Radiography 32 (2026) 103416

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Improving fracture detection in the Emergency Department: A pilot study of participation and accuracy in radiographer preliminary clinical evaluation

G. Cain*, P. Golparvar, J. Hargreaves

Jersey General Hospital, The Parade, St Helier, JE1 3QS, Jersey

A R T I C L E I N F O

Article history:
Received 21 December 2025
Received in revised form
22 March 2026
Accepted 31 March 2026
Available online xxx

Keywords:
Radiographer
Preliminary clinical evaluation
Fracture detection
Diagnostic accuracy
Emergency department
Musculoskeletal radiography

A B S T R A C T

Introduction: Missed fractures in the Emergency Department (ED) can lead to delayed treatment and patient harm. Radiographer preliminary clinical evaluation (PCE) aims to support referrers when interpreting radiographs in the absence of a definitive clinical report. This pre-implementation study evaluated radiographer participation and diagnostic accuracy in a department without an existing radiographer abnormality detection system.

Methods: A prospective service evaluation study was conducted in a general hospital. Radiographers were asked to provide PCE for consecutive ED musculoskeletal trauma radiographs. Participation was recorded. PCEs were compared with the clinical report, and sensitivity, specificity and accuracy were calculated with 95% confidence intervals. Accuracy was evaluated against a fixed performance standard using a non-inferiority test. Differences in proportions between the first and second halves of the study period, in participation and accuracy, were assessed using z-tests.

Results: Of 937 eligible examinations, 412 contained a PCE comment (44.0% participation), increasing significantly from 39.3% (182/463) in the first half of the study period to 48.5% (230/474) in the second half ($p = 0.0045$). After exclusions, 369 PCEs were analysed. Sensitivity, specificity and accuracy were 80.2%, 94.2% and 89.3%, respectively. The lower bound of the accuracy confidence interval (85.7%) exceeded the non-inferiority margin (82% accuracy), confirming PCE accuracy was statistically non-inferior to the 92% benchmark. Median time from examination attendance to PCE entry was 12 min.

Conclusion: Radiographers provided timely, accurate PCEs, achieving performance comparable with published standards, demonstrating the feasibility of implementing a PCE service.

Implications for practice: This study contributes to the evidence supporting PCE in departments without a 24-h hot-reporting service. Even without a dedicated training package, radiographers performed well, but this study emphasises that sensitivity remains a key area for further improvement.

Introduction

Missed fractures on trauma radiographs can lead to delayed treatment and adverse outcomes.[1,2] In the absence of an immediate, definitive clinical report, having radiographers provide a preliminary clinical evaluation (PCE) at the time of image acquisition can reduce these risks.[3] A PCE is a short, written comment made by a radiographer communicating the nature and location of any abnormalities.[4] The concept evolved from earlier 'red dot' systems in which radiographers flagged an image when a traumatic abnormality was suspected.[5] However, there is inherent uncertainty in red dot systems: they convey no detail about perceived abnormalities, and participation is typically voluntary, leading to ambiguity and inconsistent use.

In the United Kingdom (UK), the Society of Radiographers (SoR) has advocated replacing red dot systems with PCE for over a decade,[6] and recent guidance[4] explicitly supports radiographer PCE implementation as a 'safety net' approach to support referrers in the interim between image acquisition and a definitive clinical report being available. PCE is intended to ensure referring clinicians do not overlook abnormalities identified by radiographers, and support timely decision-making and patient safety.

* Corresponding author.
E-mail address: g.cain@health.gov.je (G. Cain).

https://doi.org/10.1016/j.radi.2026.103416

Importantly, image interpretation education is now firmly embedded in UK radiography programmes, and higher education institutions assess and assure graduates' competence in applying PCE skills at the point of registration.[4] A well-implemented PCE system helps radiographers comply with aspects of the Health & Care Professions Council's Standards of Proficiency,[7] in particular standard 13.40 "distinguish disease trauma and urgent and unexpected findings as they manifest on diagnostic images, and take direct and timely action to assist the referrer".

