Original article

Reconstruction of through-and-through osteocutaneous defects of the mouth and face with subscapular system flaps

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Background: Major ablative surgery in the head and neck region may create composite defects involving the oral mucosa, bone and the overlying facial skin. The large surface area and the three-dimensional nature of these defects pose a difficult reconstructive challenge requiring adequate bone and large, positionally versatile skin flaps.

Patients and Methods: From September 1993 to May 2000, 19 patients with through-and-through osteocutaneous defects of the mouth and face were reconstructed with composite subscapular artery system flaps. The evaluated parameters included: (i) site and dimensions of the tissue defect; (ii) specific flap properties; and (iii) review of the recipient and donor site morbidity.

Results: 10 variants of scapular osteocutaneous flaps, eight latissimus dorsi with serratus anterior and rib osteo-myocutaneous flaps, and one combination of an osteocutaneous scapular and myocutaneous latissimus dorsi flap were used to reconstruct composite facial defects with mean dimensions of: skin 54.4 cm², mucosa 56.2 cm² and bone of 8.2 cm. Ischaemic complications occurred in three patients including one total flap failure and one failure of the bony component in previously irradiated patients. The third flap was successfully salvaged. No significant long-term donor site morbidity was noted.

Conclusion: Composite flaps based on the subscapular artery system are a versatile reconstructive modality for large through-and-through defects of the mouth and face.

Key words: Jaw reconstruction – Scapular and latissimus dorsi free flaps – Defects of mouth and face

Any reconstructive method for a composite orofacial defect attempts to recreate an anatomically identical, aesthetically acceptable environment facilitating the resumption of an oral diet and allowing intelligible speech. Stable bony confines with sufficient mucosal replacement and skin coverage are prerequisites of a successful treatment best achieved with free-tissue transfer.

The most common bone sources in the free flap head and neck reconstruction are the fibula, the iliac crest, the radius and the lateral border of the scapula.^{1,3,4} In the

fibular composite flap, the skin component lacks three-dimensional flexibility whilst the skin paddle of the iliac crest is unreliable and bulky. The radial forearm flap on the other hand provides insufficient bone quantity and significant donor site morbidity including fracture of the residual radius. In order to overcome these limitations, combinations of soft tissue free flaps with alloplastic materials,^{5,6} or combinations of free and pedicled flaps^{2,7,8} or dual free flaps^{9–12} have been used. Although these solutions may achieve compartmentalisation of the reconstructive

Table 1 Through-and-through defect and type of subscapular system flap

	Defect			Subscapular system flap
	Skin (cm ²)	Mucosa (cm ²)	Bone (cm)	
H (<i>n</i> = 3)	65.3	70.6	7.83	2 LD+SA+RIB 1 SC/PSC
L (<i>n</i> = 5)	27.6	48.3	6.4	2 LD+SA+RIB 1 SC/PSC 1 SC
LC (<i>n</i> = 3)	74.7	53.7	6.7	1 SC+LD 1 LD+SA+RIB 1 SC/PSC 1 SC
LCL (<i>n</i> = 4)	58.5	52.5	8.8	2 SC 2 SC/PSC
Midface (<i>n</i> = 4)	64.5	60	9.3	3 LD+SA+RIB 1 SC
Total (<i>n</i> = 19)	54.4	56.2	8.2	8 LD+SA+ RIB 5 SC 5 SC/PSC 1 SC+LD

HLC system: classification of the segmented mandible.¹⁸

H, hemimandibular segment including the condyle; L, lateral part of the hemimandible when the condyle is preserved; C, central intercranial area; LD, latissimus dorsi; SA, serratus anterior; SC, scapular; PSC, parascapular.

requirements, the multiple donor sites – regional or distant – and the need for 2 pairs of anastomoses in the case of dual free flaps increase operative time and potential morbidity.^{9,13}

In contrast, the subscapular vessels as a single pedicle emanating from the third part of the axillary artery supply the lateral border of the scapula and overlying skin, and the latissimus dorsi and serratus anterior muscles in more than 97% of cases.¹⁴ The vascular perfusion of the cutaneous part of the subscapular flaps is by a 4 cm continuation of the circumflex scapular artery from the underlying bone enabling placement of the skin island at completely different angles to the underlying bone.^{15,16} Furthermore, the bone of the lateral scapular border is considered of adequate quality and length for comprehensive rehabilitation with osseo-integrated dental implants.¹⁷ The option of the combined latissimus dorsi/serratus anterior flap with a rib segment allows the replacement of large skin and mucosal defects with simultaneous reconstruction of the bone component with a long segment of pliable bone for complex contour restoration. Our experience with the use of subscapular system flaps for the reconstruction of orofacial through-and-through defects is reviewed and a protocol correlating specific facial defects and reconstructive options is discussed.

