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Swallowing and speech function after intraoral soft tissue reconstruction with lateral upper arm free flap and radial forearm free flap

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SUMMARY. **Swallowing, speech, and morbidity were assessed postoperatively in 25 patients, 18 of whom had had intraoral defects reconstructed by lateral upper arm free flaps (LUFF) and 7 by radial forearm free flaps (RFFF). Video fluoroscopy was used to assess swallowing, the Freiburger audiometric test to assess speech; and measurement of arm circumference to assess donor site morbidity. A questionnaire was used to evaluate swallowing, speech, and donor site morbidity subjectively.**

The degree of impairment in swallowing depended on the site of resection. Anterior and posterior resections affected swallowing more than lateral resections. Anterior resection and the use of LUFFs reduced intelligibility. There was no significant difference in impairment between LUFF and RFFF. We conclude that the LUFFs are superior to RFFFs because they can be closed primary and the incidence of donor site morbidity is slight.

Keywords: **Swallowing; Speech; Morbidity**

INTRODUCTION

The excision of oral cancers causes extensive impairment of the cavity's soft tissue. Complete excision of the tumors is vital, and the reconstruction of the resected area influences not only the postoperative recovery of patients' physiological function such as swallowing, but also affects their daily activities, psychosocial function, and vocational state. Oral and maxillofacial surgeons are faced with the task of reconstructing the affected area to reduce postoperative impairment as much as possible. Both lateral upper arm free flaps (LUFF) and radial forearm free flaps (RFFF) have been used for reconstruction because the thin, pliable character of both makes them suitable for use in the oral cavity.[1–5] However, while there are numerous studies which evaluated swallowing and speech after resection and reconstruction,[4,6–9,10–15] there are few that have assessed quality of life.[2] We compared reconstructions by LUFF and RFFF in terms of the quality of life.

PATIENTS AND METHODS

From April 1997 to December 2000 at the University of Freiburg's Department of Oral and Maxillofacial Surgery, 54 patients were operated on to reconstruct the soft tissues of the oral cavity after resections of squamous cell carcinomas, with or without mandibular resection. The reconstructions were by either LUFFs or RFFFs. LUFF was used when the resection area was large, and RFFF was used when the resection area was small. The reconstructions were primary except for three cases, which were reconstructed secondary because of necrosis of the free flap. Swallowing was allowed on postoperative day 3.

We present the results in 18 of the 54 patients who had reconstruction by LUFF and 7 patients who had RFFF. The mean age of the patients was 56.8 years (range from 41 to 75). Tables 1 and 2 list the location and TNM classification of the cancers.

The patients were divided into three groups based on the classification described by Jacobson *et al.*[16] (Fig. 1). Group I ($n = 12$) had resection of the lateral floor of mouth and lateral glossectomy. Group II ($n = 8$) had resection of the anterior floor of mouth; while those in group III ($n = 9$) had resection of oropharynx, including the soft palate and tonsillar region. Video fluoroscopic examination was done in all patients, however, Freiburger speech test and questionnaire test could not be done in 5 and 9 patients, respectively. Normal values were derived from 10 healthy men and women aged 25–35 years.

Table 1 Location and type of tumor in 18 male patients who had reconstruction with lateral upper arm free flaps

Case number	Age (years)	Location of tumor	Stage of squamous cell carcinoma	Neck dissection	Radiation therapy	Flap survival
1	61	Left floor of mouth	T1N0	R:SO L:F	Postoperative 60 Gy	Good
2	56	Anterior floor of mouth and tongue	T1N0	R:SO L:SO	Postoperative 60 Gy	Partial necrosis
3	63	Right floor of mouth, tongue and soft palate	T3N0	R:R L:SO		Good
4	56	Left floor of mouth, tongue base and pharyngeal wall	T2N0	R:SO L:R		Good
5	65	Left floor of mouth, tongue base and pharyngeal wall	T4N1	R:SO L:R		Good
6	68	Right floor of mouth and tongue	T2N2	R:R L:SO		Good
7	41	Anterior floor of mouth (secondary)	T2N1	R:SO L:R	Postoperative	Good
8	64	Anterior floor of mouth	T4N0	R:R L:SO		Good
9	67	Anterior floor of mouth and tongue	T2N0			Good
10	50	Right floor of mouth	T4N1	R:R L:SO	Postoperative	Good
11	58	Right floor of mouth, tongue base and soft palate	T3N1	R:R L:SO		Good
12	72	Right floor of mouth and tongue	T2N0	R:R L:SO		Good
13	45	Anterior floor of mouth (secondary)	T4N0			Partial necrosis
14	71	Left floor of mouth and tongue	T2N0	R:SO L:R		Good
15	59	Anterior floor of mouth and tongue	T3N2	R:R L:SO		Partial necrosis
16	46	Anterior floor of mouth	T2N0	R:R L:SO		Partial necrosis
17	63	Right floor of mouth, tongue base and soft palate	T2N0	R:R L:SO		Good
18	73	Anterior floor of mouth and tongue	T3N2	R:R L:SO		Good

Type of neck dissection: SO: supraomohyoid; F: functional; and R: radical.

