Journal of Plastic, Reconstructive & Aesthetic Surgery (2019) 72, 1785–1794

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

A flag-shaped anterolateral thigh free flap for complete circumferential hypopharyngeal reconstruction with dead space obliteration and monitoring flap inset

Tae Suk Oh[a,*], Jin Geun Kwon[a], Woo Shik Jeong[a], Soon Yuhl Nam[b], Seung Ho Choi[b], Jong Woo Choi[a]

[a] *Department of Plastic and Reconstructive Surgery, University of Ulsan College of Medicine, Asan Medical Center, 388-1 PungNap-2Dong, SongPa-Gu, Seoul 05505, Korea*
[b] *Department of Otolaryngology, University of Ulsan College of Medicine, Asan Medical Center, 388-1 PungNap-2Dong, SongPa-Gu, Seoul 05505, Korea*

Received 9 July 2018; accepted 15 May 2019

KEYWORDS
Anterolateral thigh free flap;
Hypopharynx;
Circumferential defect;
Dead space obliteration;
Monitoring flap

Summary *Background:* The challenging issues are to prevent anastomotic leakage and provide sufficient flap monitoring in circumferential hypopharyngeal reconstruction. In this study, a newly designed flag-shaped anterolateral thigh (ALT) free flap was used for circumferential hypopharyngeal reconstruction to address these issues.
Methods: Eighteen ALT flaps were harvested for reconstruction of circumferential hypopharyngeal defects from 2013 to 2016. The harvested ALT flap was sutured into a cylinder shape, and a triangular extension of the flap was used for dead space obliteration and flap monitoring. All data regarding outcomes and complications including radiographic investigations were collected retrospectively.
Results: The flap had a rectangular shape with dimensions of 29 cm × 8 cm (range, 25–31 cm × 6–10 cm). For each flap, 2–4 perforators were included (average, 2.6 perforators/flap). All flaps survived. One venous thrombosis was diagnosed early through the monitoring portion of the flap, and the flap was salvaged after thrombectomy with a vein graft. The mean follow-up period was 28.9 months (10.3). There was one case of definitive fistula (4%), which never healed because of early tumor recurrence. Three postoperative strictures were noted (21.4%).

* Corresponding author.
E-mail address: tasuko@amc.seoul.kr (T.S. Oh).

https://doi.org/10.1016/j.bjps.2019.05.038

Conclusions: For a complete circumferential hypopharyngeal defect, the flag-shaped ALT free flap design offers monitoring flap and dead space obliteration and prevents anastomotic leakage.

Introduction

Successful hypopharyngeal reconstruction requires a comprehensive understanding of the hypopharynx. First, the hypopharynx is a dynamic organ, and its function as a pathway for food and air must be preserved without any stricture. The functionally stable hypopharynx must expand and shrink, and the presence of a stricture indicates an unsuccessful reconstruction.[1] Second, although food can cause mechanical stress, saliva can cause chemical stress to structures surrounding the hypopharynx.[2,3] A small amount of salivary leakage can progress to a fatal result such as carotid blowout, which has a high mortality rate of approximately 40%.[4-6] Thus, prevention of partial necrosis or dehiscence is essential to achieve a watertight reconstruction. In summary, a successful hypopharyngeal reconstruction requires the reconstruction of a narrow tunnel with resistance to mechanical and chemical stress and without any stricture.[1]

Local flaps such as the pectoralis major musculocutaneous flap and chimeric free flaps have been used to reconstruct circumferential hypopharyngeal defects.[7] Currently, the anterolateral thigh (ALT) free flap is the mostly widely used solution to restore good speech quality owing to its relatively tolerable donor site morbidity, better swallowing function, less stricture rate, and cost-effectiveness than those of the free jejunal flap.[1,8-10] Ongoing studies are focusing on the design of the flap and how to insert an ALT free flap.[11,12] In a recent review, although many modified designs have been proposed, accumulative fistula and stricture rates of fasciocutaneous free flaps were 13% and 16.1%, respectively.[13]

To prevent such complications, an accurate understanding of hypopharyngeal defects is needed. In many cases, the suture site meets the dead space of the neck, which can delay healing of the suture site and cause leakage.[4] The elimination of this dead space is critical to prevent these complications. In addition, as a conventional monitoring flap can survive regardless of the viability of the entire flap owing to its small size, a new reliable method is needed to monitor survival of the buried flap.[14] In this study, a new design for circumferential hypopharyngeal reconstruction that can minimize these complications is presented.

