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An Endoscopic Approach to Longitudinal Structures Including Muscle Flaps and Vein, Tendon, and Nerve Grafts

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ABSTRACT

Anatomically favorable structures that have a longitudinal orientation are particularly amenable to endoscopic harvest. Typically, only a single portal is necessary for access, and an optical cavity can be maintained using a mechanical retraction device. As with all minimal invasive surgery, this can still allow rapid and often a safer tissue harvest with diminished morbidity, especially with respect to wound healing and non–aesthetic scar formation. Many plastic surgery applications have already been described facilitated by the endoscopic harvest of vein, tendon, and nerve grafts, as well as certain local or free muscle flaps.

KEYWORDS: Endoscopic harvest, vein grafts, tendon grafts, nerve grafts, muscle flaps

Unlike other practitioners of minimal invasive surgery who enjoy use of a natural body cavity as their "optical cavity," in plastic surgery ingenious methods have had to be devised to create and maintain this work space.[1] Another basic concept of traditional endoscopy has been the use of triangulation principles as a means to compensate for the two-dimensional view provided by current endoscopes.[1] This has worked well for the more mainstream aesthetic applications of endoscopic plastic surgery such as forehead browlift[2] and abdominoplasty.[3] Strictly reconstructive endeavors have lagged behind not so much for lack of innovative thinking but more for pragmatic reasons such as the difficulty in incorporating these techniques for extensive dissection of longitudinal structures or perhaps because the advantages have not been so clear-cut. Fortunately, adaptation of newer instrumentation has allowed the development of reasonable methods in this regard for endoscopic harvest of vein, tendon, and nerve grafts, in addition to certain muscle flaps.

VEIN GRAFTS

Actually, our cardiothoracic colleagues have provided some important insight on the harvest of longitudinally oriented structures that began with their switch from traditional open methods for saphenous vein graft harvest for coronary artery bypass to an endoscopic approach. Because the greater saphenous veins have been most commonly used, and because these usually are long, straight structures, access to them is particularly suited to a single-portal approach. As used in our hospital, an optical vessel dissector and small ultrare-tractor (ClearGlide; Datascope Corporation, Fairfield, NJ) can be introduced via a single transverse medial lower-limb incision either above or below the knee, as

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Figure 1 Optical vessel dissector (above) and small ultraretractor (ClearGlide) used for creation of the subcutaneous optical cavity necessary for endoscopic harvest of longitudinal structures.

indicated, for endoscopic subcutaneous dissection that creates a tunnel just above the greater saphenous vein. Both tools have an inverted pistol-grip handle (Fig. 1) that simplifies their retraction and stabilization to establish the optical cavity in conjunction with or without an open CO_2 system, so that it does not have to necessarily be dependent on gas insufflation to maintain tissue separation. The transparent, spoon-shaped, blunt plastic shield of the ultraretractor, which has a cylindrical channel through which the desired endoscope is inserted, provides the working space to permit antegrade dissection of the vein. Side branches as encountered can be coagulated with a bipolar cautery and then any remaining adventitial tissues stripped circumferentially away from the vein using a special pigtail vessel dissector, with both tools also included as standard kit components.

Extensive worldwide experience has shown that there is less postoperative pain and a lower incidence of wound complications in this group of patients where concomitant peripheral vascular disease and poor wound healing otherwise is not uncommon[4]; and superior cosmetic results accrue especially with respect to scarring, as only two or three short incisions are needed.[5] Just as crucial is the security of knowing that an evaluation of vein endothelial integrity and smooth muscle function has proved that endoscopically harvested veins are similar to vein grafts obtained with open techniques.[6]

The use of vein grafts can sometimes also be essential in reconstructive microsurgery, especially to reach recipient sites outside the zone of injury.[7] If a long piece of vein graft of large caliber is needed, endoscopic harvest similar to that used by our cardiothoracic colleagues (Fig. 2) can reduce the morbidity of an open technique for the same reasons.[8] Once elevated in a similar fashion, the retained ends of the vein at the donor site should preferably be tied off or hemoclips placed as preferred. This may also be a better technique for side branches, too, so that any thermal damage to the conduit itself is altogether avoided—probably a much more important consideration in microsurgery for venous side vein grafts where flow rates are diminished and thrombosis more likely. Our protocol is to consistently place a microvascular occlusion clamp always at the outflow end of the vein graft before retrieval. Extracorporeal examination of the graft under the microscope while irrigating it with a heparinized lactated Ringer's solution allows placement of ligatures on any residual open side branches. We do recognize that more often than not, smaller-caliber veins of short lengths are preferable, especially for replantations or digit revascularizations. Because the dorsum of the foot or hand or distal volar forearm are our preferred donor sites for such, these are typically not amenable to an endoscopic harvest, and a direct open approach must still be used.

