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A comparative study between submandibular-facial artery island flaps (including perforator flap) and submental artery perforator flap: A novel flap in oral cavity reconstruction

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ABSTRACT

Objective: The purpose of this study was to introduce submandibular-facial artery island flaps (S-FAIF), including the perforator flap, and to evaluate their application for intraoral reconstruction in comparison with submental artery perforator flaps (SMAPF).

Methods: Ninety-six patients who underwent intraoral reconstruction using an S-FAIF (n = 34) or SMAPF (n = 62) after cancer resection were recruited in this study. The flap characteristics (viz., pedicle length, flap size, venous drainage pattern, and harvest time), short-term outcomes (viz., flap partial loss, intraoral wound dehiscence, fistula, and wound infection), and long-term morbidity (viz., facial nerve palsy, neck motion restriction, and hair growth) were compared.

Results: Nine S-FAIFs were authentic perforator flaps pedicled by level I facial artery perforators, while the rest were island flaps based on level II facial artery perforators. The survival rates of S-FAIF and SMAPF were both 100 percent. Flap partial loss occurred in two patients in each group. The pedicle length of S-FAIF was shorter than that of SMAPF ($p < 0.001$). Statistics analysis revealed no significant difference regarding flap size, venous drainage pattern, short-term outcomes, neck motion restriction, or facial nerve palsy between the groups. S-FAIF required less harvest time ($p < 0.001$) and experienced less hair growth when compared to SMAPF ($p = 0.011$).

Conclusions: The S-FAIF is a robust and reliable novel flap and on par with SMAPF for reconstruction of small and medium-sized intraoral defects. It is preferred to SMAPF when technical requirements for flap harvest and hair problems are considered. It should be supplemented to the armamentarium for intraoral reconstruction.

Introduction

Even in the era of free tissue transfers for head and neck reconstruction, local flaps still serve as the substitute for free flaps. Under some circumstances, especially for compromised patients and smaller defects, local flaps, including the vertical platysma flap and the submental artery island flap, are usually better choices [1–6]. Nevertheless, the two kinds of flaps have not gained huge popularity for the following reasons. For the vertical platysma flap, a bulky and wide muscle pedicle, recognized as the flap's Achilles' heel, tremendously reduces the degree of freedom of flap rotation. Additionally, with regard to flap viability, the vertical platysma flap is inferior to the submental artery island flap and free flaps as a result of its uncertain vascularity. For the submental artery island flap—though its perforator version, the submental artery perforator flap (SMAPF), offers a technically feasible solution to unreliable oncological safety [6,7]—hair growth is still an annoying problem. Is there a desirable kind of cervical flap that can avoid the above problems simultaneously? We found that the facial artery island flap, described by Wang and Pan in a 2013 Chinese article [8], can meet this requirement perfectly. However, this flap has never been reported in English literature since its debut, and its survival mechanism and characteristics have not been further investigated.

Herein, we have renamed this flap the submandibular-facial artery island flap (S-FAIF), clearly indicating the flap donor site. We aim to evaluate and promote the application of S-FAIF for intraoral reconstruction by comparing it with SMAPF, the mainstream local flap at

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our institute, which has been proved to be a reliable reconstructive method for intraoral defects with ideal aesthetic and functional outcomes. In some cases, attempts were made to harvest S-FAIFs pedicled only by the facial artery perforators (FAPs).

Materials and methods

A retrospective case series (operated on in the Department of Oral and Maxillofacial Surgery, Xiangya Hospital, Central South University, from March 2014 to April 2018) of 96 patients, each of whom received an S-FAIF or SMAPF for intraoral reconstruction following oral cancer ablation, was performed. The patients were divided into two groups: the S-FAIF group (n = 34) and the SMAPF group (n = 62). All operations were done by Drs. Long Huang and Xin-Rong Ou, with other team members. Patient-selection criteria were as follows: (1) no prior radiotherapy and no prior neck operation violating the facial vessels; (2) no apparent level I lymph nodes metastasis; and (3) T1–T2 and small T3 oral cancers whose resultant defects were readily restored with local flaps. This study was approved by the institutional review board of Xiangya Hospital and all patients signed an informed consent agreement.