Patients and methods

This study is a retrospective review of 18 consecutive patients who had circumferential hypopharyngeal reconstruction using an ALT free flap conducted between January 2013 and December 2016. All patients were male, and the average age of the patients was 65.5 years (range, 51–83 years) (Table 1). Preoperative CCRT (concurrent chemoradiotherapy) was performed in ten patients, five patients had postoperative chemotherapy, and six patients had postoperative radiotherapy. The mean follow-up duration was 28.9 months (SD: 10.3, range: 15–51 months). Seven patients underwent reconstruction with a new ALT free flap with a flag shape and newly introduced in this study. The remaining eleven patients underwent reconstruction with a conventional ALT free flap.

Table 1 Epidemiology of the patients.

	Flag-shaped ALT free flap	Conventional ALT free flap	*p value*
Age (years)	61.9	67.9	0.18
Sex (M/F)	7/0	11/0	
Follow-up (months)	28.2	27.6	0.17
Smokers (PY)	13.1	22.7	0.37
BMI (kg/m^2)	20.6	22.6	1
Diabetes	2 (28%)	1 (9.1%)	0.52
Hypertension	2 (28%)	5 (46%)	0.63

ALT, anterolateral thigh; M, male; F, female; PY, packyears.

Flap design and harvesting

Before surgery, the location of the perforators on the anterolateral thigh was determined by prerecorded CT angiography, and the exact location of the perforator was marked by a handheld Doppler. To confirm patency of the perforators, color duplex ultrasonography was performed.

After the completion of tumor resection by an otolaryngology team, the plastic surgery team designed the flap depending on the final defect size. To reconstruct the cylinder shape, an isosceles trapezoid with a centered perforator was designed. The upper and lower sides of the isosceles trapezoid were designed to be parallel to the axis of the leg. After measuring the perimeter of the superior border and inferior border of the defect (usually 10 cm and 8 cm, respectively), each of these borders was designed to be the length of the upper side and the lower side of the isosceles trapezoid, respectively. A triangle was then added to each oblique as shown in Figure 1.

The flap was elevated from below the fascial layer, and the triangular portion was de-epithelialized except for 1 cm at the distal tip, which corresponds to the monitoring flap indicated in Figure 1. The flap was folded in the direction of the skin inward, with contact made between A and A', B and B', C and C', and D and D' (Figure 1). Sutures were applied between A and B and reinforced with a second suture line between C and D. After completion of the prefabrication, the pedicle was harvested, and the de-epithelialized

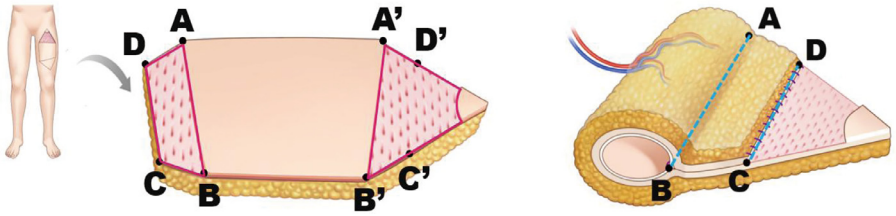


Fig. 1 Design and prefabrication of the flag-shaped anterolateral thigh free flap. De-epithelialization was performed, except for the luminal portion of the skin paddle and the monitoring flap. Prefabrication was performed using a double-layered suture.

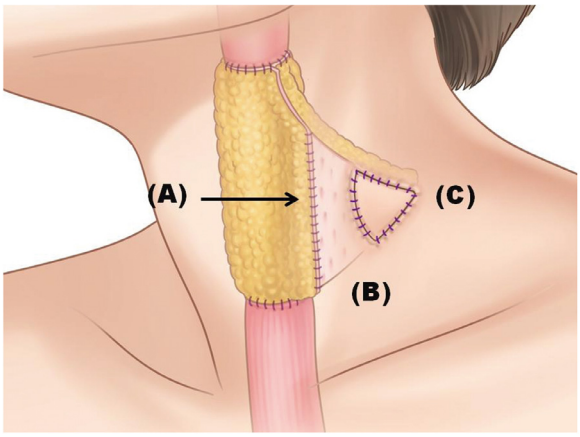


Fig. 2 Main features of the flag-shaped anterolateral thigh free flap. (A) Prefabrication using a double-layered suture to prevent leakage of the vertical suture line. (B) Dead space obliteration using de-epithelialized tissue. (C) Flap monitoring through the distal portion of the flap.

triangular portion was directed toward the dead space created by the neck dissection to obliterate the dead space (Figure 2). After key sutures were performed, microanastomoses were performed and the remaining portion was closed. All sutures were made as simple interrupted sutures using Vicryl 3-0 or 4-0 (Ethicon). During the skin closure, the monitoring flap was placed and used for flap monitoring. Considering that the shape of the prefabricated flap is similar to that of a triangular-shaped flag, the new design is called a flag-shaped ALT free flap.

The donor site was intended to be closed with a primary repair, and a split-thickness skin graft harvested from the ipsilateral thigh was performed only when the primary repair was difficult. Negative pressure wound therapy was maintained for 5 days, and it was performed for 2 days more if necessary.