At the time this study was considered, Emergency Department (ED) radiographs in our institution were routinely reported by two reporting radiographers during standard weekday hours only. No routine weekend or out-of-hours reporting was available, and a 24-h hot-reporting service was not in place. As a result, definitive clinical reports were often delayed, particularly for examinations performed outside normal working hours.

While the expansion of radiographer roles into PCE has been endorsed in UK policy,[4,6] adoption has been slow.[8,9] Key concerns include ensuring adequate accuracy of radiographer interpretations and consistent participation in providing comments.[3] To address these, it is important to benchmark radiographer performance against accepted standards and to identify areas requiring training and development. Within this context, this pilot study aimed to evaluate radiographer PCE in our hospital, which had no prior radiographer abnormality detection system, to gather evidence of participation rates and diagnostic performance, thereby informing the implementation of a permanent PCE service in line with SoR recommendations.

Methods

Study design, setting and ethics

A prospective diagnostic performance study was performed comparing PCE accuracy against a fixed standard of performance. The study took place in a single department of radiology within a General Hospital. Using the Health Research Authority decision tool,[10] the study was classified as a service evaluation and did not require full Research Ethics Committee approval. The study was recorded as a service evaluation with our local Research Ethics Committee. During the study, participation was voluntary and verbal systems of communication used to highlight abnormalities to referrers continued to operate. The PCE comments were not available to the referring clinicians and were used only for audit purposes.

Sample size and recruitment

The sample size calculation was based on a formula described by Scally and Brealey.[11] The purpose of the audit was to determine whether there was any significant difference in radiographers' ability to provide PCE comments compared with a fixed standard of performance using a non-inferiority test. In the absence of a national standard for radiographer PCE accuracy, we derived a standard from prior research on radiographer PCE in clinical practice.[12–14] Upon re-analysis of the data from these studies, an accuracy standard of 92% was estimated, and we agreed an actual rate of 82% (0.10 difference) would be clinically important. A one-tailed test was appropriate, as we were not interested in interpreting a performance better than the standard, but rather in detecting a departure below the standard, if one existed. Based on these assumptions, a sample of 354 PCE comments was required to adequately power the study. The sample was drawn from consecutive referrals from the ED for projectional radiographs of the musculoskeletal (MSK) system. Although the population was consecutive, PCE provision depended on the radiographer's voluntary participation.

All radiographers who were rostered to work in the ED X-ray room during the trial period (n = 21), out of hours inclusive, were asked to provide PCE comments on trauma radiographs. Participation in performing PCE was voluntary throughout the trial; however, department managers and project leads actively encouraged engagement during the study period. No formal incentives or mandatory requirements were introduced.

Procedure

During the pilot, radiographers were instructed to enter a PCE comment for all trauma radiographs of the appendicular and axial skeleton (see Table 1 for inclusion and exclusion criteria). PCE was limited to the identification of acute trauma pathology only (e.g., fracture, dislocation/subluxation, traumatic effusion or retained foreign body). If an acute abnormality was identified, radiographers were asked to briefly describe the nature and anatomical location of the finding using free text. If no acute traumatic abnormality was identified, "No bony injury" was selected. Selection of "No PCE" or "Uncertain" was recorded as participation for engagement analysis but excluded from diagnostic performance calculations, as these did not constitute definitive positive or negative classifications.

The images were assessed on either a Philips Digital Diagnost (Unique 1) or Fujifilm Flex (Console Advance) workstation. The radiographers were asked to evaluate the images immediately after image acquisition and to enter a PCE comment in the 'event comment' box of the Radiology Information System (RIS) (not visible to the referring clinician). Prior to the study, training sessions were held to introduce the PCE process and classification scheme (Table 2), and a quick-reference poster reminding participants of the classification system and inclusion criteria was placed directly above the X-ray image acquisition consoles.

Data scoring

All PCE entries recorded on the RIS during the study period were extracted into a spreadsheet, along with the corresponding exam details and demographics. The reference standard for determining the correctness of PCE was the definitive clinical report on each case, issued by a reporting radiographer or consultant radiologist. The report was considered the ground truth regarding the findings present.