ARTERY GRAFTS

Other longitudinally oriented and particularly narrow structures commonly used in reconstructive surgery lend themselves to endoscopic harvest in a manner similar to vein grafts. Again, our cardiothoracic colleagues have proved this point by the endoscopic harvest of the radial artery to provide a superior coronary artery bypass conduit, using a single "watchband" incision at the wrist.[9] This avoids a long, disfiguring, and sometimes sensitive forearm scar that otherwise is the most significant sequela of open retrieval.[10] The role of arterial grafts in strictly reconstructive surgery has had limited value.

NERVE GRAFTS

To avoid the residua of sensitive or disfiguring scars, expendable superficial sensory nerves can also be removed endoscopically as graft material via a single incision. Although any superficial nerve could be a candidate, the sural nerve has been that most commonly exploited because of its relatively large caliber and generous available length.[11–13] Harvest can be accomplished with the patient even in a supine position, via a small transverse incision just posterior to the lateral malleolus. This will avoid the need for stair-step incisions or a long longitudinal scar on the exposed calf, which is especially important in pediatric patients where cosmesis is always a major concern[12] (succinctly discussed by Capek and Clarke in this issue of *Seminars in Plastic Surgery*).

The actual technique for endoscopic sural nerve harvest is similar to that for endoscopic vein graft retrieval. Dissection is easiest if it proceeds from caudal to cephalad, with a thigh tourniquet employed to minimize blood staining. Initially, conventional open dissection at the lateral ankle allows identification of the sural nerve and adjacent lesser saphenous vein. The

