# Role of High Frequency Ultrasonography for Detection of Radiolucent Foreign Bodies and Their Surgical Management

**Bashir Ahmed Mir[1], Samina Shafi Wani[2], Mehmood Ul Hassan Mufti[3], Naseer Ahmad Khan[4], Asif Sultan[5], Omar Khursheed[6]**

**ABSTRACT**

**Introduction:** Delayed presentation of foreign bodies has been reported from the developing world since many decades. They are usually missed on the initial evaluation owing to the vague history or the radiolucent nature of the presenting foreign body.

**Materials and Methods:** This study was conducted on 44 consecutive patients reporting to our institution with a suspected retained foreign body in the musculoskeletal system and in whom standard radiography failed to demonstrate a foreign body. Ultrasound was performed using high-resolution *(10 MHz)* ultrasound system. After confirming the diagnosis, foreign body removal was carried out by surgical exploration.

**Results:** Most common sites of injury was hand involved in 34% followed by foot and ankle in 23% patients. Time of presentation ranged from 1 day to 20 weeks. Predominant chief complaints of the patients were: foreign body sensation 43% patients and pain in 23% patients. Wooden splinters were most common variety of foreign body present in 48% patients followed by Nail slipper injury (rubber) present in 16% patients. Length of the foreign body as given by ultrasound ranged from 3 mm to 30 mm.

**Conclusion:** Sonography is a safe, cost effective, portable, readily available and highly sensitive method to evaluate radiolucent foreign bodies, especially, in patients with clinical suspicious of foreign bodies that may remain undiagnosed in radiography. It also gives important information about the nature, size, depth, and relationship of foreign bodies to other structures and makes exploration easier for the surgeon.

**Keywords:** High resolution ultrasound, Foreign body, Wooden splinters, Nail slipper injury.

## INTRODUCTION

Foreign bodies are any objects originating outside the body. They frequently occur due to various accidental injuries such as traffic accidents, explosions or bursts, and gunshot injuries[1] and usually consist of wooden or metal splinters or glass shards or thorns, causing pain and/or functional impairment.[2] Some of these foreign bodies are obvious in the initial physical examination and can be removed.[3] The missed foreign body may remain asymptomatic for prolonged periods or else lead to a wide range of complications including pain, abscess, chronic discharging wound, necrotizing fasciitis, bone and joint destructive lesions, granulomas, with impairment of tendon mobility or triggering of digits, delayed tendon ruptures, neurodeficits, pyogenic granulomas.[4] Foreign bodies may also migrate to deeper soft tissues, into the joints or even into blood vessels with possible embolic complications. Long-term retention of foreign bodies has also led to the onset of tumors.[2] Errors in preoperative localization may lead to prolonged operational and massive soft tissue injury. A missed foreign body may remain undetected even after exploration.[4,5]

Foreign bodies can seldom be identified and removed on the basis of clinical examination alone and usually only when in a superficial location. Otherwise, imaging techniques are required to identify the foreign body and establish its exact location prior to surgical removal attempt.[2] Metallic materials are opaque on radiographs. However, it is imperative for referring physicians to understand that thorns, splinters, wooden fragments, and pieces of plastic are usually not sufficiently opaque to be visualized on radiographs.[6] In such situations, other imaging modalities like ultrasound, CT and MRI are needed for diagnosis.[7] CT has a higher cost, involves ionizing radiation, may have limited availability and can involve anesthesia in pediatric cases. MRI also has a higher cost and limited availability for evaluating nonmetallic foreign bodies. Evaluation of metallic foreign body is a contraindication for MRI. In addition, MRI often does not allow differentiation of foreign bodies from other structures that can also have low signal intensity such as scar tissue, tendons, and calcifications.[8]

Sonography has emerged as a preferred imaging modality in this setting. Many in vitro experiments and human stud-

[1]Associate Professor, [3]PG Scholar, [5]Assistant Professor, [6]Registrar, Department of Orthopedics, [4]Assistant Professor, Department of Radio diagnosis, Bone and Joint Hospital GMC Srinagar, [2]Medical Officer, Department of Sonologist SDH Chandoosa, NRHM Health services Kashmir, India

**Corresponding author:** Omar Khursheed, Govt. Housing colony, Sector 7, Ellahi bagh, Srinagar, Jammu & Kashmir, India

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ies have reported high sensitivity of sonography in detection of soft tissue foreign bodies. Sonography has been reported to show the size, shape, and location of soft-tissue foreign bodies. It has also been used to guide removal of foreign bodies. Additionally, easy availability, lack of radiation, and relatively low cost are advantages of sonography.[9] High-frequency ultrasound (≥ 7.5 MHz) identifies foreign bodies with a sensitivity of 87-93% and a specificity of 89-99%.[10] These are visualized as hyper-echoic foci with accompanying acoustic shadows. The shadow may be either partial or complete depending on the angle of insonation and the composition of the foreign body. A hypo-echoic halo surrounding the foreign object is sometimes seen, which represents edema, an abscess or granulation tissue. Aside from diagnosis, ultrasound is an effective adjunct for the actual localization of the foreign object in relation to muscles, tendons, vessels, and nerves.[6,11]

