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Studies on masticatory functions in the patients  
with surgical mandibular reconstruction

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Introduction

Mandibular reconstructions are important and indispensable surgical procedures in the patients with mandibular neoplastic lesion. The autogenous bone transplantation from the iliac crest has been widely accepted for the reconstruction of the mandibular bone defect to attain the functional and cosmetic recovery of the facial and mandibular structures. The functional recovery should be well considered in such surgical mandibular reconstruction, while jaw functions especially masticatory activity after mandibular reconstruction have not been well studied yet. In the present article, masticatory functions after mandibular reconstruction were studied recording and analyzing electromyographic activities of jaw muscles, maximum biting force and masticatory efficiency in patients with mandibular reconstruction, and the clinical significance of the findings is discussed.

Materials and Methods

Sixteen subjects out of 100 patients, ranged from 20 to 68

years old, were selected. They visited the Oral Surgery Clinic of Osaka University Dental School from 1955 to 1968 to get the hemi and partial mandibulectomy. Among these subjects 12 patients were with bone transplantation and 4 patients were without bone transplantation. Twenty-six years old three Japanese male subjects with normal occlusion were examined as the control, and a preoperative recording was also performed in one patient as the control. Clinical findings of the patients in the present report are summarized in Table I. The subjects were classified into four groups in regard to the types of mandibulectomy and with or without bone transplantation (Fig. I). Group 1 is the case with a segment resection at median and mental part of the mandible with iliac bone transplantation. Group 2 is with segment resection of the angle region of the mandible with iliac bone transplantation. Group 3 is with hemimandibulectomy of the angle and the ramus of the mandible (including condyle head and muscular process) with iliac bone transplantation. Group 4 is the case with mandibulectomy without bone transplantation.

Table I.

Fig. I.

#### Electromyography

For the recording of electrical activities of the jaw muscles, a twelvechannel electromyograph with an ink-writing recorder and fishhookshaped surface electrode (Kawamura)<sup>1</sup> were used. Electromyographs of the masseter muscle, the anterior, medial and posterior parts of the temporal muscle and the

digastric muscle were recorded simultaneously in the left and right sides under the rest position of the mandible and during powerful biting, powerful mandibular opening, lateral mandibular movement, chewing peanuts and maximum biting.

#### Maximum biting force

The maximum biting force was measured electrically by biting Zonde using the condenser method.

#### Masticatory efficiency

Peanuts (3.0g) were used as the test materials for the measurement of masticatory efficiency, and after 20 strokes of mastication the test materials were taken out to be sieved in 10 mesh screens. They were left in the oven respectively for about four hours at 100° C and transferred into the desiccator for two hours. The volume of the dry remaining particles on the 10 mesh screen was calculated following the simple sieving method (Manly).<sup>2</sup>

### Results

#### Clinical findings

Front and lateral view of the face showed satisfactory good facial appearance (Fig. II, A), but irrespective of a good bony continuation the alveolar ridges (Fig. II, B and C) were generally flat and poor in the reconstructed patients.

#### Fig. II

#### Electromyographic activities of masticatory muscles

(a) Spontaneous discharges of masticatory muscles at the rest position of the mandible.

Spontaneous discharges of masticatory muscles at the rest stage of the mandible were examined in three normal subjects (Fig. III). In the normal subjects, electromyographic activities in the anterior and medial parts of the temporal muscles in both sides revealed a slight discharges and those of another elevator muscles, such as, activities of the masseter and posterior temporal muscles were almost silent. In the resected subject without bone transplantation (patient No. 15 in the Group 4), electromyographic recording from the anterior temporal muscle in the unoperated side showed abnormally increased spontaneous discharges (Fig. III, D). Spontaneous discharges in the normal and reconstructed subjects are summarized in Table II. The majorities of electromyographic activities in the reconstructed patients (Group 1,2,3) showed a slight discharge in the elevator muscles, i.e. masseter, anterior, medial and posterior temporal muscles. Five patients in the reconstructed group (Group 2 and 3), showed increased discharges of digastric muscles in both side, though irresponsive to detectable discharges in the normal subject. There were no differences between operated and unoperated sides of the reconstructed mandible (Group 1,2,3) in the magnitude of the spontaneous discharges of masticatory muscles.

Table II

Fig. III

(b) Electromyographic activities (EMG) of masticatory muscles during forced biting.

The subjects were requested to bite powerfully for about 5 seconds. As shown in Fig. IV, in the normal subject, during powerful biting, the masseter muscle and the anterior, medial and posterior parts of the temporal muscle, and the digastric muscle were rather "silent" in both sides. The maximum amplitude of EMG of the subjects in all groups during powerful biting is summarized in Table III. In most cases of the reconstructed patients (Group 1,2,3) EMG activities of elevator muscles, such as masseter and all the three parts of the temporal muscle, were remarkably high as well as in the normal subject. On the other hand, the EMG activity of elevator muscles in the operated side was very weak (Fig. IV, C) in the Group 4, with resection of the mandible and without bone transplantation (No. 13, 14 and 15 of Group 4). Distinct appearance of muscle activities was obtained in the case (No. 13, Group 4) of the bone transplantation two years after mandibulectomy comparing to pre-transplantation (Fig. IV, C and C').

Table III

Fig. IV

(c) EMG activities of masticatory muscles during powerful opening of the mouth.

The comparison of magnitude of EMG activities of the masticatory muscles during powerful opening and ranges of the maximum opening were summarized in Table IV. In the normal subject, EMG of the digastric muscle displayed very high activity (Fig. V, A). In all patients, except for the case of median

part segment resection without bone transplantation (No. 16), EMG of the digastric muscle showed very high activities and any disturbances of mouth opening were not observed. However, exceptional case (No. 16), electromyographic activities of the digastric muscle was weak and range of the mouth opening was also limited to 2.5cm. Slight lateral deviation to operated side was always observed in all the subjects during powerful opening.

Table IV

Fig. V

(d) EMG activities of masticatory muscles and range of lateral deviation of the mandible.

The activities of masticatory muscles in the normal and reconstructed subjects during lateral movement of the mandible and the range of lateral deviation of the mandible are shown in Table V. In the normal subject, the ipsilateral masseter and digastric muscles, the three parts of the temporal muscle and the contralateral digastric muscle increased their activities during lateral movement of the mandible (Fig. VI, A, A'). In the reconstructed patients, electromyographic activities of the masticatory muscles in all cases were nearly the same as the normal subject (Table V, Fig. VI, B, B'). The range of the lateral movement was 0.7cm to both sides in the median reconstructed subject (No. 2, Group 1) as similar as that of the normal subject, and there was no disturbances of the lateral movement. In the cases of hemimandibulectomy and partial resection including mandibular angle (Group 2,3,4), the lateral

mandibular movement to the unoperated normal side was strongly restricted irrespecting with or without bone transplantation.

Table V

Table VI

(e) Electromyographic activities (EMG) of masticatory muscles during chewing.

EMG of masticatory muscles in normal and treated subjects during chewing are shown in Table VI. In the normal subject, the masseter, digastric and three parts of temporal muscles exhibited an prominent increased activity, and there were regular rhytm and reciprocal relationships between the activities of closing muscles and opening muscles (Fig. VII, A). In most of the reconstructed patients (Group 1,2,3) the same responses as the control were obtained as shown in Table VI and Fig. VII, B. But, on the contrast, the activities of the individual muscle in the resected side of mandible without bone transplantation (Group 4) were markedly decreased and at the same time those in the normal side were slightly decreased too (table VI, Fig. VII, C). In the case of segment resection (No. 13 in Group 4) with bone transplantation two years after mandibulectomy, muscle activities of the reconstructed side was characteristically increased after iliac bone transplantation (Fig. VII, C').

