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CLINICAL ARTICLE

Optimizing survival of large fibula osteocutaneous flaps for extensive full-thickness oromandibular defects: A two-stage approach with temporary orocutaneous fistula

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Introduction: Composite and large head and neck defects requiring extensive skin-mucosa coverage are often reconstructed by combining flaps. Herein, we present a simple and reliable two-stage fibula osteocutaneous (FOC) flap technique to improve the survival of a large skin paddle for oromandibular reconstructions.

Methods: From October 2011 to September 2016, 47 patients with through-and-through oromandibular defects were reconstructed using FOC flaps with large skin paddles. To ensure optimum survival of skin paddles, temporary orocutaneous fistula were left in place and closed during the second stage operation via de-epithelialization of the skin paddle and suturing of mucosa. Demographic data, operative details, and postoperative complications were recorded.

Results: The skin paddle dimensions ranged from 20 to 31.5 cm in length and 12 to 17 cm in width with an average area of 430.4 cm^2 (range 300–504). The average time between the two stages and hospital stay were 10 days and 14 days, respectively. Complications at the donor site included wound dehiscence (n = 3, 6.4%), partial skin graft loss (n = 3, 6.4%) and hematoma (n = 2, 4.3%). Recipient site complications included two (4.3%) early postoperative venous congestions that resolved after elevation and three (6.4%) partial skin flap necrosis (less than 5% surface area). All complications resolved with bedside conservative management. There was only one take-back for evacuation of recipient site hematoma (2.1%) but no flap loss.

Conclusion: Two-staged large skin paddle FOC flaps can simplify reconstruction of extensive oromandibular defects by improving the reliability of the sizable skin paddle and negating the need for a second flap.

1 | INTRODUCTION

Reconstruction of a full-thickness oromandibular defect, involving the oral mucosa, bone, and external skin of the head and neck, can be a challenging procedure due to the extensive area of resection and the multiple types of tissues involved.

In the last several decades, the incidence and recurrence of oral squamous cell carcinoma has been increasing in Taiwan. This is mostly due to the heavy consumption of betel quid combined with tobacco and/or alcohol (Adel et al., 2016). Patients undergoing resection are at risk for disfiguring defects and functional impairments such as inability to speak, eat, and retain saliva. Optimal results require a well-designed flap that provides appropriate inner lining, bone and external coverage.

Reconstruction of such composite and extensive defects can be usually accomplished in a single stage using two flaps for proper soft/bone tissue reconstruction and skin coverage.(Jeng, Kuo, Wei, Su, & Chien, 2005; Kuzon, Jejurikar, Wilkins, & Swartz, 1998) Typically, a fibula osteocutaneous (FOC) flap is combined with either another free flap such as a anterolateral thigh (ALT) flap or a regional flap like a

pedicled pectoralis major (PM) flap. Alternatively, an iliac crest free flap with a forearm flap can serve the same purpose.(Chen et al., 1999; Gabr et al., 2004; Jeng et al., 2005; Said et al., 2007) However, double or multiple free flaps require additional donor sites and vascular anastomoses which result in increased donor site morbidity and operative time.(Gong et al., 2015; Huang et al., 2002; Huang, Chen, Wei, Cheng, & Schnur, 2003)

The FOC flap has become the preferred flap for mandibular reconstruction, because the fibula can be contoured to replace a large mandibular deficit and the skin paddle can be used to resurface both intraoral and extraoral defects if required.(Lutz & Wei, 2005; Wei, Seah, Tsai, Liu, & Tsai, 1994; Yim & Wei, 1994) To minimize the number of flaps for the reconstruction of a full-thickness oromandibular defect, a double-skin paddle FOC flap can be performed. This technique was first described by Jones et al.(Jones, Vögelin, Markowitz, & Watson, 2003) and since then many groups have reported successes with its use.(Gal, Jones, & Valentino, 2009; Jones et al., 2003; Said et al., 2007) The skin paddle is first divided into two surfaces to provide intraoral lining and extraoral skin coverage. The division is most often done via de-epithelialization of a skin strip between the two skin paddles rather than a complete separation. The skin paddle can then be draped over the neo-mandible. The benefit of this approach is that it allows for the preservation of underlying perforators. A study reporting a series of 34 patients who received FOC flaps with immediate de-epithelialization for the reconstructions of full-thickness oromandibular defects reported a partial skin flap necrosis rate of 26% and a surgical revision rate of 40%.(Said et al., 2007) Upon closer examination, the higher incidence of partial skin necrosis was from flaps with larger skin paddles equal or greater than 300 cm^2.(Said et al., 2007)

