The use of the ALT Flap and Lateral Femoral Cutaneous Nerve for the Reconstruction of Carpal Soft Tissue and Ulnar Nerve Defects: a Case Report

Athanasios Karonidis · Serafeim Bouloumpasis ·
Konstantinos Apostolou · Dimosthenis Tsoutsos

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Abstract The anterolateral thigh (ALT) flap has become one of the workhorse flaps, with indications including diverse reconstructive problems. The lateral thigh area is also a useful donor site for nerve grafts. The lateral femoral cutaneous (LFC) nerve can be dissected along with the ALT flap for a substantial length, depending on the requirements of the recipient site. The LFC nerve can be used as a vascularized or non-vascularized nerve graft. The technique offers advantages and it can find clinical applications, satisfying the functional and aesthetic reconstructive requirements of a complex defect. We report the case of a patient who presented with traumatic soft tissue defect of the volar aspect of the wrist and ulnar nerve defect as a complication of a fracture of distal radius. An ALT flap was used to reconstruct the soft tissue defect. The ulnar nerve was resected due to necrosis and the gap was repaired with non-vascularized grafts of the anterior branch of the LFC nerve. The soft tissues were resurfaced successfully without complications. Functional recovery was good for the superficial branch of the ulnar nerve, whereas it was variable for the deep branch of the ulnar nerve. The anterolateral thigh area offers significant advantages as donor site in the reconstruction of complex soft tissue defects being a large source of vascularized skin, fat, fascia, muscle and nerve. This availability allows for single donor site dissection, minimizing the operating time and the associated morbidity.

Keywords ALT · Lateral Femoral Cutaneous nerve · Nerve graft · Ulnar nerve · Microsurgery

Introduction

The anterolateral thigh (ALT) region is a very useful donor site for complex vascularized flaps. Skin, fat, fascia, muscle, and nerve can be harvested from the same donor site. We present our experience in the case of a patient with traumatic soft tissue defect of the volar aspect of the wrist and ulnar nerve defect as a complication of a fracture of distal radius. This complex defect required soft tissue resurfacing and nerve grafts and it was reconstructed with an anterolateral thigh (ALT) flap and the anterior branch of the lateral femoral cutaneous (LFC) nerve.

Case Report

A 35 year old right hand dominant diver fell from a height, and sustained an intra-articular fracture of the distal radius of the left forearm (Fig. 1a). The patient reported a 3 cm laceration on the ulnar aspect of the forearm which was not addressed on initial presentation. The fracture was managed at the local hospital with closed reduction and application of cast. Following 3 weeks of casting the patient reported new severe pain at the wrist. The cast was removed, revealing an area of 8×10 cm approximately with soft tissue necrosis, possibly due to oedema and infection. X-Ray revealed suboptimal fracture reduction. At this point the patient underwent closed fracture reduction and external fixation, performed by the orthopaedics elsewhere. A random pattern abdominal flap was used for soft tissue cover. This flap was necrosed, possibly due to inability to maintain the necessary position of the forearm. Ultimately the patient was transferred to our hospital, almost 2 months after the initial injury. The external fixation was removed, as it was now 4 weeks since its application. Clinical signs of ulnar nerve paralysis with ‘claw hand’ deformity, and also paraesthesia in the median

A. Karonidis (✉) · S. Bouloumpasis · K. Apostolou · D. Tsoutsos
Department of Plastic Surgery, Burns Unit, Microsurgery and Hand
Surgery, General Hospital of Athens ‘G. GENNIMATAS’, Sifnou 33
Agia Paraskevi, 15343 Athens, Greece
e-mail: thanasiskaronidis@hotmail.com

