Complications and Peri-operative Characteristics of Flaps for Reconstruction of Defects after Ablation of Squamous Cell Carcinoma of the Floor of the Mouth

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Objective: *To determine the appropriate method to use to repair defects after ablation of squamous cell carcinoma (SCC) of the floor of the mouth (FOM).*
Methods: *A retrospective review of 119 patients who underwent surgical resections of SCC of the FOM and flap reconstructions was conducted. A Student t test was used to examine the statistical differences in operative time, length of hospital stay and complications among groups with different reconstructions.*
Results: *Advanced-stage patients were repaired with more free flaps than local pedicled flaps that provided more reconstructions for small-to-medium defects. The most common recipient complication was wound dehiscence, and patients in the anterolateral thigh flap group developed a greater number of overall recipient site complications compared with those in other groups. Patients undergoing local flap reconstructions had shorter operative times compared with those with free flap reconstructions.*
Conclusion: *In contrast to a radial forearm free flap as a more appropriate reconstruction for defects involving the tongue, an anterolateral thigh flap was better suited for defects with dead spaces. A fibular flap was appropriate for massive complex defects involving the mandible, FOM and tongue. A pectoralis major musculocutaneous flap provided the last line of reconstruction for patients with relapsed SCC or high-risk factors for microsurgical reconstructions.*
Key words: *complication, flap, floor of the mouth, squamous cell carcinoma*
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Although considerable progress has been made with chemotherapy, radiotherapy and immunotherapy in recent decades, surgery remains the mainstay of multimodal treatment for oral squamous cell carcinoma (SCC)[1-3]; however, complete excision of tumours inevitably impairs not only patients' physiological function, but also their psychosocial state[4]. To reduce postoperative impairment as much as possible, various flaps have been employed to repair defects after oral cancer ablation.

The floor of the mouth (FOM) is one of the subsites most frequently exposed to harmful toxicants, such as tobacco and alcohol, in the oral cavity. Thus, the FOM is a relatively common subsite for oral cancer, with approximately 10% of all oral cancers developing there[5]. Defects affecting the FOM need flaps that are able to preserve the local anatomy, repair physiological function and separate the oral cavity from the neck. The present study reports our experience with the use of flaps and sums up the relative characteristics in the reconstruction of defects in the FOM.

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Table 1 Comparison of patients with different types of flaps.

Characteristics		RFFF	ALTF	FF	PMMF	LF
Median age, y		55	57	55	59	54
Sex	Total	43	30	13	9	27
	Male	41	29	13	9	27
	Female	2	1	0	0	0
Tumour stage	T1 and T2	37	20	5	1	26
	T3 and T4	6	10	8	8	1
Prior treatment	Radiation therapy	0	0	0	1	0
	Chemotherapy	5	3	1	1	0
	Surgery	0	1	0	0	1
	Radiation therapy and surgery	0	0	0	5	0

ALTF, anterolateral thigh flap; FF, fibular flap; LF, local flap; PMMF, pectoralis major musculocutaneous flap; RFFF, radial forearm free flap.

Materials and methods

Data collection and analysis

The study was approved by the review board of the Ethics Committee of the School and Hospital of Stomatology of Wuhan University (No. 2019-B05). We conducted the study by selecting medical information of patients with SCC of the FOM who underwent surgery at the Department of Oral and Maxillofacial Surgery, Wuhan University, China, from January 2008 to December 2017. Patients with lesions that were closed directly were excluded. A total of 119 cases were identified. Information on patient characteristics, clinical and histopathological tumour characteristics, treatment modalities and complications was retrieved from the medical records (Table 1).

Surgical intervention

For each patient, the choice of flap type was based on surgeon experience, defect size and patient characteristics, including body habitus, donor site suitability, comorbidity and preoperative treatment. The patients who agreed to reconstruction with free flaps were treated using a two-team approach and those who received reconstruction with local flaps were treated by a single attending surgeon.