Limitations of US evaluation for soft-tissue foreign bodies include operator dependence. Familiarity with the US appearances of soft-tissue foreign bodies and a systematic evaluation of the region of interest in both the longitudinal and transverse orientations are needed for accurate assessment. A high-frequency linear transducer (7.5 MHz or higher) is needed to optimize near field spatial resolution.[12]

The purpose of this study was to determine the role of high frequency ultrasonography for detection of radiolucent foreign bodies and their surgical management.

## MATERIALS AND METHODS

This study was conducted on 44 consecutive patients reporting to our institution with a suspected retained foreign body in the musculoskeletal system and in whom standard radiography failed to demonstrate a foreign body. The study period was from September 2011 to April 2015. The study was conducted after obtaining approval from hospital ethics committee. All radiographs were reviewed by a senior radiologist. These patients were then taken for further evaluation by ultrasound scan. Ultrasound scans were performed in the department of radio diagnosis of our hospital by one of the experienced radiologists using high-resolution *(10 MHz)* ultrasound system (Sonosite. MICROMAX). In order to localize the foreign body the area of interest was scanned in both the longitudinal and transverse orientations. The surrounding soft tissue was also examined for fluid collections, tendon disorders, and injury to neurovascular structures. In ultrasound, linear lesion with distal acoustic shadow and surrounding hypo-echoic area was suggestive of foreign body. Localization of foreign body was done in relation to skin depth and surrounding muscle, bone or tendon. The opposite (contra-lateral) side was used as a control.

After confirming the diagnosis, foreign body removal was carried out by surgical exploration.

The patients' demographic data, mode of injury, duration of symptoms, clinical, sonographic findings and surgical findings were recorded.

## RESULTS

There were 34 (77%) males and 10 (23%) females with a mean age of 29 years (range 3-58 years) (Table 1). Most common sites of injury was left upper limb (15 patients). Anatomically hand was involved in 15 (34%), foot and ankle in 10 (23%), digits in 6 (13.5%), forearm in 5 (11%), elbow in 1 (2.5%), calf in 4 (9%), knee in 2 (4.5%) and buttock in 1 (2.5%) patient respectively. Many patients had multiple foreign bodies, and one of them had 4 wooden splinters in her forearm. Surgery was performed in 44 patients and 58 foreign bodies were successfully removed.

Time of presentation ranged from 1 day to 20 weeks. Predominant chief complaints of the patients were: foreign body sensation in 19 (43%), abscess in 6 (14%), discharging wound in 5 (11%), pain in 10 (23%) and palpable mass in 3 (7%) patients respectively. One patient presented with contracture of third toe. Wooden splinters (Fig 1, 2) were most common variety of foreign body present in 21 (48%) patients followed by Nail slipper injury (rubber) present in 7 (16%) patients, thorn 5 (11%), glass 5 (11%), plastic 3 (7%), stone 2 (4.5%), and graphite in 1(2.5%) patient respectively.