To enable calculation of diagnostic performance measures each PCE was classified as a true positive (TP), true negative (TN), false positive (FP) or false negative (FN). Where multiple traumatic abnormalities were present, all abnormalities had to be correctly

Table 1
Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Modality	Projectional radiography	All other modalities
Anatomy	Appendicular and axial skeleton	Visceral examinations
Reason for referral	Acute/recent[a] trauma (including suspected foreign body)	• Non-trauma related (e.g. ? osteoarthritis) • Post reduction/ manipulation • Plaster change • Post operative

[a] Trauma within the last 6 weeks.

Table 2
Preliminary clinical evaluation classification scheme and keywords with definitions.

RIS key word/s	Meaning
'No PCE'	Unable to provide a PCE (e.g. lack of time)
'No bony injury'	No acute traumatic abnormality identified
'Uncertain'	If the radiographer is uncertain of the image findings
'Abnormal' – to include a brief comment on the nature and location of the abnormality	Acute traumatic abnormality identified: Acute fracture, raised fat pads in the elbow or lipohemarthrosis in the knee, subluxation or dislocation, foreign body

described for the PCE to be awarded a full TP. Some PCE comments were awarded fractional marks for partial agreement with the report, in line with previous work.[15] Partial mark allocations were based on the likely effect on patient management of such an error in clinical practice. For example, if a clinical report described fractures of the distal radius and the ulna styloid process, but the PCE noted only the distal radial fracture, the PCE was scored as 0.75 TP and 0.25 FN. Each case thus contributed a total of 1.0 summed across TP, TN, FP, and FN.

Comparison and scoring was done by two radiographers on the project team (including a reporting radiographer) who worked together to reach consensus. To evaluate inter-arbiter agreement (i.e., consistency of marking), all cases were independently scored by an internal moderator (another reporting radiographer) who was blinded to prior scoring and the identities of the PCE authors.

Statistical analysis

Diagnostic performance outcomes—sensitivity, specificity, and accuracy—were calculated with 95% confidence intervals (CIs) using the Wilson[16] method implemented in VassarStats.[17] A non-inferiority approach was used to assess whether radiographer PCE accuracy was acceptably close to the 92% benchmark standard. The null hypothesis stated that radiographer accuracy was more than 10 percentage points below the benchmark (i.e., $\leq$82%). Non-inferiority was concluded at the 5% significance level if the lower bound of the 95% CI for accuracy exceeded 82%.[11,18,19]

Differences in proportions between the first and second halves of the study period—both in participation and accuracy—were assessed using z-tests, with statistical significance set at $p < 0.05$. Inter-arbiter agreement in the classification of PCE outcomes (TP, TN, FP, FN) was evaluated using Cohen's kappa statistic[20,21] calculated in MedCalc.[22] Data handling was performed in Microsoft Excel.[23]

Results

Radiographer participation rates

During the pilot, 948 consecutive ED X-ray exams were performed in the X-ray room that serves the ED. Eleven exams were excluded, either post-reduction or not related to acute trauma (trauma over 6 weeks ago). 937 cases were eligible for inclusion, of which 412 had a PCE comment on the RIS; an overall participation rate of 44.0%. Participation improved over time, from 39.3% (182/463) in the first half to 48.5% (230/474) in the second half of the data collection. This increase was statistically significant ($z = -2.84$, $p = 0.0045$). The individual-per-radiographer participation rate ranged from 0% to 100%; 4 radiographers provided no PCE comments during the audit period (Fig. 1). PCEs were documented in 44.9% (390/869) appendicular exams and 32.4% (22/68) axial skeleton exams.

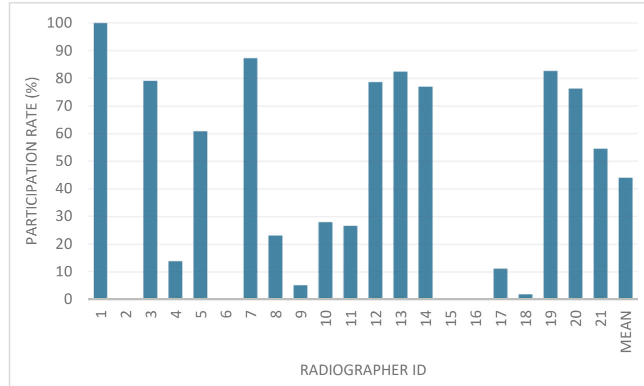

Figure 1. Individual radiographer preliminary clinical evaluation per exam participation.

