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CASE REPORT

Sensory restoration of the critical border of the small finger by an emergency heterodigital nerve transfer after circular saw injury

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Traumatic nerve injuries involving the distal part of the upper extremity may significantly affect the function of the hand if left untreated. An alternative to nerve autografts for treating digital nerve injuries are nerve transfers. We present the surgical management of a 2.5 cm nerve defect to the proper digital ulnar nerve of the small finger after circular saw injury to the palm of the hand with multiple neurovascular involvement and the use of a non-critical heterodigital nerve transfer for restoration of the critical functional border of the small finger. At 14 months postoperative the sensory recovery grading scale was S4 for the 4th finger and radial border of the 5th finger (primary repair) and S3+ for the ulnar border of the 5th finger (nerve transfer). Donor site morbidity consisted of anesthesia of the ulnar sided tip of the middle finger. Emergency nerve transfer of the proper ulnar digital nerve of the middle finger is a feasible surgical technique for the restoration of the critical ulnar digital border of the small finger after traumatic injuries but with the disadvantage of an insensate donor site.

Keywords: digital nerve transfer, sensitive nerve transfer, peripheral nerve surgery

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Introduction

Traumatic nerve injuries involving the distal part of the upper extremity may significantly affect the function of the hand if left untreated. Median and ulnar nerve injuries distal to the radio-carpal joint result in loss of pinch, fine motor movements and sensibility of the fingers while injuries to the superficial radial nerve may result in a painful neuroma. Injuries distal to the palmar aponeurosis usually involve the flexor tendons and digital neurovascular structures, therefore endangering finger function.

A functional border of the finger is considered to be a critical area for sensory input during daily activities and are considered to be the ulnar border of the thumb, the radial border of the index and middle finger and the ulnar border of the ring and small finger [1].

Upper extremity digital nerve injuries may require different reconstructive approaches depending on the extent of nerve and soft tissue damage. Nerves injuries should be primarily repaired by means of a tension-less nerve coaptation but if a gap is present then a nerve graft or nerve conduit is more suitable [2]. An alternative to nerve autografts for treating digital nerve injuries are nerve transfers. [2]. In a nerve transfer, an expendable proximal donor nerve is transected and transposed to a distal, recipient nerve stump in order to restore the function of the latter. Thus, the donor nerve offers its axons to the recipient nerve without the interposition of a tube such as in a nerve graft of nerve conduit, shortening the regeneration time [3,4].

We present the acute surgical management of a 2.5 cm nerve defect to the proper digital nerve of the small finger after circular saw injury to the palm of the hand with multiple neurovascular involvement and the use of a non-critical heterodigital nerve transfer for restoration of the critical functional border of the small finger.

Case Presentation

A 65 year old male was admitted to the emergency department after a circular saw injury to palm of his left hand corresponding to the 4th and 5th digital rays (Figure 1A). The patient had no known illnesses. The physical examination revealed normal active flexion and extension, abduction and adduction of the fingers, preservation of the blood supply to all the fingers but with a sensory deficit to the 4th and 5th fingers. The X-rays excluded any fractures. After tetanus immunization and preliminary wound care the patient was immediately booked for surgery which was performed under axillary nerve block, loupe magnification and bloodless field.

The patient had sustained complete transection of the 4th radial digital artery and nerve, 4th ulnar digital nerve, 5th radial and ulnar digital nerve, incomplete laceration of flexor digitorum superficialis and profundus to the 5th finger (less than 30%) and partial hypothenar muscle laceration (Figure 1B, Figure 2A).

The proximal and distal stumps of the aforementioned neurovascular structures were present at the wound site (Figure 2), but the proximal stump of the 5th ulnar digital nerve had an approximately 2.5 cm defect (Figure 1B and 2).