Flap design and harvesting

The surgical technique for preparing SMAPF was elaborated in our previous study [6], and the technique used to harvest S-FAIF is described below.

The patient is in a supine position with the head extended. A horizontal elliptic skin paddle is outlined in the submandibular region, with the midpoint of its superior limb at the site where the facial artery crosses the mandible (Figs. 1 and 2A). The vertical dimensions of S-FAIF should not be more than 5 cm, estimated by the skin pinching test; otherwise, there will be difficulties in closure of the donor site. The horizontal dimensions of the flap can reach the mandibular angle backwards and extend till the midline. The lateral incision extends to the mastoid process for supraomohyoid neck dissection or is linked to neck dissection incision for modified radical neck dissection.

To begin, the surgeon incises the lower limb of the skin paddle through the platysma muscle and elevates a cervical flap just to the inferior border of the mandible in the subplatysmal plane. Given that the marginal mandibular branch of the facial nerve is fully released, the dissection between the facial vessels and the flap should be minimized, avoiding the evulsion of the facial vessels from the flap (Fig. 2B).

Next, the superior incision is carried only down to the surface of subcutaneous tissue. The skin over the mandible is raised within the expected range (at least 2 cm beyond the jawline and 1–2 cm bilateral to the facial vessels) (Figs. 1A and 2A). The facial vessels are cut and ligated distally at the site 2 cm away from the jawline. With the nerve meticulously protected, subcutaneous tissues and platysma surrounding the facial vessels are harvested along with the flap. To further safeguard the facial vessels, mandible periosteum and masseter fascia should be included in the flap as much as possible. As the facial vessels generally lie just between the superficial facial nerve and the mandible, dropping the skin paddle from the bone requires more patience and caution for preservation of the nerve. The marginal mandibular branch of the facial nerve should be fully freed to let the skin paddle pass underneath it (Fig. 2C).

Then, after branches of the facial artery to the gland are divided and ligated with titanium clips, the facial artery is traced proximally when a longer pedicle is needed to achieve optimal tension-free movement. Careful dissection of the facial vein will quickly confirm whether it flows through the common facial vein to the internal jugular vein (IJV) or directly drains into the external jugular vein (EJV). Finally, the harvest of conventional S-FAIF is completed (Fig. 2D).

If a robust perforator (greater than 0.5 mm in diameter) originating from the facial artery is encountered below or at the jawline, harvesting a FAP flap is possible. In this case, the soft tissue bridge between the facial vessels and the flap can be saved (Fig. 1B). A typical perforator flap is shown in Fig. 3. The donor wound is closed primarily after inferior elevation of the lateral neck skin in a subplatysmal plane.

Outcome evaluation

The clinical data regarding demographics, tumour stage, and recipient site were collected at the time of enrolment. Flap characteristics, including pedicle length, venous drainage pattern, flap size, and harvest time, were recorded during the operation. Flap pedicle length refers to the length of the facial artery and perforator. Early flap-specific complications (viz., total flap loss, partial flap loss, intraoral wound dehiscence, fistula, and wound infection) were assessed during the hospitalization. At least 6 months post-op, each patient was called again to the clinic to evaluate the long-term flap-specific morbidity, consisting of palsy of the marginal mandibular branch of the facial nerve, restriction of neck flexion and extension, and intraoral hair growth.