In this report, we introduce a novel option of a two-stage reconstruction using a FOC flap with a large skin paddle. We report our experience and clinical outcomes of patients who underwent simultaneous reconstruction of the mandible, oral floor, and neck area for extensive full-thickness mandibulectomy defects using this technique.

2 | PATIENTS AND METHODS

A retrospective review of a prospectively maintained database at the China Medical University Hospital, Taichung, Taiwan, was undertaken. Between October of 2011 and September of 2016, patients with head and neck cancer who underwent reconstruction using this technique were included. Demographics, comorbidities, etiology of the resection, intraoperative details and complications were recorded.

A total of 41 males and 6 females were included in this study. The average BMI was 18.3 kg/m^2 (range 17–26.4) (Table 1). Underlying pathologies included squamous cell carcinoma of the oral cavity (n = 26, 55%), recurrent squamous cell carcinoma of the oral cavity (n = 13, 28%) and osteoradionecrosis of the mandible (n = 8, 17%). Forty-one (87%) patients had undergone preoperative radiotherapy and 13 (27%) patients had previous reconstructive surgeries due to recurrence. All patients had histories of either betel squid chewing (n = 39, 83%), alcohol drinking (n = 41, 87%) and/or smoking (n = 33, 70%). Five patients had diabetes mellitus (Table 1).

TABLE 1 Demographic and clinical data

Male	**41**
Female	6
Age (years)	58 (range 35–58)
BMI (kg/m^2)	18.3 (range 17.0–26.4)
Time b/w stages (days)	10 (range 8–15)
Hospitalization time (days)	14 (range 10–16)
Follow-up (months)	27 (range 13–46)
Diagnosis	
Intra-oral SCC	26 (55%)
Recurrent SCC	13 (28%)
Osteoradionecrosis after SCC	8 (17%)
Comorbid status	
Betel nut-chewing	39 (83%)
Alcohol-drinking	41 (87%)
Smoking	33 (70%)
Diabetes	5 (11%)
Previous reconstructions	13 (28%)
Pre-operative radiotherapy	41 (87%)

Abbreviation: SCC, Squamous cell carcinoma.

3 | SURGICAL TECHNIQUE

First, the perforators along the posterior border of the fibula were located using a handheld Doppler. A skin paddle was then planned with its center at the junction of the middle and third portion of the lower leg on the posterior margin of the fibula with adjustments to accommodate the location of the perforators. A tourniquet was applied above the knee and a posterior approach was taken for the skin paddle elevation. Both muscular and septal perforators were noted before proceeding to superficial dissection, identification, and preservation of the lesser saphenous vein (to augment venous outflow if necessary). Dissection was then continued subfascially toward the posterior septum. Musculocutaneous perforators supplying the soleus muscles were exposed during the process and preserved until the presence of septal perforators was confirmed. If soleus was needed for soft tissue augmentation, a portion of the soleus muscle was harvested with the segment of bone. After flap transfer and fixation of the neo-mandible, the skin paddle was draped over the neo-mandible to cover both intraoral mucosal and extraoral cutaneous defects. Where applicable, the soleus was placed appropriately to obliterate dead space and to provide soft tissue augmentation. After flap inset, an orocutaenous fistula (Figures 1C and 2C) was intentionally left open until the second stage. Patients were kept hospitalized for proper wound care and stabilization and were evaluated for suitability for the second stage. Criteria included wound healing, nutritional status, and overall patient stability. During the second stage, a strip of skin was de-epithelialized to separate the skin paddle into intraoral and extraoral portions. The oral fistula was then closed by suturing along the de-epithelialized border. The consecutive steps of the surgical technique are shown in Figure 1. Postoperative follow-up was performed at 2 weeks after the final inset and, subsequently, every 3 months during the first year.

