IJSPT
INTERNATIONAL JOURNAL OF SPORTS PHYSICAL THERAPY

Manske RC, Wolfe C, Page P, Voight ML. Diagnostic Musculoskeletal Ultrasound in the Evaluation of the Carpal Tunnel and Median Nerve. *IJSPT*. 2026;21(8):802-807. doi:10.26603/001c.165287

MSK Ultrasound Bites: Tips and Tricks

Diagnostic Musculoskeletal Ultrasound in the Evaluation of the Carpal Tunnel and Median Nerve

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Keywords: musculoskeletal ultrasound, wrist, carpal tunnel, rehabilitation, dynamic imaging

https://doi.org/10.26603/001c.165287

International Journal of Sports Physical Therapy

Vol. 21, Issue 8, 2026

The carpal tunnel is a fibro-osseous canal at the wrist that is formed by the retinaculum and bony structures. The superficial border is composed of the flexor retinaculum, the floor of the tunnel is formed by the carpal bones, the medial (ulnar) border by the hamate, and the lateral (radial) border by the trapezium. Contents that originate in the forearm and run distally through the carpal tunnel include the finger and thumb flexors and the median nerve. Carpal tunnel syndrome, when the median nerve becomes compressed or entrapped, occurs due to various issues that will be discussed in this paper.

Diagnostic musculoskeletal ultrasound (MSKUS) offers a portable, real-time, and cost-effective alternative that is gaining traction in rehabilitation and sports medicine settings. MSKUS has emerged as a valuable, non-invasive imaging modality for evaluating the size of the carpal tunnel and median nerve at the level of the wrist. MSKUS is excellent at detecting changes in carpal tunnel size, median nerve composition, thickness, and continuity. This manuscript will review the utility of MSKUS in evaluating carpal tunnel syndrome, including anatomy, common injury mechanisms, sonographic techniques, and clinical implications for those in the rehabilitation profession. Due to the confined area within the carpal tunnel and the number of structures that traverse through it, it is a very common site of pathology and symptoms. With a proper medical history and clinical examination, diagnosis is straightforward for this pathology. By integrating MSKUS into clinical practice, providers can improve the accuracy of diagnosis, enhance diagnostic confidence, monitor healing progression, and guide rehabilitation strategies to optimal patient outcomes for those with carpal tunnel overuse or injury.

INTRODUCTION

Carpal tunnel syndrome is the most frequent compressive neuropathy that is treated by healthcare professionals.[1] This condition accounts for 90% of the peripheral entrapments yet affects only 5% of the population.[2,3] Paresthesia, motor loss, and atrophy of the thenar muscles, and sensory loss in the median nerve distribution are the clinical signs and symptoms. Without a timely diagnosis, morbidity from this condition can have serious consequences. Chronic compression of the median nerve can cause irreversible damage, resulting in muscle atrophy, weakness, or total loss of sensation. Numerous causes of carpal tunnel syndrome exist and include malunion following fractures, rheumatic synovitis, amyloidosis, diabetes, pregnancy, and or soft tissue tumors.[4] The diagnosis is made via a comprehensive subjective medical history, description of symptoms, and clinical examination. Symptoms include numbness and impaired sensation in the sensory distribution of the median nerve; nocturnal numbness, tingling, and pain; thenar muscle atrophy if chronic; and occasional swelling on the volar side of the wrist. Electrophysiological testing may be useful to determine the severity of nerve injury.

ANATOMY OF THE CARPAL TUNNEL

The carpal tunnel is a narrow fibro-osseous canal at the wrist that is formed by the retinaculum and bony structures. The superficial border is composed of the flexor retinaculum, the floor of the tunnel is formed by the carpal

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bones, the medial (ulnar) border by the hamate, and the lateral (radial) border by the trapezium. Contents that originate in the forearm and run distally through the carpal tunnel include the nine finger and thumb flexors and the median nerve. Carpal tunnel syndrome occurs when the median nerve is compressed or entrapped within the carpal tunnel, causing symptoms.

