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Color Doppler Ultrasound: Effective Monitoring of the Buried Free Flap in Facial Reanimation

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Abstract

Objective. The gracilis muscle free flap has become a reliable means for smile reanimation for patients with facial paralysis. Because it is a buried flap, it presents a postoperative monitoring challenge. We sought to evaluate our experience with color Doppler ultrasound in the monitoring of gracilis free flap viability in the immediate postoperative setting.

Study Design. Case series with planned data collection.

Setting. Tertiary medical center.

Methods. Patients with facial paralysis treated with gracilis muscle free flap for smile reanimation performed between March 2009 and November 2010 were evaluated by color Doppler ultrasound and included in the study. Our experience with the use of the color Doppler ultrasound to monitor the gracilis muscle flap is presented.

Results. Forty-six patients were identified. In all cases, color Doppler ultrasound was used postoperatively to assess flow through the vascular pedicle. Outcomes included an early flap survival rate of 100%, with no instances of equivocal or absent flow on either the arterial or venous side. Color Doppler ultrasound provided important objective information regarding muscle perfusion postoperatively in several instances of equivocal postoperative perfusion of the flap.

Conclusion. Color Doppler ultrasound is a safe, noninvasive method that can be performed serially to evaluate a buried free flap. We have had success in verifying normal arterial and venous flow through the pedicle using this method of monitoring of the gracilis muscle free flap during facial reanimation, and in 3 instances, it eliminated the need for wound exploration to verify appropriate muscle perfusion.

Keywords

facial paralysis, gracilis, ultrasound, Doppler, buried free flap

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The introduction and refinement of microvascular surgery have dramatically improved the care of patients requiring complex head and neck reconstruction. Advances in microsurgical technique have made possible not only static reconstruction of a defect but also dynamic reconstruction in cases of loss of appropriate muscular function. Survival of microvascular free flaps is 95% or higher in most contemporary series.[1,2] The gracilis muscle transfer to the face, with associated neural reinnervation, results in smile reanimation in patients for whom there is inadequate or absent commissure excursion during smiling. This completely buried free flap poses a postoperative monitoring challenge because there is no cutaneous paddle, the face can become swollen as a consequence of the extensive dissection, and the possibility of edema from the implanted muscle, thus obscuring the clinical signs of a congested muscle flap due to vascular insufficiency. Limitations in the ability to monitor the buried free flap motivated the search for methods that could improve postoperative monitoring of the implanted gracilis muscle.

We hypothesize that color duplex ultrasound could serve as a useful monitoring tool for buried gracilis muscle free flaps in the face, particularly in situations in which the bedside examination is equivocal.[3-5] The objectives of this study were to review our experience with color duplex ultrasound after free muscle transfer to the face and describe its use in monitoring the buried gracilis muscle flap used for smile reanimation in patients with facial paralysis.

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Methods

Patient and Data Collection

A case series with planned data collection was performed of all patients at the Facial Nerve Center at the Massachusetts Eye and Ear Infirmary who presented for gracilis muscle transfer for treatment of their facial paralysis between March 2009 and November 2010. All patients treated during that time frame with gracilis muscle free flap for smile reanimation were included in the study. Demographic information, along with preoperative and postoperative clinical data, was collected in a database. The institutional review board at Massachusetts Eye and Ear Infirmary approved the study.

Color Doppler Ultrasound

All patients underwent gracilis muscle transfer to the paralyzed face for smile reanimation. Postoperatively, 3 methods were used for monitoring the free flap for viability: bedside standard ultrasonic handheld Doppler, physical examination, and color Doppler ultrasound in the radiology suite. The former 2 modalities were used daily, and the latter modality was employed once, within 2 days following free tissue transfer.

For the color Doppler ultrasound examination, all patients were scanned using either a 5- to 12-MHz linear probe or a 7- to 15-MHz compact linear probe (HD11; Philips Medical Systems, Bothell, WA). Initially, patients were scanned either supine or partially supine, depending on patient comfort. As the study progressed, every effort was made to scan patients in a completely supine position as this enabled better evaluation of small venous structures. On grayscale imaging, the gracilis muscle was evaluated, fluid collections were noted, and the vessels were evaluated for patency. Segmental compression of the vein was employed to evaluate for the presence of intraluminal clot. Color Doppler imaging was used to trace the vessels, and both color Doppler and Doppler waveforms were assessed at 3 sites: along the mandible, below the level of the anastomosis; at the inferior edge of the gracilis flap; and at a midpoint approximating the region of the anastomosis. For the vein, attempts were made to measure close to the region of the venous coupler (Synovis Micro Companies Alliance Inc, Birmingham, AL), which could nearly always be visualized in the transverse plane as a radial array of spokes extending from the vein (**Figure 1**). The exact location of the arterial anastomosis could not be determined by ultrasound. At each point, vessels were imaged in both the transverse and sagittal planes.