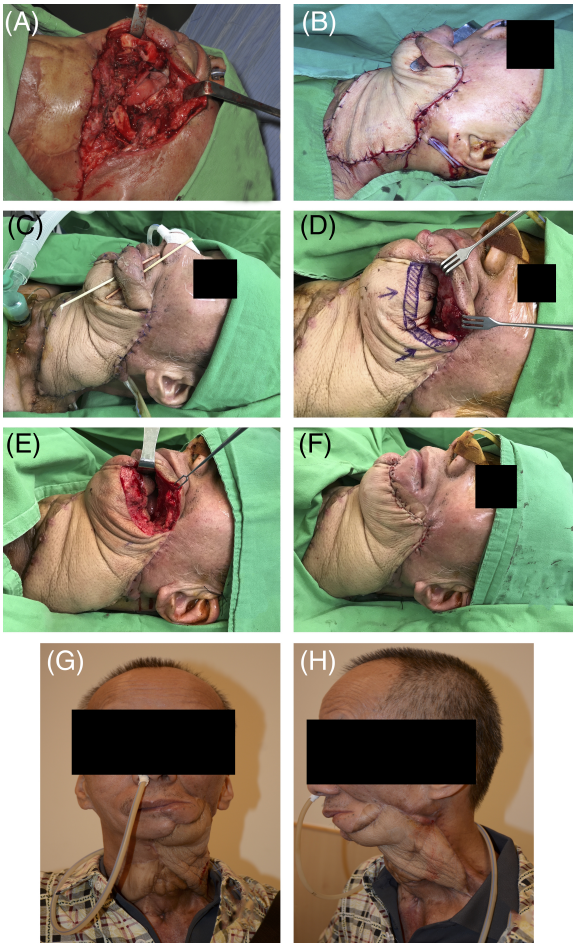

FIGURE 1 The patient presented with recurrent squamous cell cancer of the oral cavity. A, A large through–through oromandibular defect after surgical resection of the tumor. B, Immediate after free flap reconstruction. C, The orocutaneous fistula is shown just before the second stage surgery. D, The region on the skin paddle to be de-epithelialized. E, After de-epithelialization. F, After closure of the orocutaneous fistula by suturing the cheek to the de-epithelialized region. G and H, The result of reconstruction is shown at 6-month follow-up

FIGURE 2 The patient presented with osteoradionecrosis of the left mandible. A and B, Preoperative pictures show severe contracture and skin fibrosis. C, Orocutaneous fistula on postoperative day 14 after the first stage procedure. D, Immediately post-operative picture after de-epithelialization of the skin paddle and repair of the orocutaneous fistula at the second stage. E, At 3-month follow-up, there was complete healing with no complications. F, A skull X-ray showing the reconstructed mandible with fixed plates

4 | RESULTS

All reconstructions were carried out successfully with no flap loss. Thirty-three patients (70%) had unilateral and 14 (30%) patients had bilateral defect mandibular defects that required reconstruction of both intraoral and extraoral defects. In terms of recipient arteries, the transverse cervical artery was the most commonly used in 31 (66%) cases followed by the thoracoacromial artery in 12 (26%) cases. Recipient veins included external jugular vein in 28 (60%) cases, transposed cephalic vein in 15 (32%) cases and internal jugular vein branches in four (8.5%). Thirty-six (77%) cases required vein grafts (for either artery or vein) to avoid tension or size discrepancies (Table 2).

The dimensions of the skin paddle ranged from 20 to 31.5 cm in length and from 12 to 17 in width resulting in an average surface area of 430.4 cm^2 (range 300–504). The skin flap survival based on the surface area was as follows: Among the six flaps with skin paddles in the range of 300–399 cm^2 and a soleus muscle component, there was one case (2.1%) of partial skin necrosis. Three flaps with skin paddles in the range of 300–399 cm^2 and no muscle component survived completely. Twenty-three flaps had skin paddles in the range of 400–450 cm^2 along with a soleus muscle component and one case of partial skin necrosis (2.1%). Ten flaps had skin paddles ranging from 400 to 450 cm^2 without a muscle component; one (2.1%) of them experienced partial skin necrosis. Overall 29 flaps (62%) included a portion of the soleus muscle. Five flaps had skin paddles ranging from 451 to 504 cm^2 with no cases of skin paddle partial necrosis (Table 3). In terms of perforator numbers, there were six flaps with only one perforator, one (2.1%) of which exhibited partial skin necrosis. Twenty-six flaps had two perforators with two cases (4.3%) of partial skin necrosis. There was no skin necrosis in the 15 flaps with three perforators (Table 3).