A Mann-Whitney *U* test was adopted to test the measurement data of the two groups. The chi-square test was used to analyse the differences in the group venous drainage patterns, complication rates, and surgical outcomes. All statistical tests were two sided, and the level of

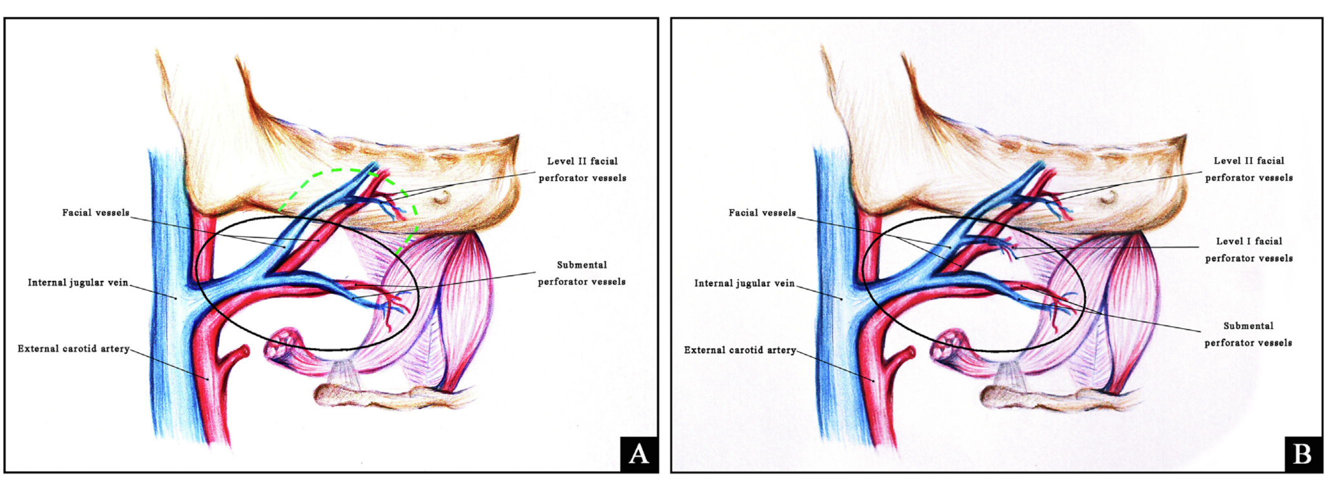

Fig. 1. Vascular anatomy of submandibular-facial artery island flap (S-FAIF) and level I facial artery perforator (FAP) flap. (A) The S-FAIF is marked by the black line; the soft tissue bridge outlined in green dotted line is designed to maintain the connection of the facial perforator vessels superior to the jawline with the flap; (B) on condition that robust facial perforator vessels are identified below the jawline, a level I FAP flap without including soft tissue bridge is available.

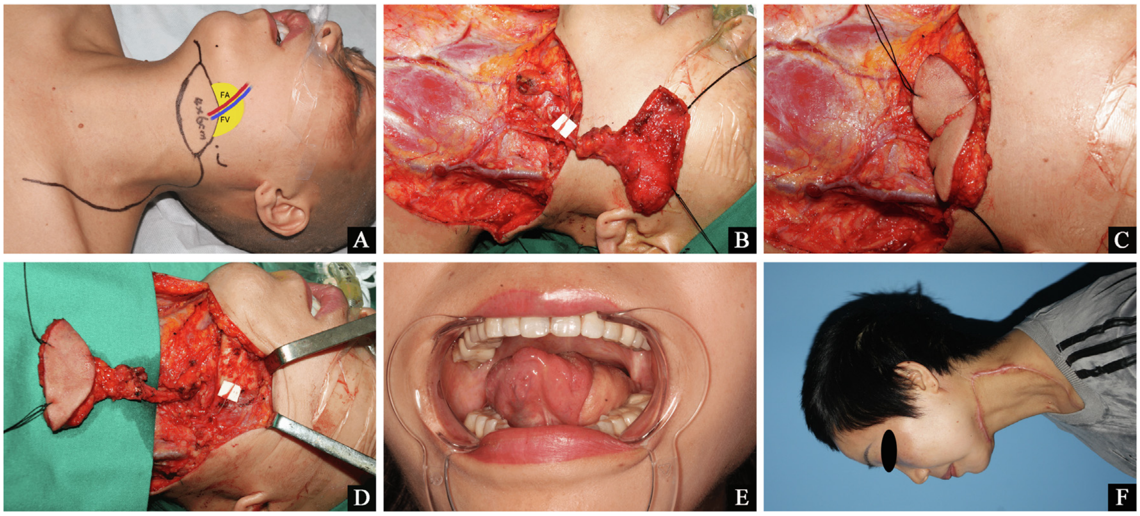

Fig. 2. Typical case of tongue reconstruction using an S-FAIF. (A) A 4 cm × 6 cm flap, with the soft tissue bridge highlighted in yellow, was designed in line with the size of the anticipated defect; (B) the dissection between the facial vessels and the flap should be minimized, provided that the facial nerve is fully released; (C) the skin paddle passed underneath the facial nerve; (D) the flap harvest was completed; (E and F) 6 months after tumour resection.

