The Anterolateral Thigh Flap
Radial Forearm’s “Big Brother” for Extensive Soft Tissue Head and Neck Defects

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Objective: The anterolateral thigh flap has recently been rediscovered in Asia as a perforator flap. The objective of this study was to describe the reliability and donor morbidity of the anterolateral thigh flap for head and neck reconstruction without transmuscular perforator dissection.

Design: Consecutive case series by a single surgeon.

Setting: A regional tertiary-referral head, neck, and skull base surgical oncology center.

Patients: The first 34 consecutive patients.

Intervention: Microvascular reconstruction with an anterolateral thigh free flap.

Main Outcome Measures: Primary insufficiency, partial necrosis, complete necrosis, and donor morbidity rates.

Results: Two flaps necrosed partially (6%). No flaps demonstrated primary insufficiency, necrosed completely, or incurred significant donor morbidity.

Conclusions: The anterolateral thigh flap can be reliably harvested without transmuscular perforator dissection and without incurring serious donor morbidity. It possesses workhorse attributes (no repositioning, remote from defect, long pedicle) and is extremely versatile (one is able to independently tailor the skin and muscle), making it ideal for the heterogeneous group of extensive soft tissue head and neck defects. When a forearm flap will likely be too thin or too morbid, the anterolateral thigh flap can be considered its “big brother.”

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THE ROLE OF MICROVASCULAR reconstructive surgery in the head and neck is now firmly established. As concerns about reliability dissipated through the 1970s, the freedom to select the best tissue match from almost anywhere on the body led a trend toward defect specialization. This trend produced a wide variety of free flaps for head and neck reconstruction, first reported in the 1980s. On the other hand, as the benefits of certain “workhorse attributes” of these flaps (no repositioning, remote from defect, long pedicle) were recognized through the 1990s, a trend toward flap specialization evolved. From the variety of free flaps first reported, the radial forearm and fibular flaps have arisen as the “flap-of-choice” for most limited soft tissue and composite head and neck defects, respectively. The combination of tissue match and workhorse attributes for these 2 extremity sites has led to their widespread popularity.

To date, however, no single flap has arisen as the flap-of-choice for the more heterogeneous group of extensive soft tissue head and neck defects. While there are advocates for musculocutaneous free flaps for the torso, such as rectus abdominis and latissimus dorsi, tissue match and workhorse limitations, respectively, seem to have dampened uniform enthusiasm for them. These limitations were characterized by the center with perhaps the longest experience with microvascular reconstructive surgery today:

The rectus abdominis musculocutaneous flap often seems too bulky. . . . Because the patient must be repositioned for elevation of latissimus dorsi, simultaneous tumor resection and flap elevation are not possible.

The anterolateral thigh flap is an extremely versatile extremity flap since its moderately thick skin and large potential muscle bulk can be independently tailored to provide ideal tissue matches for this heterogeneous group of defects. It also possesses the workhorse attributes that have made the extremity sites, such as forearm and fibula, so popular.
Fortunately, unlike them, its perforators are usually transmuscular. The centers in Asia with the largest experience harvesting the anterolateral thigh flap acknowledge that it is easier when transmuscular dissection is not required (ie, anomalous transeptal perforators are present). The objective of this study was to describe the reliability and donor morbidity for a large consecutive single-surgeon experience in harvesting this extremely versatile flap for head and neck reconstruction without transmuscular perforator dissection.

**METHODS**

The first 34 patients in whom I performed microvascular reconstruction with an anterolateral thigh flap during the 4-year period between July 1, 1999, and July 1, 2003, were the subjects of this study. The surgeries were performed in a high-volume microvascular reconstructive head and neck surgery service for Kaiser-Permanente members living in the Los Angeles, Calif, referral basin (roughly 3 million persons) who underwent oncologic resection of their advanced cancers at the regional head, neck, and skull base surgical oncology center. An extensive panel of prospectively determined preoperative, operative, and postoperative variables were recorded for all patients on a previously established digital spreadsheet. Of the 34 patients, 21 (62%) were male, with a mean age of 62.3 years (range, 11-85 years). All had advanced (T stage, 3 or 4) or resectable, and postoperative variables were recorded for all patients.

