"Figure of four" position improves the visibility of the sciatic nerve in the popliteal fossa

"Dört pozisyonu" popliteal fossada siyatik sinirin görünürlüğünü arttırmaktadır

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Summary

Objectives: We studied the influence of patient positioning on the visibility of the sciatic nerve during ultrasound (US) examination in the popliteal region.

Methods: Using a linear broad band 7-12 MHz frequency probe, US examination of 24 sciatic nerves was performed by a blinded operator to obtain the best possible image at the level of the popliteal crease (PC) and at 4 and 8 cm above the PC in the prone position. Examinations were performed in neutral prone (Group N), with a silicone roller under the foot (Group R) and in "figure of four" (Group FOF) positions. "Figure of four" position was described as: the leg to be examined is flexed and abducted to allow the foot to rest on the ankle of the contralateral leg. A visibility score for the sciatic nerve was established as follows: Score I: Nerve is identified, but borders are not clear. Score II: Nerve is identified. Borders of the nerve are clearly distinguished from the surrounding structures. Three or less fascicles are visible. Score III: Nerve is identified. Borders of the nerve are clearly distinguished from the surrounding structures. Four or more fascicles are visible.

Results: The distance of nerve division from the PC was 6.9±1.6 cm. A higher visibility score was obtained in Group FOF (2.6±0.6 vs 1.7±0.8) at the PC and at 4 cm (2.3±0.5 vs 1.6±0.8) and 8 cm (2.3±0.7 vs 1.4±0.7) above the PC, compared to Group N ($p<0.001$).

Conclusion: "Figure of four" position improves the visibility of the sciatic nerve and may have clinical impact.

Key words: Popliteal block; sciatic nerve; ultrasound.

Özet

Amaç: *Hasta pozisyonunun popliteal bölgede siyatik sinirin ultrason (US) incelemesi sırasında görünürlüğü üzerine etkisi araştırıldı.*

Gereç ve Yöntem: *Popliteal katlantı (PK) ile PK'nın 4 ve 8 cm yukarısında pron pozisyonda 7-12 MHz geniş band linear US probu kullanarak kör bir uygulayıcı tarafından mümkün olan en iyi görüntü hedeflenerek 24 siyatik sinir incelemesi yapıldı. İncelemeler nötral pron pozisyonda (Grup N), ayak altına silikon rulo konularak (Grup R) ve "dört pozisyonunda" (Grup D). "Dört pozisyonu" incelenen bacak diğer ayağın üstünde olacak şeklide fleksiyon ve addüksiyon pozisyonu olarak tarif edildi. Siyatik sinir için aşağıdaki gibi bir görünürlük skoru tariflendi: Skor I: Sinir tanınabilir ancak sınırları net değildir. Skor II: Sinir tanınabilir. Sinirin sınırları diğer yapılardan kolaylıkla ayırt edilebilir. Üç ya da daha az fasikül görülebilir. Skor III: Sinir tanınabilir. Sinirin sınırları diğer yapılardan kolaylıkla ayırt edilebilir. Dört ya da daha fazla fasikül görülebilir.*

Bulgular: *Sinirlerin PK'dan ayrılma mesafesi 6.9±1.6 cm idi. Grup D'de elde edilen görüntü skoru (2.6±0.6 ve 1.7±0.8) PK'da, PK'dan 4 cm (2.3±0.5 ve 1.6±0.8) ve 8 cm (2.3±0.7 ve 1.4±0.7) yukarısında Grup N'den daha iyiydi ($p<0.001$).*

Sonuç: *"Dört pozisyonu" siyatik sinirin görünürlüğünü iyileştirmektedir ve klinik öneme sahip olabilir.*

Anahtar sözcükler: Popliteal blok; siyatik sinir; ultrason.

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Introduction

Ultrasound (US) guidance provides the anesthesiologist with the ability to see the target nerves that he/she tries to locate, which can be done in different ways.[1] US has been utilized to facilitate the performance of popliteal sciatic blocks.[2-4] A major limiting factor in the conduct of effective US-guided regional anesthesia is the challenge of neural imaging.

Techniques have been described to optimize the US images of both the femoral nerve and brachial plexus.[5,6] However, there is limited information as it pertains to the sciatic nerve at the popliteal fossa. Our primary objective was to evaluate a patient positioning technique that facilitates the sonographic appearance of the sciatic nerve in the popliteal fossa. During this study, we introduced a new position, designated as "figure of four" (FOF), where the examined leg is flexed and slightly abducted to allow the foot to rest on the ankle of the contralateral leg. We hypothesized that our positioning intervention would generate an improved quality of neural imaging as defined by an objective rating system.