the tests was that α is equal to 0.05. All statistical analyses were performed using SPSS version 18.0.

Results

Among the 96 patients, 94 suffered from squamous cell carcinoma in the oral cavity and the remaining 2 had adenoid cystic carcinoma of the small salivary gland. The demographics and clinical information of the participants are listed in Table 1.

Of the 34 S-FAIFs, nine flaps were typical FAP flaps, while the rest were conventional S-FAIFs. The mean pedicle length was 6.89 cm (range, 6.1–8.3 cm) in the S-FAIF group and 9.28 cm (range, 7.4–10.4) in the SMAPF group; the difference between the groups was statistically significant (d = −2.39, 95% CI [−2.67 to −2.12]; $p < 0.001$). In both groups, the facial vein provided the primary venous drainage, followed by the vena comitans of the facial artery. There are two basic patterns of facial vein drainage: pattern I (the facial vein joining the EJV) and pattern II (the facial vein flowing through the common facial vein to the IJV). In the S-FAIF group, pattern I and II facial vein drainage were noted by 50 percent (n = 17) and 44.1 percent (n = 15) of the patients, respectively. In addition, there were two variations of

Table 1
Demographics, tumor stage, and recipient sites of patients undergoing S-FAIF or SMAPF reconstruction for intraoral defects.

Characteristic	S-FAIF	SMAPF
No.	34	62
Mean age	55.1	54.6
Sex		
Male	33	60
Female	1	2
Tumor stage		
T1	11	15
T2	18	37
T3	5	10
Recipient site		
Buccal	5	15
Buccal/AP	1	4
Tongue	21	30
Tongue/FOM	4	7
FOM/AP	3	3
Palate	0	3

S-FAIF, submandibular facial artery island flap; SMAPF, submental artery perforator flap; AP, aveloar process; FOM, floor of mouth.