Postoperative management

Immediately after surgery, the patient was maintained in a supine position with progressive head elevation to a sitting position after 5 days and to a wheelchair after 7 days. Computed tomography (CT) scan with contrast medium was performed 7-14 days postoperatively to assess the presence of dehiscence, and if there was no sign of dehiscence, food intake was increased progressively.

Results

The average duration for care in the intensive care unit was 1.12 days (range, 0-4 days). The mean hospital stay was 36.4 days (range, 22-89 days) in the flag-shaped ALT group and 38.36 days (range, 17-77 days) in the conventional ALT group. In the flag-shaped ALT free flap group, three patients showed signs of dehiscence with fluid collection during the follow-up CT scan. Three patients had inflammatory signs such as swelling and erythema of the neck, and thus, feeding through the Levin tube was prolonged. The inflammatory symptom was relieved in two patients, and the dehiscence recovered spontaneously as assessed by a CT scan at postoperative 1 month. However, dehiscence at the inferior margin was observed in 1/7 patients (14%; Patient 4), which was repaired using a pectoralis major muscle flap. In the conventional ALT group, 3/11 patients (27%; Patient 9, 13, and 18) showed dehiscence. In Patient 9, dehiscence at the inferior border was noted on postoperative day 11. An SCM flap was performed to cover the dehiscence by the ENT team, but the SCM flap failed. A pectoralis major musculocutaneous flap was used to close the dehiscence. In Patient 13, dehiscence at the lateral and superior borders was noted on a CT scan at postoperative day 9. First, a simple repair with debridement was attempted, but the dehiscence failed to heal. A pectoralis major musculocutaneous flap was elevated to cover the defect. In Patient 18, dehiscence at the lateral border was noted on a CT scan performed at postoperative day 9. Primary repair with debridement was performed twice under general anesthesia and the dehiscence closed.

Stricture occurred in one patient (Patient 2) in the flag-shaped ALT group. This patient complained of dysphagia and esophagogastroduodenoscopy revealed an esophageal stricture on postoperative day 451. Dilation of the stricture at the cervical esophagus was performed using a 20-mm balloon catheter. The esophageal stricture was resolved immediately after balloon dilatation, but the stricture recurred twice. Thus, repetitive balloon dilatation was performed. In the conventional ALT group, two patients (Patients 10 and 13) reported a stricture. Patient 10 suffered from dysphagia from postoperative day 90, and a CT scan revealed luminal narrowing near the anastomosis site. Balloon (16 mm) dilatation improved passage around the anastomosis site. Patient 13 reported dysphagia at postoperative day 412, and esophagography revealed an anastomosis site stricture. Treatment of the stricture was not performed because the patient's general condition was poor (Table 2).

Table 2 Complication after flag-shaped anterolateral thigh (ALT) free flap reconstruction and conventional ALT free flap.

	Flap failure (*n*/*p*)	Fistula (*n*/*p*)	Stricture (*n*/*p*)	Infection (*n*/*p*)	Hematoma (n/p)
Flag-shaped ALT group	0/0	1/14%	1/14%	0/0	0/0
Conventional ALT group	0/0	3/27%	2/18%	0/0	1/9%

n, number; *p*, percent; ALT, anterolateral thigh free flap.

For dehiscence and stricture occurrence, dehiscence-free and fistula-free survival rates were analyzed, respectively. There was no statistical significance in Kaplan–Meier analysis because of the small sample size (Figure 3).

Donor site complications did not occur, and there was no case of total flap loss. Patient data are listed in Table 3.

Patient 1 (Figure 4).

Patient 1 was a 56-year-old male with hypopharyngeal cancer. Reconstruction was performed using an ALT free flap to cover a circumferential hypopharyngeal defect. Using a 10 cm × 9 cm × 8 cm isosceles trapezoid skin paddle, a flag-shaped ALT free flap was elevated, and prefabrication was performed using a double-layered suture. After microanastomosis, the de-epithelialized tissue dead space was obliterated, and a monitoring flap was inset at the lateral aspect of the neck. During the first 10 postoperative days, erythema with swelling was noted, but inflammatory signs were resolved without surgical intervention. At postoperative 1 month, CT follow-up revealed no dehiscence.

Patient 6 (Figure 5).

Patient 6 was a 74-year-old male who had undergone total pharyngolaryngectomy for hypopharyngeal cancer. A flag-shaped ALT free flap with a 10 cm × 10 cm × 7 cm skin paddle was elevated, and prefabrication was performed. Because of the advanced age of the patient, a pharyngostoma was inserted through the vertical suture line. After 2 weeks, the pharyngostoma was removed, and there were no complications.

