Case Report
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Mandible Reconstruction with 3D Virtual Planning

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The fibula free flap has now become the most reliable and frequently used option for mandible reconstruction. Recently, three dimensional images and printing technologies are applied to mandibular reconstruction. We introduce our recent experience of mandibular reconstruction using three dimensionally planned fibula free flap in a patient with gunshot injury. The defect was virtually reconstructed with three-dimensional image. Because bone fragments are dislocated from original position, relocation was necessary. Fragments are virtually relocated to original position using mirror image of unaffected right side of the mandible. A medical rapid prototyping (MRP) model and cutting guide was made with 3D printer. Titanium reconstruction plate was adapted to the MRP model manually. 7 cm-sized fibula bone flap was designed on left lower leg. After dissection, proximal and distal margin of fibula flap was osteotomized by using three dimensional cutting guide. Segmentation was also done as planned. The fibula bone flap was attached to the inner side of the prebent reconstruction plate and fixed with screws. Postoperative evaluation was done by comparison between preoperative planning and surgical outcome. Although dislocated condyle is still not in ideal position, we can see that reconstruction was done as planned.

Key Words Mandibular reconstruction · Fibular free flap · 3D image · 3D printing · Simulation surgery.

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Introduction

Mandibular defects can result from surgical removal of head and neck cancers, osteoradionecrosis, osteomyelitis or gunshot trauma. The fibula free flap has now become the most reliable and frequently used option for mandible reconstruction. In reconstruction of mandibular defects, both functional and aesthetic aspects should be considered. Functionally, the mandible plays a key role in mastication, swallowing and speech. Aesthetically, contour and vertical height of lower third of the face is provided by the mandible. Since the mandible has a complicated three-dimensional structure, it is challenging to achieve ideal outcomes. Recently, three dimensional images and printing technologies are employed to overcome this problem. We introduce our recent experience of mandibular reconstruction using three dimensionally planned fibula free flap in a patient with gunshot injury.

Case Report

A 22-year-old male sustained gunshot injury on his left mandible angle area. After 3 months from primary operation, mandible reconstruction with fibula free flap was planned. High resolution computed tomographic scans of facial bone and low-

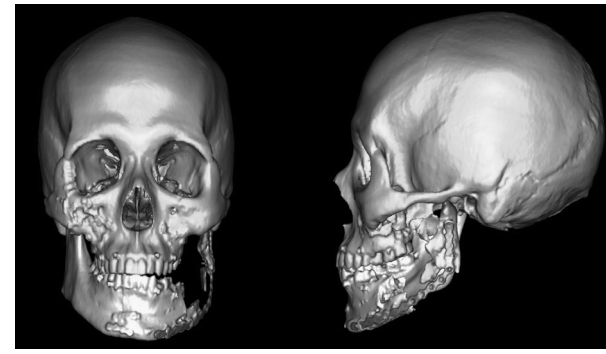

Fig. 1. Mandibular defect before relocation of bone fragments.

