Quantitation of and superficial surgical landmarks for the anterior interosseous nerve

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Object. There are scant data regarding the anterior interosseous nerve (AIN) in the neurosurgical literature. In the current study the authors attempt to provide easily identifiable superficial osseous landmarks for the identification of the AIN.

Methods. The AIN in 20 upper extremities obtained in adult cadaveric specimens was dissected and quantified. Measurements were obtained between the nerve and surrounding superficial osseous landmarks.

The AIN originated from the median nerve at mean distances of 5.4 cm distal to the medial epicondyle of the humerus and 21 cm proximal to the ulnar styloid process. The distance from the origin of the AIN to its branch leading to the flexor pollicis longus muscle and to the point it travels deep to the pronator quadratus (PQ) muscle measured a mean 4 and 14.4 cm, respectively. The mean distance from the AIN branch leading to the flexor pollicis longus muscle to the proximal PQ muscle was 12.1 cm, and the mean distance between this branch and the ulnar styloid process was 7.2 cm. The mean diameter of the AIN was 1.6 mm at the midforearm.

Conclusions. Additional landmarks for identification of the AIN can aid the neurosurgeon in more precisely isolating this nerve and avoiding complications. Furthermore, after quantitation of this nerve, the AIN branches can be easily used for neurotization of the median and ulnar nerves, and with the aid of a transinterosseous membrane tunneling technique, passed to the posterior interosseous nerve.

Key Words • brachial plexus • forearm • anatomy • surgery

There is a paucity of information in the neurosurgical literature regarding the surgical anatomy of the AIN. In the proximal forearm, the AIN, having approximately 1700 axons, arises from the median nerve and travels distally between the FDS and FDP muscles. Although it initially parallels the median nerve and is its largest motor branch in the forearm, the AIN quickly passes dorsally or dorsomedially in the interval between the FPL muscle laterally and the FDP muscle medially, providing branches to each of these muscles (approximately the radial half of the FDP muscle). Diminished in size, the AIN reaches the anterior part of the interosseous membrane and travels distally with the anterior interosseous artery (Figs. 1 and 2), extending deep to the PQ muscle where after innervating this muscle, it sends filaments to the ligaments and articulations of the intercarpal, radiocarpal, and distal radio-ulnar joints.

Although the AIN is deeply situated, its injury causes paralysis of the entire FPL and PQ muscles and a variable amount of the radial portion of the FDP muscle, especially the part serving the second digit. Characteristically, paresis or an inability to flex the terminal phalanx of the first and second digits occurs when pronation of the forearm is impaired, especially while the forearm is flexed. Although chronic wrist pain has been attributed to AIN injury, sensory defect has not. Patients may also feel a dull pain in the proximal one third of the forearm, which is aggravated by radial pressure at the level of the tendinous arch of the FDS muscle.

Materials and Methods

The AIN in 20 formalin-fixed upper extremities from 10 adult cadavers (mean age 73 years at the time of death, range 62–84 years) was dissected, and measurements were obtained between this nerve and surrounding superficial osseous landmarks. Four male and six female cadavers were used in this study. All measurements were ob-

Abbreviations used in this paper: AIN = anterior interosseous nerve; FDP = flexor digitorum profundus; FDS = flexor digitorum superficialis; FPL = flexor pollicis longus; PIN = posterior interosseous nerve; PQ = pronator quadratus.
tained using calipers. After making a skin incision over the cubital fossa and forearm, retraction of the superficial flexor muscles of the anterior forearm was performed. The humeral head of the pronator teres muscle was transected to view the proximal median nerve. Following exposure of the AIN, measurements were obtained, including distances from the medial epicondyle to the origin of the AIN (Fig. 1, A), from the ulnar styloid process to the origin of the AIN at the median nerve (Fig. 1, B), from the medial epicondyle to the origin of the AIN branch leading to the FPL muscle (Fig. 1, C), from the origin of the AIN at the median nerve to its branch leading to the FPL muscle (Fig. 1, D), from the origin of the AIN at the median nerve to its branch leading to the PQ muscle (Fig. 2, E), from the AIN branch leading to the FPL muscle to the proximal PQ muscle (Fig. 2, F), and from the ulnar styloid process to the proximal PQ muscle (Fig. 2, G); the total number of branches from the AIN in the forearm; and the diameter of the AIN at the midforearm. A statistical analysis of the difference between the left and right sides and between the sexes was performed using the Student t-test.

