Pedicled Flaps versus Free Flaps for Oral Cavity Cancer Reconstruction: A Comparison of Complications, Hospital Costs, and Functional Outcomes

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Abstract

Introduction Free flaps have been the preferred method for reconstruction after resection of oral cavity cancer. However, pedicled flaps remain valuable alternatives in appropriate settings.

Objective The main objective of the present study was to compare surgical complications, hospital costs, and functional outcomes of oral cavity cancer patients who underwent soft tissue reconstruction with pedicled flaps or free flaps.

Methods A total of 171 patients were included in the study. Ninety-eight underwent reconstruction with a pectoralis major, submental, temporalis, or supraclavicular pedicled flap, and in 73 patients, a radial forearm or anterolateral thigh free flap had been used. The cases were retrospectively reviewed, and a comparative analysis was carried out between the two groups.

Results Recipient site and flap complications, speech, and swallowing functions did not differ between groups, but donor site complications, operative time, hospital stay, and costs were significantly reduced in the pedicled flap group compared with the free flap group. However, the pectoralis major flap reconstruction resulted in a more inferior swallowing function than the free flap reconstruction.

Conclusions With comparable complications and functional outcomes, while decreasing in costs, pedicled flaps are a useful alternative to free flaps in oral cavity cancer reconstruction. However, in an extensive defect ($> 70\,cm^2$), free flaps are the reconstruction of choice for the preservation of swallowing function.

Keywords
- pedicled flap
- free flap
- oral cancer
- reconstruction

Introduction

The mainstay of treatment of oral cavity cancer in both early and advanced stages is surgery, which often affects speech and swallowing functions and also has a significant impact on the quality of life of the patient.[1–4] The reconstruction of intraoral tissue following tumor extirpation is a major challenge, and the aims should include adequate wound healing and successful functional rehabilitation.[3]

Free flaps have been referred to as the standard reconstruction of defects after resection in cases of head and neck cancer, including oral cavity cancer, because of their reliability and versatility.[5–7] However, not all defects require a free flap to achieve good outcomes and not every patient is a

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suitable candidate for a microvascular procedure. Therefore, regional pedicled flaps may be useful in treating patients with coexisting morbidities, have a short life expectancy, have poor recipient vascularity, and also in certain circumstances, including lack of microsurgical facilities and financial issues.[8–12] There has been a recent resurgence of interest in the use of pedicled flaps in addition to the "workhorse" pectoralis major myocutaneous flap, including a submental island flap, temporalis myofascial flap, and supraclavicular island flap, which increases versatility in most of the head and neck defects.[4,6,10,11,13–16] In addition, with the global strain on hospital resources during the COVID-19 pandemic, pedicled flaps can be a useful reconstruction in the current situation.[17,18]

The purpose of the present study is to compare postoperative outcomes, including surgical complications, duration of hospital stay, hospital costs, and functional results in oral cavity cancer patients who underwent surgical resection followed by soft tissue reconstruction with a pedicled flap including pectoralis major myocutaneous, submental island, temporalis myofascial, and supraclavicular island flaps or a free flap including radial forearm and anterolateral thigh free flaps.

Material and Methods

We conducted a retrospective study of patients with squamous cell carcinoma of the oral cavity who were surgically treated between November 2010 and October 2017. All procedures contributing to the present work complied with the ethical standards of the relevant national and institutional guidelines on human experimentation, and with the Helsinki Declaration of 1975, as revised in 2008, and were approved by the Research Ethics Committee of the institution.

Patients who underwent intraoral carcinoma resection and immediate soft tissue reconstruction with regional pedicled flaps (pectoralis major myocutaneous, submental island, temporalis myofascial, and supraclavicular island flaps) or microvascular free flaps (radial forearm and anterolateral thigh free flaps) were included in the study. The method of reconstruction was based on patient comorbidity and patient-physician agreement. Patients with a previous history of radiotherapy or of surgery and those who required bony reconstruction were excluded. Patients with stage T1 tumors were not included in the study because most of the defects were primarily closed, reconstructed with local flaps, or healed by secondary intention.

All patients underwent selective or comprehensive (radical or modified radical) neck dissection, and either unilateral or bilateral neck dissection, depending on the clinical status of the cervical lymph node. Patients with a primary tumor extending through the mylohyoid muscle, or with a level I cervical lymph node with a sign of extranodal extension of cancer or > 1.5 cm in diameter, were contraindicated for a submental island flap.

Postoperative adjuvant therapies, including radiotherapy or chemoradiotherapy, were considered if the tumors were of an advanced stage (stages III-IV), had close or invaded surgical margins, or exhibited an extracapsular extension of the lymph nodes.

