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Systematic Review

Artificial intelligence and point-of-care imaging in the early diagnosis of orthopaedic surgical emergencies: a systematic review

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ABSTRACT

Orthopaedic surgical emergencies such as acute fractures, dislocations, compartment syndrome, septic arthritis, and other time-critical musculoskeletal conditions need prompt and accurate diagnosis to avert serious complications and functional disability. Artificial intelligence (AI) and Point-of-Care Imaging (POCI) are promising technologies to accelerate diagnostics and support emergency clinical decision-making. Objectives were to systematically review the current evidence on the diagnostic accuracy and clinical utility of AI and POCI in the early diagnosis of orthopedic surgical emergencies. A systematic review was conducted based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA). PubMed, Scopus, Web of Science, Embase and Google Scholar were searched for studies published from January 2015 to 14 March 2026. We included studies that assessed the use of AI, machine learning, deep learning, computer vision, or picture archiving and communication system technologies for the diagnosis or triage of orthopedic surgical emergencies. Data on diagnostic performance, imaging modality, emergency condition, and clinical applicability were extracted and qualitatively and quantitatively synthesized when applicable. Thirty-three studies met the inclusion criteria. To date, most AI applications have focused on fracture detection on plain radiographs, with several systems showing diagnostic performance comparable to experienced clinicians. The availability of point-of-care ultrasonography and portable imaging allowed for rapid bedside assessment of fractures, dislocations, and selected soft-tissue injuries. The integration of AI with POCI showed promise in reducing delays in diagnosis, improving triage, and allowing timely specialist referral and surgical decision-making. However, important limitations remained, including heterogeneity in datasets, lack of external validation, and variable integration in the clinical setting. AI and POCI represent promising tools for the early diagnosis of orthopaedic surgical emergencies. Future prospective, multi-centre studies with standardized validation and real-world clinical evaluation are needed to determine their efficacy and guide large-scale implementation.

Keywords: Artificial intelligence, Point-of-care imaging, Orthopaedic emergencies, Fracture detection, Deep learning, Diagnostic accuracy

INTRODUCTION

Orthopaedic surgical emergencies are an important health problem worldwide because failure or misdiagnosis can lead to irreversible tissue damage, permanent disability, infection, limb loss, and increased mortality. These include complex fractures, dislocations, open injuries, compartment syndrome, septic arthritis, acute limb

ischemia and other time-critical musculoskeletal disorders that require prompt recognition and appropriate surgical intervention. Hence, rapid diagnostic assessment is important for the timely initiation of treatment and improvement of patient outcomes.[1]

Conventional imaging modalities, especially plain radiographs, computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonography, are the main tools for the evaluation of orthopaedic emergencies. However, limitations in imaging availability, interpretation time, access to equipment and differences in clinician expertise may lead to diagnostic delays, especially in emergency departments, rural areas and healthcare settings with limited resources.[2] POCI, including portable radiography and point-of-care ultrasonography (POCUS), has the potential to provide rapid bedside assessment and facilitate immediate clinical decision-making.[3]

The development of AI through machine learning, deep learning and computer vision has opened new opportunities for improving the interpretation of musculoskeletal imaging. AI-based systems can identify fractures, dislocations and other abnormalities on radiographs and other imaging modalities, which may improve diagnostic accuracy and reduce missed injuries.[4] Deep learning algorithms, in particular, have shown promising performance in fracture detection involving the hip, wrist, ankle, shoulder, pelvis and other anatomical sites.[5]

The combination of AI with POCI may provide additional benefits in the early diagnosis of orthopaedic surgical emergencies. AI-guided image interpretation may assist clinicians in the rapid identification of clinically meaningful abnormalities, triage of urgent cases and support of non-specialist healthcare providers in situations where immediate access to a radiologist or orthopaedic specialist is not available.[6] POCUS can also assist in the rapid bedside assessment of fractures, joint pathology, soft-tissue injuries and vascular complications, thereby reducing the time from patient presentation to diagnosis.[7]

Several challenges remain despite these advances. AI performance could be influenced by differences in image quality, patient populations, anatomical regions examined and training datasets.[8] Many algorithms are developed and validated internally using retrospective datasets, whereas external validation and prospective evaluation in real-world emergency settings remain limited. Moreover, the clinical integration of AI needs to consider interpretability, workflow compatibility, data privacy, cost and the appropriate balance between automated systems and professional clinical judgment.[9]

