Brief Report

Anatomic Anomalies Encountered in 467 Open Carpal Tunnel Surgeries

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Abstract

Carpal tunnel syndrome is the most common compression neuropathy and carpal tunnel surgery is the most frequently performed hand surgery. Anatomic anomalies may predispose the median nerve to compression. The aim of the current study was to search for anatomic anomalies in open carpal tunnel surgeries through a cross-sectional study.

During a cross-sectional study in a one-year period, 436 consecutive patients (307 females and 129 males) with the average age of 50.3 ± 2.4 years underwent 467 classic open carpal tunnel surgeries. Thirty-one patients had bilateral surgeries. A thorough inspection of the incisions was conducted to search for vascular, neural, tendon and muscular anomalies.

Forty-two (8.9%) hands (14 males and 28 females) had anomalies. The average age of the patients with discovered anomalies was 48.6 ± 7.6 years. Ten anomalies were seen on the left hands and 32 anomalies were seen on the right hands. Among the 42 anomalies, there were 16 persistent median arteries, 14 anomalies of the median nerve, 7 intratunnel intrusion of the flexor and lumbrical muscle bellies and 5 anomalies of the origin of the thenar muscles. There was no correlation between the discovered anomalies and the age, gender or hand sides.

Anatomical anomalies are not uncommon in carpal tunnel surgeries. However, the frequencies of the reported anomalies vary among different studies. Familiarity with these anomalies increases the safety of the operation.

Keywords: Anatomic anomaly, carpal tunnel surgery, carpal tunnel syndrome, palmaris profundus, persistent median artery

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Introduction

Carpal tunnel syndrome (CTS) develops as a result of the compression of the median nerve within the carpal tunnel. CTS is the most common compression neuropathy and carpal tunnel surgery is the most frequently performed hand surgery.[1]

In the majority of cases, the development of the CTS is idiopathic. However, metabolic disorders, endocrine disorders, inflammatory diseases, tumors around the carpal tunnel, occupation, trauma and infection have been suggested as a cause or an exacerbating factor for CTS. Despite Phalen's belief that a congenital anomaly is rarely the cause of median nerve compression, several anatomic variations have been described as a cause or exacerbating factor for CTS.[1–5]

The aim of the current study was to search for vascular, neural, tendinous and muscular anomalies encountered in open carpal tunnel surgeries through a cross-sectional study over a one-year period.

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Materials and Methods

This cross-sectional study was accomplished during a one-year period on 467 (336 females and 131 males) consecutive hands of 436 patients (307 female and 129 male) with the average age of 50.3 ± 2.4 years. Thirty-one patients had bilateral surgeries. The patients underwent open carpal tunnel surgery. The study period was one year from March 2014 to March 2015. A total of 391 surgeries were performed on the right hand and 76 surgeries on the left hand. The institutional review board approved the study and informed consent was obtained from each patient.

Diagnosis of CTS was based on symptoms and clinical examinations including Tinel sign, Phalen and Durkan tests. Electrodiagnosis confirmed the diagnosis of CTS in all the patients. A course of non-surgical treatments had been tried for all patients before surgery.

Surgery was performed under local anesthesia using open carpal tunnel surgery technique. After dividing the transverse carpal ligament (TCL), the median nerve was exposed from the proximal wrist crease to proximal palmar arterial arch. The thenar muscles that originated from the ulnar to midaxis of the ring finger[1] and had connections with the hypothenar muscles were considered abnormal.[6] The carpal tunnel contents were explored for probable vascular, neural, tendinous and muscular anomalies. The median nerve and its branches were identified. We used the Lanz[7] classification for abnormal anatomy of the median nerve (Group I: aberrant origin of the motor branch of the median nerve; Group II:

Figure 1. A persistent median artery.

Table 1. Reported anatomical anomalies within and around the carpal tunnel in the literature and their frequencies in this study.

