ORIGINAL ARTICLE

Needle Insertion Into the Tibialis Posterior: Ultrasonographic Evaluation of an Anterior Approach

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ABSTRACT. Rha D-W, Im SH, Lee SC, Kim S-K. Needle insertion into the tibialis posterior: ultrasonographic evaluation of an anterior approach. Arch Phys Med Rehabil 2010;91:283-7.

Objective: To investigate the ultrasonographic anatomy of the lower leg for safe and accurate needle placement into the tibialis posterior using the anterior approach.

Design: Cross-sectional study.

Setting: University rehabilitation hospital.

Participants: Healthy volunteers (N=62; 30 men, 32 women).

Interventions: Not applicable.

Main Outcome Measures: The safety window (the tibia to the neurovascular bundle) and the depth to the midpoint of the safety window (skin to the tibialis posterior) at the upper third and the midpoint of the tibia were measured with a transverse ultrasonographic scan.

Results: The safety window at the upper third of the tibia was significantly larger than that at the midpoint ($P<.01$). The safety window ranged from .64cm to 2.13cm at the upper third tibialis point and from .32cm to 1.30cm at the midpoint. The depth to the tibialis posterior at the upper third of the tibia was significantly deeper than that in the midpoint ($P<.01$). The depth ranged from 2.47cm to 4.66cm at the upper third tibias point and from 2.35cm to 4.28cm at the midpoint.

Conclusions: Ultrasonography is a useful tool in measuring the safety window and the depth to the tibialis posterior using the anterior approach. Considering the safety window, we suggest the needle placement at the upper third point of tibia rather than that at the midpoint.

Key Words: Electromyography; Rehabilitation; Ultrasonography.

THE TIBIALIS POSTERIOR is the principal invertor of the foot and may assist in powerful plantar flexion. Because the tibialis posterior is innervated by the spinal nerve roots of L5 and S1 through the tibial nerve, electrodiagnostic evaluation of this muscle is particularly useful in patients with a foot-drop for differentiating peroneal neuropathy and L5 radiculopathy.[1] Moreover, the spasticity of the tibialis posterior produces a functionally disabling equinovarus deformity in patients with spastic paralysis caused by various injuries in the central nervous system. To reduce the abnormal hypertonicity and to correct equinovarus deformity, this muscle is frequently targeted for botulinum toxin injection.[2-4]

Although needle insertion into the tibialis posterior is usually performed with the guidance of anatomical landmarks, the tibialis posterior is considered by some to be the least accessible muscle for needle placement because it is located deep within the lower leg.[5] In a previous study comparing manual localization with electrical stimulation-guided localization, the accuracy of needle placement by manual localization into the tibialis posterior was only 11%.[4] Additionally, the anterior and posterior neurovascular bundles located near the tibialis posterior muscle make the needle insertion into the tibialis posterior more hazardous and difficult.[6,7]

Through the years, modern ultrasonographic machines have progressively improved in terms of image quality. These machines are low cost, portable, and easily available, because they are standard equipment in most hospitals. Furthermore, ultrasonography is a reliable tool that allows real-time scanning of the targeted muscle, adjacent structures, and needle advancement in the tissue, thus facilitating accurate depth control of needle placement even for the small, atrophic muscles in the paretic limbs of children.[8,9] Previously ultrasonography-guided botulinum toxin injections into the muscles of the upper and lower extremities has been reported as accurate, safe, and efficient.[8] Therefore, ultrasonography-guided needle insertion into the tibialis posterior is expected to enable accurate needle placement, avoiding inadvertent injury to the adjoining neurovascular bundles.

Two methods are currently used for placing the needle into the tibialis posterior: the anterior and posterior approaches. According to a study based on cadavers,[10] access to the tibialis posterior muscle for needle insertion is safer with the anterior approach than the posterior approach because the anterior approach has a larger safety window for needle insertion. A recent study analyzing lower-extremity magnetic resonance imaging also reported that the anterior approach offers an advantageous larger safety window for needle insertion at the upper third of the tibia compared with the posterior approach, although no significant differences were observed between the anterior and posterior approaches in terms of the safety of the needle insertion at the midpoint of the tibia.[11] However, the anterior approach of ultrasonography-guided needle placement into the tibialis posterior has not yet been studied.

