Anatomical variations of median nerve at the wrist joint in open carpal tunnel release

Mohammad A. Abd-alla*, Saad A. Mohammad**, Firas T. Ismaeel***
Depts. of Anatomy*, Pathology**, Surgery***, College of Medicine, University of Tikrit

Abstract
At the wrist, the median nerve passes beneath the flexor retinaculum in a restricted space between the flexor digitorum superficialis and flexor carpi radialis muscles and it supplies the thenar eminence muscles, the first two lumbricals and gives sensory innervation to the skin of the palmar aspect of the lateral three and one-half fingers, including the nail beds on the dorsum. Carpal tunnel syndrome is a well-known clinical entity and the release of the transverse carpal ligament is considered to be the treatment of choice. Both open and endoscopic release of the transverse carpal ligament has yielded satisfactory results for this syndrome. Although these procedures are very common in surgical practice, inadequate release and operative damage to neural elements are very frustrating complication for both the patient and the surgeon. From February 2006 to April 2008 at the operative theatre of Tikrit Teaching Hospital, a team work of anatomist, surgeon and forensic medicine physician acting together in this study on 55 patients of carpal tunnel syndrome operated with open carpal tunnel release were evaluated to demonstrate incidental operative findings of variations of the standard median nerve anatomy. The present study revealed anatomical variations of median nerve at the wrist in 11 patients. In three patients, there was an aberrant branch arising from the ulnar side of the median nerve and piercing the ulnar margin of the transverse carpal ligament. Neural variations arising from the ulnar aspect of the median nerve were common and could be a cause of iatrogenic injury during open release. Surgeons should be aware of anomalous branches, which should be recognized and separately decompressed if needed.

Introduction
Median nerve which arises from the medial and lateral cords of the brachial plexus, gives off no cutaneous or motor branches in axilla or in the arm; but it supplies all the muscles of the front of the forearm except the flexor carpi ulnaris and the medial half of the flexor digitorum profundus. At the wrist, the median nerve passes beneath the flexor retinaculum in a restricted space between the flexor digitorum superficialis and flexor carpi radialis muscles and it supplies the thenar muscles, the first two lumbricals and gives sensory innervation to the skin of the palmar aspect of the lateral three and one-half fingers, including the nail beds on the dorsum(1).

Carpal tunnel syndrome is a common clinical entity. Surgical release of the transverse carpal ligament, using endoscopic as well as open procedures, is an established treatment method. Acceptable clinical results have been reported by both procedures (1, 2, and 3). However, complications occur due to median nerve anatomic variations (4, 5 and 6). Incomplete release of the median nerve is probably the most common technical error during such surgical management (7). On the other hand, iatrogenic injury of the median nerve or one of its branches is the most feared complication of carpal tunnel release (8, 9 and 10).

Many authors have tried to classify median nerve anatomical variations within the carpal tunnel like {Johnson and Shrewsbury (8); Amadio (11); Lanz (12) and Taleisnik (13)}. Lanz based on cadaveric studies and classified median nerve anomalies in four categories:
Group 0: extraligamentous thenar branch (standard anatomy).
Group 1: variations of the thenar branch.
Group 2: presence of accessory branches in the distal part of the carpal tunnel.
Group 3: proximal division of the median nerve.
Group 4: presence of accessory branches proximal to the carpal tunnel.

Group 1 is divided into four subgroups. In subgroup 1A, the motor branch of the median nerve starts beneath the transverse ligament and then bends around its distal edge (subligamentous). In subgroup 1B, the motor branch arises from the radial side of the median nerve and then passes through the transverse ligament (transligamentous). In subgroup 1C, the motor branch starts from the ulnar side of the median nerve (ulnawards). In subgroup 1D, the motor branch bends around the distal edge of the transverse ligament on the palmar surface of the ligament (supraligamentous).

Group 2 is characterized by the presence of an accessory motor branch of the median nerve; this branch starts in the distal part of the carpal tunnel.

In Group 3, a proximal division of the median nerve is present. Group 3 divided further in three subgroups according to the absence (subgroup 3A) or the presence of a median artery (subgroup 3B) or an accessory lumbrical muscle (subgroup 3C) between the two branches of the proximally divided median nerve.