Fig. 1 a The X-Ray showed distal radial fracture at the wrist. b Preoperative angiogram showed occlusion of the ulnar artery at the distal third of the forearm

nerve distribution in the hand were evident, and confirmed by electroneuromyogram (ENMG). Preoperative angiogram showed occlusion of the ulnar artery at the distal third of the forearm, and there was no continuation of the ulnar artery beyond (Fig. 1b). The patient underwent debridement and exploration. The superficial flexor tendons were exposed at zone five, although there was no flexor tendon injury (Fig. 2). There was disruption and necrosis of the ulnar nerve at the wrist extending to the hypothenar eminence at the level of nerve division to superficial and deep branch. The nerve was also surrounded by scar fibrous tissue for a length of 4 cm. This part of the nerve and scar tissue were excised. The superficial branch of the ulnar nerve was identified intact distal to the scarring. Although the median nerve was intact, carpal tunnel decompression and tenolysis were performed,

due to the presence of oedema. An ALT free flap was raised to resurface the soft tissue defect of the wrist. The LFC nerve (anterior branch) was also dissected with the flap, for at least 20 cm length (Fig. 3a), to repair the ulnar nerve defect. Although the use of ALT flap in a flow-through fashion (double end-to-end) would be desirable in terms of improving the ALT flap vascularity and hand circulation, this was not feasible as there was no continuation of the ulnar artery beyond the occlusion. Therefore the ALT artery and vein was anastomosed end-to-end with the ulnar artery and concomitant vein respectively at the level of mid forearm. The LFC nerve was cut in four cable non-vascularized grafts of 5 cm length each. Two nerve grafts were co-adapted distally at the hypothenar eminence with the deep branch of the ulnar nerve and the other two grafts were co-adapted with the

Fig. 2 The wrist wound with exposure of the superficial flexor tendons and ulnar nerve defect

superficial branch of the ulnar nerve. These four cables were co-adapted proximally at the distal forearm with the corresponding nerve fibres of the ulnar nerve stump (Fig. 3b). A small skin graft was also used at the radial border of the flap (Fig. 4a). The postoperative course was uneventful and physiotherapy program was initiated.

Although some recovery it is still expected, the patient is satisfied with the outcome. 18 months after the operation the fracture has united, with wrist flexion of 80° and wrist extension of 30°. The recovery of ulnar and median nerves was assessed based on Medical Research Council (MRC) system. The function of hypothenar muscles was nearly normal. The power of abductor digiti minimi and flexor digiti minimi was graded as M4 to M5, with no obvious muscle wasting. Sensory recovery of the ulnar border of hand and of the ulnar and radial aspect of the little finger was good and it was graded S3+, with two-point discrimination (2 PD) 8 mm at the little finger. Although there was no obvious wasting of the ring

finger, sensory recovery of the ulnar aspect was poor (<S2). Muscle wasting was noted at the first web space. Also, the first dorsal interosseous and adductor pollicis had poor functional recovery (M2). The lumbricals and the rest of interossei muscles achieved good functional recovery (M4). As such, the recovery of superficial branch of ulnar nerve was considered as good. The recovery of deep branch of the ulnar nerve was ranged from good (at the ulnar aspect of the hand) to fair to poor as the nerve passes to radial aspect of the hand. There was excellent flexor tendon function (M5), and normal sensation at the median nerve distribution in the palm (2PD 5–6 mm) and the fingers (2PD <5 mm) (Fig. 4b). The power of all fingers was good, with near normal power grip, pinch and key grips in comparison to the uninjured hand. The aesthetic result of the flap coverage was satisfactory. The donor site has healed well. No any painful neuroma has been noted thus far, nor ‘meralgia paresthetica’, and the sensitivity of the anterior thigh was similar to the contralateral thigh, despite sensory

Fig. 3 **a** The LFC nerve was dissected along with the ALT flap. **b** Two cables of LFC nerve were neuroraphied distally at the hypothenar eminence with the deep branch of the ulnar nerve and the other two cables of LFC nerve were neuroraphied with the superficial branch of the ulnar nerve. The 4 cables were neuroraphied with the corresponding nerve fibres of the ulnar nerve stump proximally at the distal forearm. The arrows indicate the areas of co-adaptation proximally and distally

Fig. 4 **a** 18 months post surgery. The small scar at the central portion of the flap represents an inadvertent minor injury. **b** There is excellent flexor tendon function, and the function of hypothenar muscles is nearly normal

nerve harvesting. This was attributed to the preservation of the posterior branch of the LFC nerve, and to the innervation provided by adjacent sensory nerves. Overall, the patient was able to return to his daily activities without any restriction.