Discussion

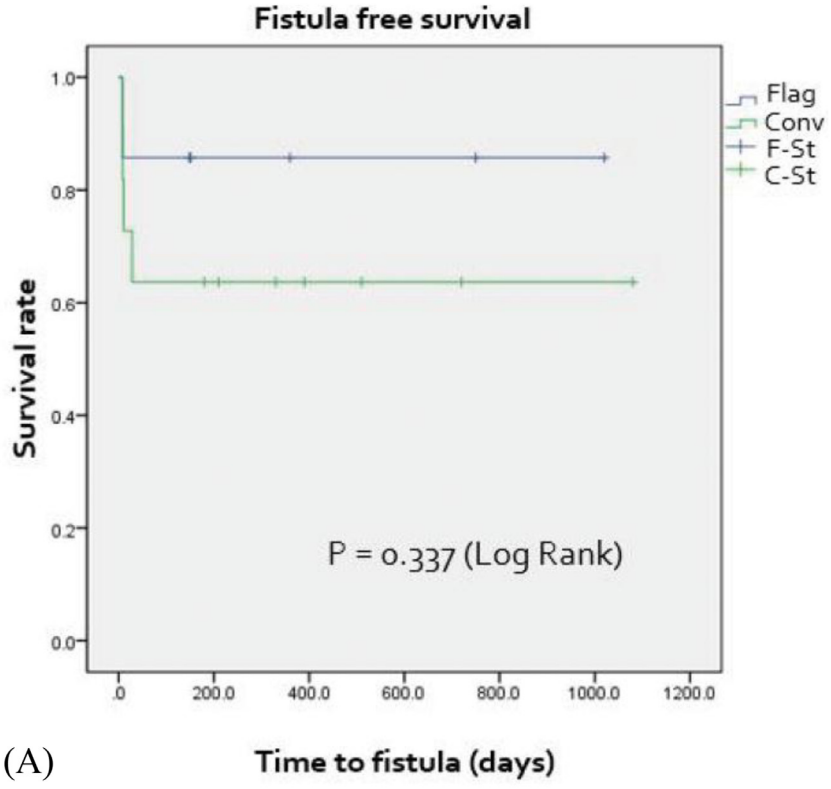
Several free flap surgical methods have been suggested for the reconstruction of circumferential hypopharyngeal defects. The earliest methods relied on the use of local cervical tissues, which resulted in the development of the pectoralis major myocutaneous flap,[15] trapezius flap,[16] and latissimus dorsi myocutaneous flap.[17] However, the local flap provided insufficient tissue, hence resulting in various complications.

The free flap was first attempted as a free visceral flap by Seidenberg et al. in 1957. The free flap gained popularity as microvascular techniques evolved during the 1970s.[18] The jejunal free flap was an improvement on the local flap, but the incidence of fistula and stricture remained problematic.[19,20] The jejunal free flap has significant limitations owing to the size discrepancy between the tongue base and the jejunal lumen, the thin wall of the jejunum, and jejunal traction during placement.[19] In addition, the relatively high rates of donor site complications such as ileus, small bowel obstruction, hernia, and spasm increased the need for new methods for the reconstruction of circumferential hypopharyngeal defects.[7]

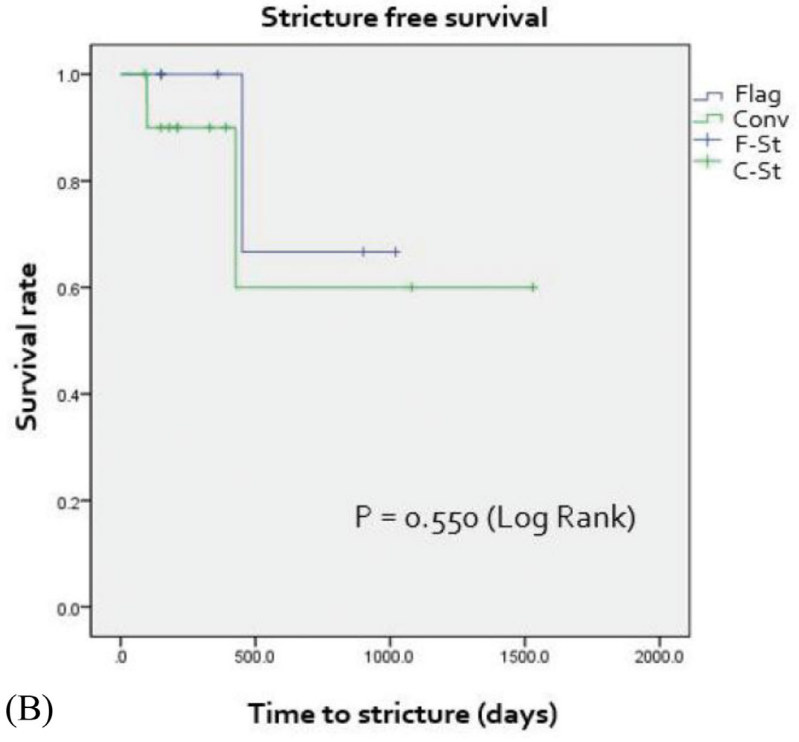
The ALT free flap is used increasingly in circumferential hypopharyngeal reconstruction and is recognized as the most reliable method.[10,11,13,21] The ALT free flap can be elevated as a fasciocutaneous flap or myocutaneous flap and can provide a large skin paddle with only one perforator that can be traced accurately and preoperatively using CT and Doppler. Thus, the ALT free flap solves the problem of the skin paddle size observed in previous methods.[22] However, the risk of developing dehiscence or fistula was higher with the ALT free flap than with the jejunal free flap because of the additional vertical line.[9,13] Several designs using the ALT free flap have been proposed. For example, many centers add the triangular extension to prevent stricture at the distal anastomosis site. However, even though there were many improvements in the design of ALT free flap, the major complication has not been solved, and hence, new methods are needed.[13]

