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Research Article

Point-of-Care Ultrasonography (POCUS) for Musculoskeletal Conditions in the Emergency Department: A Scoping Review

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Abstract - *Musculoskeletal conditions are among the most common presentations in Emergency Departments (ED) worldwide, contributing significantly to overcrowding and patient burden. While conventional radiography remains the primary imaging modality, being widely regarded as the diagnostic gold standard, emerging evidence highlights the increasing utility of POCUS. Its bedside availability, portability, versatility, and rapid diagnostic capability suggest potential benefits for reducing length-of-stay (LOS) and improving patient flow. Case reports of occult fractures missed on radiographs but later detected using POCUS raise further questions about the limitations of plain films. Beyond diagnostic accuracy, POCUS enables earlier initiation of treatment, avoids exposure to ionising radiation, and offers practical value in resource-limited settings, underscoring its growing relevance in emergency care. This scoping review evaluates the role of POCUS in diagnosing musculoskeletal conditions, outlines its advantages and limitations, assesses its potential integration into ED practice, and identifies gaps to guide future research. A total of 35 studies were included, with study selection mapped using a PRISMA flow diagram; of these, 31 studies support POCUS as a useful diagnostic tool, whereas four report limitations associated with missed ankle injuries, cervical spine injuries, and rib fractures. Overall, current evidence indicates that POCUS is a valuable adjunct in the assessment of musculoskeletal conditions, providing additional diagnostic support through the detection of secondary signs such as soft-tissue injuries, effusions, and haematomas that are not typically visible on radiography, although it cannot yet replace radiography or other gold-standard imaging modalities.*

Keywords - *Diagnostic Accuracy, Emergency Department, Musculoskeletal, Occult Fracture, Point-of-Care Ultrasound*

I. INTRODUCTION

One of the many escalating global health challenges include ED overcrowding [1]. This can be attributed to limited beds as well as a shortage in staffing such as ED physicians and nurses. Various consequences arise including prolonged LOS, higher risks of adverse events, greater morbidity and mortality, poorer patient outcomes, and an overall reduced quality of patient care [2]. Musculoskeletal conditions varying widely from severe limb-threatening injuries and fracture-dislocations to minor contusions and sprains are one of the most frequent complaints seen in EDs [3]. One study reported that musculoskeletal issues accounted for 22% of ED visits [4]. Given the potential of POCUS with its advantages of bedside availability, portability, versatility, and rapid diagnostic capability, its role in diagnosing and managing musculoskeletal conditions, reducing ED LOS, and improving patient flow continues to be actively explored. This scoping review aims to synthesise the current evidence on this topic.

Understanding ultrasound physics is essential, as knowledge of how sound waves interact with tissues enables clinicians to optimise image quality and accurately distinguish normal from pathological findings. Image quality is influenced by several factors, including transducer type and positioning, but most importantly, the operator's skill. The following section outlines key principles of musculoskeletal POCUS, while acknowledging that this overview is not exhaustive. The most commonly used probes are linear, curvilinear, and phased array, each tailored for specific applications through variations in frequency and configuration [5]. High-frequency linear probes provide excellent resolution but limited depth, making them suitable for superficial musculoskeletal structures. In contrast, low-frequency curvilinear probes offer greater depth penetration at the expense of resolution, making them useful for imaging deeper anatomy, such as the adult hip, or for use in larger patients [6]. Image orientation is determined by transducer positioning, enabling visualisation in longitudinal, transverse, coronal, or oblique planes. For musculoskeletal POCUS, the structure of interest should ideally be assessed in at least two views, generally longitudinal and transverse. On ultrasound, a healthy bone cortex is seen as a smooth, bright echogenic line with dark anechoic or hypoechoic shadowing beneath it as bone blocks sound wave penetration. Fractures are identified by a disruption, irregularity, or displacement of this bright echogenic line [3].

Figure 1. Normal Ultrasound of the Tibia using a Longitudinal Transducer Orientation [3]

Figure 2. Normal Ultrasound of the Tibia using a Transverse Transducer Orientation [3]

