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Deep circumflex iliac artery perforator flap with iliac crest for oromandibular reconstruction

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ABSTRACT

When combined with iliac bone, perforator flaps are more chimeric, and there is increased mobile skin island to reconstruct soft tissue defects in the oral and maxillofacial region. This study examined oromandibular defects reconstructed using deep circumflex iliac artery perforator flap with iliac crest (DCIAPF). We retrospectively reviewed records of 23 patients with mandibular defects received DCIAPFs after oncological resection for oromandibular reconstruction from November 2015 to August 2016. All perforators, identified before surgery by Doppler examination, were terminal perforators of DCIA. DCIAPFs were successfully harvested in all patients. The flap survival rate was 95.6% (22/23); one flap failed due to artery spasm. Three patients developed slight skinedge necrosis in the skin island. Anatomical reconstruction contour of the mandible and sufficient bone length and height were achieved, with no serious donor-site complications during the follow-up period. The results demonstrated that DCIAPF is a favorable single-flap option for oromandibular reconstruction after oncological resection with fewer donor-site complications because of its adequate bone tissue and satisfactory soft tissue, with a constant location of the perforator.

1. Introduction

Mandibular reconstruction after tumor ablation is one of the challenging tasks for oral and maxillofacial surgeons because of the mandible's esthetic importance and its primary role in speech, swallowing, and chewing with the help of dentures (Farwell and Futran, 2000; Baker et al., 2001; Schimmele, 2001). Nowadays, vascularized bone grafting is a favorable option for such reconstructions.

The utility of the free fibula osteocutaneous flap for mandibular reconstruction was recognized and became the standard therapy as noted by Hidalgo in 1989 (Hidalgo, 1989; Hidalgo and Pusic, 2002). The iliac crest flap is more favorable than the free fibula flap for some surgeons because of the large amount of bone volume, good shape and enough height, which make it an ideal choice for plate fixation and implant placement for dental restoration (Baker et al., 2001; Brown et al., 2006).

Despite numerous advantages of using the iliac crest, the widespread use of deep circumflex iliac artery (DCIA) flaps has been limited by the unnecessary bulk of the "obligatory muscle cuff" and the tethering of the skin to the bone, which renders soft-tissue placement in complex oromandibular reconstructions rather challenging (Taylor et al., 1979; Safak et al., 1997; Kimata et al., 2001; Kimata, 2003). Perforator flaps have certain advantages such as the super-selection of soft tissues with reduced bulk, increased pedicle length, and less donor-site morbidity (Wei et al., 2002; Geddes et al., 2003). Safak (Safak et al., 1997). Kimata et al. (Kimata et al., 2001; Kimata, 2003) designed a deep circumflex iliac artery perforator flap with iliac crest (DCIAPF) to reduce soft-tissue bulk of the flap and diminish donor-site morbidity and achieved some success. In recent years, few studies have focused on the perforators emitted from DCIA (Geddes et al., 2003; Bergeron et al., 2007; He-Ping et al., 2013). When combined with iliac bone, perforator flaps are more chimeric, and there is increased mobile skin island to reconstruct soft tissue defects in the oral and maxillofacial region. However, not all perforators originate from the terminal end of DCIA. The primary purpose of this article is to evaluate the feasibility and outcomes of the DCIA terminal musculocutaneous perforator flap with iliac crest (i.e., DCIAPFs) used in the simultaneous reconstruction of oromandibular defects.

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2. Materials and Methods

2.1. Patient details and characteristics

From December 2015 to August 2016, 23 patients (11 male and 12 female) aged 10–76 years (median, 53 years) were treated at the Peking University School and Stomatology Hospital, China. Diagnosis of all patients was confirmed by histological examination before segmental mandibulectomy. The inclusion criteria were the following: segmental mandibulectomy was indicated; the perforators of DCIAPFs could be clarified using a Doppler; and simultaneous oromandibular reconstruction with DCIAPF was possible. Patient characteristics are summarized in Table 1. Treatment in all cases was approved by the Ethical Committee of Peking University School and Hospital of Stomatology. All patients provided written informed consent before their inclusion.

