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Brachioradialis muscle flap for posterior elbow defects: a simple and effective solution for the upper limb surgeon

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Background: Trauma, infection, and posterior surgical approach are the most frequent causes of soft tissue defects of posterior elbow. The brachioradialis (BR) muscle flap is a rotational muscular pedicled flap, and the dominant vascular pedicle arises from the radial recurrent artery in the proximal portion of the muscle. The aim of the study was to present the BR muscle flap as a simple, safe, and effective solution for the treatment of soft tissue defects of the posterior elbow.

Methods: Five patients (3 males; mean age, 61.4 years; range, 40-73 years) with soft tissue defects of the posterior elbow underwent surgical treatment with the BR muscle flap. The causes of the defects were total elbow arthroplasty and postsurgical infection (n = 2), 1 patient with elbow arthrodesis due to neuropathic arthropathy, and postsurgical infection after open reduction and internal fixation of olecranon fractures (n = 2). All patients had a BR muscle flap and skin grafting. Orthopedic hardware was removed in 3 cases.

Results: At the mean follow-up of 45 months (range, 26-61 months), all patients had viable and functional soft tissue coverage. All patients were free of infection, whereas 1 patient had a posterior elbow discomfort in daily activities. None of the patients reported wrist problems.

Conclusions: The BR muscle flap is a reliable solution, easy to harvest without requiring microsurgical expertise for small-size posterior elbow defects. It is a 1-stage procedure with no morbidity to the harvest site that provides stable and adequate coverage even in cases with postoperative infection.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Brachioradialis; flap; elbow; defect; wound; complication; arthroplasty; fracture

The area of posterior elbow is prone to soft tissue posttraumatic or postsurgical defects due to the thin and elastic nature of the soft tissue envelope that covers this area as well as the superficial location and the prominence of the underlying osseous structures. The operative treatment of most complex types of elbow fractures and fracture dislocations is performed through the posterior (universal) approach and usually pertains to older patients who often suffer from several comorbidities that may compromise optimal wound healing (corticosteroid intake, diabetes mellitus, or peripheral vascular disease). The postoperative soft tissue defects of posterior elbow often lead to hardware

This work has been approved by the ethical committee of General Hospital KAT, Athens, Greece, and the subjects gave informed consent to participate in the study.

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exposure and usually relate with superficial or deep infection, thus increasing the difficulty of the coverage reconstructive procedure.

The reconstructive options to cover soft tissue defects of posterior elbow range from local or regional flaps to free tissue transfer. The flap options include cutaneous, muscle, and composite fasciocutaneous or septocutaneous (lateral arm and radial forearm) flaps.[17] Local flaps may have the disadvantage of an area adjacent to the defect that may also present with varying degree of inflammation, scarring, and loss of tissue elasticity. Furthermore, local cutaneous flaps may be inadequate and thin to cover the posterior elbow defect, the underlying bones, and hardware whenever exists.[4,6,9-11,16,24] Muscle flaps include the anconeus, the brachioradialis (BR), the exor carpi ulnaris, the extensor carpi radialis longus, the medial triceps brachii, and the latissimus dorsi.[1,2,8,18,22] Most of these options may be extremely useful; however, each has inherent advantages and disadvantages for its use. Among the parameters that should be considered to choose the best reconstructive option are the size and complexity of the defect, the vascular status of the available flap options, the safety and reproducibility of the procedure, and the donor site morbidity.

The BR muscle originates from the lateral supracondylar ridge of the humerus and inserts on the styloid process of the radius. The BR muscle acts as an elbow flexor when the arm is pronated, and as a pronator with the arm is supinated. The BR muscle flap is a rotational muscular pedicled flap with the pivot point of the flap at the dominant vascular pedicle. The dominant vascular pedicle in most cases is the radial recurrent artery (42%) arriving in the proximal portion of the muscle, followed by the radial (38%) and brachial (20%) arteries.[3,18,20]

The BR muscle flap is considered reliable, easy to harvest without requiring microsurgical expertise in terms of microvascular anastomosis, and provides stable coverage for small- to medium-size defects of the posterior elbow. The aim of this study was to present the BR muscle flap as a simple, safe, and effective solution for the treatment of soft tissue defects of the posterior elbow and to present midterm outcomes from our case series.