Table VI

Fig. VII

Maximum biting force

Maximum biting force in the premolar and molar regions and

EMG of masticatory muscles during maximum biting are shown in Table VII. In the normal subject, maximum biting force of the molar tooth was 49kg and that of premolar 35kg, and high activities of the tested elevator muscles were observed (Fig. VIII, A). As shown in Table VII, maximum biting force and masticatory muscles activities were the same as normal subject in the preoperated case (No. 1). In the reconstructed case (Group 1, 2,3) there were obvious differences whether the patient had natural tooth or prosthesis in the operated side. In the reconstructed patient No. 9 who had natural tooth high muscle activities and a strong biting force ( $\bar{4}$  20kg) were noted (Table VII). However, in the reconstructed patient (Group 3, No. 6) with denture, a decreased muscle activity and a low biting force ( $\bar{4}$  3kg) were found (Table VII) with tenderness of denture underlying mucous membrane. Comparing the recorded muscle activities and maximum biting force in 16 patients, there was no significant differences according to the reconstructed part of the mandible. The cases of mandibulectomy without bone transplantation (Group 4) showed a low maximum biting force, though they had natural tooth in the operated side. In the patient No. 13 in Group 4 who had bone transplantation two years after mandibulectomy activities in elevator muscles and maximum biting force were significantly increased after bone transplantation (Fig. VIII, C and D).

Table VII

Fig. VIII

## Masticatory efficiency

Masticatory efficiency and numbers of the natural teeth in the mandible were summarized in Table VIII. Masticatory efficiency of the normal subject was 66%, but that of the reconstructed subject (Group 1,2,3) was lower than the normal subject, and these results were influenced by the numbers of natural teeth especially molar tooth presented in the alveolar bone of the mandible and also by the occlusion, however they were <sup>not</sup> influenced by reconstructed part. For example, in the reconstructed patient (No. 8 in Group 3) who has 13 natural teeth presented of the reconstructed mandible and good occlusion the masticatory efficiency was 47.4%, however in the patient No. 7 in Group 2 who had 12 natural teeth but malocclusion due to the mandibular deviation by reconstruction the masticatory efficiency was only 10% (Table VIII). All patient in Group IV could not bite peanuts.

### Table VIII

## Discussion

Electromyographic activities of masticatory muscles and jaw movement.

EMG is a conventional method to analyse the masticatory muscle activity, and most of these studies have been concerned with masticatory activities under various positions and movements of mandibular bone in subjects with natural dentition, malocclusion, denture wearer, temporomandibular joint ankylosis. 3-15

The function of jaw muscles in resected and reconstructed mandibles has not yet been studied clinically with physiological standpoints.

In resting position of the normal subject, it has been accepted that a slight discharge of the anterior and medial parts of the temporal muscle and an absence of electrical activity of the masseter and digastric muscles and posterior part of the temporal muscles.<sup>10</sup> However several investigators have reported electrical "silence" in the masseter, temporal muscles in the normal subject.<sup>8,9,15</sup> In the present study, slight electromyographic activities of elevator muscles were observed in most cases of reconstructed patients as in the normal subject. However in 5 cases out of 16 patients, a slight increasing discharge of the digastric muscle was recorded and in the resected patient without bone transplantation (Group 4, No. 15) EMG showed high activities in the anterior and medial temporal muscles of normal side and the silence of activities of elevator muscles of resected side. It has been concluded that slight electromyographic activities of elevator muscles are due to the proprioceptive reflex of the elevator muscles hanging the mandible.<sup>17,18,19</sup> In these cases the proprioceptive reflex in the rest position was disordered by the changing of receptors of periodontium, condyle head and muscles are considered to be reformed.

During powerful biting in the present study, the remarkable electromyographic activities of masseter and three parts of the temporal muscle were observed in the normal subject as it was

previously reported.<sup>4,6,11, 13</sup> Analyzing the electromyographic activities of masticatory muscles it has been mentioned that in the case of temporo-mandibular joint ankylosis a low activity of elevator muscles during powerful biting seemed to indicate the disuse muscle atrophy.<sup>26</sup> However in the reconstructed patients obvious activities of masseter, anterior, medial and posterior parts of temporal muscles were recorded as well as in the normal subject. The findings obtained from the present study indicated that the masticatory muscles separated from mandible by surgery and reattached to the transplanted bone have attained functional recovery. On the contrary the EMG activities of elevator muscles in the mandibular respected patients without bone transplantation were observed as reported previously,<sup>20</sup> the activities were extremely lower than that of normal or reconstructed subjects. In the present experiment it is considered that a little activity of elevator muscles with loss of attachment to mandible in the resected patient is due to control of central nervous system.<sup>21</sup>

It is stated that digastric muscle show high-activities in the normal subject during forced opening. In the reconstructed patients (Group 1,2,3) including the patients No. 2, 3, 5, 6 (Group 2, 3) whose digastric muscle were injured by segment resection, prominent EMG activities of digastric muscle during powerful opening were found as well as in the normal subject and any disturbances of mouth opening were not found. This result indicates that the function of digastric muscle is active as normal subject, on the contrary, electrical activity

of digastric muscle in the patient No. 15 (Group 4) with resection of median part of mandible without bone transplantation is "silent" which suggest that digastric muscle is devoid of its function.

In the all patients any disturbances of mouth opening were not found but all patients with hemimandibulectomy including mandibular condyle and partial resection (Group 2,3,4) showed lateral deviation to the operated side during opening of mouth. It is interesting and important fact that the range of the lateral deviation during mouth opening is the same between in the patients whose condyles were remained and in the patients whose condyles were reconstructed.

During lateral movement of mandible, it has been reported that an obvious EMG activity of the three parts of temporal muscles and a slight activity in the digastric and masseter muscles were recorded.<sup>8,11,13</sup> The findings of EMG from the present experiment with respect to the normal subject and to the reconstructed patient were obtained same responses as previously reported and it is concluded that the muscle activity during lateral movement in the reconstructed mandible is almost as active as in the normal subject. Concerning the lateral movement to the unoperated side in reconstructed patients (Group 2,3), there was notable disturbances of the movement though the muscle activity is nearly the same as in the normal subject. This phenomenon is considered to be accounted for an influence by limitation of movement of concyle head of

operated side. In the patients of Group 2 whose condyle and external pterygoid muscle which are important to lateral movement are remained, almost the same disturbance was observed as in the patients of Group 3 with reconstructed condyle. These findings indicate that during mandibular reconstruction the position of mandibular condyle is changed and is fixed with transplanted bone under the alterative and unphysiological position. Expecting the recovery of jaw movement we have tried to remain the condyle head but without correct reposition of the condyle, the same disturbance as in condylectomy will be considered to occur.

Regarding the muscle activity during chewing in the normal subject there are marked EMG activities of masseter, three parts of temporal and digastric muscle with co-operative relationships between the closing and opening muscles as previously reported.<sup>22</sup> These findings in the reconstructed patients (Group 1,2,3) are similar to those in the normal subject and it is supposed that the functional recovery of reattached masticatory muscles are almost the same as in the normal subject. It is natural that the cases (Group 4) of resected mandible without bone transplantation displayed very low activities of masticatory muscles especially in the operated side. Every patients in Group 4 could not bite peanuts having sound half of mandible and masticatory muscle of unresected side. These findings indicate that the defect of mandible whose functions are accomplished through the highly coordinated activity of the

many mandibular muscles, their complex neural mechanisms and the movement of temporo-mandibular joint, influenced essentially to the masticatory function.

#### Maximum biting force

Maximum biting force of the first molar of mandible was 49kg in the Japanese normal subject and such force is the same as reported in the literature.<sup>23,24,25</sup> EMG activities of elevator muscles during powerful biting in the mandibular reconstructed patients were intensely active as shown in the normal subject. In the reconstructed patients who had natural teeth on the operated side, maximum biting force is a little lower than that of the normal subject but in denture wearer on the operated side maximum biting force is far lower than usual denture wearer with a complaint of severe tenderness of denture underlying mucous membrane during biting. Besides, findings of flat and insufficient alveolar ridge of the reconstructed mandible suggested that there is a difficulty of prosthetic treatment. Naturally in the patients without bone transplantation, extremely decreased maximum biting force and EMG activity were recorded which indicate the almost no masticatory function is remained having sound half of mandible with natural teeth and masticatory muscles.