**FLAP SELECTION**

The final donor site selection was made only after circumferential frozen-section margins were cleared histologically and exact final defect requirements were known. In all cases the anterolateral thigh flap was selected over the radial forearm flap (both sites were always prepared) for soft tissue defects in cases where the forearm would not have provided sufficient bulk or the extent of coverage would have inflicted significant donor morbidity (≥6-7 cm wide) (see the “Main Outcomes” subsection). The 5 major types of extensive soft tissue head and neck defects (Figure 1 and Figure 2) were subtotal or total glossectomy defects (11 defects [32%]), extensive skull base defects (9 [26%]), “through-and-through” buccal defects (8 [24%]), extensive orbitomaxillofacial defects (3 [9%]), and extensive scalp defects (3 [9%]).

**VASCULAR ANOMALIES**

Usually, the vascular supply to the anterolateral thigh skin (overlying the rectus femoris and vastus lateralis) is by way of the largest and longest descending branch of the lateral circumflex femoral artery. It runs obliquely under the rectus femoris before entering the medial edge of vastus lateralis in the mid thigh. However, in about 10% of cases the vascular supply is by way of a large anomalous pedicle from its transverse branch (transverse pedicle anomaly), which enters the muscle more superiorly. In these cases, a descending branch is usually still present, although it is smaller (<1.5 mm) and enters the vastus lateralis more inferio.

Usually, 2 to 3 transmuscular perforators run through the medial edge (1 cm) of vastus lateralis (and not through the rectus femoris). However, in about 15% of cases the superior (dominant) perforator actually runs on the medial edge of the vastus lateralis (or so close that its entire course can be seen from the intermuscular space). In these cases, while technically not transmuscular, the superior perforator is always intimately associated with the vastus lateralis (to which it sends many tiny muscular side branches and not the rectus femoris (which separates easily from it). More important, even when the superior perforator does not appear to be transmuscular, there are almost always additional definitive transmuscular perforators more inferiorly.

**MUSCLE-CUFF TECHNIQUE**

A perpendicular line is marked at the midhigh point, halfway along the anterolateral line drawn between the anterior superior iliac spine and the superolateral patella (Figure 3). The superior perforator is identified by Doppler probe in the inferolateral quadrant within 3 cm of this point. In about 10% of cases (usually correlating with a transverse pedicle anomaly), the superior perforator is identified in the superolateral quadrant. Once identified, 1 or 2 more perforators can be identified by probing inferiorly from the superior perforator on a line roughly parallel with the anterolateral line. The skin paddle is then designed around the identified perforators. If multiple skin paddles are required (ie, through-and-through buccal defects), the intervening epithelium only (to protect the important subdermal venous plexus) is excised before the skin is incised.

The medial edge of the skin paddle is incised down to the rectus femoris fascia. Blunt dissection in the extrafascial plane permits medial retraction of the muscle, readily exposing the robust main pedicle. If the pedicle appears small (<1.5 mm) or enters the vastus lateralis more inferio, further retraction of the rectus femoris superiorly (releasing the skin as necessary) invariably exposes a robust pedicle (transverse pedicle anomaly) entering the medial edge of vastus lateralis more superiorly. Once the entire course and suitability of the pedicle are confirmed, the lateral aspect of the skin paddle is incised. A 2-cm-wide cuff of medial vastus lateralis (up to 14 cm, depending on required muscle bulk) encompassing the identified perforators to the skin paddle is empirically taken with electrical cautery. No attempt is made to specifically identify or dissect any perforators, even when the entire course of the superior perforator can be seen running on the medial edge of vastus lateralis.

A pedicle length of at least 14 cm can be obtained by ligating the transverse and rectus femoris branches of the lateral circumflex femoral artery if necessary (Figure 4). If a wider cuff of muscle is required for bulk, the distal ramification of
the motor nerve (which accompanies the distal pedicle) is often incorporated in the harvested muscle. However, unless a very wide and long muscle flap is required (ie, extensive scalp reconstruction), the ramifications to the proximal muscle are spared. As soon as the pedicle is divided, the skin edges are re-approximated with penetrating skin clamps (under tension if necessary) to capitalize on intraoperative skin creep. Defects up to 12 cm wide can be closed primarily. The patient is permitted to walk anytime after 3 days.

