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Morphometry of the anterior interosseous nerve: a cadaveric study

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Abstract

Objectives: Pathophysiology and etiology of anterior interosseous nerve (AIN) syndrome are still controversial. This anatomical dissection study aimed to understand the anatomy of AIN.

Methods: From a random sample of upper extremities of whole-body human cadavers (n=10), 20 upper extremities were included in the study. Two of the cadavers were females and 8 were males (age range 34–62 years). Specimens were dissected with the elbow in extension, wrist in neutral position and forearm in pronation. After superficial dissection, the pronator teres muscle was released, and the branching pattern of the AIN and the separation of the nerve from the interepicondylar line were recorded. The branches to the pronator teres, flexor pollicis longus, flexor digitorum profundus and flexor digitorum superficialis were recorded according to their distance from the interepicondylar line.

Results: The AIN branched from the main trunk 5.1 to 47.89 mm (mean 37.58±11.25 mm) distal to the interepicondylar line. AIN gave off 1–4 branches to the pronator teres. The first branch left the AIN 10.05–83.84 mm proximal and entered the muscle 23.49–43.72 mm distal to the interepicondylar line. AIN gave 1–4 branches to the flexor pollicis longus, flexor digitorum profundus and flexor digitorum superficialis at varying distances. The origin of the branches of AIN, as well as the innervation by one or multiple branches for a muscle, was variable.

Conclusion: This study provides a detailed map of the anterior interosseous nerve innervating flexor pollicis longus, flexor digitorum profundus and flexor digitorum superficialis muscles, to serve as a guide for location of AIN block in patients with upper extremity spasticity and AIN syndrome.

Keywords: anterior interosseous nerve; cadaver; morphometry

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Introduction

The anterior interosseous nerve syndrome (AINS) is a rare forearm nerve neuropathy. Compression of the nerve due to different anatomical variations such as Gantzer's muscle[1,2] and inflammation of the anterior interosseous nerve (AIN) are the prominent considerations for the etiology of AINS.[3,4] Previously, AINS has also been described as a clinical manifestation of neuralgic amyotrophy (Personage-Turner syndrome).)[5,6] Thickening of AIN and widespread muscle oedema at the distal third of the forearm, demonstrated by magnetic resonance imaging, also support the inflammatory pathophysiology.[3,4]

The patients can usually reach spontaneous recovery by conservative treatment methods in one year.[7] Before surgical treatment, they can be followed with conservative treatments such as injections, electrical stimulation and strengthening of the remaining muscles from 3 months to 1 year.[7–9] While a compressive lesion or a precise compression level are found by magnetic resonance imaging and electroneuromyography, corticosteroid or anesthetic injections can be applied to the injury level on the purpose of treatment or to diagnose the accurate surgery level. The corticosteroid and local anesthetic injections to the proximal side of the injury level of the nerve are effective treatment options to relieve peripheral nerve neuropathy.[10] Infiltration of the pronator teres muscle with corticosteroids has been reported as an effective treatment method in patients with pronator teres syndrome.[11]

Ideal timing of surgery for AINS is controversial. Proper treatment depends on precise and accurate diagnosis.[9] Injection techniques to the AIN have been studied previously.[12,13] Diagnostic lidocaine AIN block can help to specify the spastic muscles for botulinum toxin injection to improve the contractures of interphalangal joints.[13] Most of the studies focused on the motor entry points of the median nerve branches to find the accurate localization of forearm botulinum toxin injections.[14,15] However, there are a few studies on the detailed morphology of the AIN.[16,17] The AIN arises from the posterior part of the median nerve in various forms.[17,18] Canova et al.[18] reported that the AIN of the forearm and its branches showed the least variability. Studies on the distribution of the AIN on the pronator teres muscle are controversial. Some reported the AIN arising between the ulnar and humeral heads of the pronator teres, and some more distally from the heads of the pronator teres. AIN has a branch to the flexor indicis profundus and innervates the flexor digitorum profundus of the middle finger and distally supplies the pronator quadratus muscle.[17]

Investigation of the morphological distribution of the AIN within the pronator teres muscle is important for the development of the proper injection techniques. AIN transfer has also become popular in recent years. Especially in proximal ulnar nerve injuries, reconstruction is usually performed transferring the distal branch of the AIN to the distal motor branch of the ulnar nerve.[8,19,20] Therefore, anatomical variations of the distal branches of the AIN are significant. The purpose of this cadaver study was to identify the trajectory and morphology of the AIN for augmenting its clinical applications.

