

# CLINICAL EVALUATION OF VASCULARIZED BONE GRAFTS AND OSSEOINTEGRATED IMPLANTS

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## KEY WORDS

Vascularized bone graft  
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We evaluated mandibular rehabilitation using vascularized bone graft and osseointegrated implants. Questionnaires were used to evaluate the masticatory function, and we measured the occlusal force in each patient. In addition, we measured the height of grafted bone to assess the possible relationship between masticatory rehabilitation and the change in bony height. Five of 13 patients showed over 12.0% increase in bony height after superstructure fabrication. Most of the patients who underwent tongue resection scored low points on the questionnaire. Also, most patients with resection, including resection of the angles of the mandible, showed a lower occlusal force than those without.

## INTRODUCTION

Osseointegrated implants are useful for dental reconstruction of partial and complete edentulism. The use of implants is also advantageous for fixation of prostheses in patients who have received tumor surgery. Mandibular discontinuous resection for tumor treatment decreased masticatory function. Recovery of continuity of the mandible is important to sustain occlusal force, and a vascularized bone graft is useful for reconstruction of the mandible. On the other hand, conventional prostheses are often unsuitable for rehabilitation of masticatory function because of the condition of hard and soft tissue after the reconstruction. Vascularized bone graft and osseointegrated implants are useful for rehabilitation of masticatory function and present ob-














vious advantages over conventional prosthesis.<sup>1-5</sup> Sufficient evaluation of masticatory function is important to clarify certain problems in rehabilitation that makes use of vascularized bone graft and osseointegrated implants. The purpose of this study was to evaluate masticatory rehabilitation with vascularized bone graft and implants of patients who underwent mandibular discontinuous resection by means of questionnaires on masticatory efficiency and occlusal force. The height of grafted bone was measured to investigate the possible relationship between masticatory rehabilitation and the change in bony height.

## MATERIAL AND METHODS

This study involved 13 patients (nine men and four women) ranging in age from 25 to 73 years (average, 54 years).

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TABLE I  
Overview and patients

Patient	Age	Sex	Diagnosis	Resected area	Resection of tongue	Resection of angle of mandible	Grafted bone
1	54	Male	SCC*		Yes	No	Fibula
2	51	Male	SCC		No	No	Fibula
3	45	Female	Osteomyelitis		Yes	Yes	Fibula
4	68	Female	SCC		Yes	No	Fibula
5	73	Male	Osteomyelitis		No	Yes	Fibula
6	39	Male	Ameloblastoma		No	No	Scapula
7	25	Female	Fibrous dysplasia		No	No	Scapula
8	71	Male	SCC		Yes	Yes	Tibia
9	34	Male	SCC		No	No	Fibula
10	59	Male	SCC		No	No	Fibula
11	68	Male	SCC		Yes	Yes	Fibula
12	59	Female	SCC		Yes	Yes	Fibula
13	59	Male	SCC		No	No	Fibula

\*SCC indicates squamous cell carcinoma

They underwent surgical resection of the mandible for treatment of malignant tumor (nine patients), benign tumor (one patient), fibrous dysplasia (one patient), and osteomyelitis (two patients). Five patients (patients 8–10, 12, and 13) underwent radiation therapy (40 Gy) before tumor surgery. All patients underwent mandibular reconstruction with vascularized bone graft for rehabilitation of mandibular discontinuity. Osseous donor sites involved the fibula in ten patients, the scapula in two patients, and the tibia in one patient (Table 1). The condition of the opposite jaw was conventional complete denture in three patients,

conventional partial denture in two patients, normal teeth in seven patients, and implants retained over denture in one patient. Four patients (patients 1, 8, 11, and 12) underwent tongue resection. In all patients, the hypoglossal nerve was preserved. Five patients (patients 3, 5, 8, 11, and 12) underwent resection of angle of mandible.

In nine patients, osseointegrated implants were placed in the mandible at the same time as vascularized bone graft surgery (patients 1–3, 5, 8–10, 12, and 13). Four of 13 patients had delayed placement of implants (patients 4, 6, 7, and 11). The period from implant placement to abutment connec-

tion ranged from 4 months to 15 months (mean, 8 months). Three patients (6, 8, and 10) had hyperbaric oxygen therapy 20 times before implant placement and 10 times after placement at 2 or 3 atm for 90 minutes at each session. In all patients, the fixed prosthesis was fabricated, and the follow-up period from implant placement ranged from 24 to 77 months (Table 2).