Overall three patients (6.4%) experienced partial skin necrosis and in all cases the extent of the necrosis was limited to <5% of the total

TABLE 2 Operative and postoperative details

Recipient artery	
Transverse cervical	31 (66%)
Thoracoacromial	12 (26%)
Recipient vein	
External jugular	28 (60%)
Internal jugular branches	4 (8.5%)
Cephalic transposition	15 (32%)
Required vein graft	36 (77%)
Mandibular defects	
Unilateral	33(70%)
Bilateral	14(30%)
Location of defects (w/ mandible)	
Intraoral + neck	14 (30%)
Intraoral + Extraoral + neck	33 (70%)
Postop complications	
Donor site	
Wound dehiscence	3 (6.4%)
Hematoma	2 (4.3%)
Partial skin graft necrosis	3 (6.4%)
Recipient site	
Partial skin paddle necrosis	3 (6.4%)
Venous congestion	2 (4.3%)
Hematoma	1 (2.1%)

surface area. Two cases (4.3%) of mild venous congestion in the early postoperative period resolved with head elevation. There was only one take-back for evacuation of hematoma at the recipient site. At the donor site, three cases (6.4%) of wound dehiscence and two cases (4.3%) of hematoma were managed successfully at the bedside. Three cases (6.4%) of partial skin graft loss were similarly managed conservatively with local wound care (Table 2).

The time between the two stages ranged from 8 to 15 days with an average of 10 days. The average overall hospitalization time was 14 days (range 10–16). The patients were followed for an average period of 27 months (range 13–46) after the second stage. No functional impairment was noted at the donor leg. At the recipient site one patient had salivary leakage but none had trismus indicating satisfactory mucosal resurfacing.

5 | CASE REPORTS

5.1 | Case 1

A 67-year-old man presented with recurrent squamous cell cancer of the oral cavity (Figure 1). He had previously undergone reconstruction with radial forearm and ALT free flaps and had received adjuvant radiotherapy. After wide excision, a large full-thickness oromandibular defect involving the oral mucosa, extraoral surface, and the left lateral aspect of the neck was present (Figure 1A). A fibular osteocutaneous free flap with a large skin paddle measuring 31.5 cm × 16 cm (504 cm^2) was designed and harvested from the left leg. Three perforators were identified with a handheld Doppler. The recipient vessels were the left transverse cervical artery and a branch of the internal jugular vein. At the first stage, the flap was used to completely cover the oral floor, neo-mandible, and lateral neck. As no attempt was made to divide or de-epithelialize the skin portion of the flap, a temporary orocutaneous fistula was left in place after the initial surgery. The postoperative course was uneventful and the patient was kept hospitalized for continuous monitoring of the flap until postoperative day 14 when the patient underwent the second stage procedure (Figure 1C). A strip of skin on the FOC flap skin paddle was de-epithelialized and the orocutaneous fistula closed (Figure 1D–F). All elements of the flap survived completely and the patient was discharged on postoperative day 2. At 6-month follow-up, the patient had complete healing of wounds with a good aesthetic outcome and reported no saliva leakage.

5.2 | Case 2

A 54-year-old man (Figure 2) presented with osteoradionecrosis of the left mandible. He had a previous reconstruction with an ALT free flap after the resection of an intraoral squamous cell carcinoma. The patient also suffered from severe mucosal and skin fibrosis as a result of radiotherapy. After excision of the left mandible and fibrous tissues from the oral floor/neck, a large fibular osteocutaneous flap measuring 16 cm × 26 cm (416 cm^2) was designed and harvested from the left leg. Two perforators were identified with a handheld Doppler. The recipient vessels were the transverse cervical artery and preserved external jugular vein. After flap inset, an orocutaneous fistula

