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Mandibular Reconstruction using Simulation Surgery after Segmental Mandibulectomy

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Functional and esthetic reconstruction after segmental mandibulectomy is one of the most challenging surgeries in microsurgical reconstruction field. Simulation surgery before free flap reconstruction has been performed for efficient surgery and successful results. Fibula free flap is the flap of the choice for reconstruction of the segmental mandibular defect. Straight nature of the fibula bone requires multiple segmentations to fit into mandible. 3D rapid prototype (RP) model gives a lot of information for mandibular reconstruction. The purpose of this study was to report mandibular reconstruction with free fibular flap using simulation surgery. A total of 30 consecutive patients were included for functional and esthetic evaluation. Among 30 patients, two flaps showed necrosis after radiotherapy. The other flaps were all survived and showed successful reconstruction in both function and esthetics.

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Introduction

Free fibula flap is the most useful flap for segmental mandibular defects (1-4). Free fibula reconstruction requires long operation time and special microsurgical technique. Microsurgical technique could be mastered through preclinical experiments, however, time-consuming mandibulectomy and fibular bending requires more efficient way to expedite operation. One of the easiest ways to reduce intraoperative time is using simulation surgery with virtual 3-dimensional (3D) model before surgery (4-7). Mock surgery using 3D rapid prototype (RP) model is helpful for mandibular reconstruction. Exact same size of the 3D RP model suggests more detailed characteristics about the mandibular curve and angle of the mandibular body and ramus. Surgical stent could be made with 3D RP model data

and computed tomography (CT) of the fibula bone could be bended in the computed program before operation. These clinical trials could reduce surgical operation time and the time for decision-making.

One of the most common complications after fibula free flap reconstruction is malocclusion. Occlusal instability after fibular flap reconstruction is caused by lack of knowledge about occlusion and postoperative physical therapy. Patient can detect malocclusion when one side of the mandible separated more than 20 micrometers. To reduce postoperative complication, precise reconstruction with simulation surgery, occlusal guidance with arch bar application and postoperative physical therapy are required.

In this study, 30 consecutive patients who underwent mandibular reconstruction using fibula free flaps were reviewed retro-

spectively. The postoperative results of mandibular reconstruction using simulation surgery were reviewed.

Materials and Methods

A total of 30 consecutive patients who underwent free fibular reconstruction between May 2006 and September 2015 were included in this study. Male to female patients was 14:16 and average age was 60.6±12 years old (27-77). Secondary reconstruction was performed in four patients and the others were reconstructed simultaneously with primary resection of the mandibular lesions. Thirteen patients were diagnosed as squamous cell carcinoma in the mandibular gingiva invaded into mandible and there were eight osteoradionecrosis, five osteomyelitis, two ameloblastoma and two mandibular osteosarcoma.

For simulation surgery before mandibular reconstruction, a 3D RP mandibular model was made with facial 3D CT scan data. When patient needed resection of temporomandibular joint, half-skull RP model was fabricated to verify the relationship between mandibular condyle and mandibular fossa.

Before mandibulectomy, arch bar were applied in both maxilla and mandible for occlusion except one patient with full edentulism. Thin (2.4 mm) titanium reconstruction plates (SGM plate, Seoul, Korea or Leibinger, San Diego, USA) were applied before mandibular resection. Right after mandibular resection, reconstruction plates were repositioned and intermaxillary fixation (IMF) was performed. Fibula flap was selected according to the defect. Intraoral mucosa defect with mesial side vessels direction was the indication for ipsilateral side harvest. Free fibula flap was fixed to the mandibular defect using

Table 1. Demographic data of the patients and flap survival

No	Op Date	Sex	Age	Disease	Recon type	Flap Survival	Condyle
1	2006-05-24	F	69	BRONJ	1	Yes	No
2	2006-10-25	M	69	Osteomyelitis	1	Yes	Yes
3	2006-12-07	M	54	Ameloblastoma	1	Yes	No
4	2007-08-29	F	51	SCC	1	Yes	No
5	2007-12-26	M	51	SCC	2	Yes	No
6	2008-03-26	M	51	ORN	1	Yes	No
7	2008-10-01	F	77	SCC	1	Yes	No
8	2009-04-22	M	54	ORN	1	Yes	No
9	2009-07-29	M	70	ORN	1	Yes	No
10	2009-12-02	M	62	SCC	1	Yes	No
11	2010-06-23	F	53	Ameloblastoma	2	Yes	No
12	2010-10-13	M	49	SCC	1	Yes	No
13	2010-12-29	M	63	SCC	1	Yes	No
14	2011-01-12	F	77	SCC	1	Yes	No
15	2012-11-05	F	69	SCC	1	Yes	No
16	2013-07-29	M	67	SCC	1	Yes	No
17	2013-10-21	F	68	BRONJ	1	Yes	No
18	2013-11-11	F	77	SCC	1	No	No
19	2014-02-24	F	62	BRONJ	1	Yes	No
20	2014-08-22	F	69	ORN	1	Yes	No
21	2014-09-24	M	70	BRONJ	1	Yes	No
22	2014-10-20	M	68	SCC	1	Yes	No
23	2014-10-29	F	67	ORN	1	Yes	No
24	2014-11-03	F	49	ORN	1	Yes	No
25	2014-11-24	M	70	ORN	2	Yes	No
26	2015-02-02	F	47	SCC	2	Yes	Yes
27	2015-03-30	F	68	SCC	1	No	No
28	2015-06-08	F	27	Osteosarcoma	1	Yes	No
29	2015-07-20	M	51	ORN	1	Yes	No
30	2015-09-30	F	39	Osteosarcoma	1	Yes	No

