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Original Article

Flow-through flap with wrist epithelial branch of ulnar artery for repair of finger soft tissue defect: a case series

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Abstract: Objective: To evaluate the surgical technique and the efficacy of flow-through flap with a wrist epithelial branch of the ulnar artery to repair a finger soft tissue defect. Methods: Between June 2015 and December 2017, 12 cases of soft tissue defects of fingers and injured digital artery were repaired by flow-through flap with wrist epithelial branch of the ulnar artery, including 7 males and 5 females (age range: 18-45 years old, average age: 23.6 years old). The causes of injury included electric saw injury in 7 cases, and machine crush injury in 5 cases. 5 cases were combined with tendon injury, 4 cases with fracture, 12 cases with vessel injury and 2 cases with nerve injury. The area range of the flap was 3.0 cm ×1.8 cm to 6.0 cm ×3.0 cm. The length of the pedicles of the flaps ranged from 2.3 cm to 4.7 cm, with an average length of 3.7 cm. The donor sites were sutured directly in 10 cases, and 2 cases were repaired with a full-thickness skin graft from the ilioinguinal region. Flow-through anastomoses of the distal and proximal end of the wrist epithelial branch of the ulnar artery to the distal and proximal end of the digital artery were created, so as to connect the vessels and reach the physiologic state of blood supply. Results: All flaps and skin grafts survived after operation, and all wounds healed at I phase. All patients were followed up 6-12 months (mean: 9 months). The flaps exhibited smooth appearance and soft texture, similar to that of the normal surrounding skin. At last follow-up, the two-point distance of flaps was 9-15 mm (mean: 11 mm). According to the assessment of upper limb function issued by the Hand Surgery Society of Chinese Medical Association, the hand function was excellent in 10 cases, and good in 2 cases. The ulnar wrist donor areas only had linear scar. Conclusion: Flow-through flap with wrist epithelial branch of ulnar artery exhibits strength in a concealed donor site, reliable blood supply, and simple operation. Flow-through method can be used to repair a broken or defective digital artery in I stage. It is a good method to repair a soft tissue defect of fingers.

Keywords: Soft tissue defect, surgical flap, epithelial branch of ulnar artery, flow-through, repair

Introduction

Soft tissue defects (STDs) of the hand are generally induced by diverse reasons, among which finger STDs with digital artery injuries account for a large proportion. In the past, the digital artery was repaired by vein vascular transplantation at the initial stage, and subsequently repaired by adjacent finger skin flap, abdominal pedicled skin flap, dorsal metacarpal artery skin flap, retrograde digital artery skin flap, or venous arterialized skin flap. In the above-mentioned methods, venous vessels would be incised from ulnar side of forearm during operation, resulting in extra scar and prolonged operation. Another 3 to 4 weeks are required for the pedicle division of the abdominal pedicled skin flap. The limitation of this method lies in the fact that the treatment period is prolonged and the clinical effect is far below the expected level of patients affected. Collectively, it is imperative to adopt a method that can repair STDs of the digital artery and shorten the treatment course. A total of 12 cases with finger STDs underwent flow-through flap with carpal epithelial branch of ulnar artery from March 2016 to March 2018, and their clinical efficacy was observed.

Clinical data

A total of 7 males and 5 female patients were included (age range: 18-45 years old, average age: 23.6 years old). Specifically, the defect was caused by machine crush in 5 cases, and by electric saw in 7 cases. The duration from injury occurrence to admission of patients affected was 0.5-9 hours, with an average of 3.5

hours. 5 cases were injured in the left hand and 7 cases in the right. Injury sites were: 2 cases on the palmar side of the middle segment of the index finger, 3 cases on the palmar side, 3 cases on the dorsal side, 2 cases on the dorsal side of the middle segment of the ring finger, and 2 cases on the palmar side. The area of STDs ranged from 2.5 cm ×1.5 cm to 5.5 cm ×2.5 cm. There were 5 cases complicated by tendon injury, 4 cases by fracture, 12 cases by vascular injury and 2 cases by finger nerve injury. This study was approved by the Ethics committee of Linyi Third People's Hospital and patients provided informed consent.

