

## Study Comparing the Utility of Digital Radiographs and HRUSG for Detection of Superficial Foreign Bodies and Their Depth

Arbind Kumar Singh<sup>1</sup>, Abhishek Mishra<sup>2</sup><sup>1</sup>SMO, Department of Radio-Diagnosis, Sadar Hospital, Lakhisarai, Bihar, India.<sup>2</sup>MD Radio-Diagnosis, Consultant Radiologist, Sonoscan Pvt. Ltd, Malda, West Bengal, India

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Corresponding Author: Dr. Abhishek Mishra

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**Abstract:****Background:** Retained superficial foreign bodies (FBs) are a common clinical problem and may lead to infection, granuloma, and delayed healing if undetected. Imaging plays a crucial role in their detection and depth assessment.**Aim:** To compare the utility of digital radiographs and high-resolution ultrasonography (HRUSG) in detecting superficial foreign bodies and determining their depth.**Methodology:** This prospective comparative study was conducted in the Department of Radio-diagnosis, IPGMER and SSKM Hospital, from January 2019 to August 2020. Fifty patients with suspected retained superficial foreign bodies were evaluated using digital radiography followed by HRUSG. Surgical findings served as the reference standard where available. Detection rates and depth assessment accuracy were compared using appropriate statistical tests.**Results:** Organic materials predominated, with thorn (50%) and wood (34%) being most common. Most foreign bodies were radiolucent (92%), superficial (0–10 mm depth, 84%), and subcutaneous (78%). Digital radiography detected 8% of cases, whereas HRUSG identified 98% as hyperechoic lesions, demonstrating superior sensitivity and accurate depth localization.**Conclusion:** HRUSG showed significantly higher diagnostic utility than digital radiography, particularly for radiolucent superficial foreign bodies, and is the preferred modality for detection and depth assessment.**Keywords:** Superficial foreign body, Digital radiography, HRUSG, Radiolucent, Depth assessment, Ultrasonography.

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**Introduction**

Accidental and occupational injuries frequently result in the retention of superficial foreign bodies (FBs) within the skin and subcutaneous tissues which hospitals emergency departments surgical units and primary care clinics consider to be a common medical issue [1]. Superficial foreign bodies may include a wide range of materials such as wood and glass and metal fragments and thorns and plastic and gravel. The retained objects cause major health problems for patients who do not receive immediate identification and removal because they result in persistent pain and infection and abscess formation and granuloma and delayed wound healing and neurovascular compromise. The initial stage of foreign body retention appears to be symptomless but it eventually develops into chronic inflammatory reactions or sinus formation [2]. The effective management of cases requires medical professionals to detect superficial foreign bodies early and accurately while they also need to measure the exact depth of these bodies for improved results which will help them to control risks.

The detection of retained foreign bodies through clinical examination requires additional methods because this technique does not work well when small wounds exist or when the entry point has closed or when the foreign object cannot be seen through X-ray imaging [3]. The process of palpation becomes unreliable because of edema and tenderness and patient discomfort while blind exploration leads to tissue damage and higher infection rates and harm to nearby tissues. The evaluation process for suspected retained superficial foreign bodies requires imaging as its essential component. The most accessible and affordable imaging methods which do not harm patients are digital radiography and high-resolution ultrasonography (HRUSG) according to the existing imaging options [4].

Digital radiography is the primary imaging method used to detect foreign bodies which people suspect might be inside their bodies. The system offers fast operational capabilities at a low price which makes it accessible to users in the medical field. Radiographs demonstrate exceptional sensitivity when

detecting radiopaque foreign bodies which include metal and glass and specific types of gravel or stone. Digital systems provide better spatial resolution and image processing capabilities than traditional film radiography which improves visualization and enables better control of contrast and magnification and image storage [5]. Digital radiographs provide multiple advantages but they contain fundamental restrictions. Plain radiographs cannot display radiolucent foreign bodies which include wood and plastic and thorns and certain organic materials. The use of radiographs limits medical professionals from determining how deep the foreign body lies between the skin surface and nearby soft tissue structures. The consolidation of anatomical structures will make it harder to see small or faintly radiopaque objects which will result in false-negative findings.

High-resolution ultrasonography (HRUSG) has become an important imaging technique which doctors use to assess superficial soft tissue damage that includes foreign body detection [6]. HRUSG achieves its superior spatial resolution through high-frequency linear transducers which allow doctors to see small foreign bodies that radiographs cannot detect. Ultrasound technology can identify both radiopaque and radiolucent substances which include wood and plastic that show up as hyperechoic foci with posterior acoustic shadowing or reverberation artifacts. The presence of surrounding hypoechoic edema, abscesses, and granulation tissue enables medical professionals to discover additional diagnostic information.

