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From morphological alterations to definitive clinical diagnosis – the Ultrasonography investigation's role in Carpal tunnel syndrome's diagnostics

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Abstract
Carpal tunnel syndrome (CTS) is a condition which manifests in cases of compression or tension of n.medianus in the wrist area. This condition is the most commonly diagnosed mononeuropathy from compression. EMG is the gold standard for diagnostics of n.medianus injuries. However, recently ultrasonography has proved advantageous, and it is used more often in clinical practice for the dynamic monitoring of patients' injuries. Great benefits of the US diagnostics are its broad availability and easy differential diagnosis assessment of patients with pain and numbness in the wrist area. It is important to highlight that in US examination the changes in patients' conditions are almost imminently evident, whereas in EMG diagnostics the alterations become apparent only after a few weeks. Additionally, the ultrasonography is a method for a confirmation of CTS diagnosis after such has been made based on physical examination and presence of symptoms.

Introduction

The carpal tunnel syndrome (CTS) manifests when compression or tension of the median nerve are evident at the wrist area. It is the most common compressional mononeuropathy. Due to the increased weakness of the handgrip and decreased dexterity, the condition seriously affects the quality of life [1]. CTS is common in 4-6% of the overall population [2], the main sufferers are middle-aged women (40-50y), more rarely men. Usually the condition is developed in the dominant hand and it is a commonly diagnosed condition in professions involving high vibrations, repetition of similar hand movements, such as keyboard typing, etc. [3]. One of the most highly affected profession is dentistry. Not only CTS decreases patients' quality of life, but it interferes with their daily professional activities by restricting the number and quality of the operations provided. CTS is one of the most common diagnoses in cases of reported pain, numbness or discomfort in the hand, at the area of the wrist, palm or fingers [4].

According to the data stated by Management of Carpal tunnel syndrome – Evidence-based clinical practise guideline [5], the diagnosis "CTS"is verified when there is a confirmation from patient's anamnesis, positive tests during the clinical examination, EMG data and data from US or MRI diagnostics. There is a great variety of specific clinical tests for CST such as Tinel's sign, Phalen's test, the digital test, Price-Philip's test, the test of the mill, the test of the compass, Decout's test, Luethy's test. Diagnostic scales are used in order to monitor the development of the condition. Boston's Carpal Tunnel Questionnaire has been, so far, the simplest applicable scale in clinical practice – it provides an objective evaluation of the condition and it is straightforward to the patient [6]. The questions from it follow patient's condition back to 2 weeks prior examination.

For years EMG has been accepted for the most accurate diagnostic test [5], and, nowadays, it is the gold standard [7]. However, when long-term evaluation of the results was done, there were 15% false negative results from all of the symptomatic cases; and 18% false positive results from the whole population. Additionally, EMG is a costly method for diagnostics, which involves highly-trained staff, longer appointment timings, and allegedly it causes discomfort or even pain [8]. Along with this, numerous other conditions such as swelling/trauma in the wrist area, altered temperature in the area due to inflammation, post-operative metal implant/plate presence, etc. can negatively affect the results of the EMG [7]. However, the abovementioned factors are not contraindication for an US examination and diagnostics. Therefore, lately ultrasonography has become a common and effectively used method for CTS diagnostic [9]. It is a diagnostic technique, which can be used for the visualisation of various subcutaneous anatomical structures such as joints, ligaments, muscles, peripheral nerves, blood vessels and internal organs with possible pathological changes [10]. The neuromuscular ultrasound measurement of the median nerve cross sectional area, CSA at the level of the wrist is proven to be accurate and can be used for the diagnostics of CTS [11, 2]. Furthermore, it enhances the information received from a potential EMG in confirmed CTS patients, which later can be used for screening and monitoring purposes, in cases of abnormal structures existence in the carpal tunnel.

The US diagnostics is a type of screening technique, which can be done prior EMG or MRI [5]. It ensures the visualisation of the median nerve and all of the additional structures in the carpal tunnel, so it can be used for the etiological verification of CTS. For example, it would become apparent if there are aberrant structures such as muscle or ganglion, or if there is tenosynovitis or synovitis. Also, the ultrasonography method could be used for surgery planning and risk assessment, as well as for a monitoring of the condition in post-operative period [13]. Power Doppler provides highly accurate data regarding the blood vessels position, which is crucial in surgery planning and other more invasive treatments in the area, such as corticosteroid injections.

