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ORIGINAL ARTICLE

Ultrasound detection of sciatic nerve movements with ankle dorsiflexion/plantar flexion: Prospective comparative study of a novel method to locate the sciatic nerve

Siyatik sinir hareketinin ayak bileği dorsifleksiyon ve plantar fleksiyonuyla ultrason eşliğinde görüntülenmesi: Siyatik sinirin yerinin belirlenmesinde yeni bir yöntem

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Summary

Objectives: It is possible to observe the in-vivo movements of nerves using real-time ultrasound. In this study, we aimed to visualize the movements of the sciatic nerve as a guide to identify the sciatic nerve to distinguish from surrounding tissue.

Methods: This trial was a prospective, cross-over comparative study. We included 25 healthy volunteers in this study. The movements of the sciatic nerve were visualized in the transverse view at popliteal and midthigh levels using ultrasonography. Anterior-posterior movements were assessed by measuring skin-to-nerve distance. The distances were measured during maximum ankle dorsiflexion, maximum plantar flexion and neutral position and compared with each other. We also evaluated the quality of dynamic (real-time) rotation/lateral movements of the sciatic nerve by assigning a subjective observer score.

Results: The movement of sciatic nerve was significant at popliteal region with active and passive ankle dorsiflexion which was 0.32 cm and 0.23 cm respectively (p=0.003). The movement of sciatic nerve was significant at midthigh region with active and passive ankle plantar flexion which was 0.11 cm and 0.01 cm respectively (p<0.001). Excellent rotation/lateral movement was observed in subjects at popliteal region and good rotation/lateral movement was observed at midthigh level.

Conclusion: Sciatic nerve movement can be observed with ankle dorsiflexion and plantar flexion in the transverse plane at popliteal and midthigh locations under real time ultrasound. This preliminary study suggest that observing the movements of sciatic nerve is potentially valuable in clinical sciatic nerve blocks for facilitating the localization of the sciatic nerve.

Keywords: Ankle dorsiflexion; midthigh; plantar flexion; popliteal; sciatic nerve movement; ultrasound.

Özet

Amaç: Sinirlerin *in vivo* hareketlerini gerçek zamanlı ultrason kullanarak gözlemlemek mümkündür. Siyatik siniri etrafındaki dokudan ayırt etmek ve tanımlamak için bir kılavuz olarak hareketlerini göstermeyi amaçladık.

Gereç ve Yöntem: Bu araştırma prospektif çapraz karşılaştırmalı çalışma olarak planlandı. Bu çalışmaya, 25 gönüllü dahil ettik. Siyatik sinirin hareketleri ultrasonografi kullanılarak popliteal ve orta uyluk seviyelerinde enine kesitlerde görüntülendi. Cilt-sinir mesafesi ölçülerek sinirin ön-arka hareketi değerlendirildi. Mesafeler, maksimum ayak bileği dorsifleksiyonu, maksimum plantar fleksiyon ve nötr pozisyonda ölçüldü ve birbirleriyle karşılaştırıldı. Ayrıca, siyatik sinirin dinamik (gerçek zamanlı) rotasyon/lateral hareketleri subjektif bir gözlemci puanı verilerek değerlendirildi.

Bulgular: Siyatik sinirin hareketi popliteal bölgede aktif ve pasif ayak bileği dorsifleksiyonunda, sırasıyla 0,32 cm ve 0,23 cm olarak ölçüldü ve anlamlı bulundu (p=0,003). Siyatik sinirin hareketi orta uylukta, aktif ve pasif ayak bileği plantar fleksiyonu ile sırasıyla 0,11 cm ve 0,01 cm olarak ölçüldü (p<0,001). Popliteal bölgede iyi derecede rotasyon/lateral hareket, orta uylukta orta seviyede rotasyon/lateral hareket gözlendi.

Sonuç: Gerçek zamanlı ultrason görüntüleme ile popliteal ve orta uyluk seviyelerinde enine kesitlerde ayak bileği dorsifleksiyonu ve plantar fleksiyonu ile siyatik sinir hareketi gözlenmiştir. Siyatik sinirin hareketlerini gözlemlemek, siyatik sinirin lokalizasyonunu kolaylaştırmak için siyatik sinir bloklarında potansiyel olarak faydalı olabilir.

Anahtar sözcükler: Ayak bileği dorsifleksiyon; orta uyluk; plantar fleksiyon; popliteal; siyatik sinir hareketi; ultrason.