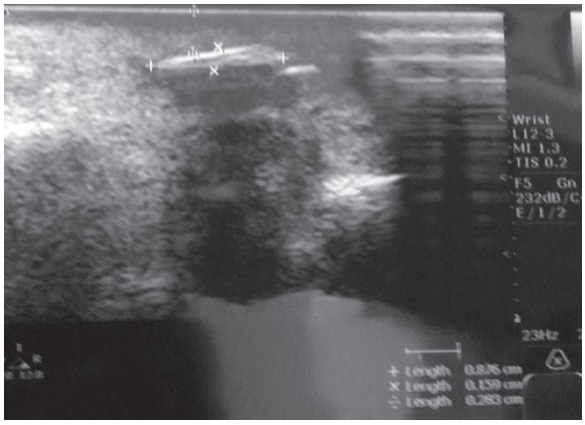


**Figure-1:** Ultrasonography of a patient showing foreign body in dorsum of hand

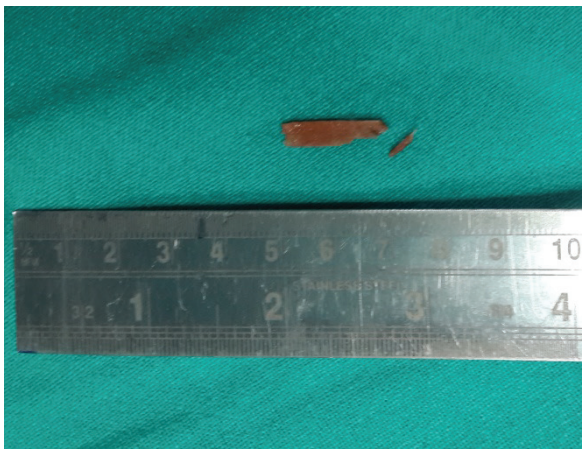

**Figure-2:** Wooden splinter measuring 20 mm extracted from patient after surgical exploration

| S. No | Age/Sex | Duration | Number/ Nature of Foreign bodies | Size (mm) | Anatomical Site |
|---|---|---|---|---|---|
| 1 | 32/ F | 2 wks | 4 wooden splinters (broomstick) | 5, 9,12,30 | Left Forearm |
| 2 | 18/ F | 3 days | 1 Thorn | 4 | Right index finger |
| 3 | 35 /M | 4 wks | 1 wooden splinter | 6 | Palm right hand |
| 4 | 58 /M | 2 wks | 1 wooden splinter | 6 | Palm right hand |
| 5 | 42/M | 6 days | 1 Glass splinter | 3 | Left forearm |
| 6 | 38/M | 16 wks | 1 Rubber (Nail slipper injury) | 8 | Sole of Right foot |
| 7 | 19/M | 2 wks | 1 wooden splinter | 7 | Left middle finger |
| 8 | 33/M | 8 wks | 2 wooden splinters | 7, 8 | Palm Left hand |
| 9 | 24/M | 12 wks | 1 Rubber (Nail slipper injury) | 15 | Sole of Right foot |
| 10 | 22/F | 4 days | 2 wooden splinters | 12, 16 | Palm Right hand |
| 11 | 22/M | 7 days | 1 Glass splinter | 7 | Right knee |
| 12 | 5/M | 6 days | 1 Thorn | 4 | Right index finger |
| 13 | 46/M | 8 wks | 1 wooden splinter | 4 | Left Ankle |
| 14 | 8/F | 10 wks | 1 wooden splinter | 12 | 1st web left hand |
| 15 | 35/F | 9 days | 1 Glass splinter | 4 | Right leg |
| 16 | 38/M | 18 wks | 1 Rubber (Nail slipper injury) | 8 | Sole of Left foot |
| 17 | 26/M | 4 wks | 1 plastic splinter | 4 | Palm Left hand |
| 18 | 21/M | 6 wks | 1 Plastic splinter | 5 | Left index finger |
| 19 | 28/F | 3 wks | 3 wooden splinters (broomstick) | 10,12,12 | Right Leg |
| 20 | 58/M | 20 wks | 1 Rubber (Nail slipper injury) | 10 | Sole of Left foot |
| 21 | 14/M | 12 wks | 1 wooden splinter | 5 | Left Forearm |
| 22 | 30/M | 4 wks | 1 Thorn | 3 | Dorsum left hand |
| 23 | 54/M | 10 wks | 2 Stone fragments | 5,7 | Right Knee |
| 24 | 45/F | 6 days | 2 wooden splinter (broomstick) | 10,25 | Right forearm |
| 25 | 32/M | 18 wks | 1 Rubber (Nail slipper injury) | 6 | Sole of Right foot |
| 26 | 38/M | 12 wks | 1 wooden splinter | 5 | 1st web Right hand |
| 27 | 6/M | 20 wks | 1 Stone fragment | 5 | Sole of Left foot |
| 28 | 3/F | 4 days | 1 wooden (Toothpick) | 7 | Left Elbow |
| 29 | 36/M | 5 wks | 1 Plastic Splinter | 4 | Right index finger |
| 30 | 24/M | 8 wks | 1 wooden splinter | 5 | Left Leg |
| 31 | 22/M | 3 wks | 3 Glass splinters | 4,5,4 | Right Leg |
| 32 | 32/M | 12 wks | 1 wooden splinter | 20 | Dorsum left hand |
| 33 | 24/F | 4 days | 1 Glass splinter | 8 | Right forearm |
| 34 | 32/M | 12 wks | 2 Thorns | 4,4 | Palm left hand |
| 35 | 7/M | 6 days | 1 Pencil lead (Graphite) | 5 | Right Buttock |
| 36 | 24/M | 4 wks | 1 wooden splinter | 12 | Right Ankle |
| 37 | 38/M | 7 days | 2 Thorns | 4,5 | Right index finger |
| 38 | 44/M | 6 wks | 1 wooden splinter | 8 | Palm Right hand |
| 39 | 16/M | 4 wks | 1 wooden splinter | 8 | 1st web Right hand |
| 40 | 26/M | 12 wks | 1 Rubber (Nail slipper injury) | 10 | Sole of Left foot |
| 41 | 22/M | 16 wks | 1 Rubber (Nail slipper injury) | 8 | Sole of Left foot |
| 42 | 46/M | 1 day | 2 wooden splinters | 8,15 | Palm Left hand |
| 43 | 20/F | 4 wks | 1 wooden splinter (broomstick) | 7 | 2nd web left hand |
| 44 | 28/M | 4 wks | 1 wooden splinter | 5 | Dorsum Left hand |

**Table-1:** Patient demographics and observations

Length of the foreign body as given by ultrasound ranged from 3 mm to 30 mm (mean length was 8 mm). The smallest foreign body detected was a thorn which measured 3 mm in length present in the dorsum of left hand.

