SIMPLIFYING HEAD AND NECK MICROVASCULAR RECONSTRUCTION

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Abstract: *Background.* Free-tissue transfer has become the preferred method of head and neck reconstruction but is a technique that is considered to use excessive hospital resources.

Methods. This study is a retrospective review of 125 consecutive free flaps in 117 patients over a 16-month period at a tertiary care university hospital.

Results. Defects of the oral cavity/oropharynx (60%), midface (9%), hypopharynx (15%), or cervical and facial skin (16%) were reconstructed from three donor sites: forearm (70%), rectus (11%), and fibula (19%). Microvascular anastomoses were performed with a continuous suture technique or an anastomotic coupling device for end-to-end venous anastomoses. A single vein was anastomosed in 97% of tissue transfers. There were five flaps (4%) requiring exploration for vascular compromise, and the overall success rate was 97.6%. The major complication rate was 13%. Mean hospital stay was 7 days for all patients and 5 days for those with cutaneous defects. Combined ablative and reconstructive operative times were 6 hours 42 minutes, 7 hours 40 minutes, and 8 hours 32 minutes for forearm, rectus, and fibular free grafts, respectively. A subset of this patient series with oral cavity and oropharynx defects (76 patients; 58%) available for follow-up (74 patients) was assessed for deglutition. Forty-three patients (58%) had a regular diet, 22 patients (30%) had a limited diet or required supplemental tube feedings, and nine patients (12%) were dependent on tube feedings with a severely limited diet.

Conclusions. This series suggests that most head and neck defects can be reconstructed by use of a simplified microvascular technique and a limited number of donor sites. Analysis of operative times and length of stay suggests improved efficiency with this approach to microvascular reconstruction. Complications and functional results are comparable to previously published results. © 2004 Wiley Periodicals, Inc. *Head Neck* **26:** 930–936, 2004

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Head and neck free flap reconstruction is commonly considered to be cost-inefficient, requiring lengthy operative times and hospital stays. Reconstruction of head and neck defects has evolved from the use of a handful of pedicled flaps to a wide assortment of free-tissue transfers. More than 20 free flap donor sites have been described for the head and neck,[1–7] including the fibula, radial forearm, rectus, lateral arm, scapula, jejunum, latissimus dorsi, scapula, lateral thigh, omental, iliac crest, ulnar, and gracilis. More recently, the rectus, forearm, fibula, scapula, and jejunal free flap with their long pedicles and large-caliber vessels have become the reconstructive flaps of choice.[3,8] As experience with free-tissue transfer has grown and success rates approach 100%, attention has shifted toward improving functional results and improving efficiency.

There is no universal agreement on the optimal reconstruction method for head and neck defects or the best technique for performing the microvascular anastomosis. True indications among flaps are lacking. Randomized controlled studies to compare one free tissue reconstruction (eg, iliac crest) to another (eg, fibula) are not available. Even the essential question of whether free tissue reconstruction has a cost or a functional benefit over pedicled flaps remains controversial. Microvascular techniques continue to evolve and simplify as the use of flaps with larger caliber vessels becomes more common. Use of continuous suture technique or the anastomotic coupler is thought to save operative time without compromising the patency rates.[7,9] Furthermore, other time-effective instrumentation[10] and patient care methods are described that can be used to decrease resource use.[11] The surgeon selects a reconstructive modality and microvascular technique on the basis of the surgeon's preference and training, known flap characteristics, patient characteristics, and anatomic considerations. We present a series of consecutive patients to whom these techniques were applied to improve overall results.

Although it is critical to maintain a wide range of techniques and free-tissue flap options when considering reconstruction, growing experience suggests that only a handful of microvascular free flap donor sites may be required for reconstructing most head and neck defects.[3,8] Ockham's Razor dictates that "entities should not be multiplied unnecessarily." Minimizing donor sites and simplifying techniques in head and neck reconstruction when possible may improve patient care not unlike the manner in which a surgeon's volume has been demonstrated to improve outcomes.[12–15]