MAIN OUTCOMES

Primary insufficiency, partial necrosis, and complete necrosis rates were selected as the main reliability outcomes. Primary insufficiency, the percentage of flaps that exhibit any clinical evidence of insufficiency (ie, venous congestion, loss of arterial bleeding to needlestick, or loss of arterial Doppler signal) of the entire flap within 72 hours of the anastomosis, was designed to be a relatively specific measure of a flap’s technical revascularizability. It intentionally excludes secondary (later) causes of pedicle insufficiency, which usually result from inflammatory causes (salivary exposure and/or infection) rather than technical deficiencies (small vessels, poor geometry, pedicle tension, etc). Partial necrosis, the percentage of flaps that experience some but not complete necrosis, was selected as a relatively specific measure of intraflap vascularity. Complete necrosis rate was selected because it is the most commonly used measure of microvascular success, and most microvascular surgeons believe it is an indicator (albeit relatively crude) of quality. Significant donor morbidity, the percentage of patients who experienced acute limb-threatening or persistent bothersome functional complaints, was selected as the main morbidity out-
also felt slightly stiffer 2 months postoperatively. Two of them rated) did admit on direct questioning that the donor leg complaints, 5 (including the patient whose wound separation (healed by secondary intention), and 1 non-infection (resolved with oral antibiotics), 1 partial wound seromas (resolved with serial aspirations), 1 wound infection (resolved with oral antibiotics), 1 partial wound separation (healed by secondary intention), and 1 non-threatening hematoma (evacuated intraoperatively). While no patients had persistent bothersome functional complaints, 5 (including the patient whose wound separated) did admit on direct questioning that the donor leg felt slightly stiffer 2 months postoperatively. Two of them (including the only patient to receive a skin graft) also felt that it was slightly weaker when climbing stairs. All denied that these complaints were bothersome or affected their daily functioning. Most symptoms resolved entirely by 1 year.

**RESULTS**

The mean total harvest time was 50 minutes (range, 41-75 minutes). Only 2 (both transverse pedicle anomalies) of the latter 30 harvests took longer than an hour. The mean skin paddle width was 10.3 cm (range, 7-12 cm), length was 14.1 cm (range, 8-19 cm), and thickness was 11 mm (range, 5-20 mm). The mean muscle width was 4 cm (range, 2-12 cm) and muscle length was 8 cm (range, 5-16 cm). The mean pedicle length was 13.2 cm (range, 8-18 cm), the arterial diameter was 2.3 mm (range, 1.5-4.0 mm), and the venous diameter (larger venae comitantes) was 3.2 mm (range, 2.5-5.5 mm). Only 1 patient (treated before the skin creep technique) did not have the wound closed primarily. All patients were walking within 1 week.

Two flaps (6%), the first folded bipaddle flaps for through-and-through buccal defects, necrosed partially (see “Comment” section). No flaps demonstrated primary insufficiency or necrosed completely. Although no patients experienced significant donor morbidity, 9 (26%) did experience minor morbidity. Two developed asymptomatic seromas (resolved with serial aspirations), 1 wound infection (resolved with oral antibiotics), 1 partial wound separation (healed by secondary intention), and 1 non-threatening hematoma (evacuated intraoperatively). While no patients had persistent bothersome functional complaints, 5 (including the patient whose wound separated) did admit on direct questioning that the donor leg felt slightly stiffer 2 months postoperatively. Two of them (including the only patient to receive a skin graft) also felt

