Intraneural Median Nerve Anatomy and Implications for Treating Mixed Median Nerve Injury in the Hand

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Abstract

Background: Nerve transfers have resulted in increased interest in the microanatomy of peripheral nerves. Herein, we expand our understanding of the internal anatomy of the digital nerve to the ulnar index and long fingers, the radial long and ring fingers, and the nerves to the second and third web spaces. **Methods:** The median nerve was dissected from the digital nerves to the antecubital fossa in 14 fresh upper extremities. The distance of proximal internal neurolysis of the fascicles to the second and third web space and proper digital nerves was measured relative to the radial styloid. Plexi encountered during proximal lysis were noted. **Results:** Digital nerves to the ulnar index and radial long fingers were lysed 2.4 ± 0.5 cm (mean $\pm$ SD), and digital nerves to the ulnar long and the radial ring fingers were lysed 3.0 ± 0.6 cm distal to the radial styloid. Fascicles to the third web space were lysed to the takeoff of the anterior interosseous nerve, 21.1 ± 1.4 cm. Plexus groupings were encountered at 4.5 ± 1.6 cm, 8.3 ± 1.2 cm and 16.1 ± 1.9 cm proximal to radial styloid. The fascicles to the second web space were lysed to 5.0 ± 1.2 cm proximal to radial styloid where a plexus grouping was encountered. Another plexus group was found at 3.3 ± 1.3 cm. **Conclusions:** We demonstrate that extended internal neurolysis of second web space, along with the digital nerves, is technically and clinically feasible. This technique can be used to treat mixed median nerve injury in the hand and wrist.

Keywords: median nerve, median nerve anatomy, peripheral nerve, neurolysis, neuroma

Introduction

Complete injury to the median nerve can result in acute loss of motor and sensory function as well as painful sequelae due to neuroma formation.⁸ The management of mixed median nerve injury is an even more challenging problem as compared with the complete injury. In these situations, the ability to separate damaged from undamaged fascicular groups would facilitate maintenance of normal function and allow surgical treatment of the damaged component of the nerve. In this article, we describe specific aspects of the internal topography of the median nerve in the distal forearm and hand and the potential implications for treatment of mixed median nerve injuries.

The technique of internal neurolysis, or what Babcock historically referred to as “hersage,”¹ was advocated by Curtis in the 1970s in the management of median nerve compression.² Although the technique of internal neurolysis has not been found to improve results of standard nerve decompression, it has been proven to be a safe technique to use to dissect between fascicular groups.⁷ This technique is also utilized to free groups of specific nerve fascicles for

transfer and to transpose neuromas proximally in the treatment of the painful extremity. Proximal transposition of a painful neuroma for hand and wrist pain has proven to be an effective strategy for pain management.^{3–6} The treatment of painful neuromas of the hand and wrist with proximal transposition requires proximal relocation of the painful neuroma, and a longer length of nerve will facilitate proximal transposition into a more vascular, less scarred environment.⁸

The anatomy of the median nerve third web space fascicles and the use of this fascicular group as nerve graft material have been described.⁹ This report describes the feasibility of performing similar internal neurolysis of the other fascicular groups within the distal median nerve.

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Figure 1. Cadaver dissection.

Note. (A) Representative example of median nerve dissection from the anterior interosseous nerve (AIN) to the digital nerves. (B) Distal plexus between third and second web space fascicular groups (arrow). (C) Proximal plexus between third and second web space fascicular groups (arrow). (D) An example of digital nerve neurolysis separating the web space fascicular groups (arrow).

Materials and Methods

The median nerves of 14 fresh cadaveric upper extremities (7 right, 7 left) were dissected from the digital nerves to the bifurcation of the anterior interosseous nerve. We used 3.5× loupe magnification. The arms were measured from the medial epicondyle to the radial styloid to obtain relative lengths. Internal neurolysis of the proper digital nerves to the ulnar index and long fingers and the radial long and ring fingers was performed. The third web space and the second web space fascicular groups were neurolysed as proximal as possible. Proximal dissection was stopped at what were deemed clinically significant plexus formations. We measured the location of plexi between adjacent fascicular groups in reference to the radial styloid.