Given the growing burden of orthopaedic surgical emergencies and the increasing availability of AI and portable imaging technologies, a comprehensive synthesis of the current evidence is warranted. The objective of this systematic review is to assess the diagnostic accuracy, clinical utility and potential role of AI and POCI in the early diagnosis and triage of orthopaedic surgical emergencies. This study reviews current evidence on the benefits, limitations and implementation challenges of these technologies and highlights priorities for future research and clinical practice.[10]

Objectives

The main objective of this study was to conduct a thorough review and synthesis of the existing data on the use of AI and POCI for the early diagnosis of orthopedic surgical emergencies. In particular, the study aimed to evaluate the diagnostic accuracy and clinical performance of AI-based technologies, including machine learning, deep learning, and computer vision, in the detection of fractures, dislocations, and other time-critical orthopaedic conditions. The study also explored the potential of POCI modalities such as POCUS, portable radiography, and other bedside imaging technologies to expedite diagnosis and clinical decision-making. Additionally, the review evaluated the potential of AI integration with POCI to improve diagnostic speed, triage, early specialist referral, and surgical decision-making. Other objectives were to identify the main limitations and challenges to implementation of these technologies, to assess their performance compared with clinicians or traditional diagnostic approaches, and to identify current evidence gaps and research priorities.

METHODS

This systematic review was conducted following the PRISMA guidelines to ensure transparency, methodological rigor, and reproducibility. The literature search involved studies published between January 2015 and March 2026, describing the development and recent clinical use of AI and POCI in the diagnosis of orthopaedic surgical emergencies. Eligibility criteria were defined before the selection of studies. Studies were included if they evaluated AI-based technologies such as machine learning, deep learning, neural networks, or computer vision and/or POCI technologies for the early diagnosis, detection, or triage of orthopaedic surgical emergencies. Eligible conditions included acute fractures, dislocations, compartment syndrome, septic arthritis, traumatic musculoskeletal injuries and other time-critical orthopedic conditions.

Eligible studies reported diagnostic accuracy, sensitivity, specificity, area under the receiver operating characteristic curve (AUC), clinical utility, diagnostic time, or impact on clinical decision-making. The studies included were randomized controlled trials, prospective and retrospective cohort studies, diagnostic accuracy studies, case-control studies, and systematic reviews or meta-analyses with relevant clinical evidence.

Exclusion criteria were studies involving non-human subjects, not related to orthopaedic emergency diagnosis,

or not evaluating AI or POCI technologies. The exclusion criteria were case reports, editorials, conference abstracts, narrative reviews, duplicate publications, and studies with insufficient data for the outcome.

Methods of data collection

We performed an extensive literature search in PubMed, Scopus, Web of Science, Embase, and Google Scholar. We used relevant keywords and Medical Subject Headings (MeSH) terms such as "artificial intelligence, machine learning, deep learning, computer vision, POCI, point-of-care ultrasound, fracture detection, orthopaedic emergencies, trauma, dislocation, and diagnostic accuracy.

Titles and abstracts were reviewed independently by two reviewers, and potentially eligible studies were taken forward for full-text review. Disagreements were resolved by discussion or by consulting a third reviewer. Data extraction was conducted using a standardized data collection form including the following: publication characteristics, study design, patient population, emergency condition, imaging modality, AI technology, comparator, diagnostic outcomes, clinical applications, and principal findings.

Analysis of the data

Data were both qualitatively and quantitatively generated. A descriptive synthesis summarized study characteristics, AI technologies, patient-oriented communication and interaction modalities, orthopaedic conditions evaluated, and clinical outcomes reported. A quantitative meta-analysis was performed where there was enough clinical and methodological homogeneity between the studies.

Where possible, we extracted or calculated diagnostic performance measures including sensitivity, specificity, positive and negative predictive values, diagnostic odds ratios and area under the receiver operating characteristic curve. Appropriate statistical models were used to generate pooled estimates; random-effects models were used in the presence of substantial clinical or methodological heterogeneity. Heterogeneity was tested using the I2 statistic and Cochran's Q test. Subgroup analyses were performed where appropriate according to imaging modality, anatomical region, type of AI technology, emergency condition, and study design. Where a sufficient number of studies was available, funnel plots and appropriate statistical tests were used to assess publication bias. Statistical analyses were performed using standard software for systematic reviews, e.g., RevMan, STATA or equivalent statistical packages.

