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Efficacy of Reverse - Flow Lateral Arm Flap for Coverage of Defects Around the Elbow in Pediatric Patients

SHERIF M. ELKASHTY, M.D.; MOHAMED ABOSHABAN, M.D. and AHMED A. TAALAB, M.D.

The Department of Plastic and Reconstructive Surgery, Faculty of Medicine, Menoufia University

ABSTRACT

Background: Coverage of defects around the elbow can be treated by a variety of procedures as skin grafts, regional flaps, muscle flaps and free flaps. The reverse flow lateral arm flap (LAF) is a valuable option in coverage of these defects. The vascular basis of this flap, via the multiple communications around the elbow between the collateral and recurrent arteries, is consistent and reliable.

Aim of the Study: To explore the utility of the reverse flow lateral arm flap (LAF) in management of defects around the cubital fossa region in pediatric patients.

Patients and Methods: This work was executed at The Menoufia University Hospitals, from October 2017 to December 2018, following our cases post-operatively for an average one year. It entailed eight patients, six boys and two girls. The age of our cases was from 4 to 11 years. Six patients had post-burn contracture release defects, and 2 patients had traumatic avulsion of antecubital skin. All the defects were covered by the reverse-flow lateral arm flap (LAF) with skin grafting of the donor site.

Results: All the flaps survived completely, except one case showed distal superficial necrosis and healed spontaneously. We applied skin graft to the flap donor site in the eight patients. Flap size ranged from 15x7 cm. to 12x5cm. Aesthetically, the flap and donor sites were satisfactory, and functionally, the range of motion of elbow was very adequate. One patient developed transient radial nerve palsy and completely recovered by conservative treatment and physiotherapy.

Conclusion: The reverse flow lateral arm flap (LAF) is a valuable single-stage option in coverage of defects around the elbow. It provides reliable and stable coverage of these defects without sacrificing major vessel or functional muscle unit. The flap had satisfactory aesthetic and functional outcome.

Key Words: *Lateral arm flap – Elbow defects – Antecubital contractures.*

Conflict of Interest: Nothing to disclose.

INTRODUCTION

Managing antecubital contractures and tissue loss is a challenge for plastic surgeons. These defects may be due to different reasons as trauma, post contracture release, post tumor ablation, etc. This critical mobile elbow area needs sound and timely reconstruction to allow early return of motion. Solutions may range from simple skin grafts, regional cutaneous flaps, abdominal or trunk flaps, up to sophisticated free tissue transfer; each option has its advantages and disadvantages **[1,2]**.

Skin grafts cannot cover vital structures; require lengthy immobilization, with high risk of recurrence. Abdominal or trunk flaps need two stages and may cause joint contractures. Coverage by local muscles would be bulky and may result in function deficit. Free flaps are very good option but require microsurgical skill and facilities along with fit patients **[3-5]**.

A valuable solution for managing antecubital contractures/tissue deficit is the reverse flow lateral arm flap. Song and colleagues were credited for this flap description and then Katsaros et al., added more flap description. This flap has proved to be a versatile option for coverage of the around-elbow defects as we will mention later in the discussion **[11,12,15-19]**.

We present this work to elucidate the efficacy of the revere flow lateral arm flap in coverage of soft tissue defects around the elbow and to delineate its advantages and disadvantages.

Relevant surgical anatomy:

- According to many cadaveric and injection studies, the profunda brachii artery ends in a constant terminal branch, called posterior radial collateral artery (PRCA), which lies in the lateral intermuscular septum, giving off septocutaneous branches to the skin territory of the lateral arm flap.
- The termination of the PRCA anastomoses constantly with recurrent arteries, which may be interosseous recurrent artery (IRA) or the radial recurrent artery (RAR) around the region of the lateral epicondyle of the humerus.

- It is the anastomoses between the PRCA and whichever recurrent arteries around the lateral epicondyle which allows division of the vascular pedicle proximally and designing the lateral arm flap as a reverse-flow pattern based on this epicondylar anastomosis. The flap will be reversely perfused by the recurrent arteries. The venous drainage of the flap parallels the arterial supply, via venae comitantes of the above mentioned arteries, in a reverse flow pattern also **[10,11,12]**.