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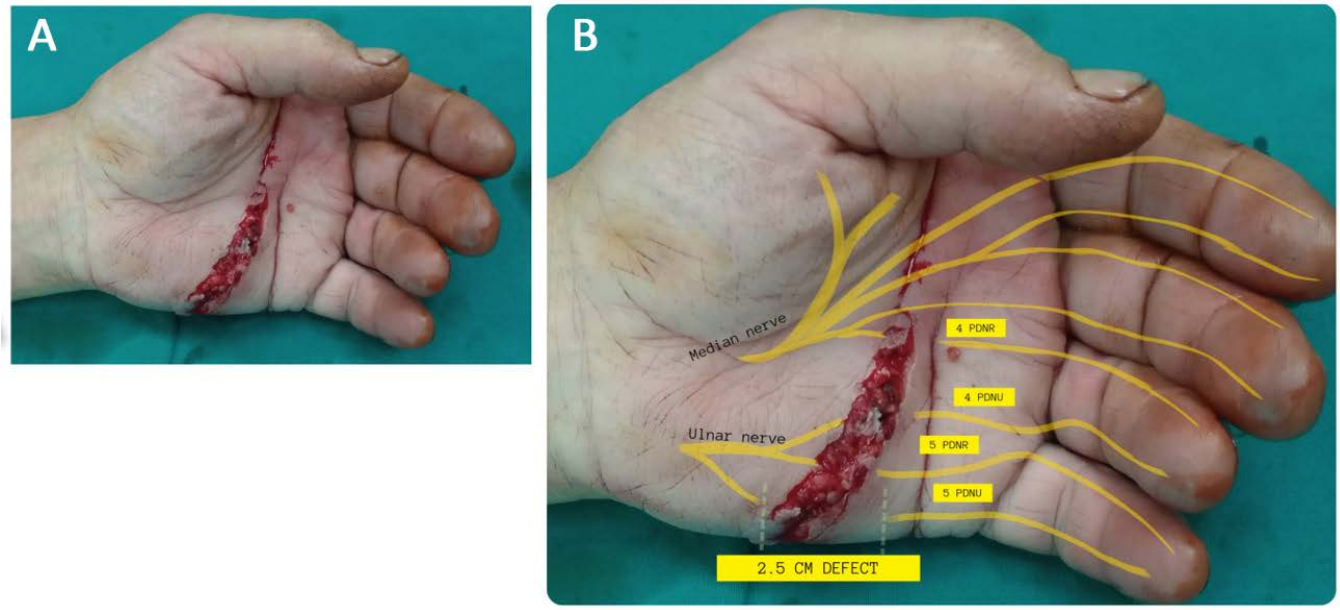

Fig. 1. A. Circular saw injury at the level of the ulnar midpalm (4th and 5th digital rays) of the left hand. B. Schematic representation of the injured ulnar nerves at the midpalm: 4 PDNR - 4th proper digital nerve radial; 4 PDNRU - 4th proper digital nerve ulnar; 5 PDNR - 5th proper digital nerve radial; 5 PDNU - 5th proper digital nerve ulnar.