THE ROLE OF MSK ULTRASOUND IN THE RADIOCARPAL JOINT

ADVANTAGES

- Non-Invasive: MSKUS is a non-invasive imaging technique that can be used on a variety of soft tissue pathologies, including those at the carpal tunnel.
- Real-Time Imaging: MSKUS allows evaluation of the carpal tunnel and its contents, and can be performed statically or during dynamic motion of wrist and forearm movement.
- High-Resolution Visualization: Sonographic assessment provides detailed images of the size and shape of the carpal tunnel, the diameter of the median nerve, and the thickness of the flexor tendons that run through the carpal tunnel.
- Accessibility and Cost-Effectiveness: MSKUS is portable, widely available, and less expensive than magnetic resonance imaging (MRI).
- Accuracy: MSKUS has a combined sensitivity of 86% to 88% and specificity of 84% for cross-sectional area measurements of the median nerve at the carpal tunnel inlet.[5,6]
- Reliability: Sonographic assessment of median nerve volume demonstrates great reliability with ICC values of 0.90.[7]

LIMITATIONS

- Operator Dependency: MSKUS requires skill and experience for accurate interpretation of findings. The ability to sonograph the carpal tunnel is largely influenced by the operator and by the availability and technical considerations of state-of-the-art equipment.
- Depth Limitations: Visualization is usually not a problem for the carpal tunnel due to its superficial location on the volar wrist.
- Artifacts and Shadows: Bone and calcifications may create image artifacts, requiring adjustments in probe positioning and frequency.

SONOGRAPHIC TECHNIQUE FOR EVALUATING THE CARPAL TUNNEL

EQUIPMENT SETUP

- Transducer Type: Because of the superficial nature of the carpal tunnel, a standard high-frequency, linear array transducer is normally used.
- Patient Positioning: The patient's forearm and wrist are placed in a supinated position with the dorsal forearm on the table. The transducer can be easily placed in either the long axis (LAX) or the short axis (SAX) to visualize the contents of the carpal tunnel. In the SAX view, the pisiform can be used as a bony landmark for the starting position of the medial side of the wrist. The transducer is placed in SAX across the wrist. Once the median nerve is found in the SAX view, the transducer can be rotated 90 degrees to the LAX view of the median nerve.
- Dynamic Assessment: Dynamic movements of wrist flexion and extension can be used to visualize tendon and nerve excursion in the carpal tunnel.

EXAMINATION PROTOCOL

NORMAL SONOGRAPHIC APPEARANCE

- When viewing images in SAX, the median nerve is easily seen as a honeycomb structure surrounded by a hyperechoic epineurium.

PATHOLOGIC FINDINGS IN INJURED CARPAL TUNNEL

- Swelling or thickening of the median nerve. The cross-sectional area of the median nerve at the level of the pisiform is normally 10 mm^2.[8] In a separate analysis of various locations from 74 studies, it was shown that a mean pooled cross-sectional area of the median nerve is 8.3 mm^2 at the wrist, 6.4 mm^2 at the forearm, and 8.3 mm^2 at the upper arm.[9] In those with carpel tunnel syndrome, the cross-sectional area jumps to 16.8 mm^2.[10]
- Flattening of the median nerve can be seen at the compression site at the flexor retinaculum. One can find the median nerve stenosis rate, which is the ratio of the minimum to the maximum anteroposterior diameter. The median nerve stenosis rate is 41.8% of those with carpal tunnel syndrome compared to 17.4% of those without.[11]
- It is not uncommon for the nerve to have an hourglass appearance due to swelling both proximal and distal to the area of compression. This is known as the "notch" sign.[12,13]
- Other structural findings can be viewed including "bowing" of the flexor retinaculum, swelling from tenosynovitis of the flexor tendons, ganglion cysts and other space-occupying lesions.[14]

CLINICAL IMPLICATIONS FOR REHABILITATION PROVIDERS

MSKUS provides real-time feedback for rehabilitation professionals, facilitating early diagnosis of median nerve compression and determining the need for intervention. Key applications include:

