The Pedicled Latissimus Dorsi Flap Provides Effective Coverage for Large and Complex Soft Tissue Injuries Around the Elbow

HAND
2018, Vol. 13(5) 586–592
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DOI: 10.1177/1558944717725381
hand.sagepub.com

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Abstract

Background: The pedicled latissimus flap has been shown to provide effective coverage of wounds around the elbow with an average size of 100 to 147 cm² but with complication rates of 20% to 57%. We believe the pedicled latissimus dorsi flap is an effective and safe technique that provides reliable and durable coverage of considerably larger soft tissue defects around the elbow and proximal forearm. **Methods:** A retrospective review was performed including all patients from Harborview Medical Center between 1998 and 2012 who underwent coverage with pedicled latissimus dorsi flap for defects around the elbow. Demographic information, injury mechanism, soft tissue defect size, complications (minor vs major), and time to surgery were collected. The size of the soft tissue defect, complications, and successful soft tissue coverage were the primary outcome measures. **Results:** A total of 18 patients were identified with variable mechanisms of injury. Average defect size around the elbow was 422 cm². Three patients had partial necrosis of the distal most aspect of the flap, which was treated conservatively. One patient required a secondary fasciocutaneous flap, and another required conversion to a free latissimus flap secondary to venous congestion. Two were lost to follow-up after discharge from the hospital. In all, 88% (14 of 16) of the patients had documented (>3-month follow-up) successful soft tissue coverage with single-stage pedicled latissimus dorsi flap. **Conclusions:** The pedicled latissimus dorsi flap is a reliable option for large and complex soft tissue injuries around the elbow significantly larger than previous reports. However, coverage of the proximal forearm remains challenging.

Keywords: elbow coverage, pedicled latissimus dorsi flap, soft tissue defect, exposed olecranon, pedicled flap

Introduction

Injuries resulting in large soft tissue defects around the elbow are challenging to treat. Because of bony prominences and the essential and large arc of motion of the elbow, soft tissue coverage around the elbow must be durable, thin and allow for repetitive flexion and extension of the elbow. In addition to the above requirements, coverage should allow for nearly immediate range of motion to prevent stiffness of the elbow, this being especially true when any underlying osseous injuries are present. Multiple options exist for small and medium defects such as primary closure, skin grafts, local random flaps, axial fasciocutaneous flaps, pedicled flaps, and free flaps.

Large defects around the elbow are more challenging, but the latissimus dorsi pedicled flap has been the workhorse for these sizable and complicated soft tissue defects.^{1-5,7-12,14,15} The latissimus dorsi is a large muscle with a broad origin

from the lower 6 thoracic and lumbar vertebrae, lower 4 ribs, and posterior ilium. Its insertion is on the intertubercular groove of the humerus with the primary blood supply originating from the thoracodorsal artery in the axilla. Several previous studies have discussed the use of the pedicled latissimus dorsi flap in coverage around the elbow.^{2-5,7,15} The exact size of the defects is not clearly identified in the majority of the papers. However, Choudry et al and Stevanovic et al reported an average wound size of 100 and 147 cm², respectively. While the pedicled latissimus dorsi flap was

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determined to provide reliable and good coverage for wounds around the elbow, the total complication rate was determined to be greater than 50% by Choudry et al and with Stevanovic et al requiring an unexpected return to the operating room nearly 20% of the time.^{3,15}

While previous work established the pedicled latissimus flap as a good option for soft tissue injuries around the elbow for sizes less than 150 cm², we hypothesize that the pedicled latissimus dorsi muscle flap can provide durable and reliable soft tissue coverage with a low complication rate for complex soft tissue wounds around the elbow that are significantly larger than previously reported.

Materials and Methods

A retrospective review was performed of all patients from 1998 to 2012 at Harborview Medical Center who underwent soft tissue coverage with pedicled latissimus dorsi flap. Only patients with soft tissue defects around the elbow that required coverage were included. Institutional review board approval was obtained. Age, sex, mechanism of injury, degree of injury, date injury occurred, date of definitive coverage, size of soft tissue defect, primary surgeons, postoperative complications, follow-up examinations, and need for additional surgeries were collected. Success of pedicled latissimus dorsi flap for coverage was the primary outcome measure as determined by surgical team. Postoperative complications were distinguished as either minor (could be treated conservatively) or major (required revision surgery). Soft tissue defect size was obtained from the operative report dictated at the time of definitive coverage.