Table 2 Location and type of tumor in patients reconstructed with radial forearm free flaps

Case number	Age/sex	Location of tumor	Stage of squamous cell carcinoma	Neck dissection
1	55/M	Left floor of mouth	T4N1	L:SO
2	75/F	Right floor of mouth and tongue	T2N1	R:R L:R
3	42/M	Left floor of mouth and tongue	T2N0	R:SO L:R
4	43/M	Left floor of mouth and tongue	T1N0	L:SO
5	42/M	Left tongue	T2N2	R:SO L:F
6	67/M	Right floor of mouth and tongue	T2N2	R:R L:SO
7	50/F	Right floor of mouth and tongue	T1N1	R:R L:SO

Type of neck dissection: SO: supraomohyoid; F: functional; and R: radical.
Case 7 also had preoperative radiotherapy. In all cases the prognosis of the flap was good.

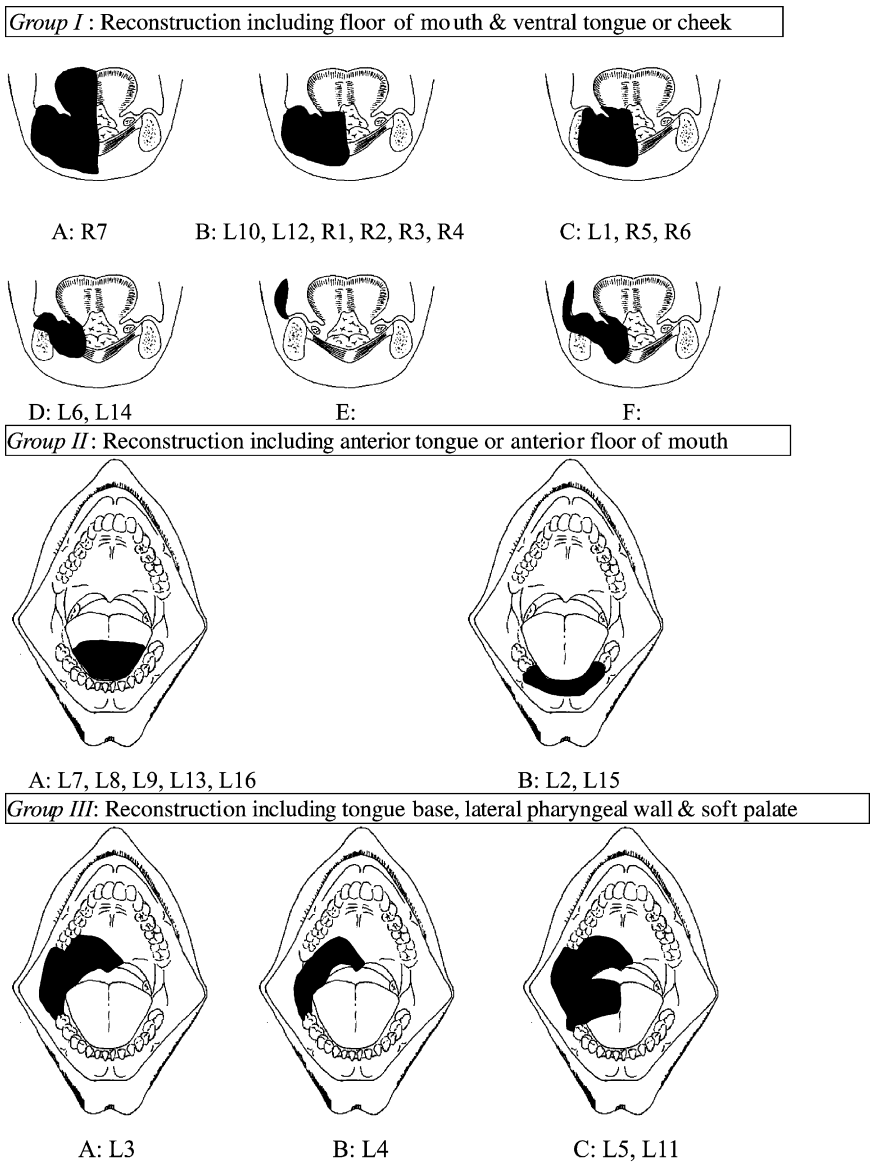

Fig. 1 Classification of the area of reconstruction in patients with LUFF and RFFF, according to Jacobson *et al.*[16] L: lateral upper arm free flap, R: radial forearm free flap.