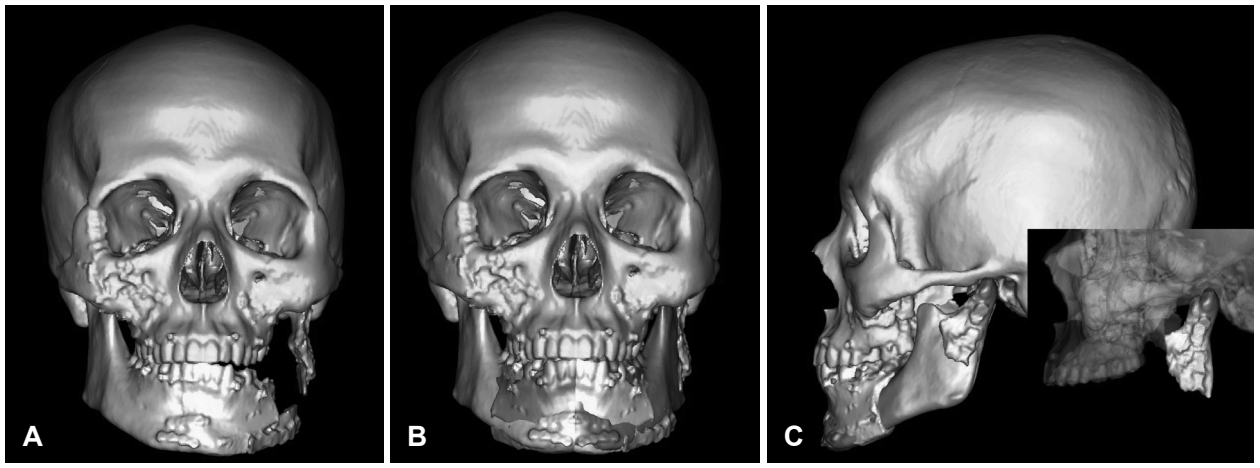

Fig. 2. A: Original defect, the plate is removed. B and C: Mirroring of unaffected right side mandible determines the proper position of bone fragments (blue-original, pink-relocated).