Surgical Technique

Patients are placed in lateral decubitus position with operative upper extremity, ipsilateral chest wall, and ipsilateral thigh prepped and draped into the operative field (Figure 1). The area to be reconstructed is prepared through meticulous debridement and wound dimensions are obtained. The incision extends from palpable posterior axillary fold to the midpoint of the iliac crest. The latissimus dorsi is identified, isolated, and raised in its entirety from the chest wall to the axilla. The entire muscle is raised and trimmed to the appropriate size as needed. At the level of the axilla, careful dissection of the subscapular artery system is performed to ligate the serratus anterior and circumflex scapular branches to increase pedicle length. It is typically not necessary to release latissimus dorsi from its insertion, but will be released when it is otherwise preventing muscle from laying flat or to cover the pedicle. The muscle is carefully tunneled through the axilla. Immediately distal to the axilla, however, the upper arm skin is incised to prevent compression of the pedicle. This results from our experience identifying the skin in that area as having less laxity. Once the

Figure 1. Intraoperative pictures of a patient who sustained a significant degloving injury around the elbow with the majority of the proximal 1/3 of ulna exposed. (a) Posterior view revealing exposed olecranon and several centimeters of proximal ulna and (b) medial elbow with minimal granulation tissue over the medial epicondyle and ulnar nerve.

flap is passed through the tunnel and inset over the wound, it is confirmed under direct visualization and handheld Doppler that there is no twisting or compression of the pedicle. Finally, examination of bleeding from the muscle edges, flap appearance, and handheld Doppler are helpful to verify that the muscle remains well perfused with no venous congestion. Hemostasis of donor site is performed and confirmed. The donor wound is closed over 2 drains: one in the anterior aspect of the wound and the second in the posterior aspect of the wound. Split thickness skin graft (STSG) is harvested from ipsilateral thigh and is used to cover muscle (Figure 2).

Results

After institutional review board approval, a total of 18 patients were identified who met inclusion criteria; 16 of 18 patients were male (Table 1). Average age was 33 years (16–54 years). The mechanisms included 12 high-speed motor vehicle collisions, 2 high velocity gunshots, 1 severe crush by train, 1 dog mauling, and 2 conveyor belt injuries. Four of 18 patients had soft tissue defects involving the antecubital fossa, 3 of 18 soft tissue defects were nearly circumferential, and 5 of 18 were distal to the elbow involving the

Figure 2. Intraoperative images after pedicled latissimus transfer with split thickness skin graft for coverage of exposed proximal third of ulna.

midforearm. Twelve of 18 patients sustained bony injuries requiring operative fixation with 11 of 18 resulting in exposed hardware.

At the time of definitive coverage, average defect size around the elbow from 18 patients was 422 cm². The overall complication rate was 27% (5 of 18): 3 patients had partial necrosis of the distal most aspect of the flap, 1 patient had significant flap congestion, and 1 patient had failure of the distal STSG secondary to a hematoma. Of the 3 patients with distal tip necrosis, 2 were successfully treated with dressing changes and the final patient had complete necrosis of the distal third of the pedicled latissimus dorsi muscle and required a fasciocutaneous flap for coverage. The patient with significant flap venous congestion was converted to a free latissimus flap, and this resulted in successful coverage. In total, 4 patients (22%) required an unplanned return to the operating room secondary to flap complications. Two were lost to follow-up after discharge from the hospital. In all, 88% (14 of 16) of the patients had documented (>3-month follow-up) successful soft tissue coverage with single-stage pedicled latissimus dorsi flap (Figure 3).

