Original Research

Localization of Hand and Wrist Anatomic Structures Among Physical Medicine and Rehabilitation Residents: Implication of Ultrasonography in Palpation Skill Verification

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Abstract

Objective
The objective of this cross-sectional study is to evaluate the accuracy of physical medicine and rehabilitation (PM&R) resident palpation skills of hand and wrist joint and soft tissue structures using ultrasonography (US) verification.

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

Results
Overall palpation accuracy for 16 joint line and soft tissue structures was 40.6%. There was no significant difference in palpation accuracy with advanced educational level (37.5% in PGY-2, 33.8% in PGY-3, 50% in PGY-4, p = 0.12). The percentage of combined accurate palpation and less than one centimeter error in accurate palpation revealed a significant improvement along the advancement of PGY training (50%, 61.3%, 69.8% in PGY-2, 3, 4 respectively, p = 0.01).

Conclusions
This study demonstrated an overall suboptimal accuracy of hand and wrist palpation skills by PM&R residents and a need to improve palpation skills among PM&R residents.

Keywords
graduate medical education; palpation; physical examination; ultrasonography; diagnostic imaging; musculoskeletal system; hand; wrist joint; wrist joint/anatomy and histology; internship and residency

Background
With a 26% prevalence in the general population,[1] hand and wrist pain are commonly encountered in physical medicine and rehabilitation (PM&R) clinics. The musculoskeletal (MSK) examination is an essential skill set in the evaluation of hand and wrist pathology.[2] Correct identification of anatomic landmarks allows for accurate diagnosis and treatment. However, several studies have demonstrated perceived difficulties and inadequate training among clinicians and medical students.[3,4]

One of the main challenges in learning the hand and wrist examination is verifying palpation accuracy of their small anatomic structures.[5] Lack of verification or immediate feedback often delays PM&R resident improvement in palpation accuracy.[6] Moreover, palpating small structures may pose a challenge for the supervising attending physician.[7]

Previous studies using ultrasonography (US) verification for resident physical examination skills were limited to large joints such as the shoulder,[7,8] knee[5,6] or a few structures in the hand and wrist.[4] To our knowledge, there have been no comprehensive studies assessing palpation skills of hand and wrist anatomic structures. Furthermore, there is underutilization of US in identifying hand and wrist pathologies despite the widespread use of it to improve the accuracy of hand and wrist injections in MSK practice.[9-11]

The objective of this study was to investigate the palpation accuracy of hand and wrist joint and soft tissue structures in PM&R residents using US verification. The second objective was to determine if there were changes with the advancement of training during PM&R residency.

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

Location	Palpation structures	Clinical significance and common pathologies
RADIAL	Distal pole of scaphoid bone	Scaphoid fracture, landmark for scaphotrapezial joint
	Ulnar collateral ligament (UCL) of 1st MCP joint	Gamekeeper's (skier's) thumb, Stener's lesion (ruptured UCL ligament displaced over the adductor aponeurosis)
	1st dorsal extensor column (APL/EPB) at the wrist	De Quervain tenosynovitis
	Trapezium-1st metacarpal joint	Basal joint arthritis (most common site for hand osteoarthritis)
	Radial styloid	Bony landmark for radiocarpal joint, bony landmark to palpate superficial radial nerve and APL/EPB
DORSAL	Lister's tubercle	Bony landmark to divide 2nd and 3rd dorsal extensor compartment, to divide dorsal radial and dorsal central region of the wrist/hand
	Scapholunate interval	Scapholunate ligament sprain, dissociation, common location for dorsal ganglion cyst
	Extensor pollicis longus	Distal intersection syndrome with ECRL/ECRB
	Snuff box	Scaphoid fracture (tenderness and pain in fracture or non-union of fracture)
ULNAR	Groove for ECU	ECU subluxation, ECU tenosynovitis
	Ulnar styloid process	Ulnar styloid impaction syndrome
VOLAR	A1 pulley at 4th finger/ray	Trigger finger
	Hook of hamate	Fracture, common in golfers, baseball and hockey players
	Ulnar nerve and artery at the wrist	Guyon's canal syndrome (ulnar nerve), hypothenar hammer syndrome (ulnar artery)
	Pisiform	Fracture, avulsion fracture from FCU
	Median nerve at the carpal tunnel	Carpal tunnel syndrome