Discussion

Complex wrist injuries including bone, soft tissue and nerve, require a combined approach to achieve a satisfactory reconstruction. Reconstructive considerations include the geometry of the defect, the functional deficit, the type of tissue defect as well as the morbidity of the donor site. In our case the defect required repair of three tissue components, bone, skin and subcutaneous tissue, and the ulnar nerve. As the flexor tendons were exposed, a fasciocutaneous flap was selected, in order to cover the exposed tendons with the fascia of the flap.

Free ALT flap with harvesting of the LFC nerve has been reported previously to be useful for combined nerve reconstruction and soft tissue coverage at the wrist, as it addresses both defects with vascularized components [1]. In our case, following treatment of the fracture, an ALT flap with the anterior branch of the LFC nerve was dissected for soft tissue coverage and ulnar nerve repair. Other reconstructive options include other free neurovascular fasciocutaneous flaps such as the neurovascular sural free flap [2] and the radial forearm flap from the contralateral side. Although the decision making depends on the surgeon's preference, the sural free flap has not found widespread use, probably due to concerns about small vessel diameter. The contralateral free radial forearm flap was not selected due to higher donor site morbidity. Alternatively, a free fasciocutaneous flap combined with sural or other nerve grafts can be harvested but this option would increase the operating time, it may require intraoperative repositioning of the patient, and it will result in additional scarring and possible donor site morbidity.

The ALT flap has become one of the workhorse flaps for soft tissue reconstruction. Dissection of the LFC nerve distal to its bifurcation, to the anterior and posterior branches, has minimal added risks. There is not much information on the anatomical features (i.e. diameter) of the LFC nerve in the literature [3], although some variations in the course and microsurgical anatomy have been described. These occur proximally up to the level of the anterior superior iliac spine (ASIS) and proximal to the inguinal ligament. The literature correlates the occurrence of Meralgia Paresthetica to procedures in the area of the ASIS and/or above the inguinal ligament [4]. Distal to the inguinal ligament the course of the LFC nerve is more predictable and it can be dissected safely up to its division to anterior and posterior branch, and a nerve graft of approximately 20 cm in length can be harvested. Intraneural dissection can be performed proximally if more nerve length is required. The whole nerve can be harvested as a vascularized graft. Alternatively, the nerve can be divided into non-vascularized cable grafts. Doi et al. reported that the vascularized nerve grafts were indicated when the nerve gap was more than 6 cm with significant skin defect [5], whereas Koshima et al. recommended the vascularized nerve grafts for nerve gaps of over 20 cm [6]. The diameter of the LFC nerve is approximately 1.5 mm or less, although this is not well documented in the literature. At the wrist level the diameter of ulnar nerve matches with 4–5 cables of the LFC nerve graft. We used four non-vascularized nerve grafts for our nerve repair. Ulnar nerve repairs have been reported to have variable functional outcomes, and certainly not as good as the outcomes reported for median nerve and radial nerve repairs. A study has shown that only 56 % of secondary ulnar nerve repairs with nerve grafts had good outcomes. This was attributed to the fact that muscles innervated by the ulnar nerve are involved in delicate movements requiring more extensive innervation and complex muscle contraction [7].

In this case report we describe the reconstruction of a complex soft tissue and ulnar nerve defect of the volar wrist with the use of the free ALT flap and ipsilateral LFC nerve. This method offers many advantages:

- The anterolateral thigh area is a donor area for well vascularized abundant soft tissue, including skin, fat, fascia, muscle, and nerve.
- This approach limits dissection to only one donor area instead of two areas if flap donor area is different from the nerve donor area (i.e. flap and sural nerve). This results in

less dissection and it reduces the operating time, the resulting scars, and the overall associated morbidity.

- The LFC nerve is a purely sensory nerve. A substantial length of nerve graft, which may exceed 20 cm, can be harvested safely up to the division to anterior and posterior branch, without any limitations.
- The whole LCF nerve can be harvested as a vascularized graft, if it is dissected in continuity with the ALT flap.
- The nerve can be divided into several non-vascularized cables, depending on the recipient site requirements.
- The nerve has adequate diameter for safe co-adaptation at the recipient site.

In conclusion, the dissection of the ALT flap including the LFC nerve can satisfy the reconstructive requirements of a complex defect, with minimal donor site morbidity. The ALT is considered as one of the workhorse flaps, whereas the LFC nerve (anterior branch) can be dissected safely for a substantial length and used as vascularized or non-vascularized nerve graft.

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