Video fluoroscopic examination

Video fluoroscopic images were recorded with a Digital Spot Imaging (DSI) system (DSI release 4.2 PHILIPS, Germany). Each patient, after being seated and positioned for a lateral view, swallowed 5 ml of liquid barium. The swallowing sequence was recorded on videotape in real time at a rate of 35–50 frames/second. The high rate was necessary because the swallowing sequence lasts from 4 to 6 seconds. The maximum fluoroscopic exposure was 4 minutes 30 seconds; the mean exposure time was 3 minutes. The videotape from each patient was analyzed in slow motion and frame to frame by a team of two oral and maxillofacial surgeons and a head and neck radiologist.

All video fluoroscopic images were obtained according to the guidelines and with the permission of the Local Ethics Committee, Freiburg University.

To evaluate the mobility of the tongue, the tongue movements necessary to swallow a bolus were divided into three stages: movement of a bolus from the front of the tongue to the middle of the tongue; movement of the bolus from the middle of the tongue to the back of the tongue; and movement from the back of the tongue to the entrance of the pharynx. To measure the distances, the different parts of the tongue moved at each stage, a

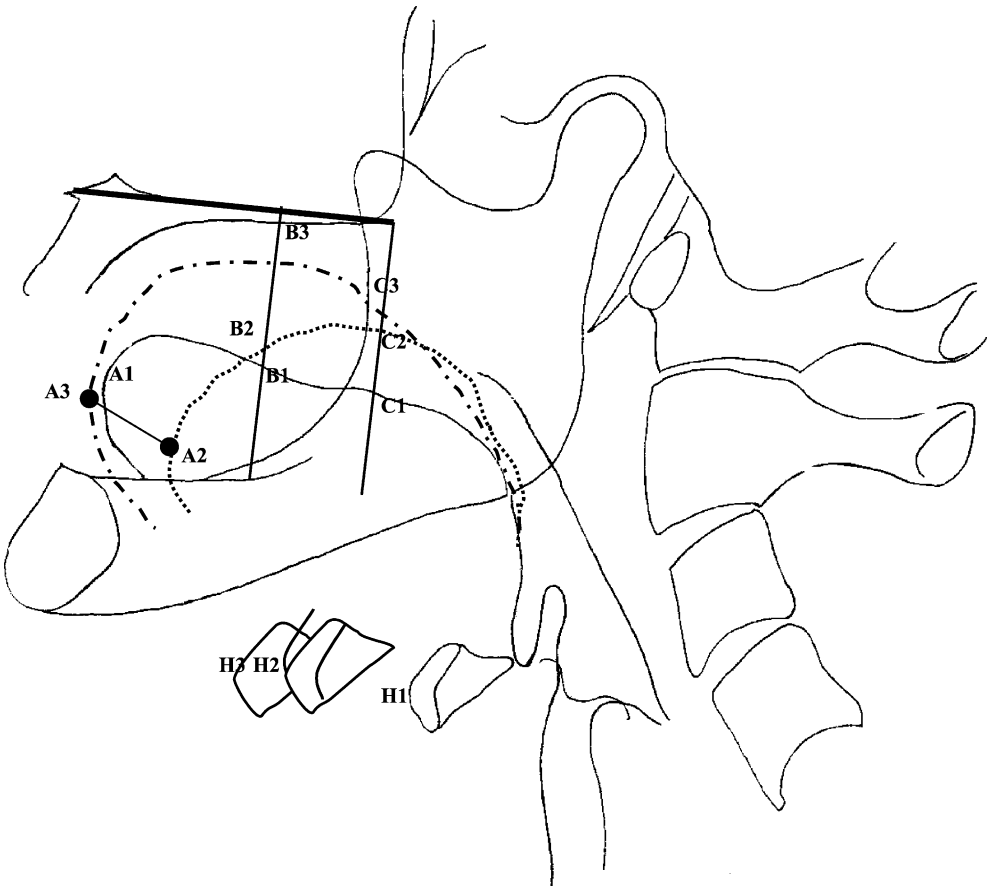

Fig. 2 Diagram of measurement of tongue movement. A: The most anterior position of the tongue. B: The mid position of the tongue: the point which intersects the tongue shape and a perpendicular line drawn from a point two-thirds the distance between ANS and PNS. C: The most posterior position of the tongue: the point, which intersects the tongue shape and a perpendicular line drawn from the PNS. H: The most anterior position of the hyoid bone. (1) The line when a bolus is moving from the front of the tongue to middle of the tongue. (2) The line when a bolus is moving from the middle of the tongue to the back of the tongue. (3) The line when a bolus is moving from the back of the tongue to the entrance of the pharynx.

