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Perforator artery repair in revascularization of extremity degloving injuries ☆

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ABSTRACT

Introduction: This article aims to expand the microsurgical treatment options for extremity degloving injuries with perforator artery repairs of the specific degloved angiosomes in upper and lower extremity.

Methods: Fourteen perforator arteries were repaired in seven patients. Four of them had circumferential degloving and 3 of them have non circumferential degloving injury. All had repair of the perforator arteries of the specific degloved segments. Four patients had additional vein repairs but none of the patients had AV shunts.

Results: All perforators provided adequate arterial supply to their specific angiosomes with some necrotic areas in neighboring angiosomes.

Conclusions: Perforator artery repair within the degloved tissues provides a direct arterial supply successfully even if one could not find an intact venous plexus.

Introduction

Degloving injuries of skin and subcutaneous tissues of extremities poses a challenge to the reconstructive surgeon. The injury occurs by avulsion of skin from the deeper structures. The plane of degloving is usually at the weakest point between the fascia and the subcutaneous tissue but may involve deeper structures as well. The injury totally or partially devascularize the degloved tissues by transecting the nourishing perforator vessels [1,2]. The types of injury are classified in four patterns; limited with abrasion/avulsion, non-circumferential, circumferential single plane, and circumferential multiplane degloving. The injury may be closed or open type [3].

The treatment options are mainly: waiting for demarcation and debridement with flap or graft reconstruction [2,4], defatting the degloved skin and use as skin graft [5], venous repairs and arterialization of the venous system by arteriovenous (AV) shunting [6–9]. It is observed that the literature always concentrates on performing the microsurgical reconstruction of extremity degloving by only using the available veins within the degloved segment (either by direct vein repair or by AV shunting) [6–9]. The perforator arteries of these angiosomes are traditionally accepted to be unrepairable due to mechanism of injury [2,7,9].

This article aims to expand the microsurgical treatment options for extremity degloving injuries with perforator artery repairs of the specific degloved angiosomes in upper and lower extremity.

Patients and methods

Seven cases were operated between 2014 and 2017. Three of them had lower extremity degloving injury and four had upper extremity injuries. The data about the characteristics of the injuries are summarized in Table 1. Four of them had circumferential degloving and 3 of them have non-circumferential degloving injury. All had repair of the perforator arteries of the specific degloved segments. Four patients had additional vein repairs but none of the patients had AV shunts.

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Table 1
Patients Data.

Patient number	Age(year)/ SexF: Female M: Male	Localization of degloving	Type of degloving	Number of perforator artery repaired	Number Veins repaired	Source of arterial supply	Viability of specific angiosomes	Viability of neighboring degloved angiosomes
1	30/F	Right thigh	Circumferential single plane	1	No vein repaired	Original proximal stump of the perforator	Totally viable	Partially necrosed
2	17/M	Right plantar skin with heel	Non circumferential Single plane	1	1	Another uninjured branch of parent artery	Totally viable	Partially necrosed
3	20/M	Total right foot dorsal and plantar skin	Circumferential single plane	4	4	Original proximal stump of the perforators	Totally viable	Totally necrosed
4	67/F	Right forearm, palm and hand dorsum	Circumferential single plane	2	No vein repaired	Original proximal stump of the perforators	Totally viable	Totally necrosed
5	47/M	Right Forearm and hand dorsum	Circumferential single plane	2	No vein repaired	One original stump One parent artery itself	Totally viable	Partially necrosed
6	41/M	1st dorsal metacarpal area	Non circumferential multiplane with amputation	2	4	Original proximal stump of the perforators	Totally viable	Not injured
7	43/M	Palmar skin	Non circumferential single plane	2	2	Original proximal stump of the perforators	Totally viable	Not injured

Results

The results are summarized in Table 1. In all cases it was possible to repair small caliber perforator arteries despite avulsion mechanism of the degloving injury. Fourteen perforator arteries were repaired in seven patients. Degloved perforators were sutured to their original proximal stumps in twelve of the fourteen perforator arteries. The original proximal stumps were not suitable for repair due to avulsion injury in two perforators. One perforator was repaired to its parent artery (posterior interosseous artery) as end to end fashion and one perforator was repaired to a different uninjured branch of its parent artery. All repaired perforator arteries supplied adequate arterial blood to their specific angiosomes with complete survival of the specific angiosomes in all cases. The repaired perforators were partially successful to provide adequate arterial supply to neighboring degloved angiosomes. There was partial necrosis of the neighboring degloved angiosomes in three cases and total necrosis of the neighboring degloved angiosomes in two cases. In two cases, neighboring angiosomes were not degloved.