Results

All cadaveric specimens had an AIN, and on all sides this nerve began at a mean distance of 5.4 cm distal to the medial epicondyle of the humerus. Proximally, the AIN was best identified using dissection and retraction between the muscle bellies of the medially placed pronator teres and laterally placed brachioradialis muscles. In fact, the division of the midpoint of the pronator teres muscle was a reliable landmark for identifying the proximal AIN. No specimen exhibited compression of the proximal AIN by variations in the FPL muscle (for example, the Gantzer muscle, which is an accessory head of the FPL muscle originating near the coronoïd process of the ulna or the medial epicondyle of the humerus). Distally, the AIN was best identified using dissection and retraction between the laterally placed palmaris longus (if present) and flexor carpi radialis muscles, and the medially placed ulnar half of the FDS muscle. In its descent into the forearm, this nerve traveled more or less between the ulna and radius, much of the time just anterior to the interosseous membrane. The distance from the medial epicondyle to the origin of the AIN ranged from 2.5 to 7.5 cm (mean 5.4 cm; Fig. 1, A); that from the ulnar styloid process to the origin of the AIN ranged from 18 to 26.5 cm (mean 21 cm; Fig. 1, B). The distance from the medial epicondyle to the origin of the AIN branch leading to the FPL muscle ranged from 6.5 to 12.5 cm (mean 8.7 cm; Fig. 1, C). The distance from the origin of the AIN at the median nerve to its branch leading to the FPL muscle, the distance ranged from 12.5 to 18.5 cm (mean 14.4 cm; Fig. 2, E). The distance from the AIN branch leading to the FPL muscle to the PQ muscle ranged from 10 to 14 cm (mean 12.1 cm; Fig. 1, F). The distance from the ulnar styloid process to the proximal AIN branch leading to the PQ muscle ranged from 5 to 10 cm (mean 7.2 cm; Fig. 1, G). The total number of branches leading from the AIN in the forearm ranged from four to seven (mean 4.5 branches). The diameter of the AIN at the midforearm ranged from
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1 to 3 mm (mean 1.6 mm). The anomalies noted in the forearm specimens included a Gantzer muscle (four specimens) and an FDP accessorius muscle (one specimen). No significant differences in the specimens were found between the left and right sides or between the sexes (Student t-test, p > 0.05). Table 1 shows values for all measurements obtained in each of the 20 specimens in our study.

Discussion

Injury to the AIN makes up approximately 1% of all upper-extremity peripheral nerve palsies. Anterior interosseous nerve palsy may arise spontaneously in approximately one third of cases. Reported causes of injury include trauma following exposure of the brachial vein in the cubital fossa for cardiac catheterization, misplaced injections dispensed therapeutically or self-administered by drug addicts, iatrogenicity following open reduction of forearm fractures or other surgical procedures of the forearm, fractures of the forearm, and anomalous muscles or bands. Rarely, Sunderland has used the biceps brachii tendon of insertion into the median nerve trunk and the AIN as arising between the pronator teres muscle and the ulnar nerve, which, on injury of the AIN, could result in there may be a Martin–Gruber anastomosis linking the AIN and ulnar nerve, which, on injury of the AIN, could result in additional paralysis of the adductor pollicis, abductor digitit minimi, and radial three dorsal interossei muscles. If a Gantzer muscle is present, the AIN will innervate it.

Sunderland has found that the AIN originates between 2.3 and 8 cm distal to the medial epicondyle. This author also found that the AIN maintains a nearly posterior to posterior lateral funicular position within the median nerve and is a separate group of fascicles up to 2.5 cm proximal to its branching from the median nerve trunk; our findings support these claims. Botte has stated that the AIN usually branches from the median nerve immediately distal to the FDS arch, 5 to 8 cm distal to the medial epicondyle of the humerus. We found that the AIN originates from the median nerve immediately distal to the AIN branch leading to the FPL muscle; D, distance from the origin of the AIN to its branch leading to the FPL muscle; E, distance from the origin of the AIN to the proximal PQ muscle; F, distance from the AIN branch leading to the FPL muscle to the proximal PQ muscle; G, distance from the ulnar styloid process leading to the PQ muscle; H, number of branches from the AIN; and I, diameter of the AIN at the proximal edge of the PQ muscle.

