Is ultrasound superior to plain radiography for detecting radiolucent soft tissue foreign bodies in the extremities?

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Abstract

A short systematic review was undertaken to assess whether ultrasound is superior to plain radiography as the first-line imaging modality for detecting radiolucent soft-tissue foreign bodies in the extremities. A structured search of MEDLINE, EMBASE, Cochrane and Google Scholar databases identified six relevant papers. The author, year, country, study type, patient characteristics, key results and study weaknesses were tabulated. The included studies demonstrated high sensitivity of ultrasound (90–99%) for detecting radiolucent foreign bodies, whereas plain radiography detected none in the comparative studies. However, most studies were small, single-centre and involved experienced operators, which limited generalisability. Overall, ultrasound appears superior to plain radiography for radiolucent foreign bodies, although larger prospective comparative studies are needed to strengthen recommendations.

Clinical scenario

A 34-year-old man presents to the Emergency Department after accidentally falling onto a wooden deck while repairing his garden fence. He reports immediate pain in his right palm and believes he may have a wooden splinter embedded in his hand. On examination, there is a small puncture wound over the thenar eminence with localised tenderness and mild swelling. No foreign body is visible externally. Neurovascular examination of the hand is normal. You suspect a retained radiolucent soft tissue foreign body (wood). Traditionally, plain radiographs would be requested as the initial imaging modality. However, given that wooden foreign bodies are often radiolucent and may not be visible on X-ray, you wonder whether bedside ultrasound would be a more sensitive first-line investigation.

Three-part question

In [patients with suspected radiolucent soft tissue foreign bodies in the extremities] is [ultrasound] superior to [plain radiography] as a first-line imaging modality?

Search strategy

A structured literature search was conducted via Ovid using MEDLINE, EMBASE and Cochrane databases. A combination of MeSH terms and free-text keywords were included:

(exp Foreign Bodies/ OR foreign bod* OR retained foreign bod* OR soft tissue foreign bod*) AND (exp Extremities/ OR exp Arm/ OR exp Leg/ OR exp Hand/ OR exp Foot/ OR extremit* OR arm* OR leg* OR hand* OR foot OR feet) AND (exp Ultrasonography/ OR ultrasound OR ultrasonograph* OR sonograph*) AND (exp Radiography/ OR exp X-Rays/ OR radiograph* OR x-ray* OR plain film*) AND (wood* OR plastic OR radiolucent)

In addition, forward citation tracking was performed using the Google Scholar "cited by" function on all included studies to identify any further relevant literature. Reference lists of selected papers were also screened to ensure no key studies were missed.

Search outcome

The search identified a total of 119 papers, with no duplicates. Following title and abstract review, 101 papers were excluded. 18 papers underwent full-text review and a further 12 were excluded: 5 of these were non-human studies and 7 were not directly relevant to the three-part question.

6 papers were selected for final analysis: 4 prospective diagnostic cohort studies, 1 retrospective cohort study and 1 retrospective case series. The key results are summarised in table 1.

Table 1

Author (year) country	Patient group	Study type (level of evidence)	Outcomes	Key results	Study weaknesses
Tahmasebi M et al. (2014), Iran	51 consecutive patients with clinically suspected radiolucent soft tissue foreign bodies in extremities and negative plain radiographs	Prospective diagnostic cohort study (Level 2 evidence)	Detection of retained foreign body confirmed by surgical exploration or ultrasound-guided removal; calculation of sensitivity, PPV and accuracy	• Foreign body confirmed in 47/51 patients • Ultrasound sensitivity: 97.9% • Positive predictive value: 92% • Overall accuracy: 90.2% • 1 false negative, 4 false positives	• No direct statistical comparison with radiography (radiographs negative by inclusion criteria) • Small sample size • Single-centre study • Ultrasound performed by experienced radiologist (may limit

	(n=51, male: 75%, mean age: 27.6)			• All initial plain radiographs were negative	generalisability) • Selection bias (only radiograph negative patients included)
Tantray MD et al. (2018), India	120 patients with clinically suspected soft-tissue radiolucent foreign body in extremities and negative plain radiographs (n=120, male: 68.3%, mean age: 26.8)	Prospective diagnostic cohort study (Level 2 evidence)	Detection of foreign body confirmed at surgical exploration; calculation of sensitivity, PPV, and accuracy of ultrasound	Ultrasound positive in 114/120 patients • Foreign body retrieved in 108/120 • Among six US-negative cases, one had a foreign body found on exploration • Sensitivity: 99.08% • Positive predictive value: 94.13% • Overall accuracy: 94.16%	• No direct statistical comparison with radiography (radiographs negative by inclusion criteria) • Selection bias (only radiograph negative patients included) • Single-centre study • Ultrasound performed by experienced radiologist (may limit generalisability)
Shresth a D et al. (2009), Nepal	23 patients with clinically suspected non-radiopaque soft tissue foreign bodies in extremities. (n=23, male: 67%, mean age: 31.7)	Retrospective diagnostic cohort study (Level 2–3 evidence)	Detection of foreign body using plain radiography and ultrasound, confirmed by surgical exploration	• Plain radiography detected 0/23 foreign bodies • Ultrasound positive in 19/23 cases • 18/19 ultrasound-positive cases confirmed at surgery (1 granuloma false positive)	• Retrospective design Small sample size (n=23) • No formal calculation of sensitivity, specificity, or comparison statistics. • Single-centre study in a resource-limited setting (may affect generalisability) • Operator-dependent ultrasound performance
Al-Zahrani	31 consecutive	Prospective diagnostic	Detection of radiolucent	• 20/31 patients had foreign bodies	• Small sample size (n=31)