Case examples

Case 1: Circumferential thigh degloving (Patient number 1 in Table 1).

A 30 year old woman had a severe traffic accident that a heavy loaded truck run over her right lower extremity. There was a total circumferential single plane degloving of the right thigh area extending to the calf. Total right thigh skin including the skin envelope of right knee was devascularized. The rotating wheel caused torsion and degloving of the entire skin at the weakest plane over the muscle fascia without causing any fracture or muscle laceration. The arterial Doppler ultrasonography revealed unaffected femoral popliteal and crural arteries. A septocutaneous perforator was found between vastus lateralis and rectus femoris muscles. The distal stump at the degloved skin was also explored and prepared for repair. The anastomosis was performed by 10/0 suture material. After repair the devascularized thigh skin capillary refill turned to pink healthy color with revascularization. It was not possible to find another perforator at medial or posterior thigh and no vein was found for repair. Suction drains were applied and the inguinal laceration was repaired. In the postoperative period it was possible to follow the patency of the perforator repair by hand held Doppler device. Skin necrosis was observed at medial and posterior thigh areas, inguinal area and around knee after ten days but the anterolateral thigh skin maintained its vascularity by the repaired perforator artery. Split thickness skin grafting was performed at fourth week. It was possible to harvest skin graft from the revascularized healthy anterolateral thigh area. The graft take was good and the patient was discharged at seventh week for follow up (Fig. 1a-h).

Case 2: Patient number 5 in Table 1.

A 47 year old male patient had skin degloving of the distal half of the dorsal and volar forearm including the entire hand dorsum to the webs. The injury occurred by an industrial roller machine. There was a skin loss in volar part of the degloved skin. The plane of degloving was between the fascia and skin leaving the veins within the fascia. The degloved skin had no veins to repair. Two perforator arteries were found in dorsal part of the degloved skin. No perforators were detected in the volar part. The distal dorsal perforator was just proximal to wrist and the perforator within the degloved skin was suitable for repair. The original proximal stump of this perforator was not appropriate for repair due to avulsion injury so end to end repair of the skin perforator directly to its parent posterior interosseous artery was performed by 10/0 suture material. The second dorsal perforator was proximally located and both stumps were suitable for end to end repair. There was a skin loss at the volar surface of forearm and it was left open for future skin grafting. It was not possible to repair any vein due to the plane of degloving. The angiosomes of the repaired perforators were well vascularized. At third week it was observed that the entire dorsum of forearm and hand survived with only the necrosis of the degloved volar skin and fifth finger. Afterwards a skin graft was applied to necrotic skin with distal part amputation of the fifth finger (Fig. 2(a)–(h)).

Case 3: Patient number 6 in Table 1.

A 41 year old male patient had localized degloving amputation of the dorsal metacarpal area of the right thumb. The skin, small part of thenar muscle, 2 cm segment of extensor tendon and a small part of metacarpal cortex was avulsed by a powerful industrial vacuum machine. It was possible to find two perforator arteries arising from the radial artery. The avulsed amputated part also included segments of distal cephalic vein branches. The tendon was repaired as a graft. The small thin bone cortex was debrided. The small muscle was preserved without repair. Two perforator arteries were repaired to their original proximal stumps by

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Fig. 1. (a) Devascularized severe circumferential degloving of the right thigh and knee skin with a traction laceration at the inguinal area. (b) Single plane degloving of the skin and subcutaneous tissues from the muscle fascia. It was possible to reach to the calf under the degloved skin from the inguinal laceration. (c) A septocutaneous perforator between vastus lateralis and rectus femoris muscles was identified and repaired to revascularize the thigh skin. It was possible to retract the inguinal laceration to perform the anastomosis. (d) At the third week, after demarcation and serial debridements. It is seen that the repaired perforator managed to revascularize its angiosome at the anterolateral thigh area. Black arrow indicates the location of the repaired perforator. (e) Total loss of skin envelope around knee and inguinal area, partial skin loss at the medial thigh and near total skin loss at posterior thigh were observed. (f) It was possible to harvest split thickness skin graft from the revascularized anterolateral thigh for closure of the neighboring wounds. (g) Lateral view three months after the injury. (h) Anterior view.

