Free Tissue Reconstruction Following Excision of Head and Neck Arteriovenous Malformations

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Objective: To evaluate free tissue transfer (FTT) as a safe and effective reconstructive technique to treat arteriovenous malformations. Vascular lesions that present a significant clinical challenge to the head and neck reconstructive surgeon are often difficult to treat and can leave large, complex defects.

Methods: Retrospective, single-institution case series.

Results: We describe 8 patients treated for extensive lesions in various parts of the head and neck reconstructed with free flaps. These malformations have a tendency to recur, which was the case in 75% of our patients (6 of 8) during a mean follow-up period of 5 years. Revision procedures are expected at a mean rate of 6.75 per person in our series.

Conclusions: Arteriovenous malformations are uncommon and challenging lesions. Use of FTT can ameliorate the large defects resulting from excision of these lesions.

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ARTERIOVENOUS MALFORMATIONS (AVMs) are aggressive vascular lesions that continue to grow during the lifetime of their host. They frequently result in clinically significant tissue deformity and destruction. These lesions are not only complicated by their growth as a mass lesion but also by bleeding, vascular complications, and adjacent tissue ulceration and necrosis. For large head and neck AVMs, methods of disease control, such as embolization and sclerotherapy, are useful adjunctive treatments but have not been shown to be effective for definitive treatment and may in fact worsen the condition.1

Surgical excision is currently the only method that holds the possibility for cure, and even this often falls short of complete elimination of the lesion. Such a resection can leave large and 3-dimensionally complex defects in tissues that have a tendency for compromised wound healing. This can result in significant cosmetic deformity and altered functionality in the head and neck region where such results can have a considerable impact on patients’ quality of life (QOL). Reconstructing such a defect often proves very challenging, and wound healing may be protracted.

Free tissue transfer (FTT) remains the standard technique for large volume and complex reconstructions. All types of tissues can be utilized, some of which have the potential to incorporate sensate and even motor functions. This technique has ameliorated not only many large defects resulting from trauma but also those due to benign causes or malignant diseases in all areas of the body. We have been able to use these techniques to repair some otherwise untreatable defects caused by these aggressive head and neck AVMs. We report our institution’s experience with free-flap reconstruction of complex defects resulting from AVM excision, including 2 case examples.

METHODS

We performed an institutional review board–expedited approved retrospective review of the University of Arkansas for Medical Sciences’ (UAMS) (Little Rock) experience with large, resected AVMs of the head and neck that required FTTs for reconstruction. A database of all patients with head and neck AVMs at UAMS and its affiliated hospitals was searched, and corresponding patient files were reviewed. Such files included office notes, procedural dictations, radiographic reports and sequential images, pathology reports, and patient correspondence.

A total of 8 patients were identified as having extensive head and neck AVMs that were resected and reconstructed with FTTs from 1998 through 2006 at UAMS. A total of 10 free-flap surgical procedures were performed during this time by 4 different reconstructive surgeons trained in microvascular surgery. The senior surgeon (J.Y.S.) resected each of the AVM lesions. Age at presentation ranged from 7 to 41 years. Four patients were female and 4...
male. The FTTs included 1 scapular fasciocutaneous, 5 rectus abdominis myocutaneous, 2 latissimus dorsi myocutaneous, and 2 radial forearm fasciocutaneous free flaps.

RESULTS

The duration of follow-up ranged from 18 to 102 months (range, >60 months). The mean age at FFT was 24 years. All 8 patients had undergone previous surgical procedures and/or treatments such as embolizations or laser treatments prior to presentation to our institution. These ranged in number from 1 to more than 30.

Each of the large AVM resections was accompanied by preoperative embolization, typically 24 to 48 hours prior to resection, and reconstructed with FTT. Of the 8 patients treated in this fashion, only 2 were not found to have recurrent disease at follow-up. Of those found to have recurrence, 100% still show evidence of some persistent disease to date. The number of revision procedures for persistent symptomatic disease as well as tissue modification ranged from none to 20 (mean, 6.75). One patient underwent 2 separate successful FTTs for 2 separate head and neck defects from a single AVM lesion. This involved 2 separate resections, each followed immediately by FTT reconstruction.

