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Case report

Ultrasound-assisted near nerve method in nerve conduction study for the diagnosis of tarsal tunnel syndrome. A case report

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ABSTRACT

Objectives: The sensitivity of nerve conduction studies (NCSs) of the medial and lateral plantar nerves for the diagnosis of tarsal tunnel syndrome (TTS) is not high enough. The near nerve method (NNM) is a recording technique for NCSs that allows the recording of large, clear potentials. The NNM was reported to improve the sensitivity of diagnoses of TTS. However, the NNM requires special skill using electrical motor threshold in positioning a needle electrode correctly. Thus, we performed the NNM with the aid of ultrasound imaging (ultrasound-assisted). The aim of this case report is to show the utility of ultrasound-assisted NNM in the electrodiagnosis of TTS.

Case report: A 69-year-old woman presented with paresthesia on the lateral sole of her right foot. Ultrasound imaging showed a space occupying lesion (SOL) posterior to the medial malleolus, caused by tenosynovitis, as discovered after surgery. We performed an NCS of the medial and lateral plantar nerves with ultrasound-assisted NNM. Ultrasound-assisted NNM allowed us to easily determine the needle insertion site just proximal to the SOL and to avoid penetrating the SOL and the vessels, and, furthermore, simplified moving the needle electrode toward the target nerve. The results of the NCS revealed that there was severe injury to the lateral plantar nerve and no injury to the medial plantar nerve.

Conclusions: In the NCS of the medial and lateral plantar nerves with NNM to diagnose TTS, ultrasound-assisted NNM can be useful for simplicity and safety.

1. Introduction

Tarsal tunnel syndrome (TTS) is a compressive neuropathy of the tibial nerve or its branches under the flexor retinaculum at the medial ankle, caused by ganglia, talocalcaneal coalition, or tenosynovitis. For the electrodiagnosis of TTS, a nerve conduction study (NCS) of the medial and lateral plantar nerves is performed. Sensory NCSs, with stimulation of the toes, or mixed NCSs, with stimulation at the sole, have been shown to be more sensitive than motor NCSs (Galardi et al., 1994; Patel et al., 2005; Preston and Shapiro, 2013). However, even in sensory or mixed NCSs, the sensitivities are not high enough (Oh et al., 1985).

The near nerve method (NNM) is a recording technique for NCSs, using an insulated needle electrode with a bare tip, positioned near the target nerve (Buchthal and Rosenfalck, 1966; Rosenfalck, 1978). The NNM allows the recording of larger and morphologically clearer potentials than those recorded using surface electrodes. Oh et al. (1985) reported that a sensory NCS of the medial and lateral plantar nerves using the NNM showed higher sensitivity in the diagnosis of TTS than did surface electrodes. However, in the NNM, clinicians must locate the needle-insertion site based on anatomical landmarks or with the aid of the muscle responses to electrical stimulation. Furthermore, the tip of the needle must be moved to the correct depth, using the lowest motor threshold of electrical stimulation (lowest MT). Therefore, the NNM requires particular skill in positioning a needle electrode in the correct location close to the target nerve.

Recently, the use of ultrasound as an aid for positioning needle electrodes in the NNM has been introduced for a few nerves (Deimel et al., 2013; Kamm et al., 2009). Therefore, we used ultrasound assist in the NNM (ultrasound-assisted NNM) for an NCS of plantar nerves, for a case of TTS caused by tenosynovitis of the flexor hallucis longus and the flexor digitorum longus. The aim of this case report is to show the utility of the ultrasound-assisted NNM for the electrodiagnosis of TTS.

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2. Case report

2.1. Clinical course

A 69-year-old woman presented with swelling on the medial side of the right ankle for 2 years. Two weeks previously, she had numbness on the lateral and calcaneal parts of the sole of the right foot and consulted a doctor. Paresthesia and sensory disturbance were recognized on the lateral and calcaneal parts of the right sole (Fig. 1a). Movement of all of the toes was impaired in abduction and adduction. There was a positive Tinel sign over the swollen tarsal tunnel (Fig. 1b). Magnetic resonance imaging showed a space occupying lesion (SOL) posterior to the medial malleolus. The patient was referred to our laboratory for the electrodiagnosis of TTS. The ultrasound image demonstrated a hypoechoic SOL posterior to the medial malleolus (Fig. 2a). In such a case, the insertion of the needle electrodes may be difficult, owing to the barrier of the SOL. We then performed an NCS of the medial and plantar nerves with ultrasound-assisted NNM, as described below. The results provided the information necessary to confirm the TTS diagnosis. The patient underwent surgical release of the tarsal tunnel. The finding in the operation and pathological examination indicated that the SOL was caused by tenosynovitis of the flexor hallucis longus and flexor digitorum longus tendons. The patient recovered from the paresthesia and the muscle weakness of the toes. She had no recurrence of symptoms within the first year after the operation. Written informed consent was obtained from the patient for this report.