Results

In the cadaveric study, the third web space fascicular group could be lysed back to the level of the anterior interosseous nerve bifurcation at 21.0 ± 1.4 cm (mean $\pm$ SD) proximal to the radial styloid. Communications or plexi with the remaining median nerve were encountered at 3 groupings along this length, 4.5 ± 1.6 cm, 8.3 ± 1.2 cm, and 16.1 ± 1.9

cm proximal to the radial styloid. The second web space was lysed 5.0 ± 1.2 cm proximal to the radial styloid. Dissection was stopped at this plexus formation, which was considered significant by the senior author. Another plexus grouping was found at 3.3 ± 1.3 cm proximal to the radial styloid. The digital nerves to the ulnar index and radial long fingers were neurolysed 2.4 ± 0.5 cm distal to the radial styloid. The digital nerves to the ulnar long and radial ring fingers were neurolysed 3.0 ± 0.6 cm distal to the radial styloid (Figure 1). Measurement data are summarized in Table 1, and the dissection approach is represented in schematic form in Figure 2.

Discussion

Median nerve injury in the distal forearm and hand is a devastating problem and a frequent cause of hand disability. An understanding of the internal anatomy of the median nerve is important when treating patients with complete or mixed injury. The fascicular anatomy of the median nerve in the hand and forearm has been explored in previous studies.^{7,10,11} Complete injury of the median nerve is typically managed with nerve repair or graft. By contrast, partial injury of the median nerve remains a challenging surgical

Table 1. Measured Distances After Internal Neurolysis.

Anatomical landmark	Distance, cm	SD
Medial epicondyle	28.0	1.7
Anterior interosseous	21.1	1.4
Motor recurrent (distal)	4.0	0.5
Bifurcation of ulnar thumb and radial index finger digital nerves (distal)	5.6	0.4
Bifurcation of ulnar index finger and radial long finger digital nerves (distal)	8.0	0.8
Bifurcation of ulnar long finger and radial ring finger digital nerves (distal)	8.0	0.8
Most distal plexus from 3rd to 2nd web space	4.5	1.6
Intermediate plexus from 3rd to 2nd web space fascicular groups	8.3	1.2
Most proximal plexus from 3rd to 2nd web space fascicular groups	16.1	1.9
Most distal plexus from 2nd to 1st web space fascicular groups	3.3	1.3
Most proximal plexus from 2nd to 1st web space fascicular groups	5	1.2
Ulnar index finger and radial long finger digital neurolysis (distal)	2.4	0.5
Ulnar long finger and radial ring finger digital neurolysis (distal)	3.0	0.6

Note. All measurements were made relative to the radial styloid. Those measurements that were distal to the radial styloid are noted; all others are proximal.

Figure 2. Progression of proximal internal neurolysis from the cadaver study represented in schematic form.

Note. (A) Schematic of median nerve (highlighted in yellow). (B) Schematic of the third web space fascicular group neurolysed (highlighted in yellow) with the location of plexus groupings noted. (C) Schematic of the second web space fascicular group neurolysed (highlighted in yellow) with the location of plexus groupings noted. (D) Schematic of the proper digital nerves neurolysed (highlighted in yellow), which allows for the transposition of the nerve into the forearm.

problem. We present an anatomical study that demonstrates a consistent internal topography of the median nerve that would potentially facilitate protecting uninjured fascicular groups of the median nerve while allowing for surgical reconstruction of injured portions. In 1992, we noted that there was an easily separable fascicular group that would otherwise innervate the third web space of the median nerve that could be neurolysed from the median nerve. We have used the knowledge extensively over the last 2 decades to

treat median nerve injuries. In this study, we describe a similar relationship with respect to the fascicular component of the median nerve innervating the second web space and proper digital nerves to the ulnar index and long fingers and radial long and ring fingers. We have used this knowledge of the internal topography in a similar fashion to manage partial median nerve injuries.

