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Neuroma-in-continuity of the median nerve managed by nerve expansion and direct suture with vein conduit

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ABSTRACT

Autologous nerve grafting is the current standard for bridging large gaps in major sensory and motor nerves. It allows both function and pain improvement with predictable results. Clinical observations of nerve elongation caused by tumours have prompted experimental animal studies of induced gradual elongation of the nerve stump proximal to the gap. This technique allows direct suturing of the two nerve ends to bridge the gap. Here, we describe a case of neuroma-in-continuity of the median nerve managed by resection and direct suture after nerve elongation with a tissue expander. We are not aware of similar reported cases. Secondary repair 3 years after the initial injury improved the pain and hypersensitivity and restored a modest degree of protective sensory function (grade S1).

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1. Introduction

Although emergency microsurgical repair in patients with median nerve severance is universally recognised, the management of a neuroma-in-continuity at a later stage from the initial injury remains poorly standardised. When the gap is large, resection of the neuroma followed by autologous nerve grafting is usually indicated to restore function, at the expense of crossing two coaptation sites.

Slowly growing tumours in contact with nerves cause nerve elongation. Similarly, inducing gradual elongation of the proximal nerve segment can allow direct suturing of the two nerve stumps to bridge the gap.

We describe a case of neuroma-in-continuity of the median nerve managed by direct suturing after nerve elongation.

2. Case report

A 42-year-old male chronic smoker presented with a neuroma-in-continuity of the median nerve 3 years after a self-inflicted injury. Emergent microsurgical repair of multifocal median nerve severance had been performed at a trauma centre in June 2008.

Partial improvements were noted 3 years after the repair procedure. The patient had recovered thumb opposition but still exhibited severe atrophy of the abductor pollicis brevis muscle. The second and third digits were excluded from pinch grasping.

He showed no recovery of sensory function (S0), with no response to the Semmes-Wenstein monofilament test or Weber discrimination test.

Pain was assessed using the Elliot score [1,2], which separately evaluates five pain modalities:

- spontaneous basal pain;
- spikes of pain;
- pressure pain;
- movement pain;
- hypersensitivity.

The patient scores each modality as absent, mild, moderate, or severe (Fig. 1).

Magnetic resonance imaging (MRI) performed 3 years after the injury showed a large, 47-mm, neuroma-in-continuity located proximal to the carpal tunnel (Fig. 2). The electromyogram indicated partial motor function recovery with about 70% of conduction loss in the opponens pollicis and abductor pollicis brevis muscles. Stimulation of the first three digits failed to produce any electrical sensory response.

Due to residual pain and anaesthesia of the pinch fingers, the patient could not return to work.

Numerous analgesic treatments had been attempted. Neither step-1 analgesics nor weak or strong opioids had provided meaningful pain relief. More specific drugs (pregabalin and gabapentin) were only partially effective and induced troublesome side effects.

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A transcutaneous electrical nerve stimulation (TENS®) glove brought transient relief without lasting improvement.

The insufficient sensitive and functional recovery 3 years post-injury prompted surgical treatment. Gradual elongation of the nerve followed by direct microsurgical suture after re-cutting in healthy nerve tissue was performed.

3. Surgical technique

The nerve repair required a two-stage procedure under ultrasound-guided truncal nerve block at the axillary level.

The first stage was performed 3 years after the primary repair procedure. A longitudinal incision was made to expose the median nerve, proximal to the neuroma and distal to the forearm motor branches. A silicone tissue expander measuring 4.9 cm by 3.9 cm by 5.1 cm (100 mL) (Eurosilicone®, ZI La Peyrolère, France) was positioned under the deep side of the nerve by displacing the muscle belly of the flexor tendons at the muscle-tendon junction level. The valve was then placed superficially in the subcutaneous adipose tissue. The muscle fascia was left open to prevent compartment syndrome during expansion.

Expansion was started 2 weeks after skin healing was complete, using two weekly injections of isotonic saline to expand the balloon by 12 mL per week. The injection was stopped if the patient reported pain. After 8 weeks, the expander had achieved its maximal volume of 100 mL (Fig. 3).

The second stage was performed 2 months after the first stage. The initial incision was extended distally to expose the neuroma. The 47-mm neuroma was then dissected and separated from the fibrous scar tissue under optical magnification. The distal end of the neuroma was found to be in contact with the proximal edge of the flexor retinaculum (Fig. 4). En-bloc excision was performed with cuts in healthy nerve tissue 5 mm away from each end of the neuroma. Total gap length was estimated at 60 mm. The

![Fig. 2. Preoperative MRI appearance of the 47-mm long neuroma-in-continuity of the median nerve.](Image)

![Fig. 3. Appearance of the forearm after full expansion of the balloon (100 mL).](Image)

![Fig. 4. Intra-operative appearance of the neuroma-in-continuity of the median nerve.](Image)
silicone expander was removed (Fig. 5) and the nerve was then directly sutured end-to-end by epi-perineural stitches of Ethilon® 9/0 (Ethicon, Auneau, France) (Fig. 6) before being wrapped in a venous conduit graft harvested at the elbow according to standard practice in our department (Fig. 7) [3].

