CASE REPORT

Dynamic Ultrasound—A Useful Tool to Demonstrate Adhesions Postcarpal Tunnel Surgery

Mei-Ting Wang 1 , Yi-Chian Wang 1 , Huey-Wen Liang 1 , Geoffrey Sithamparapillai Samuel 2 *

1 Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan, and 2 Department of Rehabilitation Medicine, Singapore General Hospital, Singapore

Received 25 March 2016; accepted 24 May 2016
Available online 5 August 2016

Abstract  Carpal tunnel syndrome is common, and open carpal tunnel release remains the treatment of choice for cases refractive to conservative treatment. However, up to 25% of postrelease patients remain symptomatic. Our case illustrates how ultrasound examination can visualize the movements of the contents of the carpal tunnel and reveal additional pathologies. A 42-year-old patient with previous bilateral open carpal tunnel release surgeries presented with recurrent symptoms of bilateral hand tingling sensation starting months after the first operation. Under real-time sonographic exam, the median nerve (MN) changed shape and migrated inferiorly when the patient extended her third finger, suggesting that the perineurium of the MN was adherent to the tendon sheath of the third flexor digitorum superficialis tendon. The patient opted to continue conservative treatment but unfortunately did not improve. Recurrent inflammation and fibrosis may have led to the adhesion of the flexor tendons to the MN which was only apparent on real-time evaluation of the displacement of the MN on ultrasound examination. We suggest that the observation of the displacement of the MN during active finger movement can be integrated into the examination of carpal tunnel syndrome patients both before and after surgical intervention and herein include an easy to follow protocol for such examinations.

© 2016, Elsevier Taiwan LLC and the Chinese Taipei Society of Ultrasound in Medicine. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

KEYWORDS
carpal tunnel syndrome, dynamic ultrasound

Conflicts of interest: None of the authors have any conflicts of interest.

* Correspondence to: Dr. Geoffrey Sithamparapillai Samuel, Department of Rehabilitation Medicine, Academia Building, Level 4, Singapore General Hospital, Outram Road, Singapore 169608.
E-mail address: geoffrey.sithamparapillai.samuel@singhealth.com.sg (G.S. Samuel).

http://dx.doi.org/10.1016/j.jmu.2016.05.001
0929-6441/© 2016, Elsevier Taiwan LLC and the Chinese Taipei Society of Ultrasound in Medicine. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Introduction

Carpel tunnel syndrome (CTS) is defined by the American Academy of Orthopedic Surgeons as: “A symptomatic compression neuropathy of the median nerve (MN) at the level of the wrist” [1]. It is a common condition affecting an estimated 3.8% of the general population and is associated with significant disability and healthcare-related expenditure [2]. Twenty-five percent of patients typically present with symptoms of recurrent activity-related or nocturnal sensation of burning, itching, tingling, or numbness of the palm of the hand, especially over the thumb, index, and middle fingers.

Diagnosis is based on clinical examination and electrodiagnostic studies, although ultrasound guided examination is increasingly being used as a means of visualizing abnormal MN size [3]. The norms of displacement of the MN during movement as observed by ultrasound examination are not yet established though [4].

For cases in which symptoms are not significantly improved by conservative means, open carpal tunnel release surgery (division of the transverse carpel tunnel ligament) is the current treatment of choice with an estimated 75% rate of symptom reduction [5]. However, considering that as many as 25% of patients postcarpal tunnel release will still experience some form of symptom or disability, there remains a need to continue to improve patient selection, surgical technique, postoperative care, and follow-up. The case discussed below illustrates the utility of sonographic real-time evaluation of the movements of the contents inside the carpal tunnel, even in the chronic postcarpal tunnel release period.

Case Report

The patient is a 42-year-old woman of ethnic Chinese descent who had past medical history of bilateral CTS with open carpal tunnel release surgeries performed on the left wrist in May 2013 and right wrist in July 2013. Additionally, she suffered a right fourth trigger finger for which she underwent a release procedure in May 2015. She had no medical history of diabetes mellitus or infiltrative conditions that may have predisposed her to CTS. Her body mass index was 22.0. She had no history of trauma to the upper limbs. She worked as a manager in a pizza restaurant prior to being disabled by her symptoms of bilateral hand paresthesia and subjective weakness.