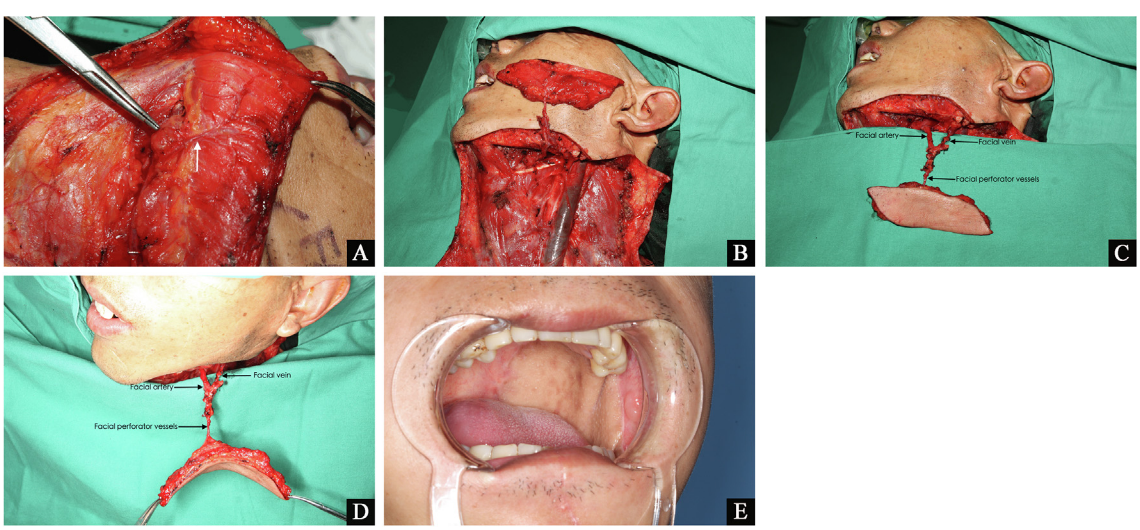

Fig. 3. Typical case of oropharyngeal reconstruction using a level I FAP flap. (A) The arrow indicates a level I FAP on the underside of the platysma; (B–D) inferior, superior, and lateral views of the flap after it was elevated; (E) 16 months after tumour resection.

Table 2
Flap characteristics.

Characteristic	S-FAIF	SMAPF	d95%CI	p
Flap pedicle length, cm			−2.39 (−2.67 to −2.12)	< 0.001
Mean	6.89	9.28		
Range	6.1–8.3	7.4–10.4		
Flap size, cm^2			−3.42 (−6.99 – 0.15)	0.060
Mean	32.35	35.77		
Range	15–50	15–55		
Flap harvest time, min			−26.02 (−32.23 to −19.81)	< 0.001
Mean	39.03	65.05		
Range	23–52	32–95		
Flap venous drainage pattern, No.				0.586
Pattern I	17	36		
Pattern II	15	25		
Variations	2*	1#		

S-FAIF, submandibular facial artery island flap; SMAPF, submental artery perforator flap.

* Including one case with absence of the facial vein and one case of the facial vein draining into the anterior vein.

\# Including one case in which the submental vein bypassed the facial vein to drain directly into the IJV.

venous drainage. In one case, the facial vein was absent in one patient; the vena comitans of the facial artery provided the venous drainage and finally drained into the IJV. The other variation of venous drainage lay in the facial vein draining into the anterior jugular vein (AJV). In the SMAPF group, pattern I and II were reported by 58.1 (n = 36) and 41.9 (n = 25) percent of the patients, respectively. One rare variation of venous drainage was encountered, when the submental vein bypassed the facial vein to drain directly into the IJV. There were no significant differences regarding the proportions of facial vein drainage patterns between the two groups ($p = 0.586$). The flap size was 32.35 (range, 15–50 cm^2) in the S-FAIF group and 35.77 (range, 15–55 cm^2) in the SMAPF group, showing no significant differences between the groups (d = −3.42, 95% CI [−6.99 to 0.15]; $p = 0.060$). The surgical procedure for harvesting S-FAIF was simpler and required less operative time than did SMAPF (d = −26.02, 95% CI [−32.23 to −19.81]; $p < 0.001$). The flap characteristics are listed in Table 2.

The flap survival rates of both groups was 100 percent. In the S-FAIF group, two conventional flaps developed mild ischemia that caused a small strip of distal skin necrosis. In contrast, in the SMAPF group, four flaps experienced venous congestion, two of which resulted in partial necrosis. In all four cases of flap partial necrosis, additional surgery was not needed, and second healing was achieved with bedside debridement. Regarding the short-term flap-specific complications (e.g., flap partial loss, intraoral wound dehiscence, wound infection, fistula), there was no significant difference between the two groups. The short-term flap-specific complications are presented in Fig. 4.

Patients were followed for a median (range) of 12.6 (6–18) months in the S-FAIF group and 21.5 (6–46) months in the SMAPF group. Cosmetically and functionally pleasing results in three patients receiving S-FAIF reconstruction were achieved at the recipient sites (Figs. 2E, 3E, and 5A). Owing to the palsy of the facial nerve, impaired profile and drooling was observed in two patients in the S-FAIF group (5.9 percent) and two patients in the SMAPF group (3.2 percent). In the S-FAIF group, the restriction of neck flexion to the normal side was reported in one patient (2.9 percent), while in the SMAPF group, it was observed in two patients (3.2 percent). There was no significant difference regarding palsy of the facial nerve and the restriction of neck flexion and extension between the two groups. Hair growth at the recipient site was reported by two patients in the S-FAIF group (5.9 percent) and 17 patients in the SMAPF group (27.4 percent). The S-FAIF group exhibited less intraoral hair growth than the SMAPF group ($p = 0.011$) (Fig. 5). The long-term flap-specific morbidities are also presented in Fig. 4. Local recurrences were found in one tongue cancer patient in each group during the follow-up period. The two patients each received an extensive ablative surgery, and the resultant defects were restored with anterolateral thigh flaps.