2.2. DCIAPF harvest

Anatomy of the terminal cutaneous perforators was clarified using a bidirectional handheld Doppler (Bidop ES-100V3; Hadeco Inc., Kawasaki, Japan) before surgery, computed tomography angiography (CTA) was performed to evaluate the perforators in 7 patients using a multislice scanner with 64-row multidetector computed tomography (Brilliance; Philips, The Netherlands), and Fig. 1 provides a schematic presentation of the perforator. Patients were placed in a supine position under general anesthesia. The DCIAPF was synchronously elevated using the ablative procedure. Based on the size and shape of the defect, a skin flap was raised by retrograde dissection from the terminal musculocutaneous perforator of the deep circumflex artery, including the perforator. An incision was first made 2 cm above the mid-point of the line between the anterior superior iliac spine and the pubic tubercle, extending up to the upper border of the skin paddle, which was centered on the perforator, and subsequently, the skin paddle was elevated towards the iliac crest, immediately above the external oblique muscle. This incision allowed identification of the perforator that emerged from the external oblique muscle and had an anterior origin. The dominant perforator was meticulously dissected free through the abdominal muscles to the parent DCIA. Leaving a small cuff of abdominal muscle attached to the perforator helped protect it from damage. Once the DCIA perforator was isolated, the inferior border of the skin was incised to meet the actual need, and the DCIP flap was elevated. The bone and DCIA were harvested in the usual manner (Fig. 2).

Intraoperatively, the calibers of the perforators were measured. If there was more than one perforator in a patient, only the larger perforator in diameter was recorded. The donor site was directly sutured layer by layer to avoid ventral hernia. Patients were advised to wear a waist protector for at least 1 month with normal bowel movements maintained.

Table 1
Patient and treatment characteristics.

Characteristics	Number
Sex (n)	
Male	11 patients
Female	12 patients
Age (years)	
Median	53 years
Range	10–76 years
Histology	
Oral carcinoma	12 patients
Osteosarcoma	2 patients
Ameloblastoma	7 patients
Ossifying fibroma	1 patient
Myofibroma	1 patient
Preoperative therapy	
Surgery+radiotherapy	2 patients
Surgery	5 patients
Defect (classification of mandibular defects by Urken)	
RB	11 patients
BS	6 patients
RBS	3 patients
CRB	2 patients
R	1 patient
Length of iliac bone (condyle + ramus + body + symphysis) (cm)	
Median	8 cm
Range	6–13.5 cm
Height of iliac bone (cm)	
Median	2.5 cm
Range	2–3 cm
Number of perforator	
One	19 patients
Two	4 patients
Caliber of perforator	
Approximately 1.0 mm	15 patients
Larger than 1.0 mm	8 patients
Length of perforating vessel	
Median	6 cm
Range	4–7 cm
Size of skin paddle (cm)	
Median	6 × 8 cm
Range	5 × 6–9 × 14 cm
Complications of donor site	
Mild donor-site pain	2 patients
Sensory deficits	3 patients
Postoperative adjuvant therapy	
Radiotherapy	4 patients (oral carcinoma)
Chemotherapy	1 patient (osteosarcoma)
Chemoradiotherapy	4 patients (3 oral carcinoma, 1 osteosarcoma)

2.2.1. Oromandibular reconstruction

The lateral cortex of the iliac crest formed the lateral wall of the mandible. The crest of the iliac bone was contoured to provide a new mandibular margin. The sawn inferior margin of the iliac crest formed the alveolar ridge. The skin island was used to reconstruct the soft tissue defect (Figs. 3–5).

The deep circumflex iliac vessels were anastomosed to the ipsilateral neck vessels. Moreover, in 1 patient, the superficial circumflex vein was included in the skin flap and anastomosed to the recipient vessels as super-drainage (Figs. 6 and 7).

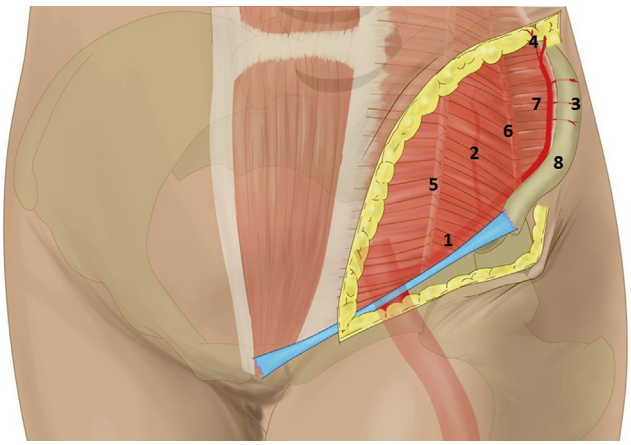

Fig. 1. Schematic presentation of the deep circumflex iliac osteocutaneous flap with the skin component nourished by the terminal musculocutaneous perforator. 1, Deep circumflex iliac artery; 2, ascending branch; 3, osteomusculocutaneous branches; 4, terminal musculocutaneous perforator, iliac bone; 5, obliquus externus abdominis; 6, obliquus internus abdominis; 7, transversus abdominis; 8, iliac crest.