Structures	Reported anatomical anomalies within and around the carpal tunnel in the literature (1, 3, 4, 6, 11)	The frequencies of the anomalies among the 467 hands of the current study
Vascular	Persistent median artery	16
	Superficial ulnar artery	——
Neural anomalies	Aberrant origin of the motor branch of the median nerve	4
	Accessory branches of the median nerve at the distal carpal tunnel	——
	High division of the median nerve	8
	Accessory branches of the median nerve at the proximal carpal tunnel	2
	Transligamentous palmar cutaneous branch of the median nerve	——
	Anomalous course of the ulnar nerve	——
	Ulnar to median nerve connection (Marinacci communication)	——
Intra-tunnel muscles and tendons anomalies	Proximal origin of the index and middle fingers FDP tendons lumbricals	4
	Accessory lumbrical	——
	Intrusion of the FDS bellies of the index, middle and ring fingers	2
	Duplicated FDS muscle	——
	Accessory FDS to the middle finger	——
	FDP muscle belly to the index finger	——
	Conjoined tendon FPL and FDP (Linburg-Comstock syndrome)	——
	Palmaris profundus	1
Extra-tunnel muscles and tendons anomalies	Palmaris longus hypertrophy	——
	Reverse palmaris longus muscle belly	——
	Bifid palmaris longus	——
	Accessory palmaris longus	——
	Accessory abductor digiti mini originating from palmaris longus	——
	Aberrant origin of the thenar muscles	5

FPL = flexor pollicis longus; FDP = flexor digitorum profundus; FDS = flexor digitorum superficialis

accessory branches of the median nerve at the distal carpal tunnel; Group III: high bifurcation of the median nerve and Group IV: accessory branches of the median nerve at the proximal carpal tunnel). A high bifurcated median nerve was defined when the division of the median nerve into 2 distinct parts occurred above the proximal wrist crease.[1] For Lanz group I aberrant origin of the motor branch of the median nerve rather than the subligamentous and transligamentous course of the motor branch was considered abnormal.[1] The base of the carpal tunnel was explored. The intrusion of the bulk of the flexor and lumbrical muscles through the carpal tunnel was examined by active and passive flexion and extension of thumb and fingers. If there was an intruding lumbrical or superficial flexor tendon muscle bulk, it was excised. A median artery of more than 1 mm in diameter was considered as a persistent median artery.[1]

Student's t and Fisher's Exact tests were used to analyze the association of vascular, neural, tendinous and muscular anomalies with sex, age and hand side. P values less than 0.05 were considered significant.

Results

Among the 467 hands, 42 (8.9%) hands had anomalies in 42

patients (14 males and 28 females). Ten anomalies were seen on the left hands and 32 anomalies were seen on the right hands. There was no bilateral anomaly. The average age of the patients with anomalies was 48.6 ± 7.6 years. The average age of the 394 patients without anomalies was 50.4 ± 2.5 years. The difference between the mean age of the patients with anomalies and patients without anomaly was not significant.

Among the 42 (8.9%) anomalies, there were 16 persistent median arteries (Figure 1), 14 anomalies of the median nerve, including 4 aberrant origins of the motor branch of the median nerve (Lanz group I), 8 bifurcated median nerves (Lanz group III), and 2 accessory branches of the median nerve at the proximal carpal tunnel (Lanz group IV); 7 intrusions of muscle bellies including 4 proximal origins of the index and middle fingers FDP tendons lumbricals, 2 intrusions of the FDS muscle bellies of the index and middle fingers and 1 palmaris profundus and 5 anomalies of the origin of thenar muscles (Table 1). The intruded portion of the flexor digitorum superficialis muscle bellies of the index and middle fingers and palmaris profundus tendon were excised. No anatomic anomaly was diagnosed in any of the patients before surgery.

There was no significant association between vascular, neural, tendinous and muscular anomalies and age, gender and hand sides of the patients.