PATIENTS AND METHODS

A retrospective review was conducted of 125 consecutive microvascular free flaps for 122 head and neck defects in 117 patients. There were 89 men and 28 women in the study population, with 34% of those patients having undergone previous radiation treatment. The mean age was 62 years, with a range between 37 and 88 years. No patients undergoing microvascular reconstruction during the 15-month study period were eliminated from the study. Reconstruction was performed immediately after oncologic ablation except in three of 122 defects that were reconstructed secondarily after trauma (n = 2) or tumor resection (n = 1). Most flap harvests were performed concurrently with the ablative portion of the operation (89%). Patient donor site, recipient site, duration of anesthesia, microvascular time, complications, and length of stay were analyzed. The complications were calculated on the basis of the number of relevant cases (eg, there were four hardware exposures and 72 cases in which hardware was placed, or 5.5%). Complications related to the donor and recipient site were assessed.

Patients with a poor Allen's test were considered for a rectus flap or an ulnar forearm flap. Four patients with poor collateral circulation from the ulnar artery underwent an ulnar fasciocutaneous flap.[16] Relative contraindication to the forearm, rectus, and fibula free flaps did occur in our patient population. Venous catheterization occurred in the upper extremity in six patients before surgery; the ipsilateral arm was used without complications. One patient underwent radial arterial puncture 6 days before the use of an ipsilateral radial forearm flap. Intraoperative thrombectomy was performed with a Foley catheter before removing the flap from the arm, and the flap had no complications. PEG tubes were placed before harvesting nine of 14 rectus free-tissue flaps. An appendectomy had been performed in one rectus free transfer patient and a midline abdominal incision in another. One patient with two-vessel outflow in the foot underwent a fibular free flap (intraoperative clamping of the peroneal vessel was performed to confirm extremity viability). Total operative time was measured from induction to end of anesthesia; reconstruction time was measured from donor site incision to end of anesthesia. Patients were evaluated preoperatively by physical examination and/or lower extremity Doppler ultrasonography. Patients were admitted directly to the floor or a step-down unit staffed by nurses specializing in otolaryngology and free flap care. Microvascular arterial anastomoses were performed by placing two sutures 180 degrees apart and then sutured in a continuous fashion. The vein was approximated with the anastomotic coupling device (Synovis Micro Companies Alliance, Birmingham, AL) if end-to-end anastomosis could be performed; otherwise, a continuous suture technique was used similar to the arterial anastomosis. When possible, the facial artery was used for arterial anastomosis. The ablative surgeons make a significant effort to preserve and clip a 1-cm facial vein stump; this allows the anastomotic coupling device to be used (end-to-end).

Patients were admitted to the step-down unit routinely postoperatively for 24 hours before transfer to the general ward. Flaps were monitored (color, Doppler, and temperature) for 48 hours every hour by the nursing staff and every 4 hours by the resident surgeon. One patient was treated postoperatively in the surgical intensive care unit for cardiac reasons; all other patients went directly to the floor or to the step-down–intensive care unit staffed by ward nurses. Pharmacologic therapy consisted of one aspirin (325 mg) per day beginning on postoperative day 1. Patients who underwent exploration or flap failure were given 5000 U intravenous heparin intraoperatively and placed on low molecular weight subcutaneous heparin.

Patients undergoing reconstruction of the oral cavity (including composite defects) or oropharynx who were available for follow-up (74 of 76 patients) were assessed for postoperative deglutition and decannulation. Diet was assessed by history, physical examination, and, when indicated, a modified swallow examination with a speech pathologist. Aspiration was defined as laryngeal penetration with thin liquids despite a routine swallow therapy trial. Although multiple patients were offered dental rehabilitation, only one patient (fibular free flap) underwent implantation for rehabilitation (not covered by insurance in our state). One patient who underwent radial bone mandibular reconstruction had iliac crest bone grafting performed 10 months postoperatively and is scheduled to receive implantation. To assess patient attitudinal and functional outcome, the University of Iowa Head and Neck Cancer Inventory (HNCI) survey was administered preoperatively and 12 months postoperatively. Scores were assessed for all patients with upper aerodigestive tract malignancies (primary cutaneous lesions excluded). Scores for this validated survey were calculated as described.[17] Dentate patients tolerating an unrestricted diet or edentulous patients on an edentulous diet were considered to have a regular diet. Patients who ate foods of limited consistency or patients still requiring tube feedings for supplementation were considered to have a limited diet.

