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Original

Masticatory efficiency before and after surgery in oral cancer patients: comparative study of glossectomy, marginal mandibulectomy and segmental mandibulectomy

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Abstract: This study evaluated the effect of oral cancer surgery on masticatory efficiency. Masticatory efficiency was measured using the ATP absorption method. Eating ability was measured using a questionnaire. Two groups were employed as controls: The "normal occlusion group" consisted of subjects who had a complete set of natural maxillary teeth opposed to mandibular teeth, and the "unilateral occlusion group" consisted of subjects who had lost their molar and premolar teeth on one side of the mandible as a result of caries or periodontal diseases. Three treatment groups, each of 6 patients, were studied: a glossectomy group, a marginal mandibulectomy group and a segmental mandibulectomy group. There were no differences in masticatory efficiency between two control groups. Masticatory efficiencies of the three oral cancer treatment groups were lower than in the unilateral occlusion group, even 12 months after surgery. Masticatory efficiency of the glossectomy group was significantly higher 12 months after surgery compared with pre-surgery. Masticatory and eating abilities of the marginal mandibulectomy group and the segmental mandibulectomy were reduced at 3 and 6 months after surgery. The masticatory efficiency 12 months after surgery was higher in the marginal mandibulectomy group than the segmental mandibulectomy group, although the difference was not statistically significant. The self assessed eating ability 12 months after surgery was significantly higher in the marginal mandibulectomy group than the segmental mandibulectomy group. These results suggest that discontinuation of the mandible may lead patients to eat only foods that do not require a substantial amount of chewing. Hence, the quality of life of patients in the marginal mandibulectomy group was considered to be better than that in the segmental mandibulectomy group. (J. Oral Sci. 46, 113-117, 2004)

Key words: oral cancer; masticatory efficiency; glossectomy; mandibulectomy; dysphagia.

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Introduction

Recent improvements in preoperative treatment and reconstruction methods have led to improvements in the quality of life of patients with oral cancer. Marginal resection is commonly employed in mandibulectomy (1,2) and this increases the amount of mandibular bone that can

be retained. However, there is no consensus as to whether mandibulectomy is as effective as more extensive surgery. Indeed, the relation between pre- and post-operative dysfunction is unclear and data are normally presented as single case reports.

Dysphagia inevitably follows surgery and its severity varies with the area resected, although there have been few attempts to quantify this relation (3-5). Moreover, there is no published data on the time to recovery of masticatory efficiency post-surgery. This aim of this study was to address these issues. Masticatory efficiency was measured by the ATP absorption method and eating ability was measured using a questionnaire method developed by Shinohara (6).

Materials and Methods

Informed consent was obtained from the participants after explaining the procedure in detail. The protocol was approved by the Ethical Committee of Nihon University School of Dentistry.

Normal occlusion group

This control group consisted of 10 male and 10 female subjects, with a complete set of natural maxillary teeth opposed to mandibular teeth and with average ages of 20.4 (range 18-28) years and 21.3 (range 18-35) years, respectively.

Unilateral occlusion group

This group consisted of 3 male and 5 female subjects with average age of 49.4 (range 31-60) years. Subjects had no evidence of malignancy in mandibular lesion, but had lost their molar and premolar teeth on one side of the mandible as a result of caries or periodontal diseases.

Oral cancer group

This group comprised 10 male and 8 female patients, average age 53.2 years, undergoing surgery in the

Table 1 Patient population (n = 18)

Patient	Sex	Age	Primary	Number of teeth	Number of teeth after surgery
A1	F	60	Tongue	12	No change
A2	F	66	Tongue	Complete denture	no change
A3	F	72	Tongue	Complete denture	no change
A4	F	19	Tongue	14	no change
A5	F	57	Tongue	14	no change
A6	M	43	Tongue	11	no change
Mean		52.8		8.5	8.5
B1	F	53	Tongue	14	11
B2	M	25	Tongue	14	9
B3	M	58	Oral floor	12	3
B4	M	65	Tongue	13	8
B5	M	58	Tongue	14	7
B6	F	37	Gingiva	14	11
Mean		49.3		13.5	8.2
C1	M	67	Gingiva	14	11
C2	M	53	Gingiva	14	8
C3	M	53	Gingiva	12	9
C4	F	70	Gingiva	6	5
C5	M	45	Gingiva	14	4
C6	M	55	Gingiva	12	9
Mean		57.5		12.0	7.7
Mean		53.5			

