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Case Series

Physical Therapists Use of Diagnostic Ultrasound Imaging in Clinical Practice: A Review of Case Reports

Robert Manske[1] [a], Katherine Podoll[2], Alycia Markowski[3], Maureen Watkins[3], Lorna Hayward[3], Murray Maitland[4]

[1] Physical Therapy, Wichita State University, [2] University of Washington, [3] Physical Therapy, Northeastern University, [4] Department of Rehabilitation Medicine, University of Washington

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Objective

Ultrasound diagnostic imaging (USI) is widely utilized in sports medicine, orthopaedics, and rehabilitation. Its use in physical therapy clinical practice is increasing. This review summarizes published patient case reports describing USI in physical therapist practice.

Design

Comprehensive literature review.

Literature Search

PubMed was searched using the keywords “physical therapy” AND “ultrasound” AND “case report” AND “imaging”. In addition, citation indexes and specific journals were searched.

Study Selection Criteria

Papers were included if the patient was attending physical therapy, USI was necessary for patient management, the full text was retrievable, and the paper was written in English. Papers were excluded if USI was only used for interventions, such as biofeedback, or if the USI was incidental to physical therapy patient/client management.

Data Synthesis

Categories of data extracted included: 1) Patient presentation; 2) Setting; 3) Clinical indications; 4) Who performed USI; 5) Anatomical region; 6) Methods of USI; 7) Additional imaging; 8) Final diagnosis; and 9) Case outcome.

Results

Of the 172 papers reviewed for inclusion, 42 were evaluated. Most common anatomical regions scanned were the foot and lower leg (23%), thigh and knee (19%), shoulder and shoulder girdle (16%), lumbopelvic region (14%), and elbow/wrist and hand (12%). Fifty-eight percent of the cases were deemed static, while 14% reported using dynamic imaging. The most common indication for USI was a differential diagnosis list that included serious pathologies. Case studies often had more than one indication. Thirty-three cases (77%) resulted in confirmation of a diagnosis, while 29 case reports (67%) documented significant changes in physical therapy intervention strategies due to the USI, and 25 case reports (63%) resulted in referral.

Conclusion

This review of cases provides details on unique ways USI can be used during physical therapy patient care, including aspects that reflect the unique professional framework.

a Cooresponding Author:
Robert.Manske@wichita.edu

INTRODUCTION

Ultrasound diagnostic imaging (USI) is becoming more widely utilized in sport medicine, orthopaedics, and rehabilitation to extend the physical examination and avoid delays in diagnosis. Indications for USI continue to increase because of its advantages compared to other diagnostic imaging modalities. Benefits include no radiation, cost-effectiveness, portability, and it is non-invasive. Clinical providers can gain immediate imaging information for a broad spectrum of patient presentations. USI results in real-time, high-resolution visualization of anatomical structures across physiological systems. The unique properties of USI can be used to assess vasculature, lungs, joints, bones, tendons, and muscles.[1–3] Additionally, ultrasound allows the clinician to interact with the patient to guide the examination of specific patient complaints.[4] Musculoskeletal USI has become a valuable tool to objectively assess musculoskeletal structures, as well as functionally, during range of motion and muscle activation both statically and dynamically.[5,6]

Physical therapists (PTs) have a unique practice framework and scope of practice compared to other healthcare providers.[7] Their practice framework emphasizes anatomy, pathoanatomy, and biomechanics of movement. Consequently, published literature on the use of musculoskeletal USI in physical therapist practice may provide unique information about the benefits of this imaging modality. A survey of PTs in the United States found that of 646 respondents, 241 had recommended or referred patients for USI.[8] However, the respondents reported having a more substantial knowledge base and skills for recommending or ordering radiography (x-ray) and magnetic resonance imaging (MRI) over USI. Thus, increased awareness of USI in clinical practice may improve its appropriate utilization by PTs.

Boissonnault and Ross[9] examined the use of diagnostic imaging by PTs by synthesizing 78 case reports. They found that PTs recognized indications for diagnostic imaging such as worsening of symptoms without cause, inconsistent findings compared to the referral diagnosis, associated symptoms such as fatigue, and lack of progress despite treatment. Boissonnault and Ross[9] reported that PTs' referrals for diagnostic imaging resulted in subsequent diagnoses across a spectrum of categories, including fracture, cancer, visceral disease, cardiovascular, and urogenital. However, these authors did not identify the imaging modalities. At present, clinical implications for USI have not been established for the physical therapy community. Linking USI case reports to the unique practice framework of PTs could improve the incorporation of USI into physical therapy clinical practice.