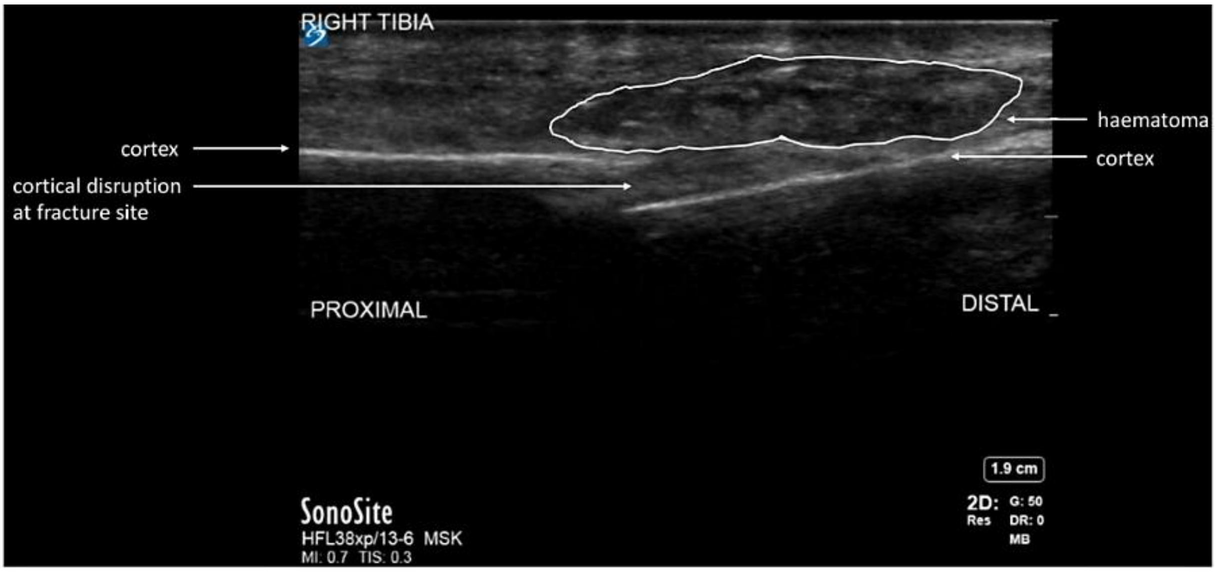

Figure 3. Cortical Disruption and Haematoma of a Tibial Fracture in a Longitudinal Ultrasound View [3]

Dislocations are identified by the loss of normal alignment between joint components. For example, in shoulder dislocations, the humeral head becomes displaced from its usual position relative to the glenoid fossa. This can be confirmed sonographically by assessing and measuring the distance between these structures [7].

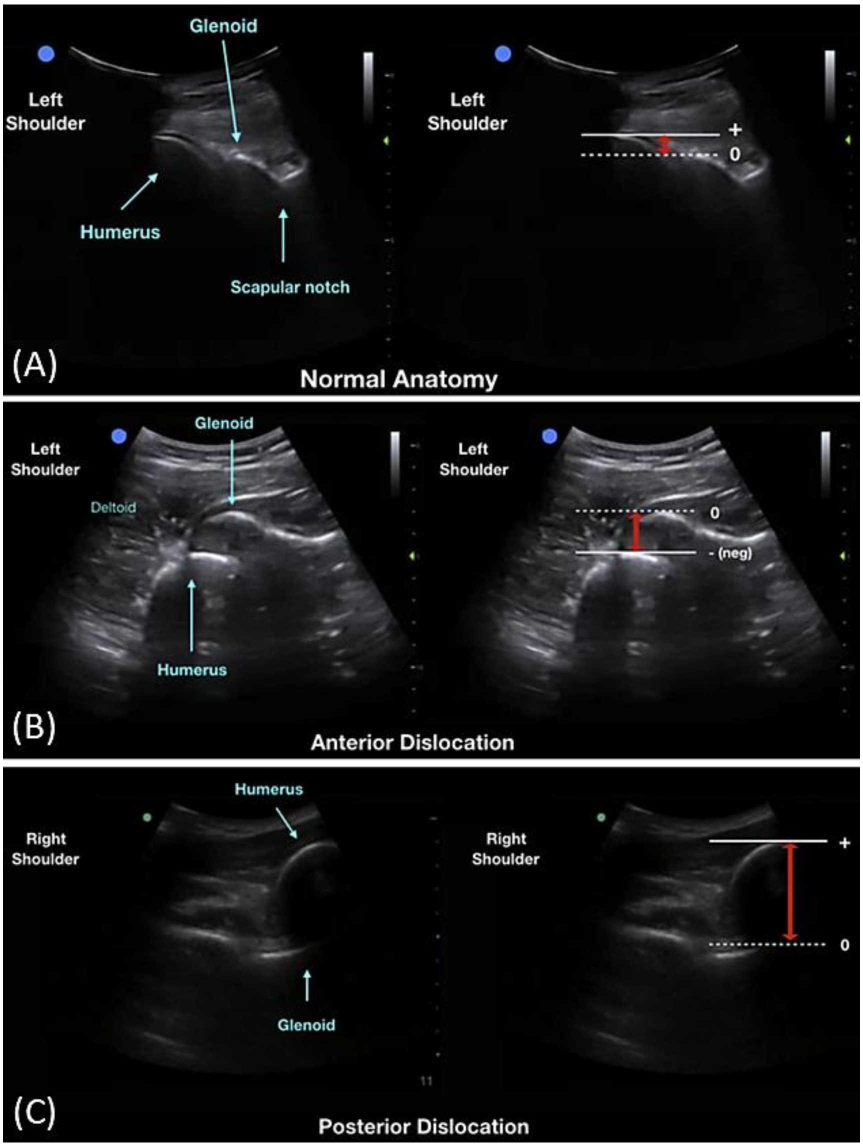

Figure 4. Shoulder Girdle Ultrasound Images acquired using a Curvilinear Probe: (A) Normal Left Glenohumeral Joint, (B) Left Anterior Dislocation with the Humeral Head Displaced Anterior to the Glenoid, and (C) Right Posterior Dislocation with the Humerus Displaced Posterior to the Glenoid. Adjacent Panels Illustrate the Measurement of Glenohumeral Distance (Red Arrows) [7]

Together, these principles emphasise the importance of understanding normal sonographic anatomy, transducer use, and image orientation in order to accurately identify fractures, dislocations, and associated soft tissue findings. While this section provides only a concise overview, mastery of these fundamentals is essential for the reliable application of musculoskeletal POCUS in clinical practice.

II. METHODOLOGY

A. Study Design

This scoping review was designed and reported following the PRISMA-ScR guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) [8].

B. Search Strategy

Scopus, Embase, PubMed, Cochrane Library, and Ovid MEDLINE were searched between 10th and 13th August 2025 using predefined variables. Only English-language publications from peer-reviewed journals within the past 10 years were considered. All primary study types were included, without restrictions on study population, encompassing observational studies (prospective and retrospective), randomised controlled trials, case reports, case series, and more. This broad approach was chosen to capture the full scope of existing literature, highlight current possibilities, identify evidence gaps, and inform directions for future research.