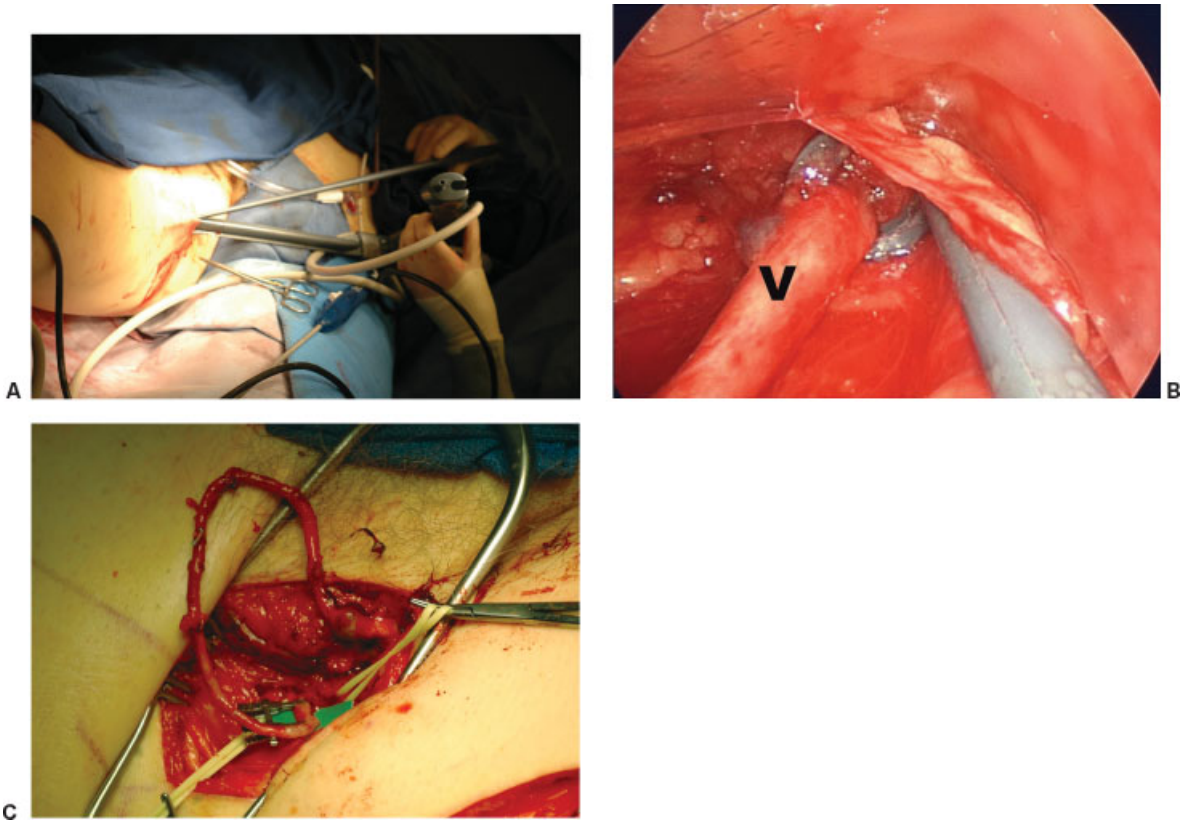

Figure 2 (A) Small ultraretractor introduced via available medial groin incision for greater saphenous vein graft harvest. (B) Monitor view of the pigtail vessel dissector stripping blood-stained adventitial tissue away from vein, *V*. (C) Creation of a temporary arteriovenous fistula in the groin using this endoscopically harvested vein graft prior to division and attachment to a free flap.

endoretractors, as described previously for vein graft harvest, are introduced to allow visualization and proximal blunt dissection at the appropriate level to separate the sural nerve from the overlying subcutaneous tissues (Fig. 3). If additional length is needed, the deep calf fascia can be divided where the medial sural cutaneous branch dives beneath to course between the heads of the gastrocnemius muscles. If the peroneal communicating branch and/or lateral sural cutaneous nerves exist, these also can be dissected proximally in the subcutaneous plane as far as desired. A pigtail or looped nerve dissector device can then be passed about the nerve to further free it up from surrounding tissues. The nerve ends are cut once the desired length has been dissected free and the graft removed. If the required nerve graft must exceed 10 cm in length, Lin et al[13] have altered this technique slightly to obtain a vascularized sural nerve graft. In this scenario, the lesser saphenous vein and intervening soft tissues are kept with the sural nerve and removed together. The vein would be revascularized as an arterial flow-through.

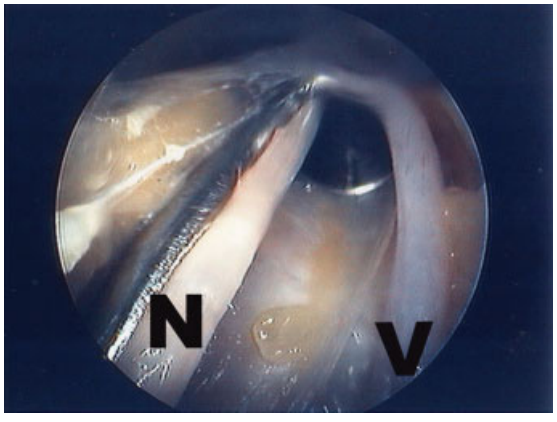

Figure 3 Endoscopic view of the sural nerve, *N*, here surrounded by a blunt tendon stripper while separating it from the adjacent lesser saphenous vein, *V*.

TENDON GRAFTS

Fortuitously, expendable and thus the most commonly used potential tendon grafts are found superficially in the distal extremities. This includes both the palmaris longus and plantaris tendons, which are distinct entities relatively separate from contiguous neurovascular or other deep structures except at the wrist or ankle, respectively. These characteristics facilitate a safe and efficient endoscopic harvest as for any longitudinal structure.