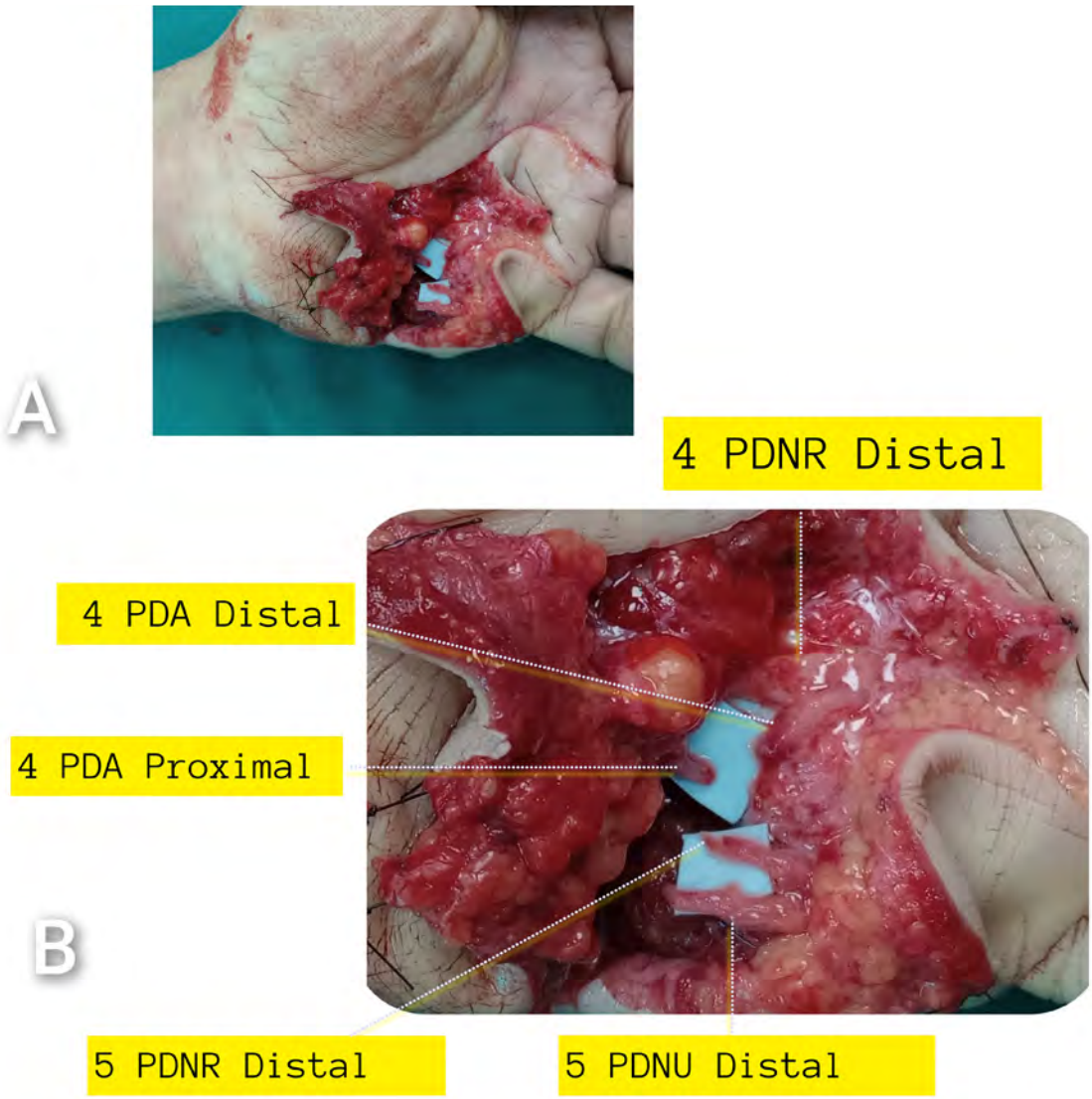

Fig. 2. A and B. Surgical exposure of the damaged neurovascular structures (overview and focused view); 4 PDNR - 4th proper digital nerve radial; 4 PDA - 4th proper digital artery; 5 PDNR - 5th proper digital nerve radial; 5 PDNU - 5th proper digital nerve ulnar.

After microsurgical repair of the radial digital artery of the 4th finger, digital nerves of the 4th and radial digital nerve of the 5th finger (end-to-end nerve coaptation), the remaining distal stump of the ulnar digital nerve of the 5th finger was addressed by a nerve transfer of the 3rd ulnar digital nerve (Figure 3) in order to decrease operative time and donor site morbidity for nerve autografts.

A Bruner's incision connecting the distal part of the wound to the base of the third finger was performed and the ulnar digital nerve was exposed, dissected and distally transected at the mid-portion of the proximal phalanx. The ulnar digital nerve of the third finger was sutured in a tension-free end-to-end fashion to the ulnar digital nerve of the fifth finger with 9-0 nylon (Figure 3A and 3 B).