2.2. Ultrasound-assisted NNM

To identify the location of the SOL and the nerve, ultrasound imaging was used. A linear probe at a frequency of 18 Hz with a short axis view was applied over the swelling posterior to the medial malleolus. A hypoechoic, clear cystic SOL was identified (Fig. 2a). The probe was then moved proximally, to the proximal border of the SOL. Ultrasound imaging visualized the posterior tibial nerve, along with the posterior tibial artery and the two posterior tibial veins (Fig. 2b). The optimal insertion site for the needle was determined to be just proximal to the SOL. The direction of the needle insertion toward the nerve was chosen based on the ultrasound image, so as not to penetrate the SOL and the vessels. At the same time, the distance between the insertion site and the nerve was measured (Fig. 2b). Based on the distance, we could plan the depth for the appropriate position of the needle tip.

In an out-of-plane approach, with a short axis view, the active needle electrode was inserted at the chosen direction and depth (ultrasound-assisted). A scale was attached on the side of the ultrasound probe, so that we could recognize how far the tip of the needle was moved under the skin (Fig. 3). As an active electrode, an insulated needle with a bare tip (NM 225U, Nihon Kohden, Tokyo, Japan) was used. The reference surface electrode was placed 3-cm anterior to the active needle electrode (Oh et al., 1985). During the insertion, on the ultrasound image, we could see a small wave or flicker in the subcutaneous tissue around the needle electrode as it moved toward the nerve. That flicker of the soft tissue suggested the position of the needle tip. Even after positioning the needle, the soft-tissue flicker could be reproduced by tapping or slightly mov-

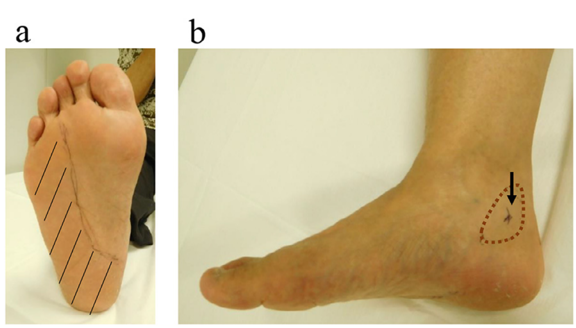

Fig. 1. Clinical findings of the right foot. (a) Paresthesia and sensory disturbance in the lateral and calcaneal parts of the sole (shaded area). (b) Tinel sign (arrow) was recognized over the swelling (dotted line) posterior to the medial malleolus.

