

Comparative analysis of the functional results of tongue reconstruction with four kinds of free flaps after radical resection of tongue cancer

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Research

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Abstract

Background

Surgery is still the treatment of choice for tongue cancer. Tongue reconstruction should be performed immediately after extensive resection of the tumor, which will affect the patient's function. The purpose of this study was to investigate the functional evaluation of four different free flaps in tongue reconstruction after a tongue cancer operation.

Methods

Forty-eight cases of tongue reconstruction with a radial forearm free(RFF flap), anterolateral thigh(ALT) flap, lateral upper arm free(LAF)flap and deep inferior epigastric artery perforator(DIEP)flap from 2014 to 2018 were analyzed. The speech function, swallowing function, tongue flexibility and patients' satisfaction with the donor area was investigated six months after repair.

Results

Twenty-one cases with RFF flaps, 18 cases with ALT flaps, 5 cases with LAF flaps and 4 cases with DIEP flaps showed complete flap survival. Speech function:39.6% of the patients exhibited normal speech, 43.8% of the patients exhibited near-normal speech, the RFF flap group was showed better recovery than did the other three groups ($p = 0.195$). The degree of tongue flexibility: 37.5% of the patients with normal postoperative tongue flexibility, 43.6% of the patients with slightly limited tongue flexibility,, 16.7% of the patients with severely limited tongue flexibility, The flexibility of the RFF flap was better than that of the other three groups($p = 0.054$). Swallowing function:47.9% of the patients had a regular diet, 33.3% of the patients had soft foods, 16.7% patients receive fluid diet, The RFF flap group showed better recovery than did the other three groups ($p = 0.248$). Donor satisfaction: 56.2% of the patients were satisfied, 41.7% of the patients were basically satisfied, 100% of the patients with LAF and DIEP flaps were satisfied. This level of satisfaction was better than that in the RFF and ALT flap groups. ($p = 0.039$).

Conclusion

The functional recovery of RFF flap in tongue reconstruction after middle and early stage tongue cancer surgery is better. However, ALT flap has been used more frequently for a large number of tissue defects caused by radical resection of tongue cancer in the advanced stage. Meanwhile, LAF and DIEP flaps can provide a sufficient tissue volume, a conceal scar, fewer complications in the donor area, and both function and beauty, which are easily accepted by patients.

Introduction

Tongue cancer is the most common malignant tumor of oral cancer. The incidence of tongue cancer has increased in the past 30 years[1, 2]. Surgical resection is an essential strategy for the treatment of tongue cancer. Radical resection can obtain a satisfactory 5-year survival rate [3, 4]. However, the tongue is a crucial organ in speaking, swallowing, and assisting the oral cavity to perform masticatory functions. Radical resection of tongue cancer often results in corresponding defects, which have a negative impact on the function and appearance of the tongue and a severe impact on the postoperative quality of life (HRQOL) [5, 6], Therefore, tongue reconstruction must be performed to maximize the recovery of tongue function and improve the patient's quality of life when the tongue

defect reaches a certain limit. However, there is no consensus on how to repair some tongue defects after radical surgery. At present, most scholars believe that different tissue flaps should be selected according to the defect size, location and other soft and hard tissue defects after tongue cancer surgery[6, 7]. The primary purpose of reconstruction is to reconstruct the functions of speech, chewing and swallowing. Most of the current research reports are based on the functional results of a reconstruction method or a comparison between reconstruction techniques. Most of them are the comparison between the free flap and pedicled flap, or between repair and non-repair. Therefore, the purpose of this study was to study the reconstruction and functional effects of four kinds of the free flap after tongue cancer surgery.

Materials And Methods

The present program was approved by the ethics committee of the Sichuan Cancer Hospital(SCCHEC2014016). This retrospective study included 48 cases of tongue reconstruction with RFF (21 cases), ALT (18 cases), LAF (5 cases) and DIEP (4 cases) flaps after tongue cancer resection from January 2014 to June 2018. Surgical and pathological records for each case were reviewed (Table 1). The type and size of the flap, speech, tongue flexibility, deglutition and patient satisfaction with the donor appearance were evaluated half a year after the operation. In speech function assessments, patients read a 200-word essay, and the accuracy of the text was rated as follow: 1-normal (accuracy over 90%), 2- near-normal (accuracy over 75%), 3-vague (accuracy less than 50%), or 4-unable to speak. The flexibility of the tongue was graded as follow: 1-normal (can protrude from the mouth), 2-slightly limited (can protrude only to the lip), 3-severely limited (cannot reach the teeth), or 4-completely limited (fixed). Deglutition was subjectively estimated based on the diet feedback from patients and was classified as follow: 1-regular diet, 2-soft diet, 3-fluid diet, or 4-nasal feeding. Donor satisfaction was classified as 1- satisfied, 2-basically satisfied and 3- not satisfied[7, 8]. A surgeon performed the clinical evaluation.

