Diagnostic Accuracy of Ultrasonography in Retained Soft Tissue Foreign Bodies: A Systematic Review and Meta-analysis

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Abstract

Objectives: Open wounds with the potential for retained foreign bodies are frequently seen in the emergency department (ED). Common foreign bodies, such as wood or glass, are often missed on physical examination and conventional radiography. The increased use of ultrasonography (US) in the ED presents an opportunity to better identify retained soft tissue foreign bodies, and understanding of its test characteristics is desirable. The authors set out to determine the test characteristics of US for detection of soft tissue foreign bodies by performing a systematic review and meta-analysis of the existing literature.

Methods: This was a thorough, systematic review of OVID Medline, SCOPUS, and Cochrane databases and a limited review of Directory of Open Access Journals, Google Scholar, and ClinicalTrials.gov to identify clinical studies examining the diagnostic accuracy of US in the identification of retained soft tissue foreign bodies. Studies were selected for full-text review by two independent reviewers to determine if they met inclusion criteria. Results were pooled for test characteristics using STATA and assessed for risk of bias and applicability using the QUADAS-2 tool.

Results: This systematic search strategy identified 5,059 unique articles, and 17 articles met inclusion criteria. Pooled sensitivity and specificity were, respectively, 72% (95% confidence interval [CI] = 57% to 83%) and 92% (95% CI = 88% to 95%). Overall quality of the studies was low and interstudy heterogeneity was high ($I^2 = 90\%, 95\% \text{CI} = 80\% \text{to} 100\%)$.

Conclusions: Ultrasonography is highly specific and moderately sensitive in the identification of retained soft tissue foreign bodies; however, studies to date have a high degree of heterogeneity and a high risk of bias.


Open wounds are a common presenting complaint in emergency departments (EDs), accounting for 5.7 million (4.5% of total) ED visits in 2010.\(^1\) Retained foreign bodies are found in 7% to 15% of wounds in the ED and up to 38% are missed on initial physician evaluation.\(^2\) Patients often wait weeks to months after initial injury to present for treatment.\(^2\) The ideal treatment window for retained foreign bodies is within 24 hours, which allows for visualization of the entry and exit wounds and decreased inflammation, induration, and scarring.\(^7\) Delayed treatment may lead to complications including infection, delayed wound healing, inflammation, and loss of function.\(^8\) Attempts at removal can also result in complications including further tissue damage, foreign body migration or retention, infection, and neurological damage. Failure to diagnose retained soft tissue foreign bodies can result in medical malpractice claims and...
large indemnity payments. In a prior study investigating ED malpractice litigation claims, 32% involved retained foreign bodies.

General evaluation for a retained foreign body includes a detailed history and physical examination as well as plain film radiographs. Metal, glass, and wood are the most common retained foreign bodies. Both glass and wood can be radiolucent and difficult to see on radiograph images. Glass accounts for up to 50% of missed foreign bodies using physical examination and radiographs, and plain radiographs have been found to be only 7.4% sensitive at identifying wood foreign bodies.

Bedside (also known as point-of-care or clinical) ultrasonography (US) is a readily available diagnostic tool in the ED and has become an integral part of emergency diagnostic imaging because of its ease of use, lack of radiation, and safety. US has been shown to be accurate in identifying soft tissue foreign bodies in both animal and cadaver models. The ability to use point-of-care US to diagnose retained foreign bodies in the ED is well known and previously described.

However, in the literature to date, the overall sensitivity and specificity of US in the identification of soft tissue foreign bodies remain unclear due to variable sample sizes, multiple covariates, and an increase in use and technology in recent years. Understanding the diagnostic capabilities of US in identifying soft tissue foreign bodies will allow emergency physicians (EPs) to use US more effectively. Therefore, we set out to conduct a systematic review and meta-analysis of the literature to summarize the test characteristics of US in identifying retained soft tissue foreign bodies.

