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ORIGINAL PAPER

Loupe magnification for head and neck free flap reconstruction in a developing country

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Abstract
Background Free tissue transfer has become the standard of care for the reconstruction of head and neck oncological defects. The Groote Schuur Hospital provides a microsurgical reconstructive service in a resource-limited setting, without access to venous couplers, invasive monitoring devices, modern microscopes or sophisticated pre-operative imaging. The reconstructive surgeons perform all anastomoses under ×4.5 loupe magnification.
Methods A retrospective chart review was undertaken of cases performed by the service over a 3-year period. Demographic factors, indications for flap cover, operative details (flap used, duration and lowest recorded temperature), intensive care and hospital length of stay, and other outcomes were recorded and evaluated (including flap and systemic complications, donor site morbidity, haematomas as well as returns to theatre).
Results Over a 36-month period, 109 flaps for head and neck reconstruction were performed. The main indication for surgery was squamous cell carcinoma of the oral cavity. The mean operating time for resection and reconstruction was 6.02 h (range of 4 to 12 h). Virtually, all reconstructions were performed using one of either radial forearm, free fibula or anterolateral thigh flaps. We report a complete flap loss rate of 6 %. All four successful salvages were undertaken in the early (less than 24 h) post-operative period. Hypothermia intra-operatively appears to correlate very closely with pejorative outcomes.
Conclusions By restricting reconstructive options to three main 'workhorse' flaps and by utilising a simultaneous two-team approach for tumour ablation and flap elevation, success rates comparable to international standards have been achieved. Limited resources should not be regarded as an impassable barrier to providing a successful microvascular head and neck reconstructive service.
Level of Evidence: Level III, risk/prognostic study.

Keywords Head and neck reconstruction · Microvascular surgery · Microsurgery · Limited resources · Developing country · Loupe magnification · Free flap · Outcomes

Introduction

Although the first free microvascular tissue transfer was reported as early as 1973 [1], there was limited enthusiasm for making use of free flaps to reconstruct head and neck defects until the late 1980s [2]. This reluctance stemmed from concerns relating to the reliability of a technique that was dependent on small-vessel anastomosis and concerns about complications and cost.

Free microvascular tissue transfer has proved be extremely versatile and reliable, however, with several centres reporting

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very low flap failure rates, with acceptable donor site morbidity and perioperative complications. It has become the preferred method of reconstruction for the majority of major head and neck defects [3]. Furthermore, it may in fact have a cost-benefit over traditional pedicled flaps in selected patients [4]. Since the first described case by Panje in 1976, reported flap success rates have ranged between 90 and 99 % [5].

Groote Schuur Hospital has a multidisciplinary head and neck service which has provided a free flap reconstruction service for head and neck oncological defects for more than 20 years. The team includes an oncologist, an otorhinolaryngologist, who performs the extirpative surgery, an anaesthetist, and plastic surgeons, who perform the free flap reconstruction.

The aims of the study were to:

1. Investigate acute outcomes of free tissue transfer reconstruction for head and neck resection defects at Groote Schuur Hospital
2. Compare these results with those of developed world units
3. Determine if there is a need to adapt our preferred reconstructive options, monitoring protocols and techniques

Material and methods

This unit performs a major head and neck tumour resection requiring reconstruction with free tissue transfer every week. All patients are assessed at a multidisciplinary head and neck oncology clinic at which time the choice of reconstruction is made. Decisions regarding the primary pathology are corroborated with directed imaging modalities including panorex and CT scans.

Whenever possible, flaps with a long vascular pedicle and large diameter blood vessels are selected. With few exceptions, the free radial forearm (RF), free fibular (FF) or free anterolateral thigh (ALT) flaps are used. The minimal bulk and pliability of the RF [6] makes it our first choice for the reconstruction of smaller defects and those requiring mobility. The ALT is chosen for larger defects and when bulk is required [7]. Thinning of the ALT to reduce bulk [8] is not performed. The FF, providing unparalleled quantity and quality of bone [9], is chosen whenever a bone defect is to be reconstructed.

Resource restrictions limit the use of pre-operative investigations, and therefore, neither CT/MR angiography nor ultrasound Doppler is routinely used to assess donor vessel patency. Donor vessels are assessed clinically. An Allen test is performed if a RF is planned even though it has questionable clinical validity [10] and should probably be supplemented with an ultrasound Doppler assessment of collateral ulnar artery flow [11]. Angiography is only used when a FF is planned in patients with an abnormal clinical examination or if there is a history of claudication or significant lower limb trauma and was not required in this case series.