- Early Detection of Injury / Accurate Injury Grading: MSKUS can quickly examine swelling, thickening, or

compression of the median nerve, and this assessment can help guide treatment planning.
- Dynamic Functional Testing: Rehabilitation professionals can use MSKUS during active movements of the wrist and forearm to assess functional movement on nerve compression and nerve mobility or assess limited nerve mobility.
- Guided Interventions: MSKUS imaging assists in dry needling and precision-guided injections, such as corticosteroids for inflammation.
- Patient Education: Real-time imaging with MSKUS serves as a visual aid to explain the nature of the injury and set realistic expectations for recovery.

LIMITATIONS AND CHALLENGES

Due to its superficial nature, the median nerve is easily visualized within the carpal tunnel. Evaluation of the median nerve can be done very expediently with MSKUS. This can be done actively in the office, at much lower cost than other imaging modalities, and pathologic findings can often be seen.

CONCLUSION

The integration of MSKUS into physical therapy practice gives therapists an advantage in evaluating carpal tunnel syndrome. By providing real-time, non-invasive visualization of the carpal tunnel, the median nerve, and surrounding tissues, MSKUS can help enhance clinical decision-making beyond what a traditional examination alone can offer. It allows physical therapists to more accurately identify swelling, observe actual structural changes, monitor progression, and tailor interventions with greater overall precision. These enhancements to practice ultimately improve the outcomes for individuals experiencing carpal tunnel syndrome.

Published: August 01, 2026 CDT.

REFERENCES

1. Seror P. Sonography and electrodiagnosis in carpal tunnel syndrome diagnosis, an analysis of the literature. *Eur J Radiol*. 2008;67(1):146-152. doi:10.1016/j.ejrad.2007.06.017

2. Azami A, Maleki N, Anari H, Iranparvar Alamdari M, Kalantarhormozi M, Tavosi Z. The diagnostic value of ultrasound compared with nerve conduction velocity in carpal tunnel syndrome. *Int J Rheum Dis*. 2014;17(6):612-620. doi:10.1111/1756-185X.12310

3. Kuo TT, Lee MR, Liao YY, Chen JP, Hsu YW, Yeh CK. Assessment of median nerve mobility by ultrasound dynamic imaging for diagnosing carpal tunnel syndrome. *PloS One*. 2016;11(1):e0147051. doi:10.1371/journal.pone.0147051

4. Yoshii Y, Zhao C, Amadio PC. Recent advances in ultrasound diagnosis of carpal tunnel syndrome. *Diagnostics*. 2020;10(8):596. doi:10.3390/diagnostics10080596

5. Soleimani-Shishavan Z, Eftekharsadat B, Markazi-Movaghar R, et al. The inlet cross-sectional area: the most reliable ultrasound parameter for the diagnosis of carpal tunnel syndrome. *Am J Phys Med Rehabil*. Published online January 13, 2026. doi:10.1097/PHM.0000000000002930

6. Luo YT, Huang YT, Chiu V, Chang YW, Horng YS. Diagnostic meta-analysis of the efficacy of ultrasonography for diagnosing carpal tunnel syndrome: A comparison between Asian and non-Asian populations. *J Formos Med Assoc Taiwan Yi Zhi*. 2025;124(7):666-674. doi:10.1016/j.jfma.2024.06.026

7. Dejaco C, Stradner M, Zauner D, et al. Ultrasound for diagnosis of carpal tunnel syndrome: comparison of different methods to determine median nerve volume and value of power Doppler sonography. *Ann Rheum Dis*. 2013;72(12):1934-1939. doi:10.1136/annrheumdis-2012-202328

8. Georgiev GP, Karabinov V, Kotov G, Iliev A. Medical ultrasound in the evaluation of the carpal tunnel: a critical review. *Cureus*. 10(10):e3487. doi:10.7759/cureus.3487