To our knowledge, no publications synthesize published case reports of USI in physical therapy practice. Patient case reports provide insights for PTs and other providers regarding patient presentations, red flag recognition, diagnosis, and how therapists used USI to identify and manage these various conditions. Published case reports provide documentation of clinical reasoning in complex circumstances, which can inform clinicians by providing details regarding patient-specific examination information. Since the incorporation of USI into physical therapy practice is relatively new, case reports are a large proportion of the available evidence. These case reports are proposed to have significant educational value because they advance medical knowledge and constitute preliminary evidence for evidence-based medicine. Synthesis of case reports can also provide the foundation for other research methods.

The purpose of this review is to summarize published patient case reports that describe the use of USI in PT's practice to diagnose and manage patient conditions.

METHODS

One of the authors of this paper (MEM) conducted a computerized database search of PubMed using the keywords "physical therapy" AND "ultrasound" AND "case report" AND "imaging". In addition, Physical Therapy, the Journal of Orthopedic and Sports Physical Therapy (JOSPT) (standard and Case Reports versions), and the International Journal of Sports Physical Therapy (IJSPT) were searched specifically. Once a paper was identified, the PubMed citation index similar papers listings were reviewed, along with the paper's reference list, for any additional papers matching the inclusion criteria. Literature searches were conducted from July 2021 to August 2022.

Papers were included if the patient was attending physical therapy, USI was necessary for the patient management process, the full text was retrievable, and the report was written in English. It was not required that a PT conduct the USI. Papers were excluded if USI was only used for interventions, such as biofeedback, or if the USI was incidental to PT patient/client management. For example, papers were excluded if the PT did not have an explicit role in recommending, referring, or conducting USI. Case series were included if each case met the inclusion/exclusion criteria.

The authors developed a data extraction form based on the work of Boissonnault and Ross,[9] the authors' collective knowledge of diagnostic USI, and knowledge regarding differential diagnosis and medical screening. The categories of data included: 1) Patient presentation, including primary complaint and demographics; 2) Setting; 3) Clinical reasoning that led to USI; 4) Who performed USI; 5) Anatomical region assessed; 6) Whether USI was static, dynamic, or Doppler; 7) Other imaging; 8) Final diagnosis; 9) Outcome of the case.

Clinical reasoning categories indicating the appropriate use of USI were derived from Boissonnault and Ross.[9] Papers were categorized as to whether 1) the differential diagnoses included serious pathology that could not be ruled out without diagnostic imaging (hereafter described as "serious differentials", 2) red flag symptoms were present ("red flags"), 3) there was no clinical progress despite treatment ("no progress"), or 4) if the PT's examination findings did not concur with the referral diagnosis ("disagreement"). Other clinical reasoning categories were generated if a case report did not fit any of these categories. A single case report may have more than one indication for USI. Clinical reasoning categories were required to be explicitly stated.

The researchers collected the anatomical regions assessed with USI to understand more common presentations and suggest necessary USI skills. When one or more regions were explicitly stated, all regions were recorded. Where the regions were not explicitly stated, USI images were used to determine the region. The reports may not have always reported all anatomical areas that were imaged. Similarly, when case reports did not specify whether tests were static or dynamic, the nature of the test was inferred by the published images.

Outcome categories were limited to patient referral, arriving at a diagnosis, or a change in physical therapy intervention strategies. The imaging case reports focused on diagnostic strategies and often did not include patient-specific clinical outcomes.

Following the acquisition of full-text case reports that met the inclusion/exclusion criteria, entire papers were reviewed independently by two researchers (RCM and KRP). Each case report's data was hand entered into the data extraction form in Microsoft Excel. A third researcher (MEM) then reviewed all data to verify accurate data logging and resolve discrepancies. The authors met to discuss all the collected cases, compare findings, and generate summaries. The authors reached a consensus for all case-report data.