C. Inclusion and Exclusion Criteria

This review included primary research published within the past 10 years that evaluated POCUS for musculoskeletal conditions in the Emergency Department and incorporated a confirmatory diagnostic test such as radiography, Computed Tomography (CT), or Magnetic Resonance Imaging (MRI). Studies were excluded if they were not full-text, not in English, published outside the 10-year window, did not focus on musculoskeletal POCUS in the Emergency Department, or involved non-human subjects.

D. Study Selection

A total of 583 studies were identified through database searches and imported into Covidence (https://www.covidence.org/). After Covidence's identification and removal of 248 duplicates, 335 studies remained for title and abstract screening, of which 293 were excluded. The remaining 42 studies underwent full-text eligibility assessment, resulting in the exclusion of 7 studies. In total, 35 studies were included in this scoping review, as illustrated in the PRISMA flow diagram below.

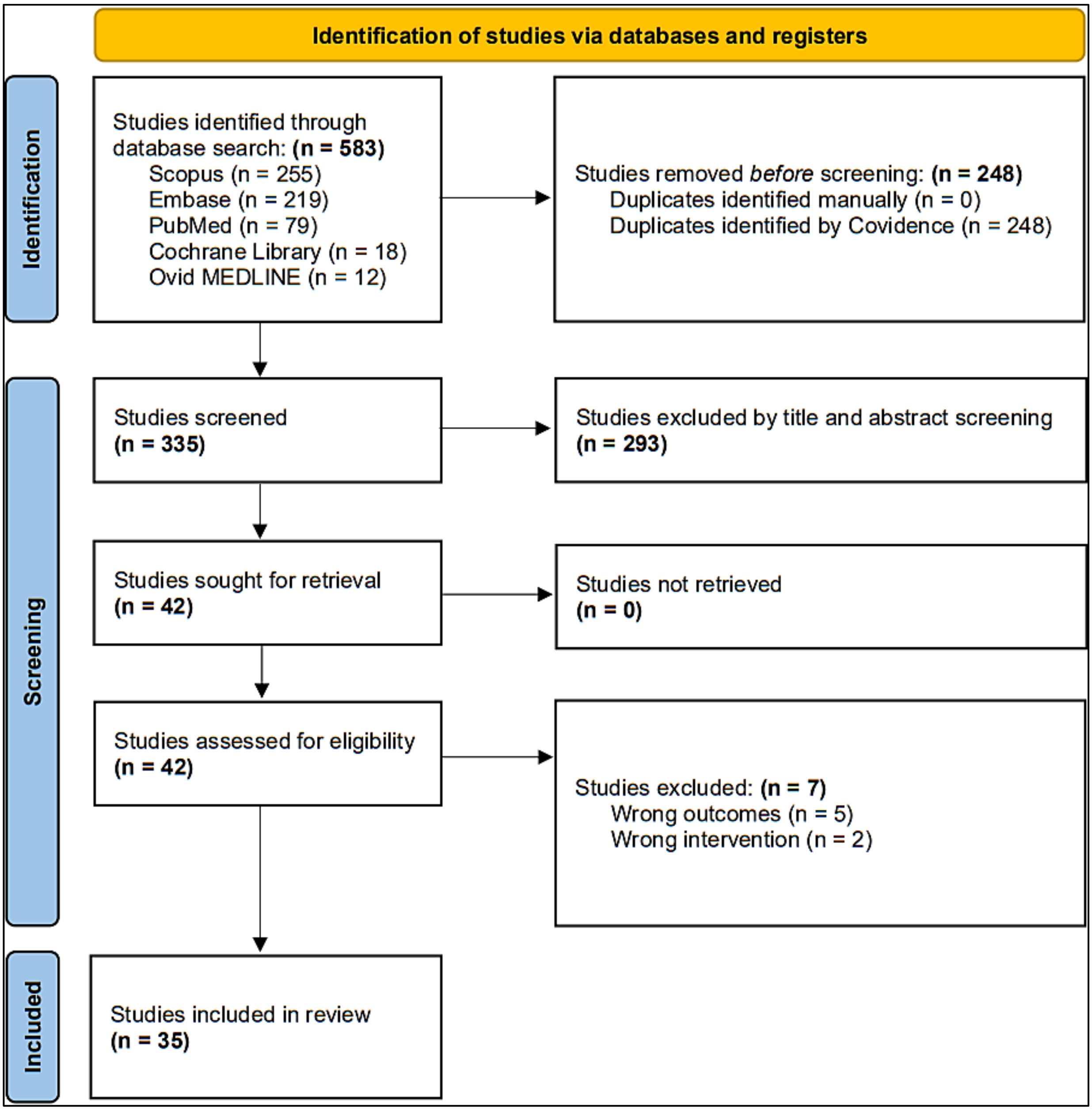

Figure 5. PRISMA Flow Diagram

III. RESULTS

A. Scope of POCUS in Musculoskeletal Conditions

From the 35 studies included in this scoping review, the range of musculoskeletal conditions assessed is notably broad. Spanning from conditions of the skull to metatarsals, essentially covering "head to toe," including fractures, joint dislocations, tendon ruptures, and more. This breadth highlights the potential feasibility of musculoskeletal POCUS as a highly valuable modality in the ED. Importantly, even non-expert ultrasound users have demonstrated strong diagnostic performance; with as little as 1 to 2 hours of training, high sensitivity and specificity have been achieved for conditions such as forearm fractures [9, 10, 11].