This study has four important outcomes. First, the application of a double-barrier suture to the vertical line resulted in the formation of a perfect barrier by spacing the distance between the two suture lines. The tissue between the suture gaps is de-epithelialized, which allows quick adhesion between the two tissues.[4] The suture method used a simple interrupted suture to maximize tensile stretching.[23] For example, in a CT scan taken on postoperative day 10, the two de-epithelialized layers were in sufficiently close contact to allow the formation of the flag portion (Figure 6). In the flag-shaped ALT free flap group, fistula occurred in only 1 case and in the inferior margin, with no problem in the vertical suture line.

Second, the flag-shaped design provided tissue to obliterate the dead space and to distribute the tension at the anastomosis site. In the case of patients with advanced head and neck cancer, severe neck dissection is performed in most cases, which can create significant dead space. This dead space can lead to not only seroma but also to wound dehiscence. Thus, proper dead space obliteration is required.[4] In the case of the flag-shaped ALT free flap, dead space obliteration is performed using the flag portion. This portion is de-epithelialized for dead space obliteration. We were concerned that the JP drain maintenance period would increase due to serous discharge from the de-epithelialized portion. However, in actual clinical practice, the maintenance period of the JP drain was 13 days in both the flag-shaped ALT group and the conventional ALT group. In addition, in the conventional flap design, if the total flap load is concentrated on the proximal anastomosis site, the portion corresponding to the flag in the flag-shaped design can enlarge



(A)



(B)

Fig. 3 Fistula and stricture free survival rates (Kaplan–Meier analysis).

Table 3 Data of patient epidemiology and complication.

Case	Age	DM	HTN	BMI (kg/m^2)	Smoker (PY)	P/R	Stage	Adjuvant CCRT	Post CTx	Post RTx	Skin paddle (cm)	Drain (days)	HS	Dehiscence (<14 days)	Dehiscence (>1 month)	Stricture	Follow-up (months)
Flag-shaped ALT free flap group																	
1	56	X	X	20.9	0	P	T3N2M0	O	X	X	$10 \times 9 \times 8$	20	38	O(SH)	X	X	17
2	68	O	O	22.1	0	R	T4aN0M0	O	X	X	$10 \times 9 \times 8$	13	21	X	X	O(BD)	37
3	51	X	X	21.9	0	P	T3N1M0	O	X	X	$10 \times 9 \times 7$	11	23	X	X	X	46
4	59	X	O	19.4	30	R	T3N1M0	O	O	O	$10 \times 8 \times 8$	16	89	O	O(PMMC)	X	40
5	66	X	X	20.4	7	P	T3N2M0	X	O	O	$11 \times 9 \times 7$	15	22	X	X	X	24
6	74	O	X	22.4	40	P	T3N0M0	O	X	X	$10 \times 10 \times 7$	6	23	X	X	X	17
7	59	X	X	17.1	15	P	T3N0M0	O	X	X	$10 \times 9 \times 8$	14	39	O(SH)	X	X	17
Conventionally designed ALT free flap group																	
8	73	X	X	17.6	50	P	T4N0M0	X	X	X	$11 \times 9 \times 7$	16	17	X	X	X	36
9	71	X	O	17.1	45	P	T4N2M0	O	O	O	$13 \times 9 \times 9$	32	64	O	O(PMMC)	X	19
10	69	X	X	18.1	30	R	T3N0M0	X	O	O	$11 \times 11 \times 9$	16	21	X	X	X	20
11	57	X	X	18.7	35	P	T3N1M0	X	O	O	$10 \times 10 \times 8$	9	X	X	X	O(BD)	29
12	73	X	O	22.9	0	P	T3N1M0	X	X	O	$12 \times 11 \times 8$	6	22	X	X	X	19
13	69	X	O	30.4	0	P	T3N1M0	O	X	X	$10 \times 10 \times 8$	10	77	O	O(PMMC)	X	17
14	62	O	O	31.9	0	P	T4N2M0	X	X	X	$12 \times 8 \times 7$	11	23	X	X	O	48
15	80	X	O	19.3	30	P	T4N1M0	X	X	O	$10 \times 6 \times 5$	10	24	X	X	X	25
16	53	X	X	21.9	30	P	T2N2M0	O	O	O	$11 \times 9 \times 8$	7	45	X	X	X	17
17	83	X	X	17.7	0	P	T4N2M0	O	X	X	$11 \times 10 \times 9$	17	39	X	X	X	23
18	57	X	X	31.1	30	P	T3N2M0	X	X	O	$11 \times 9 \times 8$	15	60	X	O(Repair)	X	51