Data analysis

Operative time, length of hospital stay and complications were calculated between each group, and a Student *t* test was used to assess statistical differences. $P < 0.05$ was considered significant. Statistical analysis was performed using SPSS version 16 (SPSS, Chicago, IL, USA).

Results

Patient demographics and tumour characteristics

A total of 119 patients received 122 flaps, with one patient receiving both a radial forearm free flap (RFFF) and fibular flap (FF) due to the absence of a cutaneous perforator of the FF. Two patients who had undergone their first reconstruction in our department and subsequently developed recurrent disease after a disease-free interval received a pectoralis major musculocutaneous flap (PMMF) as the secondary reconstruction: one had undergone an anterolateral thigh flap (ALTF) and the other a FF. The key points for the different reconstructive methods were the size, site of defects and surgeon experience after ablation of SCC of the FOM. Of the 122 reconstructions, local flaps (LF, 96%, 26/27) were mainly used for defects after ablation of T1 and T2 tumours, whereas large defects caused by T3 and T4 tumours (97%, 32/33) were reconstructed with free flaps. The choice of a free flap with T3 and T4 tumours depended on the defects in the FOM muscle group, with the first choice of flap with through-and-through defects being ALTF. Sixteen patients had received prior surgical and/or radiation therapy before reconstruction: seven (7/16, 44%) in the PMMF group, five (5/16, 31%) in the RFFF group and four (4/16, 25%) in the ALTF group. All five patients who had previously undergone radiotherapy were in the PMMF group.

Perioperative and postoperative characteristics

Operative time and length of hospital stay are shown in Fig 1. The mean operative time for tumour resection, neck dissection and flap reconstruction was 7 hours and 50 minutes in the RFFF group, 8 hours and 25 minutes in the ALTF group, 9 hours and 53 minutes in the FF group, 9 hours and 3 minutes in the PMMF group, and 6

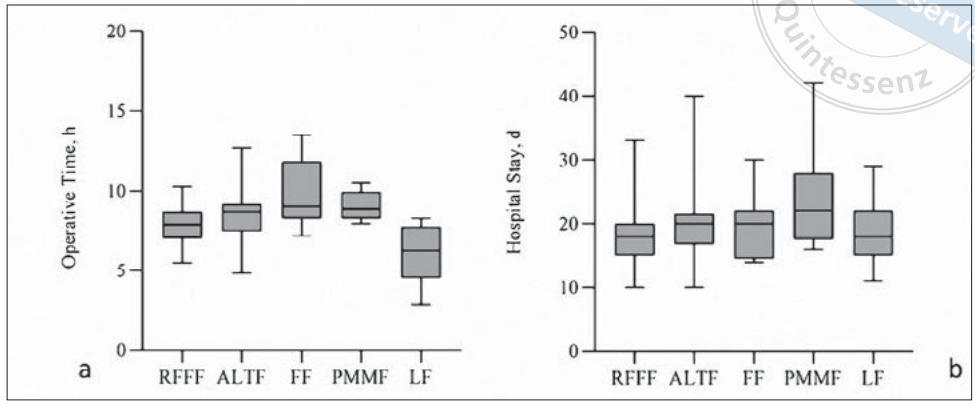

Fig 1 Operative time and hospital stay days with various types of flaps. **(a)** There was a significant difference between the operative time of different flaps ($P < 0.001$). **(b)** The length of hospital stay was shorter for the LF group than for the other groups, but the difference was not statistically significant.

Table 2 Complications in patients with various types of flaps.