At the time of the study, 19 of the 21 radiographers eligible to participate were senior radiographers with more than five years' post-registration experience. Two radiographers had fewer than five years' post-registration experience. No relationship was observed between individual participation rates and experience level.

Diagnostic accuracy

Of the 412 examinations with a PCE comment, 26 were excluded from further analysis because either the 'No PCE' (1.6%, 7/412) or 'Uncertain' (4.6%, 19/412) comment options were used. A further 17 (4.1%) PCE comments were excluded because they did not conform to the pre-agreed classification system. This left 369 PCE comments to compare against the reference standard report. The disease prevalence for acute traumatic injury was 35.0% (129/369).

The radiographer's PCE diagnostic performance outcomes are shown in Table 3 and Fig. 2. The sensitivity, specificity and accuracy were 80.2% (95% CI, 72.5–86.2), 94.2% (95% CI, 90.4–96.5) and 89.3% (95% CI, 85.7–92.1), respectively. As the lower bound of the accuracy confidence interval (85.7%) exceeded the predefined non-inferiority margin (82% accuracy), radiographer PCE performance was statistically non-inferior to the 92% benchmark. Accuracy of PCE comments was higher in the second half of the data collection period (91.5% vs 85.8%); however, this did not reach statistical significance ($z = -1.91$; $p = 0.056$). The number of axial skeletal examinations with PCE was very small ($n = 14$), making it impossible to draw meaningful comparisons with appendicular performance.

Inter-arbiter agreement

Kappa statistic demonstrated "very good" agreement[21] ($K = 0.93$; 95% CI: 0.89–0.96) between initial scoring and independent moderation when classifying the PCE comments TP, TN, FP, and FN.

Error analysis

Of the 369 evaluated PCE cases, 39.5 errors were recorded, an error rate of 10.7%. This includes both complete errors and partial errors, the latter counted fractionally. Table 3 provides a breakdown of the errors by body region. FN were the most common

Table 3
Region-specific and overall diagnostic performance of radiographer preliminary clinical evaluation (sensitivity, specificity, and accuracy with 95% confidence intervals).

Region	TP	TN	FP	FN	Sensitivity % (95% CI)	Specificity % (95% CI)	Accuracy % (95% CI)	Error rate %
Upper limb	72.25	85	8.5	12.25	85.5% (76.5–91.5)	90.9% (83.4–95.2)	88.3% (82.8–92.3)	11.7
Lower limb	29	130	5.5	12.5	69.9% (54.7–81.7)	95.9% (91.2–98.2)	89.8% (84.5–93.5)	10.2
Axial	2.25	11	0	0.75	75.0% (25.6–96.3)	100.0% (74.1–100.0)	94.6% (70.8–99.2)	5.4
Total	103.5	226	14	25.5	80.2% (72.5–86.2)	94.2% (90.4–96.5)	89.3% (85.7–92.1)	10.7

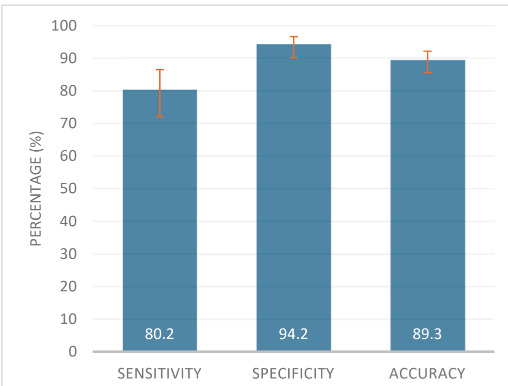

Figure 2. Radiographer preliminary clinical evaluation diagnostic performance (sensitivity, specificity, and accuracy with 95% confidence intervals).

error type, accounting for 25.5 of the 39.5 errors (64.6%), while the remaining 14 errors (35.4%) were FP.