Patients and Methods

Nineteen consecutive patients, 18 male and 1 female, operated on by the senior author (ILH), underwent

reconstruction of through-and-through defects of the mouth and face with composite subscapular system flaps from September 1993 to May 2000. Eleven patients were reconstructed after resection of new advanced T₄ squamous cell carcinomas, whereas seven patients were reconstructed after surgical ablation of recurrent tumours treated previously with surgery and radical radiotherapy. One patient underwent delayed reconstruction after a self-inflicted high-energy gunshot wound, which destroyed his mandible, maxilla, nose and anterior base of skull. With the exception of the trauma patient, all procedures were performed at the same operation as the tumour resection. Nine of the patients treated for malignancy died of their disease 6–12 months after the operation, seven are alive and disease-free and two are alive with recurrent disease. All patients were followed up as per standard oncological protocol with a minimum follow-up period of 24 months and a maximum of 9 years.

From an anatomical viewpoint, 15 defects involved the lower face and four involved the midface and/or base of skull. The classification of the composite lower face defects was based on the missing mandibular segment¹⁸ whereas the midface defects were categorised as central including the maxilla and the nasal pyramid and/or the zygoma, respectively. Variants of the scapular osteocutaneous flaps were used in 10 patients, whilst eight patients were reconstructed with a combined latissimus dorsi and serratus anterior and rib osteo-myocutaneous flap. In one patient, an osteocutaneous scapular combined with a myocutaneous latissimus dorsi flap was used. Surviving patients were reviewed, whilst the deceased patients' medical notes were retrospectively evaluated. The following parameters were assessed: (i) recipient site – sufficiency of skin, bone and mucosal replacement, aesthetic appearance, resumption of oral diet, primary or delayed healing and need for secondary operations; and (ii) donor site – flap harvesting morbidity, primary or delayed healing, aesthetic result.

Results

Four different combinations of subscapular system flaps have been used for the reconstruction of 19 through-and-through mucosa-osteocutaneous defects of the lower jaw¹⁸ or the midface (Table 1). The cutaneous surface area harvested in the latissimus dorsi with serratus anterior and rib group ranged from 30–180 cm² while in the scapular group ranged from 20–180 cm². In all four midface reconstructions, the bony part of the flap replaced the missing maxilla and base of skull. The deficient projection of the concomitant nasal bone defect was reconstructed using a titanium mini-plate to supplement the missing bony frame. The cutaneous part of the flap provided replacement of the oral mucosa and of the skin

Figure 1 (A) Through-and-through defect of the naso-ethmoidal region extending posteriorly to the base of skull and inferiorly to the maxilla. (B,C) Postoperative views following mid-face reconstruction with a composite osteocutaneous scapular flap. Arrows indicate the cutaneous component of the flap used for skin replacement (B) and mucosal lining (C).

Table 2 Outcome of subscapular system flaps with osteotomised bone component

Defect (mandible)	Flap	Bone length (cm)	Osteotomy	Fixation results	Long-term
LCL	SC/PSC	12	1	Mini plates (2.0 mm)	Stable
LCL	SC/PSC	11	1	Reconstruction plate (2.7 mm)	Stable
LCL	SC	10	1	Reconstruction plate (2.7 mm)	Partial bone resorption distal to the osteotomy site
LCL	SC	9	1	Mini plates (2.0 mm)	Stable
LC	SC	8	1	Mini plates (2.0 mm)	Stable

Figure 2 (A) Orthopantomograph demonstrating significant bone erosion of the anterior mandible by carcinoma of the floor of the mouth. (B) Postoperative image following mandibular resection from angle-to-angle and reconstruction with a scapular osteocutaneous flap. (C) Radiograph 1 year postoperatively following the removal of the reconstruction plate. White arrow on the distal part of the scapular graft demonstrating increased radiolucency/bone resorption.

defect (Fig. 1). The length of the harvested bone proved adequate in all 19 patients (rib, 6–12 cm; scapula, 6–12 cm). In the four cases of combined lateral-central-lateral and in one case of lateral-central defect, the curvature of the mandibular arch could be restored only after osteotomy of the bone strut (Table 2). All osteotomised bone flaps survived without any signs of fractures or bone absorption in the long-term follow-up. However, in one patient after removal of the reconstruction plate 1 year postoperatively, part of the bone there was radiological evidence of partial bone resorption distal to the osteotomy site (Fig. 2).