Materials and Methods

A prospective and observer-blinded study was performed after approval by the local ethics committee of Kocaeli University, and written informed consent was obtained from the volunteers. Twelve healthy male volunteers between the ages of 18 and 40 were included into the study. Exclusion criteria were inability to lay in the prone position, known peripheral nerve disease, peripheral vascular disease, and past surgery or trauma at the site of US evaluation.

All US examinations were performed by the same radiologist with experience in nerve imaging. The same Toshiba Aplio (Japan) US machine was used during all examinations. Linear broad band 7-12 MHz frequency probe was used. Tissue harmonics (THI) and compound imaging (Aplipure®) were applied during all examinations. Volunteers were positioned in the prone position on a patient examination bed. Sonographic examinations started at the level of the popliteal crease (PC). Using a ruler, the line of the PC was drawn with a pencil and distances 4 cm and 8 cm above the PC were also identified. The sciatic nerve was visualized in cross-section by placing the US probe perpendicular to the main axis view. The US probe was oriented at each location to obtain the best possible short-axis view of the sciatic nerve. These best images of the sciatic nerve were recorded at the level of the PC and at 4 and 8 cm above the PC.

Measurements: Distance from skin to nerve, skin to artery and surface area of the nerve was measured by the internal measuring program of the US device. In all cases, the level of the sciatic nerve division was identified and the perpendicular distance between the division and the PC was measured with a ruler. After all the images were recorded, a visual scoring of the nerve visibility was evaluated in a randomized manner by a blinded experienced anesthesiologist who was unaware of the patient positioning. Three different volunteer positions were used during US examinations, as follows:

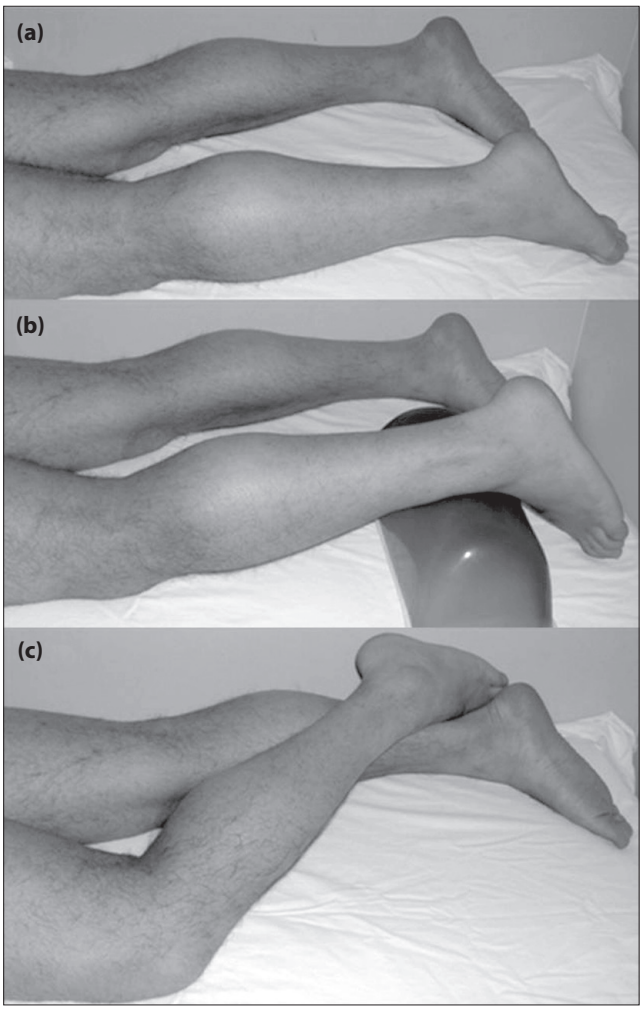

Fig. 1. Three different positions of the left leg during ultrasound examination. **(a)** Patient in neutral position. **(b)** Patient with a roller under the foot. **(c)** Patient in "figure of four" position.

Group Neutral (Group N) (Fig. 1a): Volunteers were positioned prone on the patient examination bed.

Group Roller (Group R) (Fig. 1b): A standard 11 cm thick silicone roller was placed under the volunteer's foot in prone position.

Group "Figure of Four" (Group FOF) (Fig. 1c): The leg to be examined was flexed and abducted to allow the foot to rest on the ankle of the contralateral leg.