In 12 of 13 patients, masticatory function was evaluated using a questionnaire prepared according to the format shown in Table 3. In this questionnaire, designed by Ueda *et al.*,<sup>6</sup> Japanese foods are classified into five categories according to difficulty of mastication. The foods in group 1 represent the easiest and those in group 5 the most difficult to masticate. When a patient is able to chew the foods in each group, five points are given as a masticatory function index. In addition, occlusal force was measured with Dental Prescale (Fuji Film Co, Tokyo, Japan) in 12 of 13 patients. Patients bit a horse-shoe-shaped sheet containing a color-forming material and color-developing material for 3 seconds. Occlusal force was calculated using Fuji Film Dental Occlusion Pressuregraph (Fuji Film Co). Grafted bone height was measured on panoramic radiographs taken after implant placement.<sup>7</sup> Measurements were made at 10-mm intervals in the area of grafted bone not subject to implant placement. In the area of grafted bone receiving implants, measurements were made at the center of each implant. Radiographs taken at obviously different angles from other radiographs were not used for measurement.

## RESULTS

In 58 implants placed in grafted bone, no implant was removed at the time of abutment connection surgery and during the follow-up period. Two implants were not uncovered because the direction of the implant was inadequate for prosthetic treatment, and seven implants were not uncovered because there were enough of the other

TABLE 2  
Treatments with osseointegrated implants

Patient	Number of Implants			Bone Graft Implant Placement	Follow-up Period From Implant Placement (mo)	Opposite Jaw*
	Grafted Bone	Sleep	Residual Bone			
1	3	0	2	Simultaneous	69	CD
2	4	0	0	Simultaneous	64	NT
3	4	2	0	Simultaneous	52	PD
4	4	1	2	9 months	45	CD
5	6	1	0	Simultaneous	42	FD
6	6	0	0	8 months	91	NT
7	6	1	0	6 months	41	NT
8	4	2	3	Simultaneous	77	IOD
9	6	1	0	Simultaneous	39	NT
10	4	0	0	Simultaneous	33	NT
11	3	0	1	14 months	24	NT
12	4	1	0	Simultaneous	25	PD
13	4	0	0	Simultaneous	35	NT

\*CD indicates conventional complete denture; PD, conventional partial denture; NT, normal teeth; and IOD, implants retained over denture.

TABLE 3  
Categories of foods used in questionnaires on masticatory efficiency

Group	Food
1	Bean curd Boiled rice with tea Noodles Pudding
2	Boiled fish paste Lettuce Shrimp tempura Sliced cucumber
3	Cookie Herring roe Pickled radish Tender steak
4	Cracker Rice cake cubes Salami
5	Sliced raw cuttlefish Chewing gum Dried cuttlefish Biting off a cotton thread Biting into an apple

implants for mandibular fixed prostheses in each case. All eight implants placed in the residual mandible osseointegrated clinically. The amount of occlusal force of all patients, shown in Table 4, ranged from 72 N to 759 N.

In the measurement of the height of grafted bone using panoramic radiographs taken a certain time from the fabrication of the superstructure, 5 of 13 patients showed over 12.0% increase in bony height compared with before

superstructure fabrication or at the time of superstructure fabrication (Fig 1). Four of 13 patients showed a decrease in bony height in all areas in which grafted bone was measured. Five patients who showed more than 12% increase in bony height ranged from 34 to 68 years of age, with an average of 47 years. The follow-up period from implant placement ranged from 39 to 91 months, with an average of 58 months. In some patients, grafted bone tended to decrease temporarily and thereafter increase in bony height after superstructure fabrication. In calculating the rate of increase in bony height in such patients, only the radiographs after early decrease of bony height were used. In five patients who showed over 12.0% increase in bony height, the rate of increase in the height of grafted bone ranged from 12.3% to 34.2%, and the condition of the opposite jaw was conventional complete denture in one patient, conventional partial denture in one patient, and normal teeth in three patients.

The results of evaluation of masticatory efficiency using questionnaires are shown in Table 4. The scores ranged from 25 to 90, with eight patients scoring over 60 points.

DISCUSSION

The increase in bony height among 5 of 13 patients in this study is of inter-

est. Recently, a few investigators reported spontaneous bony growth in the posterior region of the mandible. Morton and Natkin<sup>8</sup> reported bony growth beneath the fixed bridge pontics in 16 patients. Burkes *et al*<sup>9</sup> described nine patients who had excessive bony growth beneath the pontic of a posterior fixed bridge. Taylor<sup>10</sup> described a patient with spontaneous alveolar ridge growth beneath the cantilevers of an implant-supported fixed prosthesis. It is suggested that functional stress on bone during occlusion may be one reason for the bony growth. Also, in the field of orthopedics,<sup>11</sup> Lasar *et al*<sup>12</sup> reported that among 21 vascularized fibular grafts for bridging tibial defect or femoral defect, a measurable degree of hypertrophy was found in eight. It is suggested that hypertrophy of vascularized grafted bone is a relatively frequent finding. However, it is unclear why hypertrophy occurs to a much greater extent in some grafts than others. In the present study, the increase in bony height was different in each patient. In three patients (8, 10, and 12) with the decrease in bony height in all areas of grafted bone measured, the average occlusal force was 211 N. And in the five patients with more than 12.0% increase in bony height, the average occlusal force was

TABLE 4  
The results of evaluation of masticatory efficiency using questionnaires and occlusal force in each patient

Patient	Occlusal Force (N)	Questionnaire Points
1	471	25
2	263	75
3	142	25
4	323	80
5	294	75
6	696	85
7	271	80
8	272	25
9	759	80
10	289	75
11	282	20
12	72	50
13	Not measured	Not measured

437 N. However, in patient 1, who had a 471-N occlusal force, there was no obvious increase in bony height. Patient 5, with an occlusal force of 142 N, showed a 16.9% increase in bony height. The size and density of the grafted mandible were different, as was the occlusal force in each patient.