APL: abductor pollicis longus; EPB: extensor pollicis brevis; EPL: extensor pollicis longus; ECRL/ECRB: extensor carpi radialis longus/brevis; ECU: extensor carpi ulnaris; MCP: metacarpophalangeal, FCU: flexor carpi ulnaris

Methods

Sixteen PM&R residents rotating in an outpatient MSK clinic at a single institution were recruited from July 2015 to June 2016. Each resident palpated joint line and soft tissue anatomic structures in the hand and wrist on the same human model (a female PM&R resident). The model was seated with the hand and wrist on an examination table. Repositioning of the hand and wrist was at the discretion of the examining resident. Once the presumed joint line and soft tissue structures were localized, the residents marked a one centimeter size circle on the overlying skin with an ink marker. The anatomic targets for palpation were chosen based on common pain generators typically encountered during the hand and wrist examination.[2] **Table 1** reviews the clinical implications of tenderness of individual structures.

The accuracy of the circle over the joint line and soft tissue structures was verified using US.[12] US verification was performed by the first author who has more than 10 years of experience in MSK US and is also a registered MSK sonographer (RMSK)™.

When a palpation was incorrect, it was categorized as either less than one centimeter or more than one centimeter from the margin of the circle to the localized structure.[13] To avoid potential measurement errors, US verification was performed in a position similar to the palpation examination. The structure mistaken for the target was then identified and feedback was provided to the resident.

The education for palpation skills in the core curriculum include a yearly formal one hour lecture during an MSK module, one and a half hours of hands-on practice immediately following the lecture, and two hours of MSK US didactics. Weekly one hour MSK US scanning practice sessions were mandatory for residents on an outpatient clinic rotation. A total of three hand and wrist US practice sessions were offered throughout the year.

A Fisher's exact test was used to determine whether there were significant differences in the accuracy of joint line and soft tissue palpation between residents in different post graduate year (PGY). A two-tailed p value of less than 0.05 was considered statistically significant.

This study was approved by the institutional review board. Informed consent was obtained from individual residents.

Results

Sixteen residents (five PGY-2, five PGY-3, and six PGY-4 residents) completed the evaluation. The mean duration for completion of the physical examination was 11.8 ± 5.5 (standard deviation) minutes. Overall palpation accuracy for 16 joint line and soft tissue structures was 40.6% with the highest accuracy on structures in the radial aspect (45%) followed by the volar (41.3%), ulnar (40.6%) and dorsal aspects (35.9%).

Table 2 describes the accuracy of palpation by residents based on different anatomic regions and the commonly mistaken structures as the intended targets. Based on the resident level of education, there was a positive trend in the overall accuracy without a statistically significant difference (37.5% in PGY-2, 33.8% in PGY-3, 50% in PGY-4, p = 0.12). The combined accurate palpation and less than one centimeter error in accurate palpation revealed a significant improvement with advancement in PGY training in this study (50%, 61.3%, 69.8% in PGY-2, 3, 4, respectively, p = 0.01). (**Figure 1**)

The accuracy of joint palpation compared to both bony prominences and soft tissue structures was slightly lower without statistical significance (39.4% vs. 43.8%, p = 0.79).