Materials and methods

Study design

Five consecutive patients (3 males and 2 females) with soft tissue defects of the posterior elbow underwent surgical treatment with a pedicled BR muscle flap in the period 2011-2015 in the authors' institution and were included in this single-center retrospective study. Patients' characteristics regarding defect size, etiology, and comorbidities are described in Table I. An independent observer examined patients and assessed the outcome of the coverage procedure: wound healing, range of motion of the elbow, donor site morbidity, or other postoperative complications.

The mean age was 61.4 years (range, 40-73 years), and the causes of the soft tissue defect were postoperative infection after total elbow arthroplasty (TEA) (2 patients, 1 acute <4 weeks and 1 chronic infection >4 weeks) (Fig. 1, *A*), postoperative infection after open reduction and internal fixation (ORIF) of olecranon fracture (2 patients both with chronic infection >4 weeks postoperatively), and scar complications for a patient with elbow arthrodesis due to neuropathic arthropathy (Fig. 2). Soft tissue defects had a median surface of 6.2 (range, 4-9) cm^2. Orthopedic hardware exposure occurred in all cases. The coverage reconstructive procedure was performed on average 11 (range, 5-18) days after the defect occurrence. All patients had a BR muscle flap and skin grafting.

For the 2 patients with acute infection suspected (1 TEA and 1 arthrodesis, duration of symptoms <4 weeks), we took the decision to retain the hardware intraoperatively and only if the implants were stable and condition of deep soft tissue was good.[25] Surgical débridement was performed on both cases and deep cultures were

Table I Patients' data and characteristics

Patient	Age (yr)	Gender	Etiology	Defect size (cm)	Comorbidities*
1	73	F	TEA, acute† infection	2 × 3	Rheumatoid arthritis, CORT, DM
2	40	F	Post-traumatic arthritis, TEA, chronic infection	2 × 2	
3	67	M	ORIF olecranon, chronic infection	2 × 3	
4	60	M	ORIF olecranon, chronic infection	3 × 3	CORT
5	67	M	Chronic elbow dislocation, neuropathic arthropathy arthrodesis	2 × 3	
Mean	61.4				
Range	40-73				

TEA, total elbow arthroplasty; *ORIF*, open reduction and internal fixation.

* Comorbidities: corticosteroid intake (CORT), diabetes mellitus (DM), peripheral vascular disease, or others that may compromise optimal wound healing.

† Acute <4 weeks postoperatively, chronic>4 weeks postoperatively.