Therefore, in order to determine the most appropriate needle insertion point, the ultrasonographic anatomy of the lower leg was investigated for safe and accurate needle placement into the tibialis posterior using the anterior approach.

List of Abbreviations

BMI	body mass index

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METHODS

A total of 62 healthy subjects (30 men, 32 women) whose ages were evenly distributed by age (mean, 45.1y; range, 21–59y) were examined. They were healthy volunteers working in the hospital who had no history of neuromuscular disease, had normative findings in a neurologic examination, and were currently on no relevant medication. The study was approved by the institutional review board. The study was carried out with the volunteers' consent after they were briefed about the purpose of the study and the examination procedures.

Clinical Examination

Height and body weight of volunteers were measured. BMI was determined as weight divided by height squared.

The patients were placed in a supine position on the examination bed with their legs in a slight internal rotation. The lengths of the tibia (from the tibial tubercle to the bimalleolar line) in both legs were measured with a measuring tape. The upper third (the junction of the proximal and middle thirds from the tibial tubercle to the bimalleolar line, hereafter referred to as the upper third needle insertion site) and the midpoint (the midpoint of the length from the tibial tubercle to the bimalleolar line, hereafter referred to as the midpoint needle insertion site) of the tibia were marked, as reported in a previous study in which the anterior approach was used to insert a needle electrode into the tibialis posterior.[11] The circumferences of the leg at these 2 levels were measured with a measuring tape.

Ultrasonographic Examination

We performed a B-mode, real-time ultrasonography using the ACCUVIX V10 system[a] interfaced with a 5 to 12–MHz linear array transducer at the upper third and midpoint of both legs. A physiatrist who is an expert in musculoskeletal ultrasonography carried out the examinations. Ultrasonographic examinations of the tibialis posterior were performed with patients placed in the supine position on the examination bed with their legs in a slight internal rotation.

The tibialis posterior was reached just after passing the interosseous membrane.[10] For this reason, the interosseous membrane between the lateral aspect of the tibia and the medial aspect of the fibula was targeted. The interosseous membrane appears as a hyperechoic band joining the tibia and the fibula, and it separates the tibialis anterior from the tibialis posterior.[12] Therefore, a transverse plane was first obtained by placing the medial edge of the probe over the anterior tibial crest at the upper third and the midpoint of the tibia. The interosseous membrane was well imaged by shifting the probe more laterally in the transverse plane (fig 1).

When using the anterior approach, neurovascular bundles are located medial to the fibula. The tibialis posterior followed the anterior neurovascular bundle, consisting of the anterior tibial artery and veins and the deep peroneal nerve.[12] To confirm the existence of the neurovascular bundle, the anterior tibial artery was identified using a color Doppler (fig 2). The Doppler setting changed at the level where vascular structures were optimally visualized in each subject. The artery appeared as a group of pulsatile structures. The vein had a very thin echogenic wall that was often indistinguishable from the surrounding echogenic spaces.[12] The vein was confirmed using the compression technique. A weak squeeze of the calf led to an increase of blood flow in the vein and made the color Doppler signal more evident.

The safety window (the tibia to the neurovascular bundle) and the depth to the midpoint of the safety window (skin to the tibialis posterior) at the upper third and the midpoint of the tibia were measured with a transverse ultrasonographic scan in order to avoid the neurovascular bundle in the anterior approach (see fig 1). These were measured using the appropriate tools installed in the machine. Measurements

