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Effect of size difference between hemiglossectomy and reconstruction flap on oral functions: A retrospective cohort study

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Summary *Background and objective:* Forearm free flaps are used after hemiglossectomy. However, no investigation has been performed on whether oral functions are better preserved when sizes of the resection and reconstruction flap are exact matches, or whether the size of the resection should be changed. We aimed to retrospectively examine whether size differences between the resection and reconstruction flap affect speech and swallowing functions postoperatively, and to determine whether there are more favorable flap size ratios.
Methods: This is a retrospective cohort study of patients undergoing hemiglossectomy using a forearm free flap between 2006 and 2016 at Kobe University Hospital, Japan. The effect of size difference between the resection and reconstruction flap on maintained oral function was assessed. Speech and swallowing functions were assessed, and their correlation with the ratio of the flap size to that of the resected area was determined. With these data, distribution maps of the relationship between the functional level and reconstructed dimension ratio were prepared. The more suitable reconstructed dimension ratio was examined and evaluated. The Fisher exact test, Kruskal–Wallis test, and Scheffe test were used in statistical analyses.
Results: Eighty-eight patients underwent hemiglossectomy using a forearm free flap during a 10-year period. Of these cases, 66 patients were included in this study, while 22 were excluded. The ratio of the area of the reconstruction flap to that of the resection site was 0.59–2.79 (median: 1.61). Sixty patients had flaps greater than the resection area, whereas 6 had smaller

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flaps. Significant differences were found in speech intelligibility and swallowing function when the reconstructed dimension ratio was categorized as follows: ≤1.3, 1.3–1.8, and ≥1.8.
Conclusion: Our findings suggest that postoperative deterioration of oral functions after hemiglossectomy could be reduced if reconstruction is performed using a forearm free flap with a surface area 1.3 to 1.8 times greater than that of the resection area.

Introduction

After resection of half of the tongue as treatment for tongue malignancies, reconstruction must not interfere with the functions of the remaining tongue. Radial forearm free flaps are thin and flexible; therefore, they are some of the most widely utilized flaps for tongue reconstructions. Similarly, in our hospital, radial forearm free flaps are used as the first choice for reconstruction after hemiglossectomies.[1] The flap size is determined during a preoperative conference using computed tomography, magnetic resonance imaging, a photograph of the tumor, and confirmation of its size is performed intraoperatively. In addition, resection and flap elevation are often performed simultaneously, but the cross-sectional surface at the resection site cannot actually be measured. The flap size is determined based on the predicted size, and the general extent of resection is measured under general anesthesia before tumor resection. As a result, the size of the reconstruction flap does not correspond precisely to the size of the resection. Studies evaluating the relationship between the free flap templates and postoperative tongue function have been previously performed.[2,3] In these studies, the size of the defect size was measured with a surgical sponge, and the size of the reconstruction flap was designed to have almost nearly the same size. However, no investigation has been performed on whether oral functions are better preserved when the sizes of the resection and reconstruction flap are exact matches, or whether the size of the resection should be changed. Assuming the resection and flap sizes should be changed, what is the appropriate size for the reconstruction flap? The answer to this question is unclear since no previous report has determined a connection between the size of the flap and oral functions. One hypothesis is that the flap that is larger than the size of the resection may be appropriate. In other words, the forearm flap is so thin that it cannot secure the thickness of the resection in terms of the volume. Therefore, the volume may be compensated at larger sizes. We aimed to retrospectively examine whether the size differences between the resection and reconstruction flap have an impact on speech and swallowing functions postoperatively. We also aimed to determine whether there are more favorable flap size ratios.

Methods

Study design

This was a retrospective cohort study.

Setting

This study was conducted at Kobe University Hospital, Japan. The study protocol was approved by the Kobe University Graduate School of Medicine Ethics Committee (permission number 160112), and generic written informed consent was obtained from all participants.