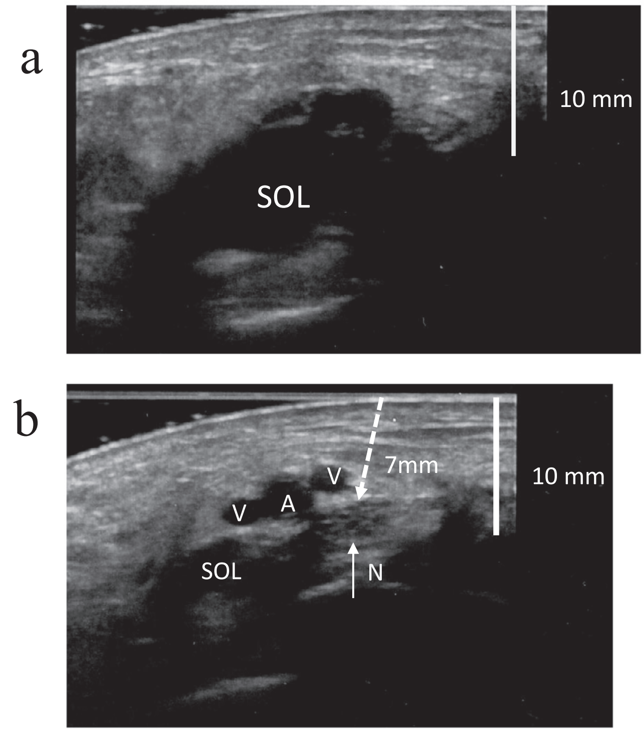

Fig. 2. Ultrasound images of the right medial ankle visualized by the probe with a short axis view. (a) At the site over the swelling posterior to the medial malleolus, a hypoechoic space occupying lesion (SOL) was observed. (b) At the site just proximal to the SOL. N (arrow): tibial nerve, A: posterior tibial artery, V: posterior tibial vein. Dashed arrow: planned route for insertion of the needle. The needle was to be inserted toward the tibial nerve without penetrating the SOL and vessels. The depth, from the tip of the needle to the target nerve, was measured as 7 mm based on the ultrasound image.

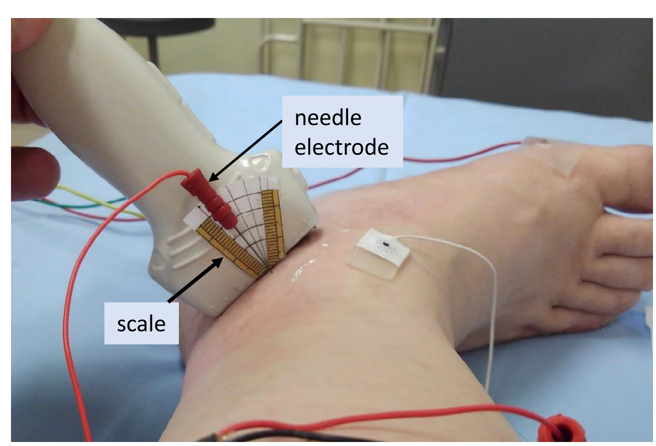

Fig. 3. Needle insertion using the ultrasound-assisted near nerve method. The needle electrode was inserted at the site chosen from the ultrasound image. The scale on the side of the probe gave information regarding the depth of the inserted needle.

ing the needle. Then, we could use the flicker for checking the position of the tip of the needle. After that, the final position of the needle electrode was confirmed based on the lowest MT. We judged the motor threshold to be lowest when current less than <1 mA (duration: 0.2 ms) through the electrode elicited a muscle action potential of the abductor hallucis muscle.

Next, the two electrodes were converted to recording electrodes, and then, the NCSs to diagnose TTS were performed. In the mixed NCS, the medial and lateral plantar nerves were stimulated with surface electrodes on the medial and lateral areas of the sole, at distances of 120 mm (Right) and 135 mm (Left). In the sensory NCS of the medial plantar nerve, the big toe was stimulated at distances of 215 mm (Right) and 230 mm (Left), with ring surface electrodes. When the sensory potential was not recognizable, the intensity was increased above the supramaximal stimulation used in the study of the same nerve on the healthy side. We classified measurement values as abnormal when: (1) the conduction velocity on the affected side was >10 m/sec slower than that on the normal side, or (2) the amplitude of the potential on the affected side was less than half of that on the normal side. The temperature of the skin on the feet was maintained at >32 °C.

In the mixed NCS of the medial plantar nerve on the affected side (Right), the conduction velocity and the amplitude showed no significant differences compared with those on the healthy side (Left) (Fig. 4, upper trace). On the contrary, in the mixed NCS of the lateral plantar nerve, the nerve action potential was absent (Fig. 4, middle trace). In the sensory NCS, dispersion of the potential was recognized only on the right side (Fig. 4, lower trace). However, the amplitude of the potential on the affected side was not lower than that on the normal side, so the result of the sensory NCS was judged to be normal. On the whole, the results indicated that there was severe injury to the lateral plantar nerve and no injury to the medial plantar nerve. This discrepancy between the two plantar nerves supported the diagnosis of TTS. All the studies were smoothly executed without repositioning the recording needle electrode.

3. Discussion

We used ultrasound-assisted NNM in an NCS to diagnose TTS. The ultrasound-assisted NNM enabled us to locate the needle insertion site just proximal to the SOL and to avoid penetrating the SOL and the vessels, and helped in moving the needle electrode close to the target nerve. To our knowledge, this is the first report of ultrasound-assisted NNM in an NCS of the medial and lateral plantar nerves to diagnose TTS.