Resection of the primary tumour and elevation of the flap are performed simultaneously by the two surgical teams to reduce operative duration and exposure to hypothermia. Reconstruction plates are bent intra-operatively based on the extirpated defect. Pre-bent plates are not utilised. Ocular loupes (×4.5 magnification) are used for both flap elevation and microvascular anastomosis. All microvascular anastomoses are hand sutured. Vein grafts are avoided. Local rather than systemic intra-operative anticoagulation is used. All patients have thromboprophylactic stockings and intermittent pneumatic calf compression applied to lower limbs not required for flap

Table 1 Patient comorbidities

Comorbidity	Number of patients
None	18
Smoker	72
Hypertension	23
Frequent alcohol use	17
HIV infection	4
Epilepsy	3
Hypercholesterolemia	2
Diabetes mellitus	2
Atrial fibrillation	1
Hypothyroidism	1
Intravenous drug abuse	1

Table 2 Histological diagnosis of resected lesions

Histological diagnosis	Number of patients
Squamous cell carcinoma	80
Sarcoma variants	7
Adenocarcinoma	5
Basal cell carcinoma	3
Ameloblastoma	2
Other	3

Table 3 Tumour site

Tumour site	Number of patients
Tongue and/or floor of the mouth	49
Lower alveolus and/or mandible	21
Primary skin malignancy	9
Upper alveolus and/or maxilla	8
Retromolar trigone	4
Buccal mucosa	3
Tonsil and/or soft palate	2
Orbital	2
Temporal	1
Hypopharynx	1

elevation. Warming blankets are routinely utilised for regions of the body not operated. Closed suction drains are routinely utilised and are positioned and secured some distance away from the anastomoses, usually in the posterior triangle of the neck. Donor sites are closed primarily where possible, but are usually skin grafted, and dressed with negative pressure wound therapy, 'crouton dressings' or other types of tie-over dressings.

Post-operatively, all patients are monitored in an intensive care or post-anaesthetic high care unit (PAHCU) setting for the first night following surgery. Patients usually have a tracheostomy performed, but are seldom ventilated post-operatively. Variables closely monitored and corrected include haemodynamic status (including arterial catheter monitoring), urine output, temperature, pain control, output from suction drains, development of haematomas and the maintenance of a neutral head position. Drains are removed after drainage is less than 50 ml per 24-h period. All patients received chlorhexidine mouthwash, perioperative broad spectrum antibiotics and prophylaxis against thromboembolism.

Regular clinical assessment of patient and flap is carried out by the plastic surgery trainee who participated in the procedure, paying particular attention to flap colour, temperature, congestion and bleeding (speed and colour) after needle stick. Invasive flap monitoring (e.g. implantable Doppler and tissue oximetry devices) is rarely used. Due to resource constraints, most patients return to the general ward the following day, where all invasive monitoring (arterial and central venous lines) is discontinued and flap monitoring is reduced to three times daily. Although there is a low threshold to return a patient to the operating theatre during the first 48-h period (concern about flap perfusion or a haematoma), salvage surgery is often delayed by other surgical emergencies competing for emergency theatre time.

A retrospective chart review was undertaken of all patients undergoing free tissue transfer reconstructions for head and neck resection defects at Groote Schuur Hospital over a 36-month period from July 2007 to June 2010. Data collected included patient demographics (age and sex), pathological type and site of tumour, comorbidities, primary reconstructive surgeon, free flap donor site(s), recipient artery and vein,

Table 4 Additional procedures at time of tumour ablation

Procedure	Number of patients
Panendoscopy	2
Panendoscopy and tracheostomy	6
Panendoscopy and MRND	6
Panendoscopy, tracheostomy and MRND	73
Panendoscopy, tracheostomy and BMRND	9
Panendoscopy, tracheostomy and SND	1
Panendoscopy and superficial parotidectomy	1
Panendoscopy, parotidectomy and MRND	2

MRND modified radical neck dissection, *BMRND* bilateral modified radical neck dissection, *SND* selective neck dissection

Table 5 Free flaps used

Free flap	Number of patients
Free fibula flap (FF)	36
Free radial forearm flap (RF)	35
Anterolateral thigh flap (ALT)	26
Free vastus lateralis flap	1
Free iliac crest flap	1
Free jejunum	1

Table 6 Recipient artery for free tissue transfer

Recipient artery	Number of patients
Facial	86
Superior thyroid	7
Transverse cervical	2
Lingual	2
Occipital	1
Superficial temporal	1
External carotid	1