Table 1. Summary of patient data.

Characteristic	No. of patients
Number of defects	122
Number of flaps	125
Number of patients	117
Sex	
Male	89
Female	28
Mean age, y	62
No. patients (%) with previous radiotherapy	40 (34)

Table 2. Classification of ablative defect site.

	Free forearm flap	Rectus	Fibula	Total
Midface	9	2	0	11
Composite mandible	19	1	24	41*
Oral cavity/pharynx	28	5	0	33
Hypopharynx	17	0	0	17
Cutaneous	14	6	0	20
Total	87	14	24	122 (125*)

Note. Defects were broadly subdivided without duplication. Because three oral cavity defects required two free flaps for reconstruction, there were 122 defects reconstructed with 125 (*) flaps.

RESULTS

Eighty-nine soft tissue flaps and 36 bone flaps used to reconstruct 122 consecutive ablative defects between August 2001 and October 2002 by a single reconstructive surgeon were studied (Tables 1–3). There were a total of 117 patients; three patients underwent a secondary ablation during the study period, there were two flap

Table 3. Defect characteristics for 41 composite defects.

Defect characteristic	No. of patients
Bone defect	
H	2
L	12
C	1
HC	0
LC	11
LCL	14
HCL	1
Soft tissue defect	
Mucosal lining	33
Cutaneous	1
Mucosa and cutaneous	7

Abbreviations: H, lateral defect of any length containing a condyle; L, lateral defect that does not include the condyle; C, anterior defect between the incisive foramina.

Table 4. Operative times and hospital length of stay.

	Forearm cutaneous	Forearm ostoecutaneous	Rectus	Fibula	Multiple flaps
Number	71	13	13	22	3
Total operative time, min	394	426	461	512	682
Reconstructive operative time	254	289	282	380	574
Hospital days, mean	7	7	7	8	9

Note. The total operative length was assessed from incision to anesthesia done time, and the flap operative time was assessed from the donor site incision to anesthesia done time. Reconstructive time was determined from the incision for raising the flap to the anesthesia done time.

failures requiring a second flap, and three patients underwent two free flaps. There were 11 midface, 41 composite, 33 oral cavity, 17 hypopharyngeal, and 20 cutaneous defects reconstructed with 83 radial forearm flaps, 16 rectus flaps, and 21 fibula flaps (Table 2). There were 12 osteocutaneous radial forearm flaps used to reconstruct eight mandibular and four midface bones. There were seven defects that had both intraoral and cutaneous epithelial surfaces requiring free vascular tissue reconstruction. Deepithelialization of a 1- to 4-cm−wide strip was used to create two distinct cutaneous paddles. Preoperative lower extremity Doppler ultrasonography in 25 patients revealed patent three-vessel outflow in 23 patients. One patient with insufficient outflow had a lateral mandibular defect that was managed with an osteocutaneous radial forearm flap. One patient with two-vessel outflow was found to have good lower extremity vascularity after intraoperative clamping of the peroneal artery. Patients with poor collateral flow from the ulnar artery during Allen's test (n = 4) underwent ulnar forearm flaps rather than radial forearm flaps.

Microvascular anastomoses were performed freehand in all cases with a resident (88%), a nurse (8%), or a medical student (4%) assisting. Residents performed a portion of the arterial suturing in 36% of cases. Composite total operative times averaged 7.1 hours, and median length of stay was 7 days. Patients with reconstructions not involving mucosal surfaces (cutaneous defects, n = 19) stayed an average of 5 days in the hospital. When anatomically possible, a singe vein was isolated in the donor site (87%) or a dominant vein was identified (9.6%) and used for venous outflow in the neck. The time to perform the microvascular anastomoses in patients with available data (n = 98) ranged from 22 to 140 minutes, with an average of 38 minutes. Average operative time and mean hospital stay were determined (Table 4).

There was one perioperative death from medical complications, three flap failures (2.5%), and two additional flaps that required anastomotic revisions for salvage (Table 5). Four flaps developed arterial insufficiency, and one developed venous insufficiency. Venous compromise occurred in an osteocutaneous fibular graft that was harvested with two veins, and one dominant vein was identified (on the basis of small size). By allowing outflow from both veins, the graft was successfully salvaged. The overall major complication rate was 13%. Donor site complications were managed conservatively with the exception of a fibula tendon exposure requiring debridement. A wound dehiscence of a rectus free flap

Table 5. Complications.