The reconstructed mandible must absorb the functional forces, and there may be a minimum size and density of bone required to absorb such forces. This could explain the difference in the amount of bony growth in each patient under study. Furthermore, investigation into the relationship between stress distribution in the reconstructed mandible, bone size and density, and increase in bony height is required.<sup>13,14</sup>

In the present study, there was a difference in the amount of occlusal force and the results of questionnaires in each patient. It was reported that rehabilitation of masticatory function in cases of postoperative mandibular discontinuity involves the condition of the opposite jaw, resection of the tongue, and the resected area of the mandible. The results of the present questionnaire revealed that patients who underwent tongue resection experienced much less masticatory efficiency (average score, 48 points), whereas those who did not undergo tongue resection had high efficiency, regardless of the

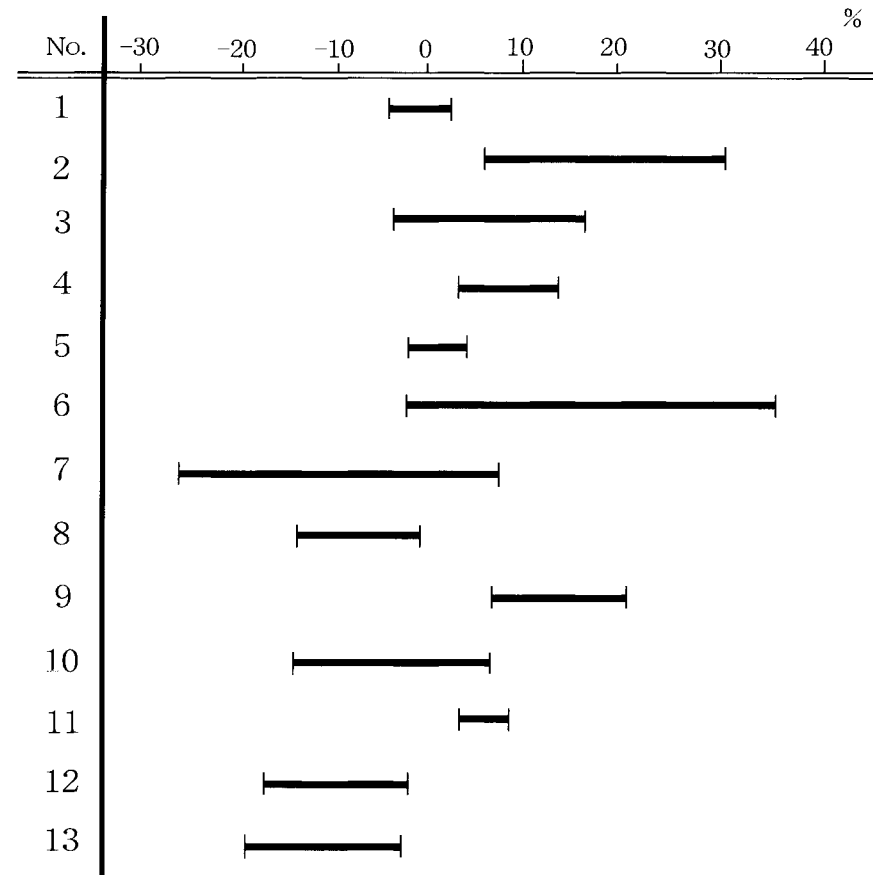


FIGURE 1. The range of increase rate in height of grafted bone in each patient.

occlusal force (mean score, 80 points). This result indicates that the tongue mobility has a considerable role in masticatory function. The preservation of the tongue therefore has an important role in postoperative masticatory function.

If it is necessary to resect the tongue, preservation of the hypoglossal nerve is essential to maintain the mobility of residual tongue. In investigation into the area of mandibular resection, most of the patients who underwent resection that included angles of mandible showed lower occlusal force (the average was 212 N) than those without the resection of angles of mandible, the average of which was 439 N. It is suggested that in cases of resection, including the angles of the mandible, masseter muscle, and medial pterygoid muscle, are also subject to injury or resection and that this causes a decrease in the amount of occlusal force.

Preservation of the masticatory muscle also has an important role for rehabilitation of masticatory function. One must consider carefully whether or not one should resect the angle of the mandible.

There are many objective methods that may be used to evaluate masticatory function.<sup>15,16</sup> However, each method only evaluates a part of a patient's masticatory function. Thus, one must consider the results obtained from both objective and subjective methods in the clinical evaluation of vascularized bone graft and osseointegrated implants.

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