Patients

Inclusion criteria

All the patients were diagnosed as having tongue malignancies and underwent hemiglossectomy, followed immediately by reconstructive surgery using a forearm free flap, during a 10-year period from March 2006 to March 2016. All the primary tumors were located in the tongue. Postoperative swallowing and speech function were evaluated, and the patients were divided into three cohorts: Excellent, Moderate, and Poor. The cases were investigated consecutively, and their medical records were reviewed. Although three surgeons were involved in elevating the radial forearm flap, only one surgeon determined the flap size and sutured it during this period. Strengthening The Reporting of OBservational studies in Epidemiology (STROBE) guidelines were used in the preparation of this study.

Exclusion criteria

Patients requiring tongue base resection, higher brain dysfunction, flap necrosis, bone invasion and history of mandibulectomy, and deceased patients were excluded from this study.

Measurement of the sizes of the resection area and flap

The remaining tongue was positioned in the rest position inside the mouth, and the resection surfaces were measured as an approximate ellipse based on long and short diameters. The remaining tongue was not pulled during the measurement. Since elevation of the forearm free flap was performed using an elliptical shape, the surface area was calculated in the same manner, namely based on the long and short diameters. Additionally, the ratio of the area of the flap to that of the resected area (flap/resected area) was calculated.

Assessment of oral functions

Functional assessments were conducted 1 year postoperatively. The relationship between factors likely to affect oral functions (i.e., age, sex, tumor site, tumor staging, resection size, flap size, radiation therapy, and neck dissection) and oral functions were examined postoperatively.

Table 1 Hirose's scoring system for speech ability.

Factor	A, by family members	B, by individuals unrelated to the patient
(1) Clearly understood	5 points	5 points
(2) Occasionally misunderstood	4 points	4 points
(3) Understood only when subject is known	3 points	3 points
(4) Occasionally understood	2 points	2 points
(5) Never understood	1 point	1 point
Scoring of A and B for speech intelligibility		
8 to 10 points	Excellently intelligible speech	
5 to 7 points	Moderately intelligible speech	
4 points or fewer	Poorly intelligible speech	

Table 2 Evaluation of postoperative swallowing function.

Factor		
(1) Food score	Normal diet	5 points
	Minced	4 points
	Puréed	3 points
	Fluid	2 points
	Tube feeding	1 point
(2) Time score for daily meal	Less than 20 min	3 points
	About 30 min	2 points
	More than 40 min	1 point
(3) Choking on food upon swallowing	Never	3 points
	Sometimes	2 points
	Always	1 point
Scoring for factors 1, 2, and 3		
9 to 11 points	Excellent	
6 to 8 points	Moderate	
5 points or fewer	Poor	

Further, the association between the ratio of the area of the flap to that of the resected area (flap/resected area) and postoperative oral functions were examined. Speech intelligibility was evaluated using Hirose's 10-point scoring system (range, 2–10 points).[4,5] A double evaluation was performed by family members and by individuals unrelated to the patient. Speech intelligibility was classified as follows: excellent (8 to 10 points), moderate (5 to 7 points), and poor intelligible speech (4 to 2 points) (Table 1).

Swallowing function was examined using the a simplye modified swallowing ability scale[6] based on dysphagia score and MTF score; a simple and practical assessment tool consisting of method of intake, time of intake, and food. The dietary patterns, amount of time it takes to eat a meal, and choking on food during meals were numerically scored (11 to 3 points) and categorized as excellent (9 to 11 points), moderate (6 to 8 points), or poor (3 to 5 points) (Table 2). In the poor functional group, the oral phase of the meal swallowing process could not be performed adequately, and post-deglutitive aspiration was suspected.

Statistical analysis

The Fisher exact test was used to compare the percentage of patients who had been affected by each parameter of speech and swallowing in relation to clinical features. The Kruskal–Wallis test and then the Scheffe test were used to compare the quantitative variables of age, dimensions of resection, radial forearm flap dimensions, and the reconstructed dimension ratio.

A p-value <0.05 was considered statistically significant, and all calculations were performed using Microsoft Excel (Microsoft Inc., Redmond, WA, USA) and SPSS, version 13.0 (SPSS Inc., Chicago, IL, USA).