Surgical complications and outcomes related to speech and swallowing functions were assessed using a scoring system, shown in ►**Table 1**. These were evaluated in every patient for at least 1 year after treatment. In addition, duration of hospital stay, and hospital costs were reviewed.

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). Clinical demographics and disease variables were analyzed using nonparametric qualitative and quantitative tests. The Fisher exact test, an independent t-test, the chi-squared test, and odds ratio (OR) with 95% confidence intervals (CIs) were used to compare the data. A p-value < 0.05 was considered statistically significant.

Results

A total of 171 patients were enrolled into the study. Ninety-eight patients underwent pedicled flap reconstruction, and 73 patients had free flap reconstruction. Patient demographics and clinical characteristics of both groups are summarized in ►**Table 2**. The two groups did not significantly differ in mean age, gender, preoperative risk factors (smoking, alcohol drinking, diabetes mellitus, chronic obstructive pulmonary disease, and American Society of Anesthesiologists [ASA] classification), primary site location, and T staging. Regarding N staging, there were more patients with clinical N0 than N+ in the pedicled flap group than in those in the free flap group (28.6 versus 12.3%, respectively, $p = 0.014$). However, no differences were detected when comparing the overall N stages and types of neck dissection (selective or radical or modified radical and unilateral or bilateral).

Table 1 Postoperative functional results of speech and swallowing scores

Score	Speech	Swallowing
5	all speech is understood (excellent)	full diet
4	speech is sometimes not understood (good)	soft diet
3	speech can be understood when conversational content is already known (fair)	liquid diet
2	speech can sometimes be understood (poor)	combined oral and feeding tube
1	nothing is understood (bad)	exclusively by feeding tube

Table 2 Demographics and clinical characteristics of patients reconstructed with pedicled flaps or free flaps

	Pedicled flaps				Free flaps		Pedicled flap group $n=98$ (%)	Free flap group $n=73$ (%)	*p-value* (Pedicled flap group vs Free flap group)
	PMMF $n=23$ (%)	SMF $n=47$ (%)	TMF $n=16$ (%)	SCF $n=12$ (%)	RFF $n=59$ (%)	ALT $n=14$ (%)			
Age (mean (range); years old	65 (56–72)	61.3 (48–70)	62.8 (57–70)	63.7 (54–76)	61.4 (45–71)	60.6 (49–69)	62.7 (48–76)	61.3 (45–71)	0.057
Gender									0.495
- Male	17 (73.9)	31 (66)	10 (62.5)	7 (58.3)	42 (71.2)	10 (71.4)	65 (66.3)	52 (71.2)	
- Female	6 (26.1)	16 (34)	6 (36.7)	5 (41.7)	17 (28.8)	4 (28.6)	33 (33.7)	21 (28.8)	
Smoke									0.178
- Yes - No	19 (82.6)	35 (74.5)	10 (62.5)	9 (75)	37 (62.7)	10 (71.4)	73 (74.5)	47 (64.4)	
	4 (17.4)	12 (25.5)	6 (37.5)	3 (25)	22 (37.3)	4 (28.6)	25 (25.5)	26 (35.6)	
Alcohol									0.876
- Yes	12 (52.2)	28 (59.6)	8 (50)	9 (75)	33 (55.9)	8 (57.1)	57 (58.2)	41 (56.2)	
- No	11 (47.8)	19 (40.4)	8 (50)	3 (25)	26 (44.1)	6 (41.9)	41 (41.8)	32 (42.8)	
DM									0.518
- Yes	4 (17.4)	10 (21.3)	1 (6.2)	1 (8.3)	7 (11.9)	2 (14.3)	16 (16.3)	9 (12.3)	
- No	19 (82.6)	37 (78.7)	15 (93.7)	11 (91.7)	52 (88.1)	12 (85.7)	82 (83.7)	64 (87.7)	
COPD									0.217
- Yes	6 (26.1)	10 (21.3)	2 (12.5)	1 (8.3)	7 (11.9)	2 (14.3)	19 (19.4)	9 (12.3)	
- No	17 (73.9)	37 (78.7)	14 (87.5)	11 (91.7)	52 (88.1)	12 (85.7)	79 (80.6)	64 (87.7)	
ASA classification									0.146
- I-II	17 (73.9)	42 (89.4)	14 (87.5)	11 (84.7)	54 (91.5)	14 (100)	84 (85.7)	68 (93.2)	
- III	6 (21.1)	5 (10.6)	2 (12.5)	1 (8.3)	5 (8.5)	0 (0)	14 (14.3)	5 (6.8)	
Primary site location									0.562
- Tongue	9 (39.1)	28 (59.6)	–	9 (75)	27 (45.8)	8 (57.2)	46 (46.9)	36 (49.3)	
- FOM	7 (30.4)	10 (21.3)	–	1 (8.3)	13 (22)	5 (35.7)	18 (18.4)	17 (23.3)	
- Buccal	6 (26.1)	5 (10.6)	4 (25)	2 (16.7)	11 (18.6)	1 (7.1)	17 (17.3)	12 (16.4)	
- Palate	–	–	5 (31.2)	–	3 (5.1)	–	5 (5.1)	3 (4.1)	
- RTM	1 (4.4)	3 (6.4)	7 (43.8)	–	3 (5.1)	–	11 (11.2)	3 (4.1)	
- Alveolar ridge	–	1 (2.1)	–	–	2 (3.4)	–	1 (3.1)	2 (2.7)	