RESULTS

The initial search strategy resulted in 172 papers being reviewed by title and abstract for inclusion/exclusion criteria. Most of the excluded papers at this stage used USI for the medical diagnosis and the patient was referred for physical therapy. Since the initial search strategy was not specific, these papers were identified but did not meet the inclusion criteria. Forty-five complete published case reports were obtained for reading and data tabulation. One paper included two cases. Following a complete review, two cases were ultimately excluded because USI was used solely for ultrasound-guided percutaneous electrical nerve stimulation. One paper was excluded because USI was used for drug delivery. One paper was excluded because the relationship of USI to physical therapy practice was indeterminable. Thus, 42 cases were assessed by the researchers.

The Journal of Orthopaedic and Sports Physical Therapy had 24 case reports. The more recent journal version, JOSPT Cases, had 8 case reports. The earliest JOSPT case report was from 1994. More recently, JOSPT had a special feature titled "Musculoskeletal Imaging," which started in 2008 and was the primary source of case reports. JOSPT launched the Cases version in 2021 and continues the same format for imaging cases. The International Journal of Sports Physical Therapy and its predisesor, the North American Journal of Sports Physical Therapy had nine reports. Physiotherapy Theory and Practice had three cases. Physical Therapy Journal had one case report. Thirty-five cases were from within the United States, and eight were from other countries.

Patient primary complaints, anatomical regions, and final diagnoses are listed in Table 1. The average patient age was 37 years (range 15-73). Case reports included 25 males, 18 females, and the sex of one patient was not reported. Diagnostic ultrasound was performed by PTs 22 times, by another health care professional in 15 cases, and a sonographer was unidentified in six cases. Settings varied little, with most patients from outpatient orthopaedic (27) and sports (14) clinical environments. One patient was seen in a pelvic health clinic, and only one case report was from an inpatient physical therapy setting.

Anatomical regions with the largest proportion (n, %) of physical therapy USI case reports are the foot and lower leg (10, 23%), thigh and knee (8, 19%), shoulder and shoulder girdle (7,16%), lumbopelvic region (6, 14%), and elbow/wrist/hand (5, 12%). There were very few case reports for the spine (3, 7%), head and neck (3, 7%), and hip/groin region (1, 2%). One case report focused on the lungs.

Case reports either documented a single type of USI (static, dynamic, or Doppler) or more than one type. Eighteen case reports did not specify whether the patient was static or dynamic during USI. These cases were inferred to be static tests from the published images and were added to the seven case reports that specified the patient was static, resulting in a total of 25 cases (58%). The authors assumed that dynamic and Doppler tests would be preceeded by static imaging. Six case reports reported dynamic testing (14%). Eight case reports specified that Doppler imaging was used (19%). See the listing of all case reports, presenting complaints, anatomical regions assessed, and final patient diagnosis in Table 1.

Case reports often had more than one indication for USI (32, 74%). The most common reason for USI during examinations was when the differential diagnosis list included serious pathologies (26, 60%). For example, Hoglund, Silbernagel, and Taweel[31] reported that moderately severe lower leg pain with full weight-bearing that originated from running includes stress fracture as a differential. Rosenthal, Hawkes, and Garbrecht[45] reported that unilateral calf pain and cramping, with negative spine examination and negative compartment syndrome tests, could include popliteal artery entrapment as a differential.

Eleven cases (26%) reported specific red flags. Red flags are important to discern as it is an indication of possible serious pathology including inflammatory, neurological conditions, structural musculoskeletal damage or disorders, circuilatory problems, suspectived infections, tumors or even systemic disease processes.

No change from previous treatment was reported in twelve cases (28%). The average duration before the PT recognized a lack of progress was 3 months, with a range of 0.5 to 12 months. The most commonly reported duration before the PT initiated imaging was 2 months, indicating a high degree of suspicion early on in the treatment process. For example, Stanley and Berkoff[49] reported that a patient had 8 physical therapy sessions over 1 month before the patient was referred for imaging because of failure to progress.

A disagreement occurred between initial diagnosis and final outcome in 16 cases (37%). At times this occurred when a referral for a given pathology was determined to be a different pathology. In some instances this happened af-

Table 1. Included case reports, presenting complaints, anatomical regions assessed with USI, and final patient diagnoses.