Literature review

Orthopaedic surgical emergencies are a major clinical problem. Delays in diagnosis can result in irreversible tissue damage, permanent disability, infection, limb-threatening complications, and increased mortality. These emergencies include complex fractures, dislocations, open injuries, compartment syndrome, septic arthritis, acute limb ischemia and other time-critical musculoskeletal conditions. Thus, early diagnosis is essential to evaluate the urgency of intervention and initiate appropriate surgical or medical treatment.[11]

Conventional imaging remains the mainstay of diagnosis in emergency orthopaedics. Plain radiography is the initial investigation of choice in suspected fractures and dislocations because of its availability, speed and relatively low cost. However, missed fractures and subtle abnormalities remain important diagnostic problems, particularly in anatomically complex areas such as the hip, wrist, pelvis and shoulder. CT and MRI offer additional diagnostic information but may be limited by availability, cost, patient transport requirements and delays in the emergency setting.[12]

The use of POCI has become increasingly important in the rapid assessment of patients with suspected orthopaedic emergencies. Point-of-care ultrasound (POCUS) can be performed at the bedside, eliminating the need to transport unstable patients to the radiology department. It has shown promise in the diagnosis of fractures, joint effusions, soft-tissue injuries, tendon pathology and vascular abnormalities.[13]

Portable radiography and other mobile imaging technologies may further facilitate rapid diagnosis in emergency departments, trauma units, prehospital environments and low-resource settings.

AI has significantly expanded the possibilities in medical imaging. Machine learning, deep learning, convolutional neural networks and computer vision systems can be used to analyze large amounts of imaging data and identify patterns that may be difficult to recognize through traditional visual assessment. The detection of fractures using AI has been widely studied, particularly with plain radiographs. Several studies have demonstrated promising diagnostic performance for hip, wrist, ankle, shoulder, pelvic, and other fractures, with some algorithms showing performance comparable to that of experienced clinicians or radiologists.[14]

AI has also been explored as a tool for detecting subtle or occult fractures. Automated image analysis in emergency settings may assist in identifying abnormalities that could otherwise be missed, thereby reducing diagnostic errors and allowing timely treatment.[15] AI systems can also support image prioritization, allowing radiographs with suspected significant abnormalities to be reviewed more rapidly. This function could be especially useful in busy emergency departments with high patient volumes and substantial radiology workloads.[16]

The combination of AI and POCI represents an important emerging area of clinical innovation. AI-assisted interpretation of bedside imaging may provide clinicians

with limited radiological expertise with additional diagnostic support at the point of care. This approach may be particularly useful in rural hospitals, emergency departments, military settings and low-resource environments where access to specialist radiologists or orthopaedic surgeons may be limited.[17]

Despite these encouraging developments, significant challenges persist. The diagnostic performance of AI algorithms may be affected by the quality and diversity of training datasets, imaging equipment, patient populations and anatomical regions.[18] Many published studies are retrospective and based on single-centre datasets, limiting their generalizability. Furthermore, the absence of external validation and prospective evaluation in real-world emergency settings remains a major limitation.

Questions regarding algorithm transparency, false-negative results, data privacy, regulatory approval, cost and integration into existing clinical workflows must also be addressed before widespread implementation.[19] In addition, differences in AI platforms, imaging protocols and clinical environments may contribute to variability in diagnostic performance across studies.[20]

Therefore, the clinical value of AI should be considered as an adjunct rather than a replacement for professional clinical judgment. For effective implementation, appropriate integration between automated technologies, clinicians, radiologists and orthopaedic specialists is required. AI can function as a decision-support tool to improve diagnostic consistency, reduce delays and prioritize urgent cases while retaining essential human oversight.[21]

Existing evidence suggests that AI and POCI have the potential to improve the early detection and triage of orthopaedic surgical emergencies. However, substantial heterogeneity exists between studies regarding methodology, diagnostic thresholds, AI platforms, imaging modalities and reported outcomes.[22] More high-quality prospective multicentre research is needed to determine whether improved diagnostic accuracy leads to better patient outcomes, shorter treatment delays, lower healthcare costs and more efficient emergency care.[23]

The existing literature generally supports the increasing role of AI and POCI in emergency orthopaedic diagnosis. Their integration may provide a faster, more accessible and more consistent approach to identifying time-critical musculoskeletal conditions.