Materials and Methods

Twenty upper extremities of 10 formalin fixed cadavers were dissected with Zeiss OPMI 9-FC surgical microscope (Carl Zeiss, Goettingen, Germany) starting from the middle third of the forearm to the wrist. Two of the cadavers were females and 8 were males (age: 34–62 years). All specimens were preserved by intra-arterial injection of 10% formalin solution, and dissected while the elbow was in extension, the wrist in neutral position and forearm in pronation. After dissection of the skin and the superficial fasciae of the flexor compartment, the pronator teres muscle was exposed and the location of the AIN was recorded with respect to this muscle. Thereafter, the pronator teres was released from its origin at the medial epicondyle (humeral portion) and the separation of the AIN was recorded as laterally, medially or posteriorly (towards the deep compartment). The distance of the nerve from the interepicondylar line was recorded in millimeters. Later, AIN branches to the flexor pollicis longus and the flexor digitorum superficialis muscles were recorded in relation to their distance from the interepicondylar line.

The cadavers used in our institution were unclaimed bodies which were delivered from Forensic Medicine according to the rules of Turkish legislation, studied according to the Helsinki protocol.

Results

The AIN separated from the main trunk posteriorly in 14 upper extremities, laterally in 5 upper extremities and medially in only 1 upper extremity (**Figures 1** and **2**). The AIN branched from the main trunk 5.1 to 47.89 mm (mean 37.58±11.25 mm) distal to the interepicondylar line.

The AIN separated from the main trunk of the median nerve before the level of the pronator teres (in the proximal 1/3 of the forearm) in 7 upper extremities and at the level of the pronator teres (in the middle 1/3 of the forearm) in 13 upper extremities (**Figures 1** and **2**), in accordance with the textbooks stating that the AIN separates usually within the pronator teres.

The AIN gave off 1–4 branches to the pronator teres. In 15 extremities, the AIN was giving a single branch to pronator teres. In 3 upper extremities, there were 2 branches, while there were 4 branches in two extremities. All the branches to the pronator teres branched from the AIN proximal to the interepicondylar line and entered the muscle distal to the interepicondylar line. In the extremities which the pronator teres had more than one branch, additional branches were highly variable, while we measured more consistent values for 15 extremities, including only 1 branch to the pronator teres (**Figure 2**). The first branch to the pronator teres parted from the AIN 10.05–83.84 proximal to interepicondylar line and entered the muscle 23.49–43.72 mm distal to the interepicondylar line. The AIN gave off 2–3 branches to the flexor pollicis longus and 1–3 branches to the radial part of the flexor digitorum profundus (**Figure 2**).

There were two branches from the AIN to the flexor pollicis longus in 14 extremities and three branches in 6 upper extremities. The first nerve to the flexor pollicis longus originated between 22.82–69.32 mm (mean 49.69±18.52 mm) and terminated between 97.94–109.41 mm (mean 102.06±3.68 mm) from the interepicondylar line (**Figure 2**). The second nerve to the flexor pollicis longus originated 35.79 to 80.9 mm (mean 59.37±16.77 mm) and terminated between 89.26 to 121.04 mm (mean 109.6±

11.43 mm) from the interepicondylar line. Furthermore, if a third nerve to the flexor pollicis longus was present, it originated between 63.87 to 110.42 mm (mean 87.15±32.92 mm) and terminated between 128.65 to 163.77 mm (mean 146.21±24.83 mm) from the interepicondylar line.

The branches to the flexor digitorum profundus muscle were similarly variable. The AIN gave 1 branch to the flexor digitorum profundus in four extremities, 2 branches in 10 upper extremities and 3 branches in six upper extremities. The first branch to the flexor digitorum profundus separated from the AIN between 53.15–69.79 mm (61.59±7.11 mm) and terminated between 61.20–90.61 mm (78.79±10.61 mm) from the interepicondylar line. The second nerve to the flexor digitorum profundus originated between 69.32–114.05 mm (81.59±18.87 mm) and terminated between 87.72–161.94 mm (114.30±30.73 mm) from the interepicondylar line. If present, the third nerve to the flexor digitorum profundus originated between 111.62–116.57 mm (114.1±3.5 mm) and terminated between 134.8–139.12 mm (136.96±3.05 mm) from the interepicondylar line.

The AIN gave a single branch to the flexor digitorum superficialis in 14, and 2 branches in 6 upper extremities. The first branch to the flexor digitorum superficialis showed high variability, being separated from the AIN between 55.2 mm proximal to 35.16 mm distal to the interepicondylar line. The first branch to the flexor digitorum superficialis entered the muscle 47.54–78.65 mm, and the second branch 64.85–130.21 mm (85.96±23.05 mm) distal to the interepicondylar line, and terminated 159.86–161.05 mm (160.16±0.26 mm) distal to the epicondylar line (**Figure 2**).

After giving off these branches, the AIN reached the pronator quadratus muscle and terminated at the deep surface of this muscle, 174–187.69 mm and 178.6±2.65 mm distal to the interepicondylar line, respectively (**Figure 1**).

Discussion

This study aimed to reveal the anatomical location and branching of the AIN innervating the flexor digitorum profundus, flexor pollicis longus and pronator quadratus muscles. Additionally, we tried to expose other branches of the AIN to understand the precise distribution of the nerve on the forearm.