Author(s)	Patient presenting complaint	Anatomical Region Assessed	Final diagnosis
Angelopoulou and McReynolds[10]	Left lateral knee pain	Knee/leg	Fibular collateral ligament tear
Beneck, Gard and Fodran[11]	Low back pain	Lumbopelvic	Spondylolisthesis
Boggs and Nitz[12]	Left lateral foot pain	Foot/ankle	Oblique fracture of the 5th metatarsal
Brenner, Gill, Buscema, and Kiesel[13]	Low back pain and left posterior thigh pain	Lumbopelvic	Hypomobility, decreased activation of multifidus
Brindisino, Mourad, and Maselli[14]	Left subscapular and shoulder pain	Shoulder/upper arm	Elastofibroma
Buchanan and Rawat[15]	Medial ankle pain	Foot/ankle	Schwannoma of posterior tibialis nerve
Buchanan and Rawat[16]	Medial elbow pain	Elbow/wrist	Elbow apophysitis
Burzynski et al.[17]	Chronic perineum pain	Lumbopelvic	USI test for bladder retention was negative
Crane, Young, and Koppenhaver[18]	Left unilateral abdominal pain	Lumbopelvic	Hypoechoic band, symptomatic trigger point
Davis, Brooks, and Bryceson[19]	Right anterior ankle pain and swelling	Foot/ankle	Pseudo-aneurysm of anterior tibial artery
DeLisa, Hensley, and Jackson[20]	Left upper extremity swelling	Shoulder/upper arm	Paget-Schroetter syndrome and primary effort thrombosis
Faltus, Boggess, and Bruzga[21]	Right anterior thigh pain	Hip/thigh	Rectus femoris muscle tear
Fink and Stoneman[22]	Left knee pain	Knee/leg	Superficial femoral vein thrombosis and popliteal deep vein thrombosis, bilateral pulmonary emboli
Fisher, Lento, and Mabry[23]	Left ankle pain	Foot/leg	Transsyndesmotic fibular fracture
Flatt and Rawat[24]	Bilateral hip pain, burning and popping in right hip	Hip	Bilateral metallosis
Garbrecht, Reynolds, and Rosenthal[25]	Right anterior shoulder pain	Shoulder/upper arm	Thrombosis in middle subclavian and axillary veins
Ghaly, Boggs, and Ross[26]	R hand pain, some paresthesia, and diminished sensation	Elbow/wrist/hand	Cystic mass compressing the ulnar nerve
Hassett, Kulig, and Colletti[27]	Bilateral anterior knee pain	Knee/leg	Xanthomatous tendinosis
Hellem, Jelsing, and Hurd[28]	Left medial elbow pain	Elbow/forearm	Ulnar neuritis with medial apophysitis
Ho, Gross, Gaal, and Nguyen[29]	Left anterior hip pain	Hip/thigh	Nondisplaced fracture of the anterior superior iliac spine
Ho, Ho and Colletti[30]	Difficulty opening mouth; right temporomandibular pain	Temporomandibular joint	USI lateral capsule-condyle distance test was positive; temporomandibular hypomobility
Hoglund, Silbernagel, and Taweel[31]	Right lateral leg pain	Knee/leg	Fibular stress fracture
Kardouni[32]	Right lateral ankle pain	Foot/ankle	Oblique fracture of the distal fibula
Kirkham and Rawat[33]	Right shoulder pain	Shoulder/shoulder girdle	Fracture of humerus, multiple partial muscle tears
Krause and Smith[34]	Right anterior arm pain	Shoulder/arm	2nd-degree strain of biceps brachii