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Introduction

In the past decade, ultrasound guided techniques have become the popular method for blocking the sciatic nerve. Although ultrasound guidance is helpful for localization of the sciatic nerve (SN), depth of the nerve at thigh may complicate the anatomical distinction of the nerve from the surrounding tissues.[1,2] Sciatic nerve echogenicity is similar to the surrounding fatty tissues, muscles and the echogenicity may vary at different tissue levels along the thigh. Even though ultrasound technology is improving fast, the ability to visualize a detailed image of the sciatic nerve with surrounding/inner tissue layers and visualization of local anesthetic spread may be limited with a 2-dimentional conventional ultrasound machine.[3]

It was noted that 37.5% of patients have a poor or average image quality and required nerve stimulation to confirm ultrasonographic appearance of the sciatic nerve.[2] Nerve stimulators are still needed not only to verify the location of the sciatic nerve but also to avoid intraneural injection and improve patient safety. However, use of a nerve stimulator to assist ultrasound guidance and to confirm location of SN may be time consuming and uncomfortable and even in some cases, it can fail to elicit a motor response to identify the SN.[4,5] Therefore, a method to allow ultrasound visualization of sciatic nerve movements would be of value regarding sciatic nerve blocks, particularly for the conditions where it is difficult to distinguish the nerve from surrounding tissues.

Neural mobilization is a well-documented modality within the literature.[6] A peripheral nerve is able to slide and stretch to accommodate changes in its bed length during joint movements.[7] It is possible to observe the *in vivo* sciatic nerve movements of neural glide, slide or stretching movement by using real-time ultrasound imaging.[8] Recent ultrasound studies have demonstrated that it is possible to visualize and quantify sciatic nerve movement, with reasonable reliability.[9] Observing the real-time movement of the sciatic nerve at popliteal or thigh levels may help to facilitate to identify the SN and distinguish it from the surrounding fascial layers and soft tissues. Based on previous neural mobilization studies, we hypothesized that a clear movement of the sciatic nerve can be observed in transverse ultrasonography images during ankle dorsiflexion and plantar flexion.[8,9]

We first introduced this modality in regional anaesthesia practice for locating the sciatic nerve and demonstrated sciatic nerve movements in a volunteer previously.[10] The principal objective of the study was to verify the significance of sciatic nerve movements in real time ultrasound images induced by ankle dorsiflexion and plantar flexion manoeuvres. We measured the anterior-posterior movements of the sciatic nerve at popliteal fossa and at midthigh region using the built-in calliper of US machine. We also assessed the rotation/lateral movements of the sciatic nerve by using an observer-assigned scoring system.

Material and Methods

The current research was designed as a volunteer based prospective cross-over study. Ethics approval was provided by the Dumlupınar University Ethical Board (No: 2017-11/8). After obtaining written informed consents, 25 subjects aged between 18 and 38 years were included in this study. Subjects were recruited by asking the operation theatre employees and healthy patients to participate. Subjects were included if they accepted to participate. Exclusion criteria were a history of major trauma or surgery of the leg involving the sciatic nerve at popliteal and thigh regions, having symptoms consistent with sciatic nerve impairment. Participants having a history of neurologic disorder that may cause nervous impairment such as diabetes mellitus or having a disorder of ankle movements were also excluded.

We explained our subjects the procedure and how to make plantar flexion and dorsal flexion manoeuvres before US scanning. The subjects were positioned prone with the lower limbs in neutral position. We provided additional support by placing a pillow under the lower leg to facilitate plantar flexion and dorsiflexion movements (Fig. 1). The ankle was not supported to allow a full joint movement. In all participants, the right leg was imaged.

The Sciatic nerve was scanned by using a 12 MHz linear ultrasound probe (11L; Logiq P6, GE Healthcare, Illinois). The nerve was scanned in transverse plane posteriorly at two separate locations: midthigh and the popliteal fossa. After positioning, the US probe was first placed transversally on the popliteal fossa (Fig. 1a). The transducer was then adjusted to visualize the popliteal artery and vein (Fig. 2). Colour Dop-

