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ORIGINAL COMMUNICATION

Anatomical Variations as Potential Risk Factors for Ulnar Tunnel Syndrome: A Cadaveric Study

M. CEM BOZKURT,[1]* SÜLEYMAN MURAT TAĞIL,[2] LEVENT ÖZÇAKAR,[3] MEHMET ERSOY,[1] AND IBRAHIM TEKDEMIR[4]

[1]*Kirikkale University Medical School, Department of Anatomy, Kirikkale, Turkey*
[2]*Süleyman Demirel University Medical School, Department of Anatomy, Isparta, Turkey*
[3]*Hacettepe University Medical School, Department of Physical Medicine and Rehabilitation, Ankara, Turkey*
[4]*Ankara University Medical School, Department of Anatomy, Ankara, Turkey*

The aim of this study was to assess the anatomical variations, especially the anomalous muscles passing through Guyon's canal and the fibrous arch forming the piso-hamate hiatus, which may play a role in ulnar tunnel syndrome. We have also focused on the relation of these structures with specific concern to the ulnar nerve. Nineteen embalmed cadavers (37 hands and forearms) were dissected. A fibrous arch extending between the pisiform and the hook of the hamate was observed in 21 hands. In majority of the cases flexor digiti minimi muscle was found to originate only from this arch. An anomalous muscle was disclosed in six hands with four of them passing through the piso-hamate hiatus with the deep branch of the ulnar nerve. In two of four cases, the superficial branch of the ulnar nerve was also accompanying the deep branch of the ulnar nerve beneath the anomalous muscle and through the piso-hamate hiatus. Because these anomalous muscles were generally found to course through the piso-hamate hiatus with the branches of the ulnar nerve, we conclude that the distal portion of the Guyon's canal has a relatively higher risk for ulnar nerve entrapment. We believe that surgeons operating on this region should take into account these various anatomic structures. Clin. Anat. 18:274–280, 2005.

Key words: accessory muscles; fibrous arch; piso-hamate hiatus; ulnar tunnel syndrome; Guyon's canal syndrome

INTRODUCTION

The ulnar nerve and the artery at the wrist passes through a fibroosseous tunnel known as Guyon's canal. The tunnel extends from the proximal edge of the palmar carpal ligament to the fibrous arch of the hypothenar muscles (Gross and Gelberman, 1985). The roof of the tunnel is formed by distal extension of the antebrachial fascia (often called the palmar or anterior carpal ligament) and the palmaris brevis muscle. The floor consists of the muscles of the hypothenar eminence, their fibers of origin, and the flexor retinaculum. The radial boundary is formed by the junction of the roof, including the palmaris brevis muscle, to the flexor retinaculum and tendons of origin of the thenar muscles. The ulnar boundary comprises the junction of the fascial roof with the fascia covering the hypothenar eminence distally and the pisiform bone proximally (Cobb et al., 1996).

Ulnar tunnel syndrome due to compression of the ulnar nerve as it passes through Guyon's canal has been a well recognized entity. It is also known as Guyon's canal syndrome. Compression of the ulnar nerve within Guyon's canal may produce a spectrum of clinical complaints including pain in the wrist with radiation into the ulnar two digits associated with motor and sensory complaints. Symptoms are

*Correspondence to: M. Cem Bozkurt, Ata Sok. 10/10 06580, Anittepe, Ankara, Turkey. E-mail: mcbozkurt2003@yahoo.com