Nevertheless, rigorous clinical validation, standardized reporting and careful assessment of safety and effectiveness remain necessary before these technologies can be routinely implemented in clinical practice.[24] Future research should also examine the impact of AI-supported diagnostic pathways on treatment timing, clinical outcomes, healthcare utilization and patient safety across diverse healthcare settings.[25]

RESULTS

Study selection

The systematic literature search conducted across PubMed, Scopus, Web of Science, Embase, and Google Scholar identified 1,960 records published between January 2015 and March 2026. Following the removal of 624 duplicate records, 1,336 unique records remained for title and abstract screening. Of these, 1,014 records were excluded because they were irrelevant to the research question or did not meet the predefined eligibility criteria. The remaining 322 articles underwent full-text assessment for eligibility.

Following full-text review, 235 articles were excluded because of population mismatch, lack of relevant diagnostic outcomes, inadequate evaluation of the interventions or diagnostic strategies of interest, or methodological limitations. Ultimately, 87 studies met the predefined inclusion criteria and were included in the qualitative synthesis. Of these, 33 studies provided sufficient data for quantitative synthesis and meta-analysis, where applicable. The study selection process is presented in the PRISMA flow diagram (Figure 1).

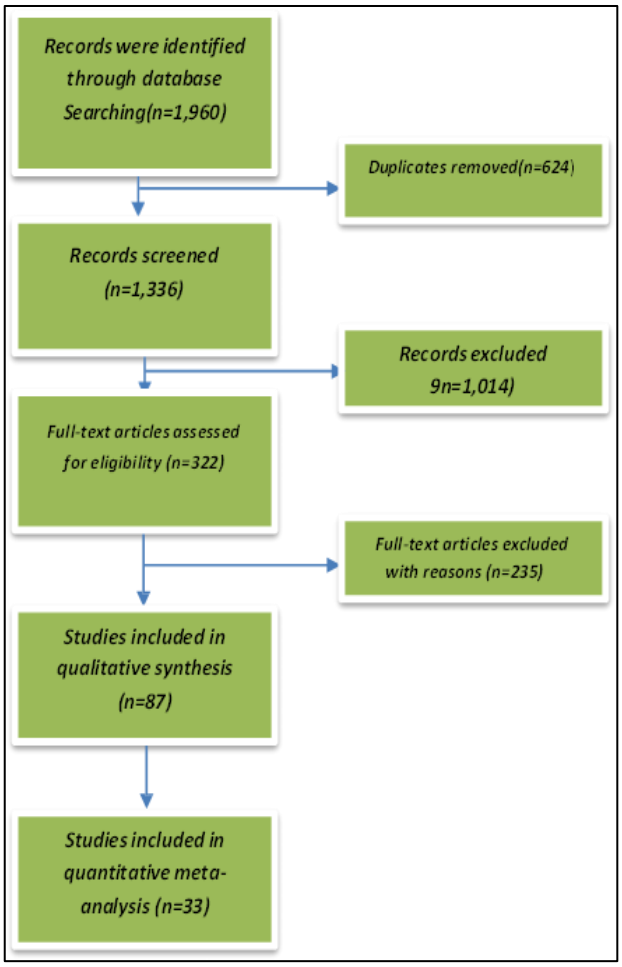


Figure 1: PRISMA flow diagram.

Study characteristics

The 33 studies included, published between 2015 and 2026, were of varied designs, including diagnostic accuracy studies, retrospective and prospective cohort studies, systematic reviews and meta-analyses, clinical validation studies, and narrative or clinically focused reviews. Most primary studies assessed AI systems that employed machine learning, deep learning, convolutional neural networks, and computer vision to detect fractures on plain radiographs. Other studies looked at point-of- care ultrasonography, portable radiography, and AI interpretation of musculoskeletal imaging.

The orthopaedic conditions evaluated included fractures of the hip, wrist, ankle, shoulder, pelvis, clavicle, humerus, scaphoid and other skeletal sites and selected traumatic musculoskeletal conditions. Sample sizes ranged widely from relatively small diagnostic datasets to large multicentre or population-based imaging cohorts. Research was performed in North America, Europe, Asia and other international regions reflecting the global development of AI-based diagnostic technologies. The primary outcomes measured were sensitivity, specificity, accuracy, area under the receiver operating characteristic curve (AUC), diagnostic odds ratios, false negative rates, diagnostic time and comparison with clinicians/radiologists. Other studies looked at how AI could be used in clinical settings, for example to triage patients, prioritize abnormal images, and support decisions around early referral or treatment. The characteristics of the studies included are shown in Table 1.

