Technical Note

Bipolar Pedicled Latissimus Dorsi Flap for Soft-Tissue Coverage and Restoration of Elbow Function

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Abstract: Bipolar latissimus dorsi transfer has been considered a viable option for the restoration of elbow flexion in patients with large traumatic defects of the anterior arm compartment. Advantages of bipolar transfer of the latissimus include stabilization of the anterior shoulder joint in addition to recreating the biceps for a direct line of pull in restoring elbow flexion with minimal donor site morbidity. Previous literature in bipolar latissimus transfer has demonstrated good outcomes in elbow flexion against gravity, range of motion, and patient satisfaction. We present a step-by-step demonstration of a bipolar pedicled latissimus dorsi transfer for restoration of elbow function and soft-tissue coverage for large traumatic defects to the anterior compartment of the arm.

Elbow flexion plays an important role in upper extremity function and activities of daily living, including feeding, dressing, and perineal hygiene. Loss of elbow flexion historically has been seen in poliomyelitis, injuries of the brachial plexus, congenital syndromes involving absence of elbow flexors, and large traumatic defects to the anterior compartment of the arm.[1] A number of surgical options exist for the restoration of elbow flexion, including the Steindler flexorplasty, nerve transfer, elbow fusion, free muscle transfer, and transfer of the pectoralis major, sternocleidomastoid, triceps, and latissimus dorsi.[1,2] Bipolar latissimus transfer has been favored by surgeons in cases of lost elbow flexion with soft-tissue defects because of the ability of restoring both without the need of staging procedures.[1]

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Received December 7, 2023; accepted March 9, 2024.

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2212-6287/231771
https://doi.org/10.1016/j.eats.2024.103016

Restoration of elbow flexion using the latissimus dorsi was first described in 1955 and has gained popularity as the result of its long pedicle, minimal donor site morbidity, and adequacy in obtaining coverage for large traumatic soft-tissue defects.[2,3] Although postoperative outcomes between unipolar and bipolar latissimus transfer are similar, the advantages of bipolar transfers include stabilization of the anterior shoulder joint in addition to recreating the biceps for a direct line of pull.[2,4] Previous literature in bipolar latissimus transfer has been limited to small sample sizes of case studies, and most have demonstrated good outcomes in antigravity elbow flexion, range of motion, and patient satisfaction.[1,2,4-6] Our described technique involves a step-by-step demonstration of a bipolar pedicled latissimus dorsi transfer for restoration of elbow function and soft-tissue coverage for large traumatic defects to the anterior compartment of the arm (Video 1).

Surgical Technique

Indications

Indications for bipolar pedicled latissimus transfer include but are not limited to poliomyelitis, brachial plexus injuries, congenital syndromes with absence of elbow flexors, and large soft-tissue defects to the anterior compartment of the arm in the setting of trauma.[1]

Materials

Materials required are electrocautery, 3 Mitek Micro Anchors (DePuy Synthes, Raynham, MA), and #2 FiberWire suture (Arthrex, Naples, FL).

Patient Positioning

The patient is placed in the lateral decubitus position on the operating room table with the operative extremity facing the ceiling and resting on a padded Mayo stand. The operative extremity and ipsilateral latissimus harvest site are prepped and draped in a sterile fashion. After latissimus harvest, the patient is transitioned from the lateral decubitus to a supine position.

Donor Site Exposure and Pedicle Preparation

The latissimus flap is raised with a large skin paddle on the lateral aspect of the flap. An incision around the skin paddle is made, and skin flaps are elevated from the latissimus muscle (Fig 1). The muscle flap is then elevated from the origin in all directions while a plane is developed between the serratus anterior. Vascular clips are applied to perforating vessels for hemostasis. Once elevated, the muscle flap is inspected to ensure appropriate perfusion. The latissimus pedicle is identified at the axilla, and clipping of the serratus branch and more proximal branches is carefully performed to skeletonize the pedicle for transfer. Care is taken to ensure the thoracodorsal nerve is protected. The wound is then closed in a layered fashion with absorbable sutures, and 2 Jackson-Pratt drains are inserted to prevent postoperative hematoma formation.

Recipient Site Exposure and Preparation

An incision is marked and made at the deltopectoral groove. Soft-tissue dissection is performed to identify the tendon of the pectoralis major. The tendon is isolated with a Penrose drain. Dissection is carried through the clavipectoral fascia, exposing the bicipital groove of the humerus along with the tendons of the coracobrachialis, biceps, and the coracoid process. Throughout this dissection, vascular clips are applied to branches of the anterior humeral circumflex artery and its venae comitantes at the inferior border of the subscapularis, also known as "the three sisters." Hemostasis is achieved using electrocautery.