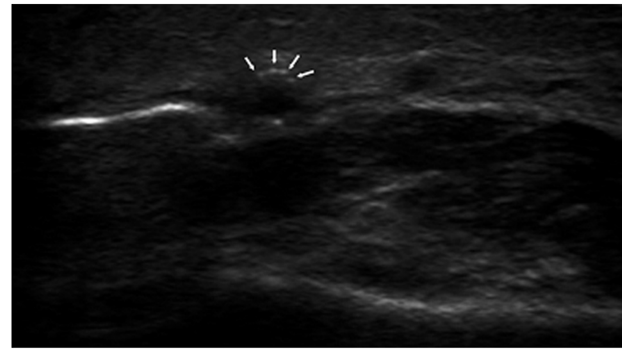

Figure 1. Doppler sonogram of vein in transverse view at the level of the venous coupler (small arrows) and thus the position of the venous anastomosis.

Table 1. The Distribution of Etiologies of Facial Nerve Paralysis in the Study Group

Etiology of Facial Paralysis	Number of Patients
Brain tumor	11
Neurofibromatosis	6
Acoustic neuroma	5
Bell's palsy	4
Congenital	4
Chronic otitis media	3
Benign facial nerve tumor	3
Trauma	2
Stroke	2
Febrile illness	2
Pregnancy-associated Bell's	1
Iatrogenic	1
Birth trauma	1
Multiple sclerosis	1

Results

Between 2009 and 2010, 46 patients met criteria for inclusion in this study. There were 18 men and 28 women participants. Patient age ranged from 8 to 60 years of age; 45 patients had unilateral facial paralysis, and 1 patient had bilateral facial paralysis. The patient with bilateral facial paralysis underwent bilateral simultaneous free gracilis transfer. The etiologies of facial paralysis of the patient population are listed in **Table 1**.

All patients underwent gracilis muscle transfer with the obturator artery coapted to the ipsilateral facial artery with 9-O nylon, with a single exception in which the superficial temporal artery and vein were used instead. The dominant of the 2 obturator veins was coapted to the ipsilateral facial vein (or the superficial temporal vein) using a venous coupling device. Twenty-three transplanted muscles were reinnervated by the masseteric branch of the trigeminal nerve, and the other 24 transplanted muscles were reinnervated through a cross-face nerve graft. All pedicles and neurroraphies were placed in a plane deep to the muscle.

All patients underwent daily serial examinations and standard Doppler auscultation at the bedside. Three patients had equivocal examinations with trace or increasing facial firmness, although no patient demonstrated obvious vascular compromise by bedside examination (significantly firm flap or complete absence of Doppler signal). Seven patients underwent color Doppler ultrasound assessment on postoperative day 2 or 3, while the other 39 patients had their

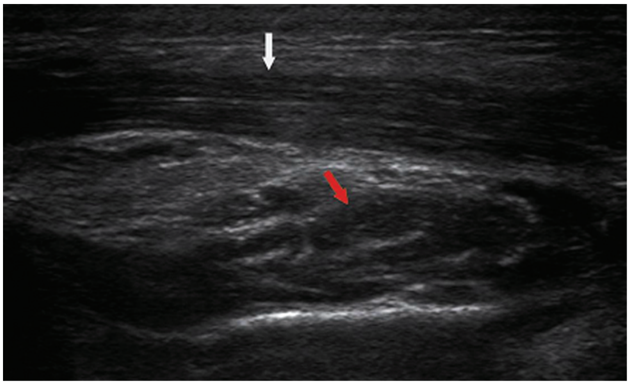

Figure 2. Color Doppler sonogram of the gracilis flap posttransplantation showing the gracilis (white arrow) and the underlying masseter muscle (red arrow).