9. Fisse AL, Katsanos AH, Gold R, Pitarokoili K, Krogias C. Cross-sectional area reference values for peripheral nerve ultrasound in adults: a systematic review and meta-analysis-Part I: Upper extremity nerves. *Eur J Neurol*. 2021;28(5):1684-1691. doi:10.1111/ene.14759

10. Klauser AS, Halpern EJ, De Zordo T, et al. Carpal tunnel syndrome assessment with US: value of additional cross-sectional area measurements of the median nerve in patients versus healthy volunteers. *Radiology*. 2009;250(1):171-177. doi:10.1148/radiol.2501080397

11. Okura T, Sekimoto T, Matsuoka T, et al. Efficacy of diagnosing carpal tunnel syndrome using the median nerve stenosis rate measured on ultrasonographic sagittal imagery: clinical case-control study. *Hand*. 2023;18(1_suppl):133S-138S. doi:10.1177/15589447211017225

12. Stonsaovapak C, Nimithpornchai S, Kimura J, Piravej K. Physiological localization by sensory and motor inching studies and structural abnormalities detected by ultrasonographic changes in carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2022;103(3):494-504.e1. doi:10.1016/j.apmr.2021.08.001

13. Padua L, Cuccagna C, Giovannini S, et al. Carpal tunnel syndrome: updated evidence and new questions. *Lancet Neurol*. 2023;22(3):255-267. doi:10.1016/S1474-4422(22)00432-X

14. Murciano Casas M de la P, Rodríguez-Piñero M, Jiménez Sarmiento AS, Álvarez López M, Jiménez Jurado G. Evaluation of ultrasound as diagnostic tool in patients with clinical features suggestive of carpal tunnel syndrome in comparison to nerve conduction studies: Study protocol for a diagnostic testing study. *PloS One*. 2023;18(11):e0281221. doi:10.1371/journal.pone.0281221

APPENDIX

CARPAL TUNNEL

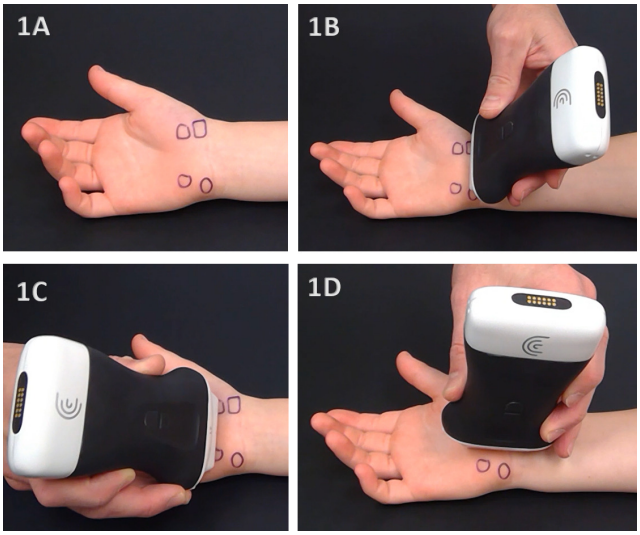


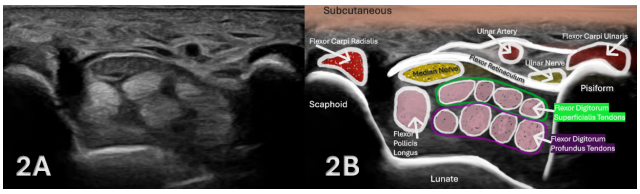
Figure 1. (A) Patient Positioning for Viewing Median Nerve in the Carpal Tunnel. (B–C) Transducer Placement over the Carpal Tunnel in Short Axis View (SAX). (D) Transducer Placement over the Carpal Tunnel in Long Axis View (LAX)

(A) For imaging the carpal tunnel, the patient should be seated comfortably in a chair facing the examiner. The forearm is positioned in supination with the palm facing upward and the dorsum of the hand resting on the examination table.