The following scoring system was established to assess the visibility of the sciatic nerve during US examinations.

Grade I (Fig. 2a): Nerve is identified, but borders are not clear.

Grade II (Fig. 2b): Nerve is identified. Borders of the nerve are clearly distinguished from the surrounding structures. Three or less fascicles are visible.

Grade III (Fig. 2c): Nerve is identified. Borders of the nerve are clearly distinguished from the surrounding structures. Four or more fascicles are clearly visible.

A preliminary study performed in our clinic following 10 sciatic nerve examinations showed that the mean value for the visual score of the sciatic nerve at the PC was 1.6±0.8. Based on this preliminary data, we calculated that we would need a sample size of 9 in each group to improve the score to 2.6, with a statistical power of 0.9 and Type 1 error of 0.05. We included 12 volunteers in each group and studied both legs to increase the power of the study and also to allow for volunteer dropouts for any reason.

Statistical analysis was performed using Wilcoxon Signed Rank test and Friedman test. Bonferroni correction test was performed. Data were presented as mean and standard deviation. A value of $p<0.05$ was considered as statistically significant.

Results

All volunteers were examined as described above in the prone position and sciatic nerves could be identified in all cases. The body mass index was 0.26±0.036, height 176±6 cm and weight 82±13 kg.

The distance of nerve division from the PC was 6.9±1.6 cm. Except for two out of 24 sciatic nerves, all had divided above 4 cm from the PC (Fig. 3). Examining patients in the prone position in all cases, the popliteal artery was posterior to the nerve and vein. The nerve was more superficial to the artery with respect to the US probe and needle location. The vein was between the tibial nerve and popliteal artery and easily compressible depending on the pressure applied with the probe.

The shape of the sciatic nerve was either round, triangular or elliptical in the popliteal fossa. The nerve appeared as a hyperechoic structure. It was not pos-

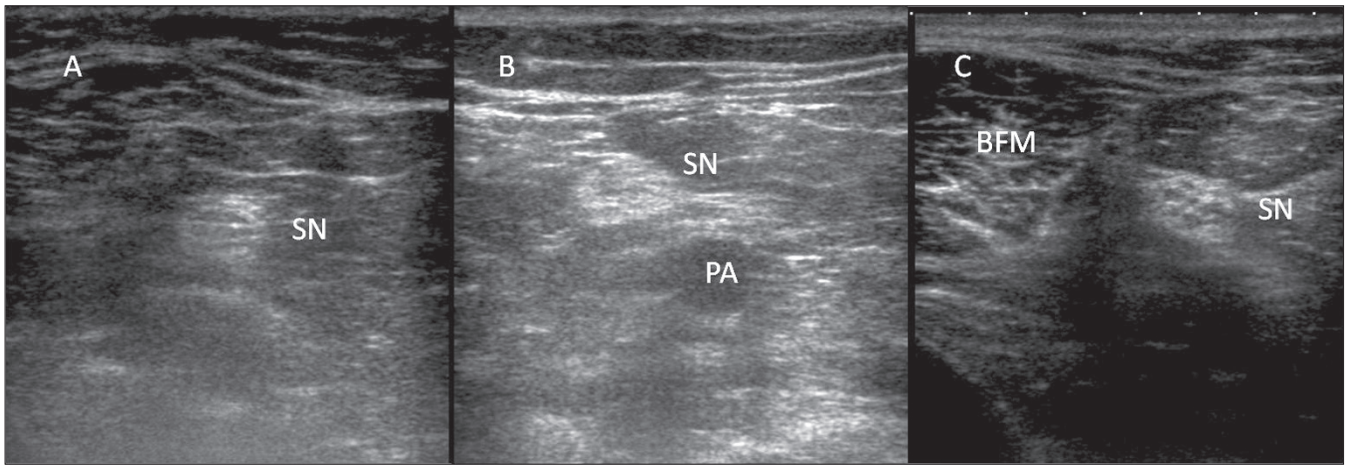

Fig. 2. Left leg, 4 cm above the PC level. **(a)** Grade I, **(b)** Grade II, **(c)** Grade III; SN: Sciatic nerve; PA: Popliteal artery; BFM: Biceps femoris muscle.