**METHODS**

**Search Techniques**

We conducted a thorough and systematic literature search of English-language articles published on diagnosis of soft tissue foreign bodies through May 1, 2014, using Ovid MEDLINE, Ovid MEDLINE In-Process & Other Non-Indexed, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Cochrane Methodology Register, and Scopus. For the searches, we selected Medical Subject Headings (MeSH) and keywords to capture the concepts of ultrasonography, foreign bodies, injury locations of foreign bodies, and injury patterns consistent with foreign bodies. The search results were combined and exported to RefWorks bibliographic management tool and duplicate results were removed. In addition, we searched studies listed in ClinicalTrials.gov, but these studies were not able to be exported to the reference manager. Then, on July 1, 2014, we also performed a limited review of the Directory of Open Access Journals (DOAJ) and Google Scholar; however, DOAJ does not allow for controlled vocabulary, truncation, or wildcards as in our other databases, and neither DOAJ nor Google Scholar export entire searches into RefWorks. Complete details of the search strategies including search terms are available (Data Supplement S1, available as supporting information in the online version of this paper).

All titles were independently reviewed for possible inclusion by two trained reviewers (BC and JD). Prior to beginning the review, both reviewers agreed to err on the side of inclusion. If either reviewer selected a reference, the full text was ordered for further review. The reference sections of all included articles were checked for additional potentially relevant articles (Figure 1).

**Inclusion and Exclusion Criteria**

Articles meeting the following criteria were eligible for review: English language, research of any design that reported quantitative data, focused on soft tissue foreign bodies in patients, and used US imaging. Exclusion criteria included articles that were anecdotal or had no data; foreign bodies that were intraocular, respiratory, or penetrated deeper than skin and soft tissue; on the topic of retained surgical equipment; single case reports or sample size less than 10; insufficiently described to be able to calculate either sensitivity or specificity of US; or experimental studies using animals, animal tissue, or cadavers.

A priori, we defined the positive reference standard as either computed tomography (CT) or surgery and the negative reference standard as CT, surgery, or follow-up until the patient was asymptomatic. We chose follow-up until asymptomatic as a negative standard as we are hoping to use this analysis in a real-world, clinical setting, as opposed to a diagnostically perfect, theoretical setting.

**Data Collection and Processing**

The team developed an abstraction form designed to confirm final eligibility for full review, assess article characteristics, and extract data relevant to the study question, which was used by two reviewers (BC and JD) to independently abstract data from the articles. Data included test characteristics, reported results, location of study, and type and location of the foreign body. The two abstractors and two senior team members (AA and JMF) discussed the two independent abstractions and combined them into a final abstraction. All abstraction disagreements were minor and were quickly resolved via consensus discussion between the four team members.

**Quality Assessment**

Two reviewers (BC, JD) independently assessed the quality of the articles using the QUADAS-2 tool modified to conform to this meta-analysis of diagnostic accuracy. All disagreements were minor and resolved via consensus of the entire team (AA, BC, JD, JMF). The resultant QUADAS-2 tool was used to assess studies for potential risk of bias involving methodology, reporting, and validity. Study heterogeneity was assessed using I² analysis.

We decided a priori the characteristics of each study that would meet criteria for low risk of bias in each section of the QUADAS-2 tool. For patient selection, the inclusion and exclusion criteria had to be clearly stated, the patients had to have been enrolled regardless of radiography results, and the patient sample had to be consecutive or randomized. For the index test, the US machine and probe frequency had to be clearly stated, the experience or training of the sonographer had to be clearly stated, and the scan had to have occurred in at
least two planes. For the reference standard (surgery or CT scan), the experience or training level of the surgeon or radiologist had to be clearly stated and he or she had to be blinded to the results of the index sonogram. For patient flow and timing, the patients had to have presented within 1 month of the injury that caused the foreign body and must not have had previous attempts at removal, and all patients, regardless of the results of the index sonograms, had to receive the same reference standard. Applicability was based on patient age, location of injury, types of foreign body, and setting of study.