PATIENTS AND METHODS

After approval of the ethical committee, this work was executed at The Menoufia University Hospitals. It was done in the period from October 2017 to December 2018 with a follow-up period of an average of 12 months. The study included eight cases, six boys and two girls. Patients' age was from 4 to 11 years. Regarding the etiology, 2 patients had traumatic avulsion of skin and exposure of vital structures of cubital fossa without fractures and 6 patients had antecubital skin defects following release of post-burn contracture of the elbow.

Patients with severe scarring at the flap territory or trauma involving the flap pedicle at the lateral epicondyle making flap pedicle question able were excluded from the study.

Surgical technique:

Pre-operative marking: We drew a line from insertion of deltoid muscle to lateral epicondyle of humerus, marking the intermuscular septum between the brachialis and triceps muscles, which contain the PRCA vessels. Flap skin paddle was centered over this line. We used an 8 MHz handheld Doppler to detect and mark the septocutaneous perforators along this line. We tailored flap dimensions individually case-by-case according to the need of each case, Figs. (1-3).

All cases were done under general anesthesia without tourniquet. We released post-burn contracture of elbow along the joint axis carefully, until the arm was fully extended. This resulted in a soft tissue defect with exposure of neurovascular structures at the floor of cubital fossa.

We incised the posterior margin of the flap reaching the fascia over the triceps, with subfascial dissection of the flap anteriorly until the septum was reached. Then, we incised the anterior margin of the flap down to the deep fascia over the biceps, with subfascial dissection of the flap posteriorly until the septum is reached. The vascular pedicle (PRCA) deep within the septum was exposed by dissection and traction of triceps muscle posteriorly, and the radial nerve and its 2 cutaneous branches were dissected and isolated by rubber bands for their protection, Figs. (4-6).

We transected the vascular pedicle (PRCA) proximally near its origin off the profunda brachii, converting the flap to a reverse flow pattern. We elevated the flap, from superiorly to inferiorly, including the septum (which contains the pedicle and septocutaneous perforators) to the skin paddle. The radial nerve was protected, while the posterior cutaneous nerve of the arm was severed routinely to allow distal elevation of the flap, but we were able to preserve the posterior cutaneous nerve of the forearm, Figs. (7,8).

At the epicondylar region, we sharply dissected the vascular pedicle (PRCA-RRA), (en bloc with the surrounding subcutaneous tissues) off the periosteum for safety and to ensure adequate reverse arterial flow and venous drainage of the flap. We never attempted to isolate these vessels.

The reverse flow flap was rotated 90 degrees to resurface the post release defect or cover the antecubital surface, then we applied skin grafts to flap donor site in all patients. The arm was splinted in extension for 2 weeks and physiotherapy was started promptly, thereafter, Figs. (9-11).

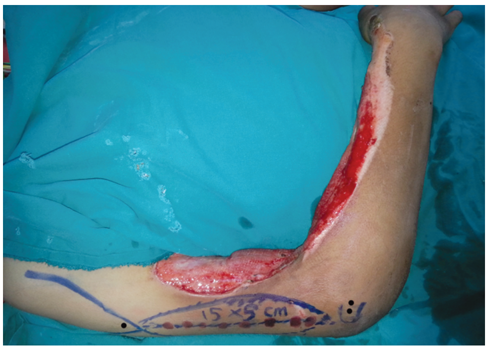

Fig. (1): Flap marking. The flap, 15x5cm, was planned to cover these vital structures and line the axis of movement of elbow joint. Deltoid insertion was marked by 1 black dot, lateral epicondyle marked by 2 black dots. Doppler detected perforators marked by red dots.

Fig. (2): Flap marking. A flap about 12x5cm was marked over a line between deltoid insertion and lateral epicondyle.

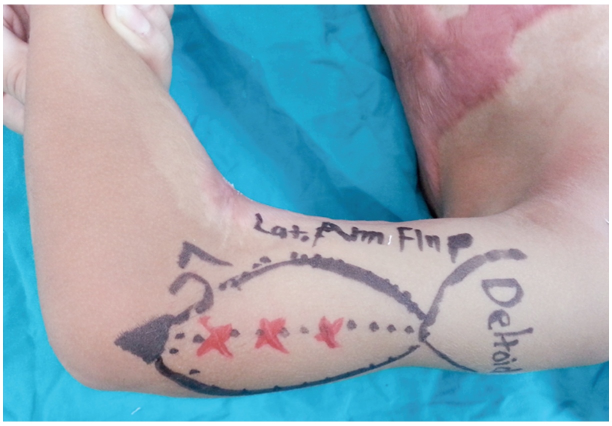

Fig. (3): Pre-operative flap marking.