Two flaps failed owing to venous thrombosis. Salvage attempts were unsuccessful in both cases. One patient was then subsequently treated with a second successful FTT, and the other defect was repaired with delayed local tissue advancement. Clinically significant morbidities that accompanied our treatment regime included blindness, facial nerve paralysis, altered speech, sleep apnea, and oral incompetence.

In all cases of FTT survival, the additional tissue offered bulk, contour, and well-vascularized tissue for defect closure that significantly improved the patient's appearance, functionality, and QOL.

CASE 1

Patient 1 is a 40-year-old woman who was referred for a massive, complicated, and previously treated left facial AVM (Figure 1). This lesion was first diagnosed in childhood (Figure 2). She had undergone 2 previous embolizations, both of which resulted in cerebrovascular accidents and right-eye blindness as well as residual right hemiparesis. She subsequently lost vision in her left eye owing to AVM involvement. The patient was also treated previously with bilateral external carotid artery ligations. In 1997, the patient’s lesion was treated by external beam radiation (9 treatments), which was subsequently stopped owing to hemorrhage. At the time of presentation to our institution, she was experiencing significant chronic pain, recurrent infections, and frequent hemorrhage from her nose and mouth that required repeated emergency department visits and many blood transfusions.

A magnetic resonance imaging (MRI) scan (Figure 3) showed a massive AVM involving the left side of the face and scalp, extending to the skull base, including the cavernous sinus. The left orbit was also completely involved as well as the left temporal lobe. The patient underwent preoperative angiography (Figure 4) with findings of feeder vessels from right bilateral ophthalmic and thyrocervical arteries to the occipital and ascending pharyngeal arteries. Balloon occlusion testing was performed to determine the safety of embolizing, and she subsequently underwent embolization of the remainder of the left internal carotid artery to the level of the petrous segment.

Surgery consisted of a 19-hour excision (Figure 5) and 6 hours of reconstruction, including a rectus abdominis FTT with a 12 × 14-cm skin paddle (Figure 6).
Owing to vascular changes from her disease and previous external carotid artery ligation, an unnamed artery and vein in the left level 3 of the neck that were deemed to be of appropriate caliber and demonstrated good flow characteristics were used for the free-flap anastomosis. Her surgery also involved tracheostomy, and the reconstruction included split-thickness skin grafts to the right nasal ala as well as the left oral commissure and left oral cavity. Her postoperative course was remarkable for a return to the operating room on postoperative day 10 for control of epistaxis and bleeding from the mouth, which included replacement of the tracheostomy tube that had been previously decannulated. This surgery also included partial debridement of multiple nonviable skin grafts. Her entire hospital course was 17 days.

Following discharge, the patient has been monitored closely through our outpatient clinic and by her referring physician. She has undergone 6 revision procedures thus far to control epistaxis, excise residual AVM, resurface the palate and buccal mucosa, reconstruct the nasal ala and lip, and debulk the free flap (Figure 7). Preoperative embolization was successfully used in 2 of these subsequent procedures. Since the initial FTT, the
The patient’s QOL has subjectively and objectively improved dramatically, as evidenced by notably fewer visits to the emergency department and improved cosmetic appearance. Findings from her most recent MRI demonstrates some possible residual AVM in the lateral pharyngeal wall and cavernous sinus, but she is currently asymptomatic and is being monitored closely.

CASE 2

Patient 2 is a 14-year-old girl who presented to our institution at the age of 7 years with a previously treated AVM of the tongue, floor of mouth, and anterior neck. At the time of presentation, the malformation was causing positional dyspnea, dysphagia, and dysarthria. She underwent an initial resection with preoperative angiography and embolization of the left lingual and facial arteries (Figure 8). The defect was then closed primarily. She was found to have recurrent malformation within 4 weeks of this first surgery as evidenced by airway obstruction, swallowing and speech difficulties, as well as increasing pain and weight loss (Figure 9). Findings from a repeated MRI showed recurrent malformation (Figure 10). She was then promptly scheduled for a second resection.