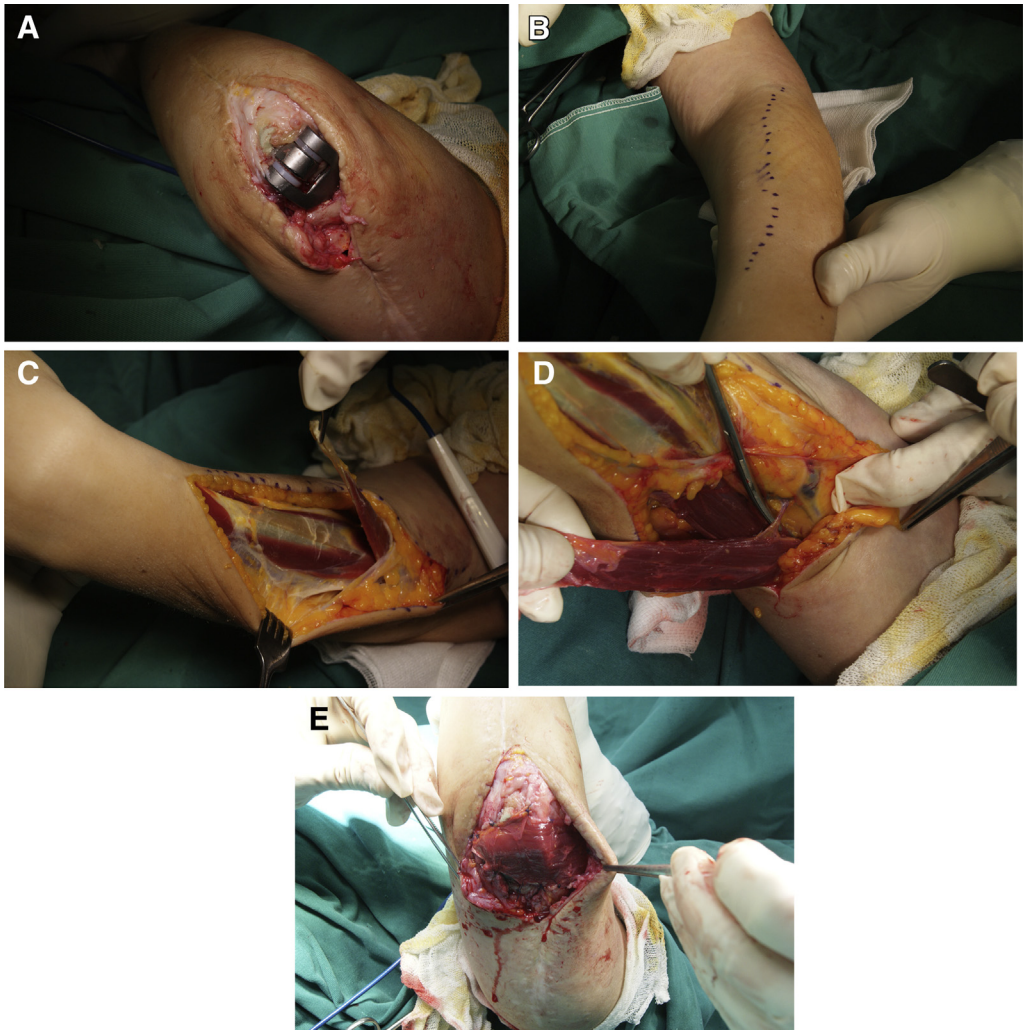

Figure 1 A 73-year-old female patient with posterior elbow defect after total elbow arthroplasty and acute infection. (**A**) The posterior elbow defect has led to exposure of elbow prosthesis (expansion of the defect has been performed in line with the prior posterior elbow approach incision). (**B**) A lazy S-shaped incision is designed over the proximal radial forearm. (**C**) We dissected the BR muscle flap from distal to proximal. We have detached the insertion of the BR distal tendon from the styloid process of the radius at its musculotendinous junction. (**D**) The dominant pedicle of the muscle arises from the radial recurrent artery (42%) and arrives in the proximal portion of the muscle and its medial border approximately 10 cm from the muscular origin and is approximately 3 cm long and of 2 mm diameter. We continued the dissection proximally up to the dominant pedicle of the flap. (**E**) After reflected proximally and rotated, the flap is sutured to the margins of the posterior elbow defect.

obtained at this operation (at least 3 specimens of deep tissue). For the 3 chronic cases (1 patient with TEA, and the 2 patients with olecranon fracture ORIF), deep cultures were obtained intraoperatively along with deep bony specimens for biopsy and cultures and hardware was removed. For all patients thorough identification and débridement of infectious tissue was performed followed by low-pressure irrigation with normal saline. Intravenous (IV) antibiotics were administered according to the culture's results.

We decided to cover the elbow defect with a 2-stage procedure with a short time interval (few days up to 3 weeks after the surgical débridement and IV antibiotics) when the wound seemed clean and infection free in order not to delay more the defect coverage and not to risk any chance of additional contaminations. We individualized the exact time point for each patient and recorded the following parameters for proceeding to the second stage: (1) the deep cultures and bony specimen results from the first operation (with concomitant hardware removal for the chronic cases) and the absence of difficult-to-treat microorganisms (deep cultures revealed *Staphylococcus aureus*-no Methicillin-resistant *Staphylococcus aureus*, and *Staphylococcus epidermidis*), (2) the decreased tendency of the C-reactive protein levels at serial postoperative measurements, (3) the erythrocyte sedimentation rate (ESR) and WBC levels and mostly their tendency in serial postoperative measurements that also supported the adequacy of treatment, (4) the satisfactory condition of soft tissues during the subsequent débridement procedures (that were performed every 2-3 days), (5) the negative results of subsequent deep cultures that were obtained during these surgical débridement procedures (although maybe false negative due to IV antibiotics administration, but in no case were positive), (6) the absence of osteomyelitis (negative cultures and biopsy results from bony