TABLE 3 Skin paddle survival in relation to size and number of perforators

Skin paddle size	Number of flaps	Compl. Survival	Partial necrosis
300 to 399 cm^2 (20–25 cm × 12–15 cm)	6 w/o soleus	5	1
	3 w/o soleus	3	0
400 to 450 cm^2 (25–29 cm × 14–16 cm)	23 w/ soleus	22	1
	10 w/o soleus	9	1
451 to 504 cm^2 (29–31.5 cm × 16–17 cm)	5 w/o soleus	5	0
Total	47	44 (93.6%)	3 (6.4%)
Number of perforators	*Number of flaps*	*Compl. Survival*	*Partial necrosis*
1	6	5	1
2	26	24	2
3	15	15	0
Total	47	44 (93.6%)	3 (6.4%)

was intentionally left in place during the first stage. The second stage operation took place on postoperative day 14 and the patient was discharged the next day. The postoperative course was uneventful. At 3-month follow-up visit, the patient had good healing of the wounds and lower extremity function. Patient reported no saliva leakage, trismus or restricted range of motion of the neck.

6 | DISCUSSION

The two options for reconstruction of extensive, full-thickness oromandibular defects are (1) a double skin paddle FOC or (2) two individual free flaps. Simultaneous resurfacing of both the intraoral lining and cheek/neck skin along with reconstruction of the mandible using the FOC flap has been well documented in the literature with variable results mostly dependent on the size of the skin paddle.(Deleyiannis et al., 2008; Jones et al., 2003; Said et al., 2007) The purpose of this report is to introduce an alternative and reliable technique for reconstruction of such large and complex defects with FOC flaps. By delaying final inset of the flap, consistent survival of skin paddles larger than 300 cm^2 can be achieved. The continuity of skin paddle is maintained at the first stage. De-epithelialization and contouring is then safely performed at a second stage. Moreover, soft tissue augmentation is also possible by harvesting a portion of the soleus muscle along with the FOC flap.(Kuo et al., 2010; Wallace, Chang, Tsai, & Wei, 2010)

In an anatomical study, Wei et al. demonstrated that the perfusion area of the peroneal artery cutaneous perforators range from 22 to 25 cm in length and 10 to 14 cm in width centered around the posterior fibular margin at the junction of the second and third portion of the fibula.(Wei, Chen, Chuang, & Noordhoff, 1986) Therefore, theoretically, the safest maximum skin paddle size would be about 350 cm^2. Nevertheless, Said et al. demonstrated that skin paddles much greater than 300 cm^2 and up to 550 cm^2 are feasible for FOC flaps by incorporating multiple peroneal artery cutaneous perforators. (Said et al., 2007) These large skin paddles can be employed to cover more than one surface in order to satisfy the reconstructive needs of extensive, full-thickness defects in head and neck reconstruction.

Even though researchers had explored the use of FOC for simultaneous reconstruction of both intra- and extra-oral defects before, it was in 2003 when Jones et al. reported a dedicated series of 16 patients with composite through-and-through mandibular defects that underwent reconstruction with double-skin paddle FOC.(Jones et al., 2003) Subsequently, larger series that use a similar approach have been published with reasonable outcomes. (Said et al., 2007) However, upon detailed assessment of the outcomes in relation to the size of the skin paddles, it becomes evident that size matters. While Jones et al. reported complete survival of all skin paddles, the largest skin paddle in the series measured 312 cm^2 (26 cm × 12 cm). When skin paddle size exceeded 300 cm^2, Said et al. found a statistically significant increase in incidence of partial flap necrosis and need for revisionary surgery. In their series of 34 patients, the incidence of partial skin necrosis was 50% with skin paddles larger than 300 cm^2 as compared to 12% with skin paddles less than 300 cm^2. In our series, all flaps measured larger than 300 cm^2; the overwhelming majority (33/47) of the flaps were in the 400–450 cm^2 range. Yet, the rate of partial skin necrosis (less than 5% surface area) was 6.4%. We attribute this to two advantages of our staged approach: avoidance of de-epithelialization and folding of the flap. We believe that these two maneuvers can put undue stress on a large skin paddle of a FOC flap.

