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Soft Tissue Foreign Bodies in Orthopedics: A Comprehensive Review and Proposed Management Algorithm

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ABSTRACT

Background and Aims: Soft tissue foreign body (STFB) injuries are a common challenge in orthopedic practice, resulting from trauma, industrial accidents, or surgical procedures. In this retrospective analysis, we aimed to evaluate the epidemiological characteristics, diagnostic approaches, and clinical management of STFB injuries, culminating in the development of a structured treatment algorithm. The overarching objective was to refine and validate an evidence-based diagnostic and therapeutic algorithm tailored to the diverse presentations of STFBs in a broad patient population.

Materials and Methods: Between 2013 and 2024, 215 patients with STFB injuries were evaluated, predominantly males aged 18–65. The upper extremities were the most frequently affected sites. Eighty-seven percent of the foreign bodies were radiopaque. Diagnostic imaging included radiography, ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI), selected based on the material's properties and injury complexity. Radiography served as the initial screening tool, while US was most effective for detecting radiolucent foreign bodies such as wood and plastic. CT and MRI were used for deep or complex cases, balancing diagnostic accuracy with cost and radiation exposure.

Results: Management strategies were individualized, weighing conservative care for asymptomatic cases against surgical intervention for symptomatic, high-risk, or complex injuries. Key considerations included material composition, proximity to vital structures, and infection risk. Surgical techniques, often guided by intraoperative imaging, aimed to minimize complications such as neurovascular injury and retained fragments. Prophylactic measures, including antibiotics and tetanus immunization, were tailored to wound contamination and vaccination history. Postoperative care emphasized wound monitoring and physical therapy to restore function.

Conclusion: This study underscores the importance of a systematic, evidence-based approach to managing STFB injuries. While radiography is essential for initial evaluation, advanced imaging techniques such as US and CT are particularly valuable for identifying radiolucent and complex foreign bodies. The choice of imaging modality should be based on the nature of the foreign material. Radiographs suffice for radiopaque objects, whereas US, CT, or MRI is necessary for materials like wood or plastic. Prompt surgical intervention, along with appropriate antibiotic and tetanus prophylaxis, is critical for managing symptomatic cases. Preoperative counseling should address the possibility of incomplete removal and the need for follow-up. Future research should aim to validate these protocols across diverse clinical settings and improve MRI diagnostic capabilities.

Keywords: Diagnosis, injuries, orthopedics, traumatology.

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INTRODUCTION

Soft tissue foreign body (STFB) injuries are among the most frequently encountered conditions in emergency departments worldwide. They represent a challenging aspect of orthopedic practice, requiring meticulous evaluation and management.[1] These injuries typically occur when external objects—ranging from small splinters to large penetrating materials—breach the skin and become lodged within soft tissues.[2] While some foreign bodies remain confined to the subcutaneous layer, making detection and retrieval relatively straightforward, others may penetrate deeper into muscles, tendons, neurovascular structures, or joint spaces.[3] Such complex presentations not only increase the technical difficulty of removal but also elevate the risk of complications—underscoring the need for vigilant diagnostic strategies, nuanced treatment protocols, and long-term follow-up.[4]

Although external trauma—such as industrial accidents, household injuries, or recreational mishaps—constitutes the predominant etiology, iatrogenic causes must also be considered.[5] Fragments from medical devices or surgical implants can persist within tissues, presenting unique diagnostic and therapeutic challenges.[6] While the majority of STFBs result from traumatic incidents, postoperative cases can also be significant sources of morbidity.[7] Incomplete retrieval or inadvertent fragmentation during orthopedic procedures may leave residual materials in adjacent tissues, complicating recovery and necessitating additional interventions.[8]

These challenges are further compounded by evolving trends in orthopedic practice. Early mobilization protocols and the shift toward outpatient surgeries mean that STFBs are increasingly managed in diverse clinical settings, where limited resources or reduced follow-up opportunities can hinder prompt diagnosis.[9] When retained, foreign bodies can lead to a range of local complications, including swelling, pain, erythema, hematoma, and abscess formation.[10] In the presence of an implant, the risk of local joint cartilage damage and synovitis increases, potentially impacting long-term outcomes.[11] Moreover, foreign materials inadvertently left in the operative field carry significant medico-legal implications, underscoring the importance of preventative measures and meticulous documentation.[12] A lack of knowledge, high operative workload, and suboptimal communication among surgical teams are common contributing factors to such oversights.[13]

Despite the high prevalence and potential consequences of STFBs, standardized and universally accepted guidelines for their diagnosis and management remain limited.[14-16] To address this gap, we compiled and analyzed the existing literature on soft tissue foreign bodies in conjunction with clinical data from our center.