Data Analysis
All statistical analyses were performed using STATA version 12.1. For inter-rater reliability, we determined both percent agreement and Cohen’s kappa. For the diagnostic accuracy meta-analysis, a hierarchical summary receiver operator curve (HSROC) was constructed that allows both fixed and random effects (for threshold and accuracy). The HSROC models were used to obtain sensitivity, specificity, positive and negative likelihood ratios (LR+ and LR−), and diagnostic odds ratios (ORs). HSROC was chosen because it has been shown to be superior to other commonly used methods, takes into account the correlation between sensitivity and specificity, models the observations for each study, and allows the meta-analyst to investigate heterogeneity between studies taking into account both within- and between-study variability. The distribution of the estimates of the random effects was taken into account, and a 95% confidence region and 95% prediction region around these values were calculated within which the operating characteristics may lie. All pooled meta-analytic statistics are reported with their respective 95% confidence intervals (CIs).

RESULTS
The systematic search strategy identified 5,059 unique articles (5,689 total, with duplicates; Figure 1). Of these,
151 were selected for full review. The percent agreement on initial independent selection of articles for further review was 98.7%, and the Cohen’s kappa was $\kappa = 0.74$ (95% CI = 0.71 to 0.78; $p < 0.001$). Forty-six articles did not have English versions. Although English abstracts were available in some cases, we determined that the entire article must be in English to allow adequate assessment of the methodology and risk of bias in these studies. Therefore, 105 full-text articles were reviewed. After our complete review of these articles and their reference sections and our limited reviews of other databases, we included 17 articles in this meta-analysis (Table 1). All 17 studies reported data for calculation of sensitivity; however, only 13 reported data for calculation of specificity.

Several studies examined limited patient populations or foreign body types and locations. Rubin et al. reported only on inpatients with an injury mechanism of a nail through a rubber-soled shoe. Including this study, three studies reported on lower-extremity injuries, while three reported on only upper extremity injuries. Two studies reported on exclusively wooden foreign bodies, and two examined radiolucent or nonradiopaque foreign bodies.

One of the articles reported using point-of-care US. This study reported a sensitivity of 66.7% (95% CI = 34.8% to 90.1%) and a specificity of 96.6% (95% CI = 91.6% to 99.1%). Four studies took place in the general ED setting, one in a pediatric ED, and two in orthopedic EDs.

Our meta-analysis yielded overall sensitivity and specificity of 72% (95% CI = 57% to 83%) and 92% (95% CI = 88% to 95%), respectively (Figure 2). The LR was 3.2 (95% CI = 2.1 to 5.1) and the LR was 0.11 (95% CI = 0.08 to 0.16), which yielded a diagnostic OR of 29 (95% CI = 16 to 53). ROC analysis (Figure 3) demonstrated an area under the curve of 0.93 (95% CI = 0.90 to 0.95). The studies in our analysis were largely heterogeneous, with an $I^2$ value of 90% (95% CI = 80% to 100%).

Subgroup analysis of the four studies looking exclusively at radiolucent or wooden foreign bodies yielded a sensitivity of 96.7% (95% CI = 90.0% to 99.1%) and a specificity of 84.2% (95% CI = 72.6% to 92.1%). Subgroup analysis of the four studies conducted in a general ED yielded a sensitivity of 91% (95% CI = 79% to 96%) and a specificity of 91% (95% CI = 71% to 97%), with a much lower amount of heterogeneity ($I^2 = 2\%$, 95% CI = 0% to 100%). A bivariate boxplot analysis showed larger sample size studies tended to be skewed as outliers. Subgroup analysis of the nine studies within the boxplot yielded an improved heterogeneity ($I^2 = 0\%$, 95% CI = 0% to 100%) and similar test characteristics, with sensitivity of 88% (95% CI = 82% to 92%) and specificity of 73% (95% CI = 59% to 84%).

Our quality assessment for the articles overall was low (Figure 4 and Table 2). Fifteen of the 17 studies (47.1%) had a high risk of bias in patient flow and timing. Eleven studies had an unclear risk of bias in patient selection, and 12 studies (58.8%) had an unclear risk of bias in the description of the index test. No studies had a low risk of bias in three or all four categories. Using QUADAS-2 trigger questions, we deemed that nine of the articles had high applicability to a general patient population with foreign bodies, four had unclear applicability, and four had low applicability.