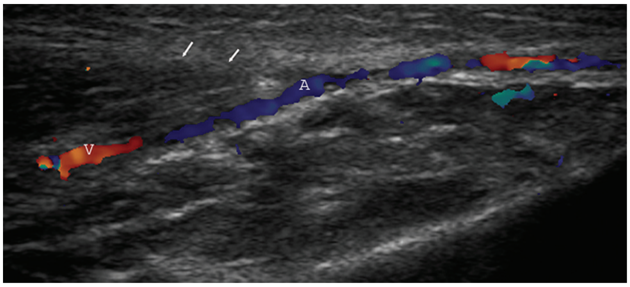

Figure 3. Color Doppler sonogram of the gracilis flap posttransplantation showing the artery (A) and vein (V) and the gracilis muscle superficial to the vessels (small white arrows).

assessment on postoperative day 1, to study the vascular anastomoses. In all cases, the examination successfully located the implanted gracilis adjacent to the masseter muscle (**Figure 2**) and the pedicle deep to the gracilis muscle (**Figure 3**) and evaluated flow through the artery and vein in every case (**Figure 4**). The use of a venous coupler facilitated visualization of the venous anastomosis (**Figure 1**). There was excellent agreement between the bedside examinations and the color Doppler evaluations. In the 3 patients with trace facial firmness, the visualization of a compressible vein on the study permitted avoidance of suture removal for direct muscle inspection or return to the operating room for formal exploration. These 3 patients needed no further postoperative interventions, and they achieved a successful outcome of oral commissure excursion.

Three patients developed postoperative wound infections requiring surgical intervention and evacuation; however, there were no associated vascular issues or discernible flap losses. One patient who had facial paralysis related to trauma underwent a second free gracilis transfer because the first free gracilis transfer did not achieve any movement. In this patient, the first gracilis was found to be well vascularized; however, it did not receive adequate neural input. The second gracilis muscle achieved acceptable commissure excursion. In this 15-month period, there were no instances of flap loss due to vascular insufficiency.

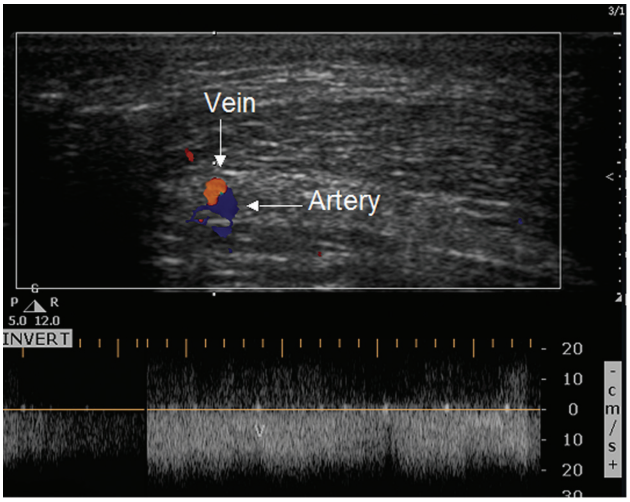

Figure 4. Color Doppler sonogram of the gracilis flap posttransplantation showing the pedicle in transverse view, artery and vein labeled. The venous wave form (below).

Discussion

Advances in techniques in microvascular surgery have broadened the treatment possibilities for patients with reconstructive problems in the head and neck region. Free tissue transfer permits reconstruction of a variety of soft and bony defects. Furthermore, reinnervated transferred muscle can provide dynamic function. The success of free tissue transfer is dependent on the maintenance of adequate perfusion of the transferred tissue. At our Facial Nerve Center, the use of the buried gracilis free flap has become commonplace for smile reanimation in patients with facial paralysis. This study describes a technology that has been successfully used to monitor gracilis flap viability after implantation into the paralyzed face.

Handheld Doppler ultrasonography is the most commonly used tool for postoperative flap monitoring.[6] Our monitoring strategy involves the use of the handheld Doppler ultrasound by the surgeons and nurses of the patient. However, its major limitation is that it may not reliably differentiate vessels perfusing a free flap from adjacent vessels in the recipient bed. Moreover, differentiating arterial versus venous flow can be difficult. In addition, when the vascular anastomoses are buried deep to the native skin and subcutaneous tissue of the face and the transferred muscle, the sound of flow in the pedicle may be difficult to appreciate.