P, primary cancer; R, recurred cancer; PY, packyear c; DM, diabetes mellitus; HTN, hypertension; HS, hospital stay; CCRT, concurrent chemoradiation therapy; Post CTx, postoperative chemotherapy; Post RTx, postoperative radiotherapy; ALT, anterolateral thigh; SH, spontaneous healing; PMMC, pectoralis major musculocutaneous flap; BD, balloon dilatation.

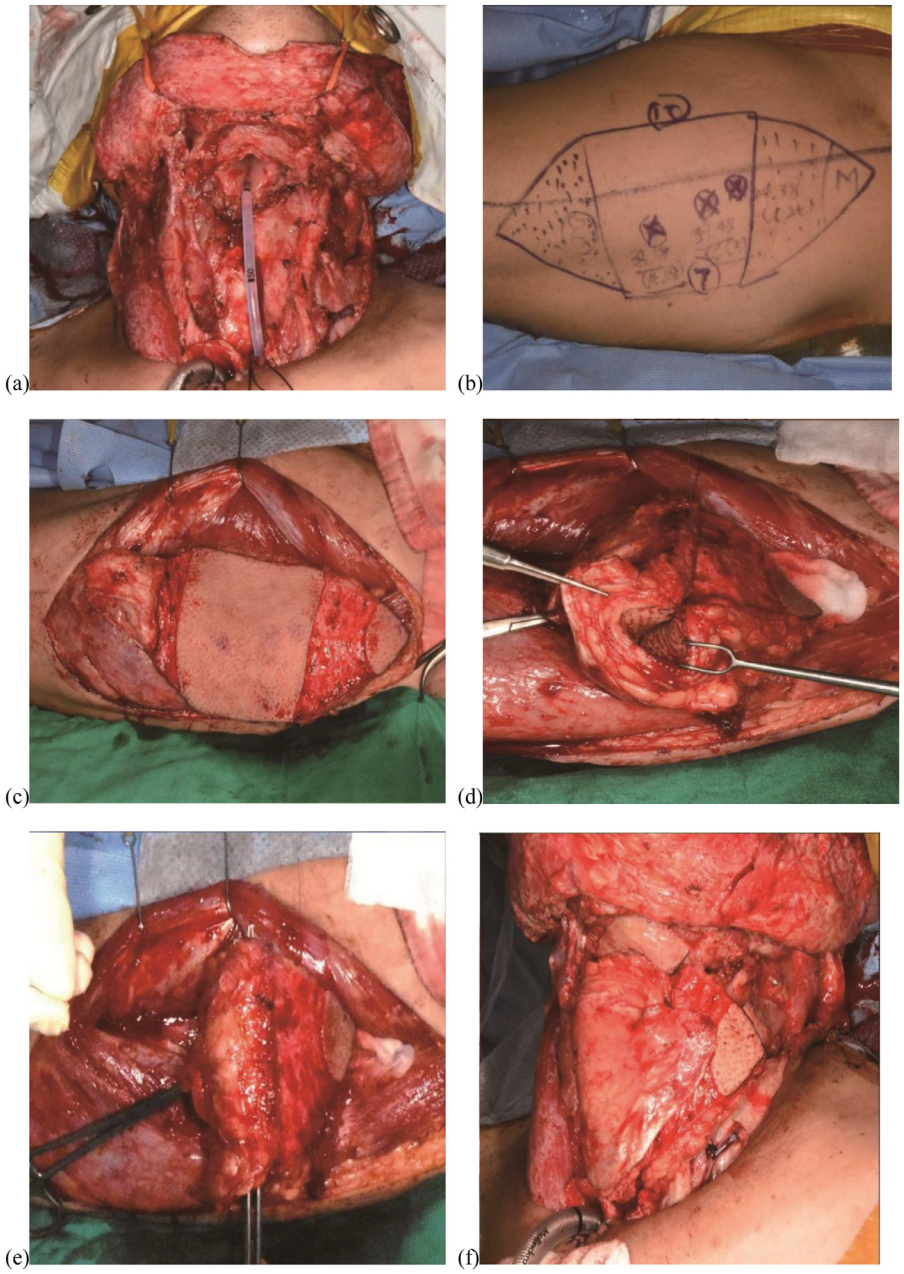


Fig. 4 (A) A 56-year-old male patient (Patient 1) had total pharyngectomy due to hypopharyngeal cancer. (B) A 10 cm × 9 cm × 8 cm isosceles trapezoid skin paddle was designed. (C) With the de-epithelialized bilateral flag portion, a below fascial elevation was done. (D) and (E) To prevent leakage at the vertical line, prefabrication with a double-layered suture was performed. (F) With the de-epithelialized tissue, the dead space was obliterated and a monitoring flap was insetted at the lateral neck.

the surrounding tissue and contact surface to reduce the load on the proximal anastomosis site. In particular, the patient is maintained in the supine position during the immediate postoperative care, and head elevation is increased by 15° daily from postoperative day 1 to provide sufficient time for adhesion between the flap and surrounding tissues.

Third, our results demonstrate that a skin monitoring flap helps detect a pending vascular compromise of the flap.[14] For monitoring the buried flap, many methods have been tried, such as handheld Doppler and implanted Doppler. However, the reliability of detecting flap failure in time for salvaging the flap has been low. A direct monitoring flap is required to overcome the complexity of vessel structure in the head and neck. In particular, the monitoring flap used in this study uses a distal tip of the flap, which can be expected to result in high and accurate sensitivity. In addition, after postoperative day 14, monitoring flap excision is performed easily under local anesthesia, and primary closure with minimal scar is possible.

Fourth, the flag-shaped design shortens the ischemic time by reducing the time for insetting. After flap elevation, prefabrication of the cylinder shape is performed