set of two-dimensional coordinates was imposed on four different areas of the tongue. The reference axis was a stationary line drawn from anterior nasal spine (ANS) to the posterior nasal spine (PNS) (heavy black line, Fig. 2). The four sites on the tongue are defined as follows, and in each patient the greatest change in distance between any two coordinates was measured in each area.

A: the tip point of a tongue;
B: the middle of the tongue, the point at the intersection of the tongue with a perpendicular line drawn from a point two-thirds of the distance from the ANS to the PNS;
C: the most posterior point on the tongue: a point formed by the intersection of the tongue and a perpendicular line drawn from the PNS; and
H: the most anterior position of the hyoid bone.

All measurements were made in centimes.

Speech test

Speech articulation was tested with a modified version of the Freiburger audiometry test[13,17] (German Industrial Standard 45621). We chose 163 monosyllabic words of a consonant–vowel–consonant (CVC) form. Nine of the words had a vowel–consonant (VC) and eight had a consonant–vowel (CV). Each patient's was instructed to read each word at intervals of 2 seconds. Each patient's reading was recorded on audio-tape at 50–60 dB. Each tape was played back to five native speakers of the language who did not know the patients. Each listener transcribed the content of the tape. The intelligibility of each patient's speech was analyzed quantitatively on a scale from 1 to 5 (1: no limitation, 2: slight limitation, 3: severe limitation, 4: hardly intelligible, 5: completely unintelligible). A mean was taken of the results from all five evaluations.

Measurement of arm circumference

For patients who had, the LUFF procedure, three points for measurement of the arm's circumference were selected. They were 1 cm above the epicondyle; the midpoint between the epicondyle and the insertion of the deltoid into the humerus, and the point of insertion of the deltoid into the humerus. For patients who had the RFFF procedure, two points for measurement were used: the anterior and posterior positions of the donor area. Both donor side and opposite side were measured and the ratios were calculated.

Questionnaire method for subjective evaluation

A standard self-administered questionnaire containing 23 questions was used to establish the patients' subjective opinion of their physical state including swallowing, speech, and donor site morbidity. Their degree of satisfaction with swallowing and speech was assessed using a visual analogue scale (VAS) on a line the midpoint of which, 0, indicated normal function and endpoints +10 and −10 increases in satisfaction or dissatisfaction, respectively.

Statistical methods

Data from the fluoroscopic examination and intelligibility tests were analyzed by Student's *t*-test was performed for each of the parameters tested (Statistical Analysis System computer program). Possibilities of less than 0.05 were considered significant.

RESULTS

Impairment of swallowing

Figure 3 shows tongue mobility values for patients after LUFF and RFFF. All patients experienced a reduction. There was a significant increase in distance A in patients after LUFF ($P = 0.001$) and RFFF ($P = 0.045$) compared with normal. There was a significant decrease in distance B (LUFF, $P = 0.011$; RFFF, $P = 0.037$) and in distance C (LUFF, $P = 0.0002$; RFFF, $P = 0.0005$) compared with normal. There was no significant change in distance H. However, there was no significant difference in mobility between patients after LUFF and RFFF.