S et al. (1995), Saudi Arabia	patients with clinically suspected radiolucent foreign bodies (wooden splinters) in soft tissues of the extremities. (n=31, male = 74%, mean age: 22.8)	cohort study (Level 2 evidence)	foreign bodies using plain radiography, CT scan and ultrasonography, with surgical exploration as the reference standard.	confirmed at surgical exploration • Plain radiography detected 0/20 confirmed foreign bodies (0% accuracy) • Ultrasound detected 18/20 confirmed foreign bodies (90% accuracy; 10% false negative rate) • No false positives reported with ultrasound • Foreign bodies embedded in the calcaneum and the talonavicular joint were not detected by ultrasound.	• Single-centre study • No formal calculation of sensitivity, specificity, or comparison statistics • No evaluation of operator variability
Gibbs TS (2006), United States	20 patients with suspected soft tissue foreign bodies in extremities (n=20, male = 50%, mean age: 30)	Retrospective case series (Level 3 evidence)	Detection and localisation of soft tissue foreign bodies using ultrasound compared with plain radiography.	• 6 radiolucent (wooden) foreign bodies were present • Radiographs were performed on 5 of these patients and detected 0/5. • Ultrasound detected 6/6 wooden foreign bodies.	• Retrospective design • Small sample size (n=20) • Not limited to radiolucent foreign bodies (included metallic and glass) • No formal calculation of sensitivity, specificity or comparison statistics • Selection bias

					(only patients who underwent ultrasound included) • Ultrasound performed by experienced sonographers (may limit generalisability)
Crawford R et al. (1989), UK	39 consecutive patients with suspected retained foreign body in the hand and negative plain radiographs (n=39, male = 82%, mean age: 41.7)	Prospective diagnostic cohort study (Level 2 evidence)	Detection and localisation of radiolucent foreign bodies confirmed at surgical exploration	• 20 radiolucent foreign bodies confirmed at surgery • Ultrasound true positives: 19/20 • False negatives: 1/20 • Sensitivity: 95% • False positives: 2 • Specificity: 89.5%	• Single-centre study • Small sample size (n=39) • Operator-dependent ultrasound performance • Only hand injuries included (limited generalisability to all extremities) • No direct statistical comparison with radiography (radiographs negative by inclusion criteria)

Comments

The evidence consistently demonstrates that ultrasound has high sensitivity for detecting radiolucent soft tissue foreign bodies in the extremities. Across diagnostic cohort studies, ultrasound sensitivity ranged from 90% to 99%, with positive predictive values of 92% to 94%.[1,2,3,4,6] In contrast, plain radiography detected none of the confirmed radiolucent foreign bodies in the studies where it was evaluated.[3,4] These findings support the plausibility that radiolucent materials such as wood are poorly visualised on radiographs but readily identified on ultrasound.

However, the findings should be interpreted with caution. Some studies included only patients with negative plain radiographs; this introduces selection bias and limits direct head-to-head statistical comparison between the imaging modalities.[1,2] Sample sizes were small (n=23–120), and all studies were single-centre, which may affect external validity.[1–4] Operator dependence is another important limitation, as ultrasound examinations were frequently performed by experienced practitioners, which may overestimate diagnostic performance in less-experienced hands.[1,2,5]

False positives and false negatives were reported in several studies. One study demonstrated a 10% false negative rate, with deeply embedded foreign bodies proving more difficult to detect.[4] These findings suggest that while ultrasound is highly sensitive, it is not infallible, particularly in anatomically complex regions.

The retrospective case series further supports the utility of ultrasound, demonstrating successful identification of all six radiolucent wooden foreign bodies, whereas radiographs detected none.[5] However, its retrospective design and small sample size limit the strength of its conclusions.

Overall, the current evidence suggests that ultrasound is superior to plain radiography for detecting radiolucent soft tissue foreign bodies in the extremities. The evidence base is limited by small, single-centre studies and potential operator dependence; however, the consistency of findings across multiple cohorts strengthens the conclusion. Larger, multicentre prospective studies directly comparing ultrasound with radiography would help to clarify its role as a first-line imaging modality and better define its generalisability.

References

1. Tahmasebi M, Zareizadeh H, Motamedfar A. Accuracy of ultrasonography in detecting radiolucent soft-tissue foreign bodies. *Indian J Radiol Imaging*. 2014;24(2):196-200.
2. Tantray MD, Rather A, Manaan Q, Andleeb I, Mohammad M, Gull Y. Role of ultrasound in detection of radiolucent foreign bodies in extremities. *Strategies Trauma Limb Reconstr*. 2018;13(2):81-85. doi:10.1007/s11751-018-0308-z
3. Shrestha, D., Sharma, U., Mohammad, R., & Dhoju, D. (2009). The Role of Ultrasonography in Detection and Localization of Radiolucent Foreign Body in Soft Tissues of Extremities. *Journal of Nepal Medical Association*, *48*(173). doi.org/10.31729/jnma.174
4. Al-Zahrani S, Kremli M, Saadeddin M, Ikram A, Takroni T, Zeidan H. Ultrasonography detection of radiolucent foreign bodies in soft tissue compared to computed tomography scan. *Ann Saudi Med*. 1995;15(2):110-112. doi:10.5144/0256-4947.1995.110
5. Gibbs TS. The Use of Sonography in the Identification, Localization, and Removal of Soft Tissue Foreign Bodies. *Journal of Diagnostic Medical Sonography*. 2006;22(1):5-21. doi:10.1177/8756479305283985
6. Crawford R., Matheson A.B. Clinical value of ultrasonography in the detection and removal of radiolucent foreign bodies. INJURY 1989;20(6):341-343. doi:10.1016/0020-1383%2889%2990008-9