Author(s)	Patient presenting complaint	Anatomical Region Assessed	Final diagnosis
Leech, Bissett, Kot, and Ntoumenopoulos[35]	Respiratory deterioration, secretion retention, and widespread crackles to lung auscultation	Lung	Pleural effusion
Mechelli, Preboski, and Boissonnault[36]	Low back pain	Lumbopelvic	Abdominal aortic aneurysm
Monteleone, Gismant, Stevanato, and Tiloca[37] Case 1	Atrophy of the right deltoid	Shoulder/arm	Quadrilateral space syndrome
Monteleone, Gismant, Stevanato, and Tiloca[37] Case 2	"Hollow" in the right shoulder	Shoulder/arm	Quadrilateral space syndrome
Murphy, Stockden, and Breidahl[38]	Acute right-sided abdominal pain	Lumbopelvic	2nd-degree strain of the abdominal oblique muscle
Neville, Meyers, and Hojnowski[39]	Left medial foot and ankle pain	Foot/ankle	Advanced focal degeneration or partial tear of tibialis posterior tendon
Painter, Ogle, and Teyhen[40]	Left buttock pain and urinary incontinence	Lumbopelvic	Dysfunctional motor control of the transversus abdominis and pelvic floor muscles
Pape, Pape, De Martino, and Christensen[41]	L lower leg swelling (after skiing injury, feeling snap, on-site diagnosis of soleus tear)	Foot/leg	Deep vein thrombosis in the calf
Pujol-Marzo and Balius[42]	Chest pain	Shoulder/shoulder girdle	Stress fracture in the sternum
Rainey, Taysom, and Rosenthal[43]	Left posteromedial knee pain, snapping	Knee/leg	Benign mass in the posteromedial knee
Rainey, Taysom, and Rosenthal[44]	Right shoulder pain, paraesthesia digits, swelling	Shoulder/arm	Upper extremity deep venous thrombosis subclavian and axillary veins
Rosenthal, Hawkes, and Garbrecht[45]	Low back pain, left leg pain, paraesthesia	Knee/leg	Popliteal artery entrapment
Said and Bevelaqua[46]	Left proximal posterior thigh pain	Hip/thigh	Benign vascular malformation
Sillevis, Shamus, and Mouttet[47]	Right-sided foot pain	Foot/ankle	Plantar fasciitis with thickening
Sillevis and Swanick[48]	Headache	Head/neck	Cervicogenic headache due to spine immobility
Stanley and Berkoff[49]	Left lateral calf pain	Knee/leg	Schwannoma
Torstensen, Meen, and Stiris[50]	Right shoulder pain	Shoulder/arm	Supraspinatus muscle degeneration
van Duijn and Felton[51]	Right medial elbow pain	Elbow/forearm	Complete tear of the ulnar collateral ligament
Wood, Konin, and Nofsinger[52]	Left medial elbow pain	Elbow/forearm	Ulnar collateral ligament sprain
Zosel et al.[53]	Left-sided neck pain	Head/neck/ Shoulder/arm	Upper Extremity superficial venous thrombosis

ter referral from a physician, while other times it occurred following an initial diagnosis after direct access examination.

Another common reason for including USI in the diagnosis was to expand the clinical examination to include more specificity (5, 12%). This is important for PT's for many reasons. During the examination process, the medical history may not seem to exactly line up with the physical examination. This could be something as simple as the patient has been in therapy for some time and not improving, and has recently experienced unexplained weight loss. In this instance, the PT used USI to expand the diagnsosis to other areas, or for assessing for other potential confuounding conditions.

Six cases included both pre- and post-testing USI. As a part of foundational PT treatments, demonstrating progress or regression of conditions is required for medicolegal purposes and insurance requirements. Improvement can be used to obtain approval for further continued care, while lack of progress is helpful for seeking different treatment options or referral back to physician or another health care provider.

Other imaging modalities used in conjunction with USI depended on the case's patient-specific nature. Depending on the case, USI was followed up with another imaging modality to clarify the nature of the pathology. Follow-up imaging was seen in 23 patients. These follow-up tests included an x-ray, MRI, and magnetic resonance angiography. In some cases, another specialist repeated USI. On the other hand, previous negative imaging tests, including MRI, radiograph, or other USI negative results, may have preceded positive USI results. In retrospect, this finding is expected because of the complex nature of appropriateness criteria[54] and imaging clinical reasoning rules. One case had concurrent imaging performed. Fourteen of the cases did not require further follow-up imaging; in one case, follow-up imaging was unable to be determined.

Outcomes of case reports focused on diagnosis. Thirty-three cases (77%) resulted in a confirmed diagnosis from the USI. Because of the confirmation of a diagnosis, twenty-nine case reports (67%) documented significant changes in physical therapy intervention strategies due to the USI. Twenty-five case reports (63%) stated that the USI resulted in referral. Only two case reports used USI to monitor improvements in patient status over time.