Treatment process

Debridement

Patients admitted to the hospital were scheduled for the debridement. The specific operations were as follows. At first, under brachial plexus anesthesia, the deactivated and severely contused tissues were thoroughly removed, the skin about 1 mm to 1.5 mm from the wound edge was incised, and the bleeding was completely stopped. Afterwards, internal fixation of the Kirschner wire was performed on patients combined with phalangeal fractures, and tendon anastomosis was carried out on patients with tendon injuries.

Wound repair

(1) Flap design and preparation of recipient area: Before operation, ultrasonic Doppler was used to detect the carpal epithelial branch of the ulnar artery. The skin flap was designed with the skin branch as the center and the skin branch as the axis. The distal end of the flap was 1 wound away from the proximal end of the pisiform bone, and the proximal end was 10 cm away from the proximal end of the palmar transverse stripes of the wrist. About 1.5 cm was left on each side of the flap axis. Incised range of the skin flap was 3-5 mm larger than that of skin defect after debridement. The fingers were debrided under the microscope, and the distal ends of the dorsal digital vein and injured digital artery were marked, and the defect length was then measured. (2) Flap harvest: Under brachial plexus anesthesia, a balloon tourniquet was applied to the upper arm (40 Kpa). A skin incision was made on the ulnar side of the flap, and subcutaneous tissue was carefully separated to protect superficial veins passing through the flap. Guided by the course and penetration point of cutaneous branches detected by Doppler before operation, the cutaneous branches of the ulnar artery were dissected and found, and the skin branch was confirmed to enter the skin flap. The skin and subcutaneous tissue were incised at the radial side of the flap, separated from the ulnar side of the ulnar flexor carpi, and the pedicle of the flap was dissociated, leaving the cutaneous branches of ulnar artery connected to accompanying veins. The tourniquet was loosened, and once the blood supply of the flap was performed well, the pedicle division of the flap was done. The area of flap was 3.0 cm ×1.8 cm-6.0 cm ×3.0 cm. The vascular pedicle of the flap was 2.3 cm-4.7 cm long, with an average length of 3.7 cm. 10 cases of donor site wound were sutured directly, and 2 cases of full-thickness skin were obtained from ilioinguinal region. (3) Flap transplantation: Under the microscope, the flap was anastomosed with the marked dorsal digital vein and digital artery, respectively in the recipient site. The proximal and distal ends of the carpal epithelial branch of ulnar artery were anastomosed to the digital artery by utilizing the flow-through method to offer blood flow.

Postoperative treatment

According to the conventional free skin flap, the patients were treated routinely after operation. The affected finger was fixed in a functional position with a plaster slab, and the skin flap was irradiated with a baking lamp at 25-30°C. Patients were given symptomatic supportive treatment with drugs involving infection prevention, expansion, anticoagulation, spasmolysis and pain relief. Two weeks later, patients could take rehabilitation exercises based on their own condition.

Treatment outcomes

All flaps survived postoperatively. In detail, one case had arterial crisis, showing thrombosis. The flap survived after removing the thrombus. All wounds were healed in stage I, and donor wounds and skin grafts were healed in stage I. All patients were followed up for 6 to 12 months, with an average of 9 months. The surviving flaps were ruddy in color, soft in texture and cosmetically acceptable in appearance, without obvious tumefaction. At the last fol-

Figure 1. A 33-year-old male patient with a defect of dorsal side of proximal interphalangeal joint of the ring finger combined with tendon injury and bone exposure. A. The wound after debridement; B. Flap design during operation; C. Harvested flap andulnar artery epithelial branch exposed during operation; D. The harvested flap during operation; E. The flap immediately after operation; F. The donor sites were sutured directly; G. The appearance of the donor site 6 months postoperatively; H. Appearance of the flap 6 months postoperatively.

low-up, the distance between two points of the flap was about 9-15 mm, 11 mm on average. Based on the trial evaluation standard of hand function evaluation of Chinese Medical Association Society of Hand Surgery, 10 cases were at the excellent level and 2 cases were good. Only a linear scar was left at the ulnar donor site of the wrist. A typical case is shown in **Figure 1**.