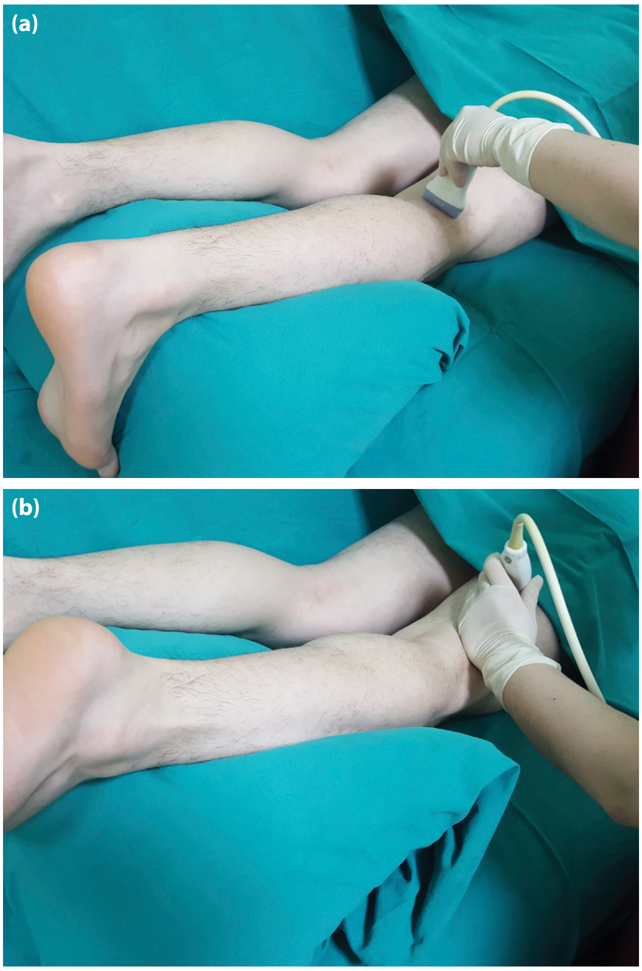

Figure 1. The position of the volunteer during the ultrasound scan of the popliteal region **(a)** and the midthigh region **(b)**. The leg was supported with a pillow but the ankle was kept unrestricted to allow a full joint movement. In all participants, the right leg was imaged.

pler was used to facilitate the visualization of the popliteal vessels. The sciatic nerve was identified which is seen as an oval heterogenous structure, just proximal to its separation to tibial and peroneal branches.

When the sciatic nerve is identified and a clear image was obtained, we asked the volunteer to make a maximum plantar flexion manoeuvre and a frozen US image was captured. The distance from the skin to the posterior border of the SN was measured (Fig. 3). Thereafter, we asked the volunteer to do a maximum ankle dorsiflexion and keep foot at that position. While the participant was maintaining the maximal ankle dorsiflexion, a frozen ultrasound image was taken and the distance from the skin to the posterior border of the SN was measured. We defined these manoeuvres as active ankle joint movements. The same measurements were performed as described above, while a research assistant was applying the

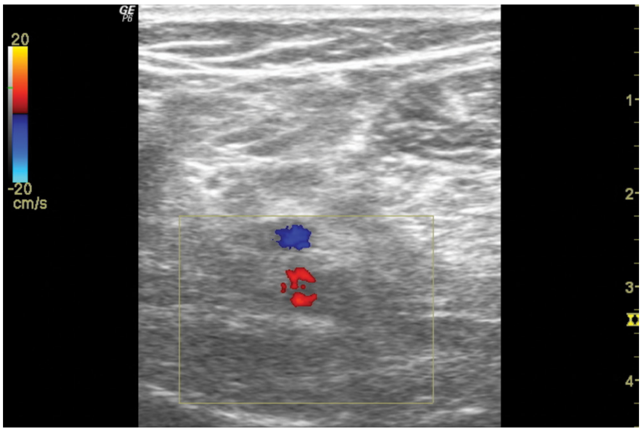

Figure 2. The ultrasound visualization of the popliteal artery, vein and the sciatic nerve at popliteal region.