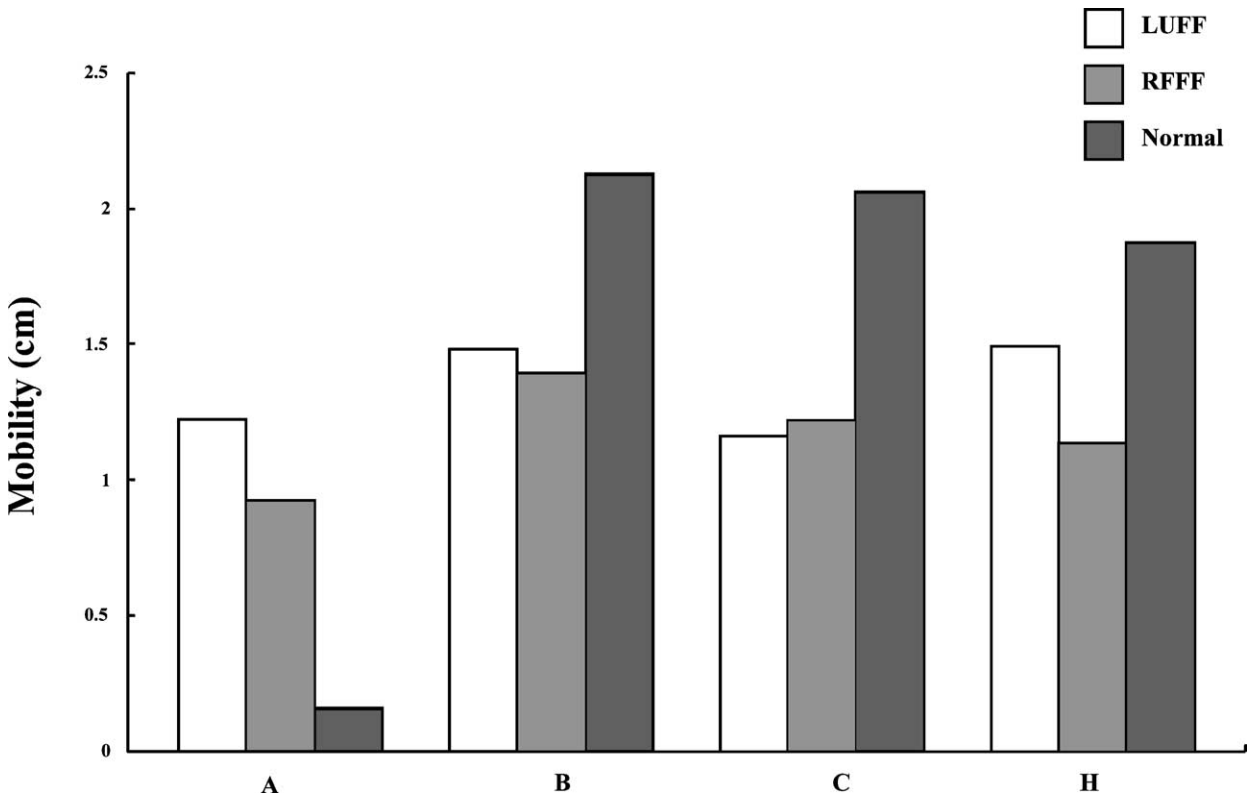

Fig. 3 Relation between the tongue mobility and method of reconstruction. LUFF: lateral upper arm free flap. RFFF: radial forearm free flap. A: The most anterior position of the tongue; B: the mid position of the tongue; C: the most posterior position of the tongue; H: the most anterior position of the hyoid bone.