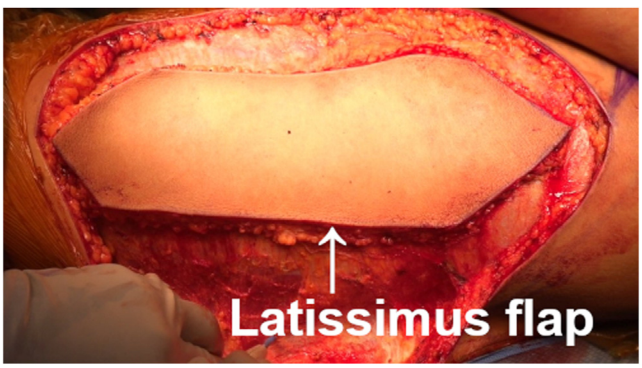

Fig 1. Intraoperative image of the left posterolateral thorax with the patient in the lateral decubitus position and the surgeon on the posterior side. A latissimus flap superficial to the thoracodorsal fascia is developed and the deep latissimus surface is separated from the underlying serratus anterior.

After the flap is raised, transfer and inset is performed for recreation of the biceps brachii function and neurovascular coverage of the soft-tissue defect of the anterior arm compartment. The initial flap is transferred by subcutaneous tunneling superficial to the brachial plexus, the pectoralis major tendon, and the vascular structures with care to avoid pressure, torsion, and tension on the pedicle (Fig 2). Inset may begin once the entirety of the muscle has been tunneled.

Proximal Fixation

Based on the position and excursion of the flap and its pedicle after tunneling, the tendon of the latissimus muscle is secured in the floor of the bicipital groove using osseous unicortical drilled tunnels, through which 3 Mitek Micro Anchors are inserted to inset the proximal tendinous portion of the latissimus muscle. The tendon is then secured with a Krackow suture (Fig 3). After this step, the patient is changed from the lateral decubitus to supine position with removal of the standard lateral decubitus padding from under the drapes.

The wound bed is prepared at this time for flap inset by debriding the proximal and distal edges of the segmental defects of the biceps brachii and brachialis muscles to a healthy muscle fiber border. Surgeons should note the medial brachial cutaneous nerve may be severed in traumatic wounds and, as such, the proximal remnant should be inspected for any additional signs of contusion or neuropraxia and the distal end may be buried in the biceps brachii muscle utilizing absorbable sutures. In doing so, this decreases the chances of a painful postoperative neuroma forming. The wound is then copiously irrigated before flap inset.

Distal Fixation

The flap is provisionally placed within the wound to ensure congruence with full coverage of any exposed neurovascular structures (Fig 4). The distal portion of the latissimus muscle should have 3 to 4 cm extra muscle length to allow for later fixation to the tendinous portion of the biceps brachii distally.

The muscle is tensioned such that the length is appropriate for elbow flexion of 90°. Any excess muscle is trimmed using electrocautery as appropriate. The latissimus muscle is inset into the defect and tacked together with the native proximal bicep and distal brachialis muscle using absorbable sutures. The distal edge of the latissimus muscle flap is secured to the distal

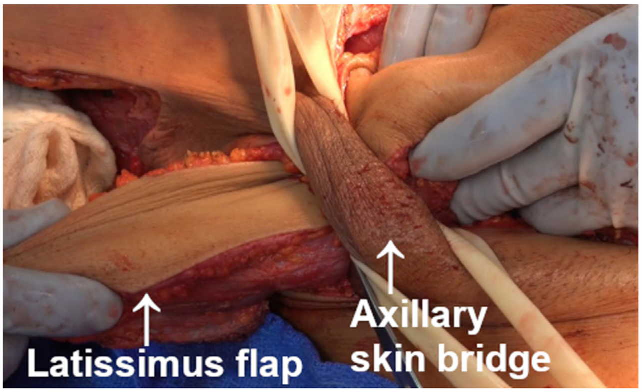

Fig 2. Intraoperative image of the left axilla with the patient in the lateral decubitus position and the surgeon on the anterior side. After release at the humeral insertion, the latissimus flap is passed through the axillary skin bridge into the deltopectoral interval.