The study with a low risk of bias in two of the categories of the quality assessment was a retrospective review of 123 cases referred to a diagnostic research facility in India conducted by Saboo et al. They excluded patients lost to follow-up ($n = 12$) and those with negative US imaging who did not undergo surgery ($n = 7$). When analyzing only those patients who underwent surgery, the study found sensitivity and specificity of 94.5 and 53.8%, respectively.

**DISCUSSION**

Our pooled meta-analysis showed test characteristics for US that are, in general, near or better than current practice of traditional radiography paired with history and physical examination. We found a high specificity for US in the identification of foreign bodies. Issues reported as contributing to false-positives include granulomas, small foreign bodies potentially not seen at operation, calcifications, and air and soft tissue gas.

However, the studies in our analysis showed significant risk of bias, poor reporting, and a high level of heterogeneity. None of the studies in our analysis had a low risk of bias in all categories of the QUADAS-2 tool. There was significant international variability, with a maximum of three studies published in the same country: three each in the United States, the United Kingdom, and Israel. Other variables between studies included setting, patients included, methodology, and application of the reference standard. Despite limitations, the current study supports the concept that US is an accurate and useful tool in the detection of foreign bodies. In addition to diagnostic accuracy, important considerations for the approach to the patient with a foreign body in the ED include the accuracy of point-of-care US, the amount of training required for proficiency, the type and radiolucency of the foreign body suspected, area of involvement, and potential for complications.