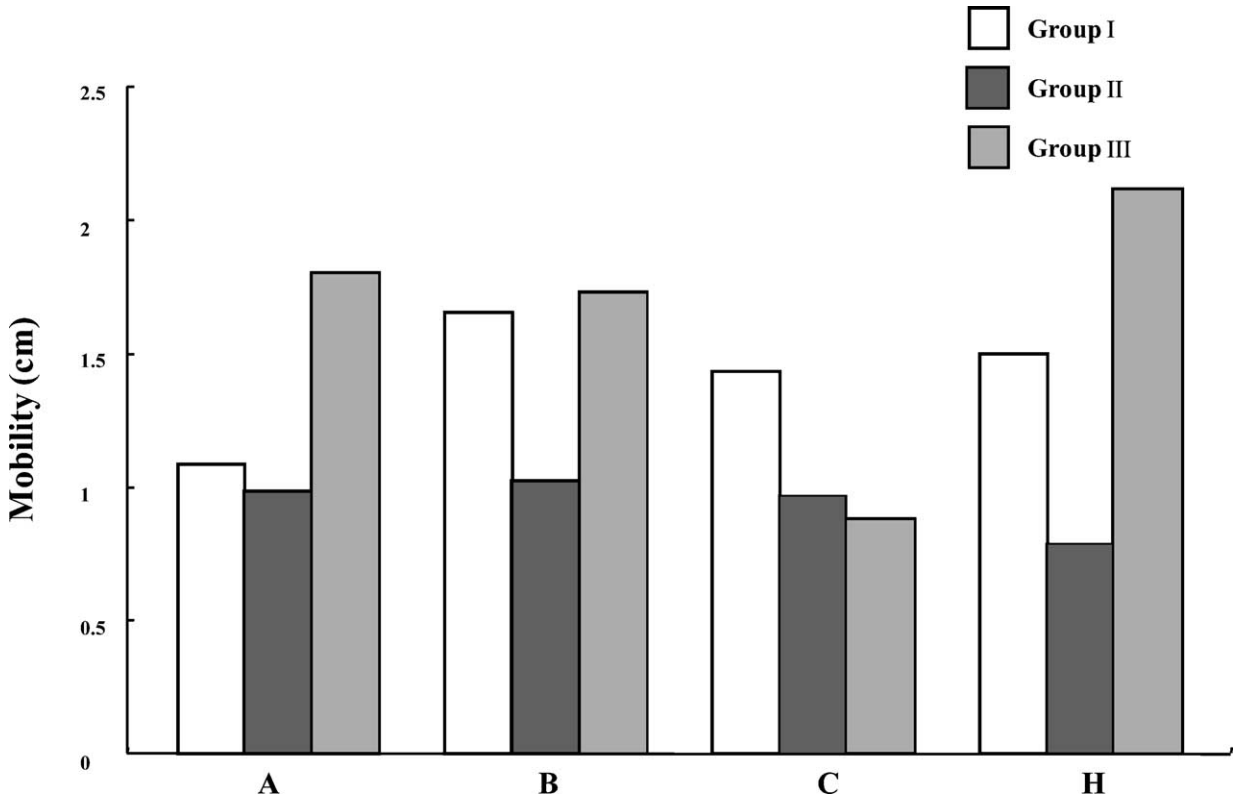

Fig. 4 Relation between mobility of the tongue and site of resection. Group I: reconstruction including floor of mouth and ventral tongue or cheek; group II: reconstruction including anterior tongue or anterior floor of mouth; group III: reconstruction including tongue base, lateral pharyngeal wall and soft palate. A: The most anterior position of the tongue; B: the mid position of the tongue; C: the most posterior position of the tongue; H: the most anterior position of the hyoid bone.

Figure 4 shows values for mobility of the tongue based on the area resected. The greatest change in mobility was in patients who had had anterior resections. A significant decrease in distance A was found in group I (lateral resection) ($P = 0.026$) and group II (anterior resection) ($P = 0.045$) compared with group III (posterior resection). A slight decrease in distance B was found in group II (anterior) compared with groups I (lateral) and III (posterior), but no significant difference in distance B was observed among the three groups. A significant decrease was found in distance C in group III (posterior) ($P = 0.025$) and a slight decrease in the same was found in group II (anterior) compared with group I (lateral). There was a significant increase in distance H in group I (lateral) ($P = 0.05$) and group III (posterior) ($P = 0.048$) compared with group II (anterior). Reductions in mobility of the tongue were caused by both destruction of motor and sensory nerves and scarring in the reconstructed areas. Anterior resection caused reductions in mobility at the tip, middle and back of the tongue, while posterior resections reduced mobility at the back of the tongue, but did not seriously affect the tip or mid portion.

Table 3 shows the results of the questionnaire swallowing. Only 4 patients after LUFF reported being unable to

Table 3 Results of the questionnaire about swallowing

	Drink the water		Day resuming swallowing				Aspiration		Difficulty with food		Degree of satisfaction (VAS)			
	Yes	No	0–15	16–50	51–100	101–	Yes	No	Yes	No	−10 to −5	−4 to 0	1–5	6–10
LUFF	13	4	5	3	3	2	8	9	7	10	10	4	2	1
RFFF	3	0	2	0	0	1	2	1	1	2	0	2	0	1
Group I	7	0	3	2	0	2	4	3	4	3	2	4	0	1
Group II	5	3	3	0	2	0	3	5	0	8	5	1	2	0
Group III	4	1	1	1	1	1	3	2	4	1	3	1	0	1

LUFF: lateral upper arm free flap ($n = 17$); RFFF: radial forearm free flap ($n = 3$). Group I: reconstruction including floor of mouth and ventral tongue or cheek ($n = 7$); group II: reconstruction including anterior tongue or anterior floor of mouth ($n = 8$); group III: reconstruction including tongue base, lateral pharyngeal wall and soft palate ($n = 5$).

swallow water. One person in group I (lateral) and three people in group II (anterior) also reported being unable to swallow. Some patients (after both LUFF and RFFF) said they regained their swallowing function within 15 days; however, the mean reported time to regain function was 92.1 days. Aspiration was reported in 10, or roughly half. Most patients were dissatisfied with their ability to swallow. Sixteen patients reported dissatisfaction (a minus value on the VAS). Ten patients after LUFF were highly dissatisfied (−10 to −5), while 4 after LUFF and 2 after RFFF patients were moderately dissatisfied (−4 to 0 on the VAS). Five patients in group II (anterior) were also highly dissatisfied with their ability to swallow (−10 to −5 on the VAS).

Speech

Seventeen patients after LUFF patients and 7 after RFFF patients took the Freiburger speech test. The same number of patients after LUFF and 3 after RFFF completed the questionnaire about speech.