Discussion

Numerous flaps based on the facial artery, including standard nasolabial flaps with an intact skin pedicle, are ultimately supplied by FAPs [9]. Hofer also pointed out that only when the FAP is isolated definitely is the flap qualified as a FAP flap [9]. According to Kannan's classification, there are three levels of FAPs: those below the jawline (level I), those between the jawline and the nasal alae (level II), and perforators superior to the nasal alae up to the glabella (level III) [10]. In this series, nine S-FAIFs were virtually pedicled by a single level I FAP; therefore, these flaps could also be called level I FAP flaps. How to judge a level I FAP of adequate calibre for clinical use? According to the criteria followed in previous anatomical and clinical studies, at least one large perforator (diameter ≥ 0.5 mm) is an essential prerequisite for preparing a successful FAP flap [11–14]. So far, authentic level I FAP flaps have never been reported, which is partly attributable to the low incidence rate of robust level I FAPs. The three level I FAP flaps described by Kannan et al. were actually advancement flaps based on level I FAPs [10].

The level II FAP flap, by contrast, has been frequently reported in the literature [9,10,12,14]. In the present study, level II FAPs were identified in all 25 cases without level I FAPs, and successfully harnessed to prepare conventional S-FAIFs. In these flaps, level II perforators arising beyond the jawline did not penetrate the flap directly, and perfused the flap via the soft tissue bridge between the flap and the facial vessels; therefore, they could not be skeletonized. Actually, these flaps could only be recognized as level II FAP–based flaps, not authentic level II FAP flaps. However, the low chance of preparing S-FAIF as a perforator flap would not degrade this flap. With conventional S-FAIF, facial vessels are also completely freed, offering adequate freedom for flap transposition. In addition, the amount of soft tissue bridge is negligible without producing a bulky pedicle.

If the cheek area is incorporated in the flap donor site, the surgeon will certainly have a better chance of preparing an authentic level II FAP flap. Even so, harvesting a flap in the cheek and neck region has many faults. First, in the process of flap harvesting, lower branches of the facial nerve would be cut deliberately [15]. Second, because the donor site on the body of the mandible is the toughest area to close, the flap size is extremely restricted [15,16]. Third, since not all oral cancer operations require the lip-splitting approach, especially for T1–T2 cancer resection, additional scarring in the cheek would pose aesthetic problems.

Overall, S-FAIF and SMAPF are best suited for the reconstruction of small to moderate-sized intraoral defects resulting from T1–T2 cancer resection [6,8], despite the fact that a few T3 oral cancer patients were admitted in this series. Owing to the contribution of the submental artery perforator to flap pedicle length, SMAPF enjoys a longer pedicle than S-FAIF, and consequently can reach farther recipient sites, such as the floor of mouth on the contralateral side and palate. Besides, S-FAIF is not recommended for buccal reconstruction in oral malignancies unless a level I FAP flap can be harvested. With the conventional S-FAIF, preserving the soft tissue bridge beyond the jawline will inevitably interfere with buccal cancer ablation, and buccal lymph nodes entwined with the facial vessels are probably involved in the flap. Although dissection of buccal lymph nodes beyond the jawline is compromised when a conventional S-FAIF is harvested, dissection of the submandibular and submental lymph nodes below the jawline (level I nodes) is not affected. Buccal lymph nodes are not included in level I nodes and generally do not need to be dissected for other oral