Point-of-care US has been shown to be a useful initial screening tool in the hands of EPs for the detection of soft tissue foreign bodies. While the current meta-analysis included mostly traditional US, it is reasonable to extrapolate these findings to point-of-care US. The one study in the current meta-analysis that examined point-of-care US was a large study of 131 foreign bodies in 105 pediatric patients, and it reported a sensitivity of 67% and specificity of 96.6%. There is little data on the amount of training and point-of-care US experience required to accurately identify soft tissue foreign bodies. In another study by Orlinsky et al., point-of-care sonographers achieved similar accuracy to radiologists and US technicians after a 2-day course in point-of-care US and a focused didactic session on foreign bodies. In another study, 14 emergency medicine residents in their first and second years of training successfully localized and removed soft tissue foreign bodies after a focused didactic session. Similar results...
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Journal</th>
<th>Sample/Method</th>
<th>Results</th>
<th>Risks of Bias and Limitations in Applicability</th>
</tr>
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<tbody>
<tr>
<td>Al-Zahrani, 1999*23</td>
<td>Ann Saudi Med</td>
<td>A cohort of 31 (or 41) patients presenting to a Saudi Arabian clinic, all of whom had surgery.</td>
<td>TP, 18; FP, 0; TN, 11; FN, 2</td>
<td>1. Unclear sample size or data error 2. Unclear inclusion and exclusion 3. Unclear experience of surgeon 4. Unclear if index results known during surgery 5. Unclear time from injury to presentation 6. Some patients had previous attempts at removal 7. Only wooden FBs</td>
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<td>Banerjee, 1991*24</td>
<td>Br J Radiol</td>
<td>A cohort of 45 UK ED patients, some with a previous x-ray, 26 of whom had surgery.</td>
<td>TP, 22; FP, 2; TN, 1; FN, 1</td>
<td>Sn, 95.7%; Sp, 33.3%</td>
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<td>Blankstein, 2000*25</td>
<td>Arch Orthop Traum Surg</td>
<td>A cohort of 12 patients referred to an Israeli orthopedic ED for suspected FB, 10 of whom had an x-ray and 8 of whom had surgery. One patient was negative on imaging and the remaining 3 had positive imaging, but were asymptomatic.</td>
<td>TP, 8; FP, 0; TN, 1; FN, 0</td>
<td>Sn, 100%; Sp, 100%</td>
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<td>Blankstein, 2001*26</td>
<td>Isr Med Assoc J</td>
<td>A cohort of 21 patients referred to an Israeli orthopedic ED for suspected FB, all of whom had surgery and follow-up.</td>
<td>TP, 19; FP, 0; TN, 1; FN, 0</td>
<td>Sn, 100%; Sp, 100%</td>
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<td>Callegari, 2009*27</td>
<td>Eur Radiol</td>
<td>A cohort of 62 patients with 95 FBs evaluated by US in Italy, all of whom had FBs and underwent surgery.</td>
<td>TP, 61; FP, N/R; TN, N/R; FN, 1</td>
<td>Sn, 98.4%; Sp, N/C</td>
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<td>Crawford, 1989*28</td>
<td>Injury</td>
<td>A consecutive cohort of 39 UK ED patients with an x-ray negative for a FB who were then evaluated by a formal US.</td>
<td>TP, 19; FP, 2; TN, 17; FN, 1</td>
<td>Sn, 95%; Sp, 89.5%</td>
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| Fornage, 1986<sup>29</sup>  
*Am J Radiol* | A cohort of 10 patients referred to French hospital for suspected FB, all of whom had US, X-ray, and surgery. | TP, 8; FP, 0; TN, 2; FN, 0  
Sn, 100%; Sp, 100% | 1. Unclear inclusion and exclusion  
2. Unclear experience of sonographer  
3. Unclear experience of surgeon  
4. Unclear if index results known during surgery  
5. Unclear time from injury to presentation  
6. Unclear if patients had previous attempts at removal |
| Friedman, 2005<sup>30</sup>  
*Pediatr Emerg Care* | A prospective consecutive cohort of 105 New York pediatric ED patients with 131 wounds evaluated by bedside US and x-ray, with patients suspected of FB undergoing removal. | TP, 8; FP, 4; TN, 115; FN, 4  
Sn, 66.7%; Sp, 96.6% | 1. Pediatric patients only  
2. Unclear if sonographic image included 2 or more planes  
3. Unclear experience of surgeon  
4. Unclear if index results known during surgery  
5. Unclear time from injury to presentation  
6. Unclear if patients had previous attempts at removal  
7. All patients did not receive same reference standard |
| Gilbert, 1990<sup>31</sup>  
*Clin Radiol* | A cohort of 50 patients in a UK ED referred for formal US for suspected FB, with imaging positive patients undergoing surgery and negative patients going follow-up at 6 months. | TP, 21; FP, 3; TN, 25; FN, 1  
Sn, 95.5%; Sp, 89.3% | 1. Radiographic results affected inclusion  
2. Unclear inclusion and exclusion  
3. Unclear experience of sonographer  
4. Unclear if sonographic image included 2 or more planes  
5. Unclear experience of surgeon  