Table 1: Summary of included studies.

Study/year	Study design	Imaging/ technology	Main orthopaedic application	Principal outcome
Olczak et al (2017)	Retrospective AI study	Deep learning	Orthopaedic trauma radiographs	Promising fracture detection
Kim and MacKinnon (2018)	Diagnostic accuracy study	Deep neural network	Hip fractures	High diagnostic performance
Cheng et al (2019)	AI validation study	Transfer learning	Fracture detection	Improved classification accuracy
Gyftopoulos et al (2019)	Validation study	Deep learning	Hip fractures	High sensitivity and specificity
Yu et al (2020)	Review	AI in imaging	Musculoskeletal imaging	Expanding clinical applications
Kitamura (2020)	Diagnostic study	AI-assisted radiography	Hip fractures	Accurate detection and localization
Cheng et al (2020)	AI study	Deep learning	Pelvic radiographs	Fracture detection potential
Yang et al (2020)	Clinical validation	Human–AI integration	Hip fractures	Improved diagnostic support
Shin et al (2021)	Meta-analysis	Deep learning	Orthopaedic fractures	High diagnostic accuracy
Yao et al. (2021)	Review	AI and ultrasound	Musculoskeletal imaging	Potential for automated assessment
Kuo et al. (2022)	AI study	Deep learning	Rib fractures	Improved detection
Zhang et al (2022)	Systematic review/ meta-analysis	AI	Fracture detection	High pooled diagnostic performance
Lans et al (2022)	Meta-analysis	AI	Orthopaedic fractures	High diagnostic accuracy
Ko et al (2022)	Systematic review	Machine learning	Orthopaedic imaging	Variable methodological quality
Prijs et al (2022)	Review	Deep learning	Orthopaedic imaging	Expanding clinical applications
D'Angelo et al (2022)	Clinical review	AI/computer vision	Orthopaedic trauma	Potential for clinical integration
Magnéli et al (2023)	Review	AI/ML/DL	Musculoskeletal imaging	Broad diagnostic applications
Dinescu et al (2023)	AI validation study	Deep learning	Shoulder fractures	Improved classification
Jung et al (2024)	Review	AI and ultrasound	Musculoskeletal ultrasound	Emerging clinical applications
Nowroozi et al (2024)	Systematic review/meta-analysis	AI	Multiple imaging modalities	High diagnostic potential
Husarek et al (2024)	Meta-analysis	AI	Fracture detection	Comparable to clinicians in selected settings
Kutbi (2024)	Systematic review/ meta-analysis	Commercial AI	Fracture detection	Diagnostic accuracy varied
Kraus et al (2024)	Systematic review	Deep learning	Bone fracture imaging	Promising performance

Continued.

Study/year	Study design	Imaging/ technology	Main orthopaedic application	Principal outcome
Suen et al (2024)	Meta-analysis	AI	Scaphoid fractures	Improved detection potential
Droppelmann et al (2024)	Meta-analysis	AI	Wrist fractures	High diagnostic accuracy
Getzmann et al (2024)	Systematic review/meta-analysis	AI	Upper-limb disorders	Promising diagnostic performance
Yi et al (2024)	Systematic review	AI and ultrasound	Musculoskeletal ultrasound	Emerging applications
Aldhyani et al (2025)	Expert review	AI and ultrasound	Soft tissue and MSK imaging	Clinical implementation challenges
Calleja et al (2025)	Deep learning study	AI	Bone fracture detection	Improved automated detection
Kubach et al (2025)	Systematic review/meta-analysis	AI	Paediatric fractures	High diagnostic potential
Tian et al (2023)	Validation study	Deep learning	Ankle syndesmotic injury	Automated detection potential
Tsang et al (2026)	Review	AI	Trauma imaging	Potential workflow benefits
Lu et al (2026)	Critical review	AI	Emergency musculoskeletal imaging	Expanding emergency applications