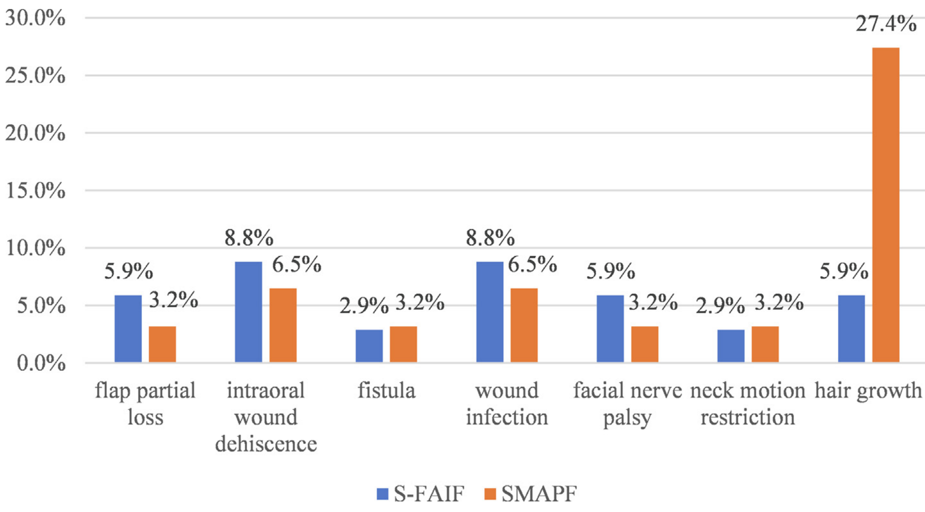

Fig. 4. The short-term flap-specific complications (viz., partial loss, intraoral wound dehiscence, fistula, and wound infection) and long-term morbidities (viz., facial nerve palsy, neck motion restriction, and intraoral hair growth) in the S-FAIF and SMAPF groups are listed on the *x* axis. The *y* axis indicates the percentage of affected flaps.

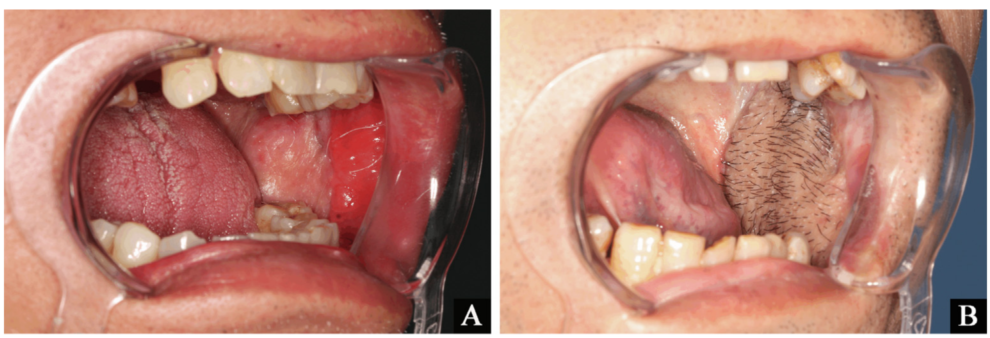

Fig. 5. A comparison of hair growth between S-FAIF and SMAPF. (A) A hairless S-FAIF for buccal reconstruction 8 months postoperatively; (B) a hairy SMAPF for buccal reconstruction 11 months postoperatively.

malignancies except buccal cancer. Therefore, using the conventional S-FAIF for defect coverage is justified in these cases. Although the recurrence rate in the S-FAIF group was low and acceptable, the oncological outcomes still require further proof in the form of long-term, prospective, controlled trials.

SMAPF has a reputation for high survival rates as a result of its robust blood supply [6,7,17]. Our results indicated that S-FAIF, whether it is prepared as a typical perforator flap or not, is as reliable as SMAPF. Two conventional S-FAIFs developed partial necrosis for the lack of surgical experience during the early stage of the series. Initially, we had no idea of what amount of soft tissue between the facial vessels and the flap should be harvested. In the two flaps, the soft tissue bridge was feeble and the facial artery was loosely connected with the flap, thereby causing deficient arterial perfusion.