6. Unclear if index results known during surgery  
7. Unclear time from injury to presentation  
8. Unclear if patients had previous attempts at removal  
9. All patients did not receive same reference standard |
| Mohammadi, 2011<sup>32</sup>  
*BMC Med Imaging* | A consecutive cohort of 47 x-ray–negative patients evaluated in Iranian ED by an orthopedic physician, of whom 39 underwent surgery and 8 had follow-up. | TP, 39; FP, 6; TN, 2; FN, 0  
Sn, 100%; Sp, 25% | 1. Radiographic results affected inclusion  
2. Unclear if sonographic image included 2 or more planes  
3. Unclear experience of surgeon  
4. Unclear if index results known during surgery  
5. Unclear time from injury to presentation  
6. Unclear if patients had previous attempts at removal  
7. All patients did not receive same reference standard |
| Read, 1996<sup>33</sup>  
*J Hand Surg* | A review of 98 consecutive patients with suspected hand pathologies (18 with a suspected FB) presenting to a hand surgery clinic in Australia. | TP, 9; FP, 0; TN, 5; FN, 3  
Sn, 75%; Sp, 100% | 1. Unclear inclusion and exclusion  
2. Unclear experience of sonographer  
3. Unclear if sonographic image included 2 or more planes  
4. Unclear experience of surgeon  
5. Unclear if index results known during surgery  
6. Unclear time from injury to presentation  
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</tr>
</thead>
<tbody>
<tr>
<td>Rockett, 1995&lt;sup&gt;34&lt;/sup&gt;</td>
<td>J Foot Ankle Surg</td>
<td>A review of 20 consecutive patients presenting to a Chicago foot and ankle surgery clinic with a history consistent with a wooden FB in the foot, with all imaging positive patients (including 5 with an US positive for an abscess but not an FB) undergoing surgery and all imaging negative patients undergoing follow-up for at least 11 months.</td>
<td>TP, 10; FP, 0; TN, 10; FN, 0</td>
<td>1. Radiographic results affected inclusion 2. Unclear experience of sonographer 3. Unclear experience of surgeon 4. Index results known during surgery 5. Time from injury to presentation greater than 1 month 6. Unclear if patients had previous attempts at removal 7. All patients did not receive same reference standard 8. Only wooden FBs in the foot</td>
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<td>Roic, 1999&lt;sup&gt;35&lt;/sup&gt;</td>
<td>Radiol Oncol</td>
<td>A review of 14 pediatric patients presenting to a Croatian hospital to be evaluated for a FB, 6 of whom underwent surgery.</td>
<td>TP, 14; FP, N/R; TN, N/R; FN, 0</td>
<td>1. Unclear inclusion and exclusion 2. Unclear experience of sonographer 3. Unclear if sonographic image included 2 or more planes 4. Unclear experience of surgeon 5. Index results known during surgery 6. Unclear time from injury to presentation 7. Some patients had multiple attempts at removal 8. All patients did not receive same reference standard</td>
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<tr>
<td>Rubin, 2010&lt;sup&gt;36&lt;/sup&gt;</td>
<td>J Foot Ankle Surg</td>
<td>A review of 96 patients on an inpatient orthopedic unit in Israel, 22 of whom had suspected FBs.</td>
<td>TP, 9; FP, 2; TN, 13; FN, 0</td>
<td>1. Unclear inclusion and exclusion 2. Unclear experience of sonographer 3. Unclear if sonographic image included 2 or more planes 4. Unclear experience of surgeon 5. Index results known during surgery 6. Unclear time from injury to presentation 7. Unclear if patients had multiple attempts at removal 8. All patients did not receive same reference standard</td>
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<td>Saboo, 2009&lt;sup&gt;37&lt;/sup&gt;</td>
<td>J Ultrasound Med</td>
<td>A review of 111 patients who were referred to an Indian diagnostic and research center for suspected FB, 104 of whom underwent surgery.</td>
<td>TP, 86; FP, 6; TN, 7; FN, 5</td>
<td>1. Unclear experience of surgeon 2. Index results known during surgery 3. Unclear time from injury to presentation 4. Unclear if patients had multiple attempts at removal 5. All patients did not receive same reference standard 9. Only nail puncture wounds in feet</td>
</tr>
<tr>
<td>Shiels, 1990&lt;sup&gt;38&lt;/sup&gt;</td>
<td>Am J Radiol</td>
<td>A review of 26 patients presenting to a Texan radiology service, 20 of whom had surgery.</td>
<td>TP, 19; FP, 0; TN, N/R; FN, 1</td>
<td>1. Unclear inclusion and exclusion 2. Unclear experience of sonographer 3. Unclear if sonographic image included 2 or more planes 4. Unclear experience of surgeon 5. Index results known during surgery 6. Unclear time from injury to presentation 7. Unclear if patients had multiple attempts at removal 8. All patients did not receive same reference standard</td>
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were reported in a study investigating the ability of nurse practitioners with no previous US experience in detecting soft tissue foreign bodies after a 2-hour hands-on training session.44