In Group 4, the accessory branches are divided proximal to the carpal tunnel in two subgroups. In subgroup 4A, an accessory thenar branch runs directly in the thenar muscles, while in subgroup 4B joins another motor branch first.

Lanz investigation was limited to analysis of motor branch anomalies to the cadaver studies; moreover, variations of the palmar cutaneous branch were not included in his study, so to overcome these limitations, Amadio (11) proposed a new classification of median nerve anomalies in the carpal tunnel. In a consecutive study of 275 carpal tunnel releases, he noticed 69 variations (25.1%) of median nerve anatomy in 50 patients. In his study, Amadio classified these patients in five groups. Group 1 consisted of proximal division anomalies with incidence of 3%. Group 2 included the variations of the motor branch (19%) which could be divided further by location and number of branches. Anatomical variations of the palmar cutaneous branch constituted a Group 3 with incidence of 2.5%. Group 4 included anomalies of the median-ulnar sensory ramus (1%), and Group 5 was reserved for unclassified anomalies. However, a combination of these anomalies may be found. A rare variation of median nerve has been described by Amadio (14).

The purpose of this study was to demonstrate incidental operative findings of variation of the standard median nerve anatomy.

**Subjects and Methods**

From February 2006 to April 2008 at the operative theatre of Tikrit Teaching Hospital, a team work of anatomist, surgeon and forensic medicine physician acting together in this study on 55 patients with open carpal tunnel release. The patients ranged in age from 26 to 58 years (mean=39 years). Of the 55 patients, 17 were men and 38 were women. The dominant hand was involved in 42 of the patients. Subjectively, all patients stated that their complaints included paresthesia and night pain over the sensory distribution of the median nerve. Clinical examination revealed a positive Phalen test and a positive Tinel’s sign over the carpal tunnel in 49
of the 55 patients.

Surgery was preferred to done under general anesthesia to take enough time for examination of the median nerve and related structures using magnification lens, so that an incision centered on the axis of the ring finger. This incision typically used was at the ulnar side of the median nerve and parallel to the thenar crease and extended slightly proximal to distal palmar wrist crease. The surgical procedure included complete division of the transverse carpal ligament and mobilization of the median nerve by releasing surrounding thick connective tissue in selected cases. After that, the surgical wound was closed and a compression dressing was applied to all patients.

**Results**

In the present study, anatomical variations of median nerve at the wrist in 11 out of 55 patients. Two patients had bifid median nerve with a persistent median artery running between the two divisions (Fig. 1). The motor branch to the thenar muscles was identified in all cases. In other two patients, the motor branch took off from the ulnar side of the median nerve in the carpal tunnel. In both of them, anatomic variation included a motor branch crossed over the palmar surface of the median nerve and exited the carpal tunnel curving around the distal and radial ridge of the transverse carpal ligament following a proximal route before entering the thenar muscles (Fig. 2).

In one patient, the sensory palmar cutaneous branch of the median nerve, separated from the radial aspect of the nerve few millimeters distal to the proximal border of the transverse carpal ligament piercing the mid substance of the ligament (Fig. 3).

In three cases, there was an aberrant branch taking off from the ulnar side of the median nerve and piercing the ulnar margin of the transverse carpal ligament (Fig. 4). In other three patients, the motor branch of the median nerve originated beneath the transverse ligament and then curved over the ligament proximally to the thenar.

In the present study, 44 of 55 patients (80%) had a normal anatomy of the median nerve. For patients of the present study, the Amadio classification system (11) used to group all the variations encountered; and according to the Amadio classification of median nerve anomalies in the carpal tunnel, two patients were in Group 1 (open branching) and two patients were in Group 2 (transretinacular). One patient was in the transretinacular palmar cutaneous branch subgroup according to the Amadio classification; and for this patient, the Lanz classification system could not be used. The patient was at special risk of iatrogenic injury during open carpal tunnel release.

A rare variation was found in three patients with a sensory branch arising from the ulnar side of the median nerve and piercing the ulnar margin of the transverse carpal ligament. These patients were included in the (unclassified) category of Amadio classification.

