

## THE ORIGIN AND POINT OF PENETRATION OF THE NERVE BRANCHES SUPPLYING THE *FLEXOR DIGITORUM PROFUNDUS*

Renata Frazão<sup>1</sup>, Nilton Alves<sup>1</sup> and Serafim V. Cricenti<sup>2</sup>

<sup>1</sup>Department of Morphology, University of Santo Amaro, Santo Amaro, SP, Brazil

<sup>2</sup>Department of Morphology, Paulista School of Medicine, Federal University of São Paulo, São Paulo, SP, Brazil

### ABSTRACT

Lesions in the nerves supplying the *flexor digitorum profundus* cause a loss of flexibility in the distal phalange of the middle phalange of the finger. A knowledge of the distribution of the nerve branches, and of their origins and points of penetration in the forearm would make the treatment of these lesions easier, especially when surgery is involved. In this study, we dissected 20 forearms from 10 formal-fixed corpses and examined the relationships of the anterior interosseous and ulnar nerves to the *flexor digitorum profundus*. The articular lines of the elbow and wrist were used as reference points. In the left upper limb, most branches of the anterior interosseous nerve (39.3%) began in the distal half of the proximal third of the forearm, whereas most branches of the ulnar nerve (54.5%) began in the distal third of the arm. As a result, most of the anterior interosseous (52.7%) and ulnar (64.9%) nerve branches penetrated in the distal half of the proximal third of the forearm. In the right upper limb, most of the branches of the anterior interosseous nerve (35.7%) began in the distal half of the proximal third of the forearm, whereas the branches of the ulnar nerve (50%) began in the distal third of the arm and in the distal half of the proximal third of the forearm. Most of the penetration points for the anterior interosseous (45.8%) and ulnar (62.8%) nerve branches began in the distal half of the proximal third of the forearm. Anatomical variations were observed in some cases.

**Key words:** *flexor digitorum profundus*, lesions, anterior interosseous nerve, ulnar nerve

### INTRODUCTION

Several types of lesions may affect the movement of the *flexor digitorum profundus* muscle. Lesions involving the entire brachial plexus are rare but may occur through stretching of the plexus. In this case, the arm, forearm, hand and finger muscles, as well as most of the shoulder muscles become paralyzed and undergo atrophy, with a loss of sensation in the entire upper limb. Partial lesions of the brachial plexus may result from knife or bullet wounds or from forced traction of the arm, particularly during birth. Klumpke paralysis of the inferior type results from partial lesion of the brachial plexus and affects the branches derived from the C8 and T1 spinal segments [4].

The median nerve supplies most of the muscles associated with pronation of the forearm, flexion of the hand and fingers and movement of the thumb. Lesions in this nerve affect flexing of the wrist and lead to ulnar deviation, the pronation of the forearm being replaced by rota-

tion of the arm [4,12]. Compression of the nerve may occur at several sites, including the fibrous arches formed by the *flexor digitorum superficialis*, the round pronator or both; compression may also be caused by the Gantzer muscle, an accessory head of the *flexor pollicis longus*, and by the vascular chains around the nerve [3,10]. Classic syndromes involving compression of the median nerve are known as the syndrome of the pronator and the syndrome of the anterior interosseous nerve [3].

The normal structures of the anterior interosseous nerve are extremely vulnerable to compression and traction. While trauma in the region where the nerve is located can initiate the syndrome, most cases apparently begin spontaneously [2]. The anterior interosseous nerve syndrome may result from a lesion in the nerve itself or from lesions in the median nerve. Noticeable weakness in the *flexor pollicis longus*, lateral portion of the *flexor digitorum profundus* and *pronator quadratus* is an indication of this syndrome.

Compression of the ulnar nerve in the wrist results in paralysis of most of the muscles of the hand, and cause the hand to assume a claw-like position with all the fingers losing movements of adduction and abduction. Lesion of the ulnar nerve in the elbow may result from arthritis in this articulation caused by old fractures. In this case, the hand does not assume the claw-like position, but a portion of the

Correspondence to: Dr. Renata Frazão, Departamento de Morfologia, Universidade de Santo Amaro, Rua Professor Enéas de Siqueira Neto, 340, Jd das Embuias, CEP 04829-300, Santo Amaro, SP, Brasil, Tel: (55) (11) 5545-8613, E-mail: anatomy@bol.com.br

This paper was presented at the XIII Pan American Congress of Anatomy, New Orleans, in September, 2000.