Complication		RFFF	ALTF	FF	PMMF	LF
Flap-related complication	Overall	3	4	0	5	6
	Partial necrosis	2	4	0	5	6
	Venous thrombosis	1	0	0	0	0
Recipient-related complication	Overall	8	12	3	7	5
	Orocutaneous fistula	0	1	0	1	1
	Wound dehiscence	2	7	1	3	0
	Hematoma	1	1	1	1	1
	Neck infection	5	2	1	1	3
	Chylous fistula	0	1	0	1	0
Donor site complication	Overall	7	0	2	0	0
	Partial loss of skin graft	2	0	0	0	0
	Wound dehiscence	0	0	2	0	0
	Delayed wound healing	2	0	0	0	0
Medical-related complication	Overall	0	0	1	0	1
	Pneumonia	0	0	0	0	1
	Pneumothorax	0	0	1	0	0

hours and 1 minute in the LF group. Compared with the patients in the free flap reconstruction group, patients undergoing LF reconstruction had significantly shorter operative times ($P < 0.001$) (Fig 1a).

The average length of hospital stay was 18.6 days in the RFFF group, 20.7 days in the ALTF group, 19.6 days in the FF group, 24.2 days in the PMMF group and 18.1 days in the LF group. Although the mean length of hospital stay in the LF group was shorter than 19.95 days in the free flap group, the difference was not statistically significant ($P = 0.108$) (Fig 1b). Nine patients with an RFFF flap spent over 21 days in hospital (21%), compared with 13 ALTF patients (43%), 6 FF patients (46%), 6 PMMF patients (67%) and 8 LF patients (30%). Neck infection and partial flap necrosis were the two most common causes of extended hospitalisation.

Complications

Complications including flap-related, recipient site, donor site and medical-related complications are displayed in Table 2. The most common flap-related complication was partial flap necrosis, six cases of which were identified in the LF group, followed by five in the PMMF group, four in the ALTF group and two in the RFFF group. No cases of total flap necrosis were presented in this study. Only one RFFF patient underwent operative revision due to venous thrombosis.

The most common of the recipient site complications was wound dehiscence, 54% (7/13) cases of which were presented in the ALTF group. Recipient site complications were most prevalent with ALTF reconstruction: seven patients had wound dehiscence, two had a

neck infection, one had an orocutaneous fistula, one had a hematoma and one had a chylous fistula. Eight patients in the RFFF group experienced recipient site complications, followed by seven in the PMMF group, five in the LF group and three in the FF group. Thus, the highest incidence of recipient site complications was found in the PMMF group (7/9, 78%), followed by the ALTF (12/30, 40%), FF (3/13, 23%), RFFF (8/43, 19%) and LF groups (5/27, 19%).

Owing to the skin graft in the donor site, the overall donor site complications were higher in the RFFF group than the other groups. The patients with RFFF reconstructions had two episodes of delayed wound healing and two cases of partial loss of skin grafts. In the FF group, two cases of wound dehiscence were identified, whereas there were no donor site complications in the ALTF and PMMF groups. In the LF group, the donor site was physically close to the recipient site; thus, in our study, all the donor site complications in the LF group were incorporated into the recipient-related complications. Of the medical-related complications, one case developed pneumonia in the LF group and the other case of pneumothorax was presented in the FF group.

Discussion

In the FOM, the choice of reconstruction depends on the size and location of the defect. The main goals are to separate the oral cavity and neck and to maintain chewing, swallowing and pronunciation. Primary closure may be sufficient for small defects that would not result in a fistula between the oral cavity and neck or limit tongue movement. For large defects, various types of flaps have been used to provide soft tissue bulk between the ventral tongue and mandible and maintain mandibular continuity.