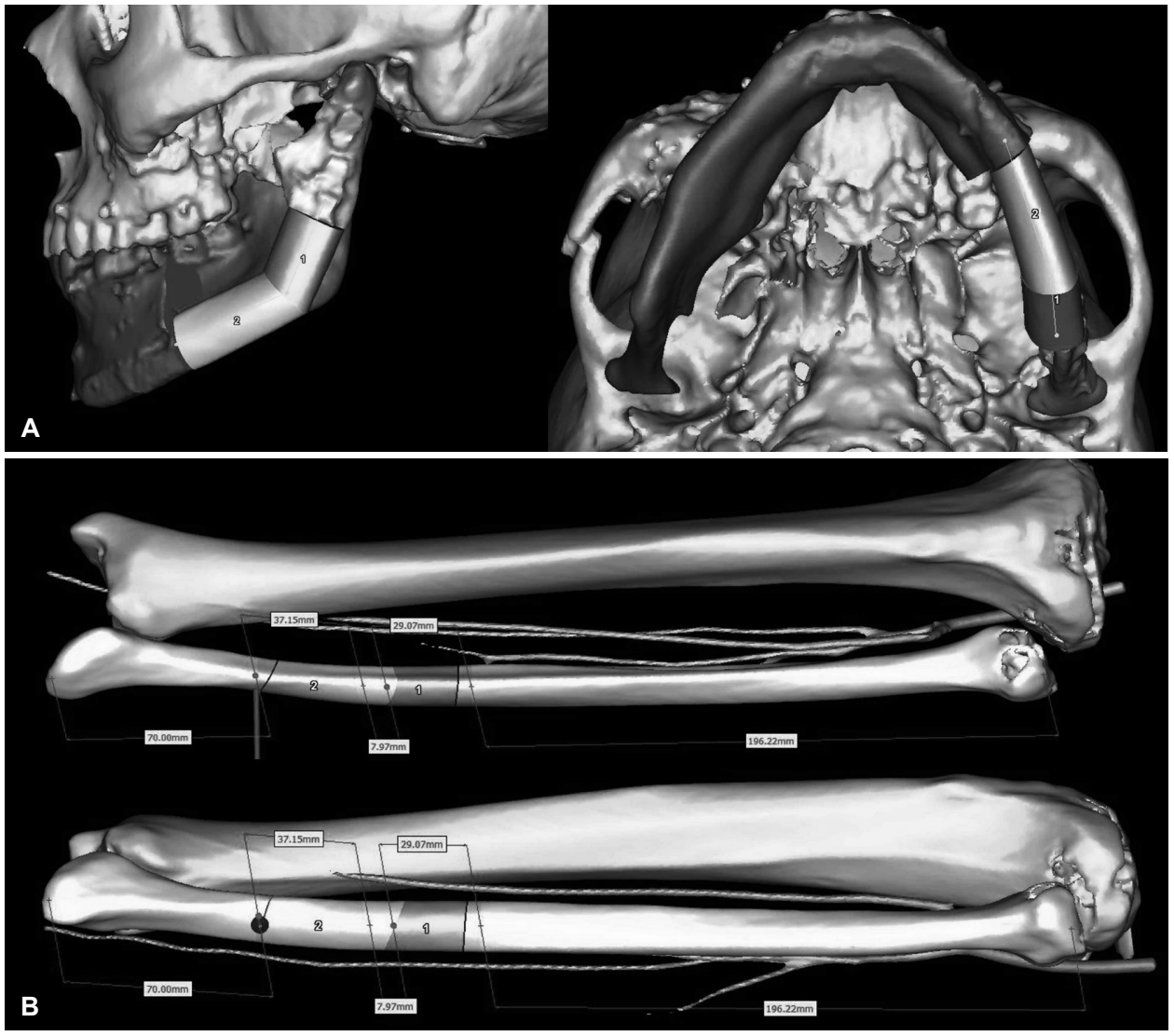

Fig. 3. Three-dimensional virtual planning. A: Virtually reconstructed mandible with fibula free flap. B: Position, length, angle of osteotomy within fibula were planned on patient's three-dimensional computed tomography of left lower leg.

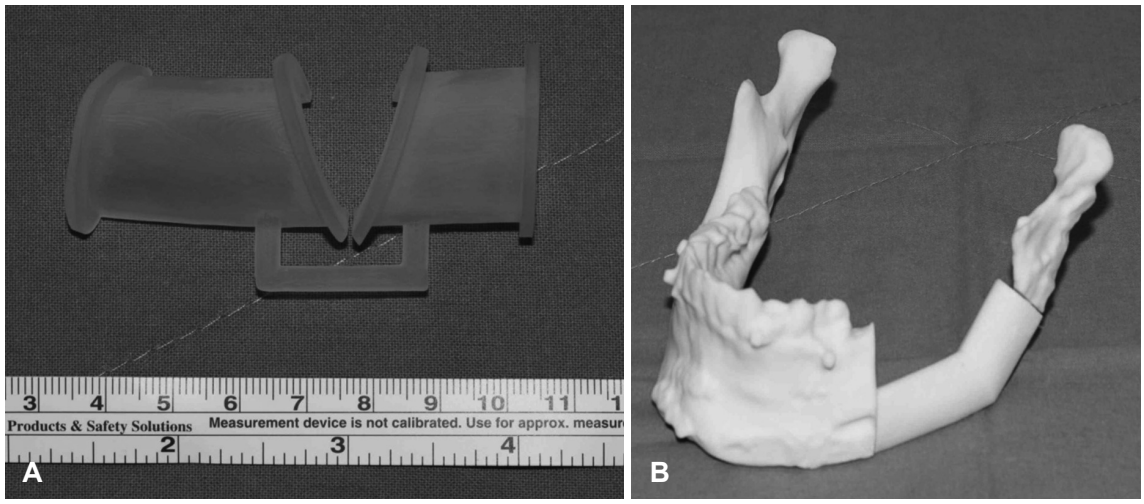

Fig. 4. Three-dimensional printing. A: 3D-printed cutting guide. B: Medical rapid prototyping (MRP) model.