In the patient who had bone transplantation two years after mandibulectomy (case No. 13 in Group 4) muscle activities and maximum biting force were far lower than those of the normal subject before bone transplantation like other patients

in Group 4, however after bone transplantation muscle activities and maximum biting force of operated side were extremely increased. The elevator muscles, masseter and temporal muscles separated from the attached area of the mandible for a long duration with lower EMG activity and biting force were thought to be so called disused atrophy, while after bone transplantation concerning the extremely increased electrical activity and biting force the muscles reattached to the transplanted bone are considered to restore their function.

#### Masticatory efficiency.

Masticatory efficiency in the Japanese normal subject showed the same result as European people.<sup>2</sup> In the mandibular reconstructed patient the masticatory efficiency was influenced mainly by the numbers of natural teeth of mandible and occlusal correlation due to the deviation of mandible irrespective of the resected and/or reconstructed regions in the mandible.

#### Summary

Electromyographic activities of jaw muscles, mandibular movement, maximum biting force and masticatory efficiency were studied in sixteen patients with mandibulectomy.

1. Electromyographic activities of the depressor and elevator muscles of the mandible were almost the same as normal subject in the patients with mandibular reconstruction, and in the patients without bone transplantation remarkable low muscle activities were observed.

2. Concerning the maximum biting force, in the patient with mandibular reconstruction with natural teeth in operated side, the maximum biting force was nearly as similar as the normal subject, but with denture on operated side biting force was far lower than usual denture wearer with the complaint of tenderness at denture underlying mucous membrane. Extremely low biting force was shown in the mandible resected patients without bone transplantation.

3. The masticatory efficiency in the mandibular reconstructed patient was lower than that of the normal subject. The locality of resection of the mandible itself did not strongly effect on the masticatory efficiency, but mandibular deviation and the number of remaining natural teeth of the mandible were well assumed to be important factors for the effective mastication.

4. Deviation to the operated side during opening and disturbance of the lateral movement of the mandible to normal side were generally observed in these patients.

5. Electromyographic activities and maximum biting force of the patient with mandibulectomy were extremely increased after bone transplantation.

6. There was no marked differences of EMG activities and maximum biting force between the patients with condylectomy and without condylectomy.

In conclusion, it may be stated that jaw muscle activities of the patients with mandibular reconstruction show almost the same activity in the normal subject and the mandibular reconstruction concerning the reposition of occlusal relation and reconstruction

of the alveolar ridge will enable patients to well recover the masticatory function.

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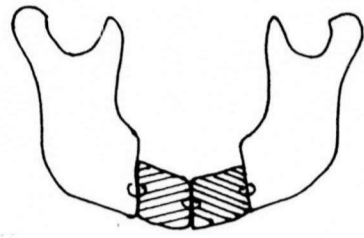
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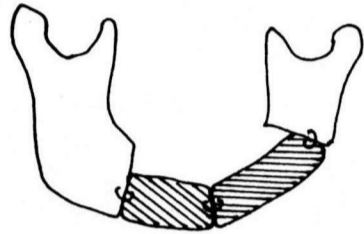
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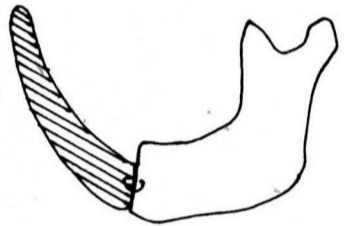
Fig I Classification of Mandibular Reconstruction



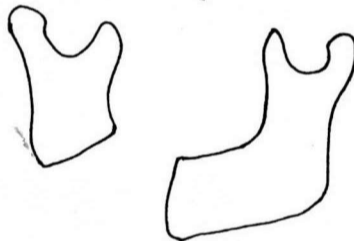
Group 1  
Reconstruction of median part  
Patient No. 2



Group 2  
Reconstruction of mandibular angle  
Patient No. 3 No. 6  
No. 4 No. 7  
No. 5



Group 3  
Reconstruction of mandibular ramus  
Patient No. 8 No.11  
No. 9 No.12  
No.10



Group 4  
Mandibular Resection  
without bone transplantation  
Patient No.13 No.15  
No.14 No.16

TABLE 1. CLINICAL FINDINGS OF 16 PATIENTS WITH MANDIBULAR RESECTION

Patient No.	Age	Sex	Diagnosis	Resected part	Bone transplantation
Preoperation					
1	24	F	Ameloblastoma	Before operation	+
Group 1					
2	51	F	Chronic osteomyelitis	4 + 4	+
Group 2					
3	26	M	Ameloblastoma	3 + angle of mandible	+
4	39	M	Ameloblastoma	3 - angle of mandible	+
5	20	F	Ameloblastoma	6 + angle of mandible	+
6	53	M	Ameloblastoma	3 + angle of mandible	+
7	28	M	Adenoid cystic carcinoma	5 - angle of mandible	+
Group 3					
8	32	F	Ameloblastoma	6 - condyle	+
9	24	F	Ameloblastoma	condyle - 5	+
10	20	F	Ameloblastoma	condyle - 3	+
11	48	F	Ameloblastoma	condyle - 2	+
12	44	F	Ameloblastoma	4 - condyle	+
Group 4					
13	28	M	Adenoid cystic carcinoma	5 - angle of mandible	-
14	42	F	Squamous cell carcinoma	2 - angle of mandible	-
15	65	M	Squamous cell carcinoma	angle of mandible - 3	-
16	58	M	Squamous cell carcinoma	6 + 6	-

Fig. II Clinical findings in the patient No.9 with mandibular reconstruction of right ramus in the mandible



- A. Front and lateral views showing satisfactory facial appearance
- B. Intraoral feature. Note flat alveolar ridge.
- C. Roentgenographic findings. Right ramus part is transplanted with iliac bone, shows good continuity and contour of the reconstructed mandible

TABLE II. ELECTROMYOGRAPHIC SPONTANEOUS DISCHARGES OF MASTICATORY MUSCLES OF NORMAL AND RECONSTRUCTED SUBJECTS

Muscle	Normal subject	Patient before operation	Patients with mandibulectomy			
		No. 1	Group 1 No. 2	Group 2 No. 6	Group 3 No. 10	Group 4 No. 15
Left side						
Masseter	-	-	-	-	-	-
Digastric	-	-	-	+	-	-
Anterior temporal	+	-	+	+	-	+
Medial temporal	+	-	+	+	-	+
Posterior temporal	-	-	-	-	-	+
Right side						
Masseter	-	-	-	-	+	-
Digastric	-	-	-	+	-	-
Anterior temporal	+	-	+	-	-	+
Medial temporal	+	-	+	-	-	+
Posterior temporal	-	-	-	-	-	+