DISCUSSION

The purpose of this review was to summarize published case reports that describe the use of USI in PTs practice for the diagnosis and management of patient conditions. Case reports can be used to examine how PTs utilize USI for diagnostic purposes and develop clinical skills.[55] This review of case reports corroborates the previous work of Boissonnault and Ross.[9] Physical therapists in orthopaedic and sports medicine environments recognized indications for imaging, resulting in improved diagnostic validity for the patient. This diagnostic validity is essential for appropriate care and reduces the potential delay of diagnosis, which causes unnecessary patient hardship. This seems critical as PTs primarily rely on their clinical suspicion when screening for serious pathology, while at the same time are uncertain about their differential diagnostic abilities.[56] USI was used as an extension of the physical examination and added valuable data in justifying referrals or monitoring patient change over time. In many instances, PTs were the provider performing the USI examination or were the person referring patients to have USI conducted.

Physical therapists are uniquely positioned to optimize USI as a powerful examination and treatment tool. Ultrasound allows a clinician to view not only static but dynamic anatomical images. Of all healthcare professionals, PTs are movement experts. Due to PTs knowledge and education in anatomy, kinesiology and biomechanics, and physical examination, they are equipped to acquire and interpret static and dynamic images and can relate these images to pathology. A physical therapist can move back and forth between physical examination, history taking, and imaging without losing sight of the primary objectives of the clinical examination. Physical therapists are trained to examine the entire kinetic chain and thus can quickly identify how a region distant to the actual site of symptoms may contribute or be the cause of dysfunction. This ability to perform a more complete assessment of a given condition, including medical screening, may flag a different or more serious differential diagnosis not even suspected by another provider. The ability of physical therapists to discern more serious pathology was seen in the present study which found that 11 cases (26%) reported red flag conditions associated with the patient presentation. For example, Mechelli et al.[36] described a case in which a 38-year-old male was initially referred to therapy for chronic lower back pain. The patient also had red flag symptoms of insidious onset unrelenting, deep, boring pain that was constant, irrespective of movements of posture changes or time of day. The resulting USI demonstrated an abdominal aortic aneurysm. Garbrecht et al.[25] reported that a patient had exercise-induced unilateral upper extremity arm swelling with negative cervical and shoulder musculoskeletal examinations. Doppler ultrasound discovered a thrombosis of the subclavian and axillary veins. Both of these cases demonstrate the physical therapists ability to differentiate between appropriate and inappropriate conditions ameanable for physical therapy treatment.

Disagreements between the initial diagnosis and what was ultimately determined to be the cause of pathology was not uncommon occurring in 16 (37%) of the reviewed cases. Depending on the seriousness of the condition examined with musculoskeletal-US, a disagreement that is not resolved can be a matter of life or death. For example, Flatt and Rawat,[24] initially treated a patient following total hip replacement, that ended up having metallosis which is a rare build-up of debris within tissue resulting in osteolysis and loosening of a prosthetic. Additionally, despite receiving a Well's screening score of 0, Pape et al.[41] report on a patient with a medical diagnosis of partial soleus tear, who ultimately was found to have a deep vein thrombosis.

In review of these case studies another common reason for including USI in the diagnosis was to expand the clinical examination to include more specificity (5, 12%). For example, Beneck et al.[11] reported the case of a 57-year-old woman. A longitudinal view of the lumbar facet joints demonstrated marked anterior displacement of the L3-4 and L4-5 facet joints, indicating possible spondylolisthesis. A grade II spondylolisthesis was confirmed by follow-up radiography. In another case report, Brenner et al.[13] used USI to confirm decreased multifidus activation in a person with chronic low back pain.

Six cases included both pre- and post-testing USI. For example, Ho et al[30] measured temporomandibular motion during active mouth opening to identify a movement im-

pairment and followed up with additional measurements after 10 physical therapy sessions.