To review the clinical applications of this study, our measurements of the proximal internal neurolysis of the

Figure 3. Cadaver example of internal plexus or “pseudoplexus” between the first and second web space fascicles.

Note. The pseudoplexus (indicated by black arrow) was approached and lysed from both proximal-to-distal and distal-to-proximal approaches. The pseudoplexus can now be dissected off of the second web space group to rejoin the first web space group.

proper digital nerves indicate that digital neuromas can be surgically treated with excision and transposition proximal to the wrist crease. As noted, we have been aware of the third web space fascicular group as an easily “separable” unit for some time, but we now expand on that showing that the second web space fascicular group can be neurolysed from the first web space and the remainder of the median nerve. The internal neurolysis of the digital nerve fascicular group is done primarily with a spreading technique with tenotomy scissors (Fischer Instruments, St Louis, Missouri). In the cadaver study, neurolysis of the digital fascicular group was stopped at the first plexus formation. At this point, we were able to consistently transpose the nerve into the forearm. This technique has been used with success clinically, and it is often feasible to lyse the digital nerve fascicular groups more proximally as compared with the cadaver study. A likely explanation is the quality of the small-caliber, fragile, digital nerves in the cadaver are not as robust as a vascularized living nerve, the assumption being that tissue planes are more easily developed in the dissection of the living nerve.

An interesting finding from our anatomic study relates to the plexi initially described by our group in 1992.⁹ Previously, we found that the pattern of plexus formation was consistent among a sample of 23 fresh cadaver upper extremities. Distally, 1 to 3 “small” plexi occurred. This was followed by a “large” plexus found approximately 14 cm proximal to the radial styloid for all specimens. In the current study, we found 3 groups of plexi from the third web space fascicular group to the adjacent nerve. They were located at 4.5 ± 1.6 cm, 8.3 ± 1.2 cm, and 16.1 ± 1.9 cm proximal to the radial styloid. The plexus group at 16.1 cm was thought to be clinically significant and the level where the senior author would

stop the dissection. Plexi between the second web space and the remainder of the nerve were found at 3.3 ± 1.3 cm and 5 ± 1.2 cm proximal to the radial styloid. Dissection in this case was stopped at the proximal plexus as this was deemed clinically significant by the senior author. The third web space numbers, especially the more robust proximal communication at 16.1 cm proximal to the radial styloid, correlate with the findings of Ross et al.⁹

We did come across multiple areas that appeared to be plexi but were not actually true communications between fascicular groups. These areas were adherent with thicker internal epineurium but were separable with meticulous dissection. The concept of how a single fascicle may leave its neighbor to travel for some distance and then rejoin the same fascicle was proposed by Williams and Jabaley and referred to as “internal plexi.”¹¹ In our study, as these fascicles were released, we found that many originally identified plexi were actually “pseudoplexi,” as we came to call them (Figure 3). Technically, identifying a pseudoplexus required dissection from both a distal-to-proximal and proximal-to-distal approach. Once the area of interest was “surrounded,” we could determine whether the inseparable plexus was in fact a fascicle that crossed over between the web space groups. Clinically, this means that one can get proximal to what would otherwise be a stopping point during neurolysis, which would allow for the transposition of the injured nerve to a safer proximal location.

Conclusions

Intraneural anatomy of the median nerve permits internal neurolysis to separate specific fascicular groups. This facilitates the management of mixed median nerve injuries where some, but not all, fascicular groups are injured and require reconstruction. For example, we show that it is technically feasible to spare intact motor function and intact sensation while addressing otherwise debilitating pain secondary to partial median nerve injury. Anatomical data correlated with previous descriptions of intraneural anatomy. To demonstrate this, we examined the intraneural anatomy of the second web space fascicular group along with the proper digital nerves to the index, long, and ring fingers. In addition, we explored the concept of the internal plexus, which we call “pseudoplexi,” and demonstrated that dissection can be carried out proximal to these areas facilitating the aim of transposing painful neuromas more proximally.

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Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain information from studies using human or animal subjects.

Statement of Informed Consent

No informed consent was needed for this cadaver study

Declaration of Conflicting Interests

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