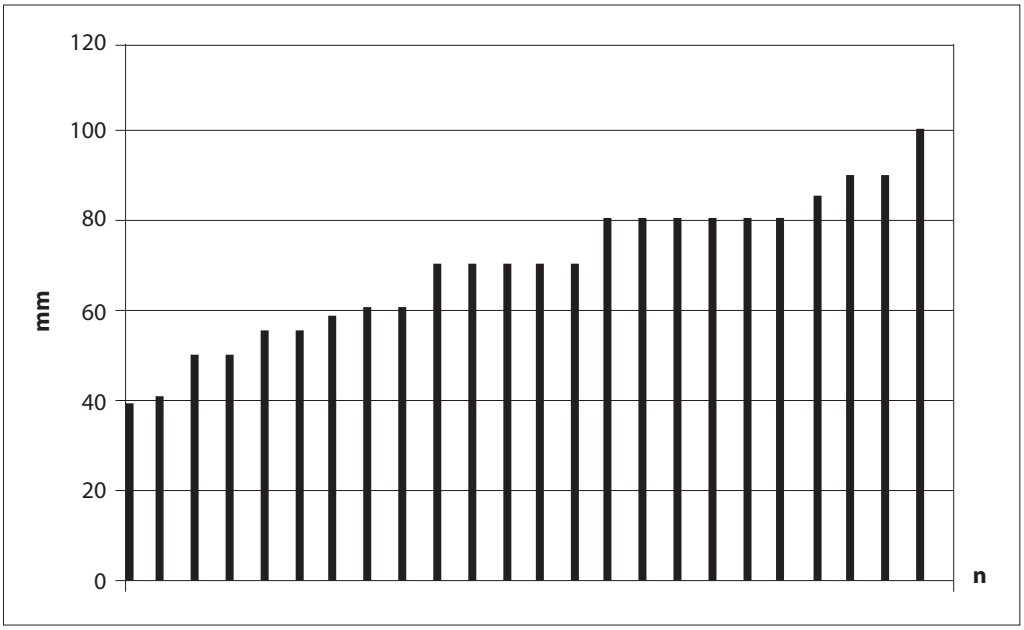

Fig. 3. Division of the sciatic nerve. Distance from the PC to sciatic nerve division site.

sible to visualize the internal hypoechoic fascicles in every case.

At the level of the PC, the distance from skin to nerve was significantly shorter in Group R than Group N ($p<0.001$). Visual score was significantly higher in Group FOF than in Group N and Group R ($p<0.001$) (Table 1). Because the sciatic nerve had already divided into the tibial and common peroneal nerve at the level of the PC in all cases (Fig. 3), data provided regarding skin to nerve distance and diameter refers to the tibial nerve (Table 1).

Visual score was significantly higher in Group FOF than in Group N at the 4 cm distance from the PC ($p<0.05$). The artery was deeper in Group N than Group R and Group FOF at the 4 cm distance from the PC ($p<0.001$). Visual score was lower in Group N than Group FOF and Group R at the 8 cm distance from the PC ($p<0.001$).

Discussion

Our primary objective was to evaluate a new position designated as "figure of four" on the sonographic appearance of the sciatic nerve in the popliteal fossa. A higher visibility score was obtained in Group FOF at the PC and at 4 cm and 8 cm above the PC when compared to Group N. Because the sciatic nerve divides into the tibial nerve medially and common peroneal nerve laterally near the apex of the popliteal fossa approximately two-thirds of the way down the thigh, measurements were made not only at the level of the PC but also 4 and 8 cm above the level of the PC. Vloka,[7] following anatomic examination of 28 cadaver legs, showed that in 75% of the legs, sciatic nerve division was within 81 mm, and all sciatic nerves were divided within 115 mm from the site of the PC. During a US study aimed at detecting the site of sciatic nerve division, Schwemmer[8] could detect the division site in 53 of 74 volunteers. Schwemmer found that at 110 mm distance to the PC, 25% of the sciatic nerve had already separated. During our examination of 24 legs at 100 mm distance from the PC, all the sciatic nerves were separated.

The sciatic nerve can be difficult to image from its origins to the mid femur secondary to the similar acoustic impedance of surrounding tissues. At the popliteal fossa, hypoechoic adipose tissue generates an interface effect with the hyperechoic sciatic nerve, thereby improving image quality. Although the sciatic nerve is the thickest peripheral nerve in the body, anisotropy is a potential problem that may be encountered. During our study, as the depth of the nerve increased, it was more difficult to identify the sciatic nerve with US. Our results confirm the findings of Bruhn et al.[9] that at the level of the PC, the nerve becomes the most superficial and there-

Table 1. Influence of patient position on US characteristics of the tibial nerve at the PC

	Neutral position	Roller	FOF
Skin to nerve distance (mm)	13.0±4.3	11.6±3.8 *	11.9±3.6
Skin to artery distance (mm)	21.4±5.9	22.7±6.9	22.0 ±3.2
Surface area of the nerve (cm^2)	0.30±0.09	0.32±0.07	0.34±0.09
Visual score	1.7±0.8	2.0±0.8	2.6±0.6**

Data are presented as mean ± SD.