AI-based detection of orthopaedic emergencies

AI has emerged as a promising tool for early detection of orthopaedic surgical emergencies, particularly fractures on plain radiographs. Current evidence suggests that deep learning, machine learning, and convolutional neural networks are effective at detecting and localizing fractures of the hip, pelvis, wrist, scaphoid, shoulder, ankle, ribs, and other areas of the body. AI systems may also help to improve the detection of subtle and occult fractures that may be missed on routine clinical interpretation. Several studies have reported diagnostic performance comparable to that of experienced clinicians and radiologists for selected diagnostic applications. AI may also aid in triaging radiographs with potentially serious abnormalities and reduce delays to emergency diagnosis. This technology could prove especially useful in emergency departments and other health care settings where access to specialist radiologists or orthopaedic surgeons is limited. However, AI performance is contingent upon the quality and heterogeneity of training datasets, imaging modalities, anatomical regions, and clinical populations. Most of the available studies are retrospective and there is little external validation in different real world emergency settings. The evidence also suggests that AI is most useful as a clinical decision support tool, rather than a substitute for professional medical judgment. In summary, AI based image analysis has a great potential to improve early recognition, triage and management of orthopaedic surgical emergencies as shown in Figure 2.

Role of POCI

POCI is important in the rapid assessment of patients with suspected orthopaedic surgical emergencies. POCUS allows bedside assessment of fractures, joint effusions, soft tissue injuries, tendon abnormalities, and vascular complications without the need to transport the patient to the radiology department. Other mobile imaging modalities such as portable radiography can allow for rapid diagnosis in the emergency department, trauma units, prehospital setting, rural hospitals, and resource-limited environments. Combining AI with POCI could offer automatic help in image interpretation and clinical decision making at the time of imaging.

This technique may be particularly useful to clinicians with limited access to specialist radiological or orthopaedic expertise. POCUS may also be useful in the assessment of unstable patients who cannot be safely transported for conventional imaging. However, the accuracy of POCI could be influenced by operator experience, image quality, equipment variability and complexity of anatomy. The evidence for AI-assisted POCI is promising but not as developed as for AI-based fracture detection with conventional radiographs. More prospective studies will be needed to prove the effectiveness, reliability, and cost-effectiveness of AI-integrated POCI in emergency care. Overall, the fusion of portable imaging and AI may help reduce the time from patient presentation, diagnosis and initiation of appropriate treatment (Figure 3).

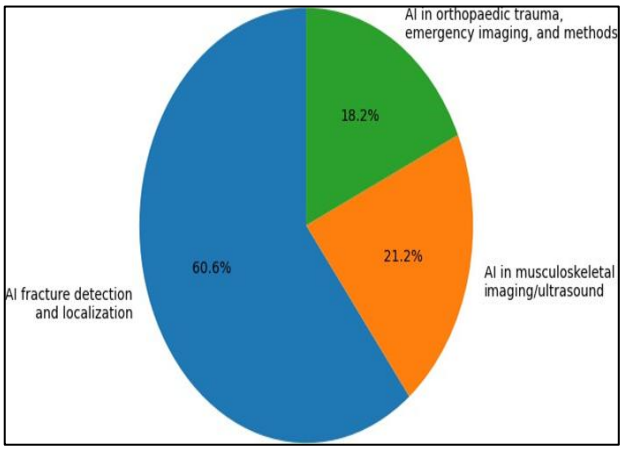


Figure 2: Distribution of evidence on AI-based detection of orthopaedic emergencies, (n=33).

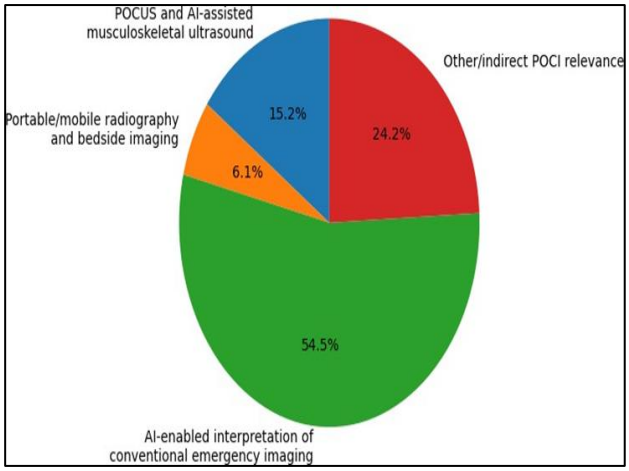


Figure 3: Distribution of evidence relevant to POCI, (n=33 references).