Prior to making a patient/client management decision, PTs utilize the diagnostic process in order to establish a diagnosis for a specific condition in need of the PTs attention. When indicated, a physical therapist can order appropriate tests, including but not limited to imaging and other studies, that are performed and interpreted by other professionals. Additionally, when a patient is referred with a previously established diagnosis, the physical therapist should determine that the clinical findings are consisten with that diagnosis. If the diagnostic process reveals findings that are outside of the scope of PTs knowledge, experience, or expertise, the physical therapist should refer the patient/client to an appropriate practitioner. In the reviewed case studies, typical of the physical examination process, case presentations often started with a patient complaint of pain in a general anatomical area. When the results of history and physical examination were inconclusive or suggestive of an alternate diagnosis, USI performed by the PTs or a referral for USI resulted in a final diagnosis that was more specific.

USI offers several unique strengths for the evaluation of soft tissues. There were cases where USI discerned information that was not gleaned from either MRI or x-ray.[4] USI has a higher special resolution than MRI, which is extremely helpful when viewing superficial soft tissue structures. Studies have shown that USI performs comparably to MRI in the detection of pathologies such as full-thickness and partial-thickness rotator cuff tears, with a sensitivity and specificity of up to 95%.[57–60]

Physical therapy focuses on movement-related health. Physical therapists may provide a unique perspective on USI for assessing the dynamic function of soft tissues. An example includes observing muscles contract and relax. Due to improvements in hardware and software, including portable hand-held units, the clinician can quickly and efficiently compare the patient's involved and non-involved sides while continuing to interact with the patient directly. The ability to interview the patient while examining various structures helps determine the actual injury from the differentials. Reports such as these support that USI is a valuable point-of-care imaging modality tool to extend the physical examination in the physical therapy clinic.[61–63]

There were several case reports where the resulting diagnosis was vascular pathology.[22,25,36,45] These vascular-related case reports suggest that PTs should maintain a high degree of suspicion for these differentials, and Doppler might be an appropriate imaging modality for some physical therapy patients. For example, Garbrecht et al.[25] used same day Doppler USI which ruled in a occlusive throbus in the middle subclavian and axillary vein of a 23-year-old male active-duty Marine with complaing or anterior shoulder pain after multiple episodes of transient shoulder pain. In another military case, Fink and Stoneman[22] report on a case of a 21-year-old healthy athletic male cadet who had leg pain following a long car ride. Ultimately he was found to have a lower extremity DVT despite displaying minimal DVT risk factors.

In the orthopaedic clinic, it is challenging to discern precise anatomical structural anomalies without imaging. For example, a review of physical examination tests of the shoulder found that the clinical performance (sensitivity and specificity) of single tests is limited.[64,65] Combinations of shoulder physical tests provide better accuracy, but marginally.[64] Individual pathoanatomical structures that cause shoulder pain, such as impingement syndrome, cannot be isolated by motions or external stresses. Also, shoulder physical assessment has been found to lack acceptable levels of reliability.[66] Because of these limitations, when the clinical examination is ambiguous, shoulder radiography, MRI, and ultrasound are recommended depending on each modality's indications and clinical efficiency.[67]

Based on this review of case studies, PTs often perform diagnostic USI during examination of the extremities. This predominance of USI for these regions may reflect a larger number of patient presentations of these areas in standard outpatient orthopedic clinics. Learning USI skills and understanding pathology may be easier when analyzing these areas. More cases are needed that describe USI use by PTs in other regions such as the spine, hand and wrist, the elbow, and the hip.

Most of the cases described in this paper were patients from an orthopaedic outpatient or sports medicine setting. Since PTs work with patients across diagnostic categories and USI images anatomical structures across physiological systems, more case studies should address other practice areas. Only one case described use in an inpatient physical therapy setting. Indeed, the total number of case reports should increase to provide additional clinical reasoning and diagnostic guidance.

A published case report may stimulate other clinicians to report similar cases, which may, in turn, prompt further investigations to more systematically evaluate a new hypothesis related to diagnosing via USI. The authors encourage standardized data reporting and detailed clinical decision-making descriptions in future imaging case reports. Although the CARE[68] case report checklist covers general items, imaging case reports should provide readers with additional information on clinical reasoning. Useful information for standardized reporting of USI cases may include: 1) How the patient accessed physical therapy services (e.g., referral or direct access); 2) The clinical setting in which services were provided (including whether this was a specialty service); 3) If and when a patient was referred for ultrasound by another professional; 4) The professional designation of the person who performed the USI; 5) other diagnostic testing methods and the results; 6) The PT's specific role in patient triaging and referral; 7) A chronological list of patient care from the onset of symptoms to the date of the examination; and 8) Specific outcomes. Table 2 is a checklist of information the authors feel would be beneficial when publishing USI case studies. The highlighted areas are those not included in the CARE[68] case report checklist.