- = Amplitude below 15  $\mu v$

+ = Amplitude above 15  $\mu v$

Fig. III. ELECTROMYOGRAPHIC SPONTANEOUS DISCHARGES OF MASTICATORY MUSCLES AT REST

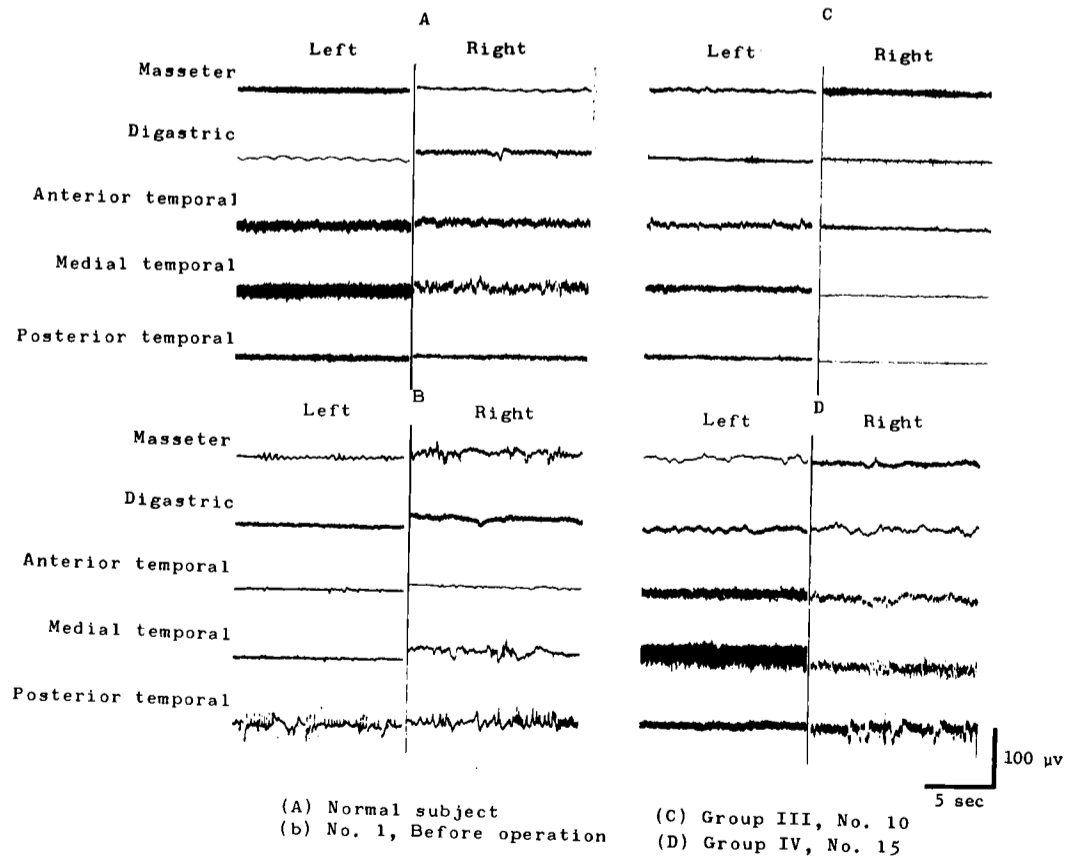


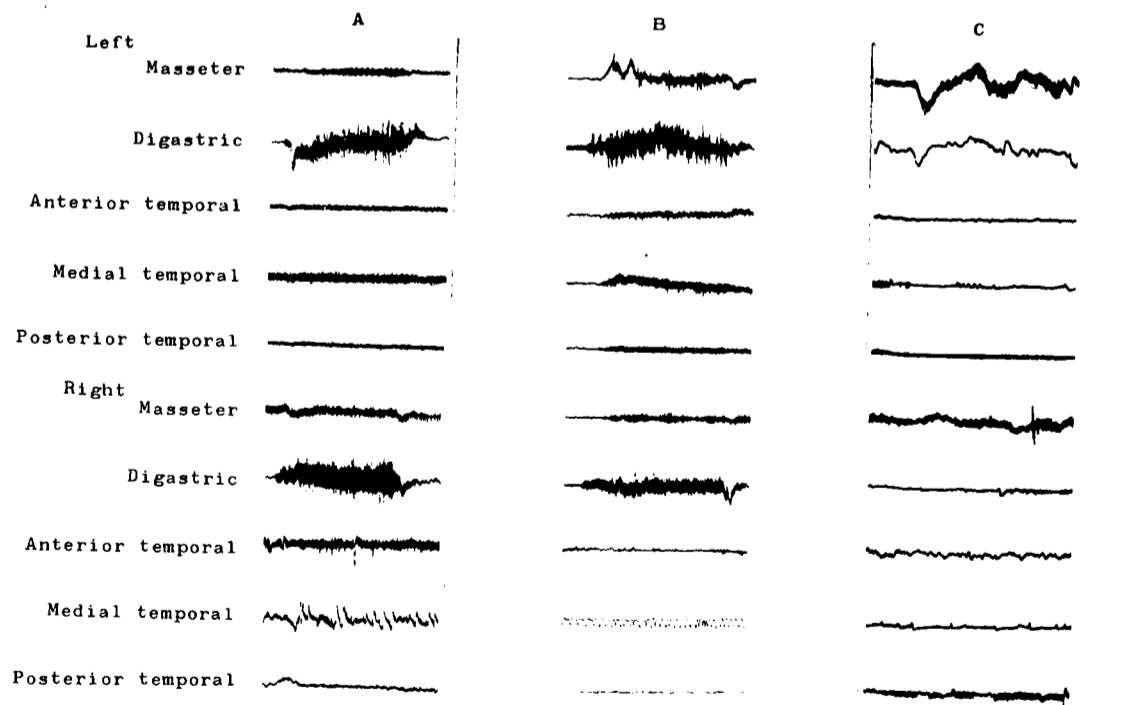


TABLE IV. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES OF NORMAL AND RECONSTRUCTED SUBJECTS DURING FORCED OPENING

Muscle	Normal subject	Patient before operation	Patients with mandibulectomy			
		No. 1	Group 1 No. 2	Group 2 No. 6	Group 3 No. 10	Group 4 No. 15
Left side						
Masseter	-	-	-	+	+	+
Digastric	++	++	+	++	++	-
Anterior temporal	-	-	-	-	-	-
Medial temporal	-	-	-	-	-	-
Posterior temporal	-	-	-	-	-	-
Right side						
Masseter	-	+	-	+	-	-
Digastric	++	++	+	++	+	-
Anterior temporal	-	-	-	-	-	-
Medial temporal	-	-	-	-	-	-
Posterior temporal	-	-	-	-	-	-
Maximum opening (cm)	4.2	4.0	3.5	4.2	4.0	2.5

- = Amplitude 0  $\mu$ v ~ 50  $\mu$ v  
 + = Amplitude 50  $\mu$ v ~ 100  $\mu$ v  
 ++ = Amplitude above 100  $\mu$ v

Fig. V. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES DURING FORCED OPENING



(A) Normal subject  
 (C) Group IV, No. 16

(B) Group III, No. 10

TABLE V. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES OF NORMAL AND RECONSTRUCTED SUBJECTS DURING LATERAL MOVEMENT

Movement to LEET side						
Muscle	Normal subject	Before Operation	Patients with mandibulectomy			
			Group 1 No.2	Group 2 No.6	Group 3 No.10	Group 4 No.14
Left side						
Masseter	+	-	-	++	++	+
Digastric	+	+	+	++	+	+
Anterior temporal	++	+	+	+	-	-
Medial temporal	++	+	+	++	-	-
Posterior temporal	++	-	-	++	-	-
Right side						
Masseter	-	+	-	-	-	+
Digastric	+	+	-	+	-	+
Anterior temporal	-	-	-	-	-	-
Medial temporal	-	-	-	-	-	-
Posterior temporal	-	-	-	-	-	-
Deviation range (cm)	0.7	0.7	0.5	1.0	0.3	0.7

Movement to RIGHT side						
Normal subject	Before Operation	Patients with mandibulectomy				
		Group 1 No.2	Group 2 No.6	Group 3 No.10	Group 4 No.14	
-	+	-	-	-	-	
+	+	+	+	-	-	
-	-	-	-	-	-	
+	-	-	-	-	-	
-	-	-	-	-	-	
++	-	+	++	+	-	
+	+	+	++	+	-	
+	-	+	+	+	++	
+	+	+	+	-	+	
++	-	-	++	-	+	
0.7	0.7	0.5	0.2	0.7	0.1	

- = Amplitude 0  $\mu$ v ~ 50  $\mu$ v  
 + = Amplitude 50  $\mu$ v ~ 100  $\mu$ v  
 ++ = Amplitude above 100  $\mu$ v

Fig. VI. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES DURING LATERAL MOVEMENTS