Figure 5 shows the point of intelligibility in those reconstructed with LUFF and RFFF. Patients after RFFF were more intelligible than those after LUFF. The mean after RFFF was 361.5 (range: 203.7–999.7), while the mean after LUFF was 409.7 (range: 186–667.7), the high score showing a decrease in intelligibility.

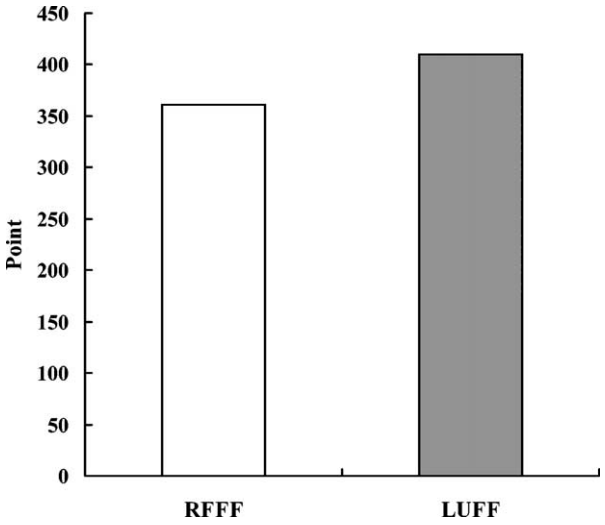

Fig. 5 Relation between intelligibility of speech and method of reconstruction. LUFF: lateral upper arm free flap. RFFF: radial forearm free flap.

Figure 6 gives the point of intelligibility in relation to the area resected. The greatest reduction in intelligibility was in patients who had undergone anterior resection (group II), but the difference from the other groups was not significant.

Table 4 gives the results from the section of the questionnaire about speech. Ten patients after LUFF

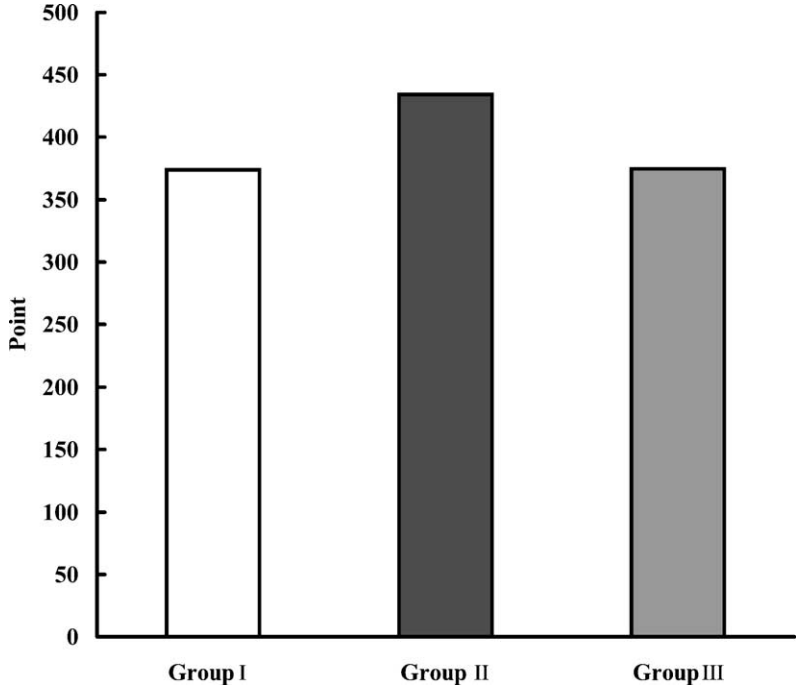

Fig. 6 Relation between intelligibility of speech and method of reconstruction. Group I: reconstruction including floor of mouth and ventral tongue or cheek. Group II: reconstruction including anterior tongue or anterior floor of mouth. Group III: reconstruction including tongue base, lateral pharyngeal wall and soft palate.

Table 4 Results of the questionnaire about speech

	Speak on the telephone			Anxiety in conversation		Day resuming speech				Degree of satisfaction			
	Good	Sometimes	Impossible	Yes	No	0–15	16–50	51–100	101–	−10 to −5	−4 to 0	1–5	6–10 (VAS)
LUFF	7	10	0	3	14	2	3	2	7	8	5	2	1
RFFF	3	0	0	0	3	1	1	1	0	0	2	0	1
Group I	4	3	0	1	6	2	2	1	1	2	3	0	1
Group II	4	4	0	1	7	0	2	2	3	4	2	2	0
Group III	2	3	0	1	4	1	0	0	3	2	2	0	1

LUFF: lateral upper arm free flap ($n = 17$); RFFF: radial forearm free flap ($n = 3$). Group I: reconstruction including floor of mouth and ventral tongue or cheek ($n = 7$); group II: reconstruction including anterior tongue or anterior floor of mouth ($n = 8$); group III: reconstruction including tongue base, lateral pharyngeal wall and soft palate ($n = 5$).

