The Pedicled Reverse-Flow Lateral Arm Flap for Coverage of Complex Traumatic Elbow Injuries

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Purpose: The pedicled reverse-flow lateral arm flap has been described primarily for the reconstruction of nontraumatic elbow wounds. We describe our experience using this flap in staged operations for soft tissue coverage after elbow trauma, including acute coverage of open fractures and salvage of infected hardware.

Methods: Review of patients who underwent staged pedicled reverse-flow lateral arm flap transfer for coverage of traumatic elbow defects.

Results: Three patients were identified; all underwent 2-stage repair with flap delay for coverage of traumatic elbow injuries. Each patient had stable wound coverage with this flap. The only complication was 5% distal flap necrosis in 1 patient.

Conclusions: The pedicled reverse-flow lateral arm flap provides reliable soft tissue coverage of traumatic elbow defects with minimal donor-site morbidity.

Key Words: traumatic elbow wound, lateral arm flap

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The management of complex wounds of the elbow is a common problem encountered by orthopedic and reconstructive surgeons. Wound etiologies include chronic bursitis, traumatic avulsion with or without fracture, complications associated with orthopedic reconstruction, acute burn as well as late burn scar contracture, pressure sore, and tumor. Reconstructive goals mandate stable soft tissue coverage of exposed structures and hardware, while allowing early mobilization for preservation of range of motion. Current options for reconstruction include skin grafts, local fasciocutaneous flaps or adipofascial turnover flaps, muscle flaps, distant pedicled flaps, and free flaps.[1,2] Skin grafts alone are inadequate in the setting of exposed nerves, tendons, bone, joint, or hardware. Skin grafts also mandate a longer period of immobilization and carry the risk of subsequent contracture with limited soft tissue padding. Remote pedicled flaps require many stages and prolonged immobilization. Muscle flaps may result in loss of critical hand or arm functions. Free tissue transfer, although an option in select individuals, requires advanced microsurgical skills and facilities, increased operative time, sacrifice of a remote donor site, and is prohibitive in some patients with underlying comorbidities. For these reasons, local or regional flap options are often more appealing.

One regional reconstructive option used for elbow wounds is the fasciocutaneous pedicled reverse-flow lateral arm flap.[1–7] The lateral arm flap was initially described by Song and colleagues[8] in 1982, and further characterized by Katsaros et al.[9] Further modifications of the lateral arm flap include neurosensory, adipofascial, and osteocutaneous variations.[5,9] Although its use has predominantly been in free tissue transfer for distant defects, transfer as a pedicled reverse-flow flap based on the radial recurrent artery (RRA) has been both anatomically and clinically proven. Historically, the pedicled reverse-flow lateral arm flap was contraindicated in the setting of traumatic open fractures around the elbow due to the zone of injury.

We have recently faced challenging traumatic elbow wounds with underlying fractures, infection, and exposed hardware after traumatic injuries. We report our series of 3 patients in whom successful reconstruction was performed using this flap despite extensive elbow trauma.

METHODS

After institutional review board approval, we reviewed patients treated with a 2-stage pedicled reverse-flow lateral arm flap for coverage of elbow defects between January and December 2010. Patient characteristics were compiled. We evaluated flap and donor-site outcomes and complications.

Operative Technique

We obtained a preoperative angiogram in all patients due to the traumatic nature of the wounds with zone of injury potentially disrupting the RRA, posterior radial collateral artery (PRCA), or both. We debrided the wounds of all nonviable tissue followed by a staged flap transfer. The first stage was creation of the pedicled reverse-flow lateral arm flap by flap delay to promote more robust blood supply. The fasciocutaneous flap was designed along an axis from the insertion of the deltoid to the lateral epicondyle, corresponding to the lateral intermuscular septum between the triceps and brachialis. Handheld Doppler ultrasonography confirmed the vessel course and its cutaneous perforators. Flap length and width were tailored based on wound dimensions. Flap dissection and elevation were carried out below the level of the deep muscular fascia. The flap was elevated from ulnar and radial margins toward the lateral intermuscular septum. The PRCA was identified in the septum and divided proximally. Care was taken not to injure the radial nerve, which runs anterior to the PRCA for a short distance before passing between brachioradialis and brachialis. Division of the posterior cutaneous nerve of the arm is usually necessary for distal transposition of the flap, and was performed in all our patients. The flap was then reinset in its native position and sutured at the skin level. The elbow wound was treated with negative pressure wound therapy during the period of flap delay. The second stage occurred at an interval of at least 15 days. Doppler ultrasonography confirmed recurrent arterial flow to the flap from the RRA. The flap was then re-elevated and dissection completed toward the distal humerus at the level of the periosteum. The flap was then transposed on the RRA pedicle and inset into the elbow wound. The donor site was closed primarily without tension. The elbow was splinted in extension for 7 days postoperatively, followed by early range of motion, unless prohibited by the orthopedic reconstruction.