B. Diagnostic Accuracy of POCUS

Of the 35 studies included in this scoping review, 31 supported the use of POCUS as a diagnostic tool for the musculoskeletal conditions under investigation. Evidence was particularly strong for diagnosing shoulder dislocations, with three studies reporting 100% sensitivity [12, 13, 14]. Similarly, results for diagnosing paediatric forearm fractures were encouraging, with POCUS sensitivity ranging from 91.5% to 95% and specificity from 86% to 96.8% [9, 10, 11, 15]. Four studies however, highlighted notable limitations, particularly high rates of missed ankle injuries, cervical spine injuries, and rib fractures (see rows marked in red in Table 1). Importantly, nine of the supportive studies reported instances where initial radiographs were negative but POCUS identified fractures that were later confirmed by reference standards such as radiography, CT, MRI, re-evaluation of prior imaging, or repeat imaging (see rows marked in green in Table 1).

Information from all 35 studies is summarised in Table 1, detailing the anatomical regions assessed, operator characteristics and training, comparator imaging modalities, and diagnostic performance metrics including sensitivity, specificity, PPV, and NPV. Overall, the table demonstrates consistent support for POCUS as a useful diagnostic tool for musculoskeletal conditions. Among the included studies, 54% reported that operators received some form of POCUS training prior to participant enrolment, while the remaining 46% did not specify training. Despite this variation, the collective evidence indicates strong support for the use of musculoskeletal POCUS as a promising diagnostic modality.

Table 1. Summary of Included Studies Evaluating POCUS for Musculoskeletal Conditions in the Emergency Department: Green Rows indicate Studies with Initial Radiograph Negative but POCUS Positive Fractures; Red Rows Indicate Studies not in Support of POCUS as a Diagnostic Tool

Author, Year	Publication Type, Sample Size	POCUS Operators	POCUS Training	Anatomic Location, Comparison Image	Outcome
Medero Colon & Chilstrom, 2015 [6]	Case report, 1	Emergency Medicine (EM) physician	-	Femur, CT	Initial radiograph negative, initial POCUS positive for fracture. Confirmatory CT demonstrated a complex, oblique fracture of the right femur through the greater and lesser trochanters.
Scheier et al., 2022 [16]	Case series, 4	Paediatric Emergency Medicine (PEM) physician	-	Tibia, Repeated radiograph	Initial radiograph negative, initial POCUS positive for fracture. A repeat radiograph several days after the injury demonstrated signs of remodelling, such as callus formation, consistent with a prior fracture.
Venn et al., 2024 [17]	Case report, 1	EM physician	-	Mandible, Radiograph	Initial POCUS positive for fracture. Radiograph after

					POCUS demonstrated a displaced mandibular fracture.
Zapolsky et al., 2017 [18]	Case report, 1	PEM attending	PEM fellowship US training	Mandible, CT	Initial POCUS positive for fracture. CT demonstrated minimally displaced fractures of the right mandibular body and left mandibular angle.
Tessaro et al., 2015 [19]	Case report, 1	PEM physician	-	Scaphoid, Review of initial radiograph	Initial radiograph negative, initial POCUS positive for fracture. Review of the initial radiographs demonstrated a scaphoid fracture.
Halm & Chaudoin, 2017 [20]	Case report, 1	EM physician	-	Clavicle, CT	Initial radiograph negative, initial POCUS positive for dislocation with fracture. CT demonstrated a posterior displacement of the medical end of the left clavicle with an associated Salter-Harris 1 clavicular fracture.
McCreary & Chan, 2025 [21]	Case series, 2	PEM physician	-	Clavicle, Repeated radiograph	Initial radiograph negative, initial POCUS positive for fracture. Repeat radiograph, although difficult to appreciate, revealed clavicle fracture.
Tomar Güneysu et al., 2023 [22]	Case report, 1	PEM physician, EM physician	-	Sternum, Repeated radiography & CT	Initial radiograph negative, initial POCUS positive for fracture. Repeat radiograph demonstrated sternal fracture, CT was performed to confirm diagnosis and exclude additional injuries but was reported normal. CT was re-evaluated, a sternum body greenstick fracture was observed.
Rogers-Shepp et al., 2025 [23]	Case report, 1	ED POCUS team	-	Elbow, Repeated radiograph	Initial radiograph negative, initial POCUS positive for secondary signs of fractures (fat pad sign & lipohaemarthrosis). Repeat radiograph at orthopaedic follow-up 1 week later showed avulsion fracture of capitellum.
Ali et al., 2024 [24]	Case report, 1	EM fellow	-	Biceps tendon, Radiology-performed ultrasound	Initial POCUS positive for ruptured distal biceps tendon. Radiology-performed ultrasound confirmed the POCUS findings.
Neill et al.,	Case report, 1	EM physician	-	Fibula,	Initial POCUS positive for