There was no peri-operative mortality. Three patients sustained microvascular ischaemic complications resulting in one total, one partial flap failure and one successfully salvaged flap. The two patients with total or partial flap loss had been previously irradiated. In the first patient, two life-threatening complications developed in the postoperative period. A carotid blow-out on the opposite side to the anastomosis occurred on the 7th postoperative day whereas 2 days later the patient developed septic shock with prolonged hypotension secondary to a perforated duodenal ulcer. In both occasions, the venous anastomosis thrombosed but the flap was successfully salvaged. However, the recipient vein (external jugular) thrombosed in its entirety in the neck on the 14th postoperative day. No further flap salvage attempts were initiated. The free flap

was removed and replaced by a pectoralis major pedicled flap. In the second patient, the poor attachment of the serratus anterior muscle to the harvested posterior rib resulted in reduced perfusion and delayed necrosis of the bony component. The serratus anterior and rib were removed whereas the latissimus dorsi was retained. The resultant bone defect in both these cases was replaced with titanium plates. In the third patient, the flap was successfully salvaged at day 3 after release of the vein sucked into a vacuum drain.

All but one of the anastomoses were performed in the ipsilateral neck. The majority of them were end-to-end, with an overall mean ischaemia time of 184 min. The common facial vein was utilised as the recipient anastomotic vein in most of the cases (Table 3).

Sufficient replacement of the skin, mucosa and bony confines was accomplished in all cases. The aesthetic appearance judged by the symmetry of the facial structures and the colour match of the reconstruction was initially considered acceptable in all but one patient who underwent sub-total mandibular resection from angle to angle (Fig. 3). Peri-operative surgical under-estimation of the amount of mandibular projection resulted in a retrognathic facial appearance. Two further patients developed some degree of late facial soft tissue hollowing when part of the latissimus dorsi component of the flap atrophied.

Figure 3 (A) Carcinoma of the floor of the mouth infiltrating the anterior mandible and the overlying skin. MRI scan demonstrating the extent of the disease. (B) Surgical specimen following the resection of the lesion. (C) Patient 6 months' postoperatively following reconstruction with an osteocutaneous scapular flap.

Table 3 Microvascular properties of the subscapular system flap transfer

Type of venous anastomosis	Subscapular system flap	Ischaemia time (min)	Complications
End-to-end: facial vein (<i>n</i> = 12)	5 LD+SA+RIB 5 SC/PSC 2 SC	188	–
End-to-side: internal jugular vein (<i>n</i> = 4)	2 LD+SA+RIB 2 SC	167	–
End-to-end: external jugular vein (<i>n</i> = 3)	1 LD+SA+RIB 1 SC 1 SC/PSC	187	Bone failure day 8 Total failure day 14 Successful flap salvage day 3

Table 4 Donor site morbidity

	Morbidity	Treatment
Scapula	Seroma (<i>n</i> = 3) Dehiscence (<i>n</i> = 1)	Aspiration Conservative
Latissimus dorsi & serratus & rib	Seroma (<i>n</i> = 3) Non-primary closure (<i>n</i> = 1) Dehiscence (<i>n</i> = 4) Pleural tears (<i>n</i> = 3)	Aspiration Skin graft Conservative Conservative

There were no qualitative differences between the flap subgroups. Resumption of oral diet was confirmed in the nine living patients, although two of them took a mixed nutrition of oral and gastrostomy tube routes.

The donor site morbidity was minimal and all skin defects but one were closed primarily (Table 4).