Discussion

This study is the first to evaluate systematic palpation skills of hand and wrist structures among PM&R residents with US verification. Palpation accuracy of hand and wrist joint and soft tissue structures was suboptimal, a finding similar to our previous study investigating palpation skills in the foot and ankle.[12] Unlike prior studies evaluating hand and wrist physical examination skills with and without US verification,[4,14,15] this study provides additional information regarding the difficulty in identifying small anatomical structures in the hand and wrist for trainees and common anatomic structures mistaken for the target item. This information can be useful for providing feedback during hand and wrist physical examination training.
We did not observe a statistically significant

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 (from most to least common)
RADIAL	Distal pole of scaphoid bone	12.5	37.5	Lunate, 1st MCP, radioscaphoid joint, scaphotrapezium joint, trapezium, lunate, 1st CMC joint
	Ulnar collateral ligament of 1st MCP joint	31.3	12.5	1st MCP base, radial collateral ligament, 1st MCP, FCR, UCL of 2nd MCP, 1st and 2nd metacarpal bone
	1st dorsal extensor column (APL/EPB) at the wrist	43.8	6.3	EPL, APB, snuff box, trapezium, EPB insertion on 1st MCP
	Trapezium-1st metacarpal joint	62.5	6.3	Snuff box/scaphoid, 2nd CMC, 1st MCP
	Radial styloid	75	18.8	Proximal radius
DORSAL	Lister's tubercle	6.25	12.5	Ulnar groove, radioulnar joint, scapholunate joint, ulnar aspect of radius, 2nd MCP on ECRL, hamate
	Scapholunate interval	6.25	18.8	Capitate, snuff box, lister's tubercle, 2nd MCP, lunate, scaphoid, trapezoid, scaphotrapezium joint
	Extensor pollicis longus	62.5	6.3	Extensor indicis/EDC, EPB
	Snuff box	68.8	18.8	APL/EPB, scaphoid, ulna to EPB
ULNAR	Groove for ECU	12.5	18.8	FCU, triquetrum, TFCC, proximal/ventral to ulna
	Ulnar styloid process	68.75	25	Ulnar groove (for ECU), proximal ulna
VOLAR	A1 pulley at 4th finger/ray	62.5	37.5	Metacarpal head/neck/shaft, extensor tendon, proximal metacarpal, dorsum of MCP joint
	Hook of hamate	6.25	18.8	Pisiform, scaphoid, 5th MCP, scaphotrapezium joint
	Ulnar N and A bundle	43.75	50	Medial to bundle, dorsal to bundle, FCU
	Pisiform	50	6.3	Triquetrum, hamate, 4th or 5th metacarpal, scaphoid, lunate
	Median nerve	75	25	Ulnar to median nerve, FDS/FDP

CMC: carpometacarpal joint, MCP: metacarpophalangeal, FCR: flexor carpi radialis, UCL: ulnar collateral ligament, APB: abductor pollicis brevis, EPB: extensor pollicis brevis; APL: abductor pollicis longus; ECU: extensor carpi ulnaris; ECRL: extensor carpi radialis longus EDC: extensor digitorum communis, N: nerve; A: artery; TFCC: triangular fibrous cartilage complex; FCU: flexor carpi ulnaris; FDS/FDP: flexor digitorum superficialis/flexor digitorum profundus