(B–C) To obtain a SAX view, place the transducer transversely across the proximal carpal tunnel, aligning it between the pisiform and scaphoid bones, Figure 1B. Gentle toggling of the transducer during scanning improves image quality by minimizing anisotropy and enhances differentiation of the median nerve from the surrounding flexor tendons. Moving the transducer slightly distally will allow viewing of the carpal tunnel outlet, Figure 1C. For the outlet view, the transducer is placed over the hook of the hamate and the trapezium tubercle.

(D) To obtain a LAX view, place the transducer in a longitudinal plane over the proximal and distal carpal tunnel in line with the median nerve. Gentle toggling of the transducer during scanning improves image quality by minimizing anisotropy and enhances differentiation of the median nerve from the surrounding flexor tendons.

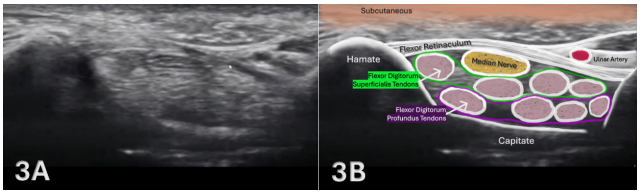
NORMAL MEDIAN NERVE IN SHORT AXIS AT THE CARPAL TUNNEL INLET



Figures 2A and 2B. SAX of Median Nerve at the Carpal Tunnel Inlet

When performing a SAX view in ultrasound, Figure 1B, it is often helpful to begin by identifying key bony acoustic landmarks. In this case, start by locating the carpal tunnel inlet after visualizing the median nerve. The median nerve is distinguished by its characteristic honeycomb appearance, displaying darker fascicles interspersed with connective tissue. This architecture contrasts with the surrounding flexor tendons, which exhibit a finer, more fibular texture. To further differentiate the median nerve from nearby structures, we utilize a technique called toggling the transducer allowing for a subtle rocking motion. Tendons are anisotropic, meaning their echogenicity changes with the angle of insonation; they may appear brighter or darker as the transducer angle shifts. In contrast, the median nerve maintains a more consistent appearance regardless of angle, aiding in its identification. At the carpal tunnel inlet, we observe the rounded dome of the pisiform on the ulnar side and the curved surface of the scaphoid on the radial side. This is commonly the region where the median nerve shows its greatest cross-sectional area. The transverse carpal ligament forms the roof of the tunnel at this level. Adjacent to the pisiform, we also see the ulnar nerve and ulnar artery, which course through the ulnar tunnel (Guyon's canal). This canal is formed by the floor of the transverse carpal ligament and contains these neurovascular structures.

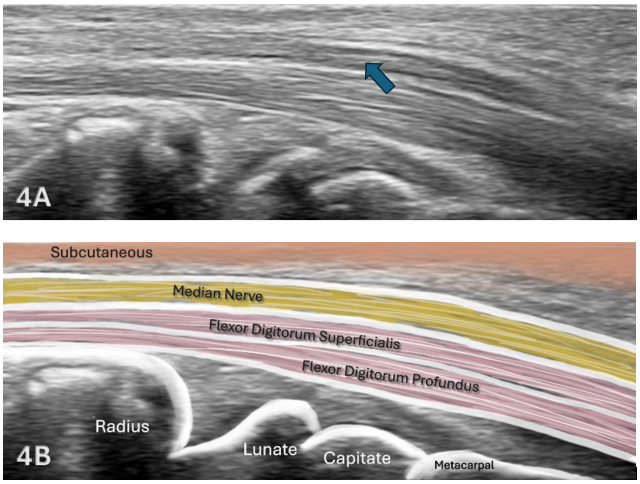
NORMAL MEDIAN NERVE IN SAX AT THE CARPAL TUNNEL OUTLET



Figures 3A and 3B. SAX View of Median Nerve at the Carpal Tunnel Outlet

To view the median nerve in SAX as it exits the carpal tunnel, Figure 1C, continue scanning distally from the carpal tunnel inlet and the pisiform gradually disappears from view and is replaced by the hook of the hamate, marking the carpal tunnel outlet. This distal region is the most common site of median nerve entrapment. At this level, the transverse carpal ligament is often thicker, contributing to potential compression of the median nerve.