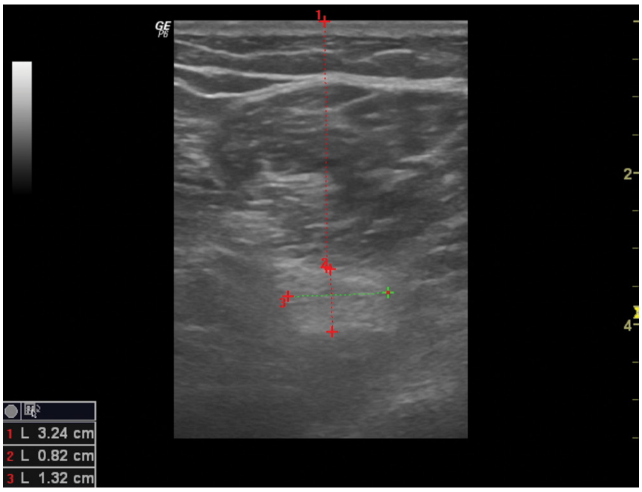

Figure 3. The ultrasound image of the skin-to-nerve measurement and sciatic nerve diameters at midthigh region.

ankle dorsiflexion and plantarflexion manoeuvres by hand. The latter manoeuvres were defined as passive ankle joint movements.

Thereafter, the sciatic nerve was scanned by following up to the midthigh level (Fig. 1b) and identified again where it was visualized between adductor magnus, semitendinosus/semimembranosus and biceps femoris muscles. The skin-to-nerve distances were consecutively measured as described above at midthigh level during active and passive ankle dorsiflexion and plantar flexion manoeuvres. The nerve movement was defined as the difference of the skin-to-nerve distances at maximum dorsiflexion and maximum plantar flexion.

The quality of lateral/rotation sciatic nerve movements was graded according to a 5-point scale during active and passive ankle movements. A score was assigned by the observer to the dynamic (real-time)

Table 1. Summary of participants' characteristics

	Mean±SD
Age (year)	29.25±11.05
Gender (male, female)	(22,2)
Weight (kg)	79.50±16.57
Height (m)	1.75±0.09
BMI (kg/m²)	26.01±5.51

SD: Standard deviation; BMI: Body mass index. Values presented as mean±standard deviation and numbers (n=24).

Table 2. Measurements of the transverse (antero-posterior) nerve movement in different conditions (n=24)

Ankle movement	Popliteal	Midthigh	p
Induced by consecutive active dorsiflexion and plantar flexion (cm)	0.32	0.11	0.003
Induced by consecutive passive dorsiflexion and plantar flexion (cm)	0.23	0.01	<0.001

rotation and lateral movements of the SN (video supplemental). A score of 1was defined as excellent movement observed and the nerve can be clearly distinguished from surrounding structures with the movement. A score of 2 was defined as a good movement of the nerve and the nerve is fairly distinguishable from surrounding tissues. A score of 3 was fair movement but the sciatic nerve is still distinguishable from surrounding tissues. 4 was very little movement is observed and the nerve is very hard to distinguish from the surrounding tissues. A score of 5 was no movements of sciatic nerve observed and the nerve is undistinguishable from surrounding tissues.

The anteroposterior and lateral diameters of the sciatic nerve were also measured at neutral position. All images were taken by the same sonographer (O.B) who was blinded to all ultrasound measurements. The sonographic measurements were performed by another researcher (M.Y) who was blinded to the ankle movements and the measurement sites. The measurements were recorded by another research assistant to the follow-up form manually. A blinded researcher (A.M) assessed the results of the study and calculated the differences between the measurements. The significance of the nerve movement was assessed by comparing the skin-to-nerve distance during maximum ankle dorsiflexion with the skin-to-nerve distance during maximum ankle plantar flexion.

Statistical analysis

Continuous variables were summarized with n (sample size), mean and standard deviation; categorical variables were summarized with n (sample size), median and 25th 75th percentiles. Normally distributed continuous variables were compared between groups using student t test and the correlations among variables were calculated by using Pearson correlation analysis. Normally distributed continuous dependent variables were analysed by paired t test. Nonnormally distributed variables were compared with Mann Whitney U test for independent groups, Wilcoxon test was used for dependent two groups and Friedman analysis were utilized for repeated measures. Spearman correlation analysis was applied to determine correlations among nonnormally distributed variables. Chi-square analyses were used for categorical variables. p value less than 0.05 was accepted significant. All data analyses were calculated by using PASW Statistics 18.

Results

25 participants successfully completed the study. One participant was excluded from the study due to missing data. Demographic characteristics of the participants were summarized in Table 1.

At the popliteal region, the antero-posterior nerve movement was found 0.32 cm during the active manoeuvres and 0.23 cm during the passive manoeuvres. With respect to the active and passive movements, there was a significant sciatic nerve movement at popliteal region induced by ankle dorsiflexion and plantar flexion ($p<0.001$).