2020 [25]				Radiograph	fracture. Radiograph after POCUS demonstrated a proximal fibula fracture.
Ang, 2025 [26]	Case report, 1	EM physician	-	Femur, Radiograph	Initial POCUS positive for neck of femur fracture. Subsequent radiographs confirmed the diagnosis.
Naheed Habibullah et al., 2023 [27]	Case report, 1	EM consultant	-	Achilles Tendon & Calcaneus, MRI	Initial radiograph positive for calcaneal fracture, initial POCUS noted a fracture but additionally, demonstrated a tendon rupture. Outpatient MRI was done which reported an avulsion fracture of the calcaneus at the attachment site of the Achilles tendon with retraction of the partially ruptured Achilles tendon.
Ali et al., 2016 [28]	Case report, 1	EM physician	-	Femur, Radiograph	Initial POCUS positive for femur fracture, subsequent radiograph confirmed diagnosis.
Ahmadi et al., 2024 [29]	Prospective study >18y, 157	EM specialists	2h lecture, 4h practical	Medial Meniscus, MRI	POCUS sensitivity, 88.8%; POCUS specificity, 89.7%; POCUS PPV, 91.9%; POCUS NPV, 85.9%; POCUS Accuracy: 89.2%
Kilic et al., 2016 [30]	Prospective study >18y, 92	Sonographers	1h theory, 2h practical, demonstration on 3 patients with patella fracture	Patella, Radiograph	POCUS sensitivity, 93.3%; POCUS specificity, 94.8%; POCUS PPV, 77.8%; POCUS NPV, 98.7%
Kozaci et al., 2017 [31]	Prospective study 5-55y, 72	EM physicians	1h theory, 1h practical, demo POCUS on 3 patients	Metatarsals, Radiograph	POCUS sensitivity, 93%; POCUS specificity, 89%; POCUS PPV, 84%; POCUS NPV, 95%
Nadler et al., 2022 [32]	Prospective study 0-21y, 120	PEM physicians	1h practical, reference manual	Ankle, Radiograph	POCUS sensitivity, 78%; POCUS specificity, 71%; POCUS PPV, 18%; POCUS NPV, 98%
Smith et al., 2024 [33]	Prospective study 6-18y, 118	PEM attendings	10 minute presentation, 2h practical, demo POCUS on 5 patients	Ankle, Radiograph	POCUS sensitivity, 60%; POCUS specificity, 96%; POCUS PPV, 69.2%; POCUS NPV, 94.3%
Bahadır Çağlar et al., 2017 [34]	Prospective study >16y, 103	Medical assistant	Had prior basic and advanced US training with experience on >100 emergency surveillance US	Nose, Radiograph	POCUS sensitivity, 84.8%; POCUS specificity, 93%; POCUS PPV, 90.7%; POCUS NPV, 88.3%

Masaeli et al., 2019 [35]	Prospective study <18y, 538	EM attendings, 3rd year EM residents	Emergency US workshop	Skull, CT	POCUS sensitivity, 92.31%; POCUS specificity, 95.87%; POCUS PPV, 79.1%; POCUS NPV, 98.6%
Ravikanth, 2021 [36]	Comparative study, 284	Sonographer	-	Cervical spine, CT	POCUS sensitivity, 78.5%; POCUS specificity, 98.4%; POCUS PPV, 93.2%; POCUS NPV, 92.8%; Accuracy: 93.2%
VK et al., 2021 [37]	Cross-sectional study, 84	EM physicians	Training in the POCUS algorithm to identify C-spine injuries, demo POCUS on 20 normal and 10 abnormal cases	Cervical spine, CT	POCUS sensitivity, 45.8%; POCUS specificity, 83.3%; POCUS PPV, 94.3%; POCUS NPV, 20.4%
Çelik et al., 2021 [38]	Prospective study ≥18y, 145	Senior EM resident	Certified for basic and advanced bedside sonography, 6 weeks rib US practice	Ribs, CT	POCUS sensitivity, 91.2%; POCUS specificity, 72.7%; POCUS PPV, 68.4%; POCUS NPV, 92.8%
Aksay et al., 2016 [39]	Prospective study >14y, 119	Sonographers	Demo POCUS on 5 patients with radiologically confirmed phalanx fracture	Proximal and middle phalanges, Radiograph	POCUS sensitivity, 79.3%; POCUS specificity, 90%; POCUS PPV, 71.8%; POCUS NPV, 93.1%
Kozaci et al., 2015 [40]	Prospective study 5-55y, 66	EM physicians	-	Metacarpals, Radiograph	POCUS sensitivity, 92%; POCUS specificity, 87%; POCUS PPV, 89%; POCUS NPV, 90%
Attard Biancardi et al., 2021 [12]	Prospective study >16y, 1206	EM physicians	All had prior US training, additional 1h theory and 1h practical training for study	Shoulder, Radiograph	Dislocation (POCUS sensitivity, 100%; POCUS specificity, 100%; POCUS PPV, 100%; POCUS NPV, 100%), Proximal humeral fracture (POCUS sensitivity, 96.6%; POCUS specificity, 99.1%; POCUS PPV, 97.7%; POCUS NPV, 98.6%)
Secko et al., 2020 [13]	Prospective study ≥18y, 65	US fellows, EM fellows	Short instructional video, demo POCUS on actual patients	Shoulder, Radiograph	POCUS sensitivity, 100%; POCUS specificity, 100%; POCUS PPV, 100%; POCUS NPV, 100%
Seyedhosseini et al., 2017 [14]	Prospective study >16y, 84	EM physicians, EM chief resident	6h US training	Shoulder, Radiograph	POCUS sensitivity, 100%; POCUS specificity, 80%; POCUS PPV, 98.7%; POCUS NPV, 100%
Epema et al., 2019 [9]	Prospective study 0-14y, 100	EM physicians, EM residents	1h US training (lecture & practical)	Distal forearm, Radiograph	POCUS sensitivity, 95%; POCUS specificity, 86%; POCUS PPV, 92%; POCUS NPV, 91%
Galletebeitia	Prospective	PEM	Theory and	Distal forearm,	POCUS sensitivity, 94.4%;