RESULTS

Patient characteristics are displayed in Table 1. Preoperative angiograms confirmed patency of the PRCA to RRA anastomosis in

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TABLE 1. Summary of Patient Information

Age, y	Sex	Comorbidities	Mechanism of Injury	Fracture	Flap Size, cm	Hardware	Length of Delay, d	Donor-Site Closure	Complications	AROM Elbow, degrees	Follow-up, mo
25	Male	None	Gun shot	Olecranon, lateral humeral condyle	12 × 5	ORIF, exfix	19	Direct	None	0–100	12
43	Male	None	Motorcycle collision	Segmental proximal ulna	15 × 7.5	ORIF	21	Direct	None	40–110	14
80	Female	Stroke, Dementia	Syncopal fall	Intraarticular distal humerus	15 × 7	Arthroplasty	15	Direct	5% Distal superficial necrosis	20–100	14

AROM indicates active range of motion; exfix, external fixation; ORIF, open reduction internal fixation.

all patients (Fig. 1). Flaps were rotated and inset after 15 to 21 days of delay (Fig. 2). Primary closure of the donor site was obtained in all patients. The posterior cutaneous nerve of the arm was divided in all patients, leading to hypoesthesia in the upper posterior arm. One 80-year-old patient had a postoperative complication, with superficial necrosis of the distal 5% of the flap, which healed in 4 weeks with wound care. Patients received early postoperative mobilization with range of motion exercises beginning after 7 days of postoperative elbow extension splinting. At follow-up, all patients reported satisfaction with flap and donor-site appearance, as well as elbow range of motion and functional abilities (Fig. 3).

DISCUSSION

Although the pedicled reverse-flow lateral arm flap has been described as unreliable for traumatic elbow injuries, we found that with careful preoperative planning and a staged approach, this flap is a safe and reliable method of reconstruction for complex elbow injuries. We found this flap to provide stable soft tissue coverage in conjunction with a consistent axial pedicle, relative ease of dissection, and without the sacrifice of a major distal vessel, despite significant soft tissue and bony elbow trauma. The donor site can usually be closed primarily, which limits donor-site morbidity. This strategy also allows early mobilization of the elbow joint, as orthopedic constraints allow, and does not sacrifice any structures required for elbow function. Also, the flap can be harvested with the patient in supine position, and without the need for intraoperative repositioning after bony repair by the orthopedic team.

The usage of this flap in the coverage of soft tissue defects in the elbow region is well reported.[1–7] We report our clinical series to demonstrate its utility in the trauma fracture population, as well as for the salvage of exposed orthopedic hardware. In our series, the only complication was distal partial thickness necrosis in 1 elderly patient, which healed with wound care only. Other reported complications include venous congestion and wound dehiscence.[3,6] This flap does generally require the sacrifice of the posterior cutaneous nerve of the arm, although the posterior cutaneous nerve of the forearm can usually be preserved. Sensory changes in the forearm have been reported to be present in up to 59% of cases.[10] Despite sacrifice of the posterior

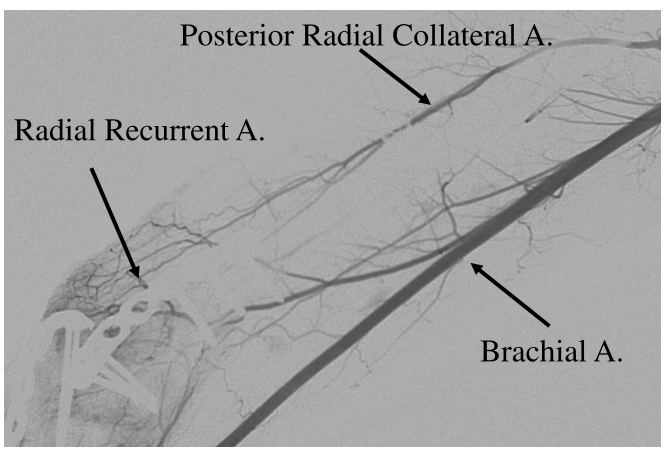

FIGURE 1. A representative preoperative angiogram in a 25-year-old man with open right olecranon and distal humeral fractures demonstrating patency of the RRA and PRCA.

FIGURE 2. The same patient from Figure 1. From top to bottom, Initial pedicled reverse-flow lateral arm flap design to cover a 12 × 5-cm soft tissue defect with open olecranon and distal humeral fractures and exposed hardware; flap after elevation, reinset, and delay; and flap after transfer into traumatic elbow defect.

FIGURE 3. The same patient from Figures 1 and 2 demonstrating elbow range of motion at 6 months postoperatively with stable wound coverage and acceptable donor-site appearance.

cutaneous nerve, none of our patients cited loss of sensation as a postoperative complaint. Nor did we experience problems with pressure necrosis of this insensate flap.

Previous reports have recommended maximal flap width of 6 cm to primarily close the donor site.[1,3,9] If closed with tension, hypertrophic and widened scars may result and negatively impact patient satisfaction with the donor site.[10] Split-thickness skin grafting may be required for flaps with widths greater than 6 cm. Nevertheless, we were able to accomplish primary tension-free closure in flaps up to 7.5 cm in width with an acceptable donor-site scar.

All of our patients received preoperative angiograms confirming the patency of the collateral circulation around the elbow. Tung and colleagues[11] have also recommended preoperative angiography, particularly in the trauma population. The scientific foundation and clinical utility of delay procedures have been well reported.[12] We chose to perform staged procedures with a delay because of concern in the literature about postoperative venous congestion, especially in the setting of trauma in the region of the pedicle, and to ensure adequate wound debridement. Although this prolongs the time to coverage and necessitates 2 procedures, we had no incidences of venous congestion or infection in our series. Instead of a staged procedure with delay, one could consider evaluating flap perfusion in the initial operation with an intravenous fluorescein injection and Wood lamp examination.[13] If the flap seems well perfused, flap transfer could be performed at the initial operation. Reports of single-stage operations, largely in the nontrauma population, are well reported.[2,11] Although the pedicled reverse-flow lateral arm flap is not without potential complications, its reliable anatomy and relative ease of harvest for coverage of soft tissue defects and hardware about the elbow make it a useful flap even for traumatic elbow wounds.

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