*flexor digitorum profundus* is still paralyzed and the flexion movements of the fourth and fifth fingers are abnormal. There is also weakness in flexion of the wrist [1,4,12]. The correct treatment of the lesions above requires anatomical knowledge of the relationship of the nerve branches to the corresponding muscle.

In this study, we examined the origin and point of penetration of the anterior interosseous and ulnar nerve branches of the *flexor digitorum profundus*, based on the dissection of 20 upper limbs.

## MATERIAL AND METHODS

Twenty upper limbs were dissected from ten formol-fixed corpses in which the *causa mortis* had not affected the structure of the forearms. The corpses belonged to the Escola Paulista de Medicina, Universidade Federal de São Paulo, and were from individuals (2F, 8M) 26 to 66 years old. Two of the corpses were Caucasian and eight were non-Caucasian.

The lengths of the forearms were measured using a common ruler. For this, the articular lines of the elbow (determined by the humeroradial and humero-ulnar joints) and the wrist (determined by the articulation between the semilunar and ulnar bones, and by the articulation between the scaphoid and the radial bones) served as references. The limbs used had been partially dissected, with the skin, subcutaneous tissue, cutaneous nerves and fascia already removed.

After identification of the median nerve along the medial arm, the *pronator teres* was removed to improve visualization of the nerve, which normally occurs between the humeral and the ulnar heads of this muscle. The *flexor digitorum superficialis* was also removed from the anterior margin of the *radius* (2/3 proximal) because the median nerve is located deep beneath the muscle. The anterior in-

terosseous nerve was identified in the cubital fossa and dissected along its entire length to the point at which it innervates the *pronator quadratus*. The ulnar nerve was identified along the medial side of the arm and dissected up to the articular line of the wrist.

The nerve branches were also measured using a common ruler, with the articular line of the elbow serving a reference. For topographical reference to the origin and penetration of the nerve branches in the respective muscles, the forearms were divided into three sections (proximal, middle and distal), with each third having proximal and distal halves. The data obtained were used to calculate the average forearm length, the distance of the origin of the nerve branches, the number of origins, the distance of the points of penetration of the nerve branches, the number of points of penetration and the length of the nerve branches. The most proximal and distal points of origin and penetration from the articular line of the elbow and the presence or absence of recurrent branches were also noted.

The data were compared statistically using Student's paired t-test. A value of  $P < 0.05$  was considered to indicate significance.

## RESULTS

Tables 1 and 2 show the points of origin and penetration of the anterior interosseous and ulnar nerve branches supplying the *flexor digitorum profundus*. Figures 1 and 2 show the frequencies of the points of origin and penetration of the anterior interosseous and ulnar nerve branches. In the left upper limb, the anterior interosseous nerve had four branches which originated above the articular line of the elbow; two branches which originated above this line belonged to the same case. In the right upper limb, this nerve had only one branch with an origin above the articular line of the elbow.

**Table 1.** Data on the anterior interosseous nerve supply to the *flexor digitorum profundus*.

	RIGHT			LEFT		
	Minimum	Maximum	Mean ± S D	Minimum	Maximum	Mean ± S D
Forearm length	19.9	27.4	24.06 ± 1.9	21.6	27.4	23.8 ± 1.8
Branch length	0.7	14.1	4.4 ± 2.7	1.1	10.8	4.5 ± 2.3
Number of origins	1	5	2.8 ± 1.3	1	6	2.8 ± 1.2
Number of penetrations	2	13	8.3 ± 3.4	5	15	7.4 ± 2.9

n=20. All distances are in cm.