Discussion

Early work from Bostwick et al showed that through the posterior arc of motion, the pedicled latissimus is capable of providing coverage to the arm.¹ The distal extent that the pedicled latissimus can reach has been an area of debate. Early work by Jutte et al showed that anterior and posterior transposition of the pedicled latissimus dorsi allow for an average reach of 8.4 and 6.5 cm distal to the olecranon, respectively.⁵ However, when used for soft tissue coverage of the elbow, previous work has shown a high complication rate of 57% with the most common complication being distal tip necrosis.³ To prevent complications, excessive compression and tension of the pedicle must be prevented. Pedicle length can be increased with careful dissection and

ligation of the branches to the serratus anterior and circumflex scapular. To further decrease tension, authors debate whether it is necessary to release the latissimus from its insertion. It is commonly believed that reach is limited mainly by pedicle length and not insertion onto the intertubercular groove of proximal humerus.^{2,12} However, Stevanovic et al divided the insertion and inset the flap such that the deep portion of latissimus became the superficial portion to avoid twisting the pedicle.¹⁵ Choudry et al also regularly detached the muscle from its insertion to improve rotation.³ In our experience, release of the muscle from its insertion is performed when needed to cover the proximal pedicle or to lay the muscle flat when being inset. Along with tension, compression of the pedicle is a concern. Tunneling of the pedicled flap avoids some scar morbidity but can cause excessive compression. Because of this, Stevanovic et al and Harvey et al both discourage tunneling.^{4,15} In our experience, incisions in the axilla cause significant contracture and morbidity and we avoid this by taking advantage of the pliable skin in the axilla to accommodate the tunnel. Immediately distal to the axilla, the skin of the upper arm is not pliable and we recommend incising it.

Our overall complication rate was 28% and significantly less than that reported by Choudry et al.³ Similar to previous reports, distal necrosis was the most common complication seen in our patients with a rate of 17%. This is very similar to the 19% reported by Stevanovic et al.¹⁵ To prevent this complication, Pierce and Tomaino stress the importance of assessing the viability of the distal most portion of the muscle once the flap is raised. The distal most muscle is commonly a watershed between the thoracolumbar perforators and thoracodorsal pedicle and can have tenuous perfusion once the flap is raised.¹⁰ Despite Jutte et al originally stating that the pedicled latissimus dorsi muscle flap can reach several centimeters distal to the elbow, some authors disagree and believe that the pedicled flap should not be used for coverage any more than 3 cm distal to the olecranon to avoid distal tip necrosis.^{3,4} Stevanovic et al, however, believe that 8 cm distal to the olecranon should be considered the maximum distal extent.¹⁵ Interestingly, they also advocated leaving the thoracodorsal nerve intact even when the flap is used only for coverage. This was to prevent atrophy of the muscle and help preserve length of the muscle.

Several authors have reported their case series of pedicled latissimus dorsi muscle flaps for coverage of elbow defects with average sizes ranging between 100 and 182 cm².^{2-5,7,15} The largest single defect mentioned was by Choudry et al at 844 cm².³ This was considerably larger than their average size of 147 cm², and with their high reported complication rate, it is unclear whether this specific flap ultimately provided successful soft tissue coverage. Our retrospective review is unique in that our average defect size at 422 cm² was significantly larger than previous reports. In all, 88% of the pedicled latissimus dorsi

Table 1. Mechanism of Injury, Soft Tissue Wound Characteristics and Classification, and Postoperative Complications for All 18 Patients.