**COMMENT**

This series, to my knowledge the largest without transmuscular perforator dissection, confirms the signature attribute of the anterolateral thigh flap that has made it especially useful for the heterogeneous group of extensive soft tissue head and neck defects—its tremendous versatility.3-10 This versatility is a product of the ability to adapt or tailor the moderately thick skin and muscle components independently.3-10 The area can provide a large (up to 25 cm wide17 and 40 cm long12) amount of pliable, moderately thick (thinner than forearm and thinner than abdomen), uniform (more so than abdomen), potentially sensate, and multipaddle skin.4,13,17,19 By thinning, others4,10,12 have made it ultrathin, rivaling the forearm’s thinness (3-5 mm).3,9,10 By harvesting a large volume (up to 12 cm wide by 18 cm long in this series) of vastus lateralis muscle, it can be made as bulky as the conventional musculocutaneous torso free flaps like rectus abdominis4 and latissimus dorsi.21 It can also be readily reinnervated to obtain functional muscle.16,17 Fascia lata can be included to obtain a substantial amount of thick vascularized fascia.4,5,9,12 Although I have not combined it with tensor fascia lata, rectus femoris, or other composite flaps (by microvascular anastomoses) on the same pedicle, several very sophisticated configurations have been described by centers in Asia.4,5,7,9,10,12 Perhaps the most obvious testament to its tremendous versatility is simply the impressive heterogeneity of extensive soft tissue head and neck defects for which I (see Figures 1 and 2) and several others have found it ideal.3,10

The results of this study confirm that the anterolateral thigh flap is also highly reliable.4,13,15,17,18 Unique to this donor site is the ability to confirm and even elevate the entire course of the main pedicle before committing to the final design of the skin paddle or muscle bulk.3 While variation in the main pedicle does exist3,8,9,18 (transverse pedicle anomaly), it does not significantly alter the harvest technique or the reliability of the flap.4,7,9,12,13,15 It also appears that earlier descriptions of absent cutaneous perforators4 likely represented cases where they were present but overlooked because of their small size.9,12 I have always found at least 1 cutaneous perforator.4,9,12,17 My confidence in their presence is so high that after identifying them on the skin surface with a handheld Doppler probe, I no longer make any attempt to specifically identify or dissect them during the actual harvest.

These results suggest, as others have found, that the anterolateral thigh flap imparts comparatively minimal donor morbidity.9 As the center in Asia with the greatest experience states: “Very few donor sites in the human body can provide such a huge amount of skin, muscle, and fascia with so little donor site morbidity.”9,10,12,19 To my knowl-

**References** 4, 5, 8-10, 12, 13, 17-19.
edge, there have been no reports of acute limb-threatening or functionally debilitating long-term morbidity. The area is readily concealed, and when closed primarily (12 cm capitalizing on “skin creep”), patients rarely experience significant functional or aesthetic morbidity. For extensive defects, I have found it to be significantly less morbid than any other soft tissue donor site (including pectoralis major, radial forearm, rectus abdominis, and latissimus dorsi).

Three studies have specifically investigated the long-term morbidity incurred by sacrificing significant portions of vastus lateralis muscle. All 3 concluded that it was functionally minimal and did not clinically affect the patient’s daily functioning. The most sophisticated of these studies used strength testing machines to measure the isometric power of the quadriceps muscles at 30° and 60° of flexion between donor and control (the patient’s normal nondonor) thighs an average of 1 year after harvest of larger (15-40 cm³) portions of vastus lateralis muscle. Neither position demonstrated a significant difference in strength (interestingly, some donor thighs were actually stronger). In another study, 32 patients who had their thigh defect closed primarily were informed of the advantages and disadvantages of the anterolateral thigh flap and radial forearm flaps. They were then asked which they would have chosen from an aesthetic point of view. Only 1 patient preferred the radial forearm flap. Interestingly, 1 patient in this study did actually undergo harvest of both flaps (for recurrent cancer). He preferred the anterolateral thigh flap for aesthetic reasons.

The skin of the paddle not incorporating the dominant perforator on my first 2 folded bipaddle flaps (for through-and-through buccal defects) developed subacute venous congestion over several days and ultimately necrosed. In these 2 cases, the paddles were created by excising a full thickness of intervening dermis. I have since modified this technique to protect the underlying subdermal venous plexus by sharply excising the epithelium only. This problem has not recurred in 6 subsequent cases, suggesting that injury to the interconnecting subdermal venous plexus (rather than folding of the flap itself) was the likely culprit.