Table 5 Circumference of the donor site (cm)

	LUFF			RFFF	
	A	B	C	A	B
Mean	0.96	0.97	0.96	0.99	0.94
SD	0.05	0.03	0.03	0.04	0.07

LUFF: lateral upper arm free flap ($n = 14$); A: 1 cm above the epicondyle; B: midpoint between the epicondyle and the insertion of the deltoid into the humerus; C: insertion of the deltoid into the humerus. RFFF: radial forearm free flap ($n = 7$); A: anterior position of the donor area; B: posterior position of the donor area.

Table 6 Questionnaire about donor site morbidity

	Raise the elbow		Turn the elbow		Stretch the elbow		Hold an article normally		Dull (upper arm) region)		Dull (forearm to elbow)		Dull (the thumb)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
LUFF	11	5	15	1	16	0	16	0	12	4	10	6	2	14
RFFF	3	0	3	0	3	0	3	0	1	2	1	2	2	1

LUFF: lateral upper arm free flap ($n = 16$); RFFF: radial forearm free flap ($n = 3$).

stated that their speech was sometimes unrecognizable, but most patients (14 after LUFF and 3 after RFFF) reported feeling no anxiety when conversing. Seven patients after LUFF reported not regaining speech until more than 100 days postoperatively, as did 3 patients in groups II (anterior) and III (posterior); the mean time reported for regaining speech was 106.2 days (range: 9–215).

The patients' degree of satisfaction with their speech was assessed by a VAS. As with swallowing, most of the patients reported being dissatisfied with their speaking ability. Thirteen after LUFF and 2 after RFFF were dissatisfied (minus on the VAS). Four patients in group II (anterior) were highly dissatisfied with their speaking ability (−5 to −10 on the scale).

Donor site morbidity

Table 5 shows the results of donor site measurements and calculations. In the patients after LUFF, the circumference of the donor side measured from the three points was 4% less than the normal side. In the patients after RFFF, the circumference of the donor side was 2–6% less than the normal side.

Five patients after LUFF were unable to raise their elbows after reconstruction, and 1 was unable to turn his elbow. They were all able to extend their elbows and hold objects in a firm grip. There was a decrease in sensitivity in the upper arm region in 12 patients and from the underarm to elbow region in 10 patients. In addition, 2 patients after RFFF had a reduction in sensitivity in their thumbs (Table 6).

DISCUSSION

We found that swallowing and speech were affected by the area than was resected, but were nor affected by the type of flap used for reconstruction.

Anterior resection of the oral cavity followed by LUFF reconstruction caused reductions in intelligibility of speech. Glossal sounds are produced with the tip and mid portion of the tongue. Certain plosives and affricates are formed by forcing part of the tongue against the teeth, alveolar ridge, or palate to direct and modify the flow of air.[13,17] Anterior resection reduced mobility of the tip of the tongue so that the tip could not touch the alveolar ridge or palate.

Harvesting LUFF requires the exposure of large muscles such as the brachialis or the lateral head of the triceps but the wound can be closed primarily.[2,5] This prevents statistical reduction in the movements of the upper arm. The RFFF does not have this advantage. No patient after LUFF reported any impediment in movement of the upper arm.

Half the patients after LUFF patients reported diminished sensation in both the proximal and distal sides of the elbow. While harvesting the flaps it is difficult to preserve the posterior cutaneous nerve of the forearm; the cutting of this nerve during harvesting may be unavoidable. The numbness that ensues from cutting the nerve may or may not improve over time.[2] The radial nerve was not injured by harvesting the LUFF.

Although the use of LUFF or RFFF had no significant effects on swallowing or speech, the LUFF offers an advantage over the RFFF. Primary wound closure can be done after a LUFF, whereas an RFFF needs a skin graft to protect the tendons and muscles responsible for movement of the hand. Serious complications, including failure of the skin graft leading to exposure of tendons have been reported after harvesting RFFF. We conclude that the LUFF is superior to the RFFF with regard to quality of life.

Our evaluation of the effect of LUFF and RFFF flaps on the quality of life in postoperative patients is that the type of flap does not significantly affect swallowing or speech. Impairment of swallowing and speech varied with the area resected. We conclude that LUFF is the better choice for intraoral reconstruction after resection of tumors.

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