Laka et al., 2019 [10]	study <15y, 115	physician, 1st year pediatric resident	practical training on healthy models along with 25 demo POCUS scans	Radiograph	POCUS specificity, 96.8%; POCUS PPV, 93.2%; POCUS NPV, 97.5%
Poonai et al., 2017 [15]	Cross-sectional study 4-17y, 169	PEM physicians	All had certification through the Canadian Emergency Ultrasound Society, additional training included viewing a 4-min video, 25 satisfactory demo POCUS scans	Distal forearm, Radiograph	POCUS sensitivity, 94.7%; POCUS specificity, 93.5%; POCUS PPV, 92.3%; POCUS NPV, 95.6%
Rowlands et al., 2017 [11]	Prospective study 0-16y, 419	EM consultants, EM senior trainees	80-min theory, 1 quiz, 2h practical (vast majority had no previous US experience)	Forearm, Radiograph	POCUS sensitivity, 91.5%; POCUS specificity, 87.6%
Haak et al., 2024 [41]	Prospective study ≥4y, 167	EM consultants, EM registrars	All had passed national ED PoCUS certification program, additional training: 2-min video, 10-min presentation	Clavicle, Radiograph	POCUS sensitivity, 93%; POCUS specificity, 93%
Boniface et al., 2020 [42]	Case series, 5	EM physician	-	Hip, CT/MRI	Initial radiograph negative, initial POCUS positive for hip effusion later diagnosed to be septic arthritis by synovial fluid microbiologic examination. CT or MRI scans were used to confirm the hip effusion.

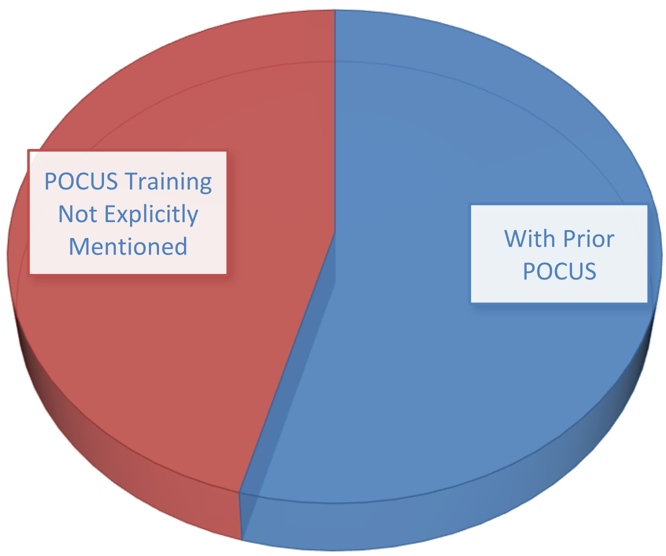

Figure 6. Pie Chart Depicting the Training of POCUS Operators in the Included Studies

C. Advantages and Limitations of POCUS in the ED

a. Safety Across Patient Groups

POCUS is a safe imaging modality for patients who should avoid ionising radiation, such as pregnant individuals or those with certain active cancers. Although there is no strict exposure limit for children, the ALARA principle (As Low As Reasonably Achievable) emphasises that any radiation dose carries some risk and should therefore be minimised [11]. In contrast, MRI has several absolute and relative contraindications, requiring patients to complete a detailed safety checklist before having one done.

Individuals with non-MRI-compatible pacemakers, implantable cardioverter-defibrillators, ferromagnetic metallic implants, or certain cochlear implants cannot undergo MRI safely. POCUS circumvents these restrictions. Furthermore, MRI and CT often require sedation, particularly for children who cannot remain still, patients with severe claustrophobia or anxiety, or those with involuntary movements such as tremors or Parkinson's disease. Ultrasound, however, requires no sedation, avoiding the associated risks and making it a more accessible and safer option for these populations.

b. Cost-Effectiveness and Resource Utilisation

Ultrasound is highly cost-effective, being substantially cheaper than other imaging modalities. One study reported that, in Europe, the average cost of a cardiac CT is approximately 3.1 times higher than that of a cardiac ultrasound, while a cardiovascular MRI is about 5.5 times more expensive [43]. POCUS also helps avoid unnecessary scans; for example, an estimated one million children in USA undergo unnecessary brain CTs annually. A prospective cross-sectional study of 538 paediatric patients demonstrated excellent concordance between brain CT and head ultrasound in detecting skull fractures, suggesting that performing head POCUS prior to CT could prevent many unnecessary scans [35].

Young patients may additionally struggle to localise pain or describe injuries, often resulting in multiple radiographs, increased radiation exposure, and higher costs [16]. When POCUS findings are positive and consistent with clinical suspicion, further investigation using more advanced imaging is better justified [6]. Integrating POCUS at triage can therefore help identify which patients require further work-up and which do not, improving efficiency and reducing unnecessary imaging [41].

c. Portability and Versatility

Ultrasound's portability and versatility allow it to be used in a wide range of clinical environments, making it one of the most adaptable imaging modalities available. Unlike radiography, CT, or MRI, which require large, immobile, and expensive machines housed within specialised facilities, POCUS can be performed at the patient's bedside with compact, hand-held devices. This mobility makes it particularly valuable in remote and rural clinics where access to advanced imaging is limited, as well as in mobile health units, including those deployed at sporting events, mission trips, and humanitarian aid settings. In addition, its use has been documented during disasters such as earthquakes, wars, and mass-casualty incidents, where rapid and accurate diagnosis is essential and other imaging options may be unavailable [12, 31].