Despite bilateral CTS release surgeries, the patient presented with recurrent symptoms of bilateral hand tingling sensation starting within months after the transverse ligament division surgery, and the recurrent symptoms was severe enough to affect her activities of daily living such as using the computer and dressing. Strikingly, she reported worsening of the tingling sensation of the left hand on flexion of the left third finger specifically.

Clinical examination of the patient revealed bilateral provoked palmar tingling on percussion of the volar wrist (positive Tinel sign). The thenar muscle size of both hands were preserved. No objectively detectable weakness of the hand muscles was documented.

A nerve conduction study performed in September 2014 was reported as “Prolonged distal motor latency and slowing of sensory nerve conduction velocity of bilateral median nerves during ring finger studies (46 m/s) compared to the ulnar side (58 m/s).”

Ultrasound examination of the left hand in that same month (September 2014) showed a left MN cross sectional area of 12 mm² at the carpal tunnel inlet (identified by the scaphoid and pisiform bones) without proximal swelling. The patient received hand physiotherapies, oral anti-inflammatory drugs, and neuropathic pain medications, but with little symptom improvement.

Repeated ultrasound examination of the patient’s left carpal tunnel was performed on May 26, 2015. A Toshiba Xario XG (Toshiba Medical Systems Corporation, Tokyo, Japan) ultrasound machine equipped with a 12–14-MHz linear array probe was operated by a sonographer with 8 years of experience. Image acquisition was set at 33 frames/s with minimal image compression.

The patient was seated with the left forearm in full supination and the wrist at a neutral angle. In addition to static evaluation of the carpal tunnel structures, dynamic

Figure 1  The longitudinal view of the left median nerve. The yellow arrow indicates the swollen portion of median nerve at the distal radius, proximal to the level of compression (diameter 1.9 mm). The area of focal compression is indicated by the blue arrow. The red arrow indicates thinning of the median nerve at the level of the distal lunate bone (diameter 1.5 mm).

Figure 2  The cross sectional view of the left median nerve of the patient. The median nerve is outlined by blue dots. The yellow arrows indicate the remnants of the transverse carpal ligament. FCR = flexor carpi radialis tendon.
assessment of the MN gliding pattern at finger flexion and extension were also performed by asking the patient to slowly flex and extend each finger in turn while continuing to observe the contents of the carpal tunnel with the ultrasound device. We started from the index and moved to the third, the fourth, and finally to the fifth finger. This sequential finger flexion was first performed at the metacarpophalangeal joint (MCPJ) to activate the flexor digitorum superficialis (FDS). Then it was repeated at the distal interphalangeal joint (DIPJ) to activate the flexor digitorum profundus (FDP).

The left MN cross-sectional area was 8 mm² at the level of the carpal tunnel inlet. In longitudinal view, there was a mild narrowing change of the left MN at the level of the carpal tunnel inlet and mild proximal swelling and hypoechoic change consistent with a diagnosis of focal compressive neuropathy (Figure 1). We were not able to comment on whether the transverse carpal ligament was completely transected (Figure 2).

Under dynamic exam, the MN would migrate inferi orly each time when the patient flexed her third finger MCPJ, suggesting that the perineurium of the left median nerve was adherent to the tendon sheath of the FDS, third finger component (Supplementary Video S1). During dynamic examination, the patient indicated that her symptoms were reproduced on each flexion of the left third finger. Supplementary Video S2 demonstrates the MN glide pattern of a normal individual where in comparison the nerve moves transversely and ulnarly [6].