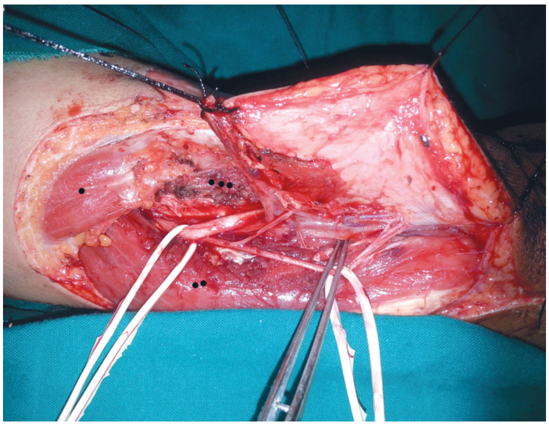

Fig. (4): The flap was elevated subfascially towards the septum. The radial nerve and its 2 cutaneous branches were identified by 2 rubber bands for protection. The PRCA was transected proximally and included in the flap. The vascular pedicle of flap was shown over tip of forceps. Deltoid marked by 1 black dot. Triceps marked by 2 black dots. Biceps marked by 3 black dots.

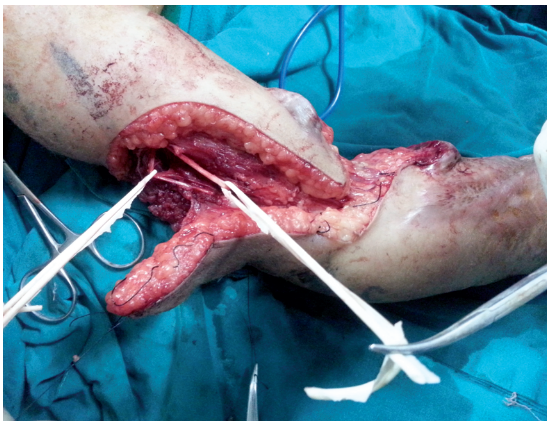

Fig. (5): The PRCA pedicle was divided proximally. Radial nerve and posterior cutaneous nerve of forearm were isolated by rubber bands and protected. The flap elevated in a proximal to distal direction.

Fig. (6): The vascular pedicle was proximally divided and the flap elevated from proximal to distal. Radial nerve and posterior cutaneous nerve of forearm were isolated by rubber bands and protected.

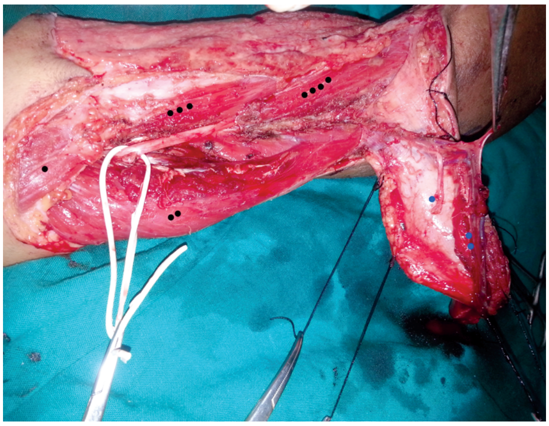

Fig. (7): The flap was elevated from proximal to distal including septum with transected post. cut. nerve of arm (1 blue dot) and the vascular pedicle (2 blue dots) held by forceps. Deltoid marked by 1 black dot. Triceps marked by 2 black dots. Biceps marked by 3 black dots. Brachioradialis marked by 4 black dots.

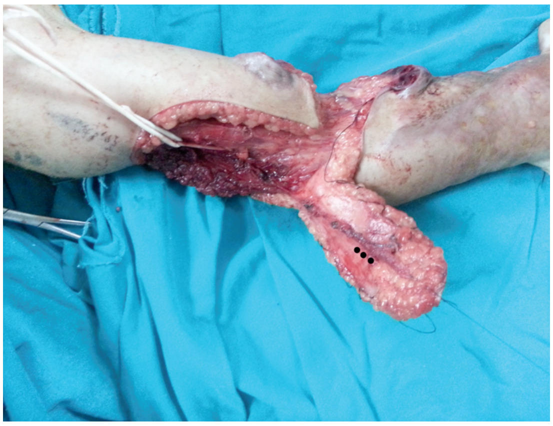

Fig. (8): The flap was elevated including the septum and vascular pedicle attached to it in a reverse-flow pattern (marked by 3 black dots).