Table 1
Patient clinical data

Clinical data	examples (n = 48) percentage (%)
Sex	20 (41.7)
Female	28 (58.3)
Male	
TNM staging	2 (4.2)
T1N0M0	20 (41.7)
T2N0M0	2 (4.2)
T2N1M0	4 (8.3)
T2N2M0	8 (16.7)
T3N0M0	6 (12.5)
T4N0M0	1 (2.1)
T4N1M0	5 (10.4)
T4N2M0	
Pathological type	43 (89.6)
Squamous cell carcinoma	4 (8.3)
adenoid cystic carcinoma	1 (2.1)
carcinoma sarcomatodes	
Differentiation degree	28 (58.3)
well-differentiated	10 (20.9)
moderately differentiated	5 (10.4)
poorly differentiated	
Free flap	18 (37.5)
ALT	21 (43.6)
RFF	5 (10.4)
LAF	4 (8.3)
DIEP	

All patients underwent radical resection of tongue cancer. The mandibular function and lingual gingival mucosa were preserved in the uninvaded early tongue carcinoma, while in severe advanced tongue carcinoma, the median lip incision flap was turned over and the mandibular alveolar resection was performed. Bilateral neck lymph node dissection was performed in patients with tumors extending across the midline, lymph node dissection in the I-III area was performed in patients with stage cN0, functional neck dissection was performed in patients with stage cN1, and radical neck dissection was performed in patients with lymph node invasion. The intraoperative frozen pathological examination ensured that the incisional margin was negative. At the same time, the flap was prepared by the recipient blood vessel. The branches of the external jugular vein, facial arteriovenous and superior thyroid artery were preserved according to the specific conditions, and the thread was used for vascular anastomosis. Through the tunnel from the maxillofacial region to the neck, the vascular pedicle was passed through the tube to the submaxillary region. The artery was anastomosed first; and then the vein was anastomosed. After the vascular anastomosis was completed, the flap was sutured with the wound surface of the recipient area. Rubber drainage strips were placed in the anastomotic area, and the broad surface of the flap and drainage tubes were positioned in the neck.

Data analysis and statistics were conducted with the help of a professional statistician. All analyses were carried out using SPSS statistical software (version 13.0; SPSS, Inc., Chicago, IL, USA). The Kruskal Wallis test was used to analyze the difference between groups; $p < 0.05$ was considered to indicate statistical significance.

Results

The study lasted 48 months and included 28 males (58.3%) and 20 females (41.7%), with an average age of 54.9 years (26–76 years). According to the (IUCC) TNM staging criteria of the International Commission on Oncology in 2002, there were 2 cases of stage T1N0M0, 20 cases of stage T2N0M0, 2 cases of stage T2N1M0 cancer, 4 cases of stage T2N2M0, 8 cases of stage T3N0M0, 6 cases of stage T4N0M0, 1 case of stage T4N1M0 and 5 cases of stage T4N2M0. There were 43 cases of squamous cell carcinoma (SCC), 4 cases of adenoid cystic carcinoma (ACC) and 1 case of sarcomatoid carcinoma. All patients were followed up for 6 to 48 months. Twenty-six patients received postoperative adjuvant radiotherapy at a dose of 55–60 Gy, 2 of whom showed recurrent disease. The overall survival rate was 85.4% (41/48).

Twenty-one patients underwent tongue reconstruction with an RFF flap (Table 2). In these patients, 2 cases were repaired in the T1 stage, 11 cases were repaired in the T2 stage, 6 cases were repaired in the T3 stage, and 2 cases were repaired in the T4 stage. Postoperative functional evaluations revealed that 10 (47.6%) patients exhibited normal speech, 10 (47.6%) patients exhibited near-normal speech, and 1 (4.8%) patient exhibited vague speech after the operation. Eleven (52.4%) patients had normal tongue flexibility, 7 (33.3%) patients had slightly limited tongue flexibility, and 3 (14.3%) patients had a severe limitation of tongue flexibility; 13 (61.9%) patients had a regular diet, 5 (23.8%) patients had soft foods, and 3 (14.3%) patients had a fluid diet after the operation. Nine (42.9%) patients were satisfied and 12 (57.1%) patients were basically satisfied with the donor area postoperatively.

Table 2
Patient and flap characteristics of RFF

No.	Sex	Age (year)	T class	Pathological type	Tumor size(cm)	Flap size(cm)	Speech	Tongue mobility	Dietary	Donor site
1	M	40	T2	SCC	2.0×3.0	6.0×7.0	1	1	1	2
2	M	42	T3	SCC	2.8×1.8	5.0×7.0	1	1	1	2
3	F	43	T4	SCC	3.4×2.1	5.0×7.0	2	1	1	2
4	F	45	T2	SCC	4.2×3.9	7.0×6.0	2	2	2	2
5	F	48	T3	SCC	5.4×3.0	8.0×6.0	2	2	2	1
6	M	49	T2	SCC	1.8×1.0	7.0×5.0	2	2	2	2
7	F	50	T1	SCC	1.6×1.0	5.0×6.0	2	2	3	1
8	M	50	T2	SCC	2.9×2.1	7.0×6.0	1	2	2	2
9	M	51	T3	SCC	2.4×2.6	5.0×7.0	1	1	1	1
10	F	52	T2	SCC	1.7×1.1	5.0×7.0	1	1	1	1
11	M	53	T4	SCC	2.7×1.2	6.0×5.0	2	2	1	1
12	F	53	T3	SCC	1.7×1.0	5.0×7.0	3	3	3	2
13	F	54	T2	SCC	3.0×4.0	6.0×8.0	1	1	1	2
14	F	55	T2	SCC	3.0×2.0	6.0×7.0	2	1	2	1
15	F	60	T2	SCC	1.0×2.0	5.0×6.0	2	1	1	2
16	F	61	T3	SCC	1.4×1.1	5.0*7.0	1	1	1	1
17	F	62	T2	SCC	1.6*1.4	5.0×7.0	1	2	1	2
18	M	62	T2	SCC	2.8×2.4	6.0×7.0	1	1	1	1
19	F	63	T1	SCC	2.5×2.6	6.0×7.0	2	2	1	2
20	F	64	T3	SCC	2.1×1.0	5.0×6.0	2	2	3	2
21	F	66	T2	SCC	1.4×1.1	5.0×7.0	1	1	1	1