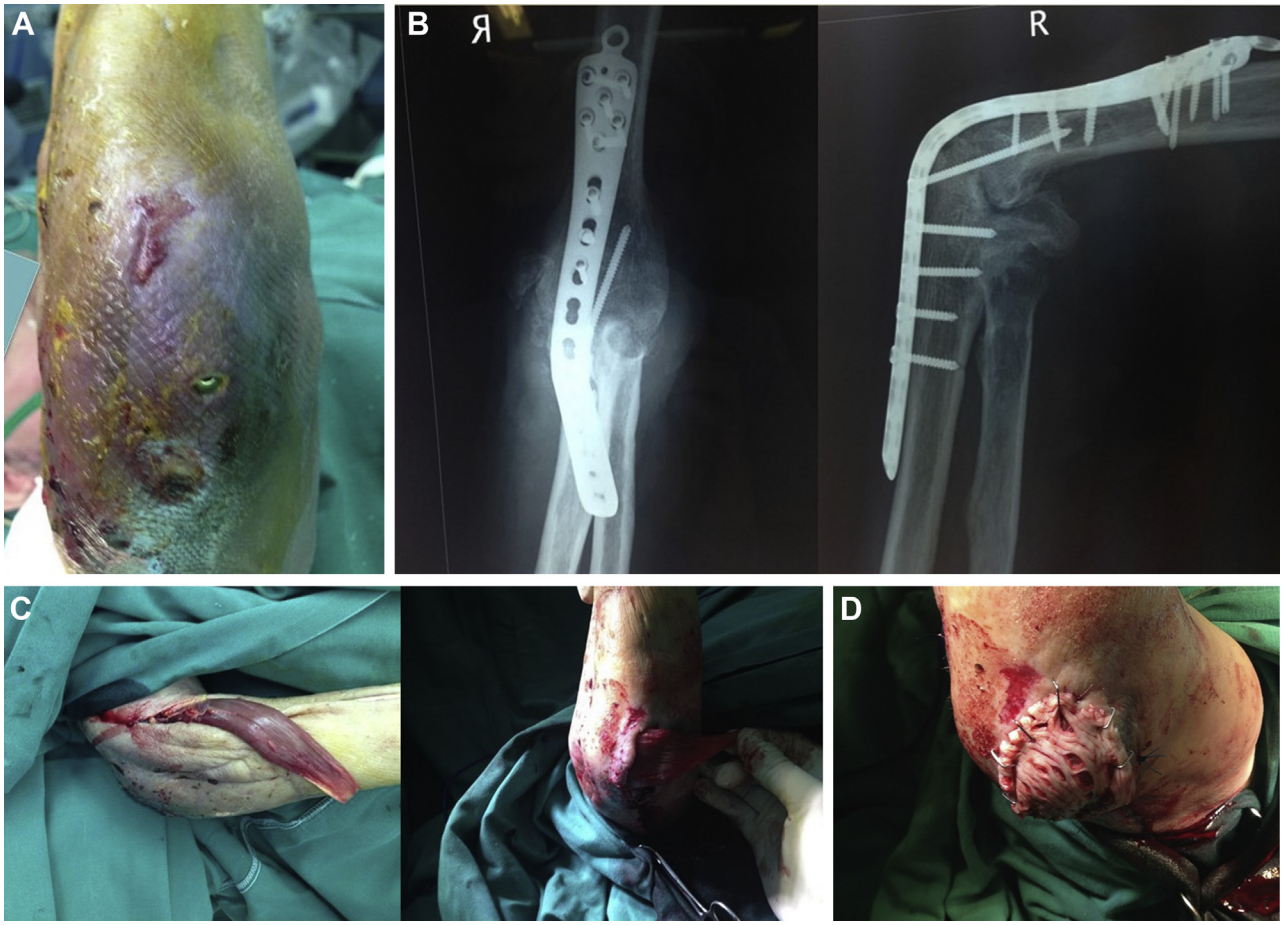

Figure 2 A 67-year-old male patient with posterior elbow defect after elbow arthrodesis that was performed for arthritis due to neuropathic arthropathy. (**A**) Posterior elbow defect as presented 6 weeks postoperatively. After débridement, the defect size was 2 × 3. (**B**) Anteroposterior and lateral radiographs of the patient showing elbow arthrodesis. (**C**) Rotating and tunneling the muscle toward the posterior elbow allows the flap to reach the posterior elbow region. (**D**) The flap was covered with a full thickness skin graft taken from the forearm.

specimens), and (7) the absence of any severe coexisting illness that could prevent any subsequent operation.