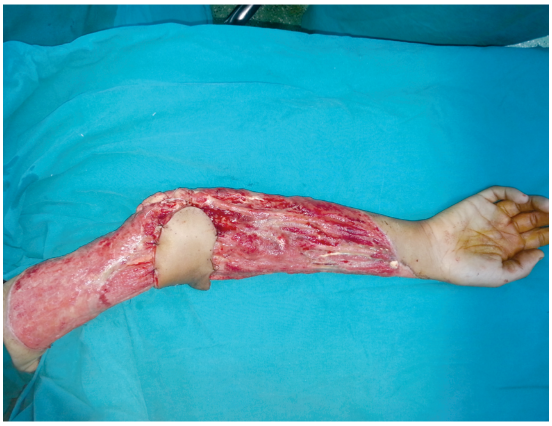

Fig. (9): The flap was rotated to cover vital structures in cubital fossa and line the mobile joint surface. Skin graft was applied to remaining raw surface.

Fig. (10): The flap rotated 90 degrees to cover the post release defect. The flap donor site was skin grafted.

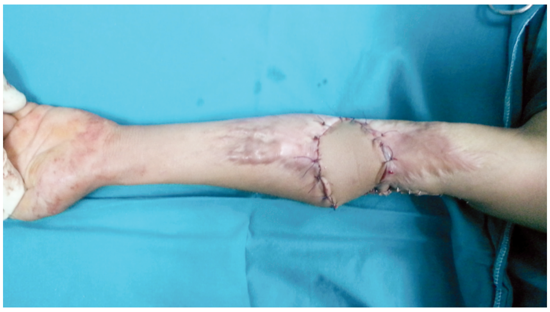

Fig. (11): The flap was rotated 90 degrees into the defect and the donor site skin grafted.

RESULTS

This study included two girls, and six boys (total eight patients). Patients' age was from 4 to 11 years. The defects were related to release of post burn contracture in 6 cases and traumatic skin avulsion in 2 cases. All the defects were covered by reverse flow lateral arm flap.

All the flaps survived completely without flap loss. In one case, there was marginal distal superficial necrosis, managed conservatively and healed spontaneously well. There was no flap congestion or wound dehiscence. Flap size ranged from 15x7cm to 12x5cm, with constant vascular pedicle in all harvested flaps. The donor site was skin grafted in all cases and showed satisfactory appearance.

Aesthetically, the flap provided stable coverage with good color and texture match and satisfactory appearance. The grafted donor sites were accepted aesthetically by both, surgeons and parents. Functionally, there was elbow full range of motion in 5 patients, and 3 patients had about 10 to 30-degree extension loss remained, Figs. (12-15).

One boy developed temporary radial nerve palsy, manifested by wrist drop. Nerve conduction study was done and revealed neuropraxia. A 3-month course of steroids, neurotonics and physiotherapy improved the condition completely.

Fig. (12): A 6-week post-operative photo. Flap provided stable coverage with about 30-degree extension loss. Skin graft take was near complete.

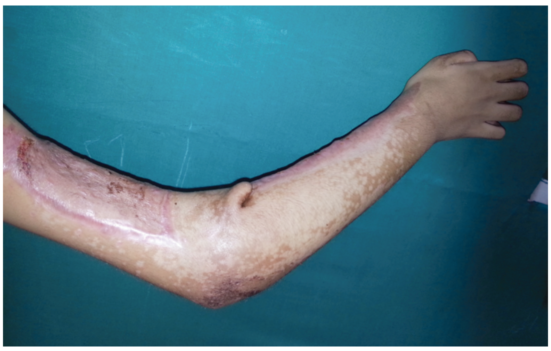

Fig. (13): A 6-week post-operative photo. The grafted donor site was acceptable and the small dog ear at the pivot point resolved spontaneously over time.