The primary benefit of HRUSG exists because it provides an accurate measurement of foreign body depth from the skin surface together with its spatial relationship to nearby tendons muscles vessels and nerves. The information needs to be obtained for both pre-procedural planning and guided removal operations. The system provides real-time imaging which enables dynamic assessment and allows image-guided extraction for particular cases to decrease surgical duration while reducing the need for tissue dissection [7]. The method of HRUSG operates without using ionizing radiation which makes it an ideal choice for treating both pediatric and pregnant patients. The presence of extensive subcutaneous emphysema and overlying dressings and deep-seated foreign bodies that exceed high-frequency probe penetration limits will reduce ultrasonography sensitivity because it depends on the operator's skills.

The comparison needs to be performed because only one modality can detect surface foreign objects while another modality identifies their burial depth. Radiographs show sufficient capacity to detect visible radiopaque objects but this technique fails to identify radiolucent foreign bodies. The detection of uppermost radiolucent materials requires highly sensitive HRUSG technology but this method demands

trained personnel who cannot work at all sites. The diagnostic value and precision of each imaging technique together with their constraints will assist doctors in choosing the right imaging method for their patients.

The ability to accurately determine both location and depth measurement becomes vital for all areas that contain essential body parts which include the hands and feet and face and body joints. The surgical procedure requires accurate depth measurement because incorrect depth estimation results in incomplete tissue removal and extended surgical assessment period and accidental damage to the patient. The distance measurement between the foreign object and the skin enables surgeons to design minimal incision procedures which lead to better cosmetic results and decreased postoperative complications.

In recent years, technological advancements in both digital radiography and ultrasonography have further expanded their diagnostic capabilities [8]. The detection of small and subtle foreign bodies has improved because of three factors which include enhanced detector sensitivity and improved image processing algorithms and higher-frequency ultrasound probes. The different studies show variability in reported sensitivities and specificities which needs systematic evaluation to determine their clinical usefulness. The type of foreign body and its size and composition and depth and duration since injury and associated inflammatory response all impact how imaging results show diagnostic accuracy.

The current research study intends to examine how digital radiographs and HRUSG technology function in detecting surface foreign objects and measuring their depth. The research study will evaluate how well both imaging methods identify superficial foreign bodies which have been retained by patients who show signs of these retained objects. The study results will deliver evidence-based recommendations which show the best imaging method to use when doctors suspect their patients have superficial foreign bodies. The research will improve diagnostic accuracy and enable medical professionals to start treatment earlier while decreasing the risks that arise from foreign bodies which remain undetected or not properly located.

The existence of retained superficial foreign bodies creates major medical problems because these foreign bodies can cause complications and make it difficult to diagnose medical conditions. The essential function of digital radiography as a primary imaging method faces challenges because the technology cannot identify objects that lack radiopacity, which requires the use of additional detection methods. HRUSG offers a promising alternative with superior soft tissue resolution and depth assessment capabilities. The clinical practice of detecting and measuring depth with these two modalities requires direct

comparative testing between them to determine which method gives better results for patient care and health outcomes.

### Methodology

**Study Design:** This study was designed as an institution-based prospective comparative study to evaluate and compare the diagnostic utility of digital radiographs and high-resolution ultrasonography (HRUSG) in the detection of superficial foreign bodies and assessment of their depth.

### Study Area

The study was conducted in the Department of Radio-diagnosis, IPGMER and SSKM Hospital. Imaging was performed in the Digital Radiograph Section and the Ultrasonography (USG) Section of the same institution.

**Study Duration:** The study was carried out over a period of 20 months, from January 2019 to August 2020.

**Study Participants:** The study population comprised patients attending the General Emergency and General Surgery Outpatient Department (OPD) of IPGMER and SSKM Hospital with suspected retained superficial foreign bodies.

### Inclusion Criteria

- Patients with a definite history of injury and clinical suspicion of retained superficial foreign body.
- Foreign bodies located in HRUSG-accessible parts of the body (e.g., extremities, superficial soft tissues).
- Patients of all age groups and both sexes.
- Patients who provided informed consent for participation in the study.

### Exclusion Criteria

- Deep-seated foreign bodies involving internal organs.
- Foreign bodies located in non-accessible areas for HRUSG, particularly regions containing air (e.g., thoracic cavity, bowel-containing regions).
- Patients who were hemodynamically unstable and unable to undergo imaging procedures.
- Patients unwilling to provide consent.

