Original Research

Evaluation of Resident Palpation Skills in Foot and Ankle Anatomic Structures Using Bedside Ultrasound

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Abstract

Objective
The objective is to determine the accuracy of foot and ankle joint and soft tissue structure palpation in Physical Medicine and Rehabilitation (PM&R) residents using ultrasonography (US) verification.

Methods
PM&R residents were tested in an outpatient musculoskeletal (MSK) clinic on palpated foot and ankle anatomic structures in a human model. Once the presumed structures were localized, residents marked a 1 cm size circle on the overlying skin with a ink marker. The accuracy of the circle over the joint line and soft tissue structures was verified using US.

Results
The overall palpation accuracy for 22 joint line and soft tissue structures was 38.0%. Accuracy by foot and ankle region, including the posterior, medial, lateral, plantar, and dorsal were 72.9%, 47.5%, 42.5%, 35% and 7.8% respectively. There was a positive trend with level of education without a statistically significant difference in palpation accuracy (30.4% in PGY-2, 38.3% in PGY-3, 44.2% in PGY-4, p = 0.11).

Conclusions
Residents in this study demonstrated suboptimal accuracy of foot and ankle anatomic structure identification by palpation. US may be a useful adjunctive tool to advance current methods of teaching musculoskeletal examination skills to PM&R residents.

Keywords
foot and ankle; ultrasonography; diagnostic imaging; musculoskeletal system; graduate medical education; physical medicine and rehabilitation medicine; physical examination

Introduction
Physical examination (PE) is a fundamental skill set for a practicing physician. Palpation is a crucial component of PE, especially in the evaluation of musculoskeletal (MSK) disorders.[1] Correct identification of anatomical landmarks allows for precise localization of a pain generator for accurate diagnosis and treatment.[2] One of the major challenges in learning and teaching palpation skills for Physical Medical and Rehabilitation (PM&R) residents is verifying accuracy.[3] Limitation of feedback or verification on accurate palpation of anatomic structures often hinders PM&R residents' improvement in their palpation skills.[4] It is often difficult for a supervising physician to discern from observation alone whether the PM&R resident is palpating the correct structure.

With increasing availability of ultrasonography (US) in the last few decades, the ability to augment traditional MSK education is now available. US is particularly well-suited for identifying MSK structures palpated during the routine physical examination. In-office US applications in PM&R practice have been used extensively in

improving the accuracy of injections. Very few studies have been conducted that utilize US as an educational tool to confirm residents' palpatory accuracy. These were limited to large joints such as the shoulder[5, 6] and knee.[3, 4]

Foot and ankle pain, affecting approximately 1 in 5 middle-aged to older people,[7] is frequently encountered in a PM&R practice. It impairs quality of life[8] and functional ability in the older population.[9, 10] Successful management of pain is important not only to improve the pain, but also to improve functional independence in this population. Palpation skills are critical for accurate diagnosis of painful foot and ankle disorders. However, due to the close proximity of the pain generators in the foot, correct palpation is challenging.[11] So far, there has been no specific information regarding PM&R residents' knowledge in this area.

The objective of this study was to investigate the accuracy of palpation on foot and ankle joints and soft tissue structures in PM&R residents using US verification.

Methods

Sixteen PM&R residents, rotating in the outpatient MSK clinic at a single institution, were recruited from July 2015 to June 2016. Each resident was asked to palpate the foot and ankle joint lines and anatomic structures of the same human model (a PM&R resident). The model was sitting on the examination table with the knee flexed at 90 degrees and ankle in plantar flexion. Based on the direction of the examining resident, the model moved his or her foot for best exposure. Once the presumed joint line and soft tissue structures were localized, the residents were asked to mark a 1 cm diameter circle of the joint and soft tissue structures on the overlying skin with a ink marker. The time for completion identifying all structures was measured. The anatomic structures for palpation were chosen based on common pain generators that the authors encountered in a foot pain rehabilitation clinic.[11] **Table 1** gives details regarding common MSK disorders, associated structures palpated and their clinical implications.