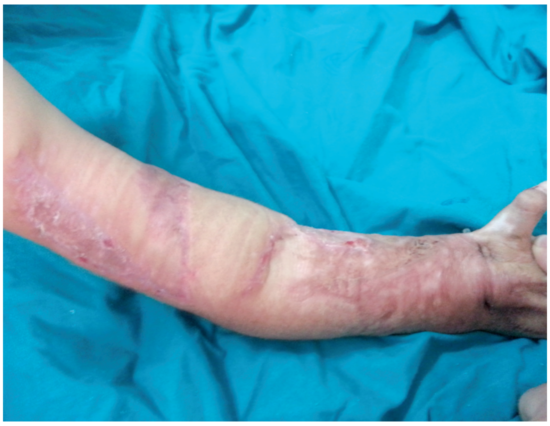

Fig. (14): A 3-months post-operative photo. The flap provided full range of motion and donor site appearance was acceptable.

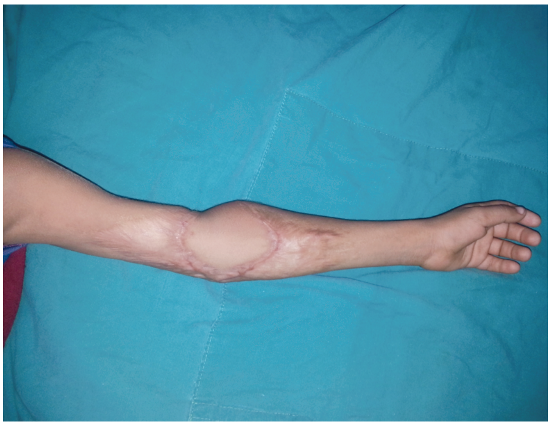

Fig. (15): A 3-months post-operative photo. The flap provided stable coverage and patient resumed a full elbow extension.

DISCUSSION

Management of antecubital contractures and/or tissue loss around the elbow, due to different causes, as trauma, burns, ulcers, tumor excision, etc., is a reconstructive challenge. This critical mobile area needs sound and timely reconstruction by supple and durable flaps to allow early return of motion to prevent stiffness. Reconstructive options include skin grafts, local fasciocutaneous flaps, muscle flaps, distant pedicled flaps, and free flaps with each option has its advantages and disadvantages **[1-5]**.

Axial fasciocutaneous flaps, as the radial forearm pedicled flap, can be used to reconstruct medium to large soft tissue defects of the elbow region. Although it has long pedicle, supple soft tissue, and easy dissection, it requires skin grafting of the donor site which may be problematic, and sacrifices a major artery which may cause hand ischemia **[6,7]**.

Distant pedicled two-stage abdominal/trunk flaps are applicable only when local and regional flaps are unavailable, or free tissue transfer cannot be done due to lack of recipient vessels or unfit patients. They are used infrequently, as they require prolonged immobilization, multiple surgical procedures, and long hospital stay as compared to simpler options **[8]**.

Free issue transfer is the state of art reconstructive option, transferring sufficient supple tissue in a single stage procedure, but requires microsurgical skills and expertise, together with surgically fit patients **[9]**.

Although the lateral arm flap was used initially as a free flap in head and neck reconstruction, the pedicled reverse flow modification provided a useful flap in covering small to medium sized anterior, posterior elbow defects with similar tissue characteristics. It provides supple and stable soft tissue coverage without sacrificing major vessel and avoiding the use of microsurgical tissue transfer **[10]**.

Controversy exists about the donor site outcome of the lateral arm flap. After analyzing donor site appearance in 123 patients, Graham et al., found the scar appearance on the lateral arm to be the main reason for patient dissatisfaction, especially true, when skin grafts were applied to the donor site, and when the patients were females. Coming as a second reason for dissatisfaction was the lateral epicondyle pain. Contrary to the previous findings, Depner et al., in their study found that scar appearance was well accepted by the patients irrespective to patients' gender. They explained this discrepancy by the fact that avoided skin grafting of the donor site by limiting flap width to 6cm allowing direct closure of the donor site **[13,14]**.

During our study, we had found many advantages of the reverse flow lateral arm flap. Its vascular anatomy was consistent and reliable with rapidly acquired learning curve. We were able to isolate and protect the radial nerve and its two cutaneous branches and include the vascular pedicle with the flap in all our cases. The flap provided a single stage supple and stable coverage of elbow defects in our patients. Being borrowed from a neighboring territory, lateral arm, the flap provided soft tissue coverage of similar skin color and texture and consequently the flap provided adequate aesthetic appearance. Being a fasciocutaneous flap, we found the flap to be thin and pliable enough to start elbow mobilization early postoperatively within 2 to 3 weeks and consequently the flap provided adequate functional outcome.