The US diagnostics has numerous advantages. It is a non-invasive, and, practically, painless procedure. By the constant visualisation which it offers, it is possible to examine and assess dynamic and quickly altering conditions and monitor the effect of the prescribed treatment and rehabilitation of the carpal tunnel structures.

Methodology

A wide-screen US with a frequency 8-14 MHz and a Power Doppler was used for the structural examination of n. medianus.

Results and Discussion

In order to correctly assess the US image, the detailed knowledge of the carpal tunnel anatomy is of great importance [14]. Canalis carpi is a non-elastic osteofibrous passage for the median nerve, which is dorsally restricted by the carpal bones and ventrally- by flexor retinaculum. N. medianus passes through the carpal tunnel along with the ligaments of m. flexor digitorum superficialis, m. flexor digitorum profundus and m. flexor pollicis longus, which is the most radially positioned. Thus, overall there are 9 ligaments passing through canalis carpalis, along with the median nerve. The ligament of m. palmaris longus lies under the surface of retinaculum flexorum, attaches to it with fibres and in such way continues within aponeurosis palmaris. The abovementioned anatomical structures are in very close proximity to each other, forming a rectangular cross-section of 15.6 mm^2, which is the size of the carpal tunnel in its middle part, varying to 16.1 mm^2 proximally, and 17.8 mm^2 distally [7]. The position of n. medianus in the carpal tunnel can have some anatomical variations, depending on the individual. Often the presence of abnormal vessels or muscles is a reason for the nerve compression.

The US examination of the carpal tunnel is relatively brief and easy. The patient is usually seated on a chair, the forearm is relaxed on flat surface in a supine position (either an examination bed, or a desk), with slightly spread fingers. The investigation involves a minimum of four different scans, in order to contemporaneously evaluate the status of the median nerve [14]. The first scan is done in the proximal part of the tunnel, and the distal part of os radii is used for better orientation. The surface of retinaculum flexorum and n.medianus are observed, usually it is a quite typical image of granular-fibrous structure (Fig. 1).

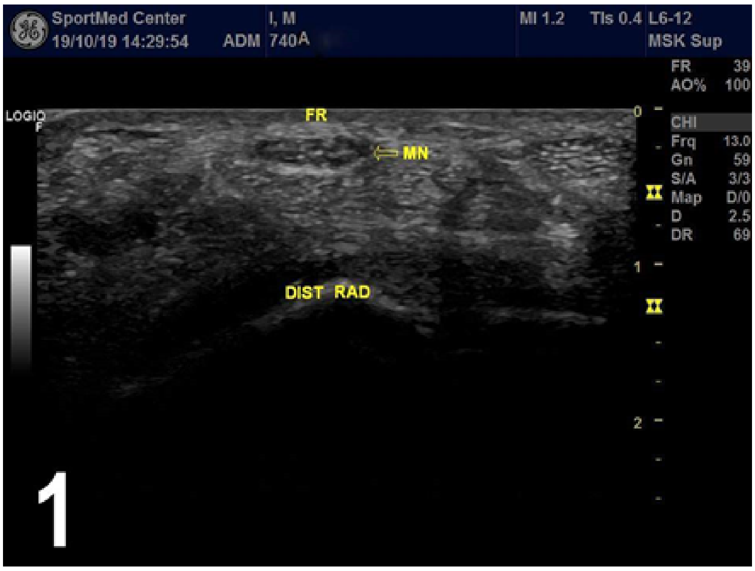

Fig. 1.: US view of the carpal tunnel anatomy (normality) – proximal scan. Done by US Logiq F6, General Electric, with linear transducer and work at 12 MHz. (FR – retinaculum flexorum; MN – n. medianus; DIST RAD – os radii, distal part) (source: Dr Martin Ivanov)

The next scan is done at the level of the retinaculum, where additional structures are visualised. Along with the retinaculum and the median nerve, os scaphoudeum, os pisiforme, os lunatum, a. and n. ulnaris, mm. fl. superficialis and mm. fl. profundus can also be seen (Fig. 2).