Complication	No. of patients
Major complications	
Total flap necrosis	3/125 (2.4%)
Anastomotic revisions	2/125 (1.6)
Partial flap necrosis	1/125 (0.8)
Cervical hematoma	2/122 (1.6)
Cervical infection	3/98 (3)
Perioperative death	2/122 (1.6)
Pharyngocutaneous fistula	1/98 (1)
Exposed hardware	4/72 (5.5)
Minor complications	
Exposed tendon	6/106 (6)

Note. Commonly reported complications listed. There were 90 patients who had ablative defects at risk for pharyngocutaneous fistula and 71 who had reconstruction that required placement of hardware.

Table 6. Functional results.

	Irradiated	Nonirradiated	Total
Diet			
Tube dependent	8 (11%)	1 (1)	9 (12%)
Limited	14 (18)	8 (11)	22 (30)
Regular	11 (15)	32 (43)	43 (58)
Tracheostomy dependent	1	0	1
Count (n)	33	41	74

Note. Functional results in patients with T3 and T4 oral cavity/oropharynx defects.

donor site occurred on postoperative day 3 and required mesh placement.

Seventy-four patients with T3 or T4 oral cavity or oropharyngeal defects (of 76 possible) were available for follow-up at 4 months (Table 5). Median follow-up was 18 months. All but one patient was decannulated, and 58% of patients were able to tolerate a regular diet. Radiation (preoperative or postoperative) was found to reduce functional outcome (Table 6). Seventeen patients (14 of whom underwent radiation therapy) underwent hemipalate or total soft palate resection. Although none of the nonirradiated patients had velopharyngeal insufficiency develop, two patients (11%) had velopharyngeal insufficiency develop that could be corrected by a local flap procedure in both cases. In one case, the fibula skin provided insufficient bulk for oral reconstruction, and a forearm flap was also used for oral tongue reconstruction. In two cases, mental skin was resected in addition to oral tongue and required a second flap (radial forearm). Twenty-eight tongue reconstructions were performed; all but two were greater than 50%, and six were total glossectomies.

By use of prospectively collected quality-of-life data collected on consenting patients with upper aerodigestive tract malignancies, the University of Iowa HNCI questionnaire was administered to patients to assess functional and attitudinal outcomes. Results are shown in Figure 1 for a total of 24 patients in this study who had completed the preoperative and 12-month evaluations. Consistent with other reports for head and neck quality-of-life data,[18,19] scores demonstrated a drop and gradual recovery but did not reach preoperative levels (Figure 1). These results compare favorably with other findings in this patient population.[18,19]

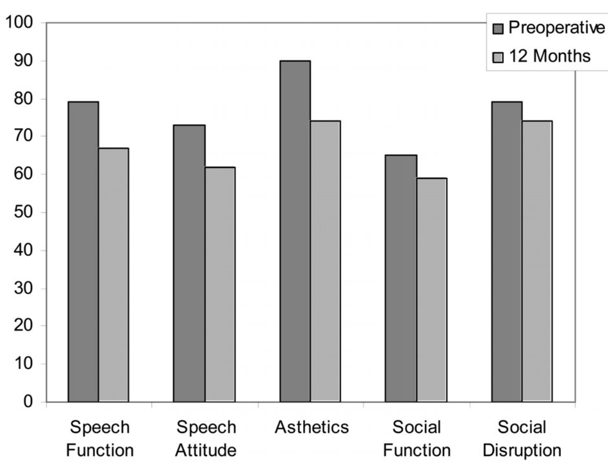

FIGURE 1. The results of Head and Neck Cancer Inventory quality of life survey in 24 patients with upper aerodigestive tract tumors who underwent free flap reconstruction.