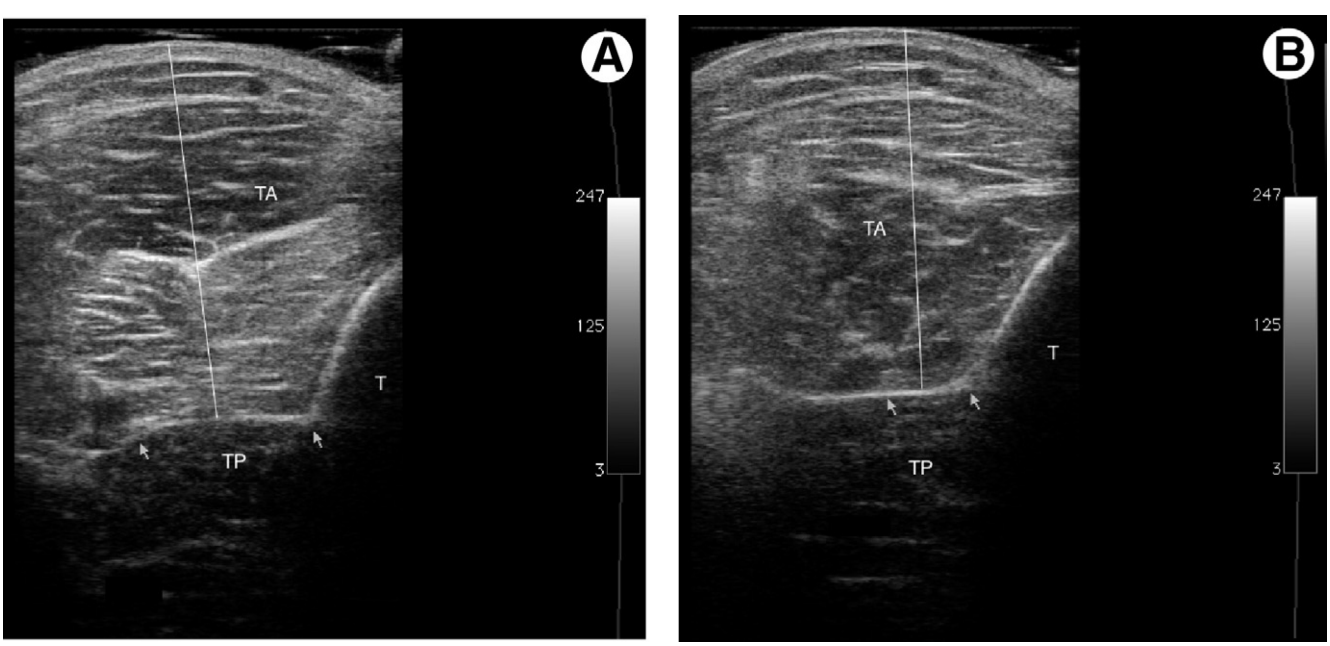

Fig 1. Parameters measured with ultrasonography. (A) Upper third of the tibia. (B) Midpoint of the tibia. The safety window is marked by white arrows, and the depth to the tibialis posterior is marked by white lines. Abbreviations: T, tibia; TA, tibialis anterior; TP, tibialis posterior.

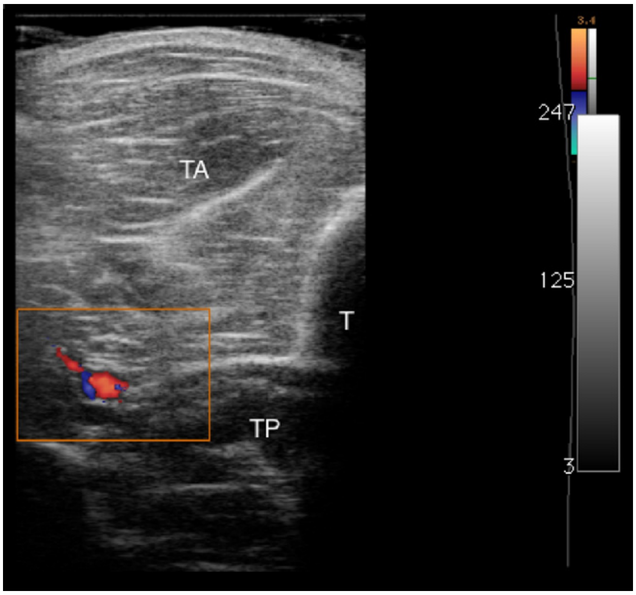

Fig 2. Confirmation of the location of the neurovascular bundle using the color Doppler mode of ultrasonography. Abbreviations: T, tibia; TA, tibialis anterior; TP, tibialis posterior.

were taken on both legs for all subjects; thus, there were 124 measurements in total.