The accuracy of the circle over the joint line and soft tissue structures was verified using US. (**Figure 1**) The ultrasound verification was done by the first author who has more than 10 years of experience in musculoskeletal ultrasound

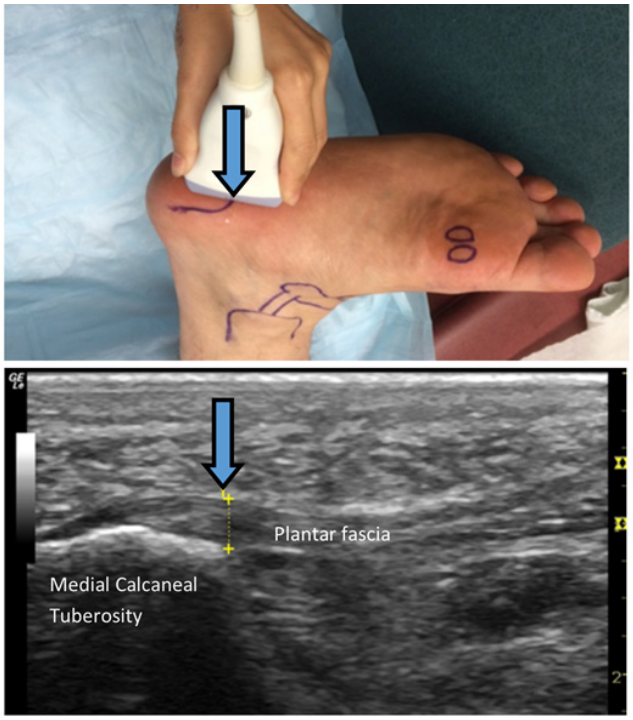

Figure 1. Bedside ultrasound of the plantar heel revealed the insertion of plantar fascia on the medial calcaneal tubercle. The arrow indicates the area the resident correctly marked as the insertion site of plantar fascia (the exact location of the plantar fasciitis)

Table 1. Structures for palpation and clinical implication in common MSK disorders

Location	Palpation structures	Clinical significance and common pathologies
MEDIAL	Medial malleolus	A landmark for ankle joint (bimalleolar line), indicating significant ankle sprain and the need of X-ray ("Ottawa ankle rules")
	Navicular tuberosity	Painful accessory navicular syndrome, osteonecrosis (Muller Weiss disease), osteochondrosis (Kohler disease)
	Talonavicular joint	Midtarsal arthritis
	Sustentaculum tali	Attachment site for spring ligament, calcaneofibular ligament, inferior border of sinus canal
	Posterior tibialis tendon	Insufficiency (most common cause of acquired flatfoot), tenosynovitis, tendinopathy, partial or full thickness tear
DORSAL	Talocrural (ankle joint, anterior recess)	Traumatic arthropathy, inflammatory arthritis
	Calcaneocuboid joint	Midtarsal arthritis, cuboid syndrome/subluxation
	Cuneiform-1st metatarsal joint	Tarsal-metatarsal arthropathy, ganglion cyst[21]
	Cuboid-4th metatarsal joint	Cuboid syndrome/subluxation
LATERAL	Peroneal tubercle	Landmark to palpate peroneus longus (plantar aspect) and brevis tendon (dorsal aspect), peroneal osteoma, peroneal retinacular injury
	Styloid process of the 5th metatarsal bone	Avulsion fracture, peroneus brevis enthesopathy
	Sinus tarsi	Sinus tarsi syndrome, subtalar joint pathology, ganglion cyst
	Peroneus longus	Tendinopathy, tenosynovitis, tear
	Peroneus brevis	Tendinopathy, tenosynovitis, tear
PLANTAR	Plantar fascia on medial calcaneal tuberosity	Plantar fasciitis, tear, rupture
	1st metatarsophalangeal joint (MTP)	Gout, hallux rigidus/limitus, hallux valgus, osteoarthritis, inflammatory arthropathy
	1st Hallucal sesamoids	Sesamoiditis
	2nd MTP	Capsulitis, subluxation, and dislocation (overlying toes)
	5th MTP	Inflammatory arthropathy (such as rheumatoid arthritis)
POSTERIOR	Retrocalcaneal bursa	Retrocalcaneal bursitis
	Insertion of calcaneal tuberosity	Insertional Achilles tendinopathy
	Achilles tendon	Achilles tendinopathy, tear, rupture

with qualification as a registered musculoskeletal sonographer (RMSK)TM. The ultrasonographer was blinded to the palpation process. When palpation was incorrect, it was further categorized into "less than 1 cm" or "more than 1 cm" from the structure localized using US.