False negative errors were often related to undercalling subtle fractures or soft tissue signs, including nondisplaced fractures, small avulsion fractures, paediatric buckle fractures, and elevated fat pads. Several FN errors related to retained foreign bodies (small glass fragments). A proportion of FN errors were fractional misses, where the primary injury was detected but additional abnormalities overlooked (e.g., distal radius fracture with unrecognised ulnar styloid fracture), or the correct anatomical location was not reported (e.g., labelling a fracture as “proximal radius” on a wrist X-ray). Of the 33 cases contributing to full or partial FN errors , 10 (30.3%) occurred in cases where terms of equivocation were used in the reference standard report, i.e. suggestive, likely, suspicious, and equivocal.

False positive errors were less frequent and primarily reflected overcalling of normal or non-acute findings, including accessory ossicles or healed fractures. A small number of cases related to overcalling subluxations and dislocations, or soft-tissue signs such as raised fat pads or lipohaemarthrosis.

PCE turnaround time

The time between exam ‘attendance’ on the RIS and the PCE entry time was assessed as a surrogate for PCE turnaround time. It is important to note, however, that this is an imperfect way to assess PCE turnaround time, as it includes the time required for image acquisition and is further confounded if the examination was attended on the RIS but delayed. Within this caveat, the median time between attendance and PCE entry was 12 min (interquartile range: 7–22 min); the outliers reflect delayed PCE documentation (Fig. 3).

Discussion

This pilot study was carried out in response to the SoR's[4] call for radiology departments without 24-h hot reporting to adopt PCE as a ‘safety net’ approach to support referrers and minimise patient risk. An immediate formal clinical report remains the gold standard, but this is not currently feasible locally due to financial and staffing limitations. By piloting radiographer PCE, we aimed to assess its feasibility and effectiveness and guide the future establishment of a permanent PCE service.

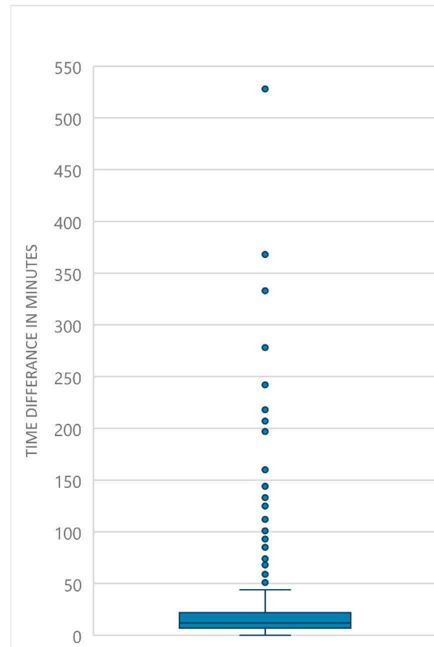

Figure 3. Distribution of time between exam attendance and preliminary clinical evaluation entry. The blue box spans the interquartile range (IQR, 7–22 min); the solid line shows the median (12 min). The whiskers extend to the minimum and maximum non-outlier values.

Radiographer engagement with the PCE process in our pilot was moderate overall. Only 44% of eligible ED trauma radiographs received a PCE comment, though encouragingly, the rate was 48.5% in the second half of data collection. Participation varied widely between individuals – while some radiographers provided a PCE on most exams they performed, four radiographers did not enter any comments during the study period. In a comparable pilot by Lidgett et al.[14] at a UK district general hospital, a 66% PCE participation was achieved. The researchers found that radiographers who received local training were significantly more likely to provide PCE than radiographers who did not. Our lower initial participation likely reflects the challenges of changing workflow and some radiographers’ hesitation. Anecdotally, some staff reported that they often forgot to provide a PCE during the trial and others were concerned about “getting it wrong”. In addition, disagreement with the implementation of a radiographer PCE system due to perceived workload impact was also cited. Prior research[24,25] suggests radiographers generally view PCE positively and as beneficial to patient care; however, time constraints, lack of confidence, limited training, and fear of litigation are common perceived barriers. With proper implementation in line with SoR recommendations,[4] a proactive clinical governance framework, local training and a preceptorship package, and regular audit and feedback, participation in a formal PCE system is likely to be significantly higher.