Also, during our work, we found the reverse flow lateral arm flap to have many privileges over other reconstructive techniques. The flap covered the neurovascular structures at the floor of cubital fossa with supple tissue, with no risk of recurrent ulceration or re-contracture, unlike skin grafts. The flap did not require sacrificing major artery or threatened hand circulation as the radial forearm flap may do. Unlike the pedicled abdominal flaps, the reverse lateral arm flap provided single stage coverage, allowed free patient and arm mobility and shorter hospital stay. We executed the flap in a short operative time without the need to do skillful microvascular anastomosis, as the free tissue transfer would require.

Tung et al., used the reverse flow lateral arm flap to cover posterior defects of elbow region in 7 patients. All their flaps survived and their patients were able to restore full range of motion at the 6 month follow-up. They had forearm parasthesia in 3 patients and conspicuous scarring in a young female patient [15]. Similarly, we used the flap in 8 patients to cover the cubital fossa. Eventually, all our flaps survived. Five patients got full range of motion and 3 patients remained with extension loss of 10 to 30 degrees. We had one boy developed radial nerve neuropraxia and the condition resolved uneventfully.

Turegun and his colleagues used the reverse flow lateral arm flap for management of eleven patients with post-burn contractures of antecubital region. They had 10 flaps survived totally. Complication occurred in 1 flap showed loss of distal edge, where they managed it by debridement and skin grafting. All patients showed satisfactory improvement of function of elbow joint [16]. In our study, we used the reverse flow lateral arm flap to manage eight patients, six with post burn contracture and two with trauma. We had 7 flaps survived totally, with complication occurred in 1 flap showed distal marginal necrosis and healed uneventfully conservatively, with all our patients also showed satisfactory improvement of function of elbow joint.

Prantl and his colleagues used the reverse flow upper arm flaps in ten patients to cover elbow wounds, over a 2-year period; they did a reverse flow lateral arm flap in 8 patients and reverse flow medial arm flap in 2 patients. Of the 8 patients with the reverse flow lateral arm flap, 6 patients had chronic ulcers, 1 patient had osteomyelitis and 1 patient had post burn elbow contracture. Their age ranged from 40 to 70 years, with flap dimensions ranged from 15x8cm. All eight reverse flow lateral arm flaps survived completely, with only one flap showed distal third necrosis and managed conservatively and healed uneventfully. All the donor sites were closed directly and healed uneventfully. The flap provided stable supple wound coverage with excellent postoperative elbow mobility [17]. In our study, we used the reverse flow lateral arm flap in 8 patients, with their ages ranged from 4 to 11 years, with flap dimensions ranged from 15x7cm to 12x5cm. All our flaps survived completely, with one flap showed distal marginal necrosis and healed uneventfully conservatively. But contrary to them, we skin grafted the donor site in all our cases. Similarly, the flap provided stable soft coverage with adequate post-operative elbow mobility.

Morrison and his colleagues used the reverse flow lateral arm flap to reconstruct post-traumatic antecubital tissue loss in a 2 stage manner in 3 patients. The flap provided stable coverage in the 3 patients. Only one flap showed distal loss and healed uneventfully [18].

Sami Ullah et al., used the lateral arm flap in 33 patients, as a free flap in 23 patients to reconstruct different body areas, and as a reverse flow flap for elbow coverage in 10 patients. The ten patients were 5 males and 5 females, and their age ranged from 6 to 26 years, with 6 patients had post burn elbow contracture, 3 patients had traumatic wounds of cubital fossa, and 1 patient had olecranon fracture with exposed plate. The flap average size was about 8x5cm. All the reversed lateral arm flaps survived completely and the donor sites were closed directly. They concluded that, this flap is safe, reliable, and can provide stable coverage [19]. In our study, we used the reverse flow lateral arm flap for cubital fossa coverage in 8 patients, 6 boys and 2 girls, their age ranged from 4 to 11 years, with 6 patients had post burn elbow contracture and 2 patients had posttraumatic skin loss. The flap size ranged from 15x7cm to 12x5cm. All our flaps survived eventually, but unlike them, we skin grafted the donor site in all our cases. Similarly, we found the flap to be reliable and can provide stable coverage.