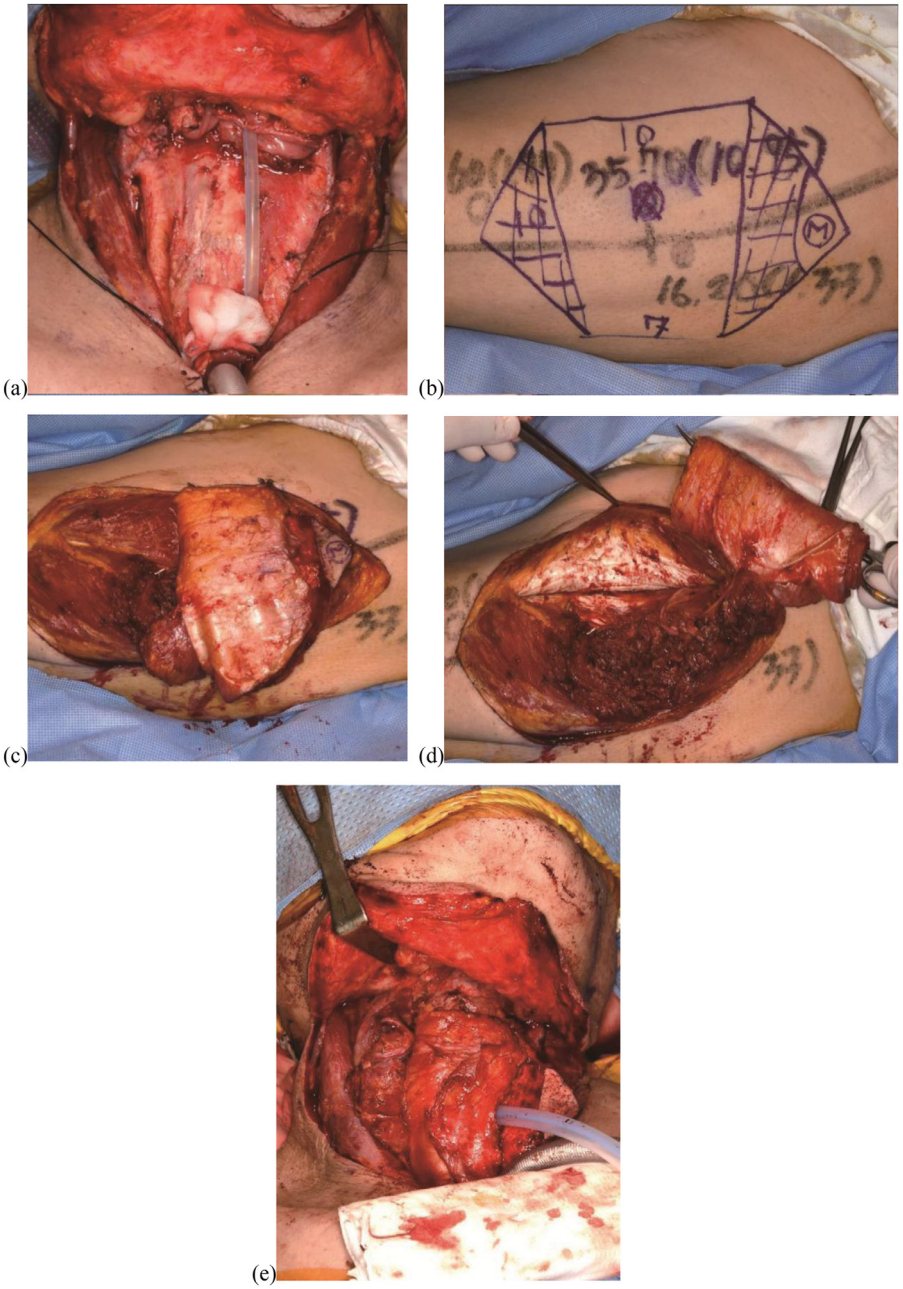


Fig. 5 (A) A 74-year-old male patient (Patient 6) underwent total pharyngectomy. (B) Using a 10 cm × 10 cm × 7 cm isosceles trapezoid skin paddle, a below fascial flap elevation was performed. (C) and (D) Before clamping, prefabrication of the cylinder with a double-layered suture was performed. (F) Dead space was obliterated, and the monitoring flap was constructed using the flag portion of the flap.

before pedicle clamping, which provides easier suturing and insetting procedures at the proximal and distal anastomosis sites. The prefabrication procedure reduces tension on each suture by distributing the tension evenly on the proximal anastomosis site.

The occurrence of neck-bulging due to discharge from the de-epithelialized tissue was a concern. However, neck-bulging was not observed during the follow-up period, and the neck contour was maintained in patients who underwent radiation therapy. Sufficient soft tissue may reduce the limitations in range of motion that can occur after radiation therapy, but further studies are needed.

In this study, three patients from the flag-shaped ALT free flap group showed inflammatory signs suspicious of early anastomotic leakage. If dehiscence is determined based on inflammatory signs immediately after surgery and ambiguous CT findings, then the dehiscence rate of this study would be higher than that found in other studies. Immediately after surgery, however, there may be differences in the determination of dehiscence due to the sensitivity of monitoring.

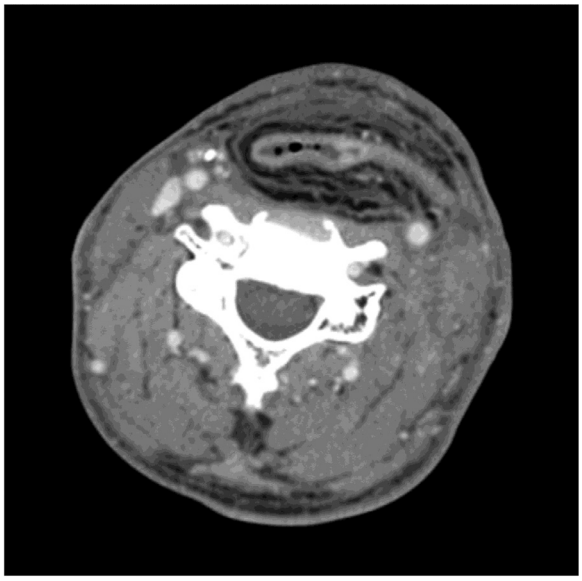


Fig. 6 Axial image of the postoperative computed tomography scan of the patient who had a flag-shaped anterolateral thigh free flap.