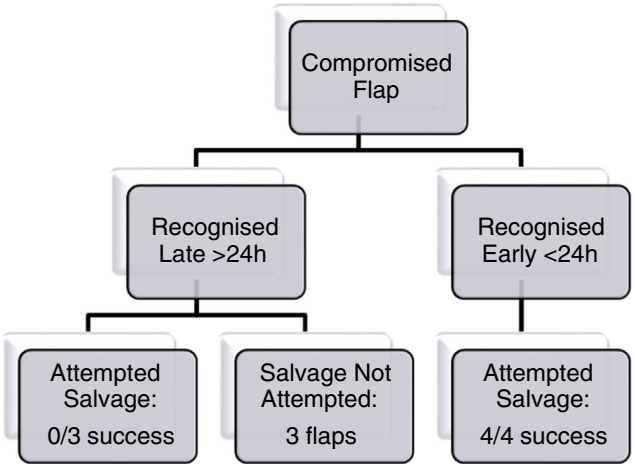

Fig. 1 Flap salvage outcomes

operative time, lowest recorded intra-operative temperature, additional procedures (e.g. tracheostomy and neck dissection), length of high care/intensive care stay, total hospital stay, flap viability (complete survival, partial loss, complete loss), flap and donor site complications and additional surgical interventions required during the acute period.

Results

One hundred and nine free flap reconstructions (mean of 36 per year) were performed over the 36-month period, of which 100 records were available for analysis. Eight records were excluded as they were incomplete or unavailable. One patient died on account of acute myocardial infarction and was excluded from further analysis. There were 65 males and 35 females with a mean age of 55 years (range 19 to 83 years). The majority of patients had at least one known comorbidity, with smoking, hypertension and frequent alcohol use being the most common (Table 1).

Squamous cell carcinoma (SCC) was the most frequent histological diagnosis, affecting 80 of the 100 patients (Table 2). The oral cavity was involved in 87 patients. Specifically, the most commonly involved structures were the tongue and/or floor of the mouth and the mandible and/or lower alveolus (Table 3). Six patients had orbital involvement (four of the skin malignancies included in this series invaded the orbit). All tumour ablations and neck dissections were performed by or under supervision of the sixth author (JJF). Additional procedures at the time of tumour ablation are tabulated in Table 4.

Most reconstructive procedures were performed by one of two senior plastic surgeons (fourth and fifth authors), with 50 by CHP and 49 by JEvZ. The most commonly used free flaps were the FF, RF and the ALT (Table 5). Free jejunum was used for one hypopharyngeal reconstruction and one free vastus lateralis myocutaneous flap was used in a patient who was found to have inadequate perforators to use a classic ALT. The internal jugular vein (or branch thereof) was used for the recipient vein in all cases. A vein graft was used in only one case, to limit tension on the anastomosis in the case of a free fibula flap reconstruction of an extensive mandibular defect. The facial artery was the most commonly used (87 patients) recipient artery (Table 6).

The mean total operating time (combined resection and reconstruction) was 6.02 h, with a range of 4 to 12 h. The mean time when FF, RF and ALT were used was 6.50, 5.46 and 6.13 h, respectively. Nineteen patients were hypothermic during the procedure, registering core temperatures under 35 °C.

Table 7 Partial flap loss summary

Patient	Details	Comorbidities	Flap used	Complication	Treatment
1	69, male SCC alveolus/mandible	Hypertension Hypercholesterolemia	FF	Necrosis of skin paddle	Debridement and secondary closure
2	76, female SCC floor of the mouth	Hypertension Smoker	FF	Partial skin paddle loss	Conservative
3	66, male SCC floor of the mouth	Smoker	FF	Partial skin paddle loss	Conservative
4	59, female SCC tongue and floor of the mouth	Hypertension Smoker	RF	Partial loss	Conservative
5	67, male SCC cheek	None	ALT	Partial loss	Debridement and secondary closure

Table 8 Complete flap loss summary

Patient	Details	Comorbidities	Flap used	Treatment
1	62, male SCC retromolar trigone	Atrial fibrillation Hypertension Smoker	FF	Flap excised and secondary closure over recon plate
2	60, female SCC floor of the mouth	Smoker	RF	Failed salvage Repeat FRFF: complete loss Salvage with tongue flap
3	63, male SCC floor of the mouth	Hypertension Smoker Diabetic Frequent alcohol use	FF	Repeat FFF: complete loss Temporalis flap: failure Repeat temporalis flap: failure Healed by secondary intention 108 days in hospital
4	58, male SCC tongue and floor of the mouth	Hypertension Smoker	RF	Healed by secondary intention
5	49, male SCC tongue	Smoker	RF	Haematoma, failed salvage Pectoralis major flap: loss of skin paddle, muscle viable Split skin graft of muscle
6	27, female SCC buccal mucosa	HIV infection	ALT	Failed salvage Flap excised and split skin graft