A second preoperative angiogram was performed with embolization of the right lingual and superior thyroid arteries. Two days after the embolization, the patient reported diminished visual acuity and was found to have a central retinal artery occlusion resulting in permanent right-sided blindness. Four days after the embolization, she underwent a 12-hour surgery that included resection of the recurrent AVM from the left tongue, a portion of the right tongue, and malformation extending down through the floor of the mouth to the preepiglottic space (Figure 11). She underwent reconstruction using a rectus abdominis myocutaneous free flap with a 5 × 15-cm skin paddle. The
proximal right lingual artery and 2 branches of the internal jugular vein were used for the anastomosis. She did not require a tracheostomy and was able to speak immediately after surgery with fairly clear speech.

Since her FTT, the patient has been monitored closely through our outpatient clinic and by her referring physician. A few months after the second resection, she presented with increased right tongue swelling (Figure 12). Examination findings were unremarkable except for an increased bulk of the FTT. Angiography did not detect any recurrence, and it was decided to monitor her closely for recurrence.

A few years later, the patient presented with a history of sleep apnea, dysphagia, and difficulty with speech. She was evaluated and found to have no signs of recurrence. However, the area of her reconstructed left tongue showed augmentation in size, and her right tonsil was very enlarged. An MRI and magnetic resonance angiography showed increased fat content of the graft consistent with puberty-related changes, and her tonsil showed benign hypertrophy (Figure 13). There was no evidence of AVM within this tissue or the remaining oral cavity or neck. She subsequently underwent surgery to decrease the bulk of the tissue and excise her tonsil. Her left tongue size continues to increase as she continues to grow and gain weight (Figure 14). She currently denies any significant dysphagia, dyspnea, or pain and complains only of some minor articulation difficulties.

**COMMENT**

Arteriovenous malformations are congenital anomalies that may become aggressive and destructive. Unlike some other vascular lesions (ie, hemangiomas), AVMs continue to grow throughout life by vessel ectasia rather than cellular proliferation. They often grow proportionately with the individual and may have subtle findings until rapid growth occurs owing to events such as puberty, pregnancy, trauma, or surgery. Presenting symptoms are typically pain, ulceration, hemorrhage, dysfunction, and deformity. Examination typically reveals a poorly defined mass with cutaneous discoloration with or without ulceration. A palpable thrill is classically found and considered pathognomonic for AVMs. These lesions are often quite psychologically damaging and can be fatal with or without surgery.

The treatment of AVMs can pose an important challenge. Treatment success is greatest in smaller, quiescent lesions compared with the extensive, aggressive lesions reported in our series. Conservative measures, such as lasers, steroids, and radiation, have no place in the treatment of AVMs and can potentially make subsequent attempts at control and/or elimination much more difficult. Proximal ligation has also proven unhelpful because this may cause growth of the malformation in a direction that may be surgically inaccessible and thwart future attempts at resection. The current, accepted treat-
Treatment for sizeable malformations consists of preoperative embolization, adequate resection, and appropriate reconstruction. Our institution’s protocol is to embolize the lesion, usually within 48 to 72 hours of the excision, which is largely supported by the literature. Determining the extent of resection may be the most difficult and critical aspect of the surgery, especially in the head and neck region. Attempts at trying to preserve as much tissue as possible can sometimes lead to incomplete resection of the malformation, resulting in recurrence and persistent symptoms. Koshima et al. stated that radical resection is essential for effective treatment of an AVM. Bradley et al., however, favor judicious postembolic resection instead of large-scale ablation. They also stated that perhaps wider resections, including normal soft-tissue margins, might prove more appropriate and beneficial in select cases.