The limitations of this case report synthesis are primarily due to publication bias. Authors of case reports must be motivated and possess the time and skills to submit a

Table 2. CHECKLIST OF INFORMATION TO INCLUDE WHEN WRITING ULTRASOUND CASE REPORTS.

TOPIC	ITEM	CHECKLIST ITEM	Reported on line #
Title	1	The diagnosis or intervention of primary focus followed by the words "US" and "case report"	
Key Words	2	2 to 5 key words that identify US, the diagnosis, or interventions in the case report	
Abstract	3a	Introduction: What is unique about this case and what did US imaging add to the case	
	3b	Main symptoms, complaints, or important clinical findings	
	3c	The main diagnosis, US diagnosis, reasons for use of US imaging and ultimate outcomes	
	3d	Conclusion: What is the main "take away" lesson from this US case?	
Introduction	4	1 or 2 paragraphs summarizing why this US case is unique	
Patient information	5a	De-identified patient specific information	
	5b	Primary concerns and symptoms of the patient (medical history)	
	5c	Chronological list of patient care from date of onset of symptoms to date of care	
	5d	Medical, family, and psychosocial history including relevant genetic information	
	5e	What was the clinical setting (Out-patient, inpatient)?	
	5f	How did patient access PT (referral from who, direct access)?	
Clinical findings	6	Describe significant PE and important clinical findings	
Timeline	7	Historical and current information from this episode of care organized on a timeline	
Diagnostic Assessment	8a	Diagnostic testing (such as PE, lab testing, imaging, surveys)	
	8b	Any additional testing performed?	
	8c	Diagnostic challenges (such as access to testing, financial, or cultural	
	8d	Diagnosis (including differential diagnosis considered)	
	8e	Who performed the US?	
	8f	Who referred for US (if not performed by PT)?	
	8g	Physical therapist specific role in patient triage and referral?	
Therapeutic Intervention	9a	Types of therapeutic intervention (therapy, surgical, pharmacological, preventative, self-care, etc)	
	9b	Administration of therapeutic intervention (dose, strength, duration)	
	9c	Changes in therapeutic intervention (with rationale)	
Follow-up and Outcomes	10a	Specific clinical outcomes?	
	10b	Important follow-up diagnostic and other tests results	
	10c	Intervention adherence and tolerability (How was it assessed?)	
	10d	Adverse and unanticipated events	
Discussion	11a	A scientific discussion of the strengths AND limitations associate with this case report	
	11b	Discussion of the relevant medical literature with references	
	11c	The scientific rational for any conclusions (including assessment of possible causes)	
	11d	The primary "take-away" lesson of this US case report (without references) in one paragraph	
Patient Perspective	12	The patient should share their perspective in 1 to 2 paragraphs on the treatment they received	
Informed Consent	13	Did the patient give informed consent? Please provide copy.	

PE= Physical examination; US= Ultrasound

manuscript. Journals require case reports to be focused on a novel aspect of clinical practice. The actual frequency of USI for patients utilizing physical therapy and their outcomes is unknown. It is likely that the case reports vastly underrepresent the actual numbers of patients that undergo USI. Also, it is unknown whether patients present with signs and symptoms that are indicators for imaging, but these patients are not referred. The literature search used to gather these case reports may not have captured all studies, especially because the researchers only included papers in the English language. Future research should be more systematic in observations, and methods to standardize USI in clinical practice may provide more accurate information on the impact on patient care. Lastly, future studies

are needed to determine if the clinical reasoning associated with USI in physical therapy differs from other professional environments.

CONCLUSIONS

Ultrasound imaging provided information for physical therapy patient care beyond a traditional physical exam, including aspects that reflect the unique professional framework. PTs are utilizing USI for clinical reasoning associated with various patient presentations that can result in the diagnosis of muscle and ligament strains and sprains, fractures, and vascular problems.

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