Table 2 (*Continued*)

	Pedicled flaps				Free flaps		Pedicled flap group $n = 98$ (%)	Free flap group $n = 73$ (%)	*p-value* (Pedicled flap group vs Free flap group)
	PMMF $n = 23$ (%)	SMF $n = 47$ (%)	TMF $n = 16$ (%)	SCF $n = 12$ (%)	RFF $n = 59$ (%)	ALT $n = 14$ (%)			
T stage									0.435
- T2	–	27 (57.4)	11 (68.8)	5 (41.7)	23 (39)	2 (14.3)	43 (43.9)	25 (34.3)	
- T3	6 (26.1)	8 (17.1)	4 (25)	3 (25)	15 (25.4)	4 (28.6)	21 (21.4)	19 (26)	
- T4	17 (73.9)	12 (25.5)	1 (6.2)	4 (33.3)	21 (35.6)	8 (57.1)	34 (34.7)	29 (39.7)	
N stage									0.054
- N0	–	20 (42.5)	6 (37.5)	2 (16.7)	8 (13.6)	1 (7.1)	28 (28.6)	9 (12.3)	
- N1	5 (21.7)	17 (36.2)	9 (56.3)	3 (25)	24 (40.7)	1 (7.1)	34 (34.7)	25 (34.3)	
- N2	11 (47.8)	8 (17)	1 (6.2)	4 (33.3)	17 (28.8)	7 (50)	24 (24.5)	24 (32.9)	
- N3	7 (30.5)	2 (4.3)	–	3 (25)	10 (16.9)	5 (35.7)	12 (12.2)	15 (20.5)	
Neck dissection Side									0.218 0.143
- Unilateral	7 (30.4)	26 (55.3)	9 (56.2)	8 (66.7)	27 (45.8)	3 (21.4)	50 (51)	30 (41.1)	
- Bilateral	16 (69.6)	21 (44.7)	7 (43.8)	4 (33.3)	32 (54.2)	11 (78.6)	48 (49)	43 (58.9)	
Type									
- Selective	1 (4.3)	19 (40.4)	6 (37.5)	2 (16.7)	10 (16.9)	2 (14.3)	28 (28.6)	12 (16.4)	
- Modified	18 (78.3)	27 (57.5)	10 (62.5)	10 (83.3)	47 (79.7)	10 (71.4)	65 (66.3)	57 (78.1)	
- Radical	4 (17.4)	1 (2.1)	–	–	2 (3.4)	2 (14.3)	5 (5.1)	4 (5.5)	
Defect size									$< 0.001^*$
(mean (range); cm^2	52.7 (36–72)	33 (24–60)	17.7 (12–24)	18.3 (9–48)	51.2 (28–80)	62.1 (36–80)	33.3 (9–72)	53.3 (28–80)	
Operation time									$< 0.001^*$
(mean (range); minutes	312 (280–360)	189 (125–250)	163 (140–210)	334 (300–420)	411 (365–480)	422 (370–490)	232 (125–420)	413 (365–490)	
Pathological margin - Clear	-	20 (42.6)	6 (37.5)	2 (16.7)	16 (27.1)	1 (7.1)	28 (28.6)	17 (23.3)	0.486
- Close/Positive	23 (100)	17 (57.4)	10 (62.5)	10 (83.3)	43 (72.9)	13 (92.9)	70 (71.4)	56 (76.7)	
Postoperative treatment									
- No	–	20 (42.6)	5 (31.2)	–	10 (16.9)	–	25 (25.5)	10 (13.7)	0.069
- RT/CRT	23 (100)	27 (57.4)	11 (68.2)	12 (100)	49 (83.1)	14 (100)	73 (74.5)	63 (86.3)	

Abbreviations: ALT, anterolateral thigh free flap; ASA, American Society of Anesthesiologists; CRT, chemoradiotherapy; DM, diabetes mellitus; FOM, floor of the mouth; PMMF, pectoralis major myocutaneous flap; RFF, radial forearm free flap; RT, radiotherapy; RTM, retromolar trigone; SCF, supraclavicular island flap; SMF, submental island flap; TMF, temporalis myofascial flap; COPD, chronic obstructive pulmonary disease.
*indicates significant difference at $p < 0.05$.