A: glossectomy group, B: marginal mandibulectomy group, C: segmental mandibulectomy group

Table 2 Surgical history of glossectomy group patients

Patient	TNM classification	Soft-tissue defect	Mandibular loss	Neck dissection	Post-operative radiotherapy
A1	T2N0M0		No	No	No
A2	T1N0M0		No	No	No
A3	T1N0M0		No	No	No
A4	T2N0M0		No	No	No
A5	T1N0M0		No	No	No
A6	T1N0M0		No	No	No

Table 3 Surgical history of marginal mandibulectomy group patients

Patient	TNM classification	Soft-tissue defect	Mandibular loss	Neck dissection	Post-operative radiotherapy
B1	T2N0M0	 R		m-RND	No
B2	T3N1M0	 R		m-RND	No
B3	T2N2bM0	 R		RND + SND	No
B4	T2N2bM0	 R		RND	No
B5	T2N2cM0	 R		RND + SND	50Gy
B6	T2N0M0			SND	No

RND: radical neck dissection, m-RND: modified radical neck dissection,
SND: selective neck dissection
R: reconstruction of forearm free frap

Table 4 Surgical history of segmental mandibulectomy group patients

Patient	TNM classification	Soft-tissue defect	Mandibular loss	Neck dissection	Post-operative radiotherapy
C1	T3N1M0			RND	50Gy
C2	T2N2bM0			RND + SND	50Gy
C3	T2N0M0			RND + SND	No
C4	T4N1M0			RND + SND	No
C5	T4N1M0			RND + SND	No
C6	T2N0M0	 R		m-RND	No

RND: radical neck dissection, m-RND: modified radical neck dissection,
SND: selective neck dissection
R: reconstruction of forearm free frap

Department of Oral and Maxillofacial Surgery, Nihon University Dental Hospital. All patients had squamouse cell carcinoma of the lower region of the oral cavity. Ten had tongue cancer, 7 mandibular gingival cancer, and 1 oral floor cancer. The 18 patients were divided into 3 equally sized treatment groups (6 patients in each group): a glossectomy group (group A), a marginal mandibulectomy group (group B) and a segmental mandibulectomy group (group C) (Table 1). Group B and C had molar teeth on one side. Table 2, 3 and 4 show the surgical and treatment history (i.e. TNM classification, soft-tissue defect, mandibular bone loss, neck dissection and post-operative radiotherapy) of the group A, B, and C. Post-operative chemotherapy was not performed in all patients. The parts of soft tissue defect were indicated in black. The segmental mandibulectomy group consisted of patients who received temporary reconstruction using a metal plate

Investigation of decrease in the number of mandible teeth

The number of teeth in the oral cancer and one-side masticatory group were recorded, as was the post-operative loss of teeth in the marginal mandibulectomy and segmental mandibulectomy groups.

Measurement of masticatory efficiency

Masticatory efficiency was measured by the absorption method using ATP-granules (Adetphos R, 710(1000 μm diameter, Kyowa Inc., Japan), as described by Shinohara (6). Briefly, participants gargled with distilled water, then masticated ATP-granules 50 times and spat the masticated granules into a beaker. They then rinsed their mouths with distilled water to collect all the remaining granules. The ATP-granules were then mixed with 2 litres of distilled water and the ATP absorbance was measured using a spectrophotometer (U-1500, Hitachi, Japan) at 259 nm. The value of masticatory efficiency was taken after 2 practices to allow patients to become familiar with this method.

Evaluation of eating ability

Eating ability was evaluated using a questionnaire method devised by Shinohara (6). The maximum grade, Grade 6, was reached when the patients could eat more than half of the foods in this grade (Table 5). The minimum ability, when the patients could only consume liquids, was Grade 1. Masticatory and eating abilities were measured before surgery, and 3, 6 and 12 months after surgery, and compared with those measures obtained from the normal occlusion group and the one-sided masticatory group.

Data analysis

Values for the masticatory efficiency were expressed as means ± S.E.M., and values for the eating ability were expressed as medians. Before and after surgery comparisons within groups were made using one-way analysis of variance for repeated measures or a Friedman's test, followed by a post-hoc Dunnet's test (masticatory efficiency) or Steel's test (eating ability), respectively. Comparisons between 2 groups at each time point were made using the Student's *t*-test (masticatory efficiency) or Mann-Whitney *U*-test (eating ability). Statistical significance was considered when $P < 0.05$.