All patients were symptom free at follow-up and no short- or long-term complications were recorded.

## DISCUSSION

A retained foreign body in the soft tissues of extremities is not very common. Diagnosis requires high index of suspicion[7] Several imaging modalities are available for detection and localization of non-radiopaque foreign body in soft tissue. Conventional radiographs should be obtained to rule out the presence of radiopaque foreign objects. As traditional radiograms are widely available, simple to perform and inexpensive, X-ray is the reference examination and will identify radiopaque FBs (glass, metal, Stone) in around 80% of cases,[2] but radiolucent bodies like wooden splinters are difficult to detect and usually missed. The missed foreign bodies

may produce immediate symptoms like wound infections or may remain asymptomatic for even decades.[5] Generally, organic materials such as thorn, wood and fish bones have low density in radiography and may remain undetected. Although materials such as plastic and glass are radiopaque, they may remain undetected in plain radiography due to the lower density in the plain radiography but plastic materials have less density and may go undetected.[13] Wood, thorn and aluminum are radiolucent and cannot be detected by plain films[14] Studies conducted by Anderson *et al*[15] and Levine *et al*[16] showed that only 15% and 7% of radiolucent foreign bodies appeared in radiographic studies, respectively. Studies done by Oikarnen et al[17] and Manthey DE et al[18] observed that conventional radiography is not able to detect radiolucent foreign body at all. In present study also no radiolucent foreign body was detected in plain radiographs.

CT scan, MRI and ultrasonography are other investigation modalities advocated for evaluation of non metallic foreign body. CT and MRI are useful to identify objects, approximate size, and determine relationships to nearby structures.[8] Computed tomography (CT) and magnetic resonance (MR) scans are very expensive and have very limited indications for FB detection as they have poor sensitivity and specificity[2] High-resolution ultrasonography is a reliable diagnostic tool in the detection of radiolucent foreign bodies in musculoskeletal system as it has a sensitivity and specificity of 90% and 96%, respectively.[2] Because of its high spatial resolution, ultrasound can identify FBs smaller than a millimeter[19], be they wood, glass, metal or plastic.[12] Ultrasonographic evaluation provides important information of the foreign body and also associated complications. Ultrasound is also accurate in predicting the foreign body's exact location, size, depth, orientation, and relationship to other structures.[8]

There were 34 (77%) males and 10 (23%) females with a mean age of 29 years (range 3-58 years). Studies done by Crawford R[4] and Tahmasebi M et al[5] also showed male predominance. This may be possibly due to high involvement of males in outdoor activities compared to females.

Time of presentation ranged from 1 day to 20 weeks which is similar to studies done by most of the authors.

Predominant chief complaints of the patients were foreign body sensation in 19 (43%) and pain in 10 (23%) patients. Studies done by Crawford R[4] and Tahmasebi M et al[5] also showed pain and foreign body sensation as predominant symptom.

Anatomically hand was involved in 15 (34%), foot and ankle in 10 (23%). This is in contrary to the studies done my most authors which showed foot and ankle involvement more than hand. The possible reason for this might me barefoot walking in underdeveloped nations.

Wooden splinters were most common variety of foreign body removed surgically in 21 (48%) patients followed by Nail slipper injury (rubber) present in 7 (16%) patients. The results are similar to the studies done by Crawford R et al[4], Sonali S et al[9], Anderson[15] and Prakash et al.[20]

In our study ultrasound was found to be accurate in predicting not only the size of the foreign body but also its exact location, depth, orientation and relationship to other structures. High resolution ultrasound makes the surgeon sound to localize accurately the foreign body thus making the removal easier, less time consuming and resulting in minimal tissue handling and operating time. It also reduces the chances of negative explorations in patients having doubtful history.

## CONCLUSION

Sonography is a safe, cost effective, portable, readily available and highly sensitive method to evaluate radiolucent foreign bodies, especially, in patients with clinical suspicious of foreign bodies that may remain undiagnosed in radiography. It also gives important information about the nature, size, depth, and relationship of foreign bodies to other structures and makes exploration easier for the surgeon.

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