Results

Of 88 cases, 66 patients (44 men and 22 women) were included in our study, while 22 were excluded for the following reasons: higher brain dysfunction, $n=1$; flap necrosis, $n=2$; bone invasion and history of mandibulectomy, $n=3$; deceased, $n=6$; and required tongue base resection, $n=10$. Patients' mean age was 61.4 years (standard deviation (SD) 14.6, range: 15–83 years). All cases were primary operative cases, and preoperative radiotherapy was not provided. Further, partial glossectomy cases were not included. Sixty-four (97%) of 66 cases had squamous cell carcinoma. The mean value of the ratio of the area of the flap to that of the resected area (flap/resected area) was 1.66 (SD 0.5, range: 0.59–2.79). Patients with a flap size smaller than the

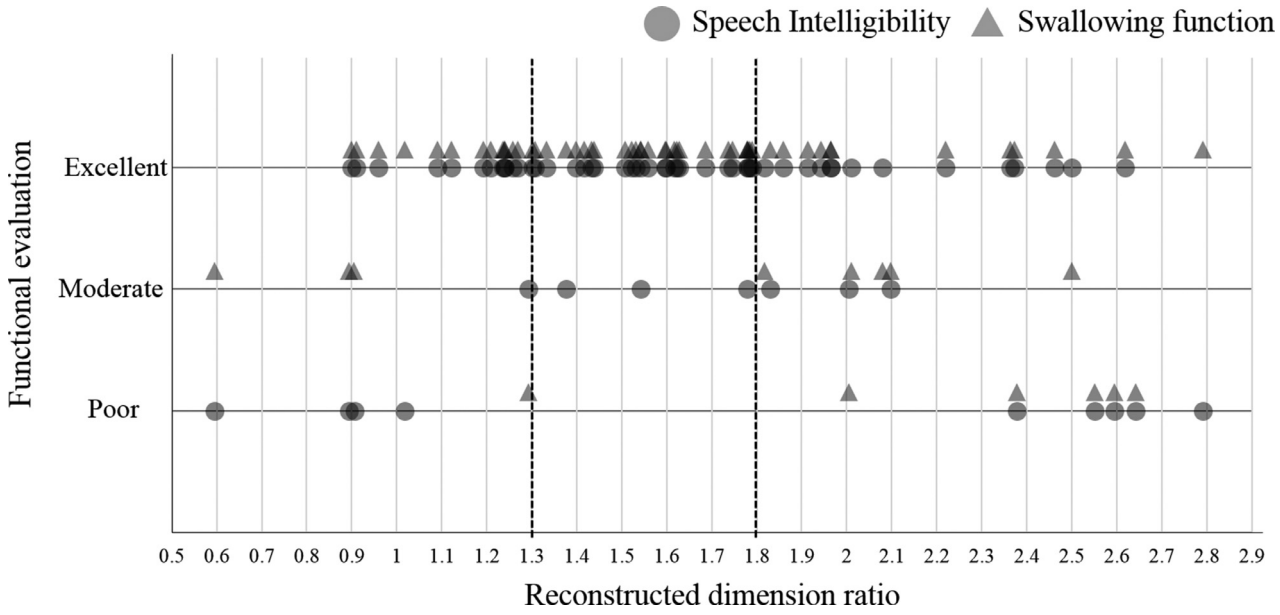

Figure 1 Distribution map of the reconstructed dimension ratio and oral functional evaluation (speech intelligibility and swallowing function). ●: Speech intelligibility, ▲: swallowing function.

size of the resection area accounted for six cases, and those with a flap size greater than the size of the resection area accounted for 60 cases.

Figure 1 shows the distribution map of the relationship between oral functions and the reconstructed flap dimension ratio. We found that a ratio between 1.3 and 1.8 (more excellent cases, and fewer median and poor cases, respectively) was appropriate for the reconstructed flap dimension ratio, and we considered the ratios of 1.3 and 1.8 as cutoff values.