A Fisher's analysis was run to determine whether there were any significant differences in the accuracy of joint line and soft tissue palpation based on resident level of education. Statistical significance was defined as $p < .05$.

This study was approved by the institutional review board.

Results

Data were collected from 16 residents (five Post-Graduate Year [PGY]-2, five PGY-3 and six PGY-4 residents). Overall palpation accuracy for 22 joint line and soft tissue structures was 38.0% with the highest accuracy on structures in the posterior aspect (72.9%) and lowest on the structures in dorsal aspect (7.8%). Palpatory accuracy of the medial, lateral, and plantar aspects was 47.5%, 42.5% and 35% respectively. **Table 2** describes the accuracy of palpation by residents based on different anatomic region and the commonly mistaken structures as the target structures.

The mean duration for completion of the physical examination was 13 ± 7.7 (standard deviation) minutes. Based on the resident level of education, there was a positive trend in the overall accuracy without statistically significant differences (30.4% in PGY-2, 38.3% in PGY-3, 44.2% in PGY-4, p=.11). (**Figure 2**)

The accuracy in palpation of joints compared to bony prominences or soft tissue structures was lower without statistical significance (28.5% vs. 50.0%, p=0.115). The frequency of incorrect palpation by less than 1 cm was significantly higher in joint structures than bony prominences or soft tissue structures (36.1% vs. 10.6%, p=0.0004).

Discussion

This is the first study to evaluate systematic palpation skills in multiple anatomic landmarks of the foot and ankle among PM&R residents. Similar to the previous studies, investigating PM&R residents' palpation skills in other body parts,[4, 5] this study demonstrated suboptimal accuracy when palpating foot and ankle joints and soft tissue structures. The current study indicates the need for more effective education on essential physical examination skills of the foot and ankle during PM&R residency.[12] In a recent survey of PM&R residency programs (36 of 78 responded), most residency programs provide some form of MSK US education, with about 40% of residency programs providing a formal MSK US curriculum.[13] In the institution where this study was conducted, PM&R residents were getting 2 hours of formal didactics on the introduction to the musculoskeletal ultrasound and weekly one-hour, hands-on practice sessions supervised by an attending

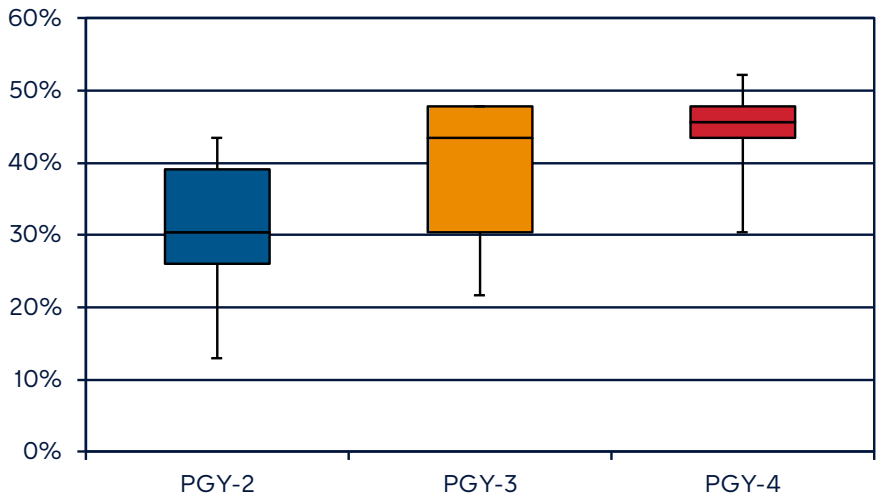

Figure 2. Accuracy of palpation skills based on Post-Graduate Year (PGY)