Results

Decrease in the number of teeth

The one-sided masticatory group had a mean of 11.5 teeth. The number of teeth in the marginal mandibulectomy group decreased from a mean of 13.5 teeth before surgery to 8.2 teeth after surgery compared with 12.0 and 7.7, respectively, in the segmental mandibulectomy group (Table 6). There were no changes in the number of teeth in the glossectomy group (Table 6).

Masticatory efficiency

There were no differences in the masticatory efficiencies of the normal occlusion and one-sided masticatory groups and these two groups exhibited greater masticatory efficiency than the glossectomy, marginal mandibulectomy and segmental mandibulectomy groups at all time points (Table 6).

Table 5 Eating ability evaluation questionnaire

Grade	Foods
6	Hard pickled Japanese radish, hard rice crackers, sliced raw abalone, peanuts
5	Sliced raw squid, raw cockle, pickled octopus, pickled shallot, half dried scallop, half dried squid, French bread, beefsteak, pickled sea cucumber
4	Ham, devil's tongue jelly, steamed fish paste, biscuits, steamed glutinous rice
3	Boiled rice, raw tuna, broiled eel, fish cake, fish cooked in broth
2	Rice gruel, bean curd, custard pudding
1	Water, coffee, soup

Table 6 Masticatory efficiency and number of teeth

Group		Masticatory efficiency (absorbance unit, mean ± S.E.M.)	Number of teeth (mean)
Normal occlusion		1.40 ± 0.09	14.0
Unilateral occlusion		1.32 ± 0.11	11.5
A: glossectomy	Pre-operation	0.58 ± 0.13	
	Post 3M	0.84 ± 0.25	pre → post
	6M	0.88 ± 0.26	8.5 → 8.5
	12M	1.04 ± 0.29	
B: marginal mandibulectomy	Pre-operation	1.21 ± 0.22	
	Post 3M	0.28 ± 0.08	pre → post
	6M	0.32 ± 0.06	13.5 → 8.2
	12M	0.85 ± 0.21	
C: segmental mandibulectomy	Pre-operation	1.19 ± 0.27	
	Post 3M	0.46 ± 0.11	pre → post
	6M	0.40 ± 0.20	12.0 → 7.7
	12M	0.56 ± 0.10	

Masticatory efficiency over time in each group is shown in Fig. 1. When comparing the post-surgery masticatory efficiency of each group with the pre-surgery measure, a significant increase of masticatory efficiency was observed in the glossectomy group 12 months after surgery. A significant decrease in masticatory efficiency was seen in the marginal and the segmental mandibulectomy groups at 3 and 6 months post-surgery (Fig. 1). There was a tendency for faster recovery in the marginal mandibulectomy group than the segmental mandibulectomy group 12 months after surgery, but the difference was not statistically significant (Fig. 1).

Eating ability

Post-operative eating abilities of patients in the glossectomy group gradually increased and reached a grade of 5.8 after 12 months (Fig. 2). Eating abilities of patients in the marginal and segmental mandibulectomy groups 3, 6 and 12 months after surgery were significantly lower when compared to pre-surgery. Twelve months post-surgery, the eating ability of the segmental mandibulectomy group was significantly less than that of the marginal mandibulectomy group (Fig. 2).

Discussion

Dysphagia is an unavoidable consequence of oral surgery for the treatment of cancer, and is associated with impaired function during the oral preparatory phase, the oral phase and the pharyngeal phase of swallowing (7). Classification and evaluation of such dysfunctions are difficult and depend on tumour size and type, the nature of resection and method of reconstruction, and the pre- and post-surgery treatment. For this reason, data are often presented as single case studies.

In the current study, the effects of resection type and loss of teeth on dysphagia were measured in three groups of patients: a glossectomy group that did not lose teeth after surgery, and two groups that did lose teeth, a marginal mandibulectomy group and a segmental mandibulectomy group. The patients' masticatory efficiencies were measured using ATP-granules and their eating abilities quantified using the questionnaire devised by Shinohara (6).

