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CASE REPORT
Hand

Reverse Flow Shunt Restricted Free Venous Flap for a Ring Avulsion Injury

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Summary: Arterialized venous flaps can be an excellent option for reconstruction of digital defects. Previously, they remained unpopular owing to the high rate of venous congestion. Different techniques of restriction of the arteriovenous shunting have been described to mitigate this problem. In this article, the authors discuss a unique case whereby a reverse flow shunt restricted venous flap was used in an Urbaniak type III ring avulsion. *(Plast Reconstr Surg Glob Open 2022;10:e4511; doi: 10.1097/GOX.0000000000004511; Published online 20 September 2022.)*

INTRODUCTION

Ring avulsion injuries can range from soft tissue laceration to complete amputation, with variable degree of injury to soft tissue, tendon, joint, and bone.[1] Multiple classification systems have been adopted for ring avulsion injuries; however, Urbaniak's[2] was the first published classification scheme. According to him, ring avulsion can be classified into three classes: (1) adequate circulation, (2) inadequate circulation, and (3) degloving/complete amputation.

Complete avulsion injuries that are not a candidate for revascularization are best reconstructed using microsurgical techniques, which can provide robust tissue coverage. Coverage of a denuded finger using locoregional flaps has been reported, but with nonsatisfying aesthetic and functional outcomes.[3]

CLINICAL CASE

We describe a novel case of a shunt restricted arterialized venous flap (AVF) to salvage an Urbaniak III ring avulsion. A 17-year-old male professional footballer presented with ring avulsion injury of his left middle finger extending to the proximal interphalangeal joint (Fig. 1). On examination, the amputate was not suitable for replantation. The patient was taken to theater on the same day for abdominal pocketing of the degloved digit to preserve structures and prevent desiccation.

Different delayed reconstructive options were discussed with the patient. A second toe transfer was rejected because of his profession. A plan was made to cover the dorsum of the digit with a subdermal abdominal tissue and use an arterialized shunt restricted venous flap to reconstruct the volar defect.

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SURGICAL APPROACH

In our case, the digit was buried for 2 weeks under the abdominal skin which was used for reconstruction of the dorsal defect. The volar skin was reconstructed using a reverse flow shunt restricted AVF measuring 2.5×6cm raised in a supra-fascial plane from the distal forearm (Figs. 2, 3). The distal volar forearm is the best donor site for reconstruction of distal digital defects; the skin is very thin and pliable, and the donor and recipient sites are included in the same operative field. The recipient site was prepared with exposure of the digital artery and one volar vein. Veins were traced before tourniquet being inflated. Shunt restriction was created by utilizing microligaclips to interrupt any communication between the venous and arterial systems. The flap was turned over 180°, and end-to-end anastomoses were performed under a surgical microscope using 10/0 S&T sutures (S&T AG, Neuhausen, Switzerland) to the artery and 11/0 S&T to the vein. This allows one arterialized afferent venous vessel and another efferent vessel for venous drainage (Figs. 3, 4). Three months postoperatively, the patient has protective sensation and near full range of motion (ROM). (**See Video [online],** which demonstrates the pliability of the flap and excellent range of motion 3 months postoperatively.)

POSTOPERATIVE MANAGEMENT AND OUTCOME

The flap was monitored clinically for 5 days after the procedure by color, surface temperature, turgor, capillary refill, and pinprick. During the hospital stay, the hand

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Fig. 1. Urbaniak type III ring avulsion injury of the left middle finger.

Fig. 2. Marking of the distal forearm as a donor site for the venous flap.

should be kept elevated to help with venous drainage. In most small-sized flaps, some degree of venous congestion is expected in the immediate postoperative period, which should improve over time. Larger flaps contribute not only to the draining capacity of the flap but also to the tension-free closure and postoperative swelling accommodation. Aggressive physiotherapy and Coban taping (Coban, 3M, St. Paul, MN) were initiated at 2 weeks. Excellent functional and aesthetic results could be obtained provided that the patient shows a high degree of motivation,

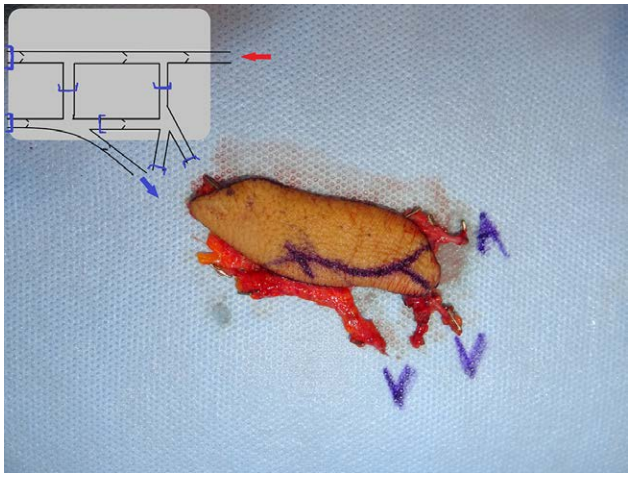

Fig. 3. Venous flap harvested from the distal volar forearm. A is the afferent vein that was arterialized and the V's are the efferent veins; one of them was anastomosed to the recipient vein. The diagram on the upper left-hand side shows the technique of clipping to improve the flow. Clips were drawn in blue color.