Currently, RFFF and ALTF are among the most popular types of free flap used for reconstruction of oral soft tissue defects. It has been widely accepted that RFFFs are thinner and more pliable than ALTFs, which provides the tongue with the possibility of flexible movement. Due to the many cases of wound dehiscence in the ALTF group, our results showed a higher incidence of recipient-related complications in this group (12/30, 40%) than in the RFFF group (8/43, 19%). The possible explanation for this is that an ALTF is not pliable enough for defects involving the anterior part of the tongue because of the tongue's frequently flexible movement. ALTFs were used mainly to repair larger or through-and-through defects, leading to a relatively higher incidence of postoperative complications. Thus, careful suturing decompression incision, flap suture anchoring with the alveolar process and flap suture slinging to the left teeth would decrease the rate of wound dehiscence. The past decades have seen the introduction of perforator-based chimeric ALTFs. With the chimeric-designed ALTFs, the anterolateral thigh muscle is filled at the muscle defects of the FOM to prevent an orocutaneous fistula and the skin is used to repair the defect affecting the tongue and oral mucosa. Furthermore, an ALTF can be trimmed individually into fasciocutaneous, adipofascial, de-epithelialised and folded flaps to meet the demands of FOM reconstruction; however, for female and obese male patients, caution should be exercised when choosing ALTFs because the flap harvesting process is tedious and time-consuming and has many technical surgical requirements. Previous studies compared differences between an ALTF and RFFF in terms of flap survival, complications, satisfaction with appearance, swallowing capacity and intelligibility of speech when they were used for reconstruction in the oral cavity and showed that both flaps were reliable with favourable results, but ALTFs are better for large soft tissue defects and those with a lower rate of donor site morbidity[6,7]. In addition, other studies found that wound infections and fistulas were more common with RFFFs due to their insufficient subcutaneous tissue for packing of compound defects after ablative surgery of FOM SCC[8,9], which is in line with our results. One of the advantages of an ALT flap is that the size of the muscular bulk can be isolated as required. In our experience, the appropriate size of muscular bulk is harvested to fill the dead spaces in the submandibular region. Thus, more ALT flaps were used for the T4 cases with a through-and-through defect than RFFF flaps in our study. Although many attempts have been made to improve reconstruction of FOM defects, the incidence of postoperative complications with free flaps was 46.5% in our patients, which was higher than other defect reconstructions for head and neck cancer[10]; however, very few published studies focus on the postoperative complications of FOM reconstruction. A previous study reported more flap necrosis during reconstruction of the tongue, FOM or oropharynx than in the buccal mucosa, oral and facial skin and the gingiva[11], which may explain the high incidence of postoperative complications in our study. When the tumour invades the FOM and mandible deeply, reconstruction can be achieved with a free compound flap, such as fibular or scapula flaps. Since its introduction in 1989, the free fibular flap has been the mainstay of repair of various mandibular defect types[12]. Although a large skin paddle based on distal septocutaneous perforators[13] and the flexor hallucis longus and soleus

muscles[14] can provide the soft tissue needed for reconstruction, an approach involving a combination of two free flaps is sometimes mandatory for a massive complex defect involving the mandible, FOM and tongue[15]. In our study, a combination of RFFF and FF was used to repair an extensive defect after tumour resection due to the absence of perforating branches of skin in the fibular flap. In some elderly patients with a poor prognosis, mandibular defects may be restored with a titanium reconstruction plate and soft tissue defects may be reconstructed with ALTF or PMMF wrapping around the plate to avoid extrusion. In the present study, some patients underwent marginal mandibulectomy because of the inadequate soft tissue margins. In this situation, only a soft tissue flap was required to cover the rest of the mandible.

The PMMF has been used frequently for head and neck reconstruction owing to its versatile design, easy dissection and reliable blood supply; however, its use has decreased dramatically since the application of the ALT flap. In our experience, PMMFs were mainly used for patients with high risk factors for microsurgical reconstructions including preoperative radiotherapy, prior surgical therapy or a high American Society of Anesthesiologists (ASA) grade. Zou et al[11] reported 24 PMMFs in patients with recurrent oral SCC, with six of them being SCC in FOM. More flap necrosis occurred during reconstruction of the tongue, FOM and oropharynx than the buccal mucosa, oral and facial skin, and gingiva. In our study, the incidence of recipient site complications and flap-related complications was 77.78% (7/9) and 55.56% (5/9), respectively. A possible explanation for this is that the mandible compresses the pedicle of the PMMF due to its bulk and postoperative oedema. The hypothesis is supported by Marques et al[16], who found no PMMF necrosis in patients with FOM SCC who underwent glossectomy and segmental mandibulectomy. Additionally, in our study, seven of nine patients with PMMF had undergone prior surgical and/or radiation therapy, which could impact the local blood supply or anatomy, thus increasing the rate of wound dehiscence, orocutaneous fistula and neck infection. For patients who had previously undergone treatment, the design of the PMMF flap that was larger than the defects, a more reliable blood supply and longer pedicle would reduce complications. Preservation of the lateral thoracic artery in addition to the thoracoacromial artery can improve unstable blood circulation in the PMMF[17]. Chen et al[18] reported that an extensive segmental PMMF via the anterior axillary line could effectively prolong the pedicle of conventional PMMF and enable better shoulder abduction.