Figure 3 The illustrated protocol for examination of the median nerve (MN) in carpal tunnel during active movements. (A) Starting position as described in Step 1: hand is resting in full supination; (B) the ultrasound view obtained in Step 1; (C) finger position as mentioned in Step 2: flexion at the metacarpophalangeal joint; (D) finger position as mentioned in Step 3: flexion and extension at the distal interphalangeal joint with the metacarpophalangeal joint in flexion; (E) starting position in Step 4; (F) the ultrasound view obtained at the start of Step 4.
To the best of our knowledge, this is the first demonstration, perineural fibrosis, and flexor tendon tenosynovitis swelling, incomplete division of the transverse carpal ligament applied to detect residual pathologies, such as MN active movements of the fingers (Figure 3):

Discussion

The carpal tunnel may be described as the confined space on the volar aspect of the wrist connecting the forearm to the hand. The “floor” of the tunnel consists of the carpal bones and the “roof” is the transverse carpal ligament (also known as the flexor retinaculum). The four tendons of the FDS, the four tendons of the FDP, and the tendon of the flexor pollicis longus all pass through the tunnel along with the MN. The tendon of the flexor carpi radialis passes through the medial part of transverse carpal ligament. The MN normally migrates transversely during various positions of the fingers and wrist. Previous studies have suggested that the displacement and swelling of the flexor tendons may cause significant pressure and shear forces on the contents of the carpal tunnel, leading to injury of the MN.

After CTS release surgery, ultrasound could still be applied to detect residual pathologies, such as MN swelling, incomplete division of the transverse carpal ligament, perineural fibrosis, and flexor tendon tenosynovitis. To the best of our knowledge, this is the first demonstration of real-time video capture of such possible adhesion of the MN to the flexor tendon, which is not apparent on static ultrasound imaging or detectable with a nerve conduction study.

As can be seen clearly from Supplementary Video S1 and S2, the MN of the patient displaces inferiorly and changes its shape compared with the normal movement patterns described above, especially on flexion of the third finger at the MCPJ. Given the correspondence with the patient’s symptoms, there is suggestion that attachment of the MN to the tendon and the shear forces generated by their relative differential movements provokes our patient’s symptoms.

The emphasis we would like to make is that the addition of a simple sequential movement of the fingers as described may clearly illustrate such pathological changes in the subsynovial connective tissue of CTS patients. The sequence of movements is easy for patients to follow. The flexion at the MCPJ and DIPJ is also easier to observe compared with wrist movements which may dislodge the ultrasound probe during examination. Actively asking the patient to repeat the movement that elicits their symptoms while observing changes within the carpal tunnel further enhances our identification of the pathologies.

We would like to suggest the below protocol for ultrasound of the carpal tunnel while the patient performs active movements of the fingers (Figure 3):

1. Position the patient comfortably with the hand in full supination and the wrist at a neutral angle. The ultrasound probe is placed transversely across the ventral wrist at the level of the distal wrist crease. The inlet of the carpal tunnel is identified on the ultrasound by presence of the scaphoid, capitate, and pisiform bones.
2. Ask the patient to slowly flex the MCPJ of the index finger to 90° from neutral and then to return to the starting position to activate the FDS tendon. Repeat this movement for the third, fourth, and fifth fingers in sequence. Observe for the movement of the MN on the ultrasound images. Normal movement should be a transverse displacement of the MN, usually towards the ulna.
3. Next, ask the patient to slowly flex the DIPJ of the index finger to 90° from neutral and then to return to the starting position to activate the FDP tendon. If the patient has difficulty performing this action, then the examiner can assist to passively flex and extend the patient’s DIPJ while the MCPJ is held in flexion (Figure 3D). Repeat this movement for the third, fourth, and fifth fingers in sequence.
4. Keeping the MN in the middle of the ultrasound screen, slowly rotate the probe 90° to obtain a longitudinal image of the MN. The bony landmarks of this view would be the radius bone at the proximal part of the nerve, followed by lunate and then capitate bone distally. Repeat the flexion and extension movements as described in Steps 2 and 3. The normal MN should glide smoothly in the longitudinal view.

Dynamic, real-time assessment is an advantage unique to ultrasound examination. As the resolution of ultrasound images keep evolving, high-resolution real-time video capture of MN gliding pattern might be an additional, informative diagnostic tool. We would suggest that the observation of the displacement of the MN during active finger movement can be integrated into the routine examination of CTS patients both before and after surgical intervention.

We look forward to future research to define the norms of MN gliding pattern both before and after surgery. Such research could be developed around a protocol as shown above to establish norms for the displacement of the MN.

References