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Fig. 2. (a) Degloving of forearm skin leaving the veins on the fascia. (b) Volar part was also degloved with some skin loss. (c) The entire hand dorsum was degloved. (d) Distal dorsal perforator repaired to parent posterior interosseous artery. (e) Proximal dorsal perforator repaired to its original stump. (f) Demarcation at fourth day after operation with good vascularity at the repaired specific angiosomes. (g) At third week the entire dorsal hand and forearm skin and subcutaneous tissue managed to survive with superficial crusts. (h) The volar skin defect and volar degloved skin band necrosis. (i) Four weeks after injury; debridement of the crusts and fifth finger stump closure performed. There was superficial skin loss at the ulnar side of hand dorsum. Possibly due to abrasion by the machine. (j) The volar defect was skin grafted.

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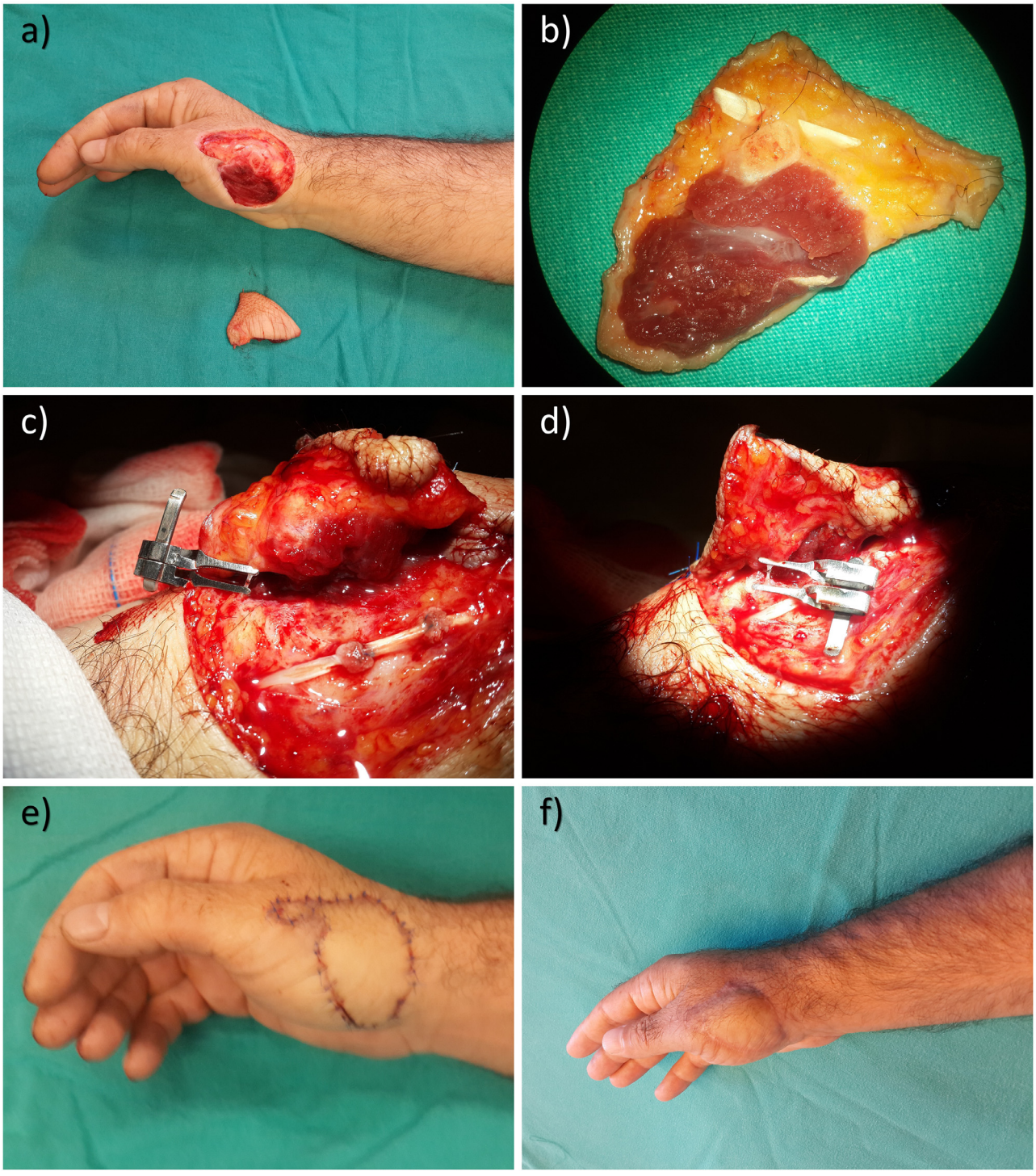