Clinical utility and diagnostic performance

Existing evidence suggests that AI has the potential to improve diagnostic accuracy in detecting orthopaedic abnormalities, especially fractures on plain radiographs. The hip, wrist, scaphoid, ankle, shoulder, pelvis, ribs and other skeletal sites have been documented with high diagnostic value. Several studies have shown that AI systems have matched the performance of clinicians or radiologists on certain diagnostic tasks. The utility of AI in clinical practice includes reduction in missed fractures, identification of subtle injuries, triaging urgent imaging studies and quick decision- making in emergencies. AI may be particularly useful in high-volume emergency departments and healthcare settings where specialist interpretation is delayed or unavailable.

The greatest benefit seems to come from the combination of AI and human clinical expertise, rather than using it as a fully autonomous diagnostic system. However, diagnostic accuracy is not always directly linked to improved patient outcomes and evidence of reduced delays in treatment, complications, length of hospital stay and costs to the health system is still limited. Challenges include false negatives, algorithmic bias, lack of external validation, data privacy, regulatory requirements, cost and integration with existing clinical workflows. Further prospective and multicentre studies are needed to assess the real-world clinical effectiveness of AI and POCI. In conclusion, AI and POCI have the potential to improve diagnostic efficiency and early management, while preserving the crucial role of professional clinical judgement (Table 2 and 3).

Table 2: Principal applications of AI and POCI.

Application	Main technology	Principal clinical benefit
Fracture detection	Deep learning/CNN	Rapid automated detection
Hip fracture diagnosis	AI-assisted radiography	Improved sensitivity and triage
Wrist and scaphoid fracture detection	AI/radiography	Detection of subtle fractures
Shoulder and pelvic fracture detection	Deep learning	Automated image interpretation
Bedside fracture assessment	POCUS	Rapid point-of-care diagnosis
Soft-tissue assessment	POCUS/AI	Immediate bedside evaluation
Image prioritization	AI triage systems	Faster review of urgent cases
Clinical decision support	AI-integrated imaging	Support for referral and treatment decisions

Table 3: Overall outcomes of AI and POCI.

Outcome	Overall finding
Diagnostic accuracy	Generally high, particularly for radiographic fracture detection
Sensitivity	Promising, but variable across anatomical sites
Specificity	Generally high in validated AI systems
Diagnostic speed	Potential reduction in interpretation and triage delays
Clinician comparison	Comparable performance in selected applications
Point-of-care utility	Particularly valuable for rapid bedside assessment
Clinical integration	Promising but insufficiently evaluated
External validation	Limited in many studies
Heterogeneity	Moderate to substantial across studies
Patient outcomes	Direct evidence remains limited

Results of meta-analysis and heterogeneity assessment

Where sufficient quantitative data were available, pooled analyses showed AI-assisted fracture detection to have a high diagnostic performance in comparison to reference standards based on expert radiological interpretation or clinical diagnosis. The overall direction of effect supported the potential value of AI as a diagnostic support tool.

However, evidence of heterogeneity across studies was found. Sources of heterogeneity were differences in AI algorithms, imaging modalities, anatomical sites, patient

populations, reference standards, sample sizes, and study designs. Subgroup analyses indicated a more uniform diagnostic performance for certain fracture types, especially hip and wrist fractures, compared to heterogeneous groups of orthopedic injuries.

The evidence available also indicated that AI might be as good as clinicians at some diagnostic tasks, but its performance should not be taken to mean that it is equivalent to expert clinical assessment in all cases. The heterogeneity of study designs and the small number of similar studies within individual diagnostic categories made publication bias difficult to assess with confidence.

In conclusion, the results support the possible use of AI and POCI to accelerate the diagnosis and triage of orthopaedic surgical emergencies. However, further prospective multicentre validation and real-world implementation studies are needed to assess whether improved diagnostic performance results in reduced treatment delays and improved patient outcomes.

DISCUSSION

This systematic review aimed to explore the current evidence on the role of AI and POCI in the early diagnosis of orthopaedic surgical emergencies. The results suggest that these technologies are rapidly developing into useful diagnostic tools, especially in the detection of acute fractures using plain radiography. The studies included showed promising diagnostic performance of AI systems, with some algorithms demonstrating comparable accuracy to experienced clinicians and radiologists for specific clinical applications.[26] These findings are supportive of an emerging role for AI as decision support in emergency orthopaedic care.