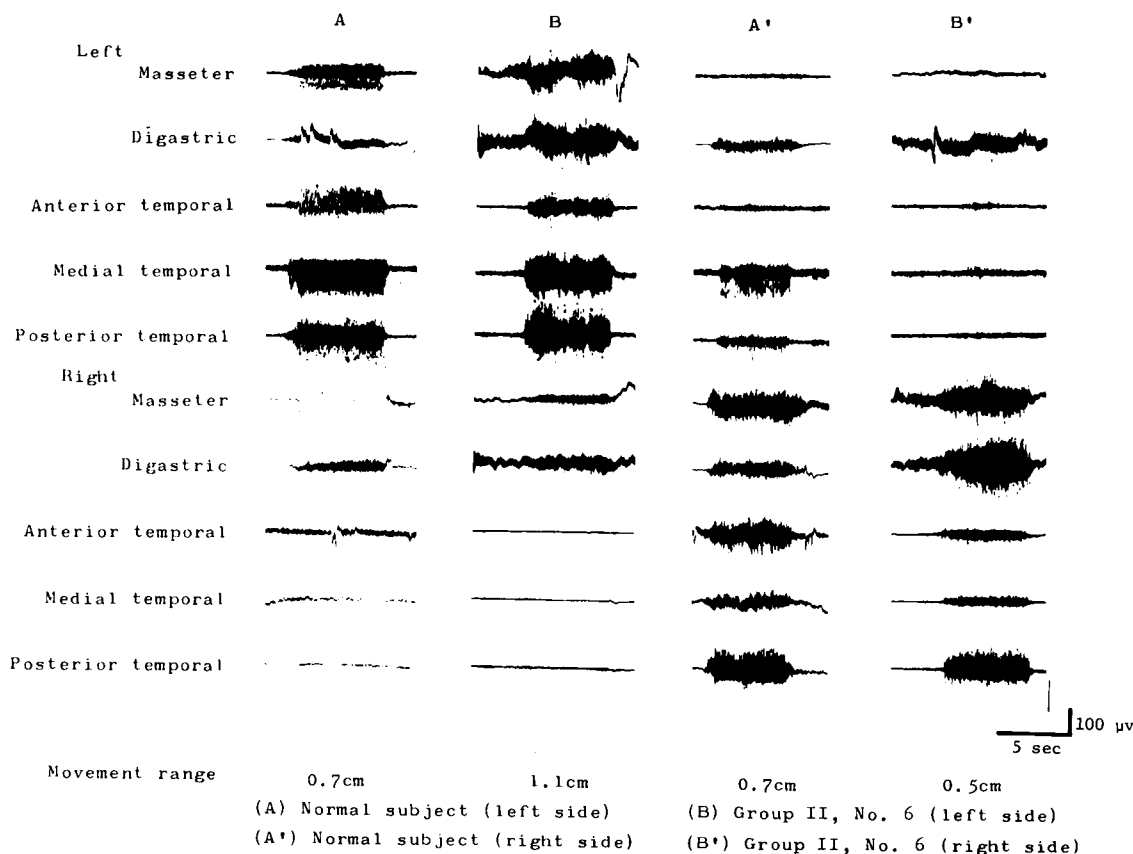




TABLE VI. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES AND MAXIMUM BITING FORCE OF NORMAL AND RECONSTRUCTED SUBJECTS

Muscle	operated side							
	Normal subject	Before Operation	Patients with mandibulectomy					
			Group 1 No.2	Group 2 No.6 *	Group 3 No.9	Group 4 No.13		
<b>Left side</b>								
Masseter	++	++	+	+	++	-		
Digastric	-	-	-	-	+	-		
Anterior temporal	++	+	++	+	++	+		
Medial temporal	++	+	+	-	++	+		
Posterior temporal	++	-	+	-	+	-		
<b>Right side</b>								
Masseter	++	++	+	-	++	-		
Digastric	-	-	-	-	-	-		
Anterior temporal	++	+	+	-	++	-		
Medial temporal	++	++	-	-	+	-		
Posterior temporal	++	+	+	-	-	-		
<b>Maximum biting force</b>								
natural tooth (kg)	6	49	4	37	4	20	4	3.5
artificial tooth (kg)	6	8	4	3				

\* a decreased muscle activity and a low biting force were found with tenderness of denture underlying mucous membrane, however obvious muscle activity were recorded during forced biting (Table III, Fig IV)

Normal subject	Before Operation	Patients with mandibulectomy							
		Group 1 No.2	Group 2 No.6	Group 3 No.9	Group 4 No.13				
++	++	++	++	+	+				
-	-	-	-	+	+				
++	++	+	++	++	+				
++	++	+	+	++	+				
++	+	-	+	-	+				
++	++	-	++	++	++				
-	-	-	-	-	-				
++	-	+	+	++	+				
++	+	+	++	+	+				
++	-	-	-	-	-				
6	49	4	37	6	30	6	36	6	29
		6	10						

Fig. VIII. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES DURING FORCED BITING

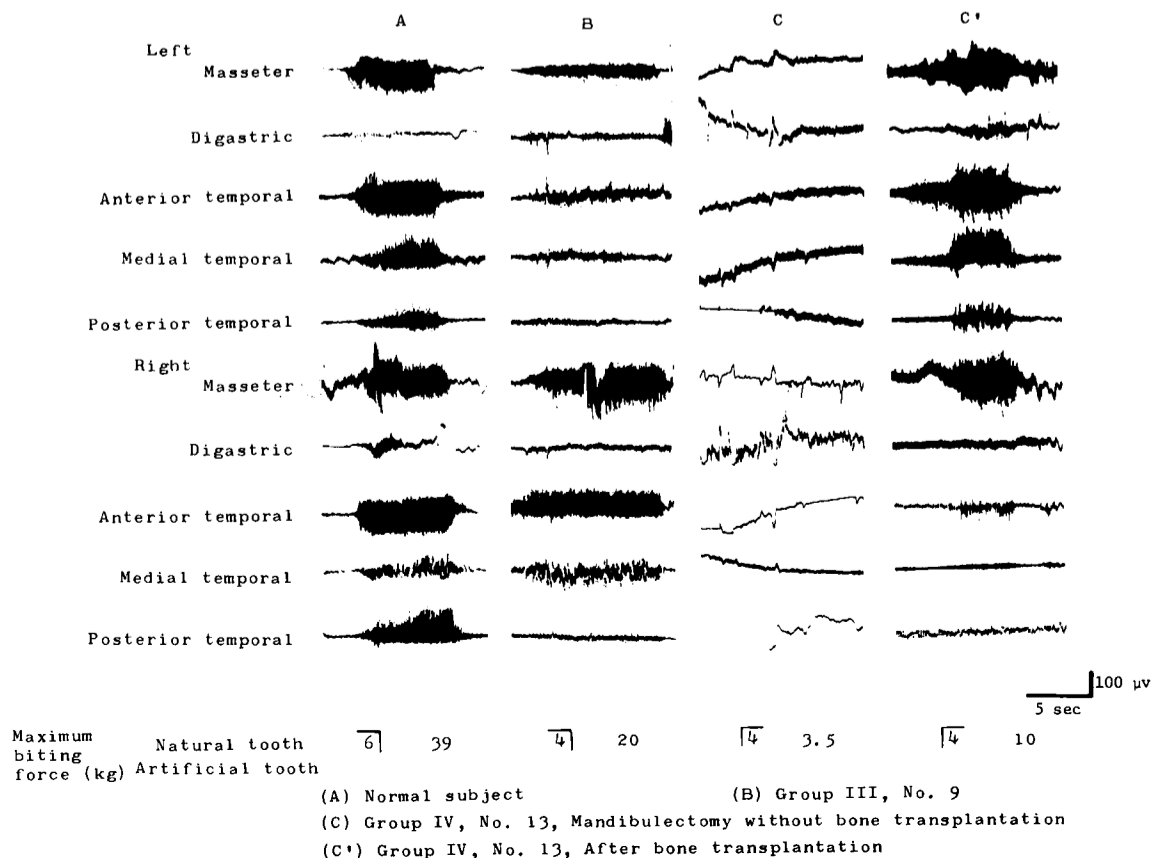


TABLE VIII. MASTICATORY EFFICIENCY OF NORMAL AND  
RECONSTRUCTED SUBJECT

	Normal subject	Before Operation	Patients with mandibulectomy					
			Group 1		Group 2			
			No.2	No.3	No.4	No.5	No.6	No.7
Masticatory efficiency %	68	42	21	26.6	42.2	21.6	34.9	10.0
Numbers of the natural teeth of the mandible	14	14	2	6	11	2	4	12

Patients with mandibulectomy

Group 3					Group 4			
No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16
47.4	10.0	41.5	18.2	0	-	-	-	-
13	11	11	7	12	12	5	5	2