The results of the mixed NCS clearly demonstrated an absence of the potential in the lateral plantar nerve and a normal value in the medial plantar nerve. However, the result of the sensory NCS of the medial plantar nerve required careful consideration. The potential on the affected side was not lower than that on the normal side, but dispersion with multiple phases was recognized only on the affected side. Previously, Oh et al. (1985) judged a case showing only dispersion to be abnormal, indicating demyelination. Thus, the dispersion on the affected side in the present case might indicate mild demyelination. However, dispersion should be classified as abnormal only when it coincides with a reduced amplitude of the sensory nerve action potential. Furthermore, dispersion can be shown even in the normal nerve in NCSs with NNM. Therefore, we judged the result of the sensory NCS of the medial plantar nerve to be normal.

Strictly speaking, the amplitude of the potential in the sensory NCS on the affected side was just a few microvolts larger than that on the unaffected side. This difference may be attributed to some technical problem or measurement error. However, we not only performed needle positioning based on ultrasound assist, but also confirmed it using the conventional electrical threshold. Accordingly, we think that the amplitude difference was not caused by the addition of the ultrasound assist.

In this case, we combined ultrasound imaging with the NNM. Our study results have several merits. First, ultrasound-assisted NNM enabled us to easily determine the insertion site just proximal to the pathological site.

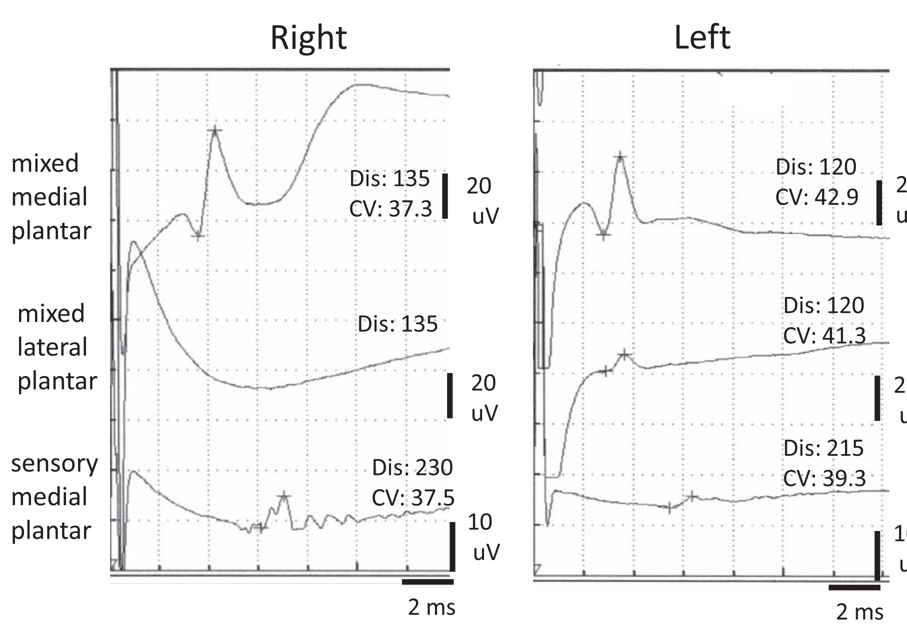

Fig. 4. Nerve conduction study using ultrasound-assisted near nerve method. Dis: distance (mm), CV: conduction velocity (m/sec) Upper trace: mixed nerve conduction study of the medial plantar nerve with stimulation of the medial sole. Middle trace: mixed nerve conduction study of the lateral plantar nerve with stimulation of the lateral sole. The compound nerve action potential of the nerve on the affected side (Right) was absent. Lower trace: sensory nerve conduction study of the medial plantar nerve with stimulation of the big toe. Temporal dispersion of the sensory nerve action potential was apparent on the affected side. Dispersion of the potential was recognized only on the right side (Fig. 4, lower trace). The amplitude of the potential on the affected side was not lower than that on the normal side.

Second, we were able to move the needle tip to the nerve more simply than before. Previously, moving the tip of the needle close to the target nerve was difficult and time-consuming when it was performed based only on the lowest MT. Using ultrasound assist, we could anticipate the depth between the nerve and the tip of the needle based on the ultrasound image, prior to the insertion. This foresight helped simplify moving the needle close to the target nerve.