Early in-hospital complications occurred in 35 % of patients. Complications were significantly more prevalent in individuals who had been hypothermic intra-operatively. Five patients had to be returned to the operating theatre for drainage of haematoma. One of these patients had a compromised flap with unsuccessful salvage. Salvage was attempted in seven compromised flaps with four (57 %) successes. All four successful salvages were undertaken in the early (less than 24 h) post-operative period. The three unsuccessful salvage attempts occurred during the late (more than 24 h) post-operative period (Fig. 1).

Partial flap loss occurred in five patients (5 %). None of these patients required a second flap. Two of them required debridement and secondary closure. The other three were managed conservatively (Table 7). Complete flap loss occurred in six patients (6 %). Three patients required additional flaps for closure (Table 8).

Flap dehiscence occurred in 10 patients (excluding the five patients with partial flap loss). Eight of these were minor and were treated conservatively. One patient required debridement and re-advancement with re-suturing of the flap. Another patient was treated with debridement, followed by dressings. Neck wound dehiscence occurred in nine patients. Five of these patients were treated conservatively with dressings. One patient required debridement and secondary closure. One patient required debridement and split skin grafting. Two

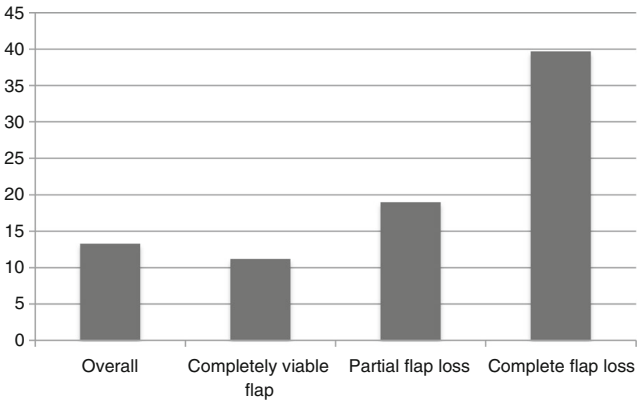

Fig. 2 Hospital stay (days) according to flap survival

Table 9 Advantages of choosing RF, FF and ALT as workhorse flaps in head and neck reconstruction

Single patient position
Simultaneous ablation and flap harvest (two teams)
Harvest and anastomosis by loupe magnification
Long pedicles (avoiding vein grafts)
Large calibre vessels for anastomosis
Versatility in design
Adequate volume
Consistent anatomy
Minimal donor site morbidity

patients required debridement and pectoralis major flaps for closure of the neck.

One patient developed a chyle leak and lung atelectasis which responded to conservative management. Two patients required debridement and repeat split skin grafting of their FF donor sites.

The mean intensive care or PAHCU stay was 1.14 days (range of 0 to 3 days). The mean hospital stay was 13.3 days (range of 5 to 108). Complete flap survival occurred in 89 patients. For completely viable flaps, the mean stay was 11.2 days (range of 5 to 34). This increased to 19 days (range of 12 to 27) when there was partial flap loss and to 39.7 days (range of 18 to 108) for complete loss (Fig. 2).

Discussion

It is widely accepted that successful free flap reconstruction of the head and neck following tumour ablation is superior to alternative methods in terms of both function and aesthetics [12].

All patients undergoing free flap reconstruction in this study had significant and advanced neoplastic disease on presentation, had at least one comorbid medical condition, and a significant percentage were smokers or had received pre-operative radiotherapy. Limited operative time makes pre-operative evaluation and flap selection even more critical than it may be in a more developed environment.

Despite the wide variety of free flaps now available, it is evident from this study and others that reducing the variety of flaps utilised by the reconstructive team is important to decrease complication rates and time to adjuvant therapy [13, 14]. Numerous authors subscribe to this philosophy, provided that the reconstructive requirements of the defect are met [12, 13, 15, 16]. These authors may differ with respect to their specific workhorse flaps, but the principle of limiting flap selection remains the same. We do not believe that limiting the selection of free flap reconstructions has in any way compromised the anatomico-functional outcomes. Kroll et al. demonstrated that free flap selection may impact the likelihood of flap survival, as some donor sites appear to have higher inherent risk of failure than others [5].