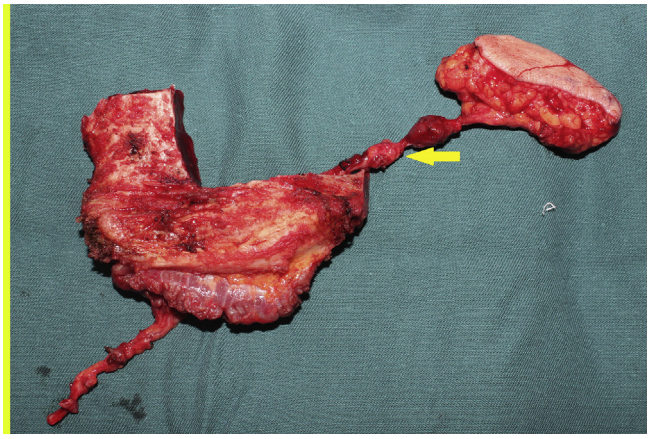

Fig. 2. Harvested DCIAPF with terminal cutaneous perforators of DCIA (yellow arrow).

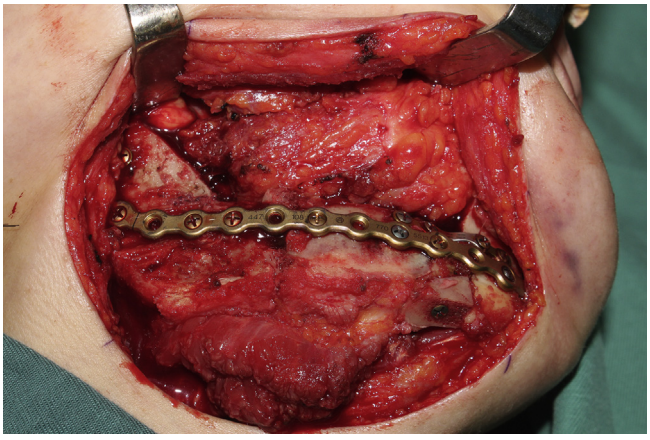

Fig. 3. Oromandibular reconstruction with DCIAPF.

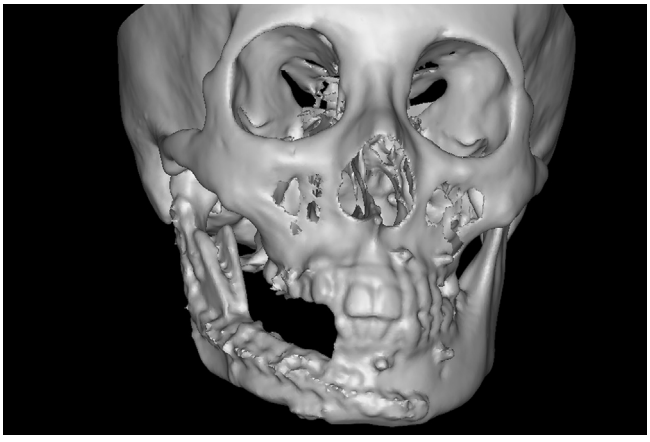

Fig. 4. Postoperative 3D CT scan showing the reconstruction contour of the mandible and bone with sufficient length and vertical height.

Fig. 5. Appearance of intraoral flap at 1-year follow-up.