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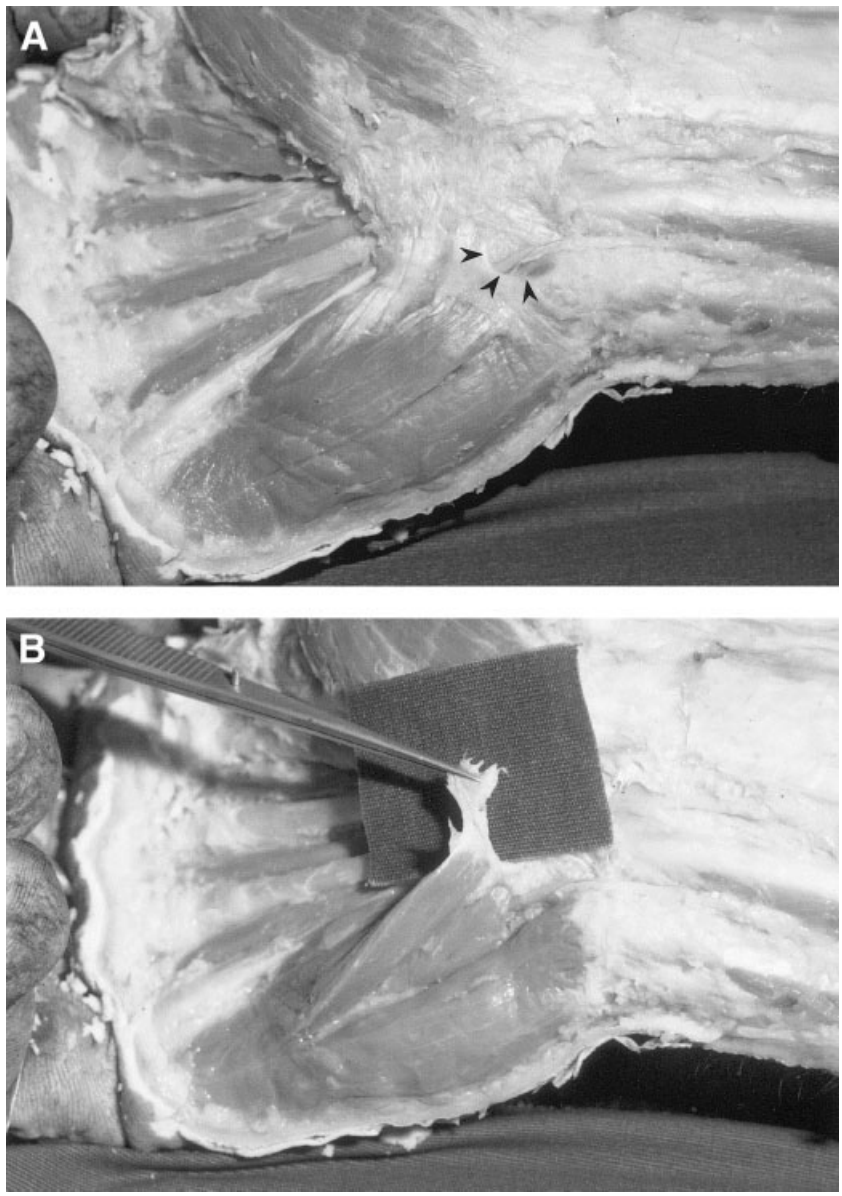

Fig. 1. **A:** Palmar view of the right hand demonstrating the fibrous arch (the arrow heads) distally in Guyon's canal. **B:** Fibrous arch removed from the pisiform and reflected for better visualization of the FDM muscle originating from it.

generally worse at night and with extreme wrist range of motion. Patients with mild symptoms are treated conservatively with nonsteroidals and splintage. Individuals irresponsive to this treatment or the ones with unidentifiable causes are candidates for surgery (Khoo et al., 1996).

The etiology of this entrapment syndrome comprises soft tissue masses (i.e., ganglia, lipoma, etc.), vascular anomalies, occupational neuritis or overuse injuries, fractures or dislocations of the carpal bones and of the distal radius and ulna, ligamentous attachments, and anomalous tendons and muscles (Khoo et al., 1996; Spinner et al., 1996; Hirooka et al., 1997; Netscher and Cohen, 1997; Santoro et al., 2000).

Accessory muscles are the most frequent anatomical variations in Guyon's canal (Dodds et al., 1990). The majority are found during cadaveric dissections and the rest are observed in the symptomatic cases (Jeffery, 1971; Swanson et al., 1972; Salgeback, 1977; James et al., 1987; Sheppard et al., 1991; Netscher and Cohen, 1997; Santoro et al., 2000).