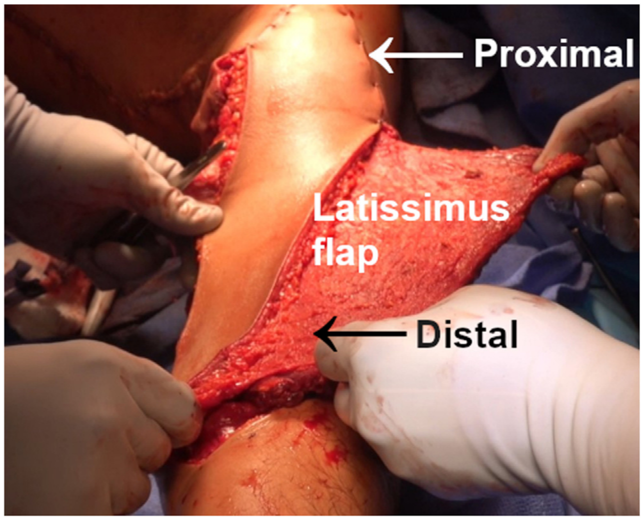

Fig 4. Intraoperative image of the left arm with the patient in the supine position. The latissimus flap is temporarily placed in the anterior arm defect to ensure a sizable fit with full coverage before distal fixation.

biceps tendon using #2 FiberWire sutures in a Krackow fashion through the muscle (Fig 5). Throughout the inset, the vascular pedicle is checked for any undue tension or twisting that may increase risk of thrombosis, and the flap is checked for signs of adequate perfusion, such as bleeding. In cases of traumatic brachial artery damage, the brachial artery bypass should be checked and seen to be without undue tension, torsion, or kinking. A healthy radial pulse should be palpable at the wrist throughout inset and closure.

Closure

A 19-Fr Jackson-Pratt drain is placed into the dependent area of the arm posteriorly and secured with suture. The skin edges of the flap are secured to the skin edges of the defect with absorbable sutures; while trimming any remaining devitalized tissue from the original injury. The deltopectoral incision is closed in a similar fashion. In cases of flexor carpi radialis muscle belly damage from initial trauma, the wrist is flexed and the flexor carpi radialis muscle belly defect is closed with absorbable suture in a figure of 8 fashion. The skin is then closed with a suture of the surgeon's choice, although staples may be used if preferred to avoid prolonged operative time. The incisions are dressed with petrolatum gauze, 4 × 4 gauze, and abdominal pads.

Postoperative Rehabilitation

A large bulky posterior slab splint is applied with maintained elbow flexion at 90° and wrist flexion to avoid undue tension during initial postoperative

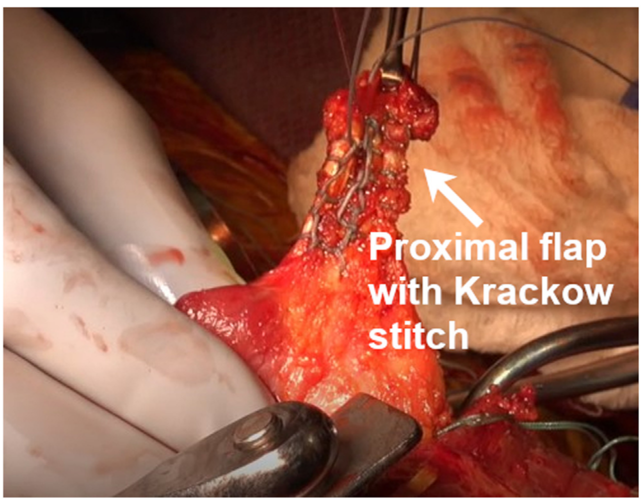

Fig 3. Intraoperative image of the left shoulder with the patient in the lateral decubitus position and the surgeon on the anterior side. Before tenodesis at the bicipital groove, the proximal latissimus tendon is sutured in a Krackow fashion.

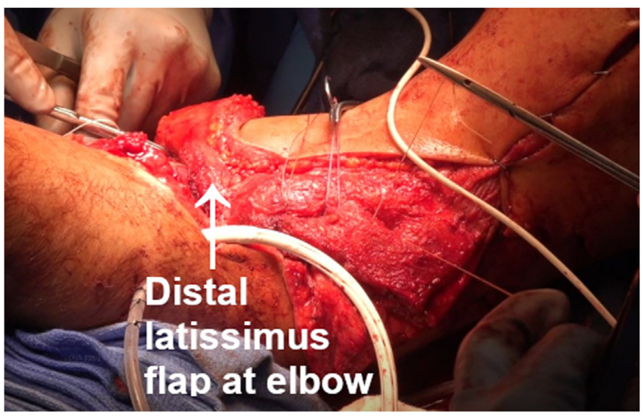

Fig 5. Intraoperative image of the left arm with the patient in the supine position. The distal portion of the latissimus flap is secured to the distal remnant of the biceps tendon in a Krackow fashion.