Patient	Age	Mechanism	Soft tissue wound	Defect size, cm ²	Injury specifics	Exposed hardware	Return to OR for flap	Final follow-up	Flap complications
1	16	MVC	Nearly circumferential, includes antecubital fossa	800	IIIB lateral condyle humerus fracture, left antecubital fossa avulsion wound with exposed radial nerve. Posterolateral skin bridge of 1.5 cm. Wound extended from distal third upper arm to antecubital fossa.	Yes	No	4 months	None
2	54	MVC	Degloving of elbow	200	Traumatic left medial elbow arthrotomy. Stable elbow. Ipsilateral distal radius fracture. Wound involved medial aspect of elbow.	No	No	5 months	None
3	49	Conveyor belt	Distal humeral amputation	825	Avulsion injury extending up to shoulder. Traumatic right arm amputation above the elbow. Revision transhumeral amputation. Wound extending proximally to near the latissimus dorsi insertion.	No	No	17 months	None
4	44	Conveyor belt	Degloving, includes antecubital fossa	525	Degloving injury of right upper extremity with no operative bony injury. Treated initially with I&D and STSG (over antecubital fossa, too) but failed. Wound was nearly circumferential around the elbow.	No	No	8 months	None
5	16	MVC—ejected	Avulsion injury around elbow, brachial artery injury	175	Severe avulsion injury of right upper extremity with no fractures. Brachial artery transection repaired with reverse saphenous vein graft. Wound was nearly circumferential around the elbow.	No	No ^a	2 weeks	None ^a
6	39	Dog mauling	Necrotizing fasciitis and vascular injury, includes antecubital fossa	500	I&D and reverse cephalic vein graft brachial to radial for vascular injury. Developed compartment syndrome and necrotizing fasciitis after dog mauling of both upper extremities. Required serial debridements. Extensive necrosis of forearm musculature. Wound involved volar forearm and antecubital fossa.	No	No ^a	2 weeks	None ^a
7	23	Crush by train	Nearly circumferential	550	Wound was nearly circumferential degloving injury of right upper extremity with nonviable triceps.	No	No	9 months	None
8	30	MVC—ejected	Posterolateral wound midbrachium to proximal forearm	325	Open distal humeral shaft fracture with avulsion of biceps, brachialis, and radial nerve. Extrusion of bone with significant periosteal stripping of humerus. Posterolateral traumatic wound that extended from the midportion of the arm to the proximal forearm with a severe amount of myonecrosis.	Yes	No	8 months	None
9	41	MVC	Midbrachium to distal forearm with exposed proximal third ulna	450	Open proximal ulna and radial head fracture. Traumatic wound from midarm to distal forearm with exposed proximal third ulna.	Yes	Yes	7 months	Necrosis of distal tip
10	23	GSW	Medial and lateral elbow wounds	425	Significantly comminuted and open distal humerus and olecranon fractures. Small entrance wound medially with large 4 × 5-cm exit wound laterally at the elbow.	Yes	No	9 months	None

(continued)

Table 1. (continued)

Patient	Age	Mechanism	Soft tissue wound	Defect size, cm ²	Injury specifics	Exposed hardware	Return to OR for flap	Final follow-up	Flap complications
11	42	GSW	Proximal forearm and posterior elbow	250	Severe proximal ulna and radius fractures treated with multiple surgeries. Developed osteomyelitis and treated with antibiotic cement spacer and with IV antibiotics. Wound involved posterior proximal forearm and elbow.	Yes	No	154 months	None
12	33	MVC	Proximal forearm and posterior elbow	450	Open elbow fracture dislocation. Proximal ulna fracture with complete proximal 1/3 bone loss. Ulnar nerve avulsion with wound involving dorsal soft tissue loss with nearly circumferential avulsion around the elbow.	Yes	Yes	2 weeks	Secondary fasciocutaneous flap
13	30	MVC	Proximal forearm and posterior elbow	300	Severely comminuted distal humerus fracture with diaphyseal and articular bone loss treated with external fixator. Proximal ulna fracture treated with ORIF. Wound involved proximal posterior forearm and posterior elbow.	Yes	Yes	80 months	Conversion to free latissimus dorsi for venous congestion
14	20	MVC	Nearly circumferential	850	Open fracture of distal humerus. Near complete amputation of arm with only 4-cm dorsal skin bridge and intact neurovascular structures.	Yes	No	6 months	None
15	33	MVC—partially ejected	Posterolateral elbow wound	475	Initially sustained open comminuted left supracondylar humerus and olecranon fracture that went on to union but developed chronic osteomyelitis with significant heterotopic ossification. After hardware removal and debridement developed large lateral elbow wound.	No	No	7 weeks	None
16	27	MVC	Posterior elbow	350	Infected distal humerus nonunion treated with multiple surgeries at outside hospital. Referred for large nonhealing left elbow wound.	Yes	Yes	3 months	Hematoma and necrosis of STSG, required repeat STSG
17	27	MVC	Posterior elbow	150	Open supracondylar humerus fracture with failed ORIF and chronic infection. Treated with removal of hardware, debridement, and placement of antibiotic cement spacer with external fixator with very tenuous closure. Definitive treatment with revision operative fixation and soft tissue coverage of wound. Wound was posterior and extended from midarm to proximal forearm.	Yes	No	7 months	None
18	48	MVC	Medial elbow and brachium	425	Closed humeral shaft with open medial epicondyle fracture, traumatic elbow arthrotomy, and significant degloving. Wound was primarily over medial elbow.	Yes	No	48 months	Necrosis of distal tip of flap treated with dressing changes