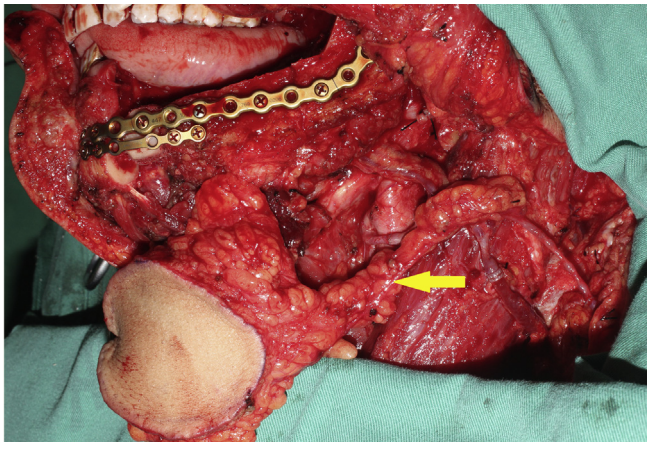

Fig. 6. Oromandibular reconstruction. DCIAPF and superficial circumflex vein (yellow arrow) were included in the skin flap and anastomosed to the recipient vessels as super-drainage.

Fig. 7. Appearance of intraoral flap at 1 year after radiotherapy.

3. Results

The terminal cutaneous perforators that were located approximately 6.5–12 cm posterior to the anterior superior iliac spine (ASIS) and approximately 1–3 cm lateral to the anterior superior iliac spine were preoperatively identified using Doppler in all patients; the courses of DCIA in all 7 patients were confirmed using CTA (Fig. 8). The CTA was able to demonstrate the subcutaneous terminal branch of DCIAP in 1 patients with 1 perforator (larger than 1 mm in diameter), and the intramuscular terminal branch in the other 6 patients with 1 perforator (5 perforators approximately 1 mm and 1 perforator larger than 1 mm in diameter); the calibers of the perforators were measured, 15 were approximately 1.0 mm,

Fig. 8. The subcutaneous terminal branch of DCIAP in CTA image.

and 8 were more than 1.0 mm in diameter; the terminal perforators in 18 of 23 patients were located approximately 7–10 cm posterior to the ASIS; all DCIAPFs were successfully harvested. The size of the skin paddles ranged from 5 to 9 cm in width and 6–14 cm in length. The bone components ranged from 6 to 13.5 cm in length. The dominant perforators were 4–7-cm in length. All donor sites were primarily closed without skin grafting. All DCIAPFs were successfully harvested and survived in 22 patients. However, 1 flap failed due to artery spasm; the patient received free iliac bone transplantation, and the bone graft survived with partial absorption. The flap survival rate was 95.6%. Three patients developed slight skin-edge necrosis, which healed after dressing change. Anatomical reconstruction contour of the mandible and the bone, with sufficient length and vertical height, were achieved, and no serious donor site complications, such as hernia, bone fracture, and gait disturbances, were observed during the follow-up period. However, mild donor-site pain was reported in 2 patients, and sensory deficits across the distribution of the lateral femoral cutaneous nerve occurred after surgery in 3 patients, 2 of whom reported gradual relief.

Nine patients received postoperative chemotherapy, radiotherapy or chemoradiotherapy. One patient with oral carcinoma developed a local infection in the second week during postoperative chemoradiotherapy, and the infection healed after dressing change in 1 week without delaying postoperative adjuvant therapy. No serious complications such as osteoradionecrosis were observed during the follow-up period in all 9 patients after postoperative adjuvant therapy.

4. Discussion

In cases with mandibular defects combined with large-scale soft tissue defects, the composite fibular flap is a common option, but it does not easily provide the mass of soft tissue required; occasionally, 2 free flaps may be used to resolve this issue. However, use of 2 flaps may increase operating challenges and complications. The classic DCIA flap described by Taylor et al. (1979) is another option for mandibular reconstruction. Each of these solutions presents certain inadequacies.

The classic DCIA flap is bulky and immobile because of the subcutaneous component, which includes a large amount of abdominal musculature. Certain modifications (Safak et al., 1997; Kimata et al., 2001; Kimata, 2003) have been made to the harvesting process of osteomusculocutaneous perforators in order to reduce the bulk of the flap and to improve maneuverability. In addition, a few authors have directed their efforts to delineate the perforators emitted from DCIA (Bergeron et al., 2007; Ting et al., 2009; He-Ping et al., 2013). In this study, the perforator was dissected free through the abdominal muscles to the parent DCIA, and leaving a small cuff of abdominal muscle attached to the perforator helped protect it from damage. Thus, the soft tissue became thinner than the classic DCIA flap. Without the "obligatory" muscular mass, donor-site morbidity can be reduced and esthetic outcomes can be improved. However, in some female patients, there was more abdominal subcutaneous fat, which looked bulky during the harvest of the flap. Because subcutaneous fat is absorbed gradually, the skin flaps became thin and appropriate during 2–3 months of the follow-up period (Fig. 5).