Discussion

Finger soft tissue defects (STDs) are frequent events clinically, most of which are complicated by vascular, nerve, tendon, and bone injuries. Soft tissue salvage is as well a major dilemma faced by surgeons. Both pedicles and free skin flaps are commonly utilized. Pedicled flaps include abdominal pedicled flaps, dorsal metacarpal artery and dorsal metacarpal artery cutaneous branch reversed island flaps, and proper digital artery reversed island flaps. The abdominal flap is described as a simple operation with wide application and lower risk. Unfortunately, abdominal pedicled flaps generally mean a prolonged course of treatment, which requires a second pedicle amputation. Additionally, such flaps would produce unacceptable pigmentation by patients. The dorsal metacarpal artery flap and the dorsal metacarpal artery cutaneous branch retrograde island flap will leave an obvious linear scar on the dorsal side of the palm [2].

Soutar [3] first introduced the concept of flow-through flap in 1983. A flow-through flap bridges the main blood vessels in the damaged area by using its own vessels, and the bridging of its arteries restores the blood supply at the distal end of the limb to the greatest extent. Vein bridging can prevent the occurrence of venous crisis to some extent, which is beneficial to venous reflux of the skin flap and distal limb, and promotes limb detumescence. Shortly thereafter, Zhang Gaomeng [4] invented the ulnar artery wrist epithelial branch flap based on an anatomical study in 1989, in which the blood supply is stable at the donor site,

and the diameter of the flap matches to the digital artery, thus facilitating anastomosis. The ulnar artery carpal epithelial branch flap has two reflux veins and two accompanying veins, which ensures the blood reflux of the flap [5]. On this basis, we adopted the flow-through flap with wrist epithelial branch of ulnar artery to restore both the finger wound and the injured digital artery.

In this study, all flaps survived postoperatively. We hypothesize that the satisfactory effects may be achieved mainly based on the following points. First, the free flow-through flap of carpal epithelium, has the merit of not sacrificing the ulnar artery, keeping a constant blood supply of flap donor area, thus increasing the rate of successful harvest [6]. Evidence suggests that the vascular pedicle is longer so that it can effectively repair the defective digital artery. The vascular pedicle of dorsal carpal branch of the ulnar artery is relatively stable and is easily incised, and the incised area can be adjusted according to the actual injuries [7]. The diameter of carpal epithelial branch of ulnar artery matches with that of digital artery, which reduces the difficulty of anastomosis [8-10]. The blood vessels in the recipient area were kept unblocked, and blood supply was restored to the maximum extent. Thus, the success rate of surgery of the patients was guaranteed as well. Secondly, the skin exhibited a good texture, and the pigmentation was almost negligible in the long-term. The wound of donor site can be sutured directly or covered with full-thickness skin in small area, which can be resumed at I phase, with a concealed donor site. Therefore, the postoperative aesthetic requirements of patients were met. Thirdly, the donor site and the recipient site are in the same surgical field of vision, so the incision of the skin flap and transplantation are conveniently operated, thus reducing the difficulty of the operation and shortening the operation time [11-13].

Limitations are also present to the technique. (1) It is not applicable to those who require a better appearance of the scar left in the donor site. (2) The ulnar scar will exert a negative influence on patients who bend over their work at a desk after operation [14-17]. (3) The pedicle of the flap is short, and the recipient area sometimes needs to bridge the blood vessels. (4) The trunk is thin, which is not suitable for anastomosis to large blood vessels.

Precautions should be noted. (1) Before operation, ultrasound Doppler should be used to locate and mark the skin branch exit point to prevent variation or missing it [18]. (2) The operation should be carried out under incomplete blood expulsion, so as to fully expose the surgical field and anatomic relationships. (3) The wound surface must be thoroughly debrided without necrotic tissue [19]. Thorough hemostasis during operation can prevent the formation of hematoma, causing compression of the pedicle. (4) More skin flaps should be taken to avoid incomplete coverage of the affected area. (5) The surgery is conducted on the deep subfascial space [20]. In order to protect the blood vessel, the flap can be thinned assisted by the microscope.

Taken together, a flow-through flap with wrist epithelial branch of the ulnar artery bears several significant strengths, involving a simple operation, less trauma, concealed donor, and satisfactory finger shape. It is an ideal method to resurface defected soft tissues of fingers.

Disclosure of conflict of interest

None.

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