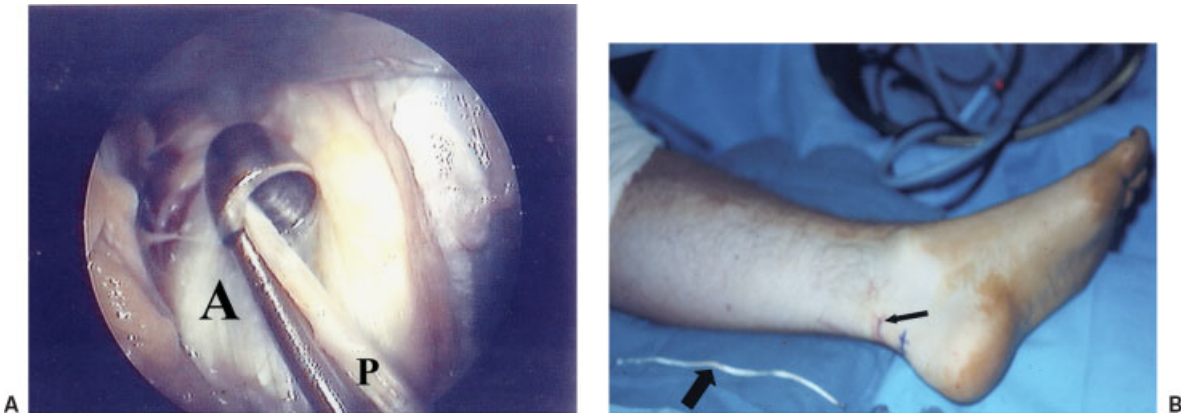

Figure 4 (A) Endoscopic view of the plantaris tendon, *P*, separated from the Achilles' tendon, *A*, as facilitated by dissection using a blunt tendon stripper. (B) The tendon graft (wide arrow) as removed endoscopically aside the medial calf, with single portal incision (narrow arrow) seen posterior to the medial malleolus and on the medial side of the Achilles' tendon.

In addition, the extremities are a somewhat privileged site in that use of a tourniquet is possible, which will minimize bleeding that could impair endoscopic visualization.

A small distal incision affords direct visualization of the desired tendon and allows open dissection as far proximally as possible to avoid injury to important adjacent structures. Using the endoscopic subcutaneous retractor of choice, the tendon can be freed up from the overlying subcutaneous tissues or fascia by blunt dissection even back to its muscular origin. This is followed by its circumferential dissection using a pigtail device or traditional blunt-tipped tendon stripper without worry of injury to any side branches as would be true for vascular or nerve structures (Fig. 4). In addition to endoscopic palmaris longus and plantaris tendon harvest, such techniques have been described for splitting the flexor carpi radialis tendon for basal joint arthroplasty[14] and retrieval of severed flexor tendons[15] and have been postulated as a future method for minimally invasive tenolysis or tendon transfer.[14]

MUSCLE FLAPS

Although the investigation of endoscopic muscle flap harvest such as for the relatively flat latissimus dorsi[16] or