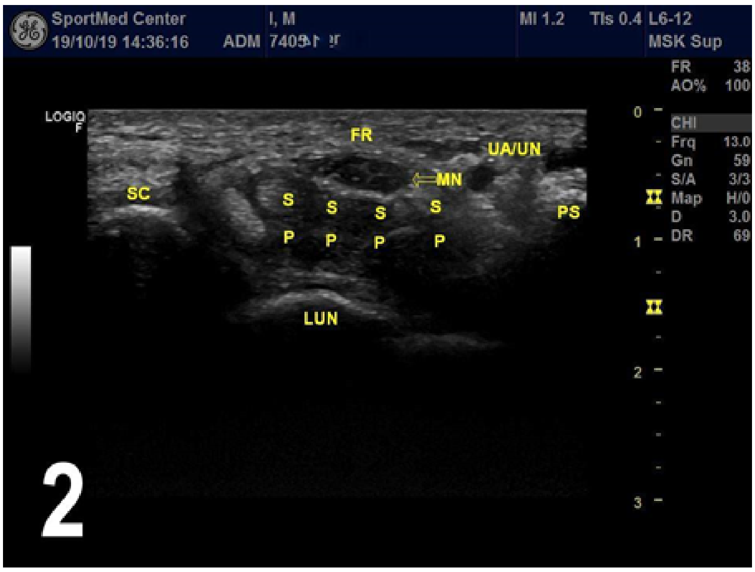

Fig. 2.: US view of the carpal tunnel anatomy(normality) – at the level of retinaculum flexorum (FR – retinaculum flexorum; MN – n. medianus; SC – os scaphoudeum; UA/UN – a. ulnaris/ n. ulnaris; PS – os pisiforme; LUN – os lunatum; S – mm. fl. superfic. (4 ligaments); P – mm. fl. prof. (4 ligaments)) (source: Dr Martin Ivanov)

On the third scan (the distal one) retinaculum flexorum, n. medianus, os scaphoudeum, a. ulnaris et n. ulnaris, os pisiforme, os lunatum, m. fl. dig. superficialis (4 ligaments), m. fl. dig. profundus (4 ligaments), m. fl. poll. longus are examined (Fig. 3).

For the last scan of the carpal tunner, the transducer should be perpendicularly rotated in order to evaluate its structure longitudinally (Fig. 4).

Additional three measurements of the nerve's width VD are made, in order to assess its condition. Usually in presence of CTS there is a difference in the measurements, when the smaller measurements are typically

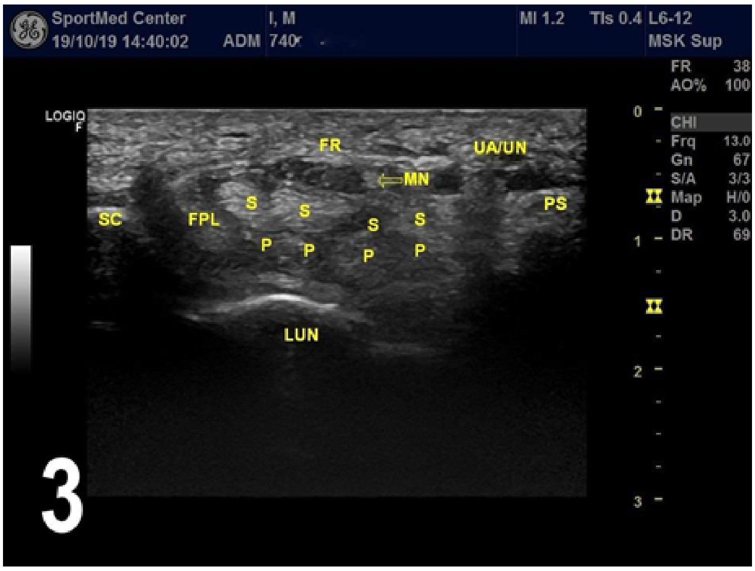

Fig. 3.: US view of the carpal tunnel anatomy (normality) – scan from the distal aspect (FR – retinaculum flexorum; MN – n. medianus; SC – os scaphoudeum; UA/UN – a. ulnaris/ n. ulnaris; PS – os pisiforme; LUN – os lunatum; S – m. fl. dig. superfic. (4 ligaments); P – m. fl. dig. prof. (4 ligaments); FPL – m. fl. poll. longus). (source: Dr Martin Ivanov)