He-Ping et al. (2013) described that the terminal part of DCIA ended as a musculocutaneous perforator. In general, perforators are present in 92%–100% of specimens (Bergeron et al., 2007; He-Ping et al., 2013). However, Bergeron et al. (2007) did not distinguish the turmoil perforators as the terminal part. Our experience in oromandibular reconstruction with DCIAPFs has confirmed the anatomical findings of perforator distribution and angiosome reported by He-Ping et al. (2013). In addition, the terminal perforators in 18 of 23 patients were located approximately 7–10 cm posterior to the ASIS. In the present study, the DCIA terminal musculocutaneous perforator flap with iliac crest was used for reconstruction of oromandibular defects for the following reasons. The first reason is the long-enough perforating vessel between the skin flap and the bone block; in our study, the length amounted to 4–7 cm, facilitating flap maneuverability, particularly when axes of the skin defect and the bone defect were not in the same plane. The second reason is that DCIAPF was used to reduce bulk and donor-site morbidity. The third reason is that DCIAPF can provide skin flaps on a larger scale as well as a sufficient amount of bone. The fourth reason is that the harvest site could be closed primarily without skin graft or mesh. In addition, DCIAPF could provide a large segment of vascularized bone that was similar to the shape of the mandible, and the iliac bone was of sufficient height and thickness to better accommodate osteointegrated implants (Moscoso et al., 1994).

Donor-site complications have been reported for different composite flaps used for oromandibular reconstruction (Shpitzer et al., 1997a, 1999, 1997b; Richardson et al., 1997). Fibular flaps have shown a greater association with donor-site healing, reduced power and sensation, tendon exposure, motor weakness of great toes, and ankle stiffness and instability (Shpitzer et al., 1999; Rogers et al., 2003). The morbidity associated with DCIA harvest seemed relatively minor (Rogers et al., 2003). In this study, hernia, bone fracture, and gait disturbances were not observed in any patient during the follow-up period. Mild donor-site pain and sensory deficits were the primary donor-site complications. Minimal donor-site morbidity was considered as 1 of the reasons for selecting DCIAPF, and the donor site was hidden under clothing. Splitting the iliac crest further reduces donor site morbidity (Taylor and Daniel, 1981; Shenaq, 1992); however, we did not attempt to do so. In this study, 3 patients with oral carcinoma developed slight skin-edge necrosis, which healed within 2 weeks. Although the skin-edge necrosis did not delay the postoperative adjuvant therapy, we needed to pay attention to the large scale of soft-tissue deficit. The primary reason was that the necrotic skin edge was beyond the cutaneous territory perfused by the perforator. Typically, the average perforator vascular zone found in the static anatomical model of DCIA is 31 cm^2 (Bergeron et al., 2007). However, in our study, skin territories were greater than 31 cm^2. Vascular territories can extend beyond their anatomical territory if an adjacent artery is occluded (McGregor and Morgan, 1973).

Various challenges, including identifying perforators, technically challenging transmuscular dissection of perforators, and

perforating vessel torsion issues, may be encountered; however, these are common to all perforator free flaps and also depend on the surgeon's experience. In the present study, we based the skin flap on the terminal musculocutaneous perforator of the deep circumflex osteocutaneous flap and used it to reconstruct the oromandibular defect. The flaps were successfully harvested in all patients without lack of the DCIA terminal musculocutaneous perforator, but the location of the perforator in this study was slightly different from the perforator zone described by Bergeron et al. (2007). During harvest, there would be an encounter with such a situation—the terminal branch of DCIAP is absent or very tiny. Therefore, only the iliac crest would be harvested, and the intraoral defect would be reconstructed using second flaps, such as groin flaps or anterolateral thigh flaps.

5. Conclusion

This clinical study demonstrated that DCIAPF has a great degree of mobility between the bone component and the skin paddle when used for composite oromandibular defect reconstruction. In addition, DCIAPF is a favorable single-flap option for oromandibular reconstruction after oncological resection with fewer donor-site complications because of its adequate bone tissue and satisfactory soft tissue and a constant location of the perforator. However, the findings, especially the occurrence rate of the terminal perforators, should be interpreted cautiously due to the small number of patients and the relatively short follow-up.

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