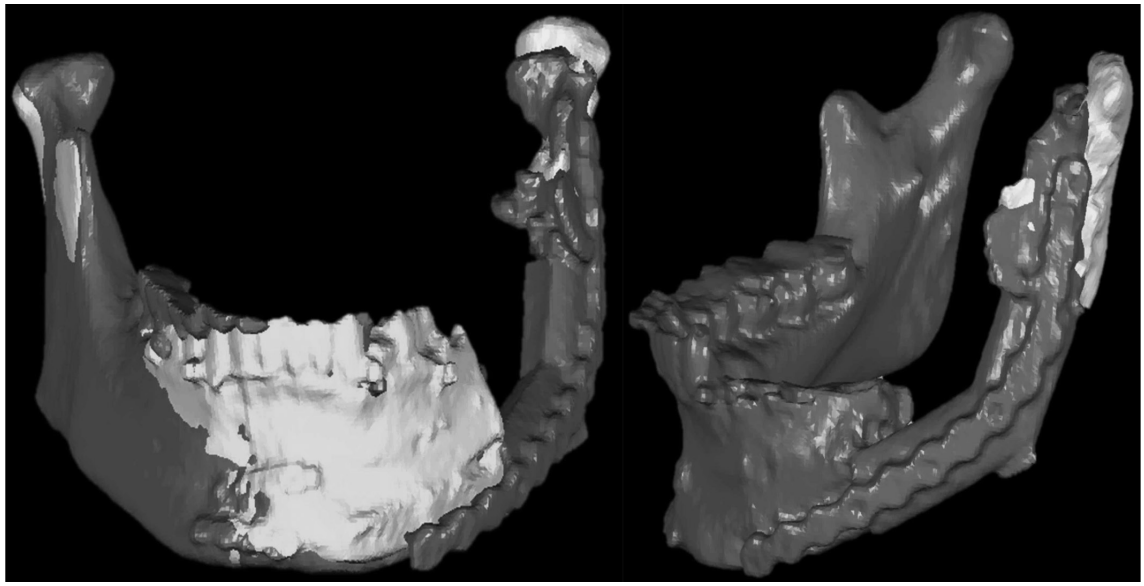

Fig. 5. Superposition of outcome with planning. Blue-postoperative outcome, Yellow/Green-planned condyle and body position.

er extremities were obtained. Defect of left body, angle and coronoid process of mandible was noted (Fig. 1).

The defect was virtually reconstructed with three-dimensional image. Because bone fragments are dislocated from original position, relocation was necessary. Fragments are virtually relocated to original position using mirror image of unaffected right side of the mandible. After virtual relocation of the fragments, the defect which has to be reconstructed with fibula free flap is determined (Fig. 2).

The surgeon has decided appropriate position and length of fibula flap. Position and angle of osteotomies within the fibula were also determined (Fig. 3). A medical rapid prototyping (MRP) model and cutting guide was made with 3D printer. Titanium reconstruction plate was adapted to the MRP model manually (Fig. 4).

Intraoperatively, about 7cm-sized fibula bone flap was designed on left lower leg. After dissection, proximal and distal margin of fibula flap was osteotomized by using three dimensional cutting guide. Segmentation was also done as planned. The fibula bone flap was attached to the inner side of the prebent reconstruction plate and fixed with screws.

Discussion

In this case report, we reconstructed the mandible of facial gunshot injury patient. Many researchers reported good outcomes in mandibular reconstruction using three-dimensional virtual planning and printing techniques. Because common

causes of mandibular defects include resection of head and neck cancer, many articles had evaluated outcomes in patients with head and neck cancers. There is relative paucity of reported cases with mandibular reconstruction using three-dimensional virtual planning.

The characteristics of gunshot injury compared to the cancer resection are following: 1) dislocation of comminuted bone fragments; 2) no image data before occurrence of defects; and 3) relatively delayed reconstruction timing from occurrence of defects. Although resolution of computed tomography had been improved, inevitable error is always present. Comminuted bone fragments make this error wide, and combined with absence of computed tomographic image before occurrence of defects, relocation of these fragments had become more difficult. We used mirror image of unaffected right side mandible to overcome this problem. Gunshot injury patients underwent reconstruction after a few months from occurrence of defects. During this period of time, resorption of bone and atrophy of damaged soft tissue make it harder to follow the preoperative planning.

Postoperative evaluation was done by comparison between preoperative planning and surgical outcome. Although dislocated condyle is still not in ideal position, we can see that reconstruction was done as planned (Fig. 5).

With the use of three-dimensional preoperative planning, a reconstruction plate that are prebent to fit MRP models and three-dimensionally printed cutting guide, we could successfully reconstruct the mandibular defect of a gunshot injury patient. The further improvement of methods for evaluating three-dimensional information, including soft tissue as well as mandible morphology will result in better surgical outcomes.

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