An ALT flap was used to reconstruct the tongue in 18 patients (Table 3). Among these patients, T2 repair was performed in 10 cases, T3 repair was performed in 1 case, and T4 repair was performed in 7 cases. Postoperative functional evaluations showed that 6 (33.3%) patients exhibited normal speech, 7 (38.9%) patients exhibited near-normal speech, and 4 (22.2%) patients exhibited vague speech after the operation. One (5.6%) patient was unable to speak after the operation (total tongue resection after recurrence of tongue cancer). Five (27.8%) patients exhibited normal tongue flexibility, 8 (44.4%) patients exhibited slightly limited tongue flexibility, 4 (22.2%) patients had a severe limitation of postoperative tongue flexibility, and 1 (5.6%) patient had completely limited tongue flexibility (total glossectomy after recurrence of tongue cancer). Seven (38.9%) patients had a regular diet, 8 (44.4%) patients had soft foods, 2 (11.1%) patients had a fluid diet, and 1 (5.6%) patient received nasal feeding (total glossectomy

after recurrence of tongue cancer). Nine (50.0%) patients were satisfied, 8 (44.4%) patients were basically satisfied, and 1 (5.6%) patient was not satisfied with the donor area postoperatively.

Table 3
Patient and flap characteristics of ALTF

No.	Sex	Age (year)	T class	Pathological type	Tumor size(cm)	Flap size(cm)	Speech	Tongue mobility	Dietary	Donor site
1	M	26	T2	ACC	2.2 × 1.3	5.0 × 6.0	2	2	1	1
2	F	31	T4	ACC	3.8 × 2.5	6.0 × 7.0	2	1	1	2
3	M	33	T4	SCC	3.6 × 3.5	6.0 × 7.0	3	3	3	2
4	M	36	T3	ACC	1.6 × 1.7	5.0 × 6.0	1	2	1	1
5	F	42	T4	carcinoma sareomatodes	5.1 × 4.7	10.0 × 14.0	4	4	4	3
6	F	48	T4	ACC	2.3 × 1.3	5.0 × 6.0	2	3	2	1
7	M	49	T2	SCC	1.0 × 1.8	6.0 × 8.0	2	2	2	1
8	F	51	T2	SCC	2.2 × 1.0	6.0 × 5.0	1	1	1	1
9	M	52	T4	SCC	2.4 × 1.0	6.0 × 8.0	3	3	2	2
10	M	54	T2	SCC	2.4 × 1.0	5.0 × 6.0	1	2	2	2
11	M	59	T2	SCC	2.2 × 2.0	5.0 × 6.0	3	2	2	2
12	F	59	T2	SCC	3.5 × 2.1	5.0 × 7.0	1	1	1	1
13	M	63	T4	SCC	1.8 × 1.2	5.0 × 6.0	3	3	3	2
14	M	65	T2	SCC	2.7 × 1.0	6.0 × 8.0	1	1	1	1
15	F	68	T2	SCC	3.0 × 2.8	6.0 × 7.0	2	2	2	2
16	M	69	T2	SCC	4.2 × 3.9	5.0 × 7.0	2	2	2	1
17	M	70	T4	SCC	3.0 × 2.8	5.0 × 7.0	2	2	2	2
18	M	73	T2	SCC	5.1 × 4.0	8.0 × 6.0	1	1	1	1

An LAF flap was used to reconstruct the tongue in 5 patients (Table 4). Among them, T2 repair occurred in 3 cases, T3 repair occurred in 1 case, and T4 repair occurred in 1 case. Postoperative functional evaluations revealed that 2 (40.0%) patients exhibited normal speech, 2 (40.0%) patients exhibited near-normal speech, and 1 (20.0%) patient exhibited vague speech after the operation. Two (40.0%) patients showed normal tongue flexibility, 2 (40.0%) patients showed slightly limited tongue flexibility, and 1 (20.0%) patient showed severely limited tongue flexibility. Two (40.0%) patients had a regular diet, and 2 (40.0%) patients had soft foods. One (20.0%) patient received a fluid diet after the operation. Five (100.0%) patients were satisfied with the donor area postoperatively.

Table 4
Patient and flap characteristics of LAF

No.	Sex	Age (year)	T class	Pathological type	Tumor size(cm)	Flap size(cm)	Speech	Tongue mobility	Dietary	Donor site
1	M	44	T2	SCC	1.9 × 2.7	5.0 × 6.0	1	1	1	1
2	M	52	T2	SCC	3.6 × 2.7	5.0 × 6.0	2	2	1	1
3	M	63	T3	SCC	4.0 × 2.6	5.0 × 6.0	2	2	2	1
4	M	68	T2	SCC	3.1 × 3.0	6.0 × 7.0	1	1	1	1
5	M	76	T4	SCC	2.5 × 4.5	6.0 × 8.0	3	3	3	1
5	M	76	T4	SCC	2.5 × 4.5	6.0 × 8.0	3	3	3	1

A DIEP flap was used to reconstruct the tongue in 4 patients (Table 5). Among them, 2 patients were treated with T2 repair and 2 patients with T4 repair. Three (75.0%) patients exhibited normal postoperative speech, and 1 (25.0%) patient exhibited vague speech after the operation. Two (50.0%) patients showed slightly limited tongue flexibility, and 2 (50.0%) patients showed severely limited tongue flexibility. One (25.0%) patient had a regular diet, 2 (50.0%) patients had soft foods, 1 (25.0%) patient received a fluid diet after the operation. Four (100.0%) patients were satisfied with the donor area postoperatively.