Another structure that may cause an ulnar nerve entrapment in the wrist is the piso-hamate hiatus located in the distal part of Guyon's canal. The piso-hamate hiatus, which lies between the piso-hamate ligament and the fibrous arch at the origin of the hypothenar muscles, is the site where the deep branch of the ulnar nerve is likely to be compressed (Uriburu et al., 1976).

Fig. 2. Palmar view of the left hand depicting the fibrous arch (held with the splinter forceps) and the accessory FDM passing beneath.

This study assesses the relation between the anatomical structures that might contribute to the ulnar neuropathy in the wrist, especially the accessory muscles and the fibrous arch forming the piso-hamate hiatus, and the ulnar nerve. It is this specific focus on the relation of these structures that distinguishes our study from the previous ones.

MATERIALS AND METHODS

Nineteen embalmed adult cadavers (14 male, 5 female) were studied. Thirty-seven upper extremities (19 left, 18 right) were dissected. In each cadaver, the skin and the subcutaneous fatty tissues were removed starting from the forearm down to the palm of the hand. At the wrist, the palmaris brevis and the palmar aponeurosis were dissected, thereby lifting the roof of Guyon's canal. The ulnar nerve and the ulnar artery were exposed. Specific attention was paid to the presence of anomalous muscles. The relationship among the ulnar nerve, its branches, and the accessory muscles (piso-hamate hiatus and fibrous arch) was explored.

RESULTS

A fibrous arch, between the hook of the hamate and the pisiform, was detected in 21 (56.7%) hands. The flexor digiti minimi (FDM) was originating from either the fibrous arch alone (13 hands) or from the hook of the hamate as well (7 hands) (Fig. 1). In one hand, despite the existence of the fibrous arch, the origin was found to be only the hook of the hamate. In the remaining 16 hands, a fibrous arch was not present and the FDM originated from the hook of the hamate.

In six hands (16.2 %), an anomalous muscle was detected in Guyon's canal. All of these aberrant muscles were unilateral (2 right-sided, 4 left-sided). These muscles were defined as accessory abductor digiti minimi (ADM) in five cases and accessory FDM (Fig. 2) in one case (Table 1). Among these six muscles, four were found to pass through the piso-hamate hiatus distally in Guyon's canal. In two of four muscles, both the superficial and deep branches of the ulnar nerve were coursing beneath the accessory muscle through the hiatus (Fig. 3). In one case, only the deep branch traversed deep to the accessory muscle. Interestingly, in the other cadaver the deep branch was found to lie beneath the muscle; whereas the superficial branch resided deep to the muscle but superficial to the fibrous arch, thus not entering the hiatus (Fig. 4). In the two cadavers where the aberrant muscles did not pass through the hiatus, the muscles were found to be superficial to the ulnar nerve and the artery in Guyon's canal (Fig. 5).

No soft tissue masses, vascular anomalies, or aberrant fibrous structures (other than the fibrous arch) were discovered throughout any of the dissections.

DISCUSSION

Accessory muscles coursing through Guyon's canal and the fibrous arch overlying the deep motor branch of the ulnar nerve and similar normal anatomic variants may predispose to ulnar entrapment (Zeiss et al., 1992). Their passage through Guyon's

TABLE 1. Definition of the Accessory Muscles

Case	Origin	Insertion[a]	Relation with the piso-hamate hiatus
1	Flexor retinaculum	Fuse with the muscle belly of the normal FDM	Passing through
2	Flexor retinaculum	Fuse with the muscle belly of the normal ADM	Passing through
3	Flexor retinaculum	Inserted with ADM	Passing through
4	Antebrachial fascia (distal forearm)	Inserted with ADM	Passing through
5	Tendon of palmaris longus	Inserted with ADM	No hiatus and passing through Guyon's canal
6	Antebrachial fascia (distal forearm)	Inserted with ADM	No hiatus and passing through Guyon's canal

[a]FDM, flexor digiti minimi; ADM, abductor digiti minimi.