DISCUSSION

Microvascular reconstruction of the head and neck has long been associated with long and difficult procedures. Several recent advancements in free flap reconstruction over the past 10 years have greatly improved patient results and surgeon efficiency. First, the development of specific techniques to address complex reconstructive problems in the oral cavity and hypopharynx have been described,[3,20–24] including complex algorithms.[8,25] Examples include the bilobed radial forearm flap for oral tongue reconstruction described by Urken et al.[26] Second, identification of highly versatile flaps with long vascular pedicles and large caliber vessels[27–30] can be used in a two-team fashion to reconstruct most defects in the head and neck.[3] Third, development of technology for microvascular surgery, including automatic hemoclip appliers, bipolar scissors,[10] and the anastomotic coupler, improved operating efficiency.

In this series, these basic principles were applied to our practice and demonstrate improved results. Flap survival and complications are consistent with other published results[29,31] and are superior to other approaches to reconstruction such as local flaps[32,33] or pedicled flaps,[34,35] in which the fistula rate approaches 15%. Although comparison is complicated by the wide range of defects and adjunctive treatments, our postoperative swallowing and decannulation outcomes demonstrate results comparable to other studies evaluating free-tissue transfer in the oral cavity.[36–38] The quality-of-life data are presented, although it is clear that the gradual improvement in patients to near preoperative levels more likely reflects patient adjustment and the insensitivity of quality-of-life measurements more than the quality of the surgical results. Quality-of-life results are consistent with other reports that demonstrate a 20% to 25% drop in quality of life at 12 months.[19]

The results of our study suggest that simplification of microvascular donor site choice and reconstructive technique when possible may improve efficiency and patient outcomes. Compared with recently published data,[11,39] we report a 32% and 31% reduction in operative times, respectively. Median hospital length of stay in this study compares favorably to the 7 to 10 days reported in the literature.[11,29,40] Although costs were not directly analyzed in this study, operating room time and length of stay are two of the most important determinants of cost for patients having microsurgery.[41] Preincision times were low because the operating staff was familiar with the required equipment and patient draping had limited permutations. Reducing operative times is important because it improves blood loss, fluids, and time under general anesthesia. Furthermore, if patient outcomes can be shown equivalent, reducing operative time can lower hospital costs.

Other authors have found that most head and neck defects could be reconstructed by use of only six donor sites.[8] That study by Disa et al found that most defects (88%–99% depending on ablative site) could be reconstructed with the jejunum, rectus, forearm, or fibula free flap. Unlike that article, we provide functional and quality-of-life data to show that results are similar to previously published results. Furthermore, we have found the ulnar flap to be important in cases in which there is poor collateral flow from the ulnar artery. Although we have included this flap as a forearm donor site, it should be noted that the ulnar flap requires specific surgical expertise. However, the positioning, instrumentation, and postoperative care are the same; therefore, the data are consolidated with the radial forearm flap data. Limiting donor sites has some obvious advantages: standardizing preoperative assessments, intraoperative efficiency, and postoperative management. In this series of 122 defects, the bone defects were addressed using the osteocutaneous forearm or fibula; however, the scapula is needed for longer defects where the patient cannot tolerate removal of the peroneal vessel on one side. The disadvantage of not electing to use the iliac crest flap is the inability to obtain full dental rehabilitation.

There is no universally accepted method of microvascular anastomosis. Evidence suggests that there is no difference in patency rates between interrupted and continuous suture techniques even at vessel sizes of less than 1.0 mm, although the continuous suture technique is more time-efficient.[9] The use of a single venous anastomosis theoretically provides a higher flow rate compared with dividing the same flow into two vessels. There was no case in which venous thrombosis occurred when the two vena comitantes formed a single common vein at the donor site. In one case (of 12) in which the dominant vein was identified on the basis of size comparison and the smaller vein clipped, a venous thrombosis formed. In cases in which a union of the vena comitantes cannot be identified in the donor site, we recommend two venous anastomoses. Relative contraindications to free flap use (eg, venous or arterial catheterization) did not seem to affect outcomes.

Although simple solutions should be used when possible, H. L. Mencken said "There is always an easy solution to every human problem—neat, plausible, and wrong."[42] There are many possible reasons not to conform to the principles previously described, and the microvascular surgeon should be able to perform a wide spectrum of free-tissue transfers with a variety of microvascular techniques. Although the principles described here are not new, this is the first report that addresses the application in a systematic fashion that may improve our ability to provide cost-efficient care to our patients.

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