Assessment of speech function

No significant difference was found between the excellent, moderate, and poor groups in terms of sex, body mass index classification, site of the primary tumor, whether postoperative radiation therapy was performed, whether neck dissection was unilateral or bilateral, pathological tumor size postoperatively, lymph node metastasis, and staging classification (Table 3). The ratio of the surface area reconstructed using a forearm free flap was examined. There was a significant difference between the reconstruction dimension ratios $\leq$1.3, 1.3–1.8, and $\geq$1.8 ($p = 0.014$). However, there were no significant differences between the three aforementioned categories for age, resected dimensions, radial forearm flap dimensions, or the total reconstructed dimension ratio (Figure 2). Figure 3 shows the distribution map of radiotherapy and/or bilateral neck dissection in relation to speech intelligibility.

Assessment of swallowing function

A significant decrease in swallowing function was found in the group that received radiation therapy postoperatively ($p = 0.0354$) and in the group that underwent bilateral neck dissection ($p = 0.0225$) (Table 3). There was also a significant difference in swallowing function between the reconstruction dimension ratios $\leq$1.3, 1.3–1.8, and $\geq$1.8 ($p = 0.0004$). In addition, we found a significant difference between these three aforementioned categories and the radial forearm flap dimensions ($p = 0.0319$) and total reconstructed dimension ratio ($p = 0.0300$) (Figure 4). Figure 3b shows the distribution map of radiotherapy and/or bilateral neck dissection in relation to swallowing function.

Discussion

Among the patients evaluated herein, 75.8% achieved excellent speech functionality and 78.8% achieved excellent swallowing functionality, accounting for most the majority of the cases. This finding suggests that if reconstruction is performed properly, patients are likely to live lead their daily lives in conditions similar to their preoperative conditions.

After resection of head and neck malignancies, reconstruction must compensate for deficiencies and should be performed with the consideration of function postoperatively. It is important that reconstruction be conducted using the appropriate tissue and the proper size. In our facility, hemiglossectomy for tongue cancer is carried out using elliptically shaped forearm free flaps. In tongue cancers, reconstruction is performed using soft tissues, such as forearm free flaps, anterolateral thigh flaps, pectoralis major flaps, rectus abdominis myocutaneous free flaps, and latissimus dorsi flaps. Particularly, in hemiglossectomies, thin, flexible flaps are often selected in order to avoid interfering with the function of the remaining tongue.[7,8] Improving the shape of the forearm free flap has also been reported to facilitate the preservation of lingual functions.[2,3]

Table 3 Effect of clinical features on speech and swallowing functions.