Among cases in which radiographers provided a PCE, diagnostic performance was high. Overall accuracy of radiographer PCE in our study was 89.3%, with a sensitivity of 80.2% for detecting acute injuries and a specificity of 94.2% for confirming no traumatic injury. Importantly, diagnostic accuracy was found to be statistically non-inferior to the 92% benchmark derived from the literature. Our findings align closely with previous studies of radiographer PCE on MSK trauma radiographs in the clinical practice setting in the UK. Verrier et al.[13] reported an accuracy of 92% for radiographer PCE, and Lidgett et al.[14] reported 89–90% accuracy in their pilot, with no significant difference between radiographer groups with and without local training. Sensitivity in these studies ranged from 80 to 86%, and specificity 91 to 97%, figures in line with our results. Earlier work by Brealey[26] proposed that any professional interpreting trauma radiographs should achieve at least 80% accuracy, with 90% considered optimal and 95% ideal. Taken together, a growing body of evidence indicates that radiographers—without formal postgraduate reporting qualifications—can interpret trauma radiographs to a high standard of accuracy (roughly 90% correct), approaching the performance of expert definitive clinical reports for MSK trauma radiographs.

Notably, radiographers tend to have higher specificity than sensitivity in the clinical practice setting. Radiographers are unlikely to overcall pathology that isn't there, though they may overlook some traumatic injuries. Although this pattern mitigates unnecessary alarm or overtreatment, the findings make it clear that targeted local training and systematic feedback are vital for improving sensitivity. Our pilot included only a small number of axial skeletal studies, too few to draw firm conclusions on that subset. Verrier et al.[13] observed that positive findings on appendicular radiographs were interpreted significantly more accurately than on axial radiographs. Encouragingly, even without a specific training package, the radiographers in our pilot performed well on appendicular trauma. Strengthening this foundation through a local training programme and ongoing feedback is necessary to improve performance, particularly sensitivity.

A clear advantage of radiographer PCE is the potential speed at which it can be made available to the clinical team. In our study, the median time from exam attendance to PCE entry was 12 min. Although this was an imperfect measure, it suggests that by the time a clinician sees a patient after returning from radiology, a PCE could already be available. Definitive clinical reports typically arrive hours or days later, unless a "hot reporting" service is operational; even then, few hospitals run a 24-h service. A PCE available within minutes can support timely care, mitigate risk and improve patient safety.[4]

Artificial intelligence (AI) is increasingly being explored for fracture detection and is likely to support—or potentially replace—radiographer PCE.[3,4] While AI algorithms have the potential to improve fracture detection and clinical decision-making, current systems have not yet been validated for routine clinical use.[4,27] The National Institute for Health and Clinical Excellence's most recent guidance on early value assessment for fracture detection AI[27] confirms that available technologies should only be used within the NHS as part of an evidence generation period—evaluating diagnostic accuracy, clinical impact, failure rates, and cost-effectiveness—before broader adoption. Oversight remains essential, both to verify AI outputs and to interpret them within the clinical context. Strengthening ED radiographers' image interpretation skills through appropriate implementation of PCE will equip them with the knowledge, skills, and confidence to identify and challenge inaccurate or misleading AI outputs.

Limitations

Participation in PCE was voluntary, and radiographers provided comments for only 44% of eligible examinations, introducing the possibility of "film-selection bias".[28] Radiographers may have been more inclined to comment on examinations they perceived as straightforward, potentially inflating observed accuracy. While participants were asked to provide their own independent interpretation, no formal blinding to the definitive clinical report was implemented. However, during the study the predominant reporting model was delayed ("cold") reporting. PCE turnaround times indicate that the majority of comments were entered contemporaneously, suggesting they were likely recorded before a clinical report was available.