Table 5
Patient and flap characteristics of DIEP

No.	Sex	Age (year)	T class	Pathological type	Tumor size(cm)	Flap size(cm)	Speech	Tongue mobility	Dietary	Donor site
1	M	56	T2	SCC	2.0 × 3.5	5.0 × 6.0	2	2	2	1
2	M	66	T4	SCC	3.3 × 4.3	7.0 × 6.0	2	3	3	1
3	M	68	T4	SCC	3.4 × 3.5	7.0 × 7.5	3	3	2	1
4	M	70	T2	SCC	3.5 × 2.1	6.0 × 7.0	2	2	1	1

(Table 1–4)Speech: 1- normal;2- near-normal;3- vague;4- unable to speak; Tongue mobility;1- flexible;2- slightly limitation;3- severely limitation;4- completely limitation; Dietary;1- regular diet,2- soft food,3- liquid diet;4-nasal feeding; Satisfaction of donor area;1- satisfied;2- basically satisfied;3- not satisfied

A functional evaluation was conducted six months after the operation (Table 6). In terms of overall recovery, 19 (39.6%) patients had normal speech, 21 (43.8) patients had near-normal speech, 7 (14.5%) patients had vague speech, and 1 (2.1%) patient was unable to speak. It was apparent that the speech function of most of the patients recovered better after the operation. The RFF flap group showed better recovery than did the other three groups (Fig. 1), but there was no significant differences among the flap groups ($p = 0.195$). There were 18 (37.5%) patients with normal postoperative tongue flexibility, 21 (43.6%) patients with slightly limited tongue flexibility, 8 (16.7%) patients with severely limited tongue flexibility, and 1 (2.1%) patient with completely limited tongue flexibility. The flexibility of the RFF flap group was better than that of the other three groups (Fig. 2), but there were no significant differences among the flap groups ($p = 0.054$). Twenty-three (47.9%) patients had a regular diet, 16 (33.3%) patients had soft foods, 8 (16.7%) patients received a liquid diet, and 1 (2.1%) patient could not eat after the operation. Most

of the patients had excellent recovery of feeding function after the surgery. The RFF flap group showed better recovery than did the other three groups (Fig. 3), but there were no significant differences among the flap groups ($p = 0.248$). Among the patients, 27 (56.2%) were satisfied, 20 (41.7%) were basically satisfied, 1 (2.1%) was not satisfied; 100% of the patients with LAF and DIEP flaps were satisfied. This level of satisfaction was better than that in the RFF and ALT flap groups (Fig. 4), and the difference was statistically significant ($p = 0.039$). (Table 7)

Due to technical limitations, Table 6 is provided in the Supplementary Files section.

Table 7
Functional results of free flap reconstruction

Characteristic	Speech (Median \pm Interquartile range)	Tongue mobility (Median \pm Interquartile range)	Dietary (Median \pm Interquartile range)	Satisfaction of donor area (Median \pm Interquartile range)
ALTF	2.0 \pm 1.0	2.0 \pm 1.0	2.0 \pm 1.0	1.0 \pm 1.0
RFFF	2.0 \pm 1.0	2.0 \pm 1.0	2.0 \pm 1.0	1.0 \pm 1.0
LAFF	2.0 \pm 1.0	2.0 \pm 1.0	2.0 \pm 1.0	1.0 \pm 1.0
DIEPF	2.0 \pm 1.0	2.0 \pm 1.0	2.0 \pm 1.0	1.0 \pm 1.0
χ^2 value	4.705	7.683	4.128	8.387
P-value	0.195	0.054	0.248	0.039

Discussion

The tongue is an organ with complex physiological and social functions that are seriously affected by tissue defects after the radical resection of tongue cancer. Partial tongue resection has a great effect on HRQOL. The repair and reconstruction of tongue defects are very demanding, but their purpose is to reconstruct the appearance, eliminate dead space, and maintain the patient's ability to chew, swallow and speak[6, 9]. Pedicled flaps and free flaps are commonly used to repair tongue defects. However, some studies suggest that with the use of pedicle flaps, the mobility of the reconstructed tongue and the recovery of speech are affected by gravity causing tongue and pedicle drooping[10]. It is also suggested that the reconstruction of the flap may impair the function of the residual tongue tissue due to the introduction of nonmotile tissue [11]. However, consecutive studies have shown that to improve postoperative speech and swallowing functions and the postoperative HRQOL, free flap reconstruction is necessary for restoration of the tongue volume and better functional outcomes in patients who have undergone resection of more than half of the tongue volume[7, 12, 13, 14]. The functional recovery of patients with free flaps repair after the operation is better, which is beneficial to improve postoperative HRQOL in this study. With the development of microsurgery, all kinds of free flaps are used in tongue reconstruction. At present, RFF flaps[15, 16], ALT flaps[13, 17], LAF flaps [8, 18], perforator flaps from the lower leg [19] and DIEP flaps[20] are also utilized in tongue reconstruction. Postoperative speech function and swallowing function quality depend on the strength, volume, and flexibility of the remaining tongue and flap repair. No study has shown that any flaps is superior to the other flaps in tongue reconstruction [21]. Therefore, this study is the first comparative analysis of the functional results of tongue reconstruction with four kinds of free flaps after radical resection of tongue cancer.