The versatility of ultrasound also extends across specialties. It can be applied in emergency medicine for trauma assessment, in obstetrics for foetal monitoring, and in cardiology for bedside echocardiography. This cross-specialty utility means that a single portable ultrasound machine can serve multiple departments or purposes within the same clinical setting, maximising cost-effectiveness. Furthermore, technological advances have led to the development of wireless probes and smartphone-compatible devices, making POCUS even more accessible and practical for use in both high-resource hospitals and low-resource field conditions [44, 45].

d. Patient Comfort and Pain Reduction

Several studies had a secondary objective of investigating the patient's pain during POCUS. A prospective study of 419 patients found that pain during ultrasound was similar to that of X-ray [11]. In another study of 169 patients with non-angulated distal forearm fractures, pain during POCUS was lower than with X-ray which was statistically significant [15]. These findings suggest that pain is not a barrier to ultrasound use in the emergency department.

Pain is sometimes accidentally inflicted where patient positioning is required for taking specific X-ray views. For example, patella fractures with negative anteroposterior and lateral radiographs often require a sunrise view radiograph which can illicit pain to the patient, but a study found that POCUS was able to detect patella fractures in four patients whose initial radiographs were negative [30]. Unlike radiography, POCUS allows imaging in multiple angles and planes without moving the patient into painful positions. In paediatric cases, children can even be scanned comfortably while seated in a pram or held securely in their parent's arms [16].

e. Diagnostic Value and Clinical Impact

Table 1 demonstrates strong support for POCUS as a reliable diagnostic modality for musculoskeletal conditions. Its versatility and ability to visualise injury sites from multiple angles and planes allow comprehensive assessment, while real-time scanning of the asymptomatic contralateral side allows for an immediate comparison [10, 31]. Importantly, nine studies reported fractures that were missed on initial radiographs but subsequently identified using POCUS, highlighting its diagnostic advantage. Beyond fractures, POCUS also detects soft tissue injuries and joint effusions that are often not clearly visible on radiographs. The identification of such secondary signs can strengthen diagnostic confidence; for example, the fat pad sign or lipohaemarthrosis in elbow fractures [23] and peritrochanteric oedema in hip fractures [6].

Another significant benefit is the potential for early diagnosis. POCUS can be performed directly at the bedside by the treating physician, often alongside history-taking, thereby streamlining the diagnostic process. Rapid diagnosis translates into improved patient comfort, earlier initiation of treatment, and faster referral. For instance, in femoral fractures, POCUS can facilitate immediate diagnosis, stabilisation, early analgesia, and a quicker referral to orthopaedics [28]. In cervical spine injuries, it enables earlier clearance, reducing collar-related complications such as soft-tissue abrasions, while supporting timely decision-making for intubation when necessary [36, 37]. Similarly, in patients with rib fractures, prompt detection helps prevent pulmonary complications by allowing timely and appropriate management [38]. By enabling early consultation and expedited referral, POCUS improves interdepartmental coordination and accelerates patient management pathways [18, 28].

Decreased time to diagnosis also has important implications for ED flow and LOS. In a study on shoulder dislocations, the median time to diagnosis with POCUS was significantly lower at 51 minutes compared with 101 minutes using radiography, allowing earlier reduction and potentially reducing muscle spasms that complicate the procedure [13]. In another shoulder dislocation study also with statistically significant results, the mean time to the first POCUS examination was 7.19 minutes compared with 20.8 minutes for radiography, while after reduction, the second POCUS was performed in 4.4 minutes compared with 18.3 minutes for radiography [14]. Similarly, in a study on ankle injuries, the median time to diagnosis was 10 minutes with POCUS versus 26 minutes with radiography [32]. Collectively, these findings highlight the value of POCUS in expediting diagnosis, improving workflow efficiency, and ultimately enhancing patient care in the ED.

f. Training and Skill Acquisition

POCUS has been shown to be effective even when performed by non-experts after brief training sessions of 1 to 2 hours. High sensitivity and specificity were achieved with minimal prior experience, and proficiency improved rapidly with each scan [9, 10, 11]. Its simplicity and rapid learning curve mean that a wide range of healthcare providers can be trained to use POCUS, making it particularly valuable during after-hours when radiologists may not be available.

g. Operator Dependence

Although POCUS is often criticised as being highly operator-dependent, there is strong evidence that high diagnostic accuracy can be achieved even by ultrasound-naïve physicians even after brief training. A prospective study in the Netherlands compared POCUS with radiography for diagnosing paediatric distal forearm fractures in 100 patients. Examinations performed by ED residents and physicians with limited prior ultrasound experience achieved a sensitivity of 95%, specificity of 86%, PPV of 92%, and NPV of 91%, demonstrating that good accuracy is attainable even with minimal training [9]. Similarly, a larger prospective study involving 419 paediatric patients found a sensitivity of 91.5% and specificity of 87.6% for POCUS compared with radiography.

The main aim was to determine if emergency physicians with minimal or no prior ultrasound experience could, after brief training, accurately rule out forearm fractures in children, a goal that was successfully met [11].

h. Risk of Missed Diagnoses and Radiation Considerations

POCUS has lower sensitivity and specificity than other gold-standard diagnostic modalities such as X-ray, CT, and MRI. Because of this, there is a risk of missed diagnoses which could lead to poor patient outcomes and medicolegal implications. Therefore, physicians are often uncomfortable about forgoing radiography when there is a clinical suspicion of a musculoskeletal condition [33, 41]. Even though ultrasound has the benefit of not having ionising radiation, it is very unlikely for a patient to undergo enough radiation exposure from X-rays and CT scans in their lifetime to cause side effects such as cancer. The benefit of diagnosis and treatment almost always outweighs the risk from X-ray and CT radiation. The American Association of Physicists in Medicine states that cancer risk is negligible or absent at exposure levels below 100 mSv. In contrast, doses at or above 100 mSv are consistently regarded as carcinogenic [46].