Parameter		Number of patients (%)	Speech intelligibility mean: 8.54 median: 10.0 range: 3.0-10.0			*p*-value	Swallowing function mean: 9.31 median: 10.0 range: 3.0-11.0			*p*-value
			Excellent	Moderate	Poor		Excellent	Moderate	Poor	
Age (years)										
Range: 15-83	≤59	24 (36.4)	20 (30.3)	1 (1.5)	3 (4.5)	0.518	20 (30.3)	2 (3.0)	2 (3.0)	0.897
Mean: 64.0	>60	42 (63.6)	30 (45.5)	6 (9.1)	6 (13.6)		32 (48.5)	6 (3.0)	4 (6.1)	
Sex	Male	44 (66.7)	31 (47.0)	5 (7.6)	8 (12.1)	0.305	34 (51.5)	6 (9.1)	4 (6.1)	0.899
	Female	22 (33.3)	19 (28.8)	2 (3.0)	1 (1.5)		18 (27.3)	2 (3.0)	2 (3.0)	
Body Mass Index	<18.5	14 (21.2)	9 (13.6)	3 (4.5)	2 (3.0)	0.618	10 (15.2)	2 (3.0)	2 (3.0)	0.834
	18.5-25	49 (74.2)	38 (57.6)	4 (6.1)	7 (10.6)		39 (59.1)	6 (9.1)	4 (6.1)	
	≥25	3 (4.5)	3 (4.5)	0 (0.0)	0 (0.0)		3 (4.5)	0 (0.0)	0 (0.0)	
Postoperative irradiation	Yes	27 (40.9)	18 (27.3)	4 (6.1)	5 (7.6)	0.367	17 (25.8)	6 (9.1)	4 (6.1)	0.035*
	No	39 (59.1)	32 (48.5)	3 (4.5)	4 (6.1)		35 (53.0)	2 (3.0)	2 (3.0)	
Neck dissection	Unilateral	57 (86.4)	45 (68.2)	5 (7.6)	7 (10.6)	0.187	48 (72.7)	5 (7.6)	4 (6.1)	0.023*
	Bilateral	9 (13.6)	5 (7.6)	2 (3.0)	2 (3.0)		4 (6.1)	3 (4.5)	2 (3.0)	
Pathological T classification	T1	10 (15.2)	7 (10.6)	2 (3.0)	1 (1.5)	0.798	8 (12.1)	0 (0.0)	2 (3.0)	0.902
	T2	50 (75.8)	38 (57.6)	5 (7.6)	7 (10.6)		40 (60.6)	7 (10.6)	3 (4.5)	
	T3	3 (4.5)	3 (4.5)	0 (0.0)	0 (0.0)		3 (4.5)	0 (0.0)	0 (0.0)	
	T4	3 (4.5)	2 (3.0)	0 (0.0)	1 (1.5)		1 (1.5)	1 (1.5)	1 (1.5)	
Pathological N classification	N0	27 (40.9)	23 (38.4)	3 (4.5)	1 (1.5)	0.159	25 (37.9)	1 (1.5)	1 (1.5)	0.131
	N1	12 (18.2)	10 (15.2)	0 (0.0)	2 (3.0)		8 (12.1)	3 (4.5)	1 (1.5)	
	N2	27 (40.9)	17 (25.8)	4 (6.1)	6 (9.1)		19 (28.8)	4 (12.1)	4 (6.1)	
Pathological TNM stage	I	5 (7.6)	4 (6.1)	1 (1.5)	0 (0.0)	0.365	4 (6.1)	0 (0.0)	1 (1.5)	0.076
	II	22 (33.3)	19 (28.8)	2 (3.0)	1 (1.5)		21 (31.8)	0 (0.0)	1 (1.5)	
	III	11 (16.7)	9 (13.6)	0 (0.0)	2 (3.0)		7 (10.6)	3 (4.5)	0 (0.0)	
	IV	28 (42.4)	18 (27.3)	4 (6.1)	6 (9.1)		20 (30.3)	5 (7.6)	4 (6.1)	
Reconstructed dimension ratio	≤1.3	17 (25.8)	12 (18.2)	0 (0.0)	4 (6.1)	0.014*	13 (19.7)	3 (4.5)	1 (1.5)	0.0004*
	1.3-1.8	25 (37.9)	24 (36.4)	4 (6.1)	0 (0.0)		27 (40.9)	0 (0.0)	0 (0.0)	
	≥1.8	24 (36.4)	14 (21.2)	3 (4.5)	5 (7.6)		12 (18.2)	5 (7.6)	5 (7.6)	
Total		**66 (100)**	**50 (75.8)**	**7 (10.6)**	**9 (13.6)**		**52 (78.8)**	**8 (12.1)**	**6 (9.1)**	

TNM: tumor-node-metastasis.
* $p < 0.05$.