**Table 2.** Data on the ulnar nerve supply to the *flexor digitorum profundus*.

	RIGHT			LEFT		
	Minimum	Maximum	Mean ± S D	Minimum	Maximum	Mean ± S D
Forearm length	19.9	27.4	24.1 ± 1.9	21.6	27.4	23.8 ± 1.8
Branch length	0.5	7.9	4.8 ± 1.7	2.1	9.1	4.7 ± 1.6
Number of origins	1	1	1 ± 0	1	2	1.1 ± 0.3
Number of penetrations	1	7	4.3 ± 2.2	1	7	3.7 ± 1.8

n=20. All distances are in cm

The anterior interosseous nerve branches with the most proximal origin to the articular line of the elbow were located 0.4 cm from this line in the right upper limb and 1.9 cm in the left upper limb. Similarly, the most distal origins from this same articular line in the right and left upper limbs were 12.1 cm and 10.8 cm away. The average number of origins was 6 cm in the right and left upper limbs. The nerve branch with the most proximal point of penetration was located 4.2 cm from the articular line of the elbow in the right upper limb and 5.2 cm away in the left upper limb. The most distal point of penetration was 15.7 cm away in the right upper limb and 14.6 cm in the left upper limb. The average distance of the points of penetration was 8.9 cm and 8.4 cm in right the and left upper limbs, respectively. In both upper limbs, the ulnar nerve had two branches which originated above the articular line of the elbow. Both upper limbs also had branches with origins in

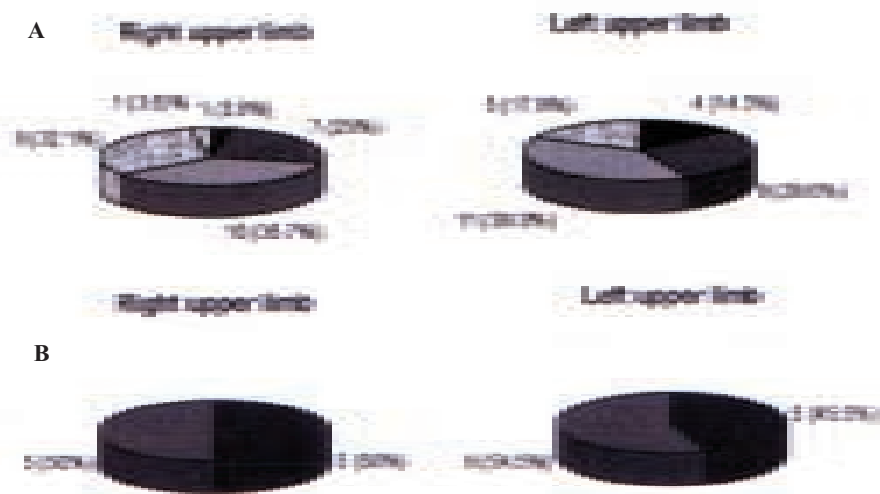
the articular line; these were considered as belonging to the distal third of the arm.

The nerve branches most distal in origin from the articular line in the right and left upper limbs were 3.8 cm and 2.9 cm away, respectively. The average distance of the origins from the articular line was 1.2 cm and 0.9 cm in the right and left upper limbs, respectively. The nerve branches with the most proximal points of penetration were located 2.2 cm away from the articular line of the elbow in the right upper limb and 1.3 cm away in the left upper limb; the most distal points of penetration were 8.7 cm away in the right upper limb and 7.9 cm away in the left upper limb. The average distance of the penetrations from the articular line was 5.1 cm and 4.4 cm in the right and left upper limbs, respectively.