Data Analysis

We used the paired *t* test to compare anthropometric and ultrasonographic parameters at the upper third and midpoint of the tibia. A Pearson correlation test was performed to confirm whether each factor was related to the safety window in the upper one third of the tibia. Data were analyzed by the SAS[b] software (version 9.1.3), and statistical significance was accepted for *P* values less than .01.

RESULTS

The mean ± SD of height, body weight, BMI, and length of the tibia were 167.81±8.14cm, 62.26±12.03kg, 21.99±2.88kg/m^2, and 31.75±2.87cm, respectively.

Table 1 shows the results of a comparison between anthropometric and ultrasonographic parameters between the upper third and midpoint of the tibia. The calf circumference in the upper third of the tibia was significantly larger than that in the midpoint ($P<.01$). The safety window in the upper third of the tibia was also significantly larger than that in the midpoint ($P<.01$). The safety window ranged from .64cm to 2.13cm at the upper third tibias point and from .32cm to 1.30cm at midpoint. The depth to the tibialis posterior at the upper third of the tibia was significantly deeper than that in the midpoint ($P<.01$). The depth ranged from 2.47cm to 4.66cm at the upper third tibias point and from 2.35cm to 4.28cm at the midpoint.

The factors affecting the safety window are shown in table 2. The anthropometric parameters including height, weight, tibia length, and calf circumference positively correlated with the safety window at the level of both the upper third and midpoint of the tibia ($P<.01$).

Table 1: Comparison of Anthropometric and Ultrasonographic Parameters Between the Upper Third and Midpoint of Tibia (n=124)

	Minimum	Maximum	Mean ± SD
Upper third			
Calf circumference (cm)	27.00	44.00	34.92*±3.41
Safety window (cm)	0.64	2.13	1.09*±0.27
Depth (cm)	2.47	4.66	3.34*±0.47
Midpoint			
Calf circumference (cm)	24.00	37.00	29.98±2.81
Safety window (cm)	0.32	1.30	0.68±0.21
Depth (cm)	2.35	4.28	3.24±0.44

*$P<.01$, upper third vs midpoint.

Table 2: Factors Affecting the Safety Window for the Tibialis Posterior Measured by Ultrasonography (n=124)

	Pearson *r*	*P*
Upper third		
Height	.465	<.01
Weight	.322	<.01
Tibia length	.398	<.01
Calf circumference	.360	<.01
Midpoint		
Height	.397	<.01
Weight	.407	<.01
Tibia length	.250	<.01
Calf circumference	.407	<.01

DISCUSSION

The advantage of ultrasonography is that it is useful for needle placement in targeted muscles. Ultrasonography also has other advantages, such as accessibility, cost effectiveness, and real-time inspection. The greatest advantage of ultrasonography is that it can be combined with electromyography. Ultrasonography makes electromyography safer and more accurate.[13,14]

Ultrasonography-guided injections of the tibialis posterior via the anterior approach can also be used for botulinum toxin injections for spastic muscles of children with cerebral palsy or adults with upper motor neuron diseases. According to Chin et al,[4] needle placement using the palpation method in children to reach the tibialis posterior has a failure rate of 88%. Previous studies in adult patients have shown that electromyography and electrical muscle stimulation, done by an experienced user, can provide effective and valuable technical support.[15] However, these methods are of limited use in patients, especially children, with poor cognition because the procedure is painful, is time-consuming, and requires the cooperation of the patient. On the other hand, ultrasonography is easy, quick, painless, and available in most hospitals; therefore, it is regarded as a valuable tool increasing the accuracy and quality of botulinum toxin injections for the tibialis posterior.

This study determined that the safety window at the upper third of the tibia was larger than that at the midpoint. Although the mean depth at the upper third of the tibia was deeper than that at the midpoint, the mean depth difference (3.34cm vs 3.24cm) between the 2 levels was not too large, and the tibialis posterior could be reached via the anterior approach with a 5-cm or 7-cm needle in both levels. Therefore, the upper third of the tibia is a more adequate place for needle placement in the tibialis posterior.