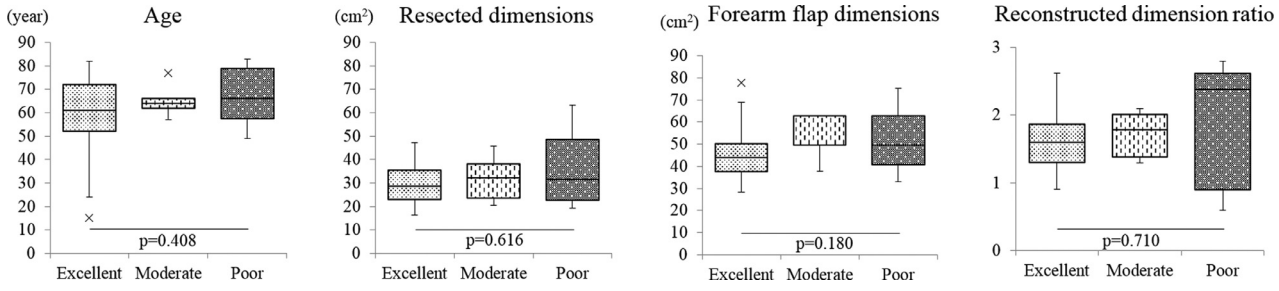

Figure 2 Box plots showing outcomes of speech intelligibility.

Various reports have investigated the factors that affect lingual functions after the resection of oral cancers.[5,7,9-11] Shin et al. previously reported that after partial glossectomy, reconstructive surgery using forearm free flaps followed by postoperative radiation therapy had a negative impact on swallowing and speech functions.[12] In another study, radiation therapy was reported to have no effect on speech function.[13] In the radiation therapy group in our study, patients with poor swallowing function were significantly greater in number, but no significant difference was found in terms of speech function.

The distribution map of radiotherapy and/or bilateral neck dissection is described in Figure 3. For speech function, there was no typical distribution with radiotherapy and/or bilateral neck dissection (Figure 3a). However, for swallowing function, patients who received radiotherapy and/or underwent bilateral neck dissection were more frequently in the moderate and poor groups. This result suggests the possibility that these treatments affect swallowing function (Figure 3b).

No previous report has thus far verified the issue of flap size with regard to function. Improvements in the shapes of flaps and in the sutures used have previously been reported to contribute to oral functions;[3,14] however, no study has investigated the issue of flap size. Reconstruction with a flap that is too small or too big can affect oral functions. Herein,