**Sample Size:** A total of 60 consecutive patients meeting the inclusion criteria during the study period were enrolled in the study. The sample size was determined based on the average number of eligible cases presenting to the department during the study period and feasibility considerations.

**Procedure:** After obtaining ethical clearance from the institutional ethics committee and informed consent from patients, detailed demographic and

clinical information was collected, including age, sex, occupation, socioeconomic status, mode and duration of injury, and relevant medical history. Clinical examination was performed to identify signs of inflammation, scar formation, swelling, tenderness, or discharging sinus at the suspected site of foreign body retention.

All enrolled patients underwent digital radiography followed by HRUSG evaluation of the affected region. Digital radiographs were obtained using the Agfa HealthCare DX-D600 system. Radiographs were assessed for the presence of radio-opaque foreign bodies, and their approximate size, location, density (metallic or soft tissue density), and estimated depth from the skin surface were noted. Foreign bodies were categorized as radio-opaque or radiolucent based on their radiographic appearance.

Subsequently, ultrasonographic examination was performed using Phillips HD7XE and GE LOGIQ P9 machines equipped with a 7–12 MHz high-frequency linear array transducer. HRUSG was used to detect both radiolucent and radio-opaque foreign bodies. The length, width, depth, and orientation of the foreign body were measured. The most superficial point along the longitudinal axis of the foreign body was marked on the skin to guide surgical removal. The relationship of the foreign body to adjacent neurovascular structures was carefully assessed to avoid procedural complications.

Foreign bodies were also categorized as clinically appreciable or not clinically appreciable based on physical examination findings. Surgical exploration findings, where available, were considered as the reference standard for confirmation of imaging results. The diagnostic performance of digital radiography and HRUSG was compared in terms of detection rate and accuracy in depth estimation.

**Statistical Analysis:** Data were entered into Microsoft Excel and analyzed using SPSS version 24.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Numerical variables were summarized as mean and standard deviation, while categorical variables were expressed as counts and percentages. Comparisons between imaging modalities were performed using appropriate statistical tests. Two-sample (unpaired) t-tests were applied to compare mean depth measurements between digital radiography and HRUSG. Paired t-tests were used when comparing measurements obtained from the same patient by two modalities. One-way analysis of variance (ANOVA) was used to compare means across more than two groups when applicable. Categorical variables, such as detection rates of radiolucent and radio-opaque foreign bodies, were compared using the Chi-square ( $\chi^2$ ) test or Fisher's exact test, as appropriate. The student's t-distribution was used to determine the p-values for t-tests. A p-value  $\leq 0.05$  was

considered statistically significant. All statistical tests were two-tailed unless otherwise specified”.

**Result**

Table 1 shows the distribution of foreign body material among the 50 cases studied. The most common foreign body identified was thorn, accounting for 25 cases (50%), indicating that organic vegetative materials were the predominant cause of foreign body injuries in this population. Wood was the second most frequent material, observed in 17 cases (34%),

further emphasizing the significant contribution of plant-based objects. In contrast, inorganic materials were comparatively less common, with plastic found in 4 cases (8%), metal in 3 cases (6%), and glass in only 1 case (2%). Overall, the findings demonstrate that the majority of foreign bodies were organic in nature (84%), while non-organic materials constituted a smaller proportion (16%), suggesting a higher risk of injury from environmental and outdoor-related exposures in the studied group.

**Table 1: Distribution of Foreign Body Material (N = 50)**

Material	Frequency (n)	Percentage (%)
Wood	17	34%
Thorn	25	50%
Plastic	4	8%
Glass	1	2%
Metal	3	6%
<b>Total</b>	<b>50</b>	<b>100%</b>

Table 2 shows the distribution of depth of foreign body among the study participants (N = 50). The majority of cases had a shallow depth of 0–10 mm, accounting for 42 patients (84%), indicating that most foreign bodies were located superficially. A smaller proportion of patients had foreign bodies at a depth of 10–20 mm (4 cases, 8%) and 20–30 mm (3 cases,

6%), suggesting that deeper impactions were relatively uncommon in this cohort. In one case (2%), the depth was not available (NA). Overall, the findings demonstrate that superficial foreign bodies were predominantly encountered in the study population, with only a limited number of cases presenting with deeper penetration.