The control group consisted of individuals who had all natural teeth and a normal occlusion while the unilateral occlusion group consisted of individuals with a complete set of natural maxillary teeth but who had lost mandibular molars and/or premolars on one side. The mean masticatory efficiency of the unilateral occlusion group was 1.32 absorbance units and was not significantly different from that of the normal occlusion group (1.40 absorbance units). This was expected since the small ATP-granules would be masticated mainly by the molars and, therefore, mastication would not be affected in the patients having normal molar occlusion on one side. Dyskinesias defune of the tongue might be expected to decrease masticatory efficiency since the masticatory efficiency pre-surgery was lowest in glossectomy group despite there being a similar mean count in all groups.

Masticatory efficiency in the three oral cancer groups was lower than in the normal occlusion and the unilateral occlusion groups after surgery. This was also seen prior to surgery, despite similar tooth counts in the marginal and segmental mandibulectomy groups and the one-sided masticatory group. These results suggest that pain as a result of the cancer may have reduced mastication in the cancer treatment groups. In addition, masticatory efficiency of the glossectomy group was significantly improved 12 months after surgery compared to the pre-surgery level, and this

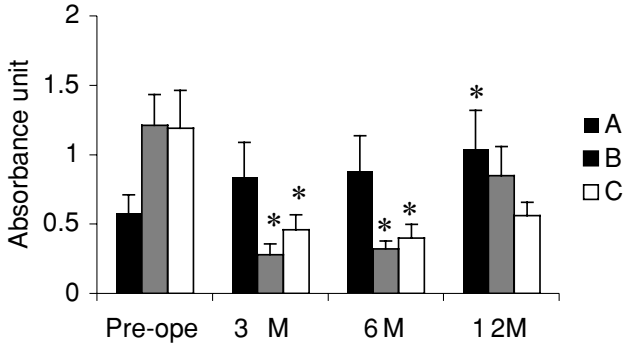

Fig. 1 Masticatory efficiencies in (A) glossectomy, (B) marginal mandibulectomy and (C) segmental mandibulectomy groups over time. Values are expressed as means ± S.E.M.
*: $P < 0.05$ vs. respective pre-operation (Pre-ope) control

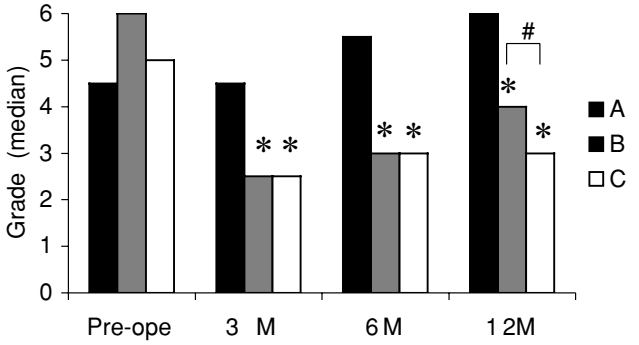

Fig. 2 Eating abilities in (A) glossectomy, (B) marginal mandibulectomy and (C) segmental mandibulectomy groups over time. Values are expressed as medians.
*: $P < 0.05$ vs. respective pre-operation (Pre-ope) control
#: marginal vs. segmental

may be due to less pain from the tongue carcinoma. The fact that it took some 12 months for improvement to be seen in mastication may be the result of gradual healing after surgical intervention. In the current study, there was a gradual improvement in masticatory efficiency and self assessed eating ability in the glossectomy group after surgery without any change in number of teeth.

Masticatory efficiency of the marginal mandibulectomy group before surgery was significantly less than that of the normal occlusion and unilateral occlusion groups, and efficiency was reduced further at both 3 and 6 months after surgery. Similar findings were obtained in the segmental mandibulectomy group. The reduction in masticatory efficiency 3 and 6 months after surgery in the two groups were attributed to tooth loss and mandibulectomy. A similar reduction was also found in eating ability, as assessed subjectively by the patient. Although there were no statistically significant differences in masticatory efficiency between the marginal and the segmental mandibulectomy group 12-months after surgery, the marginal mandibulectomy group tended to show higher masticatory efficiency than the segmental mandibulectomy group, and this may be in part due to the large soft-tissue defect in the marginal mandibulectomy group compared with the segmental mandibulectomy group (see Table 3 and 4). Moreover, self-assessed eating ability 12 months after surgery was significantly higher in the marginal mandibulectomy group than in the segmental mandibulectomy group. These results suggest that discontinuation of the mandible may lead patients to eat only foods that do not require a substantial amount of chewing. In conclusion, results of the present study suggest that the quality of life of patients undergoing marginal mandibulectomy is better than those undergoing segmental mandibulectomy.

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