The mean size of the defects in the pedicled flap group was significantly smaller than that in the free flap group (33.3 versus 53.3 cm^2, respectively, $p < 0.001$). The mean operative time was significantly shorter in the pedicled flap group than in the free flap group (232 versus 413 minutes, respectively, $p < 0.001$). Pathological reports of surgical margin (clear versus close or positive) and postoperative treatment (no versus radiotherapy or chemoradiotherapy) did not differ between the two groups.

Data pertinent to surgical complications are shown in ►**Table 3**. Donor site complications were significantly fewer in the pedicled flap group. However, shoulder dysfunction was the most common complication in patients with the pectoralis major myocutaneous flap. In contrast, partial loss of the skin graft and arm dysfunction, such as restriction of grip strength, of pinch strength, and of wrist movements, were frequently found in patients who had undergone a radial forearm free flap.

The recipient site complication rate did not significantly differ between the two groups. However, orocutaneous fistula and wound dehiscence were recorded most frequently in the pectoralis major myocutaneous flap cases. These complications were conservatively managed with necrotic tissue debridement and resuturing, wound reopening and collection removal, and local wound care.

Although there were no differences in flap complications, 5 patients in the free flap group required revision of vascular anastomosis, and 2 patients with radial forearm free flap had total flap loss, which occurred at postoperative day 9 and day 12; 1 patient with hard palate resection required postoperative palatal prosthesis, and another with oral tongue and floor of mouth defect required pectoralis major myocutaneous flap re-reconstruction. All patients with partial flap loss were successfully managed with tissue debridement and wound resuturing.

The mean duration of hospital stay was significantly shorter in the pedicled flap group than in the free flap group (20 versus 31 days, respectively, $p < 0.001$). Concerning mean hospital costs during admission, pedicled flap reconstruction was significantly less costly than free flap reconstruction (4,360 versus 7,935 US Dollars, respectively, $p < 0.001$) (►**Table 3**).

Regarding functional outcomes, most of the patients in both groups had excellent to good speech function (80.7% in the pedicled flap group and 79.5% in the free flap group, $p = 0.947$). Moreover, most patients were able to take a full or soft diet (81.7% in the pedicled flap group and 82.2% in the free flap group, $p = 0.768$). (►**Table 4**)

In comparison with the free flap group, patients undergoing reconstruction with a pectoralis major myocutaneous flap had significantly higher mean age, were more in ASA class III, more with stage T3-4, had a shorter operative time, shorter hospital stay, and lower hospital costs. However, there were no significant differences in any surgical complication, including the orocutaneous fistula rate (13% in pectoralis major myocutaneous flap and 6.8% in free flaps, $p = 0.393$). Although speech function was not different, there was a trend towards decreased ability to take a full or soft diet in the pectoralis major myocutaneous flap group compared with the free flap group (60.9 versus 82.2%, respectively, $p = 0.057$). In addition, the necessity for a prolonged feeding tube was significantly higher in the pectoralis major myocutaneous flap group (13 versus 2.7%, respectively, $p = 0.046$). It is noteworthy that out of all 5 patients who required a feeding tube for > 1 year, 3 patients were in the pectoralis major myocutaneous flap group, 2 of whom had a defect size of 70 cm,^{2} and the other had a defect size of 72 cm^2; whereas 2 patients were in the free flap group, and both had a defect size of 80 cm^2. (►**Table 5**)

In comparison with the free flap patients, the other three pedicled flaps (submental island, temporalis myofascial, and supraclavicular island flaps) had significantly more patients at stage T2 and also more at stage N0, smaller defect size, shorter mean operative time, shorter hospital stay, and lower hospital costs. The donor site and recipient site complications were also significantly fewer in this pedicled flap group when compared with the free flap group. However, the difference in flap complications and in functional results were not statistically significant (►**Table 5**).

Possible factors predicting dissatisfaction in speech function (fair or poor speech) and swallowing function (liquid diet, oral diet plus feeding tube, or obligated feeding tube) were evaluated. In the univariate analysis, T staging (T3-4 versus T2), defect size at a cutoff point of > 43 cm^2, and recipient site complications, were associated with a significantly increased risk of poor speech function. In addition, T staging (T3-4 versus T2), defect size > 55 cm^2, recipient site complications, and flap complication were significantly related to poor swallowing function. It is noteworthy that pedicled versus free flap reconstruction, flap types, and primary site location were not associated with poor speech and swallowing results (►**Table 6**). In the multivariate analysis, T staging was the only factor shown to influence poor speech function, while T staging and large defect size were the factors associated with poor swallowing function (►**Table 7**).