A further limitation relates to the reference standard used. Diagnostic accuracy estimates rely on comparison with a reference standard that, in theory, is 100% sensitive and specific,[29] yet substantial inter-observer variation exists even among experienced observers when interpreting trauma radiographs.[30] In our data, 30% of full or partial false-negative errors occurred in cases where the reference standard report used equivocal terminology. This uncertainty within the ground truth highlights the inherent limitations of using a single clinical report as the reference standard. Although such an approach was pragmatic and appropriate for this service evaluation, it inevitably introduces reference-standard bias.[28]

Conclusion

This pilot study demonstrates that radiographers can provide timely and accurate PCEs for ED trauma radiographs, with diagnostic performance comparable to published literature and statistically non-inferior to the predefined accuracy standard. Nevertheless, the study reinforces that sensitivity—while acceptable—remains the key area for further gains. Participation was moderate but improved over time, suggesting growing confidence and familiarity with the process. With appropriate governance, structured training, and routine integration of PCE into departmental protocols, radiographer participation and diagnostic performance are likely to improve. PCE represents a viable safety-net approach for departments without 24-h hot reporting, supporting early identification of abnormalities and enhancing patient safety. Continued development of radiographer image interpretation skills will also position the workforce to engage safely with emerging AI tools and maintain oversight of automated outputs. Overall, the findings support the feasibility and value of establishing a permanent PCE service within our department.

Ethics approval and consent to participate

This project was conducted as a registered service evaluation at Jersey General Hospital and, in line with local governance procedures, did not require formal Research Ethics Committee approval. All data were handled in accordance with institutional confidentiality and information-governance standards. No identifiable patient information beyond routine clinical records was used. Written consent for publication was not required as no identifiable data are included.

Funding

The authors received no external funding for this work.

Availability of data

Data supporting this study may be made available by the corresponding author upon reasonable request.

Author contributions

GC: Conceptualisation, Methodology, Investigation, Data curation, Formal analysis, Writing – Original draft, Writing - Review & Editing, Supervision, Project administration.

PG: Conceptualisation, Methodology, Investigation, Data curation.

JH: Conceptualisation, Methodology, Data Curation.

All authors reviewed and approved the final manuscript.

Generative AI use

During the preparation of this manuscript, the authors used ChatGPT to support language editing and clarity. All content was reviewed, verified, and revised by GC, who takes full responsibility for the final version.

Conflict of interest statement

The authors declare no conflicts of interest.

Acknowledgements

We thank the radiographers who participated in this project and the management team for their continued support of this service development initiative. We also thank James Harcus for providing valuable feedback on the manuscript.