Table 1. Pearls and Pitfalls

Step	Pearls	Pitfalls
Patient selection	Patients must have at least 4 of 5 latissimus dorsi strength because postoperative strength is expected to drop 1 level of function.	Performing this transfer without adequate baseline strength will lead to clinical failure.
Patient positioning	Ensure preoperative positioning will allow access to adequately transition the patient from lateral decubitus to supine after flap harvest.	Inadequate positioning measures will make for a tenuous transition and difficulty in performing the flap transfer.
Flap harvest	Carefully measure length and width of biceps defect to ensure adequate flap harvest.	A flap too small will not provide enough soft-tissue coverage and length needed to restore biceps function.
Flap transfer	Measure the flap and ensure that an adequate axillary canal has been dissected before transfer of the latissimus anteriorly.	Failure to provide adequate space or attempt to transfer too large of a graft may lead to venous kinking, stasis, and compartment syndrome.
Postoperative dressing	Ensure a window is cut in the postoperative splint to monitor the vascular status of the flap.	Inadequate capillary refill monitoring may lead to preventable flap loss.
Immobilization	Keep the shoulder at approximately 30° abduction to prevent kinking of the pedicle.	Prolonged kinking of the pedicle may lead to ischemic changes and failure of muscle transfer.

Table 2. Advantages and Disadvantages

Advantages	• Ability to obtain soft-tissue coverage and restore biceps function in single setting without staging procedures • Bipolar transfer aids in maintaining anterior shoulder stability • Good reported success rates and restoration of clinical function compared with alternative procedures for this indication
Disadvantages	• Technically demanding procedure • Isolated preoperative latissimus weakness correlates with worse postoperative outcomes • Patient must be monitored closely postoperatively to ensure the sensitive arterial pedicle is preserved and capillary refill maintained

recovery. A window is created in the splint for flap monitoring clinically with capillary refill. The shoulder is kept at 30° abduction using pillows to prevent kinking of the pedicle, which may contribute to flap failure. The patient is generally immobilized until 6 weeks postoperatively and may begin passive range of motion exercises with isometric contractions at this time. At 8 weeks, the patient may begin resisted elbow flexion exercises and progress in strengthening.[2,5]

Discussion

There has been a reported 75% rate of resisted elbow flexion strength, and previous literature demonstrates grade 3 or 4 elbow flexion strength at 3 months postoperatively in most patients.[2,6] Patients undergoing bipolar latissimus transfer as the result of trauma generally have better outcomes in strength than brachial plexus palsies.[2] Of note, Martin et al.[7] demonstrated grade 5 elbow flexion strength in most patients who underwent unipolar latissimus transfer in congenital and acquired flexion deficits. There has been reported shoulder girdle weakness in extension with isolated latissimus testing, but the previous literature demonstrates good overall shoulder strength scores, likely as the result of compensation from the teres major, pectoralis major, and subscapularis muscles.[1] It is important to note that preoperative latissimus weakness is an indication for poor outcomes in elbow flexion strength postoperatively, and the surgeon should assess isolated latissimus strength before surgery (Table 1). Preferably, at least grade 4 strength is desired, as patients can be expected to lose one motor grade of strength with muscle or tendon transfers.[1,2]

Early postoperative complications include hematoma and seroma formation with infection at the latissimus donor site. Keeping drains in until there is less than 5 mL per 24 hours can aid in preventing this complication. There have been 2 cases of compartment syndrome previously reported, likely the result of a narrow axillary canal, too large of a latissimus muscle transfer, and vein kinking.[2] The surgeon should carefully evaluate the size of latissimus muscle needed before harvest and ensure to prepare an adequately sized axillary canal. We believe that keeping the shoulder in 30° abduction postoperatively can help mitigate the risk for pedicle and vein kinking. The anterior compartment and flap monitoring should be routinely checked after creating a window in the postoperative splint, as demonstrated in our technique. Some surgeons may prefer sterile implantable Dopplers to monitor flap perfusion. The main advantage to this technique is the ability to obtain soft-tissue coverage and restore elbow function in a single setting without the need to stage procedures. Disadvantages include a narrow window of patient selection and close postoperative follow-up in addition to this rare technique being technically demanding (Table 2). Further studies with larger sample sizes and long-term follow-up should be performed to determine the superiority of bipolar latissimus transfer compared with other techniques.

Disclosures

All authors (V.H., T.A., J.G., J.M., D.A., M.C., Z.J.P., K.K.T., and K.Y.X.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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