This unit prefers the combination of flaps advocated by Lutz and Wei [12] for head and neck reconstruction (RF, FF and ALT). Table 9 summarises some of the motivations for selecting this combination of flaps. The surgical and nursing teams easily familiarise themselves with and can anticipate the requirements to streamline these procedures, and so limit operative time.

Flap choice has been influenced by the pre-requisite of having a simultaneous two-team approach for tumour excision and flap elevation. This decision has undoubtedly contributed to reduced operative time and probably also to fewer cases of intra-operative hypothermia, which has been shown to correlate with post-operative complications. The long vascular pedicles of these flaps have usually avoided the use of vein grafts, which have also been correlated with an increased risk of free flap failure [17, 18].

Both senior reconstructive surgeons (CHP and JEvZ) use ×4.5 ocular loupe magnification for both flap elevation and anastomosis. Serletti et al. found that loupes are adequate for most anastomoses, but comfort with using an operating microscope is advocated when required [19]. It is this unit's preference to make use of the operating microscope for free flaps in children. Pieptu and Luchian have shown that loupe magnification is adequate for microanastomosis of vessels greater than 1.5 mm [20]. Loupe-only microsurgery can be justified on the grounds of cost-effectiveness, portability and improved operator freedom and extends the realm of microsurgery from the exclusive application in large academic hospitals to smaller facilities [21].

Most thrombotic complications occur within the first 24 to 48 h after free tissue transfer, and haematomas generally present within the first 72 h [22]. Early identification of flap-threatening complications allows for early surgical intervention and a greater likelihood of flap salvage [23]. There is no consensus regarding the ideal duration and frequency of free flap monitoring in an intensive care environment. Cornejo recently suggested one-to-two hourly free flap monitoring in an intensive care unit for the first 72 h [22]. This is not feasible in our setting as resource limitations dictate that most of our patients are transferred to the general ward the morning after surgery.

Furthermore, our institution lacks nursing staff trained in free flap assessment, and thus, the plastic surgery resident is required to fulfill this role. As plastic surgery is a relatively understaffed division within the department of surgery, regular and frequent flap assessment logistically challenging. Initiatives to train nursing staff in flap physiology and monitoring have been advocated and may improve the early detection of compromised flaps. Invasive monitoring devices to corroborate clinical assessments were seldom used (4 out of 100 flaps). All

of our successful salvage attempts occurred in the first 24 h post-surgery.

Success rates between 90 and 99 % have been consistently reported for microvascular head and neck reconstruction. Suh et al. reported a complete flap loss rate of 0.8 % and a partial loss rate of 3 % in a series of 400 free flaps in 388 patients [24]. Disa et al. reported a complete flap loss rate of 1.4 % and a partial loss rate of 3 % in a series of 726 free flaps in 698 patients [13]. The complete loss rate in this series was 6 % and the partial loss rate was 5 %. None of the partial losses required a second flap. All three unsuccessful flap salvage attempts occurred after the first 24 h. Increasing the post-operative intensive care/PAHCU stay to that of international standards and prioritising flap salvage surgery in the emergency operating room could potentially improve our flap salvage rate.

Numerous technologies have been developed with the aim of making microsurgical procedures safer, more reliable and with lower complication rates. The aim of this paper is not to suggest that these technologies are unjustified in their use. It is merely to highlight that a successful microvascular head and neck reconstructive service is possible in a resource-constrained environment.

Conclusion

Free flap reconstruction following head and neck extirpative surgery can be reliably undertaken in under-resourced settings. Limitations in the availability of pre-operative radiological investigations, invasive monitoring devices, anastomotic devices and intensive care are not barriers to providing a successful service. Limiting flap selection to reliable workhorse flaps with large calibre pedicles allows anastomosis under loupe magnification with low complete flap loss rates. A two-team approach facilitates shorter operating times, which may contribute to these results.

Ethical Standards This retrospective study has been approved by the Groote Schuur Hospital and University of Cape Town ethics committee in accordance with the ethical standards set forth in the 1964 Declaration of Helsinki and its amendments. No details are included in the study that may be used to identify its subjects. All authors have approved of the study and consent to its submission for publication.

Conflicts of Interest Gary dos Passos, Alan D. Rogers, Christopher E. Price, Conrad H. Pienaar, Donald A. Hudson, Jacobus E. van Zyl, Johannes J. Fagan declare that they have no conflict of interest.

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