METHODS

This study was conducted with the approval of Erzincan Binali Yıldırım University Clinical Research Ethics Committee, dated 13/06/2024, under decision number 2024-08/03. Between 2013 and 2024, a total of 215 patients with a preliminary diagnosis of STFB penetration presented to our orthopedic clinic. The study population included a broad demographic spectrum—both pediatric and adult patients—though the majority were between 18 and 65 years of age. Individuals over 85 years old were not represented in our dataset. Data obtained from the patients were evaluated using SPSS version 25 (IBM, New York, USA). Each patient underwent a systematic diagnostic workup, which included:

Clinical Assessment

A detailed clinical history was obtained from all patients, focusing on the mechanism of injury, time elapsed since the incident, any relevant occupational or environmental exposures, and prior attempts at foreign body removal. Physical examination emphasized wound characteristics, local signs of infection, potential neurovascular compromise, and range of motion in the affected area.

Imaging Modalities

Plain radiography was performed as the first-line imaging modality in all patients, aiming to detect radiopaque foreign bodies such as metal or glass. Ultrasound (US) was utilized when radiographs were inconclusive or when a radiolucent object such as wood or plastic was suspected. Computed tomography (CT) was reserved for evaluating deeply embedded foreign bodies, complex injury patterns, or suspected neurovascular involvement. Magnetic resonance imaging (MRI) was selectively employed to assess soft tissue complications including abscess formation, tendon or ligament injuries, or when metal artifact reduction sequences were needed.

Data Collection and Analysis

Demographic data collected included age, sex, occupation, and the anatomical location of the injury. Characteristics of the foreign body were documented in terms of composition (radiopaque vs. radiolucent), size, depth, and location. Management strategies (surgical vs. conservative), antibiotic administration, tetanus prophylaxis, and post-treatment complications were also recorded and analyzed.

Based on the clinical and radiological evaluations, as well as the data collection and analysis outlined in the above sections, a retrospective review was conducted involving 215 patients who presented to our emergency department

or orthopedic outpatient clinic with a preliminary diagnosis of foreign body penetration. Patient age and sex were recorded as part of the study data. The location of the foreign bodies under the skin, as well as their radiopacity, was determined using ultrasound and radiographic imaging. Patients whose imaging data were not accessible through the hospital system were excluded from the study. In cases where history and physical examination findings led to a decision for surgical intervention, it was observed that patients had active complaints regardless of the size of the foreign body. Additionally, tetanus vaccination status was checked for all patients, regardless of whether they received surgical or conservative treatment. Tetanus prophylaxis was administered according to the patient's vaccination history and the nature of the injury.

RESULTS

Between 2013 and 2024, a total of 215 patients were treated in our clinic for foreign body penetration. These patients were categorized into four groups based on age range, sex, affected extremity, and whether the foreign body was radiopaque or non-radiopaque. Among them, 123 (57.20%) were male and 92 (42.80%) were female (Fig. 1). Patients under 18 years of age accounted for 23.25% of the total, while those aged 18-65 years comprised 70.23%. Notably, no patients over 85 years of age presented to our clinic (Table 1).

Foreign bodies in the upper extremity were most frequently observed in males aged 18-65 years, at a rate of 22.7%. Of all foreign bodies, 188 were radiopaque and 27 were non-radiopaque. Necessary interventions were performed in the emergency department or operating room settings for all patients. Post-interventional radiographic evaluations were conducted using plain radiography or fluoroscopy.

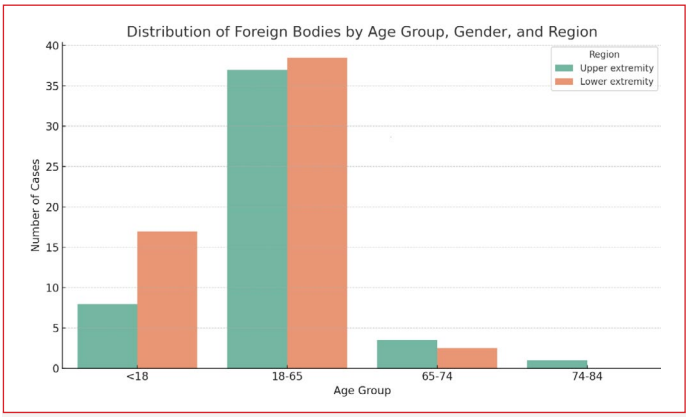

Figure 1. Distribution Histogram.