The safety window widely varied from person to person, ranging from .64 to 2.13cm at the upper third of the tibia and from .32 to 1.30cm at the midpoint in this study. This width is not wide enough for a blind needle insertion. We sought to uncover whether the safety window could be estimated by using calf circumference, tibia length, height, and weight. However, correlation coefficients were low, although they were statistically significant. Therefore, we concluded that it is not possible to estimate the safety window from anthropometric values. Considering the narrow and safety window of the anterior approaches varying among the different subjects, image guidance is thought to be helpful for an accurate and safe needle placement in the tibialis posterior. In the cases in which blind needle insertion is inevitable, the anterior approach with needle insertion along the lateral margin of the tibia is a relatively safe method. However, several cases showed that the artery and vein traveled along the lateral margin of the tibia (fig 3). Therefore, image guidance is recommended for an accurate and safe needle insertion.

In addition, in any transverse view of ultrasonography by the anterior approach or by the posterior, one cannot show the whole cross-sectional image of the tibialis posterior in 1 field of view. However, the anterior approach of ultrasonography-guided needle placement in the tibialis posterior has the ability to use the interosseous membrane as a landmark, because the visible interosseous membrane can distinguish the tibialis posterior from the tibialis anterior.

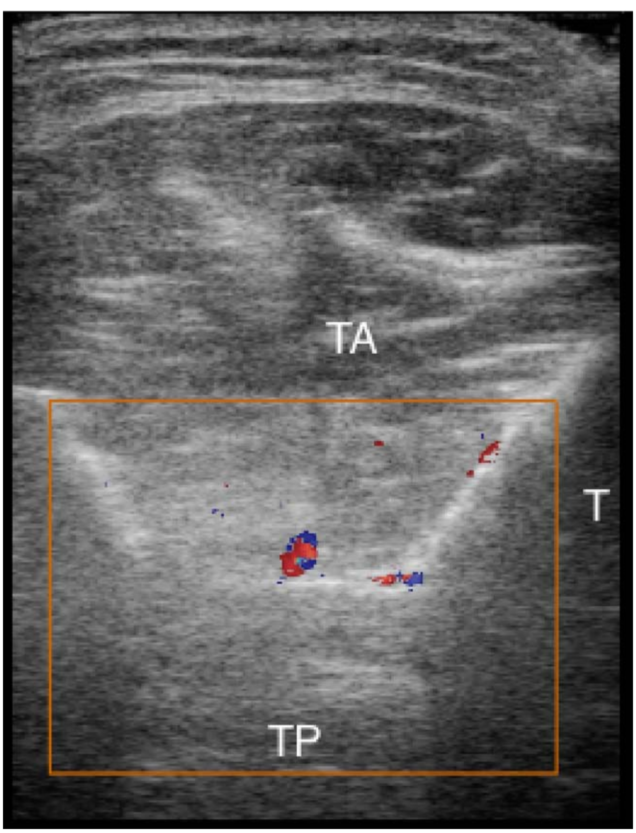

Fig 3. Additional vascular bundles were observed at the level of the interosseous membrane adjacent to the lateral margin of the tibia. The flow of the vascular bundle was confirmed by the color Doppler mode of ultrasonography. Abbreviations: T, tibia; TA, tibialis anterior; TP, tibialis posterior.

To our knowledge, this study is the first to measure the safety window of the anterior approach for needle placement in the tibialis posterior using ultrasonography. Furthermore, the study setting (living patients) resulted in the accurate length of the safety window, which is far better than studies with cadavers, whose soft tissue volume is different from that of live patients.

Study Limitations

This study is limited because the participants had normative BMI. It is unclear whether ultrasonographic real-time scanning is able to gain an adequate image in obese patients. Therefore, further studies are needed to apply ultrasonography in various cases. Studies recruiting paralyzed patients with muscle atrophy also need to be carried out.

CONCLUSIONS

When using the anterior approach, ultrasonography is a useful tool in measuring the safety window and the depth to the tibialis posterior. Compared with the conventional needle insertion guided by anatomical landmarks, ultrasonographic guidance or pre-evaluation might be more helpful for needle placement because they allow for a higher accuracy and lower incidence of neurovascular injury. Also, we suggest a needle insertion at the upper third point of the tibia to approach the tibialis posterior rather than the insertion at the midpoint, considering the safety window.

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