**Discussion**

In the present study, the classification of median nerve anatomical variations within the carpal tunnel is based on Lanz classification study. Therefore, the findings regarding Group 1 is divided into four subgroups. In subgroup 1A (subligamentous), only three patients (27.3%) were demonstrated with subligamentous motor branch of the median nerve, while by Lanz study with a value of 31% (12). The subgroup 1B (transligamentous) was absent in the
present study, while in other studies the incidence varies from 23 to 80% (8, 12 and 14). In subgroup 1C (ulnawards), the present data of this subgroup was 18.2% compared to 10% in Taleisnik study (13). The subgroup 1D (supraligamentous) was not distinguished in any case of the present study.

In Lanz study, Group 2 with an incidence of 7.3% (12), but none of patients in this study demonstrated such a variation of the median nerve.

The incidence of Group 3, according to Lanz (12) was 2.8%; likewise, in Amadio’s (11) study the approximate incidence of proximal division was 3%; but in the present study, the incidence of proximal division was 1.8%.

The incidence of both subgroups 4A and 4B was measured as 1.7%.

According to Stančíč et al. (15), in a study of 100 hands that underwent a carpal tunnel release only 47.7% showed the standard anatomy of the median nerve. Previous investigators have reported a lower incidence in anatomical variations of the median nerve at the wrist (12 and 11). According to present data anatomical variations were present only in 20% of the patients.

In Stančíč et al. (15) study, the 65 patients having anatomical variations of the median nerve were classified by the Lanz system. Thirty-one patients had an extraligamentous thenar branch (Group 0), 13 had a subligamentous branch which started beneath the transverse ligament and then bended around it (Group 1A), 12 had a transligamentous branch which passed through the foramen (Group 1B), three had an ulnawards thenar branch (Group 1C), and one patient had a supraligamentous thenar branch (Group 1D).

The importance of palmar cutaneous branch has been mentioned by other investigators before the Amadio classification. The position of this branch is quite constant arising proximal to the wrist and passing through the flexor retinaculum between flexor carpi radialis and digital flexors compartments (13). This nerve is at high risk for iatrogenic injury during carpal tunnel release. In present study, palmar cutaneous branch was in the normal position in 19% of the patients. All surgeons should keep in mind the above mentioned anatomical variations of the median nerve.

The ulnar branch presented with its usual course within the carpal tunnel, while the radial half was detected within a separate compartment. Furthermore, the radial branch contained the palmar cutaneous nerve which perforated the transverse ligament. The radial and ulnar part of the median nerve rejoined distal to the transverse ligament. Riche-Cannieu anastomosis is the connection between the deep branch of the ulnar nerve and the motor branch of the median nerve in the palm of the hand. This anatomic variation is thought to be quite common and provides double innervation to thenar muscles (17). The importance of this variation is that thumb function is preserved even if the innervation of the motor thenar branch is lost. According to present data, variations of the median nerve within the carpal tunnel were found in 20% of all cases.

The presence of these anomalies may affect both clinical manifestations and surgical outcome. Consequently, awareness of anomalous branching of the median nerve and skillful techniques during surgical decompression is of great importance. Anomalous branches and courses should be recognized and separately decompressed. Surgical incision should be made at the ulnar side of palmaris longus tendon to avoid iatrogenic
injury of the thenar branch in Lanz’s subgroups 1A, 1C, and 1D which represent the 25% of all cases. Keeping the incision to the ulnar aspect of the wrist is also beneficial in preventing injury to superficial palmar branch as well.

References

Fig (1) A bifid median nerve (arrows) with persistent medial artery (arrowhead) running between the two divisions, in 37 years old man.

Fig (2) Motor branch arising in the carpal tunnel and piercing the transverse ligament laterally (over the tip of the scissor).

Fig (3) Transretinacular palmar cutaneous branch (arrow) of the median nerve, in the right wrist joint of 44 years old woman.
Fig (4) Three cases of sensory branch (arrows) arising from the ulnar side of the median nerve and piercing the ulnar margin of the transverse carpal ligament.