The anterolateral thigh is naturally exposed with the patient in the supine position and is remote from the head and neck. The pedicle is also extremely long (up to 20 cm [see Kimata et al⁵]). To my knowledge, it is longer than any other reported. This exceptional length (see Figure 4) permits access from scalp defects to central and even infraclavicular recipient pedicles, when needed. The pedicle is also extremely long and sinuous, highly branching, interconnected transmuscular perforator through piece-by-piece division of muscle fibers can be as reliable. However, it is difficult to imagine that it will not always remain more time consuming. Furthermore, the most experienced centers in the world now recommend harvesting at least 2 perforators if possible. On the other hand, even a neophyte can safely and quickly harvest this flap if a small cuff of vastus lateralis is empirically taken incorporating the identified transmuscular perforators to the paddle. However, some very experienced perforator flap surgeons believe that any amount of time and effort is justified in attempting to minimize unnecessary bulk and morbidity. While this may be true for most musculocutaneous torso flaps, I do not believe it is true for the anterolateral thigh flap.

Unlike most musculocutaneous torso flaps, the skin perforators of the anterolateral thigh are unilateral and peripheral, coming through only the very medial edge of the muscle. This very important anatomic distinction means that a large amount of skin can be harvested without transmuscular dissection and without also including (by necessity) most of the underlying (often excessive) muscle bulk. In fact, since the vastus lateralis tapers to about 1 cm as it overlaps the vastus intermedius medially (and further atrophies with denervation) and this additional bulk is indeed very small. For me, the bulk argument is also diminished by the fact that moderate and uniform additional bulk is precisely the reason I select it over the radial forearm flap for extensive soft tissue head and neck defects.

It is also important to remember that transmuscular dissection still requires division of some muscle to skeletonize the perforator. Therefore, empirically harvesting a small cuff of muscle incorporating several perforators, rather than meticulously dissecting 1 or 2 individually, actually sacrifices very little additional muscle. To place this in clinical perspective, the long-term functional morbidity of harvesting much larger portions of vastus lateralis muscle has now been shown through several objective studies (including isometric strength testing) to be functionally minimal and not clinically significant. To understand how this can be, one must remember that there is, to varying degrees, functional overlap between anatomically associated muscles. This is why most musculocutaneous donor sites have shown remarkable improvement in objective strength testing of their primary function over time. The potentially synergistic muscles in the area are challenged and hypertrophy over time, helping to compensate for the acute loss of the primary muscle’s function. What is particularly unique about the vastus lateralis (in addition to its unilateral and peripheral perforators) is the fact that, as part of the quadriceps femoris muscle group, it is partnered with 3 other naturally synergistic muscles (rectus femoris, vastus medialis, and vastus intermedius). I believe this is why, even after harvest of substantial portions of vastus lateralis (for bulk), acute functional deficits are relatively minor (if present at all) and seem to improve sooner and more completely than the traditional musculocutaneous torso donor sites.

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At my center, the well-documented reliability, functional, aesthetic, and resource advantages of microvascular free-tissue transfer have essentially eliminated the indications for pedicled flaps (2 pedicled flaps among more than 200 free flaps).1,3,20,27 Simply put, I believe that in experienced hands the tremendous advantages of free flaps in the head and neck far outweigh the additional hour or so it takes to revascularize them.20,27 Although some of the most experienced centers in Asia now prefer a thinned anterolateral thigh flap even for limited soft tissue defects,4,9,12,13,19 I do not believe it is the answer to all soft tissue defects. Therefore, I still prefer the radial forearm's natural thinness and ease of harvest for limited defects (roughly 3 radial forearm flaps were selected for every anterolateral thigh flap) and accept the slightly greater donor morbidity.17-19,25 On the other hand, I strongly agree that the conventional musculocutaneous torso flaps (pectoralis major,20 rectus abdominis,21,22 and latissimus dorsi23) are often simply too bulky,9 even for most extensive soft tissue head and neck defects.

CONCLUSIONS

The anterolateral thigh flap can be reliably harvested without transmuscular perforator dissection and without incurring serious donor morbidity. It possesses workhorse attributes (no repositioning, remote from defect, long pedicle) and is extremely versatile (one is able to independently tailor the skin and muscle), making it ideal for the heterogeneous group of extensive soft tissue head and neck defects. When a forearm flap will likely be too thin or too morbid, the anterolateral thigh flap can be considered its “big brother.”

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