Discussion

Microvascular free flaps are currently the preferable flaps for soft tissue reconstruction of the oral cavity because of their reliability, versatility, and good functional results.[5–7,13,19] However, free flap reconstruction requires substantial perioperative resources, which may not be available in many head and neck cancer centers. In addition, with the current COVID-19 pandemic situation, the more complex reconstruction with longer operative time and longer hospital stay may potentially increase risk of viral transmission.[17,18] Therefore, a variety of pedicled flaps have been performed more frequently in these situations.[8,10,17,18] Nevertheless, the difference in the cost-effectiveness of surgery involving these two types of flaps has been a matter of debate in the literature.[5–7,11,13,14,20,21]

In the present study, patients with oral cavity cancer who underwent soft tissue reconstruction with pedicled flaps or free flaps were compared. There were no differences in

Table 3 Surgical complications, hospital stay, and hospital costs of patients

	Pedicled flaps				Free flaps		Pedicled flaps $n=98$ (%)	Free flaps $n=73$ (%)	*p-value* (Pedicled flaps vs Free flaps)
	PMMF $n=23$ (%)	SMF $n=47$ (%)	TMF $n=16$ (%)	SCF $n=12$ (%)	RFF $n=59$ (%)	ALT $n=14$ (%)			
Donor site complications									<0.001*
- No	13 (56.5)	47 (100)	16 (100)	11 (91.7)	35 (59.3)	13 (92.9)	87 (88.8)	48 (65.8)	
- Yes	10 (43.5)	–	–	1 (8.3)	24 (40.7)	1 (7.1)	11 (11.2)	25 (34.2)	
- Wound dehiscence	2 (8.7)	–	–	1 (8.3)	–	1 (7.1)	3 (3.1)	1 (1.4)	
- Partial loss of skin graft	–	–	–	–	11 (18.6)	–	–	11 (15.1)	
- Restricted arm function	–	–	–	–	13 (22.1)	–	–	13 (17.8)	
- Shoulder dysfunction	8 (34.8)	–	–	–	–	–	8 (8.1)	–	
Recipient site complications									0.163
- No	12 (52.2)	42 (89.4)	13 (81.2)	9 (75)	41 (69.5)	8 (57.1)	76 (77.6)	49 (67.1)	
- Yes	11 (47.8)	5 (10.6)	3 (18.8)	3 (25)	18 (30.5)	6 (42.9)	22 (22.4)	24 (32.9)	
-Orocutaneous fistula	3 (13)	–	–	1 (8.3)	4 (6.8)	1 (7.1)	4 (4.1)	5 (6.8)	
- Wound dehiscence	6 (26.1)	2 (4.3)	1 (6.2)	–	8 (13.6)	2 (14.3)	9 (9.2)	10 (13.7)	
- Minor infection	1 (4.3)	2 (4.3)	2 (12.5)	–	4 (6.8)	2 (14.3)	5 (5.1)	6 (8.2)	
- Hematoma	1 (4.3)	1 (2.1)	–	2 (16.7)	2 (3.4)	1 (7.1)	4 (4.1)	3 (4.1)	
Flap complications									0.317
- No	21 (91.3)	41 (87.2)	13 (81.2)	8 (66.7)	46 (77.9)	11 (78.6)	83 (84.7)	57 (78.1)	
- Yes	2 (8.7)	6 (12.8)	3 (18.8)	4 (33.3)	13 (22.1)	3 (21.4)	15 (15.3)	16 (21.9)	
- Partial loss	2 (8.7)	6 (12.8)	3 (18.8)	4 (33.3)	7 (11.9)	2 (14.3)	15 (15.3)	9 (12.3)	
- Total loss	–	–	–	–	2 (3.4)	–	–	2 (2.7)	
- Revision of the anastomosis	–	–	–	–	4 (6.8)	1 (7.1)	–	5 (6.8)	
Hospital stay									< 0.001*
(mean (range); days)	24 (18-36)	20 (14-30)	17 (14-24)	21 (10-41)	31 (22-36)	30 (24-39)	20 (10-41)	31 (22-39)	
Hospital cost									< 0.001*
(USD)	5,226	4,023	3,958	4,555	8,023	7,598	4,360	7,935	

Abbreviations: ALT, anterolateral thigh free flap; PMMF, pectoralis major myocutaneous flap; RFF, radial forearm free flap; SCF, supraclavicular island flap; SMF, submental island flap; TMF, temporalis myofascial flap; USD, United States Dollars.
*indicates significant difference at $p < 0.05$.