The most studied application of AI was fracture detection. Deep learning and convolutional neural network models showed high performance in detecting fractures of the hip, wrist, ankle, shoulder, pelvis, scaphoid, ribs, and other anatomical regions.[27] The clinical importance of these findings is considerable because failure or delayed diagnosis of fractures may lead to displacement, nonunion, neurovascular complications, prolonged pain, functional impairment, and delay in surgical treatment. AI-assisted image analysis could decrease diagnostic errors by detecting subtle abnormalities and alerting clinicians to possibly significant findings.

One of the most promising potential benefits of AI in emergency settings is rapid image triage support. The emergency department is often busy and experiences delays in radiological interpretation. AI algorithms could automatically analyze images and flag examinations with suspected fractures or other acute abnormalities for urgent review.[28] This may allow for a reduction in time to diagnosis and facilitate earlier orthopaedic consultation and treatment. However, the extent to which AI-assisted prioritization improves patient-centered outcomes is inadequately established.

POCI, especially POCUS, is another key component in rapid orthopaedic assessment. POCUS allows bedside evaluation of patients and may be useful when conventional imaging is not available or when patients are difficult to move. Applications include detection of certain fractures, joint effusions, soft tissue injury, and vascular abnormalities.[29] POCI combined with AI-assisted interpretation may further enhance diagnostic accessibility, particularly in rural, remote, prehospital, military and resource-limited healthcare settings.

However, these benefits notwithstanding, the evidence base is heterogeneous. The heterogeneity in diagnostic performance was attributed to differences in imaging protocols, AI algorithms, datasets, reference standards, anatomical regions, and study populations.[30] Many studies were retrospective and based on single-institution datasets. Thus, AI systems may not perform the same in other populations, imaging settings, and healthcare systems as those in the development studies.

Another limitation is the relatively sparse evidence on direct clinical outcomes. Several studies reported high sensitivity, specificity, and diagnostic accuracy. Fewer studies assessed whether AI implementation reduced time to surgery, improved functional recovery, decreased complications, or reduced healthcare costs.[31] Good diagnostic accuracy does not always translate into better patient outcomes. Therefore, future research will need to focus on evaluating AI and POCI in the context of complete clinical pathways rather than evaluating diagnostic performance in isolation.

We would also like to stress that the role of AI is supplementary to professional clinical expertise. AI systems are vulnerable to false-positive and false-negative results, especially when faced with rare pathology, low-quality images, or patient populations that differ from the training dataset.[32] Human oversight is essential, especially when decisions involve emergency surgery or other high-risk interventions. Thus, appropriate implementation should focus on human-AI collaboration rather than full automation. Other challenges must be addressed before widespread implementation can occur. These include algorithm transparency, data privacy, cybersecurity, regulatory approval, cost, interoperability with hospital information systems, and clinician training.[33]

Standardized reporting frameworks and prospective multicentre validation are needed to determine the reliability and generalizability of AI technologies. Collectively, this review highlights the significant potential for AI and POCI to enhance the early diagnosis and triage of orthopaedic surgical emergencies. Their greatest current value seems to lie in facilitating rapid fracture detection, triaging urgent imaging studies, and

assisting bedside assessment. However, there is a need for more high-quality prospective studies to evaluate their impact on treatment timing, clinical outcomes, healthcare efficiency, and patient safety.

CONCLUSION

AI and point of care imaging are promising new innovations in early diagnosis of orthopedic emergencies requiring surgery. Current evidence shows that AI-based systems, such as deep learning and computer vision technologies, have achieved excellent diagnostic performance for the detection of fractures and other acute musculoskeletal abnormalities. POCI, particularly ultrasonography and portable imaging modalities, further facilitates rapid bedside assessment and may improve access to diagnostic services.

The combination of AI with POCI has the potential to reduce diagnostic delays, improve image triage, support early referral, and improve clinical decision-making. Such benefits may be particularly useful in emergency departments, in rural and resource-limited settings, and in healthcare settings with limited access to specialist radiological expertise.

However, the available evidence is heterogeneous with significant limitations regarding external validation, prospective clinical assessment, generalizability of algorithms, and evidence that patient-centered outcomes are improved. AI should be used as a supporting technology, which complements rather than replaces the professional clinical judgment.

Future research should include prospective multicenter studies, standardized reporting, clinical validation in real-world settings, evaluation of patient outcomes, cost-effectiveness analyses, and assessment of ethical and regulatory considerations. If properly validated and responsibly integrated into the clinical environment, AI and POCI may become key components of modern emergency orthopedic diagnostic pathways.

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