Third, the insertion site for the needle was chosen so as not to penetrate the SOL or the vessels, so that we could perform the needle insertion safely. The safety can be confirmed by ultrasound imaging, because, if the needle pushes the SOL or vessels, those structures will move or change their shape.

Recent advances in ultrasound technology enable the visualization of peripheral nerves with high resolution. The use of ultrasound imaging in needle positioning toward a nerve is applied in various fields, such as peripheral nerve block for regional anesthesia. However, the use of ultrasound imaging in NNM has been reported only in the lateral femoral cutaneous nerve (Deimel et al., 2013) and the sural nerve (Kamm et al., 2009). Now, the present case is the first application of ultrasound imaging to the NNM of the medial and lateral plantar nerves. This case, as well as the previous studies, showed that ultrasound imaging improved the accuracy and simplicity of the NNM. Therefore, clinical applications of ultrasound-assisted NNM for other nerves are recommended.

However, there were several technical limitations in our approach. First, we did not use an in-plane approach but, rather, an out-of-plane approach. The out-of-plane approach provides helpful information for safe and simple needle insertion, by demonstrating the relative positions of the nerve and vessels in one display. However, the needle itself cannot be visualized. We can mostly compensate for the invisibility of the needle based on two kinds of technical feedback, the scale attached to the ultrasound probe and the flicker of the subcutaneous soft tissue. However, final adjustment and confirmation of the depth of the needle using the lowest MT is required.

Second, in this study, we did not have reference values from a large normal population at our institute, so we judged the abnormalities by comparing values between the affected and unaffected sides of the foot. However, determining reference values at each institute is desirable for more critical judgement of abnormalities in NCS with NNM.

4. Conclusion

We demonstrated the utility of ultrasound-assisted NNM in an NCS of the medial and lateral plantar nerves to diagnose TTS. Ultrasound-assisted NNM allowed us to easily determine the needle insertion site just proximal to the SOL and to insert the needle safely without penetrating a SOL or vessels. It also simplified moving the needle electrode toward the target nerve. This case study suggests that, in the NCS of the medial and lateral plantar nerves with NNM to diagnose TTS, ultrasound-assisted NNM can be useful for simplicity and safety.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Buchthal, F., Rosenfalck, A., 1966. Evoked action potentials and conduction velocity in human sensory nerves. Brain Res. 3, 1–122.

Deimel, G.W., Hurst, R.W., Sorenson, E.J., Boon, A.J., 2013. Utility of ultrasound-guided near-nerve needle recording for lateral femoral cutaneous sensory nerve conduction study: does it increase reliability compared with surface recording? Muscle Nerve 47 (2), 274–276.

Galardi, G., Amadio, S., Maderna, L., Meraviglia, M.V., Brunati, L., Dal Conte, G., Comi, G., 1994. Electrophysiologic studies in tarsal tunnel syndrome. Diagnostic reliability of motor distal latency, mixed nerve and sensory nerve conduction studies. Am. J. Phys. Med. Rehabil. 73 (3), 193–198.

Kamm, C.P., Scheidegger, O., Rösler, K.M., 2009. Ultrasound-guided needle positioning in sensory nerve conduction study of the sural nerve. Clin. Neurophysiol. 120 (7), 1342–1345.

Oh, S.J., Kim, H.S., Ahmad, B.K., 1985. The near-nerve sensory nerve conduction in tarsal tunnel syndrome. J. Neurol. Neurosurg. Psychiatry 48 (10), 999–1003.

Patel, A.T., Gaines, K., Malamut, R., Park, T.A., Toro, D.R., Holland, N., 2005. American Association of Neuromuscular and Electrodiagnostic Medicine. Usefulness of electrodiagnostic techniques in the evaluation of suspected tarsal tunnel syndrome: an evidence-based review. Muscle Nerve 32 (2), 236–240.

Preston, D.C., Shapiro, B.E., 2013. Chapter 24 Tarsal tunnel syndrome. Electromyography and neuromuscular disorders clinical-electrophysiological correlations. Third edition, Elsevier Saunders, London.

Rosenfalck, A., 1978. Early recognition of nerve disorders by near-nerve recording of sensory action potentials. Muscle Nerve 1 (5), 360–367.