- = no activity of peanuts eating

0 = no examination

Fig I Classification of Mandibular Reconstruction

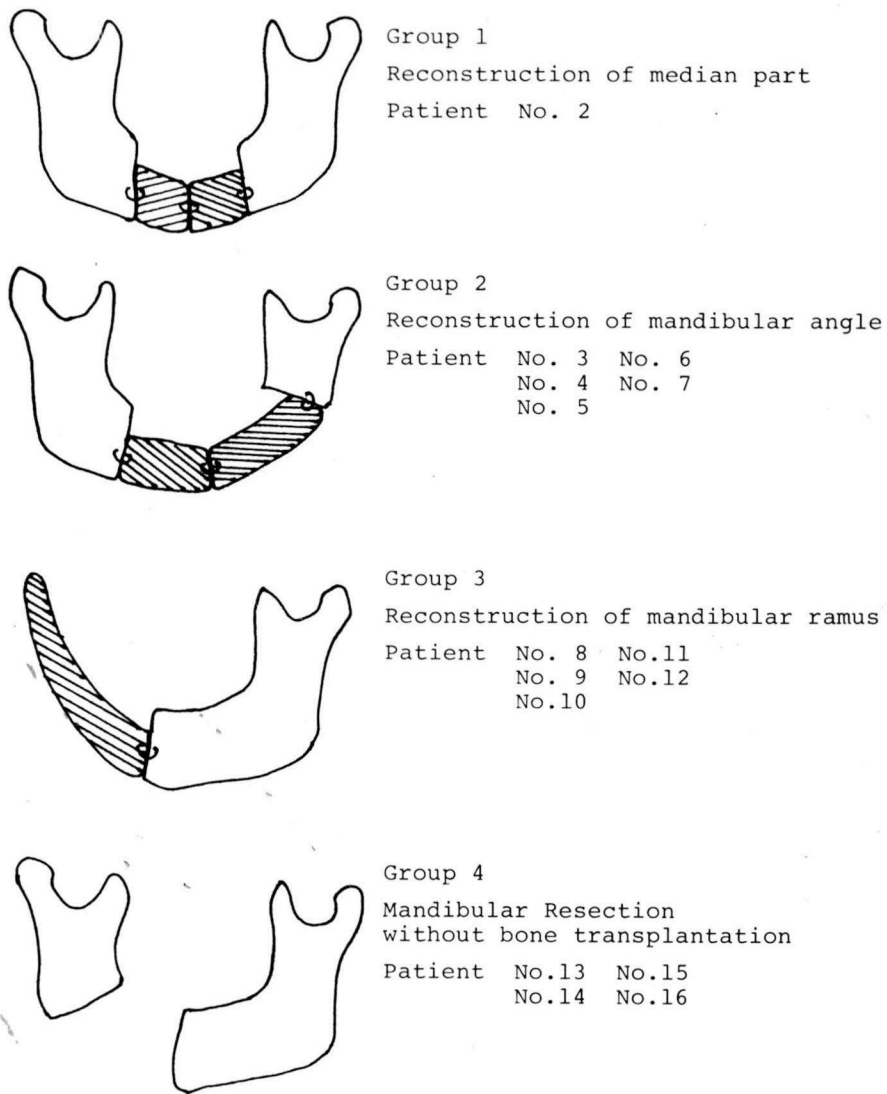


TABLE 1. CLINICAL FINDINGS OF 16 PATIENTS WITH MANDIBULAR RESECTION

Patient No.	Age	Sex	Diagnosis	Resected part	Bone transplantation
Preoperation					
1	24	F	Ameloblastoma	Before operation	+
Group 1					
2	51	F	Chronic osteomyelitis	4 + 4	+
Group 2					
3	26	M	Ameloblastoma	3 + angle of mandible	+
4	39	M	Ameloblastoma	3 - angle of mandible	+
5	20	F	Ameloblastoma	6 + angle of mandible	+
6	53	M	Ameloblastoma	3 + angle of mandible	+
7	28	M	Adenoid cystic carcinoma	5 - angle of mandible	+
Group 3					
8	32	F	Ameloblastoma	6 - condyle	+
9	24	F	Ameloblastoma	condyle - 5	+
10	20	F	Ameloblastoma	condyle - 3	+
11	48	F	Ameloblastoma	condyle - 2	+
12	44	F	Ameloblastoma	4 - condyle	+
Group 4					
13	28	M	Adenoid cystic carcinoma	5 - angle of mandible	-
14	42	F	Squamous cell carcinoma	2 - angle of mandible	-
15	65	M	Squamous cell carcinoma	angle of mandible - 3	-
16	58	M	Squamous cell carcinoma	6 + 6	-

Fig. II Clinical findings in the patient No.9 with mandibular reconstruction of right ramus in the mandible



- A. Front and lateral views showing satisfactory facial appearance
- B. Intraoral feature. Note flat alveolar ridge.
- C. Roentgenographic findings. Right ramus part is transplanted with iliac bone, shows good continuity and contour of the reconstructed mandible

TABLE II. ELECTROMYOGRAPHIC SPONTANEOUS DISCHARGES OF MASTICATORY MUSCLES OF NORMAL AND RECONSTRUCTED SUBJECTS

Muscle	Normal subject	Patient before operation	Patients with mandibulectomy			
		No. 1	Group 1 No. 2	Group 2 No. 6	Group 3 No. 10	Group 4 No. 15
Left side						
Masseter	-	-	-	-	-	-
Digastric	-	-	-	+	-	-
Anterior temporal	+	-	+	+	-	+
Medial temporal	+	-	+	+	-	+
Posterior temporal	-	-	-	-	-	+
Right side						
Masseter	-	-	-	-	+	-
Digastric	-	-	-	+	-	-
Anterior temporal	+	-	+	-	-	+
Medial temporal	+	-	+	-	-	+
Posterior temporal	-	-	-	-	-	+

- = Amplitude below 15  $\mu$ v  
 + = Amplitude above 15  $\mu$ v

Fig. III. ELECTROMYOGRAPHIC SPONTANEOUS DISCHARGES OF MASTICATORY MUSCLES AT REST

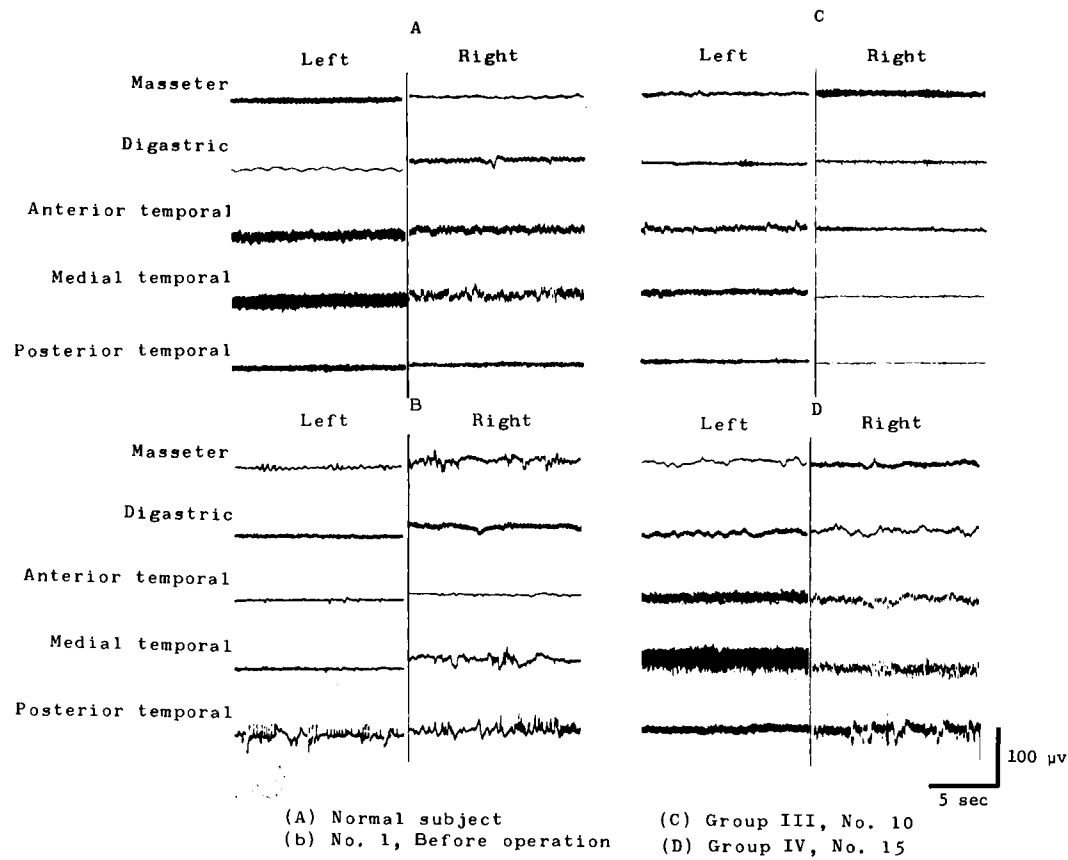




TABLE IV. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES OF NORMAL AND RECONSTRUCTED SUBJECTS DURING FORCED OPENING