Table 4 Speech and swallowing outcomes of patients

	Pedicled flaps			Free flaps			Pedicled flap group	Free flap group	*p-value*
	PMMF *n* = 23 (%)	SMF *n* = 47 (%)	TMF *n* = 16 (%)	SCF *n* = 12 (%)	RFF *n* = 59 (%)	ALT *n* = 14 (%)	*n* = 98 (%)	*n* = 73 (%)	(Pedicled flaps vs Free flaps)
Speech									0.947
- Excellent	5 (21.7)	28 (59.6)	13 (81.2)	6 (50)	34 (57.6)	6 (42.9)	52 (53.1)	40 (54.8)	
- Good	–	10 (21.3)	3 (18.8)	4 (33.3)	14 (23.7)	4 (28.6)	27 (27.6)	18 (24.7)	
- Fair	10 (43.5)	8 (17)	0 (0)	2 (16.7)	8 (13.6)	2 (14.3)	14 (14.3)	10 (13.7)	
- Poor	4 (17.4)	1 (2.1)	0 (0)	0 (0)	3 (5.1)	2 (14.3)	5 (5.1)	5 (6.8)	
- Bad	4 (17.4)	–	–	–	–	–	–	–	
Swallowing									0.768
- Full	7 (30.4)	29 (61.7)	12 (75)	5 (41.7)	32 (54.2)	4 (28.6)	53 (54.1)	36 (49.3)	
- Soft	7 (30.4)	11 (23.4)	3 (18.8)	6 (50)	20 (33.9)	4 (28.6)	27 (27.6)	24 (32.9)	
- Liquid	2 (8.7)	7 (14.9)	1 (6.2)	1 (8.3)	5 (8.5)	1 (7.1)	11 (11.2)	6 (8.2)	
- Oral + feeding tube	4 (17.4)	–	–	–	1 (1.7)	3 (21.4)	4 (4.1)	4 (5.5)	
- Feeding tube	3 (13)	–	–	–	1 (1.7)	1 (7.2)	3 (3.1)	2 (2.7)	

Abbreviations: ALT, anterolateral thigh free flap; PMMF, pectoralis major myocutaneous flap; RFF, radial forearm free flap; SCF, supraclavicular island flap; SMF, submental island flap; TMF, temporalis myofascial flap.

demographics and preoperative risks between the two groups, which are comparable to those of previous studies.[3,5,7–9,13,19,21–25] However, some studies reported that patients in the pedicled flap group were significantly older than those in the free flap group.[4,16,26] In addition, the proportion of patients with ASA class I-II to those with ASA class III-IV was variably reported as lower,[4] similar,[5] or higher,[6,27] in the pedicled flap group compared with in the free flap group. Concerning disease characteristics, there were no differences in primary tumor location, T staging, and overall N staging, which are similar to those recorded in previous studies.[3,5,8,9,19,21,24] However, the number of patients with N0 stage was significantly higher in the pedicle flap group than in the free flap group. It is noteworthy that 42.5% of submental island flap patients had N0 neck because obvious signs of level I lymph node metastasis in patients is a contraindication for this flap.

Although the mean defect size of the pedicled flap group was significantly smaller than that of the free flap group (33.3 versus 53.3 cm^2, respectively), the submental island flap and pectoralis major myocutaneous flap were able to be used for reconstruction of a defect as large as between 60 and 72 cm^2.

Regarding surgical complications, donor site complications were significantly higher in patients with free flap reconstruction. Most of them were skin graft loss (18.6%) and restricted arm function (22.1%), exclusive to radial forearm free flaps. However, 34% of the patients who underwent pectoralis major myocutaneous flap reconstruction had shoulder dysfunction. These common complications were also reported in previous studies.[7,8,21,23–25] Although no significant differences were found between overall recipient site complications and flap complications, 2 patients with radial forearm free flaps had late total flap failure occurring between postoperative day 7 and day 14. Both of them had no evidence of delayed infection or residual tumor; therefore, this incidence was most likely to be attributed to vascular pedicle compression during oral rehabilitation.[28,29] Operative time and hospital stay were longer in the free flap patients, and hospital costs were almost twice as much in the free flap group. These results were also reported in previous studies.[6,8,11,22,25]

Regarding functional outcomes, no difference in speech function was detected, a finding similar to that of other studies,[8,9,11,23,25,26] and ~ 80% of the patients in both groups in the study had excellent to good speech. In addition, the number of patients who were able to take a full or soft diet did not significantly differ between the two groups. Again, a finding similar to that reported in other studies.[2,3,8,9,11,12,23–26]

Pectoralis major myocutaneous flap is one of the essential reconstructive pedicled flaps in head and neck cancer. The flap was most frequently compared with free flaps in the oral cavity and various head and neck defects.[2,3,5,6,13,19,21–23] We analyzed these two flap groups and demonstrated that patients undergoing pectoralis major myocutaneous flap reconstruction were significantly older, associated with more comorbidities, and having more extensive primary