The Biological Effects of Ionising Radiation VII report estimated that solid cancer or leukaemia develops in approximately 1 in 100 individuals for every 100 mSv of radiation exposure [47]. Conventional X-ray effective doses for adults typically range from around 0.01 mSv for a lateral skull X-ray to about 0.5 mSv for an abdominal X-ray [48]. To put this into perspective, to reach a cumulative dose of 100 mSv, the level associated with a measurable increase in cancer risk, one would have to obtain approximately 200 abdominal X-rays.

CT however, delivers considerably higher doses, ranging from about 0.5 mSv for extremity imaging up to 15 mSv for an abdomen-pelvis or ureteric study, meaning 7 CT scans are enough to reach 100 mSv [49]. Large-scale investigations have provided further insights into cumulative radiation risk. At Maastricht University Medical Centre, a cohort study of 49,978 patients found that only 1% received a high cumulative dose of ≥100 mSv from one or more CT examinations within five years [46]. Similarly, a nationwide Chinese study analysing more than 3.3 million X-ray examinations across 1.1 million patients over 16 years reported an average cancer incidence risk of just 0.01% from diagnostic X-ray exposure. While this risk is considered acceptable in clinical practice, patients with recurrent imaging, particularly those with congenital or oncological conditions face higher cumulative exposure and therefore potentially increased risk [50].

A retrospective study conducted at an urban tertiary trauma centre over 7.7 years reported that only 1.9% of 6,901 emergency department patients undergoing CT had accumulated high radiation doses due to multiple or repeat imaging. Within the 1.9%, cumulative CT doses reached an average of 122 mSv, corresponding to a lifetime attributable cancer risk of 1 in 82 [49]. These studies indicate that, for the majority of patients undergoing imaging that involves radiation, the exposure is often not a major concern. Other downsides of ultrasound is that the waves do not penetrate bone, which causes deeper structures to appear as anechoic or hypoechoic shadows and makes accurate interpretation more challenging [25]. Additionally, ultrasound cannot fully assess the extent or orientation of a fracture line, which limits its ability to characterise some injuries [19].

i. Patient-Related Challenges

Several practical challenges can limit the accuracy of POCUS in fracture diagnosis. Probe pressure may cause pain at the injury site, therefore requiring analgesia, and interpretation can be difficult in the presence of overlying effusion or in patients with a large body habitus. In children, growth plates complicate image interpretation, and there is a risk of mistaking normal ossification centres for fractures [9, 15, 22, 33]. Although POCUS has a steep learning curve, specificity and diagnostic accuracy improve with experience [9].

IV. DISCUSSION

Musculoskeletal POCUS demonstrates considerable potential but is most appropriately used as an adjunct rather than a substitute for established imaging modalities such as radiography, CT, or MRI. While existing evidence suggests that clinicians can achieve strong diagnostic accuracy even with limited training, further research is needed to confirm these findings and to reduce methodological bias, particularly through improved standardisation of operator expertise. Nonetheless, several limitations persist. POCUS generally has lower sensitivity and specificity compared with conventional imaging, which restricts its capacity as a stand-alone diagnostic tool. A negative examination should not exclude further imaging where clinical suspicion remains high. These limitations are especially relevant when evaluating subtle fractures or anatomically complex regions, such as paediatric ossification centres, where interpretation may be challenging.

Operator training remains a critical component of safe and effective POCUS use. Anatomical regions such as the physis, epiphysis, and metaphysis require particular attention within training curricula due to their complexity. Standardised education programmes, complemented by ongoing supervised clinical practice, would help ensure consistent image acquisition and interpretation, ultimately promoting greater diagnostic reliability. Such measures will support the broader integration of musculoskeletal POCUS into routine practice across multiple specialties.

V. CONCLUSION

Musculoskeletal POCUS offers clear advantages in settings where rapid, accessible, and bedside imaging is valuable, particularly in the emergency environment. However, its role remains complementary to conventional imaging, given current limitations in sensitivity, specificity, and operator-dependent interpretation. Realising the full potential of POCUS will require rigorous, high-quality research, broader exploration across diverse clinical contexts, and the development of robust, standardised training frameworks. With continued refinement and evidence development, musculoskeletal POCUS is well positioned to become a reliable and widely applicable tool that enhances patient care across clinical specialties.

VI. FUTURE RECOMMENDATIONS

Future research should prioritise methodological rigour and broader clinical evaluation. Blinding POCUS operators to patient history and mechanism of injury would help reduce information bias and strengthen the validity of future studies. Research designs should also better reflect real-world practice by allowing operators to select the most appropriate transducer for each examination, thereby enhancing the generalisability of findings.

Another important direction is to expand research beyond the ED. Investigating the role of musculoskeletal POCUS in departments such as geriatrics where falls are a common presentation often associated with significant injuries, including fractures may provide valuable insight into its broader clinical utility. Given that falls are recognised as one of the "geriatric giants," exploring POCUS use in this population could help clarify its impact on early and accurate fracture assessment, ultimately improving care for this vulnerable group.

Conflicts of Interest

There are no conflicts of interest concerning the publishing of this paper

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