Table 2. Accuracy of palpation by residents based on different anatomic region

Location	Target bony and soft tissue structures	Correct (%)	Missed within 1 cm (%)	Common structures mistaken as target structures
MEDIAL	Medial malleolus	100	0	
	Navicular tuberosity	62.5	0	Talus, talonavicular joint
	Talonavicular joint	43.8	25	Talus, navicular
	Sustentaculum tali	12.5	0	Talus, navicular
	Posterior tibialis tendon	25	18.8	Posterior tibial nerve, flexor digitorum longus tendon
DORSAL	Talocrural (ankle joint, anterior recess)	0	31.3	Talus, tibia
	Calcaneocuboid joint	6.3	31.3	Cuboid, calcaneus
	Cuneiform-1st metatarsal joint	18.8	37.5	Navicular-cuneiform joint, 1st metatarsophalangeal joint
	Cuboid-4th metatarsal joint	12.5	31.3	Metatarsal bone, cuboid
LATERAL	Peroneal tubercle	25	12.5	Calcaneus, talus
	Styloid process of the 5th metatarsal bone	56.3	6.3	5th metatarsal, metatarso-phalangeal joint
	Sinus tarsi	43.8	12.5	Cuboid, calcaneocuboid joint
	Peroneus longus	43.8	18.8	Peroneus brevis, posterior tibialis tendon
	Peroneus brevis	43.8	25	Peroneus longus, posterior tibialis tendon
PLANTAR	Plantar fascia on medial calcaneal tuberosity	37.5	18.8	Distal plantar fascia
	1st metatarsophalan-geal joint (MTP)	37.5	62.5	Neck of 1st metatarsal, metatarsal head
	1st Hallucal sesamoids	18.8	12.5	1st MTP joint, 2nd MTP joint
	2nd MTP	50	37.5	2nd MT neck, metatarsal head
	5th MTP	43.7	56.3	Proximal metatarsal, metatarsal neck
POSTERIOR	Retrocalcaneal bursa	37.5	12.5	Calcaneal tuberosity, Kager's fat pad
	Insertion of calcaneal tuberosity	87.5	12.5	Fat pad, calcaneus
	Achilles tendon	100	0	

physiatrist during outpatient MSK clinic. Rho et al. demonstrated the accuracy of acromioclavicular joint line palpation was 16.7%, and lateral knee joint line palpation was 58.3% among PM&R residents in one academic institution.[4] Gazzilllo et al. reported the average accuracy rate of the biceps tendon palpation was 0% among PM&R residents, 12% among PM&R fellows and 4% among board-certified MSK physicians.[5] These studies demonstrated that even physicians specializing in MSK medicine lacked critical palpation skills. These results indicate a need for a more effective MSK examination curriculum in PM&R residency, particularly in the area of palpation skills.

There was a positive trend in the accuracy of palpation skill with advanced training during residency, although this was not statistically significant. Interestingly, there was no significant difference throughout PGY years in the frequency of incorrect palpation by less than 1 cm (20% in PGY-2, 18.2 % in PGY-3 and 22.7% in PGY-4, p=.616), suggesting the need for better educational methods to teach precise palpation skills. Decreased accuracy in palpation of the overall joint structures, particularly by less than 1 cm, compared to the bony prominence, is consistent with the previous report of higher accuracy of bony prominence (landmark) palpation in large joints[14] and lower accuracy of blind joint injections in the foot and ankle.[15] The most common structure mistaken for MTP joint was the neck of the metatarsal, likely due to its anatomic characteristics of the dimple between the head and the shaft, mimicking the dimple of the actual joint line.[16] Immediate feedback on this anatomic detail, with bedside MSK US, to the learner could be one example to improve MSK PE.[14, 17]

The application of US in MSK PE has been supported by a few studies.[18, 19] Woods et al. demonstrated improved palpation accuracy after US-assisted palpation of the long head of biceps tendon in the shoulder. However, most of these studies were limited to large joint structures.[20] As previously described, not all structural palpation requires additional MSK US verification or introduction.[14] A prospective case-control study is necessary to evaluate the impact of MSK US utility on the systemic palpation skills in the foot and ankle.

A limitation of the current study is the small number of recruited subjects at a single institution. Therefore, it is difficult to generalize the findings. In addition, using a single, young, healthy model may not represent the real patient populations with aging changes and multiple pathologies. Future study using different human models with different age and with/without pathologies is necessary.

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Conflicts of Interest

The authors declare they have no conflicts of interest.

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