The RFF flap is still the main flap currently used for tongue reconstruction[12]. In this group of patients, 21 (43.6%) tongues were rebuilt with an RFF flap, which is also the main repair method. Postoperative functional evaluations revealed that after the operation, 47.6% of the patients had normal speech and 47.6% of the patients had near-normal speech. In 52.4% of the patients, the postoperative tongue flexibility was normal, whereas 33.3% of the patients had slightly limited postoperative tongue flexibility. Furthermore, 61.9% of the patients ingested a regular diet, and 23.8% of the patients received soft foods after surgery. The postoperative functional recovery was better in the RFF flap group than in the other three groups (Figs. 1, 2, 3). Thus, our study shows that RFF is still a suitable method for tongue reconstruction. The functional recovery of patients with tongue reconstruction using an RFF flap is satisfactory, especially when the tongue defect involves 1/3 – 1/2 of the organ; 13 (61.9%) patients of this study underwent repair of stage T1 and T2 defects. Therefore, for patients with tongue defects involving less than 1/2 of the organ, we tend to recommend the use of an RFF flap for tongue reconstruction. The main disadvantage of the RFF flap is that interception of the RFF involves cutting off the radial artery, which is the main artery for the forearm. This procedure can affect the sensation and motor function of the hand, and the concealment of the surgical wound is not ideal. Second, grafts are needed to block the donor area, and the scar is so apparent that it is difficult for many people to accept [22, 23]. In this study, only 9 (42.9%) patients were satisfied with the donor area postoperatively, which was the lowest level of satisfaction of any group (ALT, 50%; LAF and DIEP, 100%) (Fig. 4). Thus, the RFF flap procedure is not suitable for young people with high standards for appearance or for professionals with special requirements.

It is precisely because of some shortcomings of the RFF flap procedure that the ALT flap is widely used in tongue reconstruction, especially for a large number of tissue defects caused by the radical resection of advanced tongue cancer, as the RFF flap is thin, has insufficient tissue, and easily forms scars that reduce the flexibility of the reconstructed tongue. In contrast, the ALT flap can provide a sufficient tissue volume [13, 24, 25]. In this study, 18 (37.5%) patients received an ALT flap for tongue reconstruction, which was the second most commonly used method. The postoperative functional evaluations revealed that 33.3% of the patients exhibited normal speech, 38.9% of the patients exhibited near-normal speech, and 22.2% of the patients exhibited vague speech after the operation. Furthermore, 38.9% of the patients had a regular diet, 44.4% had a soft diet, and 11.1% received a liquid diet; these percentages were slightly lower than those after the RFF procedure. We conclude that most of the patients treated with ALT flaps have advanced tongue cancer, that the defect after the operation is more significant, that the repair flap is thicker, and that the duration of flap atrophy is relatively long. In this study, 8 (44.4%) patients received ALT flaps to repair T3 and T4 defects. An HRQOL study reported that the postoperative assessment time should be 12 months later as a critical factor [26]. In this study, the tongue function was evaluated six months after the operation. Fifty-five percent of the patients were satisfied and 44.4% of the patients were basically satisfied with the donor area—slightly higher percentages than those for the RFF flap. Therefore, we believe that for patients with advanced tongue cancer, in which the tongue body defect is subtotal glossectomy or even total glossectomy involving resection of most of the tongue body and tongue root, postoperative aspiration and swallowing are a serious problem, and the ALT flap is a better choice[27, 28].

In addition to studies on RFF and ALT flaps, there have also been reports of using LAF and DIEP flaps for tongue reconstruction. In this study, 5 (10.4%) patients received an LAF flap for tongue reconstruction, and 4 (8.3%) patients received DIEP flaps for tongue reconstruction; postoperative functional evaluations of speech function and swallowing function showed almost no significant differences between the RFF and ALT flap procedures. (Fig. 1, 2,3).However, the donor satisfaction was 100% (Fig. 4), which was also the most significant advantage of the LAF and DIEP flaps, both of which were perforating flaps, and the donor's vessels were not important functional vessels. The postoperative complications of the donor area were significantly reduced to the minimum, which was better

than the corresponding results of the RFF and ALT procedures. We think that the LAF flap is thin and easy to shape, can even carry definite sensory nerves to partially restore nerve function, and has little effect on the donor area after the operation. However, it is necessary to recognize the thickness of the LAF flap, the large variation in the donor vessel and caliber, the short vascular pedicle, and so on, and thus the requirements of this microsurgical technique are higher. There is evidence that the average artery diameter is 1.1 mm (0.8 to 1.4 mm) and that the mean vein diameter is 1.2 mm (0.9 to 1.5 mm) [29,30,31].

For the DIEP flap, the blood supply of the flap mainly depends on the inferior abdominal artery, which is the branch of the external iliac artery. Blood is mainly supplied to the middle and lower part of the rectus abdominis muscle, and most of the segmental branches appear near the semicircular line, which is mainly the perforating branch of the musculocutaneous artery. The perforating branch whose diameter after penetrating the deep fascia is greater than 0.5 cm, is the application base of the DIEP flap[20, 32]. In clinical work, the advantages were as follows: (1) adequate tissue and blood supply; (2) preservation of donor muscles, fascia and nerves and prevention of donor area injury, complications and rectus abdominis atrophy [20, 32], with a shortened postoperative recovery time;(3) a flap that was not easily deformed (without muscle tissue) after the operation; (4) a concealed donor area, which was more in line with the aesthetic requirement; (5) a donor area and recipient area that could be operated on at the same time, which shortened the operation time;and(6)separation of the perforating branch from the intramuscular segment, which lengthened the pedicle and made the flap design more flexible and more compliant[20, 32].However, there are still some shortcomings in the DIEP flap procedure, such as a large variation in the perforating branch position and diameter, complicated steps during the operation, etc. Furthermore, the procedure is not suitable for obese patients; the DIEP flap is too bloated, and fat liquefaction may occur after the operation, so it is not suitable for tongue reconstruction.