Table 1. Distribution of soft tissue foreign body injuries by age, gender, and anatomical location

	<18 Y	18-65 Y	65-74 Y	74-84 Y	Total
Male					
Upper extremity	11	49	5	2	67
Lower extremity	16	38	2	0	56
					0
Female					
Upper extremity	5	25	2	0	32
Lower extremity	18	39	3	0	60
Total	50	151	12	2	215

DISCUSSION

This comprehensive retrospective observational study identified the subsequent epidemiological and diagnostic imaging findings. Epidemiological data indicate that 57.2% of patients were male, predominantly aged 18–65. This corroborates global studies linking occupational risks and high-risk activities to STFBs.[17,18] The majority of upper extremity injuries affected manual laborers, artisans, and mechanics.[19] No instances were recorded in individuals over 85, prompting concerns about potential underdiagnosis or healthcare-seeking behavior.[20]

Diagnostic imaging findings indicate that radiography serves as the initial examination. However, its limitation in detecting radiolucent materials necessitates additional imaging.[21,22] Ultrasound demonstrates exceptional sensitivity in detecting hardwood splinters, rendering it essential in emergency situations. However, the proficiency of the operator remains a critical factor.[23–25] CT demonstrates reliability in challenging cases; however, it is associated with high costs and significant radiation exposure.[26] MRI, although infrequently used in acute scenarios, is capable of detecting sequelae such as tendon, ligamentous, and neurovascular injuries.[27–29]

Our research findings and expertise inform a soft tissue foreign body treatment strategy that prioritizes individualized care, matching intervention strategies to each patient's clinical presentation (Fig. 2). Symptomatic foreign bodies located near vital tissues or at elevated risk of infection necessitate surgical extraction.[30,31] Conservative management may be appropriate for asymptomatic, inert foreign bodies with minimal clinical risk.[32,33] While antibiotics and tetanus prophylaxis are crucial for preventative care, in resource-constrained environments, patient education and wound management take precedence.[34]