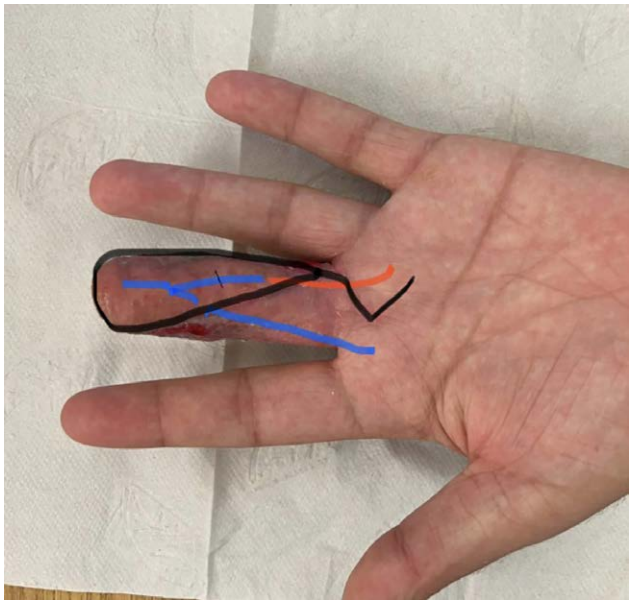

Fig. 4. Markings show how the flap was transferred to the finger and the anastomosis pattern.

especially in terms of compliance to the strict hand therapy regimen.

DISCUSSION

AVFs are advantageous as there is no need to sacrifice a major artery of the donor site, the flap can be harvested easily without deep dissection, and can provide thin pliable tissue readily available to cover multiple skin defects if needed.[4] Recently, multiple techniques have been described to improve the AVF's outcome. Two techniques showed very successful results: (1) the retrograde pattern in which valves act as shunt restrictors, thus enhancing the flap perfusion and reducing the rate of flap failure[5] and

(2) the antegrade shunt restriction technique in which ligating clips are used to act as "simulated valves" maintaining secured separation between the venous and arterial circulations.[6,7] Lombardo et al[8] discussed how to improve the viability of AVFs by combining both techniques: the retrograde flow and shunt restriction, achieving more reliable isolation between the venous and arterial systems.

In the absence of microsurgical facilities, a tubed groin flap could be used for reconstruction of circumferential finger defects; however, this is bulky and would need multiple operations. Another option is to discuss amputation with the patient; however, this was not accepted by our patient. Locoregional flaps in this case would be challenging due to the size of the defect and also the problems it would cause to the remaining digits. Superficial circumflex iliac artery perforator and anterolateral thigh flaps were also considered as other microsurgical options; however, they are too bulky in comparison to the free venous flap.

Giesen et al[9] reported reconstruction of a circumferential avulsion injury in one finger (left little finger) in a 47-year-old male patient using a retrograde arterialized free venous flap harvested from the flexor side of the forearm. The flap size measured about 100 cm2, and the donor site could not be closed directly; hence, a skin graft was used for closure. They included the medial cutaneous nerve of the forearm to innervate the flap; however, the patient experienced neuropathic pain all over the reconstructed digit postoperatively.

Another case was reported by Takeuchi et al[4] in which a 21-year-old male worker sustained a complete amputation at the level of the distal interphalangeal joint of his right index finger and complete degloving injuries at the level of the proximal interphalangeal joint of his right middle and ring fingers. A large venous flap was needed, so they used the dorsum of the foot as a donor site. The flap was transferred to the defect of the middle and ring fingers and was wrapped around both fingers. The donor site was covered with full-thickness skin grafts. The surgical syndactyly was separated 1 month after the primary procedure, and both fingers showed good postoperative active range of motion. We think that the thin hairless tissue from the distal volar forearm is the best donor site as long as a small flap size is required, and hence, primary closure is possible. However, if the needed flap size is relatively big necessitating a skin graft for closure, then the dorsum of the foot would be a better donor site option.

Although we did not use a neurotized flap, the patient developed protective sensation. This was because the patient had sensory reeducation with therapy. Sensory reeducation is important, and restoration of protective sensation can be achieved, particularly in young patients. Ozcelik et al[10] studied the sensory recovery outcomes of fingertip replantations without nerve repair. They reported that patients who received sensory education had significantly better results in sensory testing. They overall concluded that restoration of satisfactory sensation was achieved in their patients even without neurorrhaphy.

CONCLUSIONS

Complete degloving injuries of the fingers that are not amenable to replantation may result in poor cosmetic and functional outcome. If the underlying skeleton and tendons are intact, soft tissue coverage using AVFs offers a custom-made flap for digital reconstruction. Shunt restriction techniques provide further enhancement of peripheral perfusion and reduction of venous congestion, helping to achieve unparalleled results.

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