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

Se Won Lee, MD,1 Phuong Uyen Le, DO,2 Craig Van Dien, MD,3 Stepfanie Lai, DO,1 Eric Aguila, MD4

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.\(^9,10\)

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. 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. 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. 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. Unlike prior studies evaluating hand and wrist physical examination skills with and without US verification, this study provides additional information regarding the difficulty in identifying small anatomic 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
| 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, radiosaphoid 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
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 approaches 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 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.

Author Affiliations
1. Department of Physical Medicine and Rehabilitation, Sunrise Health GME Consortium, MountainView Hospital, Las Vegas, NV
2. Division of Physical Medicine and Rehabilitation, Department of Internal Medicine, Lehigh Valley Health Network, Allentown, PA
3. Department of Physical Medicine and Rehabilitation, JFK Johnson Rehabilitation Institute, Edison, NJ
4. Department of Physical Medicine and Rehabilitation, VA Southern Nevada Healthcare System, Las Vegas, NV

References
1. Dahaghin S, Bierma-Zeinstra SM, Reijman M, Pols HA, Hazes JM, Koes BW. Prevalence and determinants of one month hand pain and hand related disability in the elderly (Rotterdam study). Ann Rheum Dis. 2005;64(1):99-104. https://doi.org/10.1136/ard.2003.017087
2. Young D, Papp S, Giachino A. Physical examination of the wrist. Orthop Clin North Am. 2007;38(2):149-v. https://doi.org/10.1016/j.ocl.2007.02.011
3. Coady DA, Walker DJ, Kay LJ. Teaching medical students musculoskeletal examination skills: identifying barriers to learning and ways of overcoming them. Scand J Rheumatol. 2004;33(1):47-51. https://doi.org/10.1080/03009740310004108
4. Bitterman J, Lew HL, Kirshblum S, Enam N, Pierce D, Ma RT. Design and implementation of a musculoskeletal ultrasound curriculum for physical medicine and rehabilitation residents: pilot data on improvement of palpation accuracy in Physical Examination. Am J Phys Med Rehabil. 2020;99(12):1177-1183. https://doi.org/10.1097/PHM.0000000000001487
5. Mehta P, Rand EB, Visco CJ, Wyss J. Resident accuracy of musculoskeletal palpation with ultrasound verification. J Ultrasound Med. 2018;37(7):1719-1724. https://doi.org/10.1002/jum.14523
6. Rho ME, Chu SK, Yang A, Hameed F, Lin CY, Hurh PJ. Resident accuracy of joint line palpation using ultrasound verification. PM R. 2014;6(10):920-925. https://doi.org/10.1016/j.pmrj.2014.02.006
7. Gazzillo GP, Finnoff JT, Hall MM, Sayeed YA, Smith J. Accuracy of palpating the long head of the biceps tendon: an ultrasonographic study. PM R. 2011;3(11):1035-1040. https://doi.org/10.1016/j.pmrj.2011.02.022
8. Woods R, Wisniewski SJ, Lueders DR, Pittelkow TP, Larson DR, Finnoff JT. Can ultrasound be used to improve the palpation skills of physicians in training? A Prospective Study. PM R. 2018;10(7):730-737. https://doi.org/10.1016/j.pmrj.2017.11.016
9. Evers S, Bryan AJ, Sanders TL, Selles RW, Gelfman R, Amadio PC. Effectiveness of ultrasound-guided compared to blind steroid injections in the treatment of carpal tunnel syndrome. Arthritis Care Res (Hoboken). 2017;69(7):1060-1065. https://doi.org/10.1002/acr.23108
10. Favero M, Hoxha A, Frallonardo P, et al. Efficacy and safety of ultrasound-guided intra-articular glucocorticoid injection in erosive hand osteoarthritis. Pain Med. 2020;pn1a261. https://doi.org/10.1093/pm/pnaa261
11. Koh SH, Lee SC, Lee WY, Kim J, Park Y. Ultrasound-guided intra-articular injection of hyaluronic acid and ketorolac for osteoarthritis of the carpometacarpal joint of the thumb: A retrospective comparative study. Medicine (Baltimore). 2019;98(19):e15506. https://doi.org/10.1097/md.00000000000015506
12. Lee SW, Le PU, Van Dien C, et al. Evaluation of resident palpation skills in foot and ankle anatomic structures using bedside ultrasound. HCA Healthcare Journal of Medicine. 2020;1(3):9. https://doi.org/10.36518/2689-0216.1029
13. Christoforetti JJ, Delong J, Hanypsiak BT, et al. Precision and accuracy of identification of anatomical surface landmarks by 30 expert hip arthroscopists. Am J Orthop (Belle Mead NJ).
14. Johnson CC, Zusstone E, Miller TT, Nwawka OK, Lee SK, Wolfe SW. Clinical tests for assessing the presence and quality of the palmaris longus tendon: diagnostic accuracy of examination compared with ultrasound. *J Hand Surg Eur Vol.* 2020;45(3):292-298. [https://doi.org/10.1177/1753193419895160](https://doi.org/10.1177/1753193419895160)

15. Al-Azzani W, Hill CE, Passmore C, et al. Evaluation of junior doctor hand examination skills. *Orthopaedic Proceedings*. 2017;99-B(Suppl_8).

16. Walrod BJ, Schroeder A, Conroy MJ, et al. Does Ultrasound-enhanced instruction of musculoskeletal anatomy improve physical examination skills of first-year medical students?. *J Ultrasound Med*. 2018;37(1):225-232. [https://doi.org/10.1002/jum.14322](https://doi.org/10.1002/jum.14322)

17. Ahn JS, French AJ, Thiessen ME, et al. Using ultrasound to enhance medical students’ femoral vascular physical examination skills. *J Ultrasound Med*. 2015;34(10):1771-1776. [https://doi.org/10.7863/ultra.15.14.11014](https://doi.org/10.7863/ultra.15.14.11014)

18. Siddiqui IJ, Luz J, Borg-Stein J, et al. The current state of musculoskeletal ultrasound education in physical medicine and rehabilitation residency programs. *PM R*. 2016;8(7):660-666. [https://doi.org/10.1016/j.pmrj.2015.11.010](https://doi.org/10.1016/j.pmrj.2015.11.010)

19. Finnoff JT, Hall MM, Adams E, et al. American Medical Society for Sports Medicine (AMSSM) position statement: interventional musculoskeletal ultrasound in sports medicine. *PM R*. 2015;7(2):151-68.e12. [https://doi.org/10.1016/j.pmrj.2015.01.003](https://doi.org/10.1016/j.pmrj.2015.01.003)