NORMAL MEDIAN NERVE IN LAX VIEW AT THE CARPAL TUNNEL



Figures 4A and 4B. LAX View of Median Nerve at the Carpal Tunnel

For a LAX view of the median nerve, Figure 1D, the transducer is placed into a longitudinal over the carpel tunnel. In this view, the median nerve appears superficial, lying above the flexor digitorum superficialis and flexor digitorum profundus tendons. The median nerve is easily recognized by its fascicular architecture, which remains distinct in this orientation. This scanning plane provides a clear view of the carpal tunnel space, and you may gently mobilize the flexor tendons to observe their movement. While both the tendons and the median nerve exhibit excursion during finger motion, the median nerve displays less excursion compared to the tendons beneath it. This dynamic observation is a helpful method for evaluating median nerve mobility and for identifying structures within the carpal tunnel.

PATHOLOGY: CARPAL TUNNEL SYNDROME

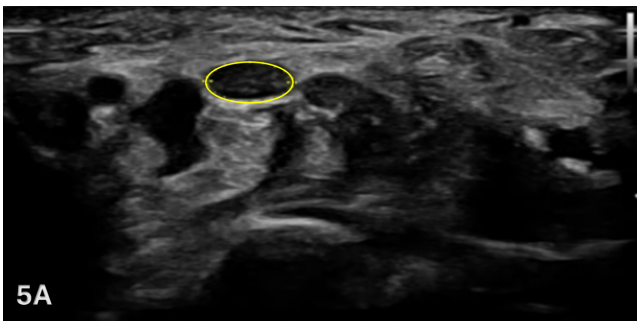


Figure 5A. SAX View of Median Nerve in the Carpal Tunnel

Ultrasound features of carpal tunnel syndrome include a hypoechoic, thickened median nerve with loss of the normal "honeycomb" fascicular pattern. Cross-sectional area thresholds aid diagnosis: <8 mm^2 is normal, 8–12 mm^2 is borderline, and >12 mm^2 is abnormal. A CSA increase of >2 mm^2 from the forearm (pronator quadratus level) to the wrist carpal tunnel is 100% specific for carpal tunnel syndrome. In Figure 5A, the circumference measures 10 mm^2.

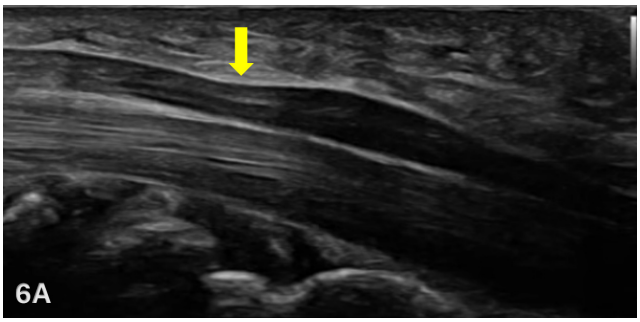


Figure 6A. LAX View of Median Nerve in the Carpal Tunnel.

In diagnostic ultrasound of the median nerve at the wrist, the "notch sign" highlighted above with the yellow arrow refers to a key finding observed in the LAX view in cases of carpal tunnel syndrome. As the median nerve approaches the proximal carpal tunnel, it typically appears thickened and hypoechoic, reflecting early swelling due to compression. At the level of the flexor retinaculum, the nerve then abruptly flattens, creating a distinct "notch" or step-off in its contour. This change in shape of being thickened proximally and flattened distally is known as the notch sign and is a hallmark of median nerve entrapment at the carpal tunnel inlet. This finding is often seen in conjunction with other sonographic features such as volar bowing of the flexor retinaculum and an increased cross-sectional area of the median nerve in the transverse view. The notch sign provides visual confirmation of mechanical compression and supports the clinical diagnosis of carpal tunnel syndrome.