Fig. 3. (a, b) Avulsion amputation of composite skin muscle tendon and bone by a powerful vacuum machine. (c) The first perforator artery repaired. (d) The second perforator artery repaired. One of the distal veins repair is seen left to the perforator repair. (e) Two weeks after replantation by perforator arteries. (f) Result at third month.

10/0 suture material. Four vein repairs were performed (two distal and two proximal repairs in a flow through fashion). No complication occurred postoperatively and the small avulsed segment had survived without vascular problems (Fig. 3(a)–(f)).

Discussion

Microsurgical reconstruction of degloving injuries is difficult but worthwhile. Traditionally these injuries are treated with skin grafts and pedicled or free flaps. However, we think that it is important to revascularize the original tissue to avoid inadequate coverage or skin bulkiness. Microsurgical repair of nutritious vessels can provide adequate arterial supply to preserve the vitality in degloving injuries of extremities. Kurata et al. states that the arterial supply is more critical than the venous drainage, though both are important [1]. However, the perforator arteries of the degloved segments are believed to be unrepairable due to avulsion during degloving. Therefore, AV shunts are used for arterialization of the degloved

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segments [6–9]. Lo et al. think that the planes of arm degloving preserve large longitudinal superficial venous plexus whilst directly transecting the arterial perforators, which are perpendicular to the fascia and by reason of the arterial circulation in the degloved segment is at the subdermal and dermal plexus levels, and they are generally unsuitable for anastomosis [9]. Slattery et al. also stated that the direct microvascular anastomosisis was not feasible [7]. Both authors referred to the study of McGregor [2].

Our results showed us that, contrary to statements in literature, it was possible to repair perforator arteries in patients with degloving injuries. Moreover, all repaired perforators were able to provide adequate arterial supply to their angiosomes with complete survival despite avulsion mechanism of the degloving injury.

Lo et al. in their comprehensive study divided the injuries into non-critical and critical depending on adequacy of perfusion. The critical injuries are divided into salvageable and non-salvageable. They stated that salvageable injuries are those in which the superficial venous system is intact for attempted AV shunting. Our results also showed that the degloved skin and subcutaneous tissues were still salvageable despite the lack of an intact superficial venous system. In this series no vein repairs were performed in three of the seven patients.

We think that it is critical to find the distal stump of the degloved perforator artery. It is preferred to repair the degloved perforator artery to its original proximal stump as we did in twelve of the fourteen perforator repairs. However, if the proximal stump is not suitable for repair for any reason the parent artery or a nearby uninjured artery can be dissected.

In perforator flap dissection neighboring vascular territories can be added to the flap by using the linking connections of the angiosomes [10]. The repaired perforators in our cases were partially successful to supply adequate perfusion to neighboring vascular territories. The degloved neighboring angiosomes of five patients had partial necrosis in three cases and total necrosis in two cases. This was possibly due to damage to these linking connections during degloving. We believe that at least one perforator artery must be repaired for each degloved angiosome to increase chance of total survival.

Conclusion

The microsurgical treatment options for extremity degloving injuries are not limited to vein repair and AV shunts. Perforator artery repair within the degloved tissues provides a direct arterial supply successfully even if one could not find an intact venous plexus.

Declaration of Competing Interest

All authors report no conflict of interest in relation to the content of this manuscript.

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