Muscle	Normal subject	Patient before operation	Patients with mandibulectomy			
		No. 1	Group 1 No. 2	Group 2 No. 6	Group 3 No. 10	Group 4 No. 15
Left side						
Masseter	-	-	-	+	+	+
Digastric	++	++	+	++	++	-
Anterior temporal	-	-	-	-	-	-
Medial temporal	-	-	-	-	-	-
Posterior temporal	-	-	-	-	-	-
Right side						
Masseter	-	+	-	+	-	-
Digastric	++	++	+	++	+	-
Anterior temporal	-	-	-	-	-	-
Medial temporal	-	-	-	-	-	-
Posterior temporal	-	-	-	-	-	-
Maximum opening (cm)	4.2	4.0	3.5	4.2	4.0	2.5

- = Amplitude 0  $\mu$ v ~ 50  $\mu$ v  
+ = Amplitude 50  $\mu$ v ~ 100  $\mu$ v  
++ = Amplitude above 100  $\mu$ v

Fig. V. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES DURING FORCED OPENING

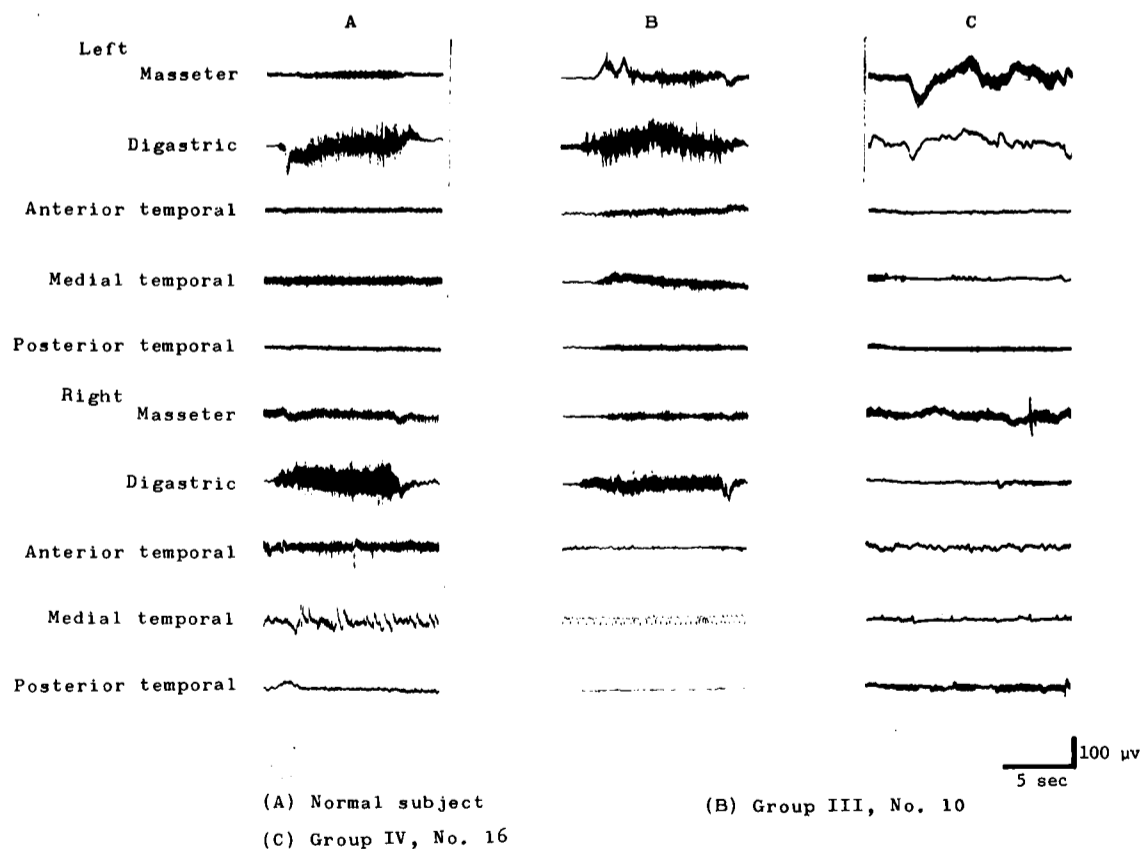


TABLE V. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES OF NORMAL AND RECONSTRUCTED SUBJECTS DURING LATERAL MOVEMENT

Movement to LEET side						
Muscle	Normal subject	Before Operation	Patients with mandibulectomy			
			Group 1 No.2	Group 2 No.6	Group 3 No.10	Group 4 No.14
Left side						
Masseter	+	-	-	++	++	+
Digastric	+	+	+	++	+	+
Anterior temporal	++	+	+	+	-	-
Medial temporal	++	+	+	++	-	-
Posterior temporal	++	-	-	++	-	-
Right side						
Masseter	-	+	-	-	-	+
Digastric	+	+	-	+	-	+
Anterior temporal	-	-	-	-	-	-
Medial temporal	-	-	-	-	-	-
Posterior temporal	-	-	-	-	-	-
Deviation range (cm)	0.7	0.7	0.5	1.0	0.3	0.7

Movement to RIGHT side						
Normal subject	Before Operation	Patients with mandibulectomy				
		Group 1 No.2	Group 2 No.6	Group 3 No.10	Group 4 No.14	
-	+	-	-	-	-	
+	+	+	+	-	-	
-	-	-	-	-	-	
+	-	-	-	-	-	
-	-	-	-	-	-	
++	-	+	++	+	-	
+	+	+	++	+	-	
+	-	+	+	+	++	
+	+	+	+	-	+	
++	-	-	++	-	+	
0.7	0.7	0.5	0.2	0.7	0.1	

- = Amplitude 0  $\mu$ v ~ 50  $\mu$ v  
 + = Amplitude 50  $\mu$ v ~ 100  $\mu$ v  
 ++ = Amplitude above 100  $\mu$ v

Fig. VI. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES DURING LATERAL MOVEMENTS