canal is relatively common and is often found bilaterally (Dodds et al., 1990; Zeiss et al., 1992). In a cadaver study, Dodds et al. (1990) reported a 22% incidence of anomalous muscles associated with Guyon's canal. In a similar radiologic study, Zeiss et al. (1992) recorded an incidence of 25%. In the former study, 46.2% was bilateral and in the latter one this ratio was 67.0%. Dodds et al. (1990) observed that majority of the anomalous muscles originated from the antebrachial fascia and all of them, including the ADM, inserted on the ulnar side of the base of the proximal phalanx of the little finger. They suggested that those muscles be classified as accessory ADM. Zeiss et al. (1992) reported that the anomalous muscles were found to arise anywhere between the mid-forearm and the proximal part of Guyon's canal along the antebrachial fascia, undersurface of palmar carpal ligament, or radial aspect of pisiform bone. However, all inserted with the ADM muscle. In our study, the incidence of the accessory muscles was found to be 16.2% and all of them were unilateral. As opposed to Dodds et al. (1990), but in keeping with Zeiss et al. (1992), the origins of these muscles varied (Table 1). In accordance with the aforementioned studies, the majority of the muscles were classified as accessory ADM. We believe the relatively lower incidence and unilateral presence of the variations could be attributed to the differences between the populations.

Despite the fact that soft tissue masses are mentioned to be the most frequent cause of Guyon's canal syndrome, we have not found any ganglia, lipoma, or arterial malformations in the Guyon's canal throughout our dissections. This is similar to the findings of Dodds et al. (1990).

A definition for the fibrous arch from which the hypothenar muscles originate does not exist in classic anatomy textbooks. Abductor digiti minimi usually

Fig. 3. Palmar view of the right hand demonstrating the accessory ADM muscle (the arrows) passing through the piso-hamate hiatus and the superficial and deep branches of the ulnar nerve coursing beneath (fibrous arch and FDM muscle lifted).

Fig. 4. Left hand. Accessory ADM (*) and the deep branch of the ulnar nerve passing through the piso-hamate hiatus, the superficial branch traversing between the accessory muscle and the fibrous arch (the fibrous arch has been cut for better illustration, the arrow pointing to its remnant lateral end).

arises from the pisiform, the tendon of flexor carpi ulnaris, and the pisohamate ligament. Flexor digiti minimi arises from the hook of the hamate and the flexor retinaculum (Williams et al., 1995) (Fig. 6). Despite the skepticism on their definition, there have been reports in the literature describing the fibrous arch or the piso-hamate hiatus. Hayes et al. (1969) described a ligamentous band passing from the pisiform to the hook of the hamate in all of the cadavers in their study. This structure was superficial to the deep branch of the ulnar nerve, and the abductor and the flexor of the little finger gained part of their origin from this arch. Hayes et al. (1969) emphasized the possible role of this band in compression of the ulnar nerve. Likewise, Lotem et al. (1973) observed this fibrous band in 50 cadaver hands. Uriburu et al. (1976) defined the piso-hamate hiatus as a narrow oblique opening in the floor of Guyon's canal between the fibrous arch and the opposite piso-hamate ligament. They have reported that the deep branch of the ulnar nerve and the ulnar artery left Guyon's canal and entered the deep palmar space via this hiatus (Fig. 7A). Dellon and Mackinnon (1988) have designated another fibrous arch at the origin of the FDM with an incidence of 40%. They have proposed this band to be another entrapment site for the deep branch of the ulnar nerve. In our study, we have observed the fibrous

Fig. 5. Right hand. Accessory ADM originating from the antebrachial fascia under the palmaris longus tendon (the arrow) in the distal forearm and passing through Guyon's canal superficial to the ulnar nerve and the artery.

arch, extending between the hook of the hamate and the pisiform, with an incidence of 56.7% (Fig. 1). We have found this arch as a concave tendinous anatomical structure from which FDM muscles originated partially or totally (Fig. 7B). This data pertaining to the origination of FDM muscles solely from this fibrous arch has not been reported hitherto in the literature. None of the ADM muscles were found to originate from this fibrous arch. Although we have delineated this arch as Hayes et al. (1969) and Lotem et al. (1973), its incidence and its relation with the hypothenar muscles were somewhat different. Our definition for this fibrous arch is different than the one of Dellon and Mackinnon (1988).