In this study, while there was no significant difference in postoperative function, LAF and DIEP flaps could provide a sufficient tissue volume, a concealed scar, and fewer complications in the donor area, both functional and aesthetic, and could be used to repair the defects of advanced tongue cancer. The number of LAF and DIEP flaps in this study is too small. We believe that with the in-depth review of applied anatomy of LAF and DIEP flaps, the continuous improvement of prosthetic techniques by head and neck surgeons, the renewal and development of microsurgical techniques and equipment, and the popularization and application of modern imaging techniques, The application value and status of LAF and DIEP flaps in the repair of tongue cancer defects will be increase, and the role of them will become more important.

Conclusion

According to the functional evaluation of four kinds of free flaps after tongue reconstruction, the function after RFF flap repair was relatively good for the patients with middle and early stage tongue cancer. However, ALT flap has been widely used for tissue defect caused by radical resection of tongue cancer in the advanced stage. Meanwhile, LAF and DIEP flaps can provide a sufficient tissue volume, a concealed scar, and fewer complications in the donor area, both functional and aesthetic, which are readily accepted by patients.

List Of Abbreviations

Radial forearm free(RFF) flap,

Anterolateral thigh(ALT) flap,

Lateral upper arm free(LAF)flap

Deep inferior epigastric artery perforator(DIEP)flap

Declarations

Ethics approval

The present program was approved by the ethics committee of the Sichuan Cancer Hospital [SCCHEC2014016]

Availability of data and materials

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Conflict Of Interest

The authors declare that they have no conflict of interest.

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Authors' Contributions

Li C is the corresponding author, and he contributed to the conception of the study. Cai YC is the first author, contributed significantly to analysis and manuscript preparation; Wang W, Zhou YQ, Sun R and Liu W perform the data collection, Shui CY performed the clinical evaluation. Pei J performed the data analyses.