After wound closure the hand was placed in an intrinsic-plus position for three weeks with recommendation for hand therapy but the patient was non-adherent to the prescribed hand therapy regimen.

On the first postoperative day, after terminalization of the anesthesia, the baseline for sensibility was established using the modified British Medical Research Council sensory recovery grading scale (5) and reevaluated at 5 months and 14 months postoperative (Figure 4). At 14 months all fingers had achieved normal sensibility with the exception of the donor site area (S0) while the recipient area achieved protective sensibility (S3+). Nevertheless, the patient was satisfied with the result and had successfully resumed work.

Discussions

Restoration of sensation in the hand should be regarded as important as correcting motor deficits [1,4]. The ulnar innervated small finger and hypothenar region serve as important sensory input for the inner hand [1,4]. Traumatic lesions involving these regions may cause significant long-term discomfort and disability [1] and achieving protective sensation in this region is important for wound preven-

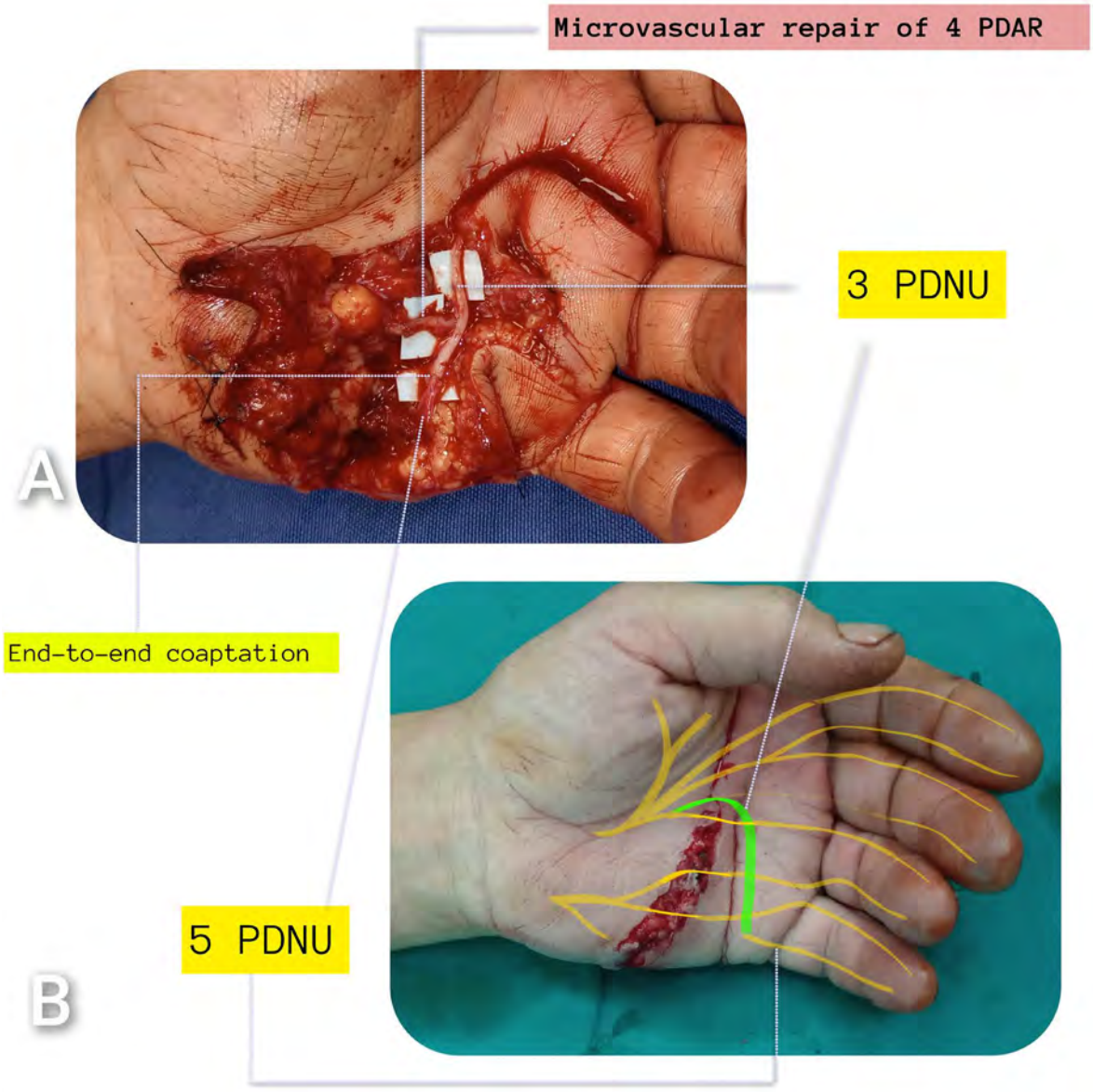