* In Group R, skin nerve distance was shorter than in Group N ($p<0.001$).
** Visual score was better in Group FOF than in Group N and Group R ($p<0.001$).

Table 2. Influence of patient position on US characteristics of the tibial nerve/sciatic nerve at the 4 cm distance from the PC

	Neutral position	Roller	FOF
Skin to nerve distance (mm)	14.9±3.7	14.4±3.5	14.4±3.1
Skin to artery distance (mm)	25.7±3.2*	23.0±3.8	23.3±3.4
Surface area of the nerve (cm^2)	0.39±0.11	0.36±0.06	0.39±0.08
Visual score	1.6±0.8	1.8±0.7	2.3±0.5**

Data are presented as mean ± SD.

* Popliteal artery was deeper in Group N than Group R and Group FOF ($p<0.001$).
** Visual score was better in Group FOF than in Group N and Group R ($p<0.001$).

Table 3. Influence of patient position on US characteristics of the sciatic nerve at the 8 cm distance from the PC

	Neutral position	Roller	FOF
Skin to nerve distance (mm)	21.07±5.4	21.5±5.0	23.4±5.4
Skin to artery distance (mm)	30.2±7.3	30.6±7.6	29.3±5.7
Surface area of the nerve (cm^2)	0.48±0.13	0.44±0.12	0.48±0.12
Visual score	1.4±0.7*	1.9±0.7	2.3±0.7

Data are presented as mean ± SD.
* Visual score was lower in Group N than Group FOF and Group R ($p<0.001$).

fore relatively easy to locate. However, when proceeding more proximally toward the tibial and common peroneal nerve junction, it may be challenging to locate the sciatic nerve with US guidance.[10]

Patient positioning and certain maneuvers can be used to improve the visibility of anatomic structures/lesions during US examination. Hsu et al.[6] reported that lateral 45° rotation of both lower extremities would facilitate the femoral nerve coming closer to the skin and moving away from the femoral artery. Although US-guided popliteal nerve block was described in the prone position in 2004,[11] to the best of our knowledge, the influence of patient positioning on the ease of sciatic nerve block has not been reported. Khabiri et al.[12] suggested using a "gapped supine" position for lateral approach to popliteal block. Although the suggested position allows easy manipulation of the probe and stable patient position, the influence of this approach on nerve visibility was not studied.

We included Group R because it is common practice to perform popliteal sciatic nerve block with the aid of a pillow or a kind of roller. The patient is more comfortable and it is easier to observe the motor response to nerve stimulation. We found that both the use of a roller and FOF technique im-

proved the visibility of the sciatic nerve at all levels examined (Tables 1-3). Relieved compression of the nerve by the surrounding tissues seems to increase surface area around 10% (Tables 1-3). In addition to the slight increase in surface area, both the use of roller and also FOF (except at 8 cm) brought the nerve closer to the skin and thus improved the visual score. Although lateral approach use in plane technique allows clear visualization of the needle shaft, we believe that as long as there is no difficulty in patient positioning, the prone approach to US-guided sciatic nerve block is more ergonomic for the practicing anesthesiologist. With FOF technique, once the sciatic nerve is localized in the popliteal region, it can be traced proximally up to the gluteal or subgluteal region. If for any reason the site of division cannot be identified, both tibial and common peroneal nerves can be selectively blocked. It should be stressed, however, that this was merely a study on visualizing the popliteal fossa and its contents (mainly nerves); therefore, it is not possible to comment on whether these different patient positions would contribute to an easier application of the block.

Although we tried to establish a relatively simple and reproducible scoring system, inter-observer and intra-observer variability might be the limitation of this study. Despite attempts to improve the visibility of the sciatic nerve at 8 cm from the PC level, experience is still required to ensure successful blocks. Since the conduct of this study, we have routinely performed popliteal blocks in the FOF position with success. Yet further clinical comparative studies are required to test the clinical significance of FOF on block performance time.

In conclusion, FOF is a simple method that improves the visibility of the sciatic nerve at the popliteal fossa; it does not require an additional apparatus and allows stability of the studied leg.

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