Even though de-epithelialization of the FOC flap can be performed at the first stage, the blood circulation especially at the most proximal part may be compromised. We elected to delay the de-epithelialization process in order to avoid any disruption to the subdermal plexus of the skin paddle.(Choi, Kim, Oh, Koh, & Jeong, 2017; Saint-Cyr, Wong, Schaverien, Mojallal, & Rohrich, 2009) In our practice, immediate de-epithelialization is routinely done for FOC flaps with smaller skin islands (<300 cm^2). In the study by Said et al., partial skin paddle necrosis happened in 7 out of 30 patients (23%) who had immediate de-epithelialization. In 4/34 patients epithelialization was not needed. Still, half of these flaps experienced partial skin paddle necrosis, as the skin flap was folded at the vermillion edge.

As shown by a previous study, neovascularization becomes well established between the transferred free flap and the recipient site by the eight postoperative day.(Black, Chait, O'Brien, Sykes, & Sharzer, 1978) We believe that neovascularization from surrounding tissue that occurred during the period between two stages allowed us to improve the chance of complete survival of the skin paddle. Only, three flaps experienced partial necrosis of the skin paddle in our study. The partial necrosis sites were located at the most proximal edge of the skin paddle (most distal from the perforator) and were limited to <5%. They were debrided and closed with a local advancement flap during the second stage.

An alternative to immediate de-epithelialization and contouring of the skin paddle of FOC would be an additional free flap. The second flap not only de facto doubles the risk of donor site complications but also creates a second scar. Also, it does require a second microsurgical team for simultaneous harvest adding to complexity of the reconstruction. Unavailability of a second team would mean longer operative time both for the harvest of the flap and the additional set of microsurgical anastomosis. Moreover, unless the second flap is anastomosed to a branch of the first flap, an additional set of recipient vessels needs to be identified and harvested. In the context of preoperative radiotherapy or secondary reconstruction, this can be quite challenging (Halle et al., 2009). Eighty-seven percent of our patients had pre-operative radiotherapy and 28% had previous reconstructions. To overcome the lack of preferred recipient vessels and to avoid radiotherapy-damaged vessels, we performed anastomoses to larger, more proximal vessels such as the transverse cervical artery and the thoracoacromial artery. For recipient veins, larger veins were chosen. We often transposed the cephalic vein and preserved the previously used external jugular vein. In 36 cases, "Y" shaped vein grafts were taken from the dorsum of the foot or hand to improve the venous drainage of the flap via connecting the superficial lesser saphenous vein. In cases of recurrent cancers, very common in our patient population to due to the field effect of carcinogens, one needs to be prudent with expenditure of available donor sites. The reconstructive surgeon needs to save flap options for possible future recurrence. We still resort to two free flaps when the spatial orientation of

FIGURE 3 At 5-month follow-up of a patient who had mandibular reconstruction with a free FOC with a skin paddle of 27 cm × 15 cm (405 cm^2). The donor site showed good healing with no contour irregularities and reasonable appearance and no evidence of functional deformity

the mucosal and skin defects is such that cannot be reconstructed with a large FOC flap. (Gabr et al., 2004)

With the current approach, the whole process is simplified. Adequate reconstruction of both intraoral and extraoral defects is accomplished with a single flap. Although a second operation is warranted, it is very simple and fast. As only de-epithelialization and suturing of the mucosa and skin to the de-epithelialized region are required, the entire process usually lasts no more than 30 min in our experience and it can be easily performed as an outpatient procedure.

The main disadvantage of a two-stage procedure is the delay in recovery of 10 days on average. However, we believe the delay in time is a good trade-off in exchange for a better surgical outcome with reduced donor site morbidity, postoperative complications, and improved quality of life compared to other two-flap approaches. Second, a risk of infection arises after the first operation, as an oral fistula is created and may result in saliva leakage. This can be overcome by careful wound cleaning and proper dressing. The larger than usual donor site area did not seem to affect postoperative outcomes, all minor complications were treated conservatively without any long-term consequence. A reasonable appearance can be achieved with a meticulous technique (Figure 3).

7 | CONCLUSION

By staging the de-epithelialization and final inset, FOC can be safely and reliably used to reconstruct extensive full-thickness oromandibular defects. The presented technique avoided jeopardizing the flap during initial inset, minimized donor site morbidities and improved the survival rate of FOC flaps with a large skin paddle. As it negates a second free flap, this technique can be beneficial in selected patients who have limited donor tissues for reconstruction and those who cannot tolerate long operations.

CONFLICT OF INTEREST

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