Table 5 Demographics, clinical characteristics, and outcomes of patients

	PMMF vs Free flaps			Other pedicle flaps vs Free flaps	
	PMMF group $n = 23$ (%)	Free flap group $n = 73$ (%)	*p*-value	Other pedicled flap group $n = 75$ (%)	*p-value*
Age (mean (range; years old)	65 (56–72)	61 (45–71)	$< 0.001^*$	62 (48–76)	0.355
Gender					
- Male	17 (73.9)	52 (71.2)	1	48 (64)	0.383
Smoke					
- Yes	19 (82.6)	47 (64.4)	0.126	54 (72)	0.378
Alcohol					
- Yes	12(52.2)	41 (56.2)	0.812	45 (60)	0.739
DM					
- Yes	4 (17.4)	9 (12.3)	0.504	12 (16)	0.639
COPD					
- Yes	6 (26.1)	9 (12.3)	0.184	13 (17.3)	0.49
ASA					
- I-II	17 (73.9)	68 (93.2)	0.021^*	67 (89.3)	0.446
Primary site location			0.764		0.325
T stage					0.016^*
- T2	–	25 (34.3)	0.002^*	43 (57.3)	
- T3-4	23 (100)	48 (65.7)		32 (42.7)	
N stage					$< 0.001^*$
- N0	–	9 (12.3)	0.138	28 (37.3)	
- N1-3	23 (100)	64 (87.7)		47 (62.7)	
Neck dissection Side					
- Unilateral Type	7 (30.4)	30 (41.1)	0.463	43 (57.3)	0.051
- Selective	1 (4.3)	12 (16.4)	0.061	27 (36)	0.087
- Modified	18 (78.3)	57 (78.1)		47 (62.7)	
- Radical	4 (17.4	4 (5.5)		1 (1.3)	
Defect size (cm^2)	52.7	53.3	0.835	26.9	$< 0.001^*$
Donor site complication					$< 0.001^*$
- Yes	10 (43.5)	25 (34.2)	0.462	1 (1.3)	
Recipient site complication					0.012^*
- Yes	11 (47.8)	24 (32.9)	0.22	11 (14.7)	0.112
- Orocutaneous fistula	3 (13)	5 (6.8)	0.393	1 (1.3)	
Flap Complication					
- Yes	2 (8.7)	16 (21.9)	0.224	13 (17.3)	0.538
Hospital stay (days)	24	31	$< 0.001^*$	19	$< 0.001^*$
Hospital cost (USD)	5,226	7,935	$< 0.001^*$	4,178	$< 0.001^*$
Speech					
- Excellent-Good	15 (65.2)	58 (79.5)	0.262	64 (85.3%)	0.392
Swallowing					
- Full-Soft	14 (60.9)	60 (82.2)	0.057	66 (88%)	0.262
- Obligate Feeding tube	3 (13.0)	2 (2.7)	0.046^*	–	0.242

Other pedicled flaps including submental island flap, temporalis myofascial flap, and supraclavicular island flap, Free Flaps including radial forearm free flap, and anterolateral thigh free flap.
Abbreviations: ASA American Society of Anesthesiologists; DM, diabetes mellitus; PMMF, pectoralis major myocutaneous flap; USD, United States Dollars; COPD, chronic obstructive pulmonary disease.
*indicates significant difference at $p < 0.05$.

Table 6 Univariate analysis of factors predicting dissatisfaction of speech and swallowing

Factors	Speech dissatisfaction		Swallowing dissatisfaction	
	OR (95%CI)	*p-value*	OR (95%CI)	*p-value*
Flap[a]	0.50 (0.18–2.29)	0.851	0.43 (0.23–1.98)	0.842
Flap type[b]	0.89 (0.61–1.22)	0.922	1.00 (0.81–1.63)	0.995
Primary site location	0.54 (0.25–1.04)	0.086	0.56 (0.27–1.07)	0.114
T staging (T3-4 vs T2)	9.14 (3.79–21.98)	$< 0.001^*$	7.61 (3.41–16.96)	$< 0.001^*$
Defect size[c]	1.12 (1.08–1.28)	$< 0.001^*$	1.08 (1.04–1.12)	$< 0.001^*$
Recipient complications	6.53 (2.16–17.14)	$< 0.001^*$	7.15 (3.14–16.27)	$< 0.001^*$
Flap complications	0.77 (0.46–1.50)	0.061	3.39 (1.44–7.96)	0.005^*

Abbreviations: CI, confidence interval; OR, odds ratio.
*indicates significant difference at $p < 0.05$.
[a]pedicled flaps versus free flaps.
[b]pectoralis major myocutaneous flap versus submental island flap versus temporalis myofascial flap versus supraclavicular island flap versus radial forearm free flap versus anterolateral thigh free flap.
[c]cutoff point for speech dissatisfaction is 43 cm^2 and for swallowing dissatisfaction is 55 cm^2.