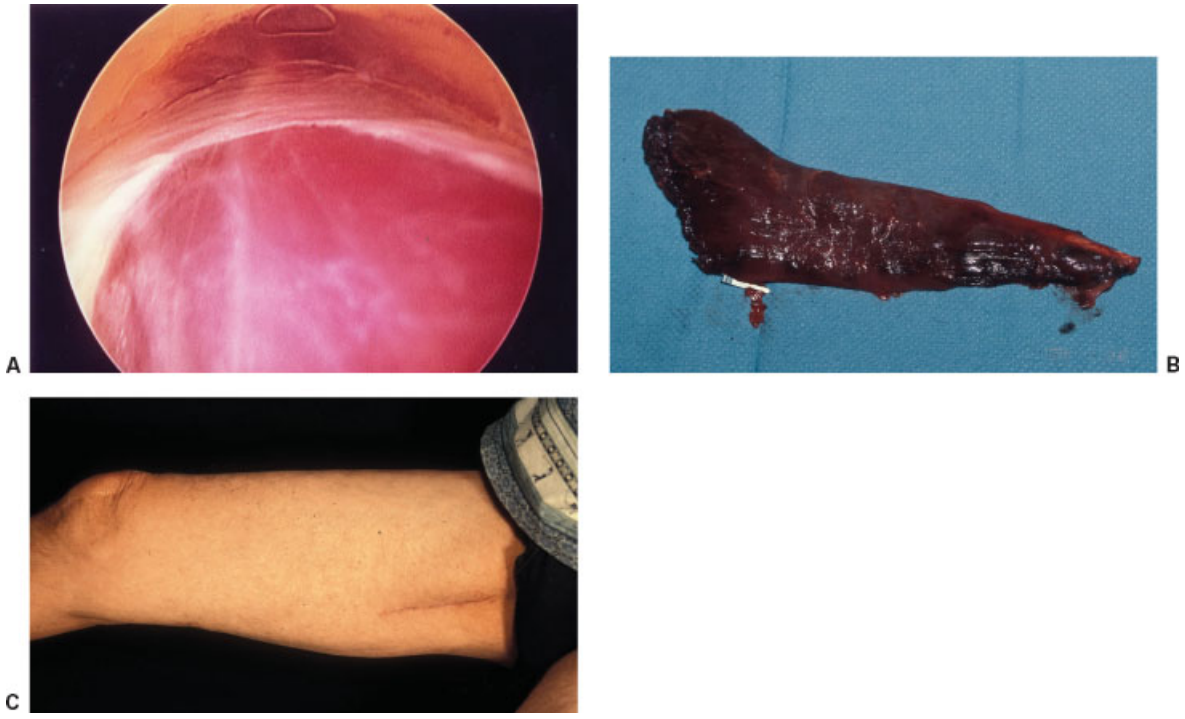

Figure 5 (A) Monitor view of endoscopic dissection of the gracilis muscle (below). (B) The retrieved free muscle flap. (C) Donor site scar of the proximal medial thigh reflects the current need for an open dissection of the vascular pedicle.

rectus abdominis[17] muscles already have widespread advocates, long, longitudinally oriented muscles without inscriptions and minimal attachments would appear to be more ideal candidates, using the same simple approach as already described for vein graft harvest. In this regard, the commonly used gracilis muscle as a local rotation or free flap has been the most publicized.[18–20]

Our technique for elevation of the gracilis muscle[20] has been to first make a vertical incision on the medial thigh just proximal to the knee joint, staying posterior to the anticipated course of the greater saphenous vein. Beneath the deep fascia, the gracilis tendon can be readily palpated below the sartorius muscle and circumscribed with a Penrose drain. Distal traction on the tendon allows proximal visualization of the exact location of the muscle itself. At ~10 cm distal to the pubic tubercle, an arrow corresponding with the usual site of entry of the vascular pedicle into the gracilis muscle is drawn. This area must not be violated by any endoscopic dissection to avoid risk of pedicle injury. The endoscopic subcutaneous retractor is introduced distally in the subfascial plane (Fig. 5), and, with continuous visualization, proximal blunt dissection completely around the muscle will separate loose connective tissues continuing up to the arrow as marked. During this maneuver, if the nondominant pedicle emanating from the superficial femoral vessels is encountered, this can be cauterized.

The vascular pedicle itself must still be approached cautiously via the proximal open incision, which also allows some distal subcutaneous dissection to join the end point of the endoscopic dissection. The rest of the harvest and transfer of the muscle will follow conventional techniques. Someday, once endoscopic equipment is not so cumbersome, or perhaps using better-controlled robotic dissection,[21] this entire process could be done without a proximal incision, which still results in significant scarring as seen (Fig. 5). Jeng et al[22] otherwise have shown that the same current endoscopic approach can be entirely performed "open" if modified only by making slightly longer incisions.

CONCLUSION

The potential benefits of endoscopic plastic surgery include an improved and magnified direct visualization of the desired structure, which may be accessed via ever smaller incisions that can be strategically hidden, which in turn reduces the overall necessary dissection and tissue trauma inflicted. These advantages are precisely the goals of any plastic surgery intervention. Structures whose anatomy has a longitudinal orientation will be quite amenable to a relatively simple dissection via a single portal approach using endoscopic techniques. Muscles, tendons, veins, arteries, and nerves have readily been so harvested with reasonable results. Resistance still exists with respect to mainstream acceptance of such an approach in reconstructive surgery, perhaps justifiably so because the available tools and techniques can still be considered cumbersome and must await further refinements as this role evolves.

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