At the midthigh region, the nerve movement was found 0.11 cm during the active manoeuvres and 0.01 cm during the passive manoeuvres. With respect to the active and passive movements, there was a significant sciatic nerve movement induced by ankle dorsiflexion and plantar flexion ($p<0.001$) (Table 2).

The movement of the sciatic nerve observed at the popliteal region was significantly superior than the

Table 3. Values of skin-to-nerve distances (expressed as centimetre) during active and passive ankle joint movements (mean±standard deviation) (n=24)

Ankle movement	Popliteal region	Midthigh region
Active manoeuvres		
Maximum dorsiflexion	1.13±0.47	3.28±0.83
Maximum plantar flexion	1.45±0.53	3.39±0.72
Passive manoeuvres		
Maximum dorsiflexion	1.10±0.44	3.20±0.74
Maximum plantar flexion	1.33±0.52	3.21±0.74
p value	<0.001*	<0.001**

*One Way Repeated Measures Analysis of Variance; **Friedman Repeated Measures Analysis of Variance on Ranks.

midthigh region induced by active (p=0.003) and passive (p<0.001) ankle joint manoeuvres (Table 2).

All skin-to-nerve distances at popliteal and midthigh levels during active and passive ankle joint movements and p values were summarized in Table 3.

At the popliteal region, induced by active ankle joint movements; excellent quality of sciatic nerve movement was observed in 14 of subjects (58.3%), good quality of the sciatic nerve was observed in 10 subjects (41.7%).

At the popliteal region, induced by passive ankle joint movements; excellent quality of sciatic nerve movement was observed in 12 of subjects (50%), good quality of the sciatic nerve was observed in 10 subjects (41.7%). Ultrasonic visualization of the SN movement was fair in 1 subject and was poor in 1 subject (Fig. 4).

At the midthigh region, induced by active ankle joint movements; Excellent quality of sciatic nerve movement was observed in 2 subjects (8,3%), good quality of the sciatic nerve was observed in 9 subjects (37.5%). Ultrasonic visualization of the SN was fair in 11 subjects and was poor in 2 subjects.

At the midthigh region, induced by passive ankle joint movements; Excellent quality of the sciatic nerve movement was observed in 3 of subjects (12.5%), good quality of the sciatic nerve movement was observed in 6 subjects (25%). Ultrasonic visual-

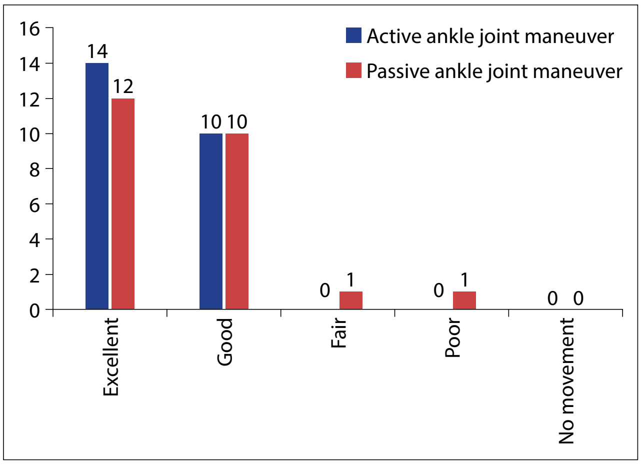

Figure 4. Number of patients categorized according to the sciatic nerve movement at popliteal region.

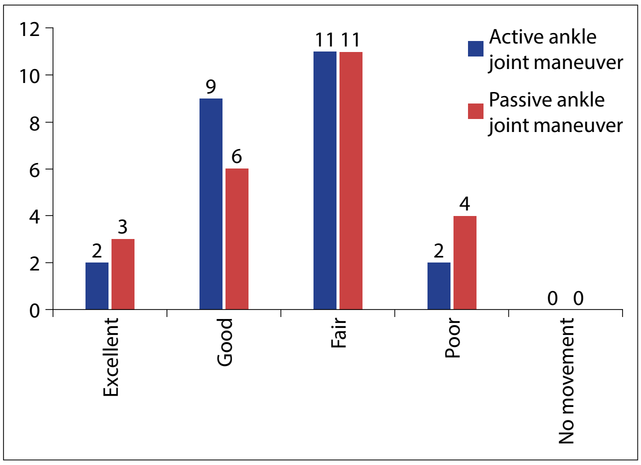

Figure 5. Number of patients categorized according to the sciatic nerve movement at midthigh region.

ization of the SN movement was fair in 11 subjects and was poor in 4 subjects (Fig. 5).