**Table 2: Distribution of Depth of Foreign Body (mm) (N = 50)**

Depth (mm)	Frequency (n)	Percentage (%)
0–10	42	84%
10–20	4	8%
20–30	3	6%
NA	1	2%
<b>Total</b>	<b>50</b>	<b>100%</b>

Table 3 shows the distribution of anatomical location of foreign body among 50 patients. The majority of foreign bodies were located in the subcutaneous (SC) tissue, accounting for 39 cases (78%), indicating that superficial tissue involvement was the most common presentation. Intramuscular (IM) foreign bodies were observed in 5 patients (12%), while subcutaneous/muscular (SC/MS) involvement was seen in 2 cases (4%), suggesting relatively fewer

cases with deeper soft tissue penetration. Intra-articular (IA) and intravascular (IV) foreign bodies were rare, each reported in 1 case (2%), highlighting the uncommon but potentially serious nature of such locations. Additionally, 1 case (2%) was categorized as not available (NA). Overall, the findings demonstrate that most foreign bodies were superficially embedded, with only a small proportion involving deeper or critical anatomical structures.

**Table 3: Distribution of Anatomical Location of Foreign Body (N = 50)**

Anatomical Location	Frequency (n)	Percentage (%)
Intra-articular (IA)	1	2%
Subcutaneous/Muscular (SC/MS)	2	4%
Subcutaneous (SC)	39	78%
Intramuscular (IM)	5	12%
Intravascular (IV)	1	2%
NA	1	2%
<b>Total</b>	<b>50</b>	<b>100%</b>

Table 4 shows the distribution of X-ray characteristics of foreign body among the study participants (N

= 50). The majority of cases were radiolucent (RL), accounting for 46 patients (92%), while only 4

patients (8%) had radiopaque (RO) foreign bodies. This indicates that most foreign bodies in the present study were not directly visible on plain X-ray imaging, as radiolucent objects typically do not produce a clear shadow on radiographs. The small proportion of radiopaque cases suggests that only a limited number of foreign bodies could be readily identified

on X-ray. Overall, the findings highlight that reliance solely on X-ray may lead to under-detection in a significant proportion of cases, emphasizing the need for clinical correlation and, when necessary, additional imaging modalities for accurate diagnosis.

X-Ray Finding	Frequency (n)	Percentage (%)
Radiolucent (RL)	46	92%
Radiopaque (RO)	4	8%
<b>Total</b>	<b>50</b>	<b>100%</b>

Table 5 shows the association between X-ray and USG characteristics among 50 cases. Out of the 4 radiopaque lesions detected on X-ray, all 4 (100%) were found to be hyperechoic on USG, with no cases categorized as not applicable (NA). Among the 46 radiolucent lesions on X-ray, the majority, 45 cases (97.8%), were also hyperechoic on USG, while only 1 case (2.2%) was recorded as NA. Overall, 49 out

of 50 cases (98%) demonstrated hyperechoic features on USG, and only 1 case (2%) fell under the NA category. These findings indicate a strong concordance between X-ray findings and hyperechoic appearance on USG, suggesting that most lesions, whether radiopaque or radiolucent on X-ray, tend to present as hyperechoic on ultrasonography.

X-Ray Characteristics	Hyperechoic on USG	NA	Total
Radiopaque	4 (100%)	0	4
Radiolucent	45 (97.8%)	1 (2.2%)	46
<b>Total</b>	<b>49 (98%)</b>	<b>1 (2%)</b>	<b>50</b>

## Discussion

The current research shows that most superficial foreign objects found in this study were organic materials which included 50% thorn and 34% wood as the main form of foreign objects. The existing pattern matches earlier research which shows that outdoor areas and agricultural sites have more plant-based foreign objects than other locations. The study conducted by Tahmasebi M et al. (2014) [9] showed that thorn became the most frequent foreign object because it appeared in 66% of patients who suffered from environmental and work-related strong injuries. The study conducted by Tantray M.D. et al. (2018) [10] revealed that wooden and thorn fragments made up about 70% of radiolucent foreign bodies which appeared in extremities. Our results support previous research which shows that organic substances are the main reason for surface tissue foreign body injuries that affect working males".

The research demographic data showed that 56% of the patients studied within the age range of 20 to 50 years while 76% of the patients identified as male. The research by Macedo Filho ET al. (2005) [11] showed that 92% of patients with superficial foreign bodies who visited their hospital were male patients with an average age of 35 years. The two groups show this similarity because adult males have higher risk of penetrating injuries through their work activities and outdoor time.