Unlike SMAPF, S-FAIF has hardly any problems of venous return. The facial vein always has close contact with its arterial counterpart at the jawline; thus, it can be easily included in the flap. Also, the vena comitans of the facial artery, the second draining vein, eventually joined the IJV and extensively anastomosed with the facial vein. These factors work together to ensure the venous drainage of S-FAIF. Previous studies showed considerable differences in the distribution of facial vein drainage patterns. Choudhry et al. found that 95 percent of facial veins drained into the IJV (pattern II) in 40 adult cadavers, whereas only 5 percent terminated in the EJV (pattern I) [18]. In the present study, pattern I was detected in 17 S-FAIF patients (50 percent) and 36 SMAPF patients (58.1 percent), which was consistent with most previous reports [6,16,19].

The variation of facial vein draining into the AJV, reported to occur in 16 percent of Zhou et al.'s series [16], was found in only one S-FAIF in this study. The facial vein was absent in one S-FAIF. This rare variation was also reported in previous findings [20,21]. Luckily, this flap survived well, indicating that the vena comitans of the facial artery can provide enough venous drainage in the absence of the facial vein. Anyhow, multiple venous variations indicate that, regardless of S-FAIF or SMAPF, flap preparation should be performed prior to neck dissection, as this strategy could earlier identify and better protect the relevant vessels of the flap [6].

In this study, we observed similar low incidence rates of donor-site morbidity in the two groups. As S-FAIF and SMAPF are harvested below the jawline, the risk of facial nerve palsy is minimal as long as surgical techniques are strictly implemented. However, because the submental artery from the facial artery is frequently intimately related to the marginal mandibular branch of the facial nerve, SMAPF-elevation procedure carries a significant risk of injury to the facial nerve [22]. For S-FAIF, it is the same case. In our series, because the facial nerve needed to be skeletonized and released during the operation, temporary paralysis was anticipated in some cases, but most patients recovered as time elapsed. Moreover, lateral lip-splitting approach performed in buccal cancer patients was also an important cause of long-term facial nerve paralysis. Three of four cases of long-term facial nerve paralysis were observed in buccal cancer patients. With this surgical approach, protecting the distal end of the facial nerve was very difficult to achieve; reinnervation of the facial nerve probably needed more time. In our experience, provided that the width of the flap was not more than 5 cm, the restriction of neck flexion and extension rarely occurred. This is why we insist that the optimal indications of S-FAIF and SMAPF for intraoral reconstruction are T1–T2 staged oral cancers.

For the submental artery island flap, the problem of hairs varied considerably in different races. Rahpeyma reported that intraoral hair growth was seen in nearly all the male patients [23]. Although the submental artery island flap is supposed to have no hairs genetically, in some ethnicities, such as Chinese and East Asian people [23], the hair problem was still reported by some patients in our series. Mostly, the lateral neck is a less hair-bearing area than the submentum in the Chinese population. For male patients with beards on the submentum, S-FAIF is evidently a more pleasing and preferred reconstructive option compared to SMAPF for intraoral reconstruction.

S-FAIF involves a shorter learning curve than does SMAPF. To ensure the oncological safety of SMAPF, removing the fatty tissue and nodal basins adhering to the submental artery and its perforators requires much patience and caution [6]. By contrast, for S-FAIF, there is no need to dissect the perforators in most cases. Even if a FAP flap is harvested, dissecting a short septocutaneous perforator is still a less time-consuming and less technically challenging procedure. When the surgeon is less experienced in preparing perforator flaps, S-FAIF provides a reliable alternative in select patients. Conversely, if the surgeon is proficient and confident, the two techniques can be substituted for one another.

Conclusions

The S-FAIF is a robust and reliable novel flap and on par with SMAPF for reconstruction of small and medium-sized intraoral defects. The rotation arc of S-FAIF allows for reconstruction of most recipient sites except the palate and contralateral floor of the mouth. S-FAIF is preferred to SMAPF when technical requirements for flap harvest and intraoral hair problems are considered. It should be supplemented to the armamentarium of reconstructive tools for oral cavity reconstruction.

Declaration of Competing Interest

The authors declare no conflicts of interest.

Acknowledgment

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