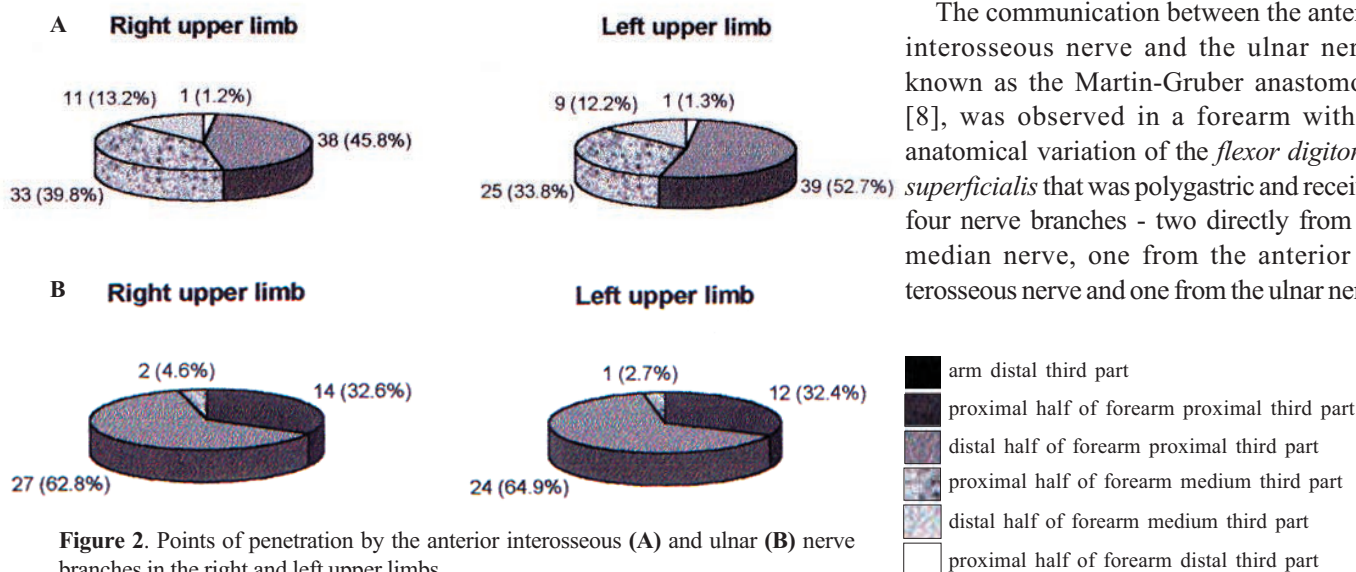
In the right upper limb, a branch from the median nerve originated in the distal third of the forearm and penetrated the distal half of the proximal third of the *flexor digitorum profundus* of the forearm.

The muscles of the left and right forearms showed no significant differences in their innervation by the anterior interosseous nerve. However, when innervated by the ulnar nerve, there was a significant difference ( $P < 0.05$ ) between the muscles of the two forearms. In all dissections, the branches of both nerves penetrated the superficial face of the muscle ventral surface. In seven cases, the anterior interosseous nerve issued branches to the *flexor digitorum superficialis*, and in only one of these cases were there two origins for the same muscle. This nerve had just one branch with an origin above the articular line of the elbow. In three cases, the ulnar nerve issued branches to the *flexor digitorum superficialis*.

The communication between the anterior interosseous nerve and the ulnar nerve, known as the Martin-Gruber anastomosis [8], was observed in a forearm with an anatomical variation of the *flexor digitorum superficialis* that was polygastric and received four nerve branches - two directly from the median nerve, one from the anterior interosseous nerve and one from the ulnar nerve.



**Figure 1.** The origin of the anterior interosseous (A) and ulnar (B) nerve branches in the right and left upper limbs.



**Figure 2.** Points of penetration by the anterior interosseous (A) and ulnar (B) nerve branches in the right and left upper limbs.

## DISCUSSION

In the 20 corpses examined, the anterior interosseous nerve always accompanied the anterior interosseous artery between the *flexor pollicis longus* and the *flexor digitorum profundus* muscles, and ended in the *pronator quadratus*. These findings agree with those of Collins and Weber [2] and Lake [8].

According to Collins and Weber [2], the anterior interosseous nerve issues motor branches to the *flexor digitorum superficialis* in 30% of the cases. Our results were very similar, since the anterior interosseous nerve issued branches to the *flexor digitorum superficialis* in seven (35%) of the 20 limbs dissected.

The ulnar nerve was always located behind the medial epicondyle of the humerus. This observation agrees with Bannister *et al.* [1], Gray [6] and Stern [12], although Gray [6] asserts that the ulnar nerve may sometimes be located anteriorly to the medial epicondyle of the humerus. The ulnar nerve issued branches to the *flexor digitorum superficialis*. Others [5, 6, 10] have made similar observations. Based on a study of 30 dissected limbs, Sabongi and Caetano [10] noted that only one case (3.3%) showed this type of variation. This frequency was smaller than the 15% observed here.