Kohout et al. described their institution’s method of determining the extent of tissue resection based on intraoperative bleeding patterns. They also used intraoperative Doppler ultrasonography in addition to image-based preoperative planning in making these decisions. Marler and Mulliken agree with this form of intraoperative surgical decision-making and state that “the pattern of bleeding from the wound edges is the best way to determine whether or not the resection is adequate.” Kohout et al. reviewed their series of 81 patients with head and neck AVMs treated over a 20-year period, which included 11 who were treated with embolization, resection, and free-flap reconstruction. In the case series reported by Kohout et al., they described the use of frozen sections in 3 cases that did not prove helpful during the associated surgical procedures. They have since abandoned this technique and discourage its use. At our institution, we have not used frozen section analysis and instead rely on observation. Unlike the case of hemangiomas, currently there are no immunohistochemical stains that can reliably identify AVMs from other malformed vessels. Instead, the pathologist must rely on well-defined morphologic features under permanent section analysis. Some centers, including ours, are actively pursuing a histologic marker.

Kohout et al recommend reconstructing with local tissue whenever possible. Most AVMs treated at our institution are actually reconstructed in this manner. However, some studies theorize that FTT, with its physiologically normal vascular supply, may potentially act as a “regulating flap” by suppressing residual AVM because it seems to provide an environment that discour-
ages microfistula opening or collateral formation. Tark and Chung\textsuperscript{13} reported a series of 3 patients treated with embolization and subtotal AVM excision that histologically showed a change to normal tissue 4 months after FTT reconstruction, with no evidence of recurrence at least 4 years after resection. Our institution’s experience does not support this because of 8 patients treated with embolization and subtotal AVM excision still had evidence of AVM on follow-up examination.

Hong et al\textsuperscript{14} reviewed 6 patients treated with embolization followed by anterolateral thigh FTT that included a sensory neurorrhaphy. Only 2 patients required secondary surgical procedures for contouring, and none were found to have recurrent malformation during the mean 17-month follow-up period. Yamamoto et al\textsuperscript{15} reported the reconstruction of large head and neck AVMs with FTT in 7 patients over a 10-year period. Three of these patients were later found to have recurrence of the malformation. The feeding arteries of the AVM were used as recipient vessels in many of these cases and were reportedly resected back until found to be macroscopically normal. Tark and Chung\textsuperscript{13} also used the enlarged vessels for the microvascular anastomosis in their series of 3 patients. Bradley et al,\textsuperscript{9} however, recommended that microvascular anastomoses be performed away from the larger, pathologic vessels in their review of 300 patients with AVM, 85 of whom underwent embolization and resection. In our institution’s experience, the enlarged vessels not felt to be pathologically involved with the malformation were used as recipient vessels most of the time.

Free-flap selection is ideally tailored to the specific lesion and patient characteristics. The donor site is important to consider in this process, and the intraoperative consequences, such as length of time for harvesting and the need for patient repositioning, may be factors in the decision. Some flaps may provide a good color and texture match, whereas others may provide opportunity for sensation\textsuperscript{16} or movement.\textsuperscript{9} Prelamination, the incorporation of preformed cartilage into the flap for reconstruction in a staged fashion prior to tissue transfer, may also be used for complex facial areas requiring reconstruction, such as the nose.\textsuperscript{16} In our series, rectus abdominis, radial forearm, scapula, and latissimus dorsi flaps were used without consideration given to sensation or movement capabilities.

Despite performing the most thorough resection, revision procedures are frequently required to remove residual malformation, improve the contouring of the tissues, and treat wound complications. Patients with AVMs should be counseled that the reconstructive plan is a multistep process and does not typically end with the FTT. Our institution averaged 6.75 revision procedures per patient, most of which were combined with follow-up resections for recurrent disease. Despite its many advantages, FTT is no guarantee of uncomplicated postoperative healing. The skin edges of excised AVMs are still prone to sloughing and may separate from the free flap.

In conclusion, FTT should be considered in cases of large head and neck AVMs in which a significant cutaneous and soft tissue resection is undertaken. In addition, FTT should be considered in cases involving large volume defects, composite defects, or skull base involvement. This transplanted tissue has the potential to restore structural integrity and improve local wound. Although FTT typically results in a prolonged, multistep process, most patients will be satisfied with the surgical outcome, and malformation control will be optimized.

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REFERENCES