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Figures

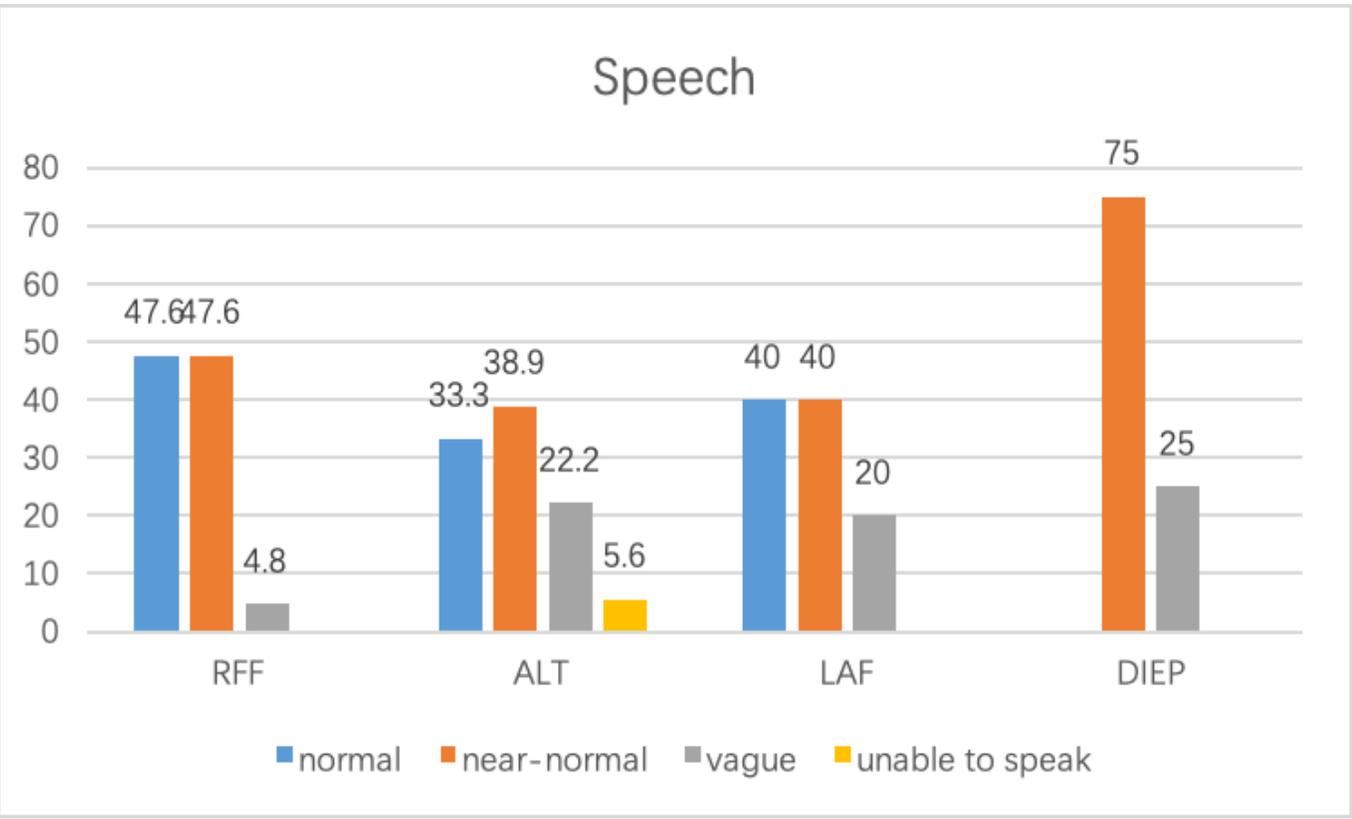


Figure 2

Speech contrast between four groups

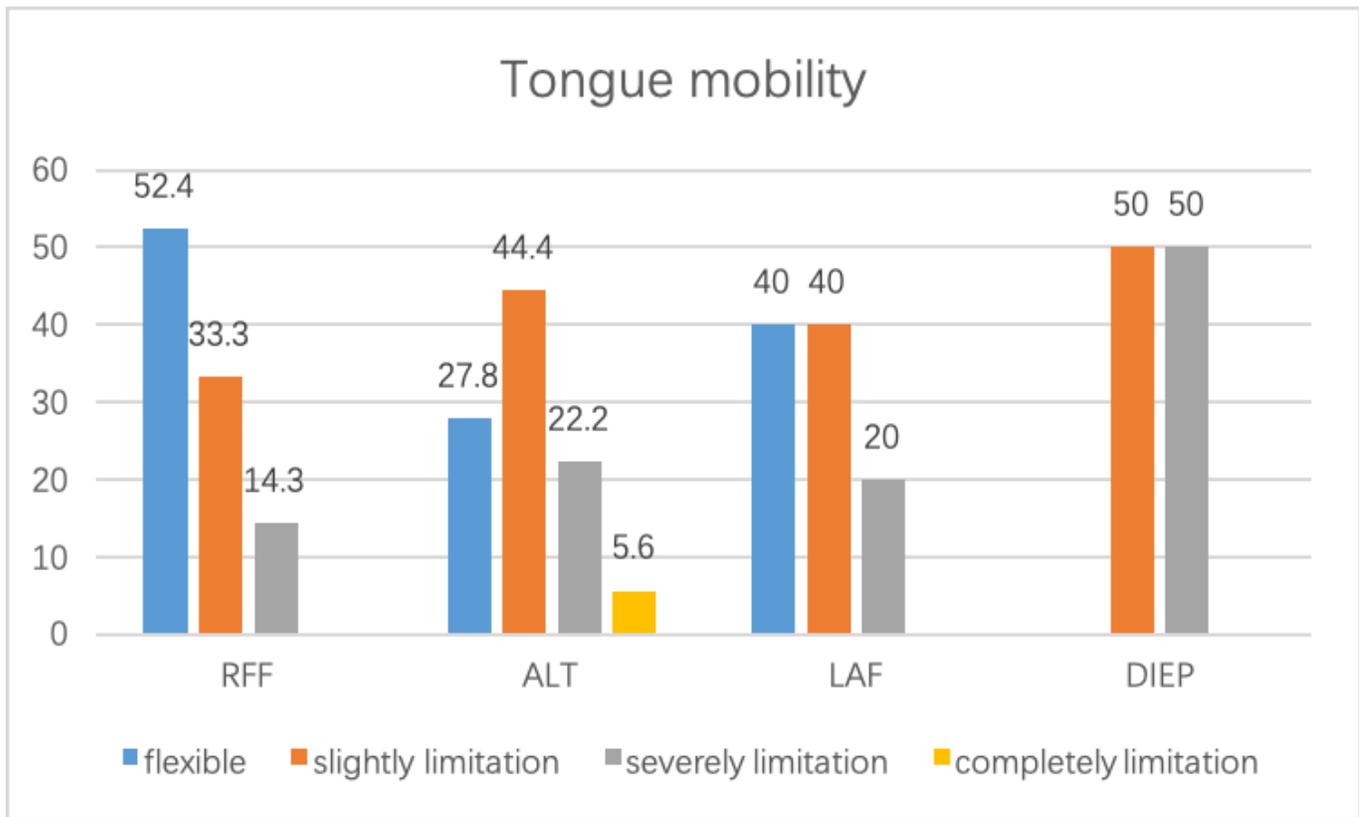


Figure 4

Tongue mobility contrast between four groups