The nerve was mostly observed as an oval heterogenous structure, hyperechogenic connective tissue and multiple hypoechogenic dots (representing the nerve fibres), with 0.65±0.15 cm in anteroposterior width and 0.95±0.17 cm in medial-to-lateral width at popliteal region. At the midthigh region, the SN was measured as 0.71±0.17 cm in anteroposterior width and 1.25±0.19 cm in medial-to-lateral width.

Discussion

Main findings of our study indicate that a significant movement of the sciatic nerve is observed under ultrasonography visualization in transverse images, induced by ankle plantar flexion and dorsiflexion at both popliteal and midthigh regions. This is the first study in the literature that report the use of ultrasonographic visualization of the sciatic nerve movement to recognize and locate the sciatic nerve. Up to date, various methods have been described to facilitate the identification of the sciatic nerve to use in ultrasound guided sciatic nerve blocks. These methods include using the anatomical landmarks of bones, neurostimulator assistance along with ultrasound guidance and identifying surrounding muscles and fascial planes using ultrasound at the block site.[11–13] One other method offered for facilitating the nerve localization is "figure of four" positioning of the legs.[14] Scanning the nerve up along its course may also be helpful.[2] Ultrasonographic scanning of vessels close to the sciatic nerve may help to facilitate SN location. Detecting the doppler flow of the internal pudendal artery and inferior gluteal vessels, at the gluteal region was also reported to identify the SN.[1] As there is not any vascular structure in the sub-gluteal or midthigh region, scanning a vessel close to the SN cannot be offered at these locations.[2,4] Detection of the arteria comitans was also reported as a method to facilitate the ultrasound localization of the sciatic nerve in the gluteal and thigh regions where the arteria comitans accompanies the sciatic nerve.[4]

Our method is a novel technique different from these for facilitating the localization of the SN which can be used at various levels of the leg. As no additional tool other than ultrasound is needed, we find this an easy method that is applied during the block performance. Both active (performed by the patient) or passive (performed by an assistant) ankle joint movements would help to move the sciatic nerve and facilitate its location. A better SN movement was observed at the popliteal region in our study. However, a good nerve movement was also found at the midthigh of the leg. This may be due to more superficial location of the SN at popliteal region than the midthigh.

It is important to achieve a circumferential spread of local anesthetics around the tibial and peroneal nerves which was also defined as: "coin sign".[15,16] However, injection of small amounts of local anaesthetic within the para-neural sheath leads to more successful blocks than performing a perineural injection.[17,18] Intraneural technique needs a precise location of the SN along with the needle tip during the injection. Our method may help to locate the SN precisely during the block procedure when intraneural injection technique is used.

A secondary objective of this study was to determine the real-time observed movement of the SN in dynamic US images. We used an observer assigned scoring system to assess this. We observed a good sciatic nerve movement according to our observer grading scores (video supplement). As ultrasonography is a dynamic procedure, real-time observation of the SN movement may be a better indicator and static ultrasound images may not reflect this aspect of the sciatic nerve movement. We recommend the performers to refer to the dynamic US visualization and focus on real-time US scanning when using our method.

The volunteer-based nature of the study may limit the ability of evaluating the effect of SN movements on block success. Our aim was to demonstrate the movements of the SN in a practical manner to help its location. The ease of visualizing the movements of the sciatic nerve at popliteal and midthigh levels would suggest an advantage in performing the injections at these levels and this may potentially improve efficacy of sciatic nerve blocks. A future clinical prospective randomized study is needed to prove its effect on the block success. One limitation of our technique may be the difficulty of application in trauma patients with possible constraint of ankle joint and sciatic nerve movements.

In conclusion, a good quality of sciatic nerve movement can be observed in transverse plane at the popliteal and midthigh regions under real time ultrasound imaging. Both active and passive dorsiflexion and plantar-flexion foot manoeuvres lead to apparent movements of the sciatic nerve which is easily observed under ultrasound visualization. This is a novel, simple and successful sonographic technique to identify the sciatic nerve at popliteal and midthigh regions which may offer an additional tool to determine the location of the sciatic nerve during sciatic nerve blocks.

Ethics Committee Approval: Ethics approval was provided by the Dumlupınar University Ethical Board (date: 25.10.2017, number: 2017-11/8).

Conflict-of-interest issues regarding the authorship or article: None declared.

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