When a skin island is not available to monitor a buried flap, alternative methods are necessary to ensure flap viability. A variety of monitoring techniques and devices have been reported in the literature. A portion of a buried flap can be brought up to the skin to serve as a monitoring segment, as has been described in jejunal flaps used for esophageal reconstruction.[7] An implantable Doppler probe is a means of assessing the vascular flow to a flap and is used by some surgeons.[6] Microdialysis is a sampling technique that studies the biochemistry of tissues such as a buried free flap to determine the presence of venous or arterial compromise. Its use has been reported in the monitoring of a buried only fibular bone graft; however, it is quite expensive.[8] Near-infrared spectroscopy is a noninvasive technique that monitors flap tissue oxygenation and can also be used to monitor a buried flap.[9,10]

In the current report, we find that color Doppler ultrasound is an additional, useful tool that can be used to monitor buried gracilis flaps in the postoperative period.[3-5,11] It is a noninvasive tool that can be used repeatedly to evaluate the perfusion and status of a buried gracilis flap. It is straightforward to perform by an experienced operator and can be performed at the bedside if transport to the radiology suite is contraindicated. This preliminary series suggests that the device can unequivocally identify a pedicle that is buried deep to the gracilis muscle and evaluates the vessels along their course in real time. Moreover, it can evaluate the quality of the muscle and determine the presence of seroma or hematoma that may require intervention. The presence of a venous coupling device did not limit evaluation of venous flow but rather simplified identification of the site of venous anastomosis. Our monitoring strategy currently involves the use of handheld Doppler, physical examination by the surgical team, and the color Doppler ultrasound. The color Doppler ultrasound can be especially useful if there is any concern for vascular compromise. Color Doppler ultrasound has been found, by other microvascular surgeons, to be useful in the monitoring of other buried free flaps such as fibula and jejunal flaps, and herein we describe a series of patients for whom its utility is again identified.[10]

Shortcomings of color Doppler ultrasound include that it may not be available at all centers and the cost of such a device can range from $30,000 to $225,000.[4] While expensive, the device may already be a part of a radiology department's armamentarium based on its other clinical uses. In our center, the color Doppler ultrasound is available in the radiology suite and is used primarily by radiologists. However, the device is mobile and has the potential to be brought to a patient's bedside. This is a limitation if flap evaluation is desired after hours, when a radiologist may not be immediately available. However, it is feasible to educate the surgical team about how to use the device to evaluate the flap, to assist in making urgent clinical decisions after hours. For example, color Doppler ultrasound technology is already being used by otolaryngologists to evaluate patients with thyroid masses. Given the current limitations, this technology has not replaced handheld Doppler ultrasound or expert physical examination to monitor our buried gracilis flaps; however, it can offer additional information, especially in clinical situations in which a flap's vascular integrity is in question.

An important limitation of this study is the fact that it is not a randomized trial comparing multiple buried flap–monitoring methodologies. Despite this relative weakness, we have found the technology to be useful for monitoring buried gracilis free flaps implanted in the paralyzed face and believe it may have an important role to play when the index of suspicion for vascular compromise is moderate to high. The ability to assess and verify flow through the vascular anastomosis gives us critical information that is beyond what we can acquire, in certain clinic situations, through physical examination and handheld Doppler alone. In the 3 instances of subtle suggestion of venous compromise, reexploration was not necessary based on findings using this technology. All 3 of these patients had successful outcomes with good commissure excursion after reinnervation.

The transfer of free muscle represents a relatively high-flow state compared with the lower-flow bony free flaps; therefore, the incidence of thrombotic events is lower. The fact that no vascular compromises were identified in the present report establishes that there were no false-positive assessments using the technology. The false-negative rate could be determined only in a much larger series.

Conclusion

Buried free flaps such as the gracilis muscle free flap pose a postoperative monitoring challenge for the facial reanimation surgeon. The color duplex ultrasound is a tool that can be successfully used to evaluate the vascular integrity of a buried free muscle flap. Future studies comparing color duplex ultrasound to other available monitoring tools are needed to determine an optimal monitoring strategy.

Author Contributions

Kalpesh T. Vakharia, corresponding author, significant work in creating the project, acquiring the data, analyzing and interpreting the data, writing the manuscript, and approving the final version; **Douglas Henstrom**, significant contribution in creating the project, acquiring the data, analyzing and interpreting the data, revising the manuscript, and approving the final version; **Robin Lindsay**, significant contribution in creating the project, acquiring the data and interpreting the data, revising the manuscript, and approving the final version; **Mary Beth Cunnane**, significant contribution in creating the radiology portion of project, acquiring the data, analyzing the radiology images and interpreting them, and also help in revising the manuscript and approving the final version; **Mack Cheney**, significant contribution in creating the project, interpreting the data, revising the manuscript, and approving the final version; **Tessa Hadlock**, significant contribution in creating the project, acquiring the data, analyzing and interpreting the data, revising the manuscript, and approving the final version.

Disclosures

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