Note. OR = operating room; MVC = motor vehicle collision, GSW = gunshot wound, I&D = irrigation and debridement; STSG = split thickness skin graft; ORIF = open reduction internal fixation; IV = intravenous.

*Patient was lost to follow-up after discharge from hospital (after 6 weeks).

Figure 3. Successful and stable coverage after a single-stage pedicled latissimus dorsi flap for a large degloving injury of the proximal third of ulna. (a) Anterior view and (b) posterior view.

flaps in our study ultimately provided successful and stable soft tissue coverage for defects around the elbow. The 2 pedicled flaps that were not ultimately successful were for defect sizes of 300 and 450 cm², respectively. It is important to note that both were used for soft tissue injuries of the proximal forearm and the graft size recorded included that area. In these 2 cases, successful soft tissue coverage was ultimately obtained after the first flap (defect size 300 cm²) was converted to a free flap secondary to venous congestion, and in the second case (defect size 450 cm²), a fasciocutaneous flap provided coverage over the distal 1/3 of the wound secondary to necrosis of this portion of the pedicled flap.

The donor site morbidity of the latissimus dorsi flap has been well studied. The first evaluation of the donor site revealed an acceptable cosmetic and functional morbidity with 23 of the 24 patients pleased with the overall outcome of their surgery.¹³ Russel et al determined that mild to moderate shoulder weakness does occur but can be sufficiently mitigated with therapy to improve range of motion and recruitment of synergistic muscle units. More recently, Lee and Mun performed a systematic review of all literature on functional impairment after latissimus dorsi muscle transfer.⁶ They concluded that “functional impairment of the shoulder *could* develop after latissimus dorsi muscle flap transfer” and that it is necessary that surgeons inform their patients of this appropriately before surgery. Even though Lee and Mun concluded that harvesting the pedicled latissimus dorsi flap *could*, they did not demonstrate that it *did* cause functional impairment of the shoulder. None of our patients reported any subjective, definable range of motion or gross strength deficits beyond the injury that prompted the latissimus dorsi transfer. It is important to note that only standard shoulder motion and

strength testing was performed in the clinic and did not include formal patient-reported or clinical outcome measures.

There exist several shortcomings in the current study. Most significantly is the retrospective nature of the review. Measurements of the soft tissue defects were not standardized and are a source of variability between the different providers. The area specifically covered by the flap itself was not separately recorded from the wound in total. A prospective study where the measurements of the soft tissue defect were standardized would be much more reliable. Furthermore, the degree of follow-up with the patients was variable. While nearly all patients had follow-up later than 6 weeks after the definitive surgery, 2 patients were lost to follow-up after their discharge from the hospital. These 2 patients reflect the itinerate nature of some of our patients in this multistate trauma center. Finally, successful coverage in our study was objectively defined as a stable and well-healed soft tissue envelope as evaluated by the surgical team. A more thorough measurement would include an analysis of limb function and would have successful coverage confirmed by health care professionals other than just from the surgical team.

In summary, the pedicled latissimus dorsi flap is an excellent option for reconstruction of larger than previously reported soft tissue defects around the elbow. However, care must be taken when used for coverage distal to the olecranon due to the risk of distal tip necrosis. For these types of wounds or other large and distal wounds, a free latissimus dorsi flap or fasciocutaneous flap should be strongly considered.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Because of the retrospective nature of the study, informed consent obtained from the patients was not required by the institutional review board. However, all protected health information was kept appropriately confidential.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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