During the coverage of the defect with the flap, we performed a new surgical débridement and we obtained deep cultures again to detect any new species. Although all cultures were negative, we administered in all cases according to the first cultures a 3-week IV antibiotic regimen and 3 weeks per os. For the chronic cases, we did not perform hardware exchange (for the 2 olecranon osteosyntheses, union was achieved and no further hardware was needed after removing the initial construct, whereas for the patient with TEA, we placed the external fixator away from the site of infection after removing the prosthesis).

Surgical anatomy

The origin of the BR muscle is on the lateral supracondylar ridge of the humerus and the insertion on the styloid process of the radius (Fig. 1, *C*). The dominant pedicle of the muscle arises from the radial recurrent artery (42%) that arrives in the proximal portion of the muscle as a proximal branch of the radial artery, or it may arise directly from the radial (38%) or brachial arteries (20%).[20] The muscular branch of the radial recurrent artery arises from the radial artery at the medial border of the muscle approximately 10 cm from the muscular origin and is approximately 3 cm long and of 2 mm diameter (Fig. 1, *D*). In addition, the radial artery gives off 3 minor muscle branches at variable positions.[19]

With the arm pronated, the BR assists in elbow joint flexion, whereas with arm supinated, it acts as a pronator.[23] The radial nerve is in close proximity to the arterial supply on the underside of the muscle.

Surgical technique

Under general anesthesia, patients were in the supine position with tourniquet applied, the shoulder was at 90° of abduction, and the elbow at a right angle. We prepared and assessed the defect both before and after tissue débridement, and for every patient, we recorded the maximum final defect size.

To isolate the BR muscle, a lazy S-shaped incision was designed over the proximal radial forearm (Fig. 1, *B*). We divided the distal tendon at the musculotendinous junction, taking care to identify and protect the dorsal sensory branch of radial nerve. Division of the tendon will allow for expeditious dissection

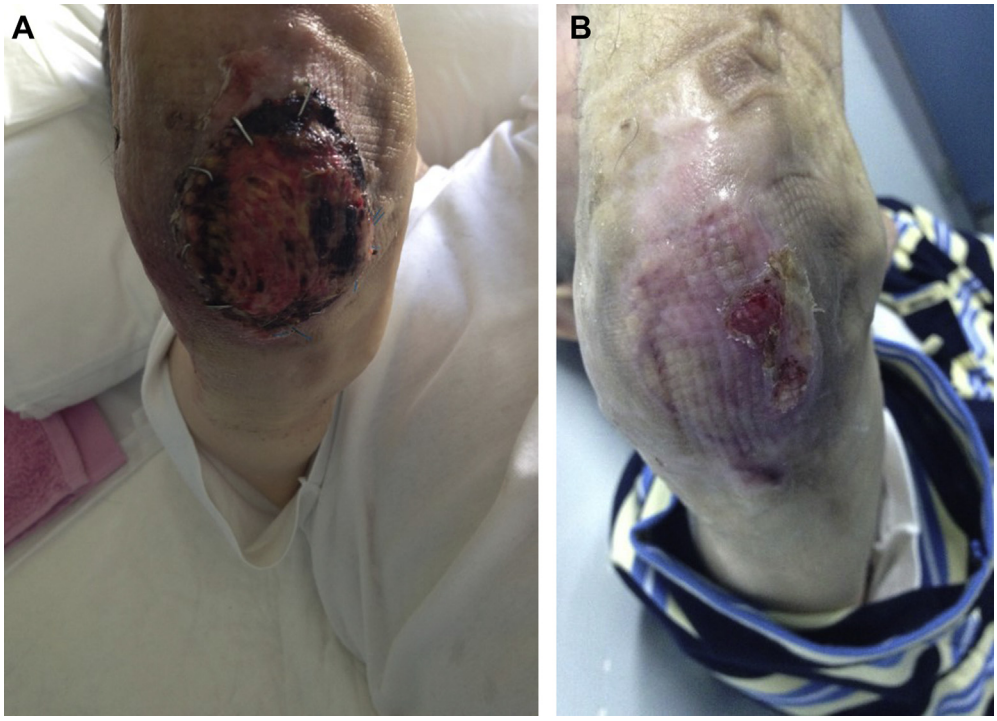

Figure 3 Progress of wound healing and flap viability for the patient shown in Figure 2 with elbow arthrodesis and hardware retention. (**A**) Nine days postoperatively; (**B**) 1 month postoperatively.

proximally to the level of the dominant pedicle that enters proximally on the underside of the muscle approximately 10 cm from the muscular origin (Fig. 1, *C* and *D*). The dominant vascular pedicle marks the pivot point of the muscle flap. We mobilized the muscle off the radial nerve and traced to its origin. We performed dissection up to the dominant pedicle and then reflected the ap proximally to cover the elbow. After releasing the tourniquet, the muscle began to bleed and the flap turned pink. Rotating and tunneling the muscle toward the posterior elbow allows the flap to reach the posterior elbow region. We then placed the BR flap and sutured it to the margins of the defect without any tension at 90° of elbow exion (Figs. 1 and 2). We closed the donor site primarily and covered the flap with a split thickness skin graft (STSG) taken from the forearm, lateral arm, or thigh (Fig. 2, *D*). For the dressing of the STSG, we used the traditional method of bolster dressing using sterile gauge bolster in a way to increase the contact of the graft with the underlying tissue bed to avoid fluid and hematoma formation underneath, to avoid movement and shear forces to the graft, and to avoid uneven and excessive pressure. This was kept in place continuously for 5 days. For the 2 patients with prior olecranon fracture ORIF in which the hardware was removed, we used a posterior above elbow loose splint for 15 days. We took the advantage that both these patients have shown fracture union both intraoperatively and radiologically, and we put a loose posterior splint to avoid compromising BR flap and skin graft viability. For the patient with the external fixator and for the 2 patients with hardware retention, we used a simple sling. The donor site of the STSG was dressed with paraffin fine mesh gauze (Jelonet), which was covered with 10 layers of dry sterile gauze.

Short- and midterm follow-up were performed to assess wound healing, flap incorporation and viability, elbow and wrist range of motion, and any flap or other complications. We determined viability of the muscle flap by the good intake of the overlaying skin graft.

Results

Patients

Patients' characteristics are shown in Table I.

Wound healing and functional results

There were no intraoperative or postoperative complications. At short-term follow-up, the wound healing was successful at 3 weeks postoperatively for all patients and no necrosis, infection, or other flap complications occurred (Fig. 3).

At the mean follow-up of 45 months (range, 26-61 months), all patients had viable and functional soft tissue coverage with no defect nor infection recurrence, or no wound dehiscence nor surgery-related complication (Fig. 4). For 2 patients with hardware retention, the coverage reconstructive procedure with the BR flap along with tissue débridement allowed hardware salvage without infection recurrence (Fig. 3). All patients were free of infection, whereas 1 patient had a posterior elbow discomfort in daily activities. None of the patients reported wrist problems. Clinical examination results for elbow range of motion are depicted in Table II.

Figure 4 Clinical appearance 1 year after the use of the brachioradialis flap in a 40-year-old female patient with posterior elbow defect after total elbow arthroplasty (TEA) and chronic infection. We performed removal of TEA, resection arthroplasty, and the coverage of the defect in 2 stages. One year after the procedure, the patient had viable and functional soft tissue coverage, no infection recurrence or wound dehiscence (left), no wrist problems, and satisfactory elbow range of motion (middle and right).

Discussion

The aim of this study was to report the authors' experience using the BR muscle flap for the coverage of small-size posterior elbow defects. The BR muscle flap is a reliable and safe solution for such post-traumatic or postsurgical defects and is characterized by an easy and reproducible harvesting technique. It offers effective, stable, and adequate coverage for small-size defects of posterior elbow and does not require microsurgical expertise for microvascular anastomosis. Additional advantages are the 1-step procedure and the absence of donor-site morbidity regarding elbow flexion and pronation and wrist motion. As disadvantages it should be noted that there is a need for coverage with skin graft, that although a muscle flap, it may sometimes be thin and inadequate in case of women, and finally that it cannot be used for the coverage of larger defects.

The posterior elbow defects that upper limb surgeons or general orthopedic surgeons face are predominantly post-traumatic or postsurgical in etiology and may lead to recurrence or require multiple surgical procedures and interventions if not carefully evaluated and treated. The significance of these defects lies in the fact that they may cause exposure of osseous structures of the elbow joint and orthopedic hardware such as total or hemi-elbow prosthesis or osteosynthesis material. Wound complication after TEA occurs in 6%, whereas after ORIF of elbow fractures, this may reach 12%.[12,14] The aim of any reconstructive procedure when treating these defects is to offer adequate soft tissue coverage to protect the underlying structures, and concomitantly to minimize donor site morbidity.

Among several options for soft tissue reconstruction of posterior elbow defects, the best choice can be performed after considering the characteristics and etiology of the defect as well as the general condition of the patient and any concomitant comorbidities. Muscle flaps for elbow coverage are the preferable choice when infection is present or significant defects need to be covered because they provide more bulky tissue than fasciocutaneous aps to obliterate dead space.[17] A relative contraindication to use perforator flaps for such defects is patients with peripheral vascular disease. Besides, it is important to evaluate

Table II Operation data and clinical outcome

Patient	Hardware exposure	Hardware removal	Follow-up (mo)	Extension	Flexion	Pronation	Supination
1	Yes	No	30	−20	100	60	60
2	Yes	Yes	26	NA	NA	NA	NA
3	Yes	Yes	61	−10	120	70	70
4	Yes	Yes	50	−10	120	70	70
5	Yes	No	58	0	0	50	50
Mean			45				
Range			26-61				

NA, not applicable.

carefully the integrity of the muscle flap and its dominant pedicle to ensure that they were not included in the previous zone of injury and thus have not been damaged from fracture, surgery, or infection. Finally, donor site morbidity is especially considered when muscle flaps are chosen due to the possibility for loss of function.

In this study, none of the patients had infection recurrence at the midterm follow-up, neither flap complications nor disturbance of flap viability, incorporation, and wound healing. This optimal result is possibly because the flap has a relatively constant pedicle anatomy because in most cases this originates from radial recurrent artery. Even if the main pedicle does not arise from this source, the other 2 most common pedicle sources of this flap (radial and brachial artery) also provide rich perfusion to the BR muscle flap. Previous studies have mentioned that a cutaneous portion can be included with the BR flap due to the consistent perfusion in the cutaneous portion directly above the muscle belly, and this may eliminate the need for skin grafting.[13,15]

Other muscle perforator flaps are available for posterior elbow defects such as the anconeus, the medial triceps brachii, and the flexor carpi ulnaris flaps. The anconeus muscle covers small-size defects of the lateral radiocapitellar joint, and posterior elbow including the distal triceps tendon insertion and the olecranon.[21] The anconeus muscle flap is not appropriate for patients with peripheral vascular disease due to its small rotation arch and in cases that it is involved in the zone of injury.[5] The medial triceps brachii flap provides good coverage for small- to medium-size defects of posterior elbow and also yields good results regarding wound healing and flap incorporation.[7] The relatively constant anatomy of the main pedicle of this flap contributes to these optimal outcomes. However, it is not clear whether the use of the medial triceps brachii flap leads to any donor site morbidity or whether this flap provides such stable and good coverage in cases with prior infection or infected orthopedic hardware.[7] The flexor carpi ulnaris serves for larger defects. The disadvantages of this flap are that it has no constant anatomy for the dominant pedicle and that donor site morbidity may occur because the muscle used is a dominant flexor and ulnar deviator of the wrist.[22]

The limitations of our study are the small sample size and retrospective nature. Larger studies are needed to clarify the best indications and contraindications of this muscle pedicled flap especially in this difficult scenario of posterior elbow defect along with postoperative or post-traumatic infection.

Conclusion

The BR muscle flap is a pedicled flap that gives a reliable solution to cover small-size posterior elbow defects. It is easy to harvest without requiring microsurgical expertise, and is a 1-stage procedure with no morbidity to the harvest site that provides stable and adequate coverage even in cases with postoperative and post-traumatic infection.

Disclaimer

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