Fig. 3. A. Nerve transfer of the proximal ulnar digital nerve of the 3rd finger (3 PDNU proximal) to the distal ulnar digital nerve of the 5th finger (5PDNU distal). Upper blue background depicts the donor nerve while the caudal background depicts the end-to end coaptation site of the nerve transfer. B. Schematic representation of the 3 PDNU to 5PDNU transfer.

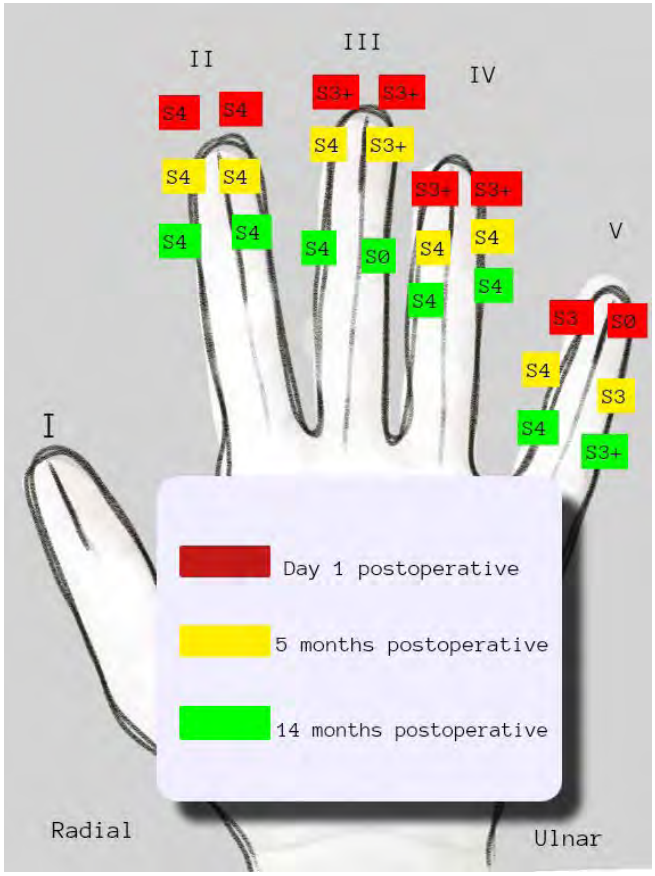

Fig. 4. Graphic representation of postoperative results according to the modified BRMC scale at day 1 (red color), 5 (yellow color) and 14 months (green color) .

tion [4]. Protective sensation is defined by some authors as achieving at least S3 or greater on the modified BRMC sensory recovery scale or on the Highet-Zachary scale [1,4].

When a primary nerve repair cannot be achieved the gold standard for nerve reconstruction is the nerve autograft. Common nerve graft donors for reconstruction of digital nerves from the ipsilateral upper extremity consists of the medial antebrachial cutaneous nerve (MABCN), lateral antebrachial cutaneous nerve (LABCN) and last but not least the posterior interosseous nerve (PIN) [6]. All of these are excellent candidates but require an additional proximal incision, prolongation of operative time and imply a donor site morbidity. An alternative to nerve autografts are nerve conduits which are suitable for defects less than 3 cm [7] or processed nerve allografts (PNA) for defects up to 7 cm [8] but they may not be available in some countries.