The study found that 64% of foreign bodies existed in the lower extremities of the body which included 38% of cases found in the foot and 16% of cases found in the leg. Tantray M.D. et al. (2018) observed that approximately 75% of foreign bodies were removed from lower limbs which corresponds with this finding. The predominance of lower limb involvement can be attributed to barefoot walking or inadequate protective footwear in rural settings. Our study found that 78% of foreign bodies existed in the subcutaneous plane which matched their shallow penetration depth because 84% of cases showed less than 10 mm penetration. Shiels W E et al. (1990) [12] proved that most soft tissue foreign bodies detected through sonography existed as subcutaneous objects which remained within 1 cm of the skin surface.

The study requires us to examine the differences between digital radiography and high-resolution ultrasonography (HRUSG). The study results showed that 92% of foreign bodies appeared as radiolucent materials on X-ray due to the presence of organic materials. The X-ray system in our research achieved an 8% detection rate while HRUSG testing showed 98% detection ability. The study results demonstrate that plain radiography tests face major challenges when trying to find radiolucent substances. Manthey DE et al. (1996) [13] reported that radiography detected only 9% of wooden foreign bodies, whereas ultrasonography identified 93%.

The research conducted by Horton LK et al. (2001) [14] demonstrated that sonography outperformed radiography when it came to detecting foreign bodies that did not show up on X-ray, achieving a detection rate of almost 95%. The values match our HRUSG results, which showed 98% sensitivity, thus proving that ultrasound provides better diagnostic performance for those situations.

The findings from our study become more certain because of the imaging characteristics which we discovered. HRUSG showed that 98% of foreign bodies appeared as hyperechoic objects which showed no relation to their radiographic characteristics. This observation matches the sonographic description which Jacobson JA et al. (1998) [15] established because they found that ultrasonography detected wooden foreign bodies with 95% accuracy which showed up as hyperechoic foci that created posterior acoustic shadowing. The study by Peterson JJ et al. (2002) [16] showed that wooden foreign bodies become invisible on radiographs while they create specific echogenic patterns which develop hypoechoic inflammatory halos during ultrasound examination. The study found that patients developed three different types of inflammatory reactions which included 36% granuloma formation and 22% inflammatory fluid production and 6% abscess formation. The study results demonstrate that HRUSG serves two purposes because it helps to find medical conditions and it evaluates how tissues respond to treatment.

Digital radiography maintains its effectiveness for detecting radiopaque substances that include metal and specific glass pieces. Our investigation found that 8% of foreign objects in the study were radiopaque and X-ray imaging could detect all of them. The method would have failed to detect most cases because organic materials appeared as radiolucent on radiography. Aras MH et al. (2010) [17] demonstrated that plain radiography for non-metallic foreign bodies showed reduced sensitivity compared to ultrasonography. The study found that ultrasound technology showed better results than traditional radiography when detecting small and shallow objects in the comparative evaluation.

The study found no statistically significant link between X-ray features and the average size and depth of objects ( $p > 0.05$ ) which demonstrated that radiography has a fundamental limitation because its ability to detect materials depends more on their composition than their actual size or depth. HRUSG used its high spatial resolution and dynamic assessment capabilities to accurately detect foreign bodies at multiple depths and various sizes.

Our findings match the results of previous studies which show that ultrasonography detects 93% to 98% of superficial foreign bodies while radiography only works for radiopaque objects. Our cohort includes mostly organic foreign bodies which show

through skin and subcutaneous tissue because this type of foreign body presence supports the use of HRUSG as the preferred imaging method for cases where clinicians suspect an issue despite negative results from radiographs. The combination of first conducting radiography and then performing HRUSG for radiolucent cases guarantees the highest level of diagnostic precision while enabling safe and exact foreign body elimination.

### Conclusion

The present study demonstrates that superficial foreign bodies were predominantly organic in nature, with thorn (50%) and wood (34%) being the most common materials. The majority of foreign bodies were radiolucent (92%), superficially located within 0–10 mm depth (84%), and embedded in the subcutaneous plane (78%). Digital radiography showed limited diagnostic utility due to its inability to detect most radiolucent objects, identifying only 8% of cases. In contrast, high-resolution ultrasonography (HRUSG) demonstrated excellent detection capability, with 98% of foreign bodies appearing hyperechoic and accurately localized in relation to surrounding structures. These findings highlight the superior sensitivity and depth assessment capability of HRUSG over digital radiography. Therefore, HRUSG should be considered the preferred imaging modality for suspected superficial foreign bodies, particularly when radiographs are negative.

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