Discussion

Table 1 demonstrates the reported anatomic anomalies within and around the carpal tunnel. Lindley *et al*. found 31 anatomic anomalies in 30 (5.7%) hands out of 526 carpal tunnel surgeries.[1] Singer and Ashworth found 74 anatomic variations in 60 (41%) hands out of 147 carpal tunnel surgeries.[3] Tountas *et al.* reported anatomic anomalies in 38 out of 382 hands.[5]

Willis *et al.* have reviewed the reports of discovered anatomic anomalies in carpal tunnel surgeries in the English language.[4] They found that abnormal flexor and lumbrical muscles bellies intruding through the carpal tunnel were the most frequent anomalies.[4] Intratunnel intrusion of muscle bellies of the finger flexors and lumbricals increases the contents of carpal tunnel and may produce a piston-like dynamic compression of the median nerve.[1,2]

The incidence of the palmaris profundus has been reported to be one in 1600 cadaveric dissections. Palmaris profundus may originate as a separate muscle in the middle third of the forearm, from the ulna, radius and fascias of different flexor muscles deep to the superficialis muscles. Its tendon courses deep into the carpal tunnel as a tenth tendon that may stray from a dorsal to palmar position within the carpal tunnel, inserting into the palmar aponeurosis. We did not explore the origin of the palmaris profundus. This is a limitation of our study that the anatomic variations were explored only through the surgical incisions.[8,9]

Usually the thenar muscles are attached to radial half of the TCL and the central part of the TCL dissociates the origin of the thenar and hypothenar muscles. Contraction of the connected extratunnel thenar-hypothenar muscles may increase the carpal tunnel pressure and produce CTS.[3] The most common anatomic variations in the Singer and Ashworth study were the muscles overlaying the transverse carpal ligament. In their study, the thenar muscles in 21 out of 147 hands originated from the hypothenar muscles.[4] Yavari *et al*. found abnormal thenar and hypothenar muscle connections in 35 (22.6 %) out of 155 patients.[6] Lindley *et al.* found 2 aberrant thenar muscle origins among 526 patients.[1]

The incidence of a persistent median artery varies among different races in normal individuals from 1.1% to 16%.[1] In the study by Lindley *et al.* as well as in our study, the most frequent anatomic anomaly was a persistent median artery (16 or 3.42%). The presence of a persistent median artery is important because it may be associated with other anomalies, particularly a high bifurcated median nerve.[2] A complicated persistent median artery exacerbates the symptoms of CTS due to induced inflammation and is treated by excision of the artery.[1]

A high bifurcated median nerve in the carpal tunnel is more vulnerable to compression because it has a greater cross-sectional area than a single nerve.[4] Aberrant branching of the median nerve predisposes the nerve to inadvertent injury during release of the transverse carpal ligament. Lanz regarded and presented the Poisel classification of the course of the motor branch (extraligamentous, subligamentous and transligamentous) for his group I. Poisel considered the subligamentous (31%) and transligamentous (23%) course of the motor branch abnormal.[7,10] In the current study, we did not consider the subligamentous and transligamentous course of the median nerve as anomalies because of their high prevalence.

In our study, none of the anomalies were diagnosed before surgery. Attempts have been made to recognize anatomic anomalies by ultrasound and magnetic resonance imaging; however, they are not routine examinations. Today's trends are toward very small incisions and endoscopic carpal tunnel surgeries that preclude a thorough exploration of carpal tunnel's contents. Some anatomical anomalies may go unrecognized and some may predispose the median nerve to injury and prevent an endoscopic and closed carpal tunnel surgery.

Anatomical anomalies are not uncommon in carpal tunnel surgeries. In the literature, some studies have focused on a single anomaly, particularly the median nerve, and some studies have investigated groups of anomalies; however, the reported frequencies of these anatomic abnormities are different. Familiarity with these anomalies increases the safety of the operation and may prevent persistent or recurrent carpal tunnel syndrome.

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