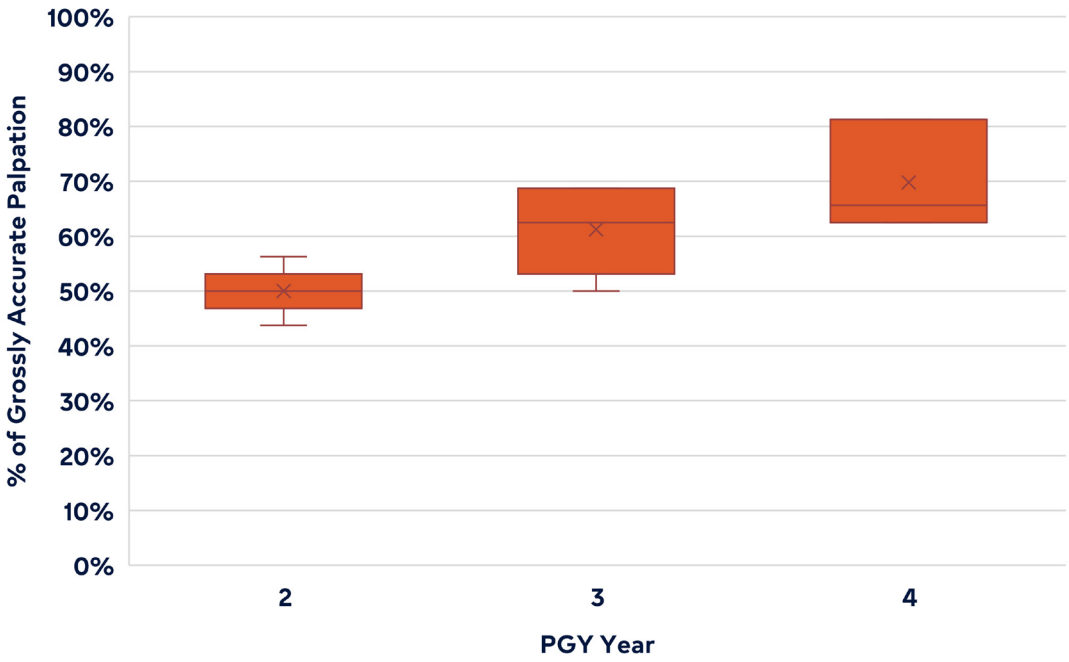

Figure 1. Percentage of combined accurate palpation and less than one centimeter error in palpation based on post-graduate year (PGY) level.

difference in palpation accuracy between PGY. However, combining palpation accuracy and less than one centimeter error in palpation accuracy revealed a significant improvement with advancement in PGY training. Based on our findings, it is reasonable to conclude that while residents gain improved understanding of regional anatomy with advancement in training, palpation accuracy remains imperfect. For this reason, there is a need to improve palpation skill amongst residents of all PGY. MSK US is emerging as an important educational tool that provides immediate feedback and anatomic detail to the learner, which can be used to improve palpation skill.[4,16,17] The implementation of MSK US education in PM&R residency programs (40% according to the PM&R program director survey in 2014) is encouraging.[18] However, the educational content has to be established and examined for its efficacy.[18] In addition, the emphasis of these curricula has been placed on the interventional aspect of US.[19] It may, therefore, be necessary to evaluate these curricula, their learning objectives and approachs to different PGY levels to identify the best educational structure for individual trainees.

This study also highlights structures with the most inaccurate localizability. Small bony prominences (Lister's tubercle and distal pole of scaphoid) and small joints/grooves (scapholunate interval and groove for ECU) were palpated with less accuracy than larger bony prominences, such as radial styloid and ulnar styloid. This is consistent with previous studies showing higher accuracy of bony prominence palpation in large joints.[6,16] This study revealed no significant difference between bony versus soft tissue palpation in the hand and wrist. This finding is inconsistent with our previous foot and ankle study, which demonstrated increased difficulty with small joint compared to soft tissue structure palpation in the foot and ankle.[12] The palpation accuracy of both hand and foot bony structures was suboptimal (39.4% and 28.5% respectively in hand/wrist and foot/ankle bony palpation). Moreover, the identification of structures commonly mistaken for the intended anatomic targets provides useful information for resident education. This information can be important as structure misidentification may have clinical implications for patient care. A limitation of the current study is the small number of recruited residents at a single institution. Therefore, it is difficult to generalize the findings. In addition, a single, young healthy female model does not represent the general patient population. A future study using different human models of various ages, genders, body

mass indexes and with/without pathologies is necessary. Another limitation of the study is the lack of longitudinal testing of residents through their PGY training that would allow us to assess whether the ultrasound education provided as a part of this study improved palpation skills. In addition, the information of attendance at palpation skill education along with advancement of training was not collected systematically.

Conflicts of Interest

The authors declare they have no conflicts of interest.

Drs. Lai and Lee are employees of MountainView Hospital, a hospital affiliated with the journal's publisher.

This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare affiliated entity. The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any of its affiliated entities.

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