There are some limitations to the design of the flag-shaped ALT free flap. In this study, the upper and lower sides of the isosceles trapezoid flap were set parallel to the lower extremity axis. Considering that the linking vessels on the thigh run parallel to the lower extremity axis, as the height of the isosceles trapezoid flap increases, the upper and lower sides of the flap, which form the superior and inferior border of the defect, respectively, may be located outside of the angiosome, leading to a decrease in blood supply. Therefore, if the defect is large, such as a defect caused by total pharyngolaryngoesophagectomy, the application of this design should be reconsidered. The patients discussed in this study were all Asian population; hence, there is a chance of underestimating the thickness of the subcutaneous layer at the thigh because in the obese patient population, the tubularization using the flag-shaped ALT free flap can be meaningless due to thick subcutaneous layer. In addition, if the radiologist does not have a clear understanding of the flag-shaped design, the imaging may be misinterpreted as dehiscence. Therefore, proper communication between the radiologist and ENT team is required.

Conclusion

The flag-shaped ALT free flap design presented in this study offers a potential approach for monitoring flap, dead space obliteration, and prevention of anastomotic leakage for the patients who need circumferential hypopharyngeal defect reconstruction. Future studies with more cases and long-term follow-up should be performed.

Financial disclosure statement

The authors have no commercial associations or financial disclosures to declare.

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