The *flexor digitorum profundus* was not innervated by the ulnar nerve alone, in contrast to the report by Sunderland [13]. Similarly, in no case was the *flexor digitorum profundus* innervated by the anterior interosseous nerve alone, contrary to the observations of Collins and Weber [2], Spinner [11] and Sunderland [13].

The communication between the anterior interosseous and ulnar nerves, known as the Martin-Gruber anastomosis, has been classified as type Ia [9], type I [14], and as *oblique anastomosis* [7]. Collins and Weber [2], as well as Thomson [14], observed a Martin-Gruber anastomosis in 15% of their cases, with 50% of these being derived from the anterior interosseous nerve. Nakashima [9] dissected 108 forearms and noted this communication in 12% of the cases. The incidence (5%) of this communication in the present study was smaller than that reported by others. Nakashima [9] stated that communications between the median or anterior interosseous and ulnar nerves are common in the proximal part of the forearm. We agree with this observation since the communication seen here originated from the anterior interosseous nerve in the proximal half of the proximal third of the forearm and converged on the ulnar nerve in the proximal half of the medium third of the forearm. Wiens and Lau [15] and Dellon and Mackinnon [3] stated that this type of communication recruits motor fibers from the anterior interosseous nerve to the ulnar nerve to innervate the hand muscles.

Since most branches of the anterior interosseous nerve converging on the *flexor digitorum profundus* originated in the distal half of the proximal third of the forearm, and since most penetrations by both nerves also occur in this

region, we conclude that lesions in the branches of both nerves may occur more often in the distal half of the proximal third part of the forearm.

## ACKNOWLEDGMENTS

The authors thank the Departamento de Morfologia, Escola Paulista de Medicina, Universidade Federal de São Paulo, for providing access to the corpses, and Prof. Casemiro Fernando Leite (Universidade Metodista de São Paulo) for statistical analyses.

## REFERENCES

1. Bannister LH, Berry MM, Collins P, Dyson M, Dusseck JE, Ferguson MWJ (1995) *Gray's Anatomy: the Anatomical Bases of Medicine and Surgery*. Churchill Livingstone: London.
2. Collins DN, Weber ER (1983) Anterior interosseous nerve syndrome. *South. Med. J.* **76**, 1533-1537.
3. Dellon AL, Mackinnon SE (1987) Musculoaponeurotic variations along the course of the median nerve in the proximal forearm. *J. Hand Surg.* **12**, 359-363.
4. Di Dio LJA (1974) *Sinopse de Anatomia*. Guanabara Koogan: Rio de Janeiro.
5. Goss CM (1988) *Anatomia Henry Gray*. Guanabara Koogan: Rio de Janeiro.
6. Gray H (1985) *Anatomy of the Human Body*. Lea and Fabiger: Philadelphia.
7. Hirasawa K (1931) Untersuchungen über das periphere nervesystem, plexus brachialis und die nerven der oberen extremitäten. *Arb. Anat. Inst. Kaiserlichen*. **A2**, 135-137.
8. Lake PA (1974) Anterior interosseous nerve syndrome. *J. Neurosurg.* **41**, 306-309.
9. Nakashima T (1993) An anatomic study on the Martin-Gruber anastomosis. *Surg. Radiol. Anat.* **15**, 193-195.
10. Sabongi JJJ, Caetano EB (1996) Estudo anatômico dos ramos musculares do nervo ulnar no antebraço. *Rev. Bras. Ortop.* **31**, 193-198.
11. Spinner M (1970) The anterior interosseous - nerve syndrome. *J. Bone Joint Surg.* **52A**, 84-94.
12. Stern JT Jr (1997) *Core Concepts in Anatomy*. Lippincott - Raven Publishers: Philadelphia.
13. Sunderland S (1968) *Nerves and Nerve Injuries*. William and Wilkins: Baltimore.
14. Thomson A (1983) Third annual report of the committee of collective investigation of the anatomical society of Great Britain and Ireland for the year 1991-1992. *J. Anat.* **27**, 183-194.
15. Wiens E, Lau SCK (1978) The anterior interosseous nerve syndrome. *Can. J. Surg.* **21**, 354-357.

Received: October 17, 2000

Accepted: April 5, 2001