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* Values in columns A through G represent centimeters; those in column I, millimeters; A, distance from the median epicondyle to the origin of the AIN; B, distance from the ulnar styloid process to the origin of the AIN; C, distance from the median epicondyle to the origin of the AIN branch leading to the FPL muscle; D, distance from the origin of the AIN to its branch leading to the FPL muscle; E, distance from the origin of the AIN to the proximal PQ muscle; F, distance from the AIN branch leading to the FPL muscle to the proximal PQ muscle; G, distance from the ulnar styloid process leading to the PQ muscle; H, number of branches from the AIN; and I, diameter of the AIN at the proximal edge of the PQ muscle.
et al., have noted that the AIN can be anesthetized distally at a site 1 cm medial and 3 cm proximal to the Lister tubercle (dorsal radial tubercle).

Novak and Mackinnon have surgically transferred the distal AIN to the deep branch of the ulnar nerve at the wrist in an attempt to reinnervate the intrinsic muscles of the hand. In all eight patients in their study, intrinsic hand muscle strength was improved at the 18-month follow-up examination with no reported deficit in pronation. Earlier, Ustün, et al., had found in a cadaveric study that the AIN branch to the PQ muscle may be suitable for transfer to the motor branch of the ulnar nerve. The AIN branch to the PQ muscle has approximately 900 myelinated fibers according to Wang and Zhu and approximately 1165 myelinated fibers according to Novak and Mackinnon. Wang and Zhu have reported transferring the PQ muscle branch of the AIN to the deep branch of the ulnar nerve by using as grafts the sural nerve or the dorsal cutaneous branch of the ulnar nerve. Three of fourteen patients in their study regained normal muscle strength of the ulnar-innervated hand muscles by the most recent follow-up examination. Similarly, Schultz and Aiache have reported success in a patient with a median nerve injury in the proximal forearm who had undergone reinnervation of the thenar muscles following a transfer of the ulnar nerve branch to the third lumbrical muscle to the recurrent branch of the median nerve. Surgical exploration of the AIN may be undertaken following 6 to 12 weeks of conservative therapy; however, other authors have advocated waiting up to 6 months. Surgical release of the AIN is generally successful. During surgery, the proximal AIN can be identified by first localizing the median nerve in the cubital fossa as it travels medial to the brachial artery. More distally, the pronator teres muscle may need to be divided, and the AIN may be identified between the FPL and FDP muscles. Based on our findings, we assert that neurotization procedures could be performed between the AIN and the ulnar nerve or PIN. Indeed, the AIN could easily be brought in proximity to the PIN by passing the AIN directly to this nerve, over the dorsal extensor musculature, and through the interosseous membrane. Furthermore, we could routinely use the AIN proximally toward the distal humerus without obvious injury to the median nerve trunk, and thus provide a longer segment of nerve for transfer.

The segmental innervation of the AIN to both the FDP and FPL muscles originates from C-7, C-8, and T-1; innervation for the PQ muscle stems from C-8. The radial nerve is composed of fibers from C-6, C-7, C-8, and sometimes T-1. More specifically, the PIN supplies the supinator muscle with C-6 fibers predominantly and the remaining dorsal forearm muscles with C-7 and C-8 fibers. These facts make an AIN to PIN neurotization procedure more segmentally congruent. Ustün, et al., have found that motor branches of the median nerve to the pronator teres, FPL, and PQ muscles may be suitable for neurotization of the PIN. Loss of the PQ muscle does not constitute a major problem because it is easily compensated for by the pronator teres and secondary pronator muscles. The loss of FPL muscle function results in a loss of interphalangeal flexion of the first digit, which can be easily counterbalanced. This joint has a secondary role in first digit motion, and denervation of the FPL muscle can be addressed by arthrodesis, tenodesis, or tendon transfer procedures. Haase and Chung have used a sural nerve graft to coapt the AIN to the motor branch of the ulnar nerve at the wrist with good success in one patient.

Conclusions
Our study data have revealed potentially useful superficial osseous landmarks for identifying the AIN. It is our hope that these data will aid the neurosurgeon in avoiding complications and more easily identifying this nerve when attempting to decompress it in patients with an AIN injury. Additionally, our data may prove useful in identifying branches, such as the distal AIN, that may be used in a neurotization procedure to the PIN or ulnar nerve.

References
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