In contrast to previous published studies demonstrating that the AIN separates from the main trunk posteriorly, we found that it separated not only posteriorly, but also laterally from the main trunk in 5 (25%) upper extremities and medially in one upper extremity (5%).[16,21,22] The AIN separated from the main trunk 37.58 mm from the interepicondylar line. This measurement is close to the measurements of previous studies as 45 mm and 43 mm from the interepicondylar line.[16,21] The small standard deviation of our measurement (11.25 mm) signified a little variability in this location.

Vincelet et al.[16] reported that the AIN gave two branches to flexor pollicis longus and 72±15 mm distance to the interepicondylar level. However, Lepage et al.[15] demonstrated a single branch to the flexor pollicis longus. We observed that the AIN usually gave off 2 branches to the flexor pollicis longus, and the number of the branches was 2 or 3. The level of the separation of the nerves and the level of the entry to the muscle were different from

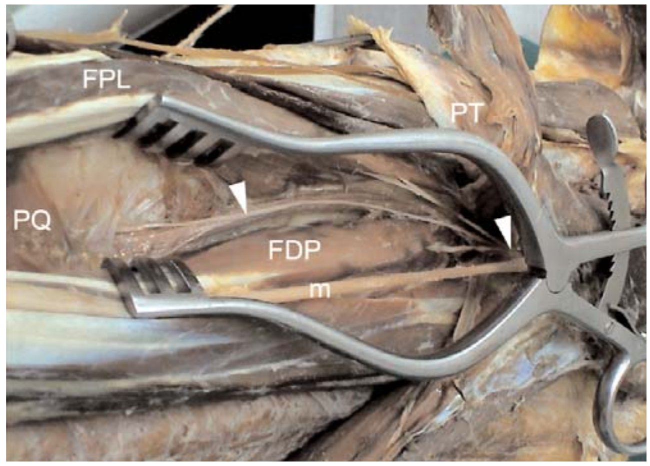

Figure 1. Course of the anterior interosseous nerve (AIN). **Arrowheads:** AIN; **FDP:** flexor digitorum profundus; **FPL:** flexor pollicis longus; **m:** median nerve; **PQ:** pronator quadratus; **PT:** pronator teres. [Color figure can be viewed in the online issue, which is available at www.anatomy.org.tr]

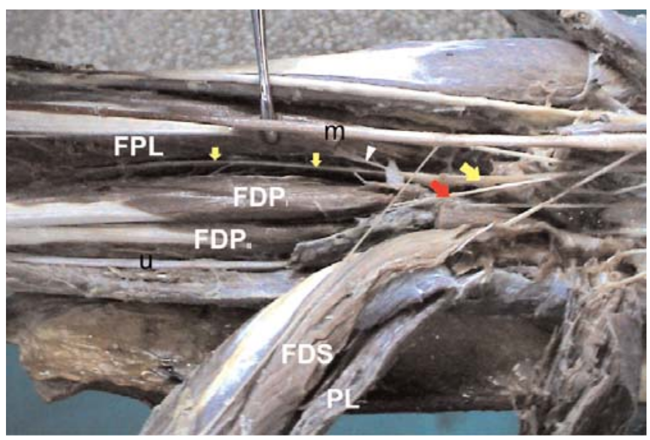

Figure 2. Branches of the anterior interosseous nerve (AIN). **FDP:** flexor digitorum profundus; **FDS:** flexor digitorum superficialis; **FPL:** flexor pollicis longus; **m:** median nerve; **PL:** palmaris longus; **u:** ulnar nerve; **yellow arrows:** AIN; **red arrow:** nerve to FDP; **arrowhead:** nerve to FPL. [Color figure can be viewed in the online issue, which is available at www.anatomy.org.tr]

each other. Nevertheless, a significant relationship was not found between these values. In this study, the flexor pollicis longus branches separated from the main trunk 22.82–110.42 mm distal to the interepicondylar line. We demonstrated more variability for the flexor pollicis longus branches compared to other studies.[16,21] The AIN gave off 1–3 branches to the flexor digitorum profundus, similar with the previous studies.[16,21]

Conclusion

In this study, we showed that the origin of the branches of the AIN, as well as the innervation by one or multiple branches for a muscle, was highly variable. However, the level of the origin of the AIN was less variable compared to other branches of the median nerve. Therefore, we conclude that the anterior interosseal nerve is probably the best option for free muscle transfer to restore flexion of fingers. By knowing the exact location of the AIN, the surgical operations in this area will be safer, particularly for nerve transfer. This study also provided a detailed map of the AIN innervating the flexor pollicis longus, the flexor digitorum profundus and the pronator quadratus, to serve as a guide for the location of the proper nerve block in patients with upper extremity spasticity and AINS.

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