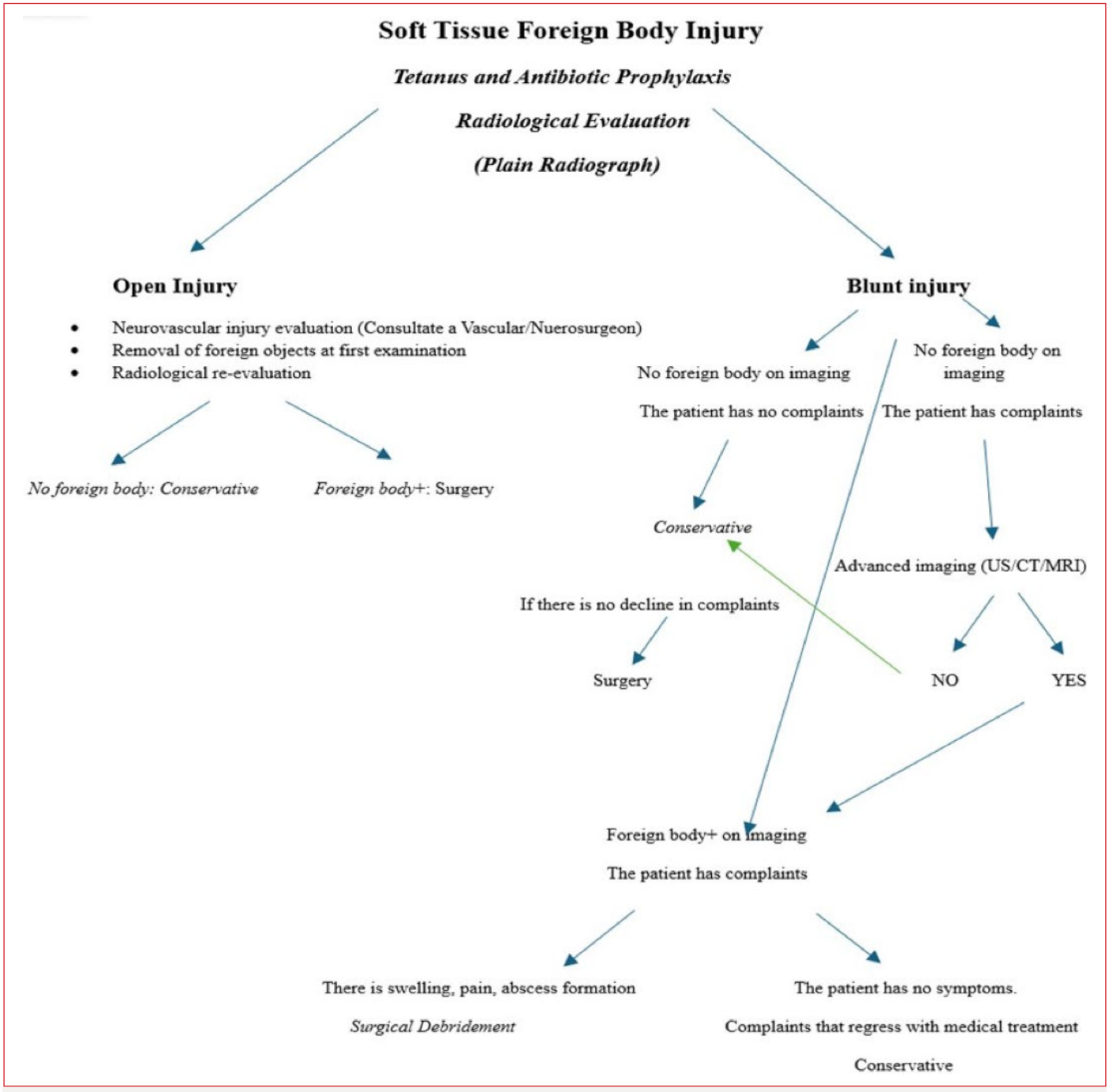

Figure 2. Treatment algorithm for soft tissue foreign body injuries.

Management of STFBs requires a comprehensive approach that integrates clinical evaluation, risk assessment, and tailored interventions. Initial assessment should focus on identifying signs of infection or neurovascular compromise, as these factors significantly influence the treatment pathway.[35–38] High-risk features, such as systemic symptoms or proximity to vital structures, often necessitate urgent intervention, while stable cases may allow for more conservative strategies.[39–42]

The decision between surgical and non-surgical management hinges on multiple factors, including patient symptoms, foreign body characteristics, and potential complications.

Surgical removal is typically prioritized when the object causes functional impairment, poses an infection risk, or threatens adjacent anatomical structures. In contrast, asymptomatic, inert foreign bodies may be monitored, provided there is a reliable follow-up plan to detect delayed issues such as migration or late-onset infection.[42,43]

Prophylactic measures play a critical role in minimizing complications, particularly in contaminated wounds. Antibiotic selection should account for the nature of the injury and local resistance patterns, with an emphasis on avoiding unnecessary use. Tetanus prophylaxis must not be overlooked, especially in cases involving soil-contaminated or puncture wounds, where Clostridium tetani exposure is a concern.[44,45]

Surgical intervention demands precision to avoid secondary damage to surrounding tissues. Advanced imaging modalities, such as intraoperative ultrasound, can enhance accuracy in locating deeply embedded objects. Postoperative management should address wound healing dynamics, with closure techniques adapted to the level of contamination and tissue integrity.[46–48]

Long-term follow-up is essential to ensure proper healing and functional restoration. Regular wound inspections help identify infections or other complications early. For injuries involving musculoskeletal structures, rehabilitation through physical therapy can optimize recovery, reducing the risk of chronic pain or mobility restrictions. A multidisciplinary approach, involving surgeons, infectious disease specialists, and rehabilitation teams, may further improve outcomes in complex cases.[49–51]

Complications and Challenges

Missed or Retained Fragments: Failure to visualize or completely remove all fragments can result in persistent infection, abscess formation, or chronic inflammatory reactions.[52] Thorough imaging, careful preoperative planning, and intraoperative vigilance are essential to minimize the risk of retained foreign bodies.[53]

Neurovascular Injury: Surgical dissection near vessels and nerves requires advanced imaging and meticulous technique to reduce the risk of iatrogenic injury. Intraoperative ultrasound or nerve monitoring can support safer removals.[54]

Pediatