Management of Posttraumatic Posterior Elbow Defects by Nonmicrosurgical Reconstruction

Manoj Dinkar Pawar[1] Parag Sahasrabudhe[1] Nikhil Panse[1] Ameya Rajan Bindu[1] Rohit Dagadu Phulwer[1]

[1] Department of Plastic & Reconstructive Surgery, B.J. Government Medical College and Sassoon Hospital, Pune, Maharashtra, India

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Address for correspondence Manoj Dinkar Pawar, MS, M.Ch. DNB, Indraprastha Sahakari Housing Society Phase 2, Plot no. 602, Deep Bunglow, Hadapsar, Pune, Maharashtra 411028 (e-mail: manojpawar.surg@gmail.com).

Abstract

Introduction Reconstruction of posterior defects is challenging due to the quality and uniqueness of the excess skin at the elbow that is durable, thick, pliable, and without much subcutaneous tissue. The goal of reconstruction is to cover the elbow defects with a durable skin cover that will facilitate full passive range of motion. In this era of microsurgery, free tissue transfer is feasible for almost any defect. However, in this article, we discuss various locoregional and pedicled flap options and the protocol followed at our institute to tackle posttraumatic posterior elbow defects.

Materials and Methods This is a retrospective analysis of 48 patients with posttraumatic posterior elbow defects admitted from January 2012 to February 2020. Posterior elbow defects were assessed according to the size and location and managed with a nonmicrosurgical reconstruction.

Results Of 48 patients, 32 were managed with nonmicrosurgical flaps. Eighteen patients had large defects and 14 had small defects. Reverse lateral forearm flap was the workhorse flap for defect coverage. Of 32 flaps, nine developed complications; however, no patient had total flap necrosis.

Conclusion Posterior elbow defects are a difficult problem to tackle. To achieve optimal results, all patients with elbow trauma should be attended and managed by orthopaedic and plastic surgeons in collaboration for optimal results. We believe that most of these defects can be resurfaced by nonmicrosurgical reconstruction with proper planning and execution and their utility cannot be understated.

Keywords

- posterior elbow defects
- classification of elbow defects
- nonmicrosurgical reconstruction
- management of posterior elbow defects
- elbow defects

Introduction

Despite numerous options available for the soft tissue reconstruction of posterior elbow defects, it remains a challenge due to unique quality of the excess skin that is thick, pliable, and without much subcutaneous tissue.[1] The olecranon process is an important pressure point and the skin over it is lax[2] during extension and taut at full flexion. The reconstructive goal of posterior elbow defects is to provide a durable skin cover that will facilitate full active and passive range of motion. In this era of microsurgery, free tissue transfer is feasible for almost any defect. However, in this article, we discuss various locoregional and pedicled flap options and the protocol followed at our institute to tackle posttraumatic posterior elbow defects. Bony fixation, reconstruction, and

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orthopaedic rehabilitation are beyond the scope of this writeup and not discussed.

Materials and Methods

After clearance from institutional ethics committee, a retrospective analysis was conducted at our hospital by including all patients with posttraumatic posterior elbow defects reconstructed with nonmicrosurgical flaps from January 2012 to February 2020. Patients having anterior elbow defects and defects covered with free flaps were excluded from the study. Patients with injuries of and around the elbow were managed primarily by orthopaedic surgeons. Coverage of defects was performed secondarily after bony stabilization by plastic surgical unit. Data was collected from electronic medical records, departmental operative registers, and photographic records.

Defect Assessment and Evaluation

The spectrum of injury varied from compound fractures and dislocations of proximal radius, ulna, and distal humerus to extensive open and comminuted fractures with defects involving exposed joint, vital structures, or implants with or without loss of skin and/or bone. Adequate bone alignment and stabilization were achieved by the orthopaedic surgeons either with internal or external fixation and then the patients were referred to plastic surgery unit for soft tissue coverage. Almost all patients were reconstructed secondarily after a delay of ~2 to 3 weeks due to multiple reasons. Most of the patients had some degree of joint stiffness, edema, and an external fixator in situ. Coverage with a durable skin cover and achieving complete wound healing was the primary reconstructive goal. Patients were followed up for 3 months postoperatively; however, some were lost to follow-up. Patients were assessed for wound healing and status of flap. The range of movements of the elbow was not assessed. Patients were then assessed by orthopaedic surgeons after healing of flaps for the management of orthopaedic hardware, need of any secondary procedures, and physiotherapy.

For ease of description, elbow defects were assigned an α-numerical value as described later (►**Fig. 1**). Cubital crease was used as a reference. Two parallel lines were drawn at the point where the crease starts to fade medially and laterally. The part of the elbow in between these lines was anterior elbow and rest was considered as posterior elbow region. Posterior elbow was further divided in to medial, central, and

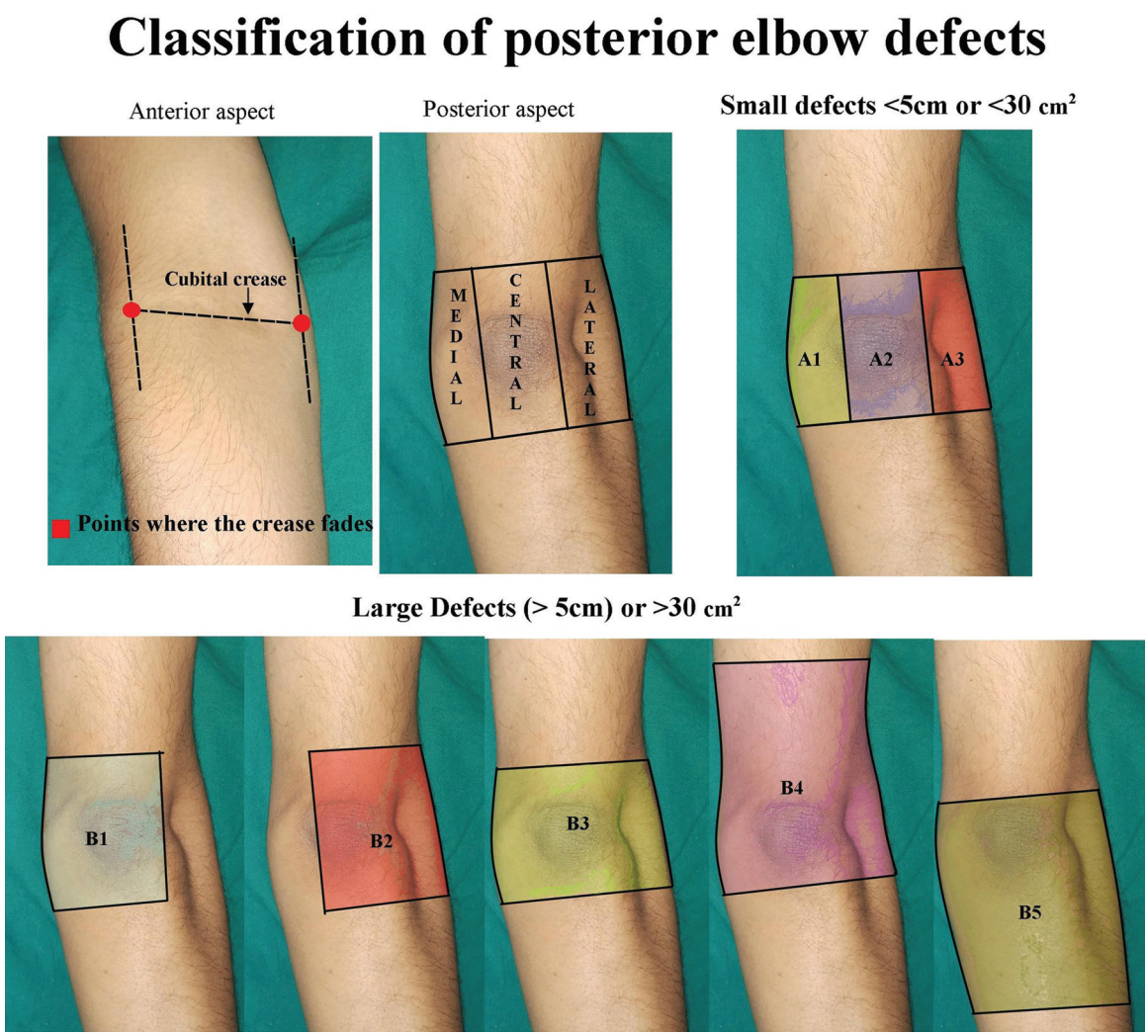

Fig. 1 Classification of posterior elbow defects.

lateral compartments. The part of the elbow between the lateral border of the olecranon and the lateral end of cubital crease was the lateral compartment. The part of the elbow between the medial border of the olecranon process and the medial end of elbow crease was the medial compartment. The elbow between two borders of the olecranon process was the central compartment.

Defects with exposed vital structures were again subclassified according to size as small (A) (<5cm or <30cm^2) and large (B) (>5cm or >30cm^2).

Small defects (A) were thus classified and labeled according to location as:

1. Medial (A1)
2. Central (A2)
3. Lateral (A3)

Large defects (B) involving multiple subunits were labeled as:

1. Mediocentral (B1)
2. Laterocentral (B2)
3. Medio-latero-central (B3)
4. Defects of posterior elbow extending proximally on to the arm (B4)
5. Defects of posterior elbow extending distally on to the forearm (B5)

Flap Planning and Execution

The defects were assessed and resurfaced with a locoregional or pedicled flap as deemed appropriate taking into consideration the various factors like size, location, extent, need for secondary procedures, methods of fixation, neurovascular injury, exposed vital structures, and positioning required for flap harvest. Only defects with exposed bones, hardware, joint, and vital structures were managed with a flap cover and the rest were skin grafted. The perforators around the elbow joint were assessed and marked preoperatively in all patients with 8 Hz handheld Doppler. All flaps were marked with the elbow in 90 degrees of flexion and shoulder in abduction.

1. Size: Small defects were managed with local transposition flaps preferably based on the perforator adjacent to the defect. Proximally based local flaps were preferred where feasible based on the musculocutaneous perforators of the radial recurrent artery (RRA) along the axis of the brachioradialis muscle. Brachioradialis with its overlying skin paddle is usually spared from complex traumatic elbow injuries and also rarely the site for pins of external fixator. Thus, it was a safe and reliable flap for moderate sized defects for lateral, central. and mediocentral defects. The brachioradialis muscle flap was preferred for small central and lateral defects (►**Fig. 2A, B**).
   For small and large sized defects of either compartment, distally based local fasciocutaneous (LFC) flaps were harvested preferably including a perforator at its base (►**Fig. 3A–C**). A propeller flap based on RRA perforator was used for small lateral and central defects.
2. Location: Central defects were technically easier to resurface with flaps from the lateral side due to proximity of the ulnar nerve and medial cutaneous nerve of forearm encountered medially. Reverse lateral arm (RLA) flap was our flap of choice for central and mediocentral defects (►**Fig. 4A–C**). Distally based posterior ulnar recurrent artery (PURA) flap was considered in defects with extensive trauma to the lateral aspect of the arm with external fixator in situ precluding a laterally based flap. However, position required for the harvest was shoulder in external rotation and abduction in presence of a fixator (►**Fig. 5A–C**).
3. Extent of the defect**:** For moderate-to-large defects extending distal to the elbow with exposed ulna/radius with or without a fracture required a large flap. The radial artery originates deep just distal to cubital fossa and often escapes trauma. The pedicled radial forearm flap (RFF) was our flap of choice for such defects (►**Fig. 6A, B**). For similar and large medio-latero-central defects associated with brachial artery injury, supracondylar humerus fractures, an elbow spanning external fixator or doubtful Allen's test, we preferred an inferiorly based abdominal flap or a lateral thoracic flap based on multiple perforators along the midaxillary line (►**Fig. 7A–C**).
   With moderate-to-large defects involving the posterior elbow and extending proximally with an external fixator in situ, a pedicled musculocutaneous latissimus dorsi (LD)

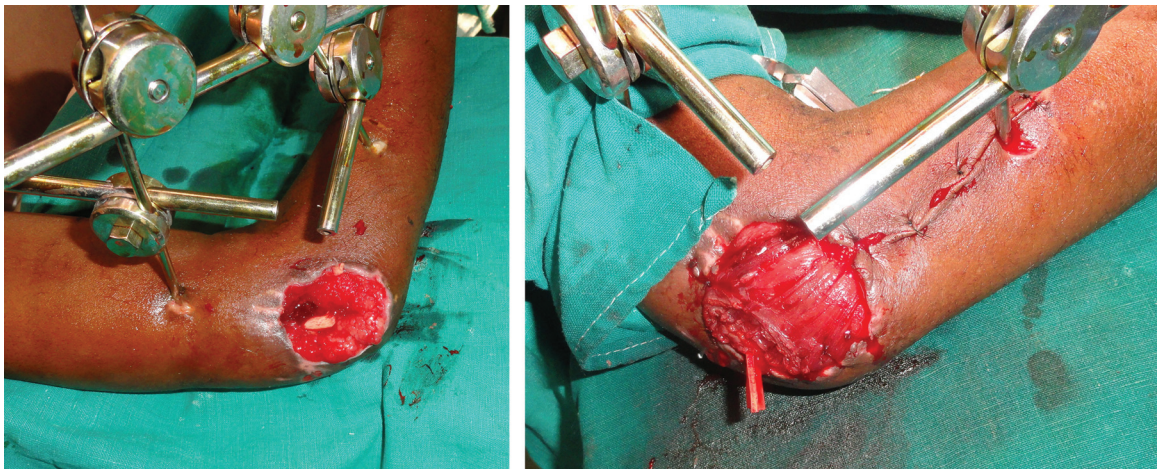

Fig. 2 (**A**) Small lateral defect with exposed bone. (**B**) Defect resurfaced with brachioradialis muscle flap.

Fig. 3 (**A**) Large mediocentral defect with exposed vital structures and Kirschner wire. Large fasciocutaneous flap marked based on an audible perforator at its base. (**B**) Flap inset with complete defect coverage. (**C**) Well settled flap.

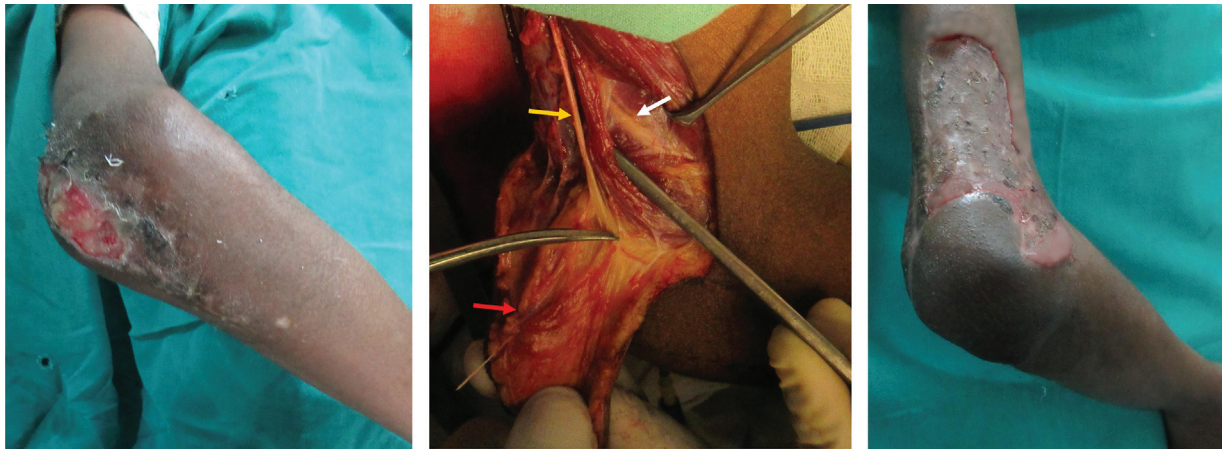

Fig. 4 (**A**) Mediocentral defect. (**B**) Harvested reverse lateral arm flap. The posterior antebrachial nerve is dissected free from the flap (yellow arrow). The radial nerve is seen anteriorly (white arrow). The pedicle is seen in the flap (red arrow). (**C**) Postoperative image of the flap.

flap harvested in lateral position was utilized to resurface the defect (►**Fig. 8A, B**).

4. Concomitant ulnar nerve injury**:** Elbow defects with acute ulnar nerve injury needing repair were managed simultaneously with primary nerve coaptation and anterior transposition followed by flap cover depending on the location. Defects associated with a crush component resulting in a concomitant ulnar nerve defect more than 5 cm necessitating a cable graft were managed with tagging of ulnar nerve ends and defect closure with a flap and secondary reconstruction of nerve with sural nerve cable graft after 3 months.

Results

Forty-eight patients were included in the study analysis with trauma being the etiological factor in all. Road traffic accidents were the most common presentation ($n = 38$) followed by industrial accidents ($n = 8$) and domestic accidents ($n = 2$). Four patients presented with exposed implant. The age of the patients varied from 8 to 72 years with mean age being 38 years, with one pediatric patient. Thirty-five patients were males, whereas 13 patients were females. The defect size varied from as small as 2×2cm to as large as 14×12cm. Sixteen patients had degloving injury without exposure of any vital structures and were managed with skin grafting. Thirty-two patients were managed with some locoregional or pedicled flap cover (►**Fig. 9**). Fourteen patients were small defects (A) and 18 were large complex defects (B). Four patients had ulnar nerve injury out of which one was repaired primarily and transposed anteriorly and then covered with flap. In one patient, nerve grafting was done as a secondary procedure after 3 months. Remaining two patients were lost to follow-up. Eight patients had partial graft loss of the donor site out of which one was small size defect and seven patients were large defects. Three patients needed regrafting of the donor site and the rest healed secondarily. Nine out of 32 flaps developed some complication out of which 6 flaps had minor complications of marginal necrosis. These were managed conservatively till eschar formation and then allowed to heal by autoseparation of eschar followed by secondary healing. However, three flaps developed major complications of more than 50% flap necrosis out of which one was managed with a secondary flap for coverage and two needed secondary grafting. Reverse lateral arm flap was used as a secondary salvage flap for one defect (►**Fig. 10A–C**). Seven patients developed infection with pus discharge and indurated wound margins that were managed with broad-spectrum antibiotics. None of the patients had total flap necrosis (►**Table 1**).

Discussion

Posterior elbow defects often prove to be a complex reconstructive problem. With proper planning and execution, most traumatic posterior elbow defects can be managed by

Fig. 5 (**A**) Large laterocentral defect. (**B**) Harvesting the posterior ulnar recurrent artery flap. The pedicle is included in the flap and ligated (red arrow). The medial cutaneous nerve of forearm can be seen in close proximity to the pedicle (yellow arrow). (**C**) Late postoperative image showing the reach of the flap.

Fig. 6 (**A**) Large mediolateral defect demonstrating lack of local flap options. (**B**) Defect resurfaced with pedicled radial forearm flap. Note there is no external fixator.

a nonmicrosurgical flap cover. They provide adequate and durable skin cover that can facilitate early mobilization with minimal donor site morbidity. In our experience, almost all posterior elbow defects can be managed with the following flaps—RLA flap, propeller flaps, LFC flaps, PURA artery flap, pedicled LD flap, pedicled RFF, and abdominal flaps. The authors follow the algorithm given in ►**Fig. 11** for coverage of posterior elbow defects. Microsurgical reconstruction with free flaps is the go-to-option in most of complex defects, but it is time consuming, needs surgical expertise and infrastructure that may not always be available in all hospitals. Besides, nonmicrosurgical locoregional and pedicled flaps for elbow coverage should be in the armamentarium of any plastic surgeon and their utility cannot be understated.

In a reconstructive algorithm for soft tissue coverage of the elbow, Jensen and Moran found pedicled LD flap, anconeus flap, pedicled RFF, and free anterolateral thigh flap to be most useful and reliable for coverage of most elbow defects.[3] Sherman often used free scapular, parascapular, rectus, and gracilis muscle flaps as free flap options for coverage of the elbow.[4]

RLA flap was the workhorse flap for most central, medial, and complex defects in our series due to its advantages of reliable skin paddle and ease of harvest with the forearm rested on the patient's abdomen, not sacrificing any major vessels of the limb, and without need of microsurgical anastomosis. Also, it is associated with minimal donor site morbidity and skin graft at a location that can be easily covered with clothing. An elbow spanning fixator poses technical difficulty in the harvest. Patel and Higgins[5] highlighted the versatility and reliability of RLA flap for posterior elbow wounds. Their study also included RFF, brachioradialis, pedicled LD, and local perforator flaps as coverage options for posterior elbow that correlates with our case series. The RLA flap can also be based anterior to the lateral epicondyle to include perforators of RRA in the flap base, which minimizes the kink and prevents venous congestion as suggested by Devale et al.[6] In a recent review article by Gandolfi et al,[7] the lateral arm flap was the most reported flap in their review due to its obvious advantages.

The brachioradialis muscle flap and the overlying skin paddle based on RRA perforators can be harvested as a

Fig. 7 (**A**) Circumferential elbow defect with exposed Kirschner wires. Posterior aspect. (**B**) Defect resurfaced with lateral thoracic flap. Image demonstrating flap delay by taking parallel incisions till necessary flap length is attained. (**C**) Postoperative image showing good flexion.

Fig. 8 (**A**) Large defect of the posterior elbow extending proximally on to the arm. (**B**) Well-settled latissimus dorsi flap. Note the reach of the flap is well beyond the elbow joint.

muscle flap, musculocutaneous, or a fasciocutaneous flap as its vascularity originates deep from the RRA and is often spared from injury with an advantage of closing the donor sire primarily.[8] Brachioradialis muscle is expendable in presence of functioning biceps brachii and a useful option to cover small central and medial defects.

RFF is a versatile flap and can be used for most defects around the elbow.[9] Various reconstructive algorithms for elbow defects put forth by Choudry et al,[10] Bishop,[11] and Jensen and Moran[3] describe RFF as the workhorse flap in their respective series.

However, patients with extensive trauma often have an elbow blocking external fixator on the lateral aspect and it becomes technically challenging to harvest RFF in a flexed elbow and externally rotated shoulder and should be considered only in defects without external fixator or where positioning is suitable. We opted for inferiorly based abdominal flap and the lateral thoracic flap for complex defects in extensive trauma with external fixator. It is a safe alternative than sacrificing an important vessel in such extensive trauma. The unstable elbow is usually stabilized with an external fixator in ~90 degrees flexed position with pins on the lateral aspect of the humerus and radius with two elbow spanning rods. This arrangement allows proper positioning of the upper limb on the abdomen for an inferiorly based abdomen flap. Large abdominal flaps are prone for developing venous congestion, marginal necrosis and can be too bulky in women and obese individuals. We suggest considering alternate flaps in such patients as the limb positioning can be cumbersome.

Few Indian studies also describe lateral thoracic and thoracoepigastric flaps for elbow defects.[12,13] We consider lateral thoracic flap based on multiple perforators along the midaxillary line to be a vital lifeboat for large elbow defects as it is reliable and provides a skin paddle large enough to cover circumferential elbow defects.

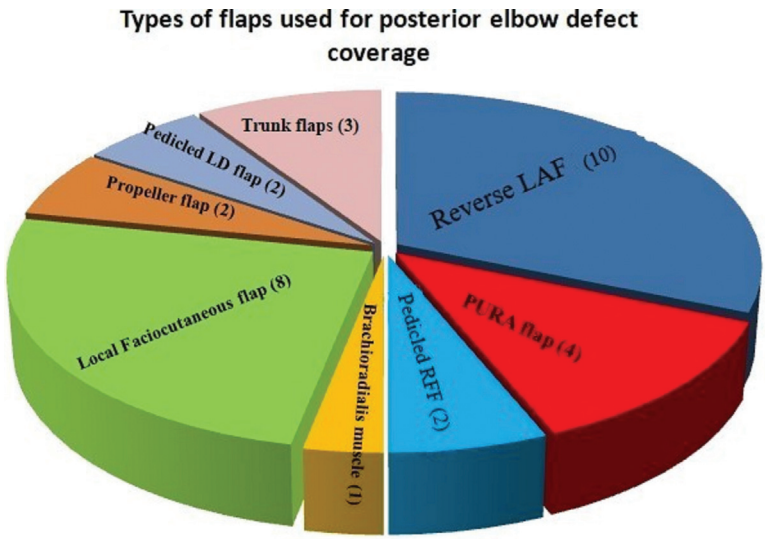

Fig. 9 Pie chart showing number of flaps performed. LD, latissimus dorsi; LAF, lateral arm flap; PURA, posterior ulnar recurrent artery; RFF, radial forearm flap.

Fig. 10 (**A**) Large medio-latero-central defect that was the result of necrosis of a previous fasciocutaneous flap based on perforators of radial recurrent artery. (**B**) Immediate postoperative image showing a healing reverse lateral arm flap that was utilized as a salvage flap. (**C**) Well-settled flap showing flexion at the elbow.

Table 1 Master chart

Serial no.	Age	Sex	Defect size	Area (in cm^2)	Location	Defect type	Flap done	Donor site complications	Minor Complications		Major complications >50% flap necrosis	Any secondary procedure required
									Marginal necrosis	Infection		
1	70	M	8 × 5cm	40	Mediocentral	B1	Reverse lateral arm flap		Marginal necrosis	Yes		No
2	25	F	2 × 2cm	4	Central	A2	Propeller flap					
3	23	F	3 × 5cm	15	Medial compartment	A1	Local FC flap					
4	60	M	12 × 8cm	96	Mediocentral extending proximal to elbow	B4	Pedicled LD MC flap	Partial graft loss of donor site				
5	61	M	7 × 5cm	35	Laterocentral	B2	Reverse lateral arm flap					
6	35	M	3 × 3cm	9	Lateral	A3	Local FC flap					
7	34	M	12 × 8cm	96	Medial, central, and lateral compartment	B3	Reverse lateral arm flap		Marginal necrosis of flap	Yes		Debridement and secondary healing
8	28	M	6 × 4cm	24	Laterocentral	B2	Reverse lateral arm flap					
9	27	M	2 × 2cm	4	Lateral	A3	Brachioradialis muscle flap					
10	42	F	14 × 12cm	168	Laterocentral with exposed ulna	B5	Trunk flap (lateral thoracic flap)	Partial graft loss	Marginal necrosis			Needed regrafting of donor site
11	38	M	7 × 7cm	49	Mediocentral	B1	Reverse lateral arm flap		Marginal necrosis			
12	18	M	3 × 2cm	6	Posterior	A2	Propeller flap based on RRA perforator					
13	70	F	6 × 5cm	30	Laterocentral	A3	Pedicled radial artery forearm flap	Partial graft loss				
14	36	M	7 × 4cm	28	Laterocentral	A3	Posterior recurrent ulnar artery flap					
15	35	M	12 × 8cm	96	Large defect distal to ulna with exposed ulnar implant	B5	Inferiorly based abdomen flap	Partial graft loss		Yes	Yes	Debridement of flap followed by skin graft
16	25	F	3 × 3cm	9	Medial	A1	Local FC flap					
17	73	M	6 × 4cm	24		A2						

Table 1 (*Continued*)

Serial no.	Age	Sex	Defect size	Area (in cm^2)	Location	Defect type	Flap done	Donor site complications	Minor Complications		Major complications >50% flap necrosis	Any secondary procedure required
									Marginal necrosis	Infection		
					Central compartment		Local FC flap based on RRA perforator					
18	54	M	5 × 4cm	20	Lateral compartment	A3	Local FC flap					
19	25	M	10 × 6cm	60	Laterocentral with exposed implant	B5	Inferiorly based abdomen flap	Partial graft loss of donor site				
20	28	M	6 × 6cm	36	Mediocentral	B1	Local FC flap based on RRA perforator			Yes	Yes	Lateral arm flap
21	47	M	7 × 6cm	42	Laterocentral	B3	Posterior ulnar recurrent artery flap	Partial graft loss	Marginal flap necrosis			Regrafting of donor site
22	70	F	3 × 3cm	9	Central	A2	Local FC flap					
23	18	M	14 × 8cm	112	Laterocentral proximal to elbow	B4	Pedicled LD MC flap	Partial graft loss				Regrafting of donor site
24	39	M	8 × 6cm	48	Central, medial, and lateral compartment	B3	Pedicled radial forearm flap	Partial graft loss		Yes		
25	60	F	6 × 6cm	36	Laterocentral	B2	Local FC flap					
26	35	M	7 × 4cm	28	Mediocentral with exposed implant	A1	Reverse lateral arm flap			Yes		
27	62	M	4 × 4cm	16	Central	A2	Local FC flap					
28	59	F	8 × 6cm	48	All 3 compartments	B3	Reverse lateral arm flap			Yes	Yes	Debridement and skin grafting
29	35	F	6 × 6cm	36	Laterocentral	B3	Reverse lateral arm flap					
30	27	M	7 × 5cm	35	Mediocentral	B1	Reverse lateral arm flap		Marginal necrosis			
31	58	M	7 × 5cm	35	Mediocentral	B1	Reverse lateral arm flap					
32	12	M	5 × 5cm	25	Central	A2	Posterior ulnar recurrent artery					

Abbreviations: FC, fasciocutaneous; LD, latissimus dorsi; MC, musculocutaneous; RRA, radial recurrent artery.

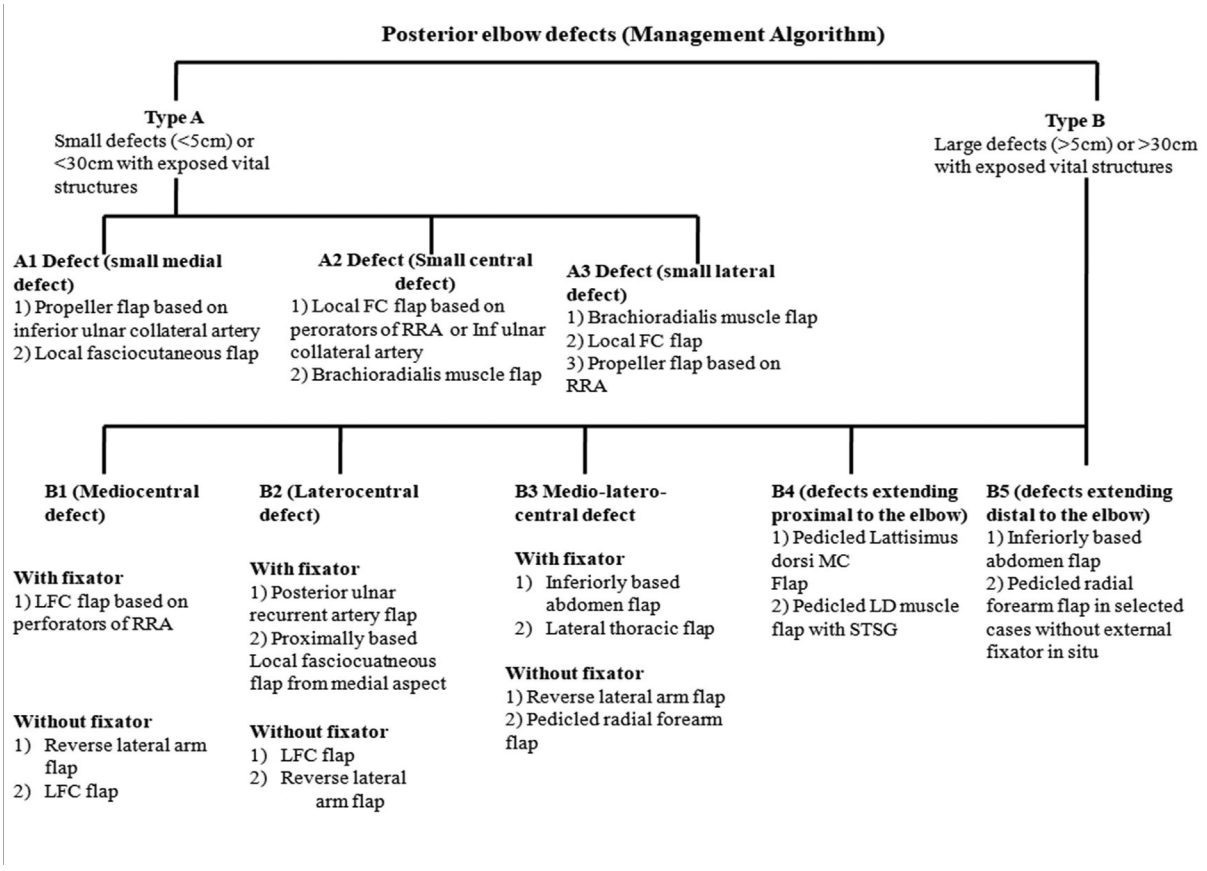

Fig. 11 Posterior elbow defects (management algorithm).

Gandolfi et al reported use of propeller flaps based on radial collateral artery perforator and posterior ulnar recurrent artery perforator for elbow defect coverage.[7] Propeller flaps in our study were based on perforators from RRA similar to that reported by Panse and Sahasrabudhe.[14] Islanded perforator flaps based on PURA for elbow coverage resulted in better donor site cosmesis as reported by Mateev et al.[15]

The PURA flap provides a large skin paddle extending proximally up to midarm and comprising almost the entire medial circumference of the arm enabling coverage of complex moderate to large laterally located defects. However, it involves tedious dissection of ulnar and medial cutaneous nerve of forearm. The RLA flap and PURA flaps included in our series are reliable axial pattern[16] flaps that can cover complex medial and lateral defects, respectively, with ease.

The pedicled LD MC was our flap of choice in extensive trauma with elbow defects extending proximally on to the arm, inadequate local flap options, and extensive zone of trauma with poor recipient vessels.[17] The flap provides adequate bulk with acceptable donor site morbidity. We could cover defects as distal as 3 to 5 cm beyond the elbow joint, which correlates with recommendations of Stevanovic et al,[18] Harvey et al,[19] and Rogachefsky et al.[20] Flap was inset with shoulder abducted to 90 degrees and externally rotated. However, skin grafting of the donor site was inevitable for large flaps. It should be used with caution in patients with concomitant lower limb fractures who depend on crutches for ambulation.

Flexor carpi ulnaris (FCU) muscle flap also finds mention for soft tissue coverage of elbow.[2,21] Anconeus, brachioradialis, FCU, and triceps muscle flaps were considered by Choudry et al for elbow coverage. We preferred only brachioradialis muscle flap for moderate size defects as FCU and triceps are not expendable and anconeous is unreliable. FCU is a powerful ulnar deviator[2] and flexor of the wrist, a vital action for "hammering" movement in unskilled workers, which form a significant number of our patients. The authors believe FCU should be avoided in this group of patients unless other options are exhausted.

A major limitation of locoregional flaps is the unaesthetic donor sites. However, in units like ours catering mainly to low-income group of patients consisting of daily wage earners and manual workers, early return to work and rehabilitation has to be given a priority with available infrastructure and constraints. Besides, the typical Indian clothing consisting of full sleeve shirts conceals all the possible donor sites.

Limitations of the Study

1. Ours is government run tertiary care center where patients are referred from peripheral rural areas. Regular follow-up was often not possible.

2. All the defects in our study were reconstructed secondarily that resulted in postoperative stiffness.
3. The focus of this article was only on coverage of the posterior elbow defects. Patients were not assessed for range of motion postoperatively as most of the patients had stiff elbow joints preoperatively.

Conclusion

Posterior elbow defects are a difficult problem to tackle. To achieve optimal results, all patients with elbow trauma should be attended and managed by orthopaedic and plastic surgeons in collaboration with bony stabilization and soft tissue cover achieved simultaneously as early as possible. We believe that most of these defects can be resurfaced by nonmicrosurgical locoregional flaps with proper planning and execution and their utility cannot be understated. They can be considered as the first choice in selected patients owing to their reliability, durability, ease of harvest, and minimal donor site morbidity. They prove to be very useful in centers that lack a dedicated plastic surgical unit or are not very well equipped with microsurgical infrastructure and expertise.

Conflict of Interest
None.

Financial disclosure
None.

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