Discussion

Combined oral and facial defects of skin, bone and mucosa occur after ablation of advanced T₄ carcinomas, high-energy gunshot wounds or following severe facial infections in the immune-compromised patient. The subscapular flap system¹⁶ offers the potential for reconstruction of these complex defects by harvesting a variety of flaps based on a single vascular pedicle.^{13,15} The branching pattern of the subscapular vascular axis allows segmental splitting to composite units perfused either by the circumflex scapular or the thoracodorsal vessels. The main bone sources are the lateral border of the scapula and the vascularised rib, respectively.^{8,19} The lateral border of the scapula provides a straight segment of 10–14 cm of highly vascularised corticocancellous bone.^{20,21} Replacement of anterior or anterolateral mandibular segments requires bone stock of comparable volume to the mandible in order to withstand caudal displacement as a result of the extensive scar formation in the neck (especially after radiotherapy), and as a result of the action of the powerful residuae of the suprahyoid muscles.¹⁸ The lateral scapular border is of sufficient size with a favourable cortical/cancellous bone ratio enabling reconstruction of the anterior mandibular segment with potential implant osseointegration.^{17,22}

In contrast, the thin midface bony structures pose a different reconstructive challenge due to their complex spatial orientation. Slender, easily contourable bone is advantageous in these non load-bearing areas.²³ The vascularised rib wrapped in the serratus anterior muscle can cover most of the necessary bone requirements of the midface while the latissimus dorsi will provide sufficient cutaneous coverage.

The unique shape of the mandibular curvature across its central portion cannot be reproduced without osteotomising the bone of the flap.

The use of segmental osteotomies may influence the gradient blood flow to the most distal bone part in inverse proportion to the number of osteotomies. However, the segmented bone grafts tend to remain viable in most cases.^{24–27} The length of the available bone and the potential devascularisation in case of osteotomies have been cited as potential drawbacks for the use of the scapular flap.^{3,26} In our series, the reconstructed bone defects did not surpass 12 cm and the available bone stock was sufficient in all cases. Osteotomising the scapula bone does not seem to have any detrimental effect on the bone viability, as long as excessive periosteal stripping and detachment of the infraspinatus and subscapularis muscles is avoided. Nevertheless, the increased cortical nature of the bone could be considered as a potential disadvantage when multiple osteotomies are applied³ and, therefore, the number of osteotomies we used was limited to one per case. The type of fixation, especially when rigid reconstruction plates of 2.7 mm are used, is also likely to influence the vascular supply in the distal part of the bone flap compromising an already decreased blood supply distal to the osteotomy site.^{1,24} Therefore, we currently favour either the use of mini-plates, or in case of lateral-central-lateral defects, where the plate provides an additional frame for the mandibular contour, the use of low profile 'locking screw' 2.0 mm plates.

Flap harvest-associated morbidity is quite low in the subscapular group of flaps. The donor site can be closed primarily in most of the cases and, apart from occasional seromas, no further significant complications should be expected in the short term. In contrast, both the ilium and the fibular composite graft donor sites result in increased

immobilisation periods with potentially significant systemic morbidity including pneumonia and deep vein thrombosis.²⁷ Harvesting scapula bone may result in initially decreased scapulohumeral joint function because of the interruption of the infraspinatus, the subscapularis and the teres major muscles, the prime movers of external rotation.²⁰ However, long-term scapulohumeral joint function is not severely affected apart from a minor limitation of 1–12° in five different shoulder range-of-motion activities.¹⁵ Harvesting vascularised ribs with serratus anterior may cause winging of the scapula when the nerve supply to the slips of the muscle is compromised and when significant portions of latissimus dorsi overlying the angle of the scapula have also been harvested.

Unfavourable location of the donor site prohibiting a two-team approach is considered a major disadvantage for the wide use of subscapular system flaps. Nevertheless, intra-operative positioning of the patient with the use of a 'bean bag' facilitate harvesting of the cutaneous part of the flap from the ipsilateral side of the defect simultaneously with the resection without the need for placing the patient in a lateral decubitus position. However, the final stage of the flap requiring dissection of the vascular pedicle in the axilla can only be performed with the patient in the lateral decubitus position.

Conclusions

Variants of the scapular flap are favoured for the anterior/anterolateral skin-mandible-mucosa defects. In midface defects, rib offers two distinct advantages over scapula: (i) malleability of a long strut of bone in a non load-bearing area of complex spatial orientation; and (ii) a long vascular pedicle facilitating anastomotic options even in the contralateral side of the neck without the need for vein grafts.

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