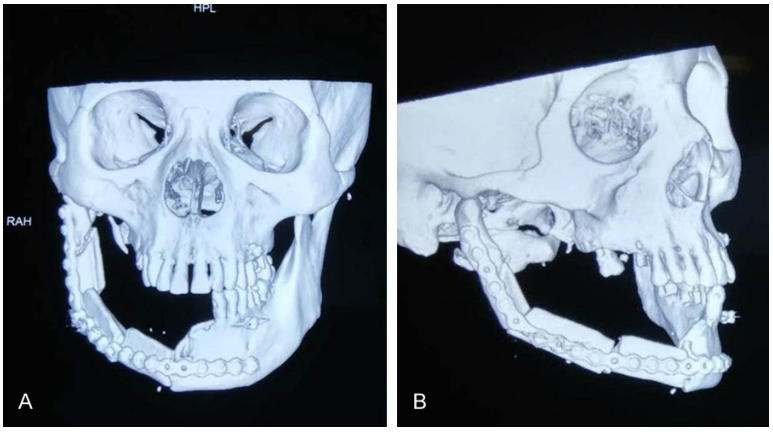

Figure 5. Postoperative positive view of three-dimensional reconstruction by CT scan of the mandible (A). Postoperative side view of the three dimensional reconstruction by the CT scan of the mandible (B).

Figure 6. Postoperative facial appearance of the patient.

od, the operation is very difficult and the operation effect is difficult to guarantee. Luo et al. [17] had reported that an operation, of using 3D printing technology and iliac bone graft to treat mandibular ameloblastoma, was completed successfully, and the facial appearance of the patient recovered well and the occlusion was good. However, in this case, because of the large size of the tumor, the conventional iliac bone graft was difficult to obtain satisfactory bone volume. So, the vascularized fibula was used to satisfy the bone graft and apply toward the 3D printing technology. The preoperative CT scan data was imported into Mimics software 17.0 to establish a three dimensional model of mandible. It could truly reproduce the anatomical morphology of the mandibular ameloblastoma and the extent degree of invasion of the tumor in the bone tissue. It could also directly determine the boundary of the tumor area. The preoperative 1:1 scale model of lesion mandible is conducive to the design of reasonable lesion resection surgery. The human mandible has good symmetry. The mandibular mirror image model of the healthy side was very similar to the original morphology of the affected mandible when it was without lesions. Mimics software 17.0 was used to generate the mirror image of the mandible and print out the 1:1 scale physical mirror image model. Preoperative bending and shaping of titanium plate was performed on the mirror image model. After removal the mandibular ameloblastoma area of the mandible, the bent and shaped titanium plate could be implanted directly at both ends of the defect. This eliminated the need for intraoperative bending and shaping of the titanium plate, by repeatedly placing and measuring it *in vivo* contrast. This can reduce the difficulty of operation, shorten the operation time and reduce the amount of bleeding during operation. By contrasting the tumor model with the mirror image model, the length of the pre-fetch of the vascularized fibula in the operation and how to achieve the best reconstructive effect was achieved. At the same time, because the titanium plate is bent and shaped according to the mirror image model, it can not only make a good anatomical reduction after the operation, but also makes the facial contour of the patient more symmetric and with a better aesthetic effect.

Application of 3D mirror image and printing technology has many advantages. First, the 1:1 scale 3D printing tumor model and the mirror image model are both an intuitive measurement tool and a surgical design simulation

mold. It can avoid the shortcomings of the two dimensional images, such as the X-ray and the CT scan. So, it can provide more local information for the clinical surgeon, such as the size, boundary and scope of the tumor. This can reduce the risk of recurrence due to insufficient resection of the tumor or increased surgical trauma due to excessive resection. Second, the models helped the patient and his families to understand the difficulty and risk of surgery and eventually to reduce postoperative disputes. The models can be used to show the operation process before surgery, and to tell family members about the difficulty and the corresponding treatment plan. This helps to eliminate doubts, reduce psychological burden, increase coordination and trust, and reduce postoperative disputes [18]. Third, by referring to the models, the titanium plate can be pre-bent and pre-shaped before operation. The pre-bent and pre-shaped titanium plate can not only promote the operation reconstruction with its radian, but also play the role of "a standard ruler" to judge the effect of operation. If the bone graft is reconstructed according to the bent and shaped titanium plate, it is indicated that the preoperative reconstruction form is achieved. Fourth, preview of operation process can be done with the models. It is possible to judge the difficulty of operation and the problems that may occur in advance. This is very conducive to the development of individualized and optimal surgical procedures for patients.

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Disclosure of conflict of interest

None.

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