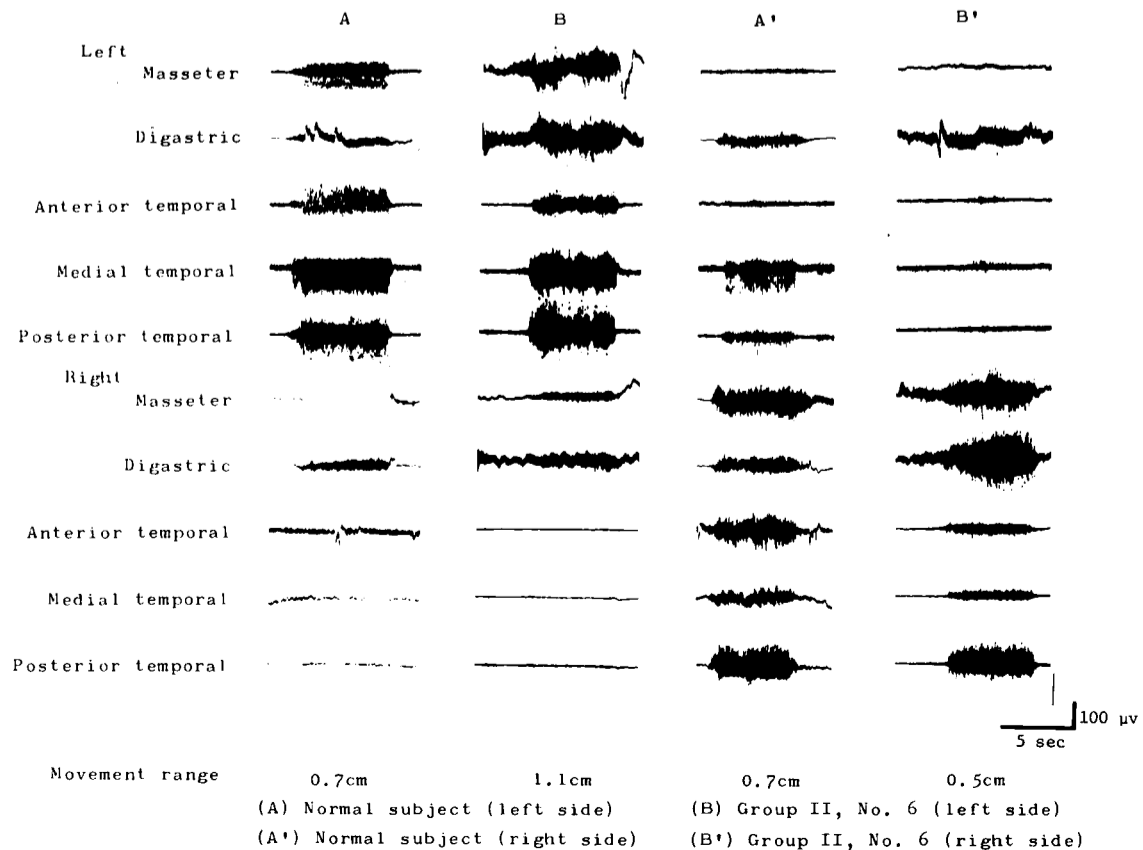




TABLE VI. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES AND MAXIMUM BITING FORCE OF NORMAL AND RECONSTRUCTED SUBJECTS

operated side

Muscle	Normal subject	Before Operation	Patients with mandibulectomy			
			Group 1 No. 2	Group 2 No. 6 *	Group 3 No. 9	Group 4 No. 13
<b>Left side</b>						
Masseter	++	++	+	+	++	-
Digastric	-	-	-	-	+	-
Anterior temporal	++	+	++	+	++	+
Medial temporal	++	+	+	-	++	+
Posterior temporal	++	-	+	-	+	-
<b>Right side</b>						
Masseter	++	++	+	-	++	-
Digastric	-	-	-	-	-	-
Anterior temporal	++	+	+	-	++	-
Medial temporal	++	++	-	-	+	-
Posterior temporal	++	+	+	-	-	-

Maximum biting force  
 natural tooth (kg)  $\overline{6}$  49  $\overline{4}$  37  $\overline{4}$  20  $\overline{4}$  3.5  
 artificial tooth (kg)  $\overline{6}$  8  $\overline{4}$  3

\* a decreased muscle activity and a low biting force were found with tenderness of denture underlying mucous membrane, however obvious muscle activity were recorded during forced biting (Table III, Fig IV)

unoperated side

Normal subject	Before Operation	Patients with mandibulectomy			
		Group 1 No. 2	Group 2 No. 6	Group 3 No. 9	Group 4 No. 13
++	++	++	++	+	+
-	-	-	-	+	+
++	++	+	++	++	+
++	++	+	+	++	+
++	+	-	+	-	+
++	++	-	++	++	++
-	-	-	-	-	-
++	-	+	+	++	+
++	+	+	++	+	+
++	-	-	-	-	-
$\overline{6}$ 49	$\overline{4}$ 37	$\overline{6}$ 30	$\overline{6}$ 36	$\overline{6}$ 29	$\overline{6}$ 10

Fig. VIII. ELECTROMYOGRAPHIC ACTIVITIES OF MASTICATORY MUSCLES DURING FORCED BITING

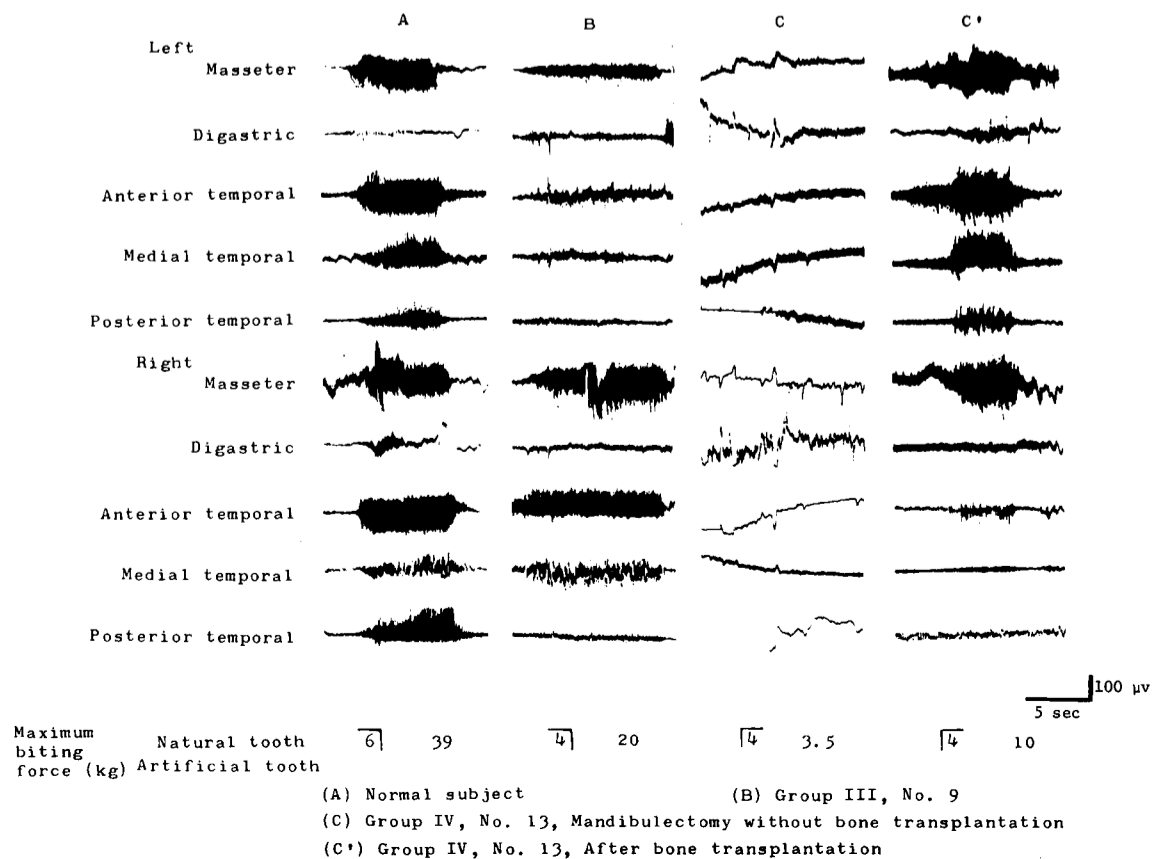


TABLE VIII. MASTICATORY EFFICIENCY OF NORMAL AND RECONSTRUCTED SUBJECT

	Normal subject	Before Operation	Patients with mandibulectomy					
			Group 1		Group 2			
			No.2	No.3	No.4	No.5	No.6	No.7
Masticatory efficiency %	68	42	21	26.6	42.2	21.6	34.9	10.0
Numbers of the natural teeth of the mandible	14	14	2	6	11	2	4	12

Patients with mandibulectomy

Group 3					Group 4			
No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16
47.4	10.0	41.5	18.2	0	-	-	-	-
13	11	11	7	12	12	5	5	2

- = no activity of peanuts eating

0 = no examination