Table 7 Multivariate analysis of factors predicting dissatisfaction of speech and swallowing

Factors	Speech dissatisfaction		Swallowing dissatisfaction	
	OR (95%CI)	*p-value*	OR (95%CI)	*p-value*
T staging (T3-4 vs T2)	6.23 (2.44–58.95)	$< 0.001^{*}$	8.00 (1.95–37.31)	0.026^*
Defect size[a]	4.12 (0.78–34.56)	0.211	9.74 (1.16–41.51)	0.039^*

Abbreviations: CI, confidence interval; OR, odds ratio.
*indicates significant difference at $p < 0.05$.
[a]cutoff point for speech dissatisfaction is 43 cm^2 and for swallowing dissatisfaction is 55 cm^2.

tumor staging. Surgical complication rates were not different between the two groups. Although orocutaneous fistula was observed more frequently in the pectoralis major myocutaneous flap group than in the free flap group, no significant difference was detected (13 versus 6.8%, respectively, $p = 0.393$), which is similar to a previous study (12 versus 6%, respectively).[19] In addition, patients who underwent pectoralis major myocutaneous flap reconstruction had a shorter operative time, shorter hospital stay, and lower hospital costs. Regarding functional outcomes, no difference in speech function was demonstrated between the two groups. However, Hsing et al. reported a more inferior speech function in the pectoralis major myocutaneous flap group than in the free flap group.[3] In contrast, Zhang et al. demonstrated a better outcome in cases involving a pectoralis major myocutaneous flap than an anterolateral thigh free flap.[21] Although fewer patients in the pectoralis major myocutaneous flap group were able to take a full or soft diet, no significant difference was demonstrated, similar to previous studies.[2,3,12,21,24] The pectoralis major myocutaneous flap group has a higher rate of a prolonged feeding tube than the free flap group (13 versus 2.7%, respectively, $p = 0.046$). However, the rates in both groups were lower than those found in previous reports (23–34 versus 8–21%, respectively).[2,19]

Comparing the group that had undergone submental island, temporalis myofascial, and supraclavicular island flaps with the free flap group, there were no differences in demographics and comorbidities, but the pedicled flap group had significantly less extensive T staging and N staging, and also a smaller mean defect size. In addition, these three pedicled flaps had a significantly shorter operative time, shorter hospital stay, lower hospital costs, and fewer donor site and recipient site complications, without significant differences in speech and swallowing functions compared with the free flaps.

Some previous studies reported that patients with pedicled flap reconstruction had higher surgical complications and more unsatisfactory functional results than those with free flap reconstruction.[5,6,13,19] In the present study, pedicled flaps did not increase the risk of speech and swallowing dissatisfaction. Still, high tumor staging and large defect size were found to be the influencing factors in the multivariate analysis. In addition, pedicled flaps had comparable complications and functional outcomes to free flaps with shorter operative time, shorter hospital stay, and lower hospital costs. However, with a substantial defect (between 70 and 72 cm^2), a pectoralis major myocutaneous flap resulted in a more inferior swallowing function than free flaps regarding prolonged feeding tube use.

These four pedicled flaps have particular characters that might be appropriate in some specific conditions of oral cavity defects. In a significant (up to 70 cm^2) defect, a pectoralis major myocutaneous flap can be helpful, especially in patients unsuitable for a free flap. A submental island flap with good flap volume is suitable for a small to a large (up to 60 cm^2) oral tongue and buccal mucosa defect. A temporalis myofascial flap is ideal for a small to a medium defect of the hard palate, retromolar trigone, and posterior buccal mucosa. The supraclavicular island flap, a very pliable flap, is suitable for the floor of the mouth and buccal mucosa reconstruction.

Conclusions

The oral cavity is involved in a substantial range of functions, including speech, mastication, and deglutition, which require appropriate reconstruction in the cases of any defects. Pedicled flaps, including pectoralis major myocutaneous, submental island, temporalis myofascial, and supraclavicular island flaps, are reliable, have acceptable complication rates, and acceptable functional results with a shorter operative time, shorter hospital stay, and lower hospital costs when compared with the radial forearm and anterolateral thigh free flaps in soft tissue reconstruction of the oral cavity. In addition, these pedicled flaps are accessible in both academic and community settings. However, in a substantial defect (> 70 cm^2), free flaps are the reconstruction of choice in preserving swallowing function. Each of these pedicled flaps has its particular character, suitable for a selected oral cavity defect. Therefore, pedicled flaps can be a beneficial option for the reconstruction of many oral cavity defects.

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Conflict of interests

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