Op: operation, Recon: reconstruction, F: female, M: male, SCC: squamous cell carcinoma, ORN: osteoradionecrosis, BRONJ: bisphosphonate related osteonecrosis of the jaw, Condyle: including condyle during mandibulectomy

bicortical screws. Postoperative IMF was performed about 1 week and mouth opening exercise was performed using elastic rubber ring guidance. Postoperative flap survivals, postoperative occlusion, esthetic results, food taking were evaluated.

Results

All fibular flaps were survived after operation. Patients' demographic data and cause of bone defects is listed in Table 1. Two patients who had undergone radiotherapy for 8 weeks showed progressive necrosis of the flaps. These two flaps were removed under local and general anesthesia. Seven patients passed away during follow-up periods and among them, four patients died of recurrent squamous cell carcinoma. The others died of other causes such as cerebral infarction and pneumonia. Simulation surgery and prebending R-plate could reduce surgical operation time dramatically.

Occlusal stability after segmental mandibulectomy was obtained in 29 patients. One full edentulism patient reported liquid diet after operation. This edentulous patient required dental implant and overdenture for restoration, however, prosthodontic treatment is pending due to economic status. Dental implants were placed in the reconstructed mandible in four patients without any failure. All patients were satisfied with the esthetic results. No patient complained about donor site morbidity postoperation 3 months. Patients who underwent dental implant therapy reported improved solid food intake.

Discussion

Fibula free flap is one of the most popular free flaps for the mandibular reconstruction (7, 8). The advantages of the fibula free flap are long bone, consistent vessels, concomitant skin harvest and enough bone volume for dental implant installation (1, 4, 9). However, straight nature of the fibula bone needs multiple segmentations for fitting mandibular contour. Intraoperative segmentation and fixation is time-consuming procedure. Prolonged operation time increases ischemic hypoxia of free flap which is related with flap failure. To decrease ischemic time, osteotomy without disconnecting peroneal vessels, surgical stent application and simulation surgery were clinically tried. Osteotomy without disconnecting peroneal vessels is good to maintain blood supply to the fibular flap, however, exact prefabrication is necessary for adapting in the mandibular defect. If the prebent fibula flap does not fit, miniplates for fixation of the fibular osteotomy should be removed and reapplied (10, 11). This procedure protracted anastomosis of the vessels and increase ischemic injury. Delayed anastomosis and

reperfusion could jeopardize free flap (12-14).

Titanium reconstruction plate (R-plate) is rigid and easy to apply in the segmental mandibular bone defect (15, 16). There are controversies about miniplates application vs R-plate insertion during fibular free flap reconstruction. Each methods has advantages and disadvantages such as easy to apply (R-plate) and removal (miniplates), rigidity for early masticatory function (R-plate), no risks for skin exposure (miniplates) and easy to fix the fibular flap (R-plate).

Recently, virtual simulation surgery before mandibular reconstruction was tried in many institutions (5, 17-19). The advent of preoperative virtual surgical planning with 3D RP model and simulation surgery before operation has resulted in more efficient and less traumatic and fast surgery (15). When ischemic time has been reduced below one hour, success rate of free flap is increased dramatically. Experienced surgeons know the procedure completely and two-team approach can reduce operation time. However, a novice needs special program to master microsurgical reconstruction. Preclinical can use virtual program and could make surgical guidance for fibular osteotome.

Conclusion

Simulation surgery before mandibular reconstruction is the most efficient way to reduce operation time and postoperative complication such as malocclusion, facial asymmetry and flap necrosis. In this study, 28 patients were satisfied with the mandibular reconstruction and showed good occlusion. Postoperative physical therapy for occlusal guidance is mandatory for successful results.

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