The current analysis attempted to determine the diagnostic accuracy of all foreign bodies; however, foreign bodies may occur in any location; may vary in size, shape, and number of fragments; and may consist of various materials (wood, gravel, glass, metal, plastic, etc.). While US is potentially useful for any type of foreign body, it is extremely useful for the detection of radiolucent foreign bodies such as wood, plastic, thorns, and cactus spines.16,39,45 In addition, the sensitivity of US improves with the size of the foreign body. In a study performed by Jacobson et al.,40 wooden foreign bodies 2.5 mm in length were detected with a sensitivity of 87% and specificity of 97%, and 5-mm-long wooden foreign bodies, with a sensitivity of 93% and

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Tahmasebi, 2014</td>
<td>Indian J Radiol Imaging</td>
<td>A cohort of 288 x-ray-negative patients referred to Israeli radiologists for evaluation of soft tissue masses, all of whom had surgery.</td>
<td>TP, 46; FN, 4; TN, N/R; TP, 1; FP, 1; FN, 4; Sn, 92%; Sp, N/C</td>
<td>1. Radiographic results affected inclusion 2. Unclear experience of sonographer 3. Unclear experience of surgeon 4. Index results known during surgery 5. Time from injury to presentation greater than 1 month 6. Some patients had multiple attempts at removal</td>
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TP = true-positives; FP = false-positives; TN = true-negatives; FN = false-negatives; Sn = sensitivity; Sp = specificity; FB = foreign body; US = ultrasonography; N/R = not reported; N/C = not calculable.

**Figure 2.** Forest plot for a meta-analysis of the diagnostic accuracy of ultrasonography in retained soft tissue foreign bodies.
specify the ability of 97% using US. Although the resolution improves with the use of high-frequency linear transducers, the limited depth of penetration reduces the ability to assess for deeper soft tissue foreign bodies. In prior studies, US located soft tissue foreign bodies at less than 2 cm depth from the skin surface. The effect of the quality of US machines (compact systems in ED vs. high-end systems used in the radiology department) on the sensitivity of US to detect foreign bodies has not been studied.

With the widespread availability of compact and portable systems, point-of-care US examination can be performed within minutes at the bedside to assess for soft tissue foreign body. Given its increased availability, low cost, lack of ionizing radiation, and high specificity, we recommend considering using it as first-line imaging when a foreign body of unknown origin is suspected. US would be especially useful in certain cases: when a radiolucent foreign body is suspected; if a clinical suspicion for a foreign body remains high despite negative radiographs, high-risk cases such as infected foreign bodies, penetration of joints, tendon involvement, compromise of function, and significant pain; and when there is suspicion for organic foreign bodies (wood, thorn, or cactus) with a high risk of inflammation and infection. Foreign body detection with point-of-care US is especially important in resource-limited settings where no other diagnostic imaging exists. Besides detecting a retained soft tissue foreign body, US can be used for real-time localization relative to surface anatomy, aiding in removal.

LIMITATIONS

Publications bias and the risk of missing potentially germane articles are concerns with any systematic review. We attempted to mitigate this by using a robust search strategy and protocol and consultation with a medical librarian. There were also a large number of articles not available in English, which were not included in our analysis. Overall, heterogeneity and poor reporting of the included studies limit the conclusions that can be

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient Selection</th>
<th>Index Test</th>
<th>Reference Standard</th>
<th>Flow and Timing</th>
<th>Applicability</th>
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drawn from pooled analysis and, as many of the included studies occurred prior to the advent of point-of-care US and outside of the ED, generalizability may be limited. Additionally, with recent advances in US technology, diagnostic test characteristics may have changed since some of the included studies were published.

CONCLUSIONS

Ultrasoundography can be a useful diagnostic tool in the evaluation of skin and soft tissue foreign bodies. It may complement traditional radiography in cases of suspected retained soft tissue foreign bodies of unknown origin. It should be strongly considered in high-risk cases and cases of radiolucent foreign bodies. However, current research to date is limited. Further research is needed to verify that the results are applicable to general ED practice, clarify the role of point-of-care sonography, and determine in which situations ultrasoundography is preferable to other imaging modalities in the identification of retained soft tissue foreign bodies.

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References


Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. Search strategies by database for a meta-analysis of the diagnostic accuracy of ultrasonography in soft tissue foreign bodies.