Although free flaps are the gold standard for oral cavity reconstruction, local pedicled flaps may be helpful for some patients who are elderly and have complex chronic comorbidities or who cannot afford expensive health care costs. In our study, platysma myocutaneous flaps were used in 12 cases, submental island flaps in nine cases, buccinator myomucosal flaps in four cases and sternocleidomastoid myocutaneous flaps in two cases. One of the greatest advantages of cervical pedicled flaps is that they avoid the need for a separate donor site. Another advantage is that LF reconstruction is a quick procedure, as in our cases where the mean surgical time was 6 hours and 1 minute, which was significantly shorter than for the free flap reconstruction groups; however, there are several concerns regarding the use of cervical pedicled flaps in oral reconstruction. First, controversy exists regarding the potential risk of transferring occult metastasis to the recipient site. To reduce the risk, some authors have proposed a submental artery island perforator flap and sternocleidomastoid perforator flap[19,20]. Second, debate remains as to whether a cervical pedicled flap is appropriate after the identification of nodal metastasis. Third, neck dissection and prior radiotherapy may affect the blood supply of cervical pedicled flaps. Finally, a cervical pedicled flap can only provide enough volume of tissue for small-to-medium defects. In the LF group in our study, 26 of 27 cases were at early tumour stage. No extracapsular metastases were identified in patients with LF reconstructions on preoperative imaging, which was confirmed by pathological examination; however, postoperative pathological examination detected positive lymph nodes in 14 patients. In the LF group, one patient had previously received chemotherapy and none had previously undergone neck dissection or radiotherapy. No complications were identified in the patient who had undergone chemotherapy. We propose that prior radiotherapy and extracapsular extension of the cervical nodes are contraindications for LF reconstruction.

To the best of our knowledge, this study represents one of the largest reported series of reconstructions of FOM defects following cancer surgery; however, the study inevitably has some limitations due to its retrospective nature. Long-term complications like localised numbness of donor site were not evaluated because some patients died or were lost to follow-up. Swallowing and speech functions were not compared between different types of flaps because impairment of swallowing and speech increased with defect size, and the choice of the flaps varied significantly with the defect size and clinical stage. There was a greater number of T3 and T4 tumours in the FF group than those

in the LF group. Moreover, postoperative radiation therapy or chemoradiotherapy can adversely affect speech and swallowing.

Conclusion

Patients in the ALTF group developed a greater number of overall recipient site complications compared with those in the other groups, while the overall donor site complications were significantly higher in the RFFF group. LFs are an appropriate choice for reconstructing small-to-medium FOM defects without extracapsular cervical metastasis and prior radiotherapy. Compared with RFFF, ALTF is better for large through-and-through defects, but it is less suitable for defects involving the anterior part of the tongue. For complex defects involving the mandible, FF is an optimal choice. PMMP provides a good choice for recurrent FOM SCC or patients with high risk factors for microsurgical reconstructions, which makes it the last-line reconstruction for FOM defects.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Qu DENG carried out the experiments and drafted the manuscript; Drs Qiu Sheng XU conducted the statistical analysis; Drs Xu Hui ZHANG and Jing Chan XIE reviewed the literature; Prof Yi Fang ZHAO and Yan Ping HU revised the manuscript comprehensively; Prof Jun JIA designed and supervised the study.

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