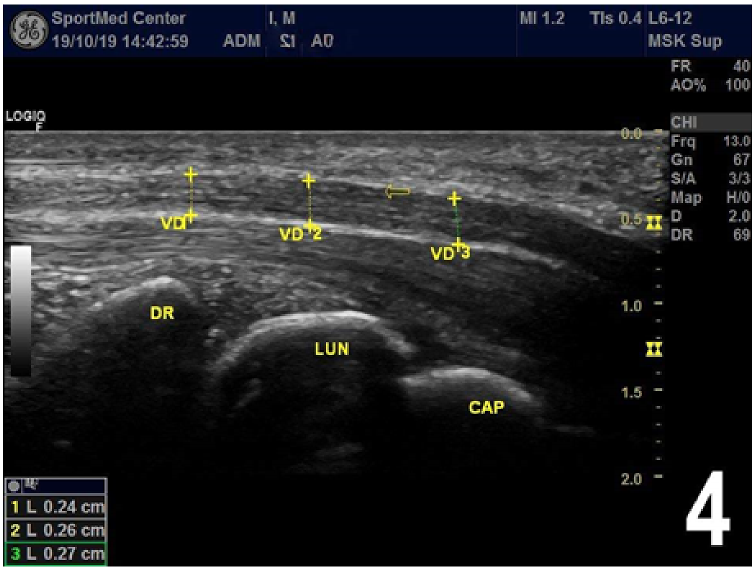

Fig. 4.: US view of the carpal tunnel anatomy(normality)- scan from the longitudinal aspect. (source: Dr Martin Ivanov)

in the middle part, where the degree of compression is the greatest. It is mandatory that a measurement the cross-section of n.medianus has been made – cross sectional area (CSA), depending on the capacity of the diagnostic equipment (Fig. 5). Or the CSA can be calculated after measurement of the width and length are taken (Fig. 6). It is suggested that any values of n. medianus' CSA above 12 mm^2 are pathological, where 10 mm^2 is the commonly accepted norm [10, 12].

Conclusion

Ultrasonography is a specific, quick and painfree method for examination, diagnostics and assessment of numerous conditions and diseases. The US methodology allows clinicians to establish the cause-effect links

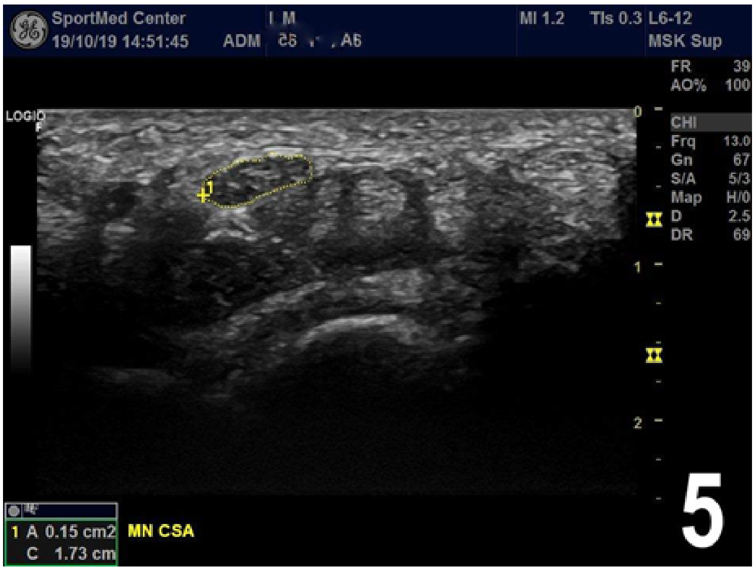

Fig. 5.: US view of the carpal tunnel anatomy (normality) – measurement of the CSA. (source: Dr Martin Ivanov)

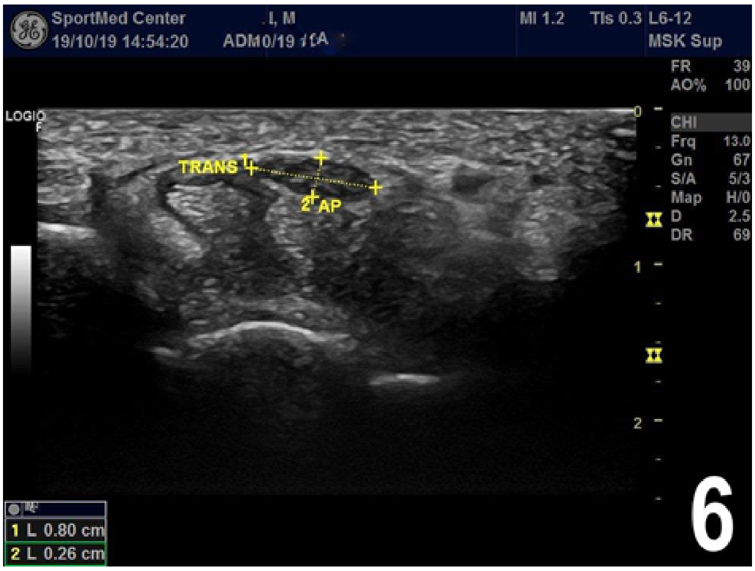

Fig. 6.: US view of the carpal tunnel anatomy(normality)- measurement of n.medianus (length and width). (source: Dr Martin Ivanov)