The upper limb was immobilised in a long-arm splint with the elbow in 90° of flexion and the wrist in slight flexion of 20°, for 6 weeks, to avoid any additional tension on the suture. The elbow was released after 3 weeks.

Analgesic therapy combining a strong opioid and pregabalin was given for 3 months.

4. Results

MRI was performed after 2 years of follow up. Median nerve diameter was regular, with continuity of the intra-neural fascicules and no neuromatous thickening (Fig. 8).

The degree of thumb opposition recovery was good and similar to that noted preoperatively. The wasting of the abductor pollicis brevis was unchanged.

The patient continued to perform pinch grasping using the ulnar digits instead of the second and third digits.

Sensory function was slightly improved, with recovery of protective deep sensation graded 51; the patient felt the largest Semmes-Wenstein monofilament (6.65) on the tips of all three digits. Weber’s two-point discrimination test was 20 mm.

The overall degree of pain relief was good, with no spontaneous pain, pain to mobilisation, or hypersensitivity (Fig. 1).

The patient was able to return to work 12 months after the surgical procedure. Nevertheless, he was disappointed by the final result, which he felt failed to meet his expectations.

5. Discussion

Early primary repair of median nerve injuries is common practice to ensure the best recovery of sensory and motor function and to minimise the severity of pain due to nerve scarring.

At a longer interval from the repair procedure, the painful dysesthesia related to nerve regrowth is difficult to interpret [4]. A neurona-in-continuity with incomplete recovery is difficult to manage, particularly as the patients themselves often raise specific challenges.

In patients with good motor recovery and residual isolated pain due to nerve regrowth in a zone of fibrous scar tissue, wrapping the neuroma in a fascial flap relieves the pain without objectively improving sensory function, motor function, or hypersensitivity [2].

Nerve coaptation is crucial to allow the recovery of sensory and motor function and also appears to be the best solution for relieving the pain [5,6]. In the absence of satisfactory functional recovery, the best option remains resection of the neuroma by re-cutting in healthy nerve tissue followed by direct coaptation.

Direct microsurgical suturing with mild tension of the two stumps may be feasible if the gap is small. Temporary
imobilisation of the adjacent joints in flexion may be required to limit the tension applied to the sutures [7,8].

Larger gaps do not allow direct suturing. Autologous grafting is then indicated to allow axon regeneration. However, due to the need for two suture rows, nerve grafting increases the risk of axonal loss due to scar formation and misdirection, resulting in lower recovery rates compared to direct suturing [5,6].

To overcome the nerve gap, an alternative to grafting may be nerve elongation. The additional length obtained by elongating the nerve proximally to the neuroma can allow direct tension-free suturing. This technique can be likened to the stretching of nerves in contact with slowly growing tumours, which can double the length of the nerve, while having only a minimal effect on function [9]. The use of slow expansion for nerve lengthening was first suggested by several authors in 1989 [10–12]. D’Anjou et al. [10] and Milner [11] conducted electrophysiologic investigations to evaluate the rat sciatic nerve behaviour in response to gradual elongation induced by a balloon expander.

Sudden nerve elongation (greater than 8% of the nerve length) can cause a conduction block due to alterations in the intra-neural microvasculature [13]. In contrast, gradual elongation spares the local blood supply [14]. Histological studies show inflammation of the endoneurium, changes in axon distribution, and segmental axon demyelination without cytoskeleton alterations [15–17]. These structural histological and immuno-histochemical changes induced by the balloon expander are minimal and constitute indicators of nerve adaptability [14,18]. Nerve elongation by up to 200% seems feasible without functional impairments, despite a transient decrease in nerve conduction [10,11,15].

The results in our patient were modest and the subjective improvement disappointing due to the insufficient degree of sensory recovery. The long time interval of 3 years between the unsuccessful primary repair and secondary nerve repair procedures may have contributed to this result, and shorter delays may improve the outcomes [9,12]. The degree of pain relief, however, was marked and at least as substantial as that reported with flap wrapping in the absence of neuroma resection [2].

Animal studies comparing nerve expansion to autologous grafting have shown comparable results with the two techniques in terms of conduction and muscle recovery [19–21].

6. Conclusion

The potential of nerves for elongating and the feasibility of induced nerve elongation open up new therapeutic possibilities and create new surgical indications in patients with nerve gaps. To our knowledge, ours is the first instance in which nerve elongation was transferred from animal studies to a human patient.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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