References

1. NHS Resolution. *Learning from Emergency Medicine compensation claims* [Internet]; 2022 Mar 28. Available from: https://resolution.nhs.uk/2022/03/28/learning-from-emergency-medicine-compensation-claims/.
2. NHS Resolution. *Clinical negligence claims in Emergency Departments in England: missed fractures [Internet]*. London: NHS Resolution; 2022 Mar. Available from: https://resolution.nhs.uk/wp-content/uploads/2022/03/2-NHS-Resolution-ED-report-Missed-Fractures.pdf.
3. Harcus J, Stevens B, Pantic V, Hewis J. Preliminary clinical evaluation: where are we? An international scoping review. *Radiography*. 2024;30(5):1474–1482.
4. The Society and College of Radiographers (SoR). *Radiographer preliminary clinical evaluation*. 2nd ed. SoR; 2024. Available from: https://www.sor.org/getmedia/11c376c4-2297-4c0c-8c70-24516055e033/021224_Radiographer-Preliminary-Clinical-Evaluation_D1-4.
5. Berman L, de Lacey G, Twomey E, Twomey B, Welch T, Eban R. Reducing errors in the accident department: a simple method using radiographers. *Br Med J (Clin Res Ed)*. 1985 Feb 9;290(6466):421–422.
6. The Society and College of Radiographers. *Preliminary clinical evaluation and clinical reporting by radiographers: policy and practice guidance*. London: The Society and College of Radiographers; 2013.
7. Health and Care Professions Council. *Standards of proficiency – radiographers* [Internet]. London: HCPC; 2023. Available from: https://www.hcpc-uk.org/standards/standards-of-proficiency/radiographers/.
8. Snaith B, Hardy M. Radiographer abnormality detection schemes in the trauma environment—An assessment of current practice. *Radiography*. 2008 Nov 1;14(4):277–281.
9. Harcus JW, Stevens BJ. Radiographer abnormality flagging systems in the UK–A preliminary updated assessment of practice. *Radiography*. 2023 Jan 1;29(1):234–239.
10. *HRA decision tool, Medical Research Council*. Medical Research Council; 2018. Available from: https://www.hra-decisiontools.org.uk/research/.
11. Scally AJ, Brealey S. Confidence intervals and sample size calculations for studies of film-reading performance. *Clinical radiology*. 2003 Mar 1;58(3): 238–246.
12. Brealey S, Scally A, Hahn S, Thomas N, Godfrey C, Crane S. Accuracy of radiographers red dot or triage of accident and emergency radiographs in clinical practice: a systematic review. *Clinical radiology*. 2006 Jul 1;61(7): 604–615.
13. Verrier W, Pittock LJ, Bodoceanu M, Piper K. Accuracy of radiographer preliminary clinical evaluation of skeletal trauma radiographs, in clinical practice at a district general hospital. *Radiography*. 2022 May 1;28(2): 312–318.
14. Lidgett T, Pittock L, Piper K, Woznitza N. A pilot study to assess radiographer preliminary clinical evaluation (PCE) introduced for emergency department adult appendicular X-ray examinations: comparison of trained and untrained radiographers. *Radiography*. 2023 Mar 1;29(2):307–312.
15. Piper KJ, Paterson AM, Godfrey RC. Accuracy of radiographers' reports in the interpretation of radiographic examinations of the skeletal system: a review of 6796 cases. *Radiography*. 2005 Feb 1;11(1):27–34.
16. Wilson EB. Probable inference, the law of succession, and statistical inference. *J Am Stat Assoc*. 1927 Jun 1;22(158):209–212.
17. Lowry R. VassarStats 2023: website for Statistical Computation. http://vassarstats.net/.
18. Ahn S, Park SH, Lee KH. How to demonstrate similarity by using noninferiority and equivalence statistical testing in radiology research. *Radiology*. 2013 May;267(2):328–338.
19. Schumi J, Wittes JT. Through the looking glass: understanding non-inferiority. *Trials*. 2011 May 3;12(1):106.
20. Cohen J. A coefficient of agreement for nominal scales. *Educational and psychological measurement*. 1960 Apr;20(1):37–46.
21. Fleiss JL, Levin B, Paik MC. *Statistical methods for rates and proportions*. John wiley & sons; 2013 Jun 12.
22. MedCalc Software Ltd. Inter-rater agreement (Kappa) [Internet]. Ostend (Belgium): MedCalc Software; Version 23.4.1. Available from: https://www.medcalc.org/en/calc/kappa.php.
23. Microsoft. *Microsoft excel*. Microsoft Corporation; 2023 [Computer software].
24. Lancaster A, Hardy M. An investigation into the opportunities and barriers to participation in a radiographer comment scheme, in a multi-centre NHS trust. *Radiography*. 2012 May 1;18(2):105–108.
25. Neep MJ, Steffens T, Owen R, McPhail SM. Radiographer commenting of trauma radiographs: a survey of the benefits, barriers and enablers to participation in an Australian healthcare setting. *Journal of medical imaging and radiation oncology*. 2014 Aug;58(4):431–438.
26. Brealey S. Quality assurance in radiographic reporting: a proposed framework. *Radiography*. 2001 Nov 1;7(4):263–270.
27. National Institute for Health and Care Excellence. *Fracture detection: artificial intelligence (AI) software on X-rays for fracture detection in acute trauma (HTE20) [Internet]*. London: NICE; 2025. Available from: https://www.nice.org.uk/guidance/hte20/chapter/1-Recommendations.
28. Brealey S, Scally AJ. Bias in plain film reading performance studies. *The British journal of radiology*. 2001 Apr 1;74(880):307–316.
29. Whiting P, Rutjes AW, Reitsma JB, Bossuyt PM, Kleijnen J. The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews. *BMC medical research methodology*. 2003 Nov 10;3(1):25.
30. Robinson PJ, Wilson D, Coral A, Murphy A, Verow P. Variation between experienced observers in the interpretation of accident and emergency radiographs. *The British journal of radiology*. 1999 Apr 1;72(856): 323–330.