Conclusion:

Our results in this study were more or less comparable to the results of the above mentioned studies. We found the following advantages of the reverse flow lateral arm flap; consistent vascular pedicle and anatomy, no need to sacrifice major vessel or functional muscle, providing a single stage stable supple coverage with an acceptable aesthetic and functional outcome, and the ability of the flap to cover anterior and posterior defects of elbow joint.

REFERENCES

1- Joshua M.A. and Kevin C.C.: Flap Reconstruction of the Elbow and Forearm: A Case-Based Approach. Hand Clin., 30 (2): 153-163, 2014.

2- Stevanovic M. and Sharpe F.: Soft-tissue coverage of the elbow. Plast. Reconstr. Surg., 132 (3): 387e-402e, 2013.

3- Davami B. and Perkhamene G.: Versatility of local fasciocutaneous flaps for coverage of soft tissue defects in upper extremity. J. Hand Microsurg., 3 (2): 58-62, 2011.

4- Patel K.M. and Higgins J.P.: Posterior elbow wounds: Soft tissue coverage options and techniques. Orthop. Clin. N. Am., 44: 409-417, 2013.

5- Ravikiran N., Shashank C., Aniket D., et al.: Reconstruction of post-traumatic upper extremity soft tissue defects with pedicled flaps: An algorithmic approach to clinical decision making. Chin J. Traumatol., 21 (6): 338-351, 2018.

6- Megerle K., Sauerbier M. and Germann G.: The evolution of the pedicled radial forearm flap. Hand (NY), 5: 37-42, 2010.

7- Zenn M.R. and Jones Glyn: Radial Forearm Flap. In: Reconstructive Surgery: Anatomy, Technique, and Clinical Applications. QMP, Inc; St Louis, Missouri, p. 885, 2012.

8- Rockwell W.B. and Ley E.: Abdominal Flaps. In: Rayan G.M., Chung K.C., editors. Flap Reconstruction of the Upper Extremity: A Master Skills Publication. American Society for Surgery of the Hand; Rosemont IL, p. 171-177, 2009.

9- King E.A. and Ozer K.: Free skin flap coverage of the upper extremity. Hand Clin., 30: 201-209, 2014.

10- Sauerbier M. and Geissler G.: Lateral Arm Flap for Hand Wrist Coverage. In: Moran S.L., Cooney W.P., editors. Soft Tissue Surgery: Master Techniques in Orthopedic Surgery. Lippincott Williams and Wilkins; Philadelphia, PA, pp. 179-180, 2009.

11- Song R., Song Y. and Yu Y.: The upper arm free flap. Clin. Plast. Surg., 9: 27-359, 1982.

12- Katsaros J., Shusterman M., Beppu M., et al.: The lateral upper arm flap: Anatomy and clinical applications. Ann. Plast. Surg., 12: 489-500, 1984.

13- Graham B., Adkins P. and Scheker L.: Complications and morbidity of the donor and recipient sites in 123 lateral arm flaps. J. Hand Surg. Br., 17: 189-192, 1992.

14- Depner C., Erba P., Rieger U.M., et al.: Donor-site morbidity of the sensate extended lateral arm flap. J. Reconstr. Microsurg., 28: 133-138, 2012.

15- Tung T.C., Wang K.C., Fang C.M. and Lee C.M.: Reverse pedicled lateral arm flap for reconstruction of posterior soft-tissue defects of the elbow. Ann. Plast. Surg., 38: 635-641, 1997.

16- Turegun M., Nisanci M., Duman H., et al.: Versatilityof the reverse lateral arm flap in the treatment of post-burn antecubital contractures. Burns, 31: 212-216, 2005.

17- Prantl L., Schreml S., Schwarze S., et al.: A safe and simple technique using the distal pedicled reversed upper arm flap to cover large elbow defects. J. Plast. Reconstr. Aesthet. Surg., 61 (5): 546-551, 2008.

18- Morrison C.S., Sullivan S.R., Bhatt R.A., et al.: The pedicled reverse-flow lateral arm flap for coverage of complex traumatic elbow injuries. Ann. Plast. Surg., 71: 37-39, 2013.

19- Sami Ullah, Muhammad Asif, Muhammad Ubaid, et al.: Lateral Arm Flap: Its Usage as Pedicled and Free Flap. Cureus, 12 (2): e12136, 2020.