The clinical implication of this fibrous arch, contributing to the ulnar nerve entrapment, is usually an indirect impact on the ulnar nerve. This type of a compression usually stems from the existence of extra structures in the canal (i.e., ganglia or accessory muscles). As the arch stands as a fixed barrier, the intracompartmental pressure becomes increased conceivably. As we have demonstrated in our study, in all four hands with accessory muscles passing through the piso-hamate hiatus, the deep branch of the ulnar nerve was coursing beneath these muscles. Moreover, in two hands the superficial branch was also accompanying the deep branch (Fig. 3). We believe that although Guyon's canal syndrome has characteristic patterns of motor and sensory loss, depending on where the ulnar nerve has been compressed (Shea and McClain, 1969), the clinical symptomatology would rather be in accordance with the relation of the nearby anatomical structures where variations are not uncommon. Additionally, we suggest that the ulnar nerve is more prone to compressions in the distal portion of Guyon's canal as far as the accessory muscles and the tendinous arch forming the piso-hamate hiatus residing in this region are concerned. In patients where FDM originates totally from the fibrous arch, the pisohamate tunnel release surgery must be carried out with care and vigilance to avoid impairment of flexion of the little finger.

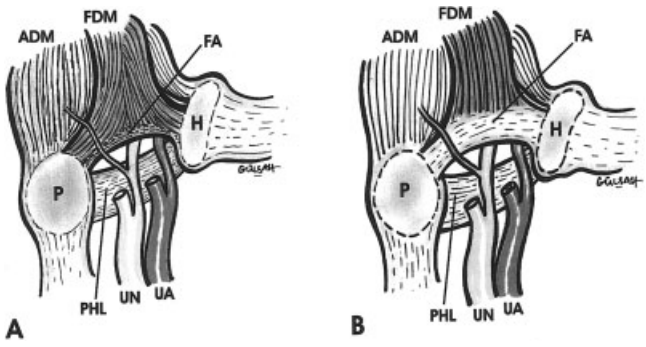

Fig. 7. **A:** Fibrous arch and the piso-hamate hiatus that have been previously described. **B:** Fibrous arch that we have described in our study. FA, fibrous arch; PHL, piso-hamate ligament.

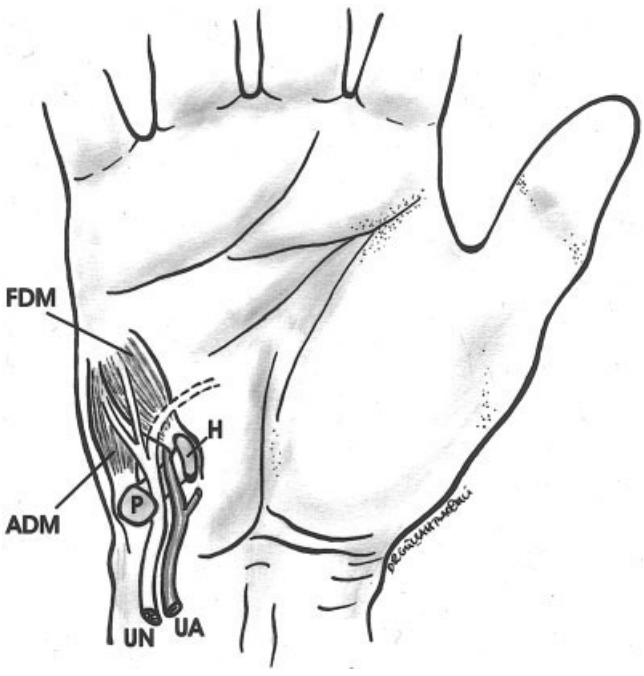

Fig. 6. Normal anatomy of the origins for ADM and FDM muscles. P, pisiform; H, hook of hamate; UN, ulnar nerve; UA, ulnar artery.

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