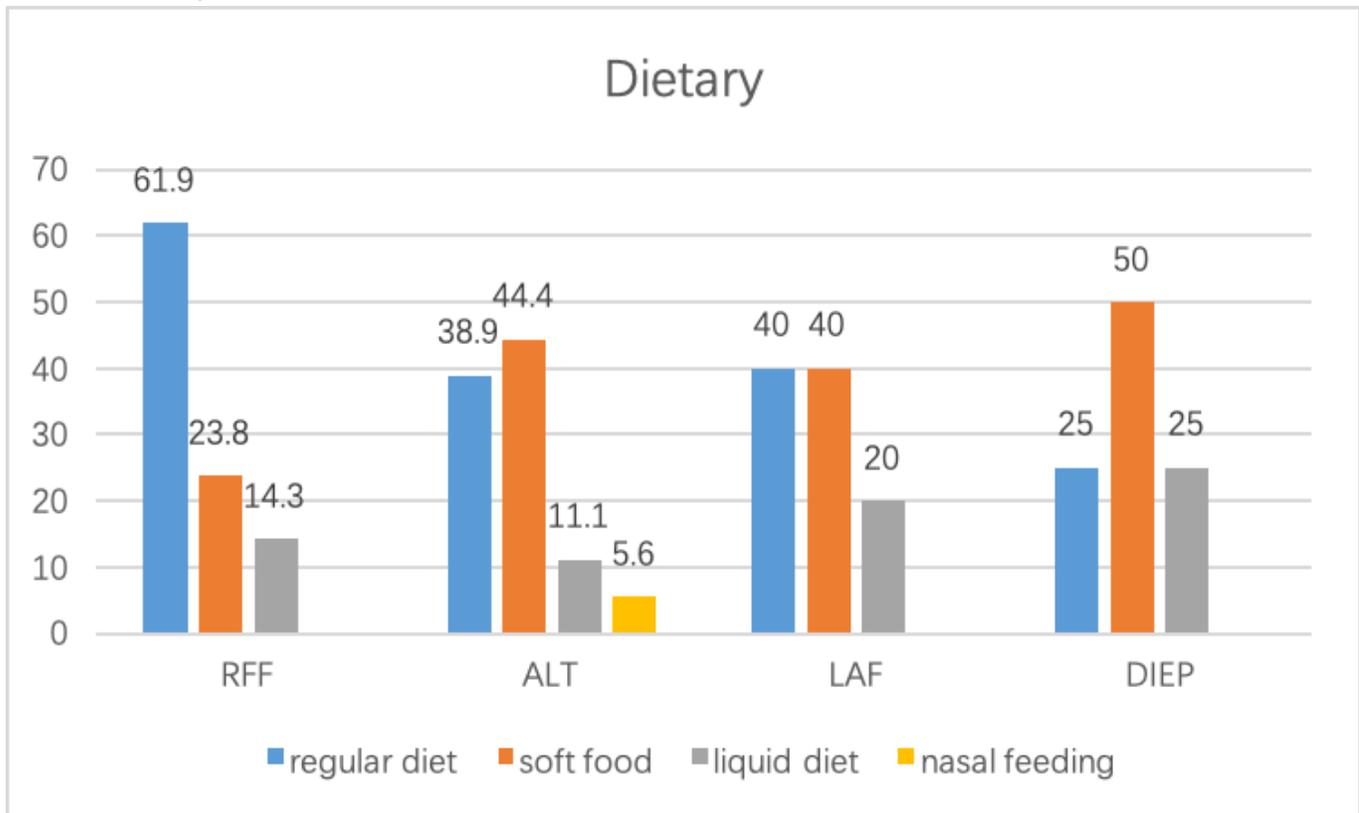


Figure 6

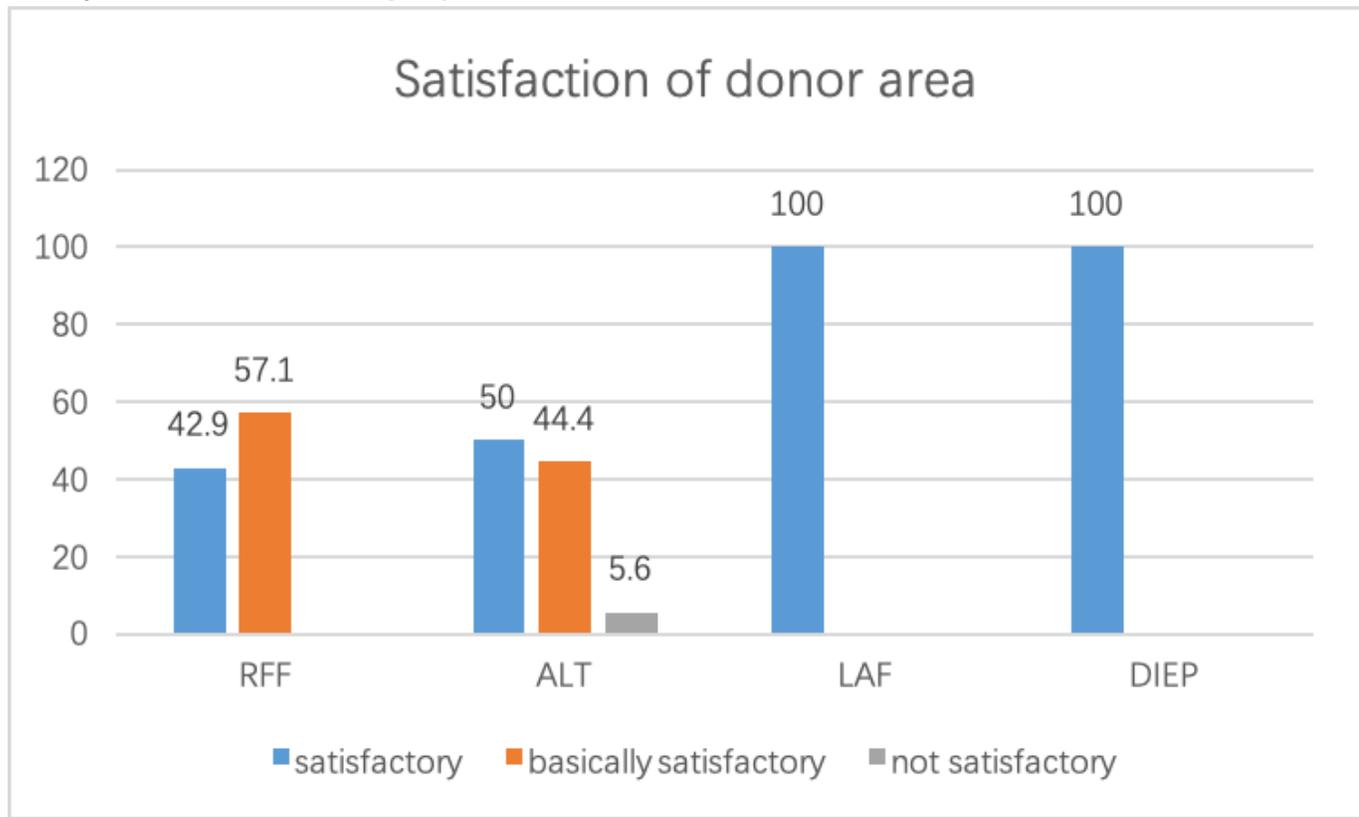


Figure 7

Satisfaction of donor area contrast between four groups

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