Among the previously mentioned reconstructive options are also nerve transfers which are seen as a logical extension to nerve repair and nerve graft [3,9]. Nerve transfers rely on the transposition of a healthy donor nerve to the distal recipient nerve stump, that provides healthy axons for their target area [7]. Recent studies reported that protective sensation of the fingers is possible with nerve transfers and distal nerve transfers appear to be more successful that proximal ones [1,4].

In our case, a heterodigital nerve transfer was chosen to bridge the 2.5 cm defect of the proper ulnar digital nerve of the small finger. The proper ulnar digital nerve to the long finger was successfully transferred and protective sensation was obtained (S3+) as reported by other authors [1,4]. This approach was considered to be time-saving and less technical difficult as only one digital nerve required reconstruction.

Biodegradable nerve conduits or processed nerve allografts would have been the most suitable alternatives for our clinical scenario but due to a lack of national medical device regulation this option was unavailable.

Nerve autografts are considered a gold standard in nerve reconstruction [2]. Donor nerves such as the PIN or LABCN serve as a source of autogenous grafts that may be harvested from the ipsilateral upper limb but with the disadvantage of an increased operative time and donor site morbidity. We consider this method to be more suitable when multiple digital nerves require reconstruction.

Interestingly, some studies reported that sensory recovery was similar (S3) when nerve grafting and distal sensory nerve transfers for treating proximal ulnar lesions were used [4] suggesting that both methods provide similar results when treating distal sensory loss in the ulnar fingers.

End-to-end nerve coaptation was chosen as this was deemed less technical difficult, although end-to-side repairs offered similar results (4).

Although the transfer of a non-critical digital nerve to a critical digital nerve may be seen as an elegant operation it comes with the price of a partial insensate finger which

may be bothersome for some patients and this must be explained before the surgery.

Another limitation of using heterodigital nerve transfers from the same plane (ie volar surface) for digital sensory restoration are the limited number of nerve transfers available. Keeping in mind that at least the opposing thumb and index finger together with small finger are necessary for a functional sensate hand (4), four non-critical nerve donors could be considered for a transfer. It seems more likely that the patient will accept the loss of sensation to one non-functional critical border of a finger instead of four, therefore this aspect must be discussed with the patient when more than one nerve transfer is being planned. In such cases the MABCN, LABCN or PIN would probably be more acceptable in terms of donor site morbidity.

Homodigital nerve transfer as described by Chen C. et al (10), where the dorsal branch of the proper digital nerve was used to bridge nerve defects of the proper digital nerve between the proximal interphalangeal joints and common digital nerve is an interesting alternative when a nerve transfer is considered but since the operator had no surgical experience with this technique it was abandoned.

Conclusion

Emergency nerve transfer of the proper ulnar digital nerve of the middle finger is a feasible surgical technique for the restoration of the critical ulnar digital border of the small finger after traumatic injuries to the volar hand but carries the disadvantage of an insensate donor site.

Taking the latter into account, it would be prudent that such option should be reserved for cases where one critical digital border is involved, where decreased operative time is desired (multi-structural repair/reconstruction is required), the patient is willing to accept the exchange of sensibility from a non-critical to a critical digital area and for patients that want to avoid additional donor morbidity such as nerve autografts.

Further studies are needed in order to determine if emergency heterodigital nerve transfers are superior to other reconstructive methods for restoration of critical digital areas in the hand.

Authors' contribution

IB (Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Validation; Visualization; Writing – original draft; Writing – review & editing)
MA, FC (Conceptualization; Methodology; Supervision; Writing – review & editing)

Conflict of interest

None to declare.

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Ethical statement

The study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all subjects involved in the study.

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