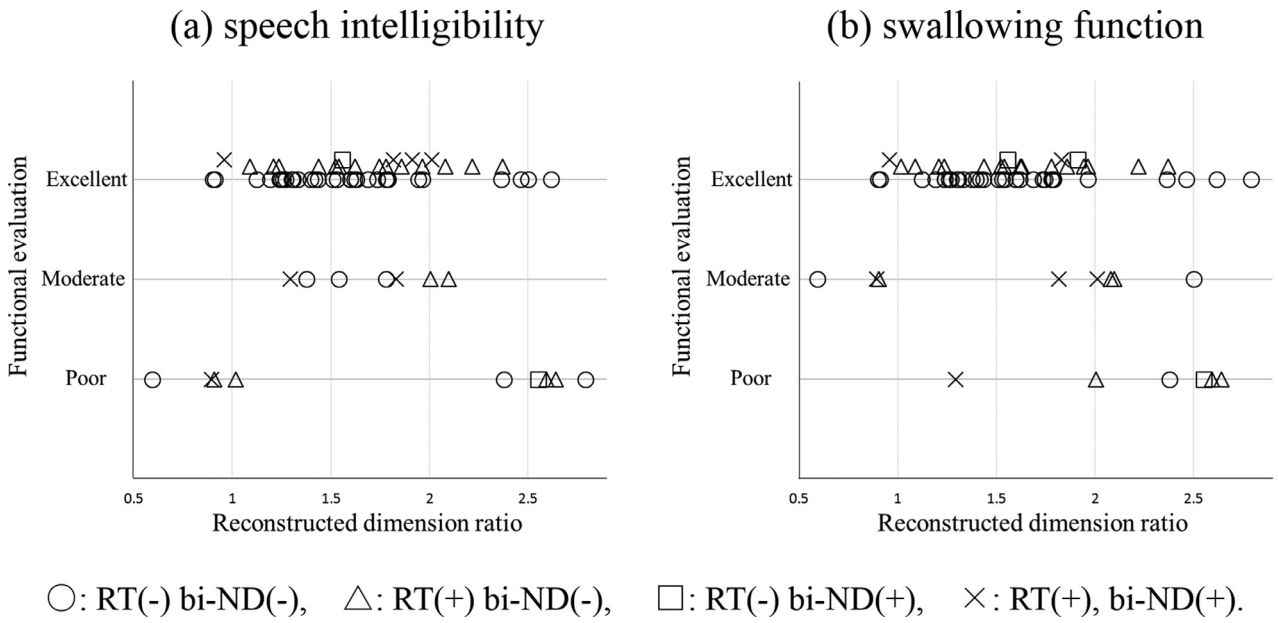

Figure 3 Distribution map related to bilateral neck dissection (bi-ND) and radiation therapy (RT). ○: RT (-), bi-ND (-); △: RT (+), bi-ND (-); □: RT (-), bi-ND (+); ×: RT (+), bi-ND (+).

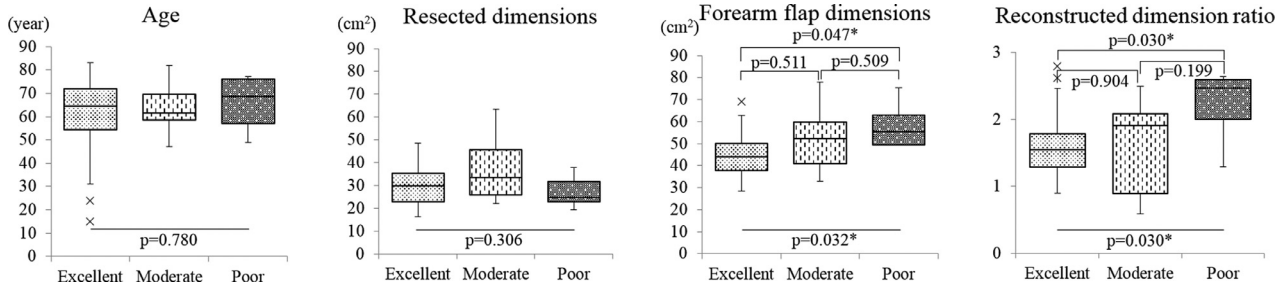

Figure 4 Box plots showing outcomes of swallowing function. The asterisk indicates statistically significant result ($^*p < 0.05$).

a higher number of patients had better oral functions when the reconstruction dimension ratio was between 1.3 and 1.8. For both speech and swallowing functions, there were significant differences in the reconstruction dimension ratios $\leq$1.3, 1.3–1.8, and $\geq$1.8. Therefore, it was suggested that setting the flap size to 1.3–1.8 times the resection dimension might preserve postoperative swallowing and speech functions.

In the scope of hemiglossectomy, no previously reported study on the size of reconstruction flaps has compared the latter with the resection plane and connected it to lingual functions. This may be because there is an unspoken agreement among reconstructive surgeons that, ultimately, using a flap size comparable to that of the loss might be the best option. However, unlike the resected tongue, the tongue reconstructed with a free flap is simply a mass of tissue without motion functionality (i.e., in a sense, a foreign body). Therefore, some functions may be impossible to replicate if a flap with the same size as the resected tongue is used for reconstruction. In this regard, making the flap size larger may compensate for various functions.

Thickness and volume of the free flaps are important when considering free flap reconstruction after oral tumor resection. The radial forearm flap is a thin, flexible flap, and the thickness of subcutaneous tissue depends on the individual.

The present study is limited by the small number of patients and the single center design. A larger study involving more patients who underwent reconstruction at different centers will be necessary to confirm our study findings and to identify other ways to ensure optimal oral functions after tongue reconstruction. Further investigation is needed before definite conclusions about these factors can be drawn.

Conclusion

Our study findings suggest that, for the sake of speech and swallowing functionality, use of forearm free flaps with a size 30% to 80% larger than the resection site might be a better option when performing reconstructions following hemiglossectomy.

Conflict of interest

There are no conflicts of interest to disclose.

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