between the morphology of the anatomical structures and patients' subjective complaints and symptoms. It is an essential method for contemporaneous evaluation of various conditions such as compression-related syndromes, injuries of the soft tissues, and sport traumas. The opportunity to dynamically examine and visualise the structures is often of crucial importance for the selection of correct treatment and the monitoring of the therapy effects.

References

[1] Люцканова С, Троев Т, Заралиева А. Съвременни физикални методи за лечение на синдрома на карпалния канал. Съвременни медицински проблеми. 2016, 1, 41-43.

[2] Chammas M, Boretto J, Burmann LM, Ramos RM, dos Santos Neto FC, Silva JB. Carpal tunnel syndrome - Part I (anatomy, physiology, etiology and diagnosis). Rev Bras Ortop (English Ed [Internet].

2014 Sep; 49 (5): 429- 36. DOI: https://doi.org/10.1016/j.rboe.2014.08.001 [PMid:26229841 PMCid:PMC4487499]

[3] Atroshi I, Gummesson C, Johnsson R, McCabe SJ, Ornstein E. Severe carpal tunnel syndrome potentially needing surgical treatment in a general population. J Hand Surg Am [Internet]. 2003 Jul; 28 (4): 639- 44. DOI: https://doi.org/10.1016/S0363-5023(03)00148-5

[4] Костова В. Периферни невропатии в професионалната патология. 1996.

[5] Graham B, Peljovich A, Afra R, Cho M, Gray R, Stephenson J, Gurman A, MacDermid J, Mlady G, Patel A, Rempel D, Rozental T, Salajegheh M. American Academi of Ortopedic Surgeons. Management ot Carpal Tunnel Syndrome. Evidence-besed Clinical Practice Guideline. Feb 29 2016

[6] Jongs R. Carpal Tunnel Questionnaire. J Physiother [Internet]. 2017 Apr; 63 (2): 119. DOI: https://doi.org/10.1016/j.jphys.2017.02.001 [PMid:28325483]

[7] Петрова Ю, Миланов И. Canalis carpi syndrome - ЕМГ или ехографска оценка? Първа национална конференция за клиничн електромиография и евокирани потенциали. Трявна, 2013.

[8] Werner RA, Andary M. Electrodiagnostic evaluation of carpal tunnel syndrome. Muscle Nerve [Internet]. 2011 Oct; 44 (4): 597- 607. DOI: https://doi.org/10.1002/mus.22208 [PMid:21922474]

[9] Михалева В, Михайлова М, Павлов С, Маринова Д, Ангелова М, Филкова С. Карпал тунел синдром - анатомични вариации и тестове за диагностика. Варненски медицински форум. 2017; VI (2): 79-84.

[10] Балтов А. Ставна ехография в съвременната ревматология. 2013; 11: 117-120.

[11] Cartwright MS, Hobson-Webb LD, Boon AJ, Alter KE, Hunt CH, Flores VH, et al. Evidence-based guideline: Neuromuscular ultrasound for the diagnosis of carpal tunnel syndrome. Muscle Nerve. 2012 Aug; 46 (2): 287- 93. DOI: https://doi.org/10.1002/mus.23389 [PMid:22806381]

[12] Köroğlu Ö. Estimating the most accurate sonographic measurement in the diagnosis of carpal tunnel syndrome: Which is the best? Turkish J Phys Med Rehabil [Internet]. 2019 May 31; 65 (2): 177- 83. DOI: https://doi.org/10.5606/tftrd.2019.2421 [PMid:31453559 PMCid:PMC6706835]

[13] Карабинов В, Георгиев Г. Синдром на карпалния канал - често срещано и подценявано състояние. MD. 2017; 4: 2-5.

[14] Griffith J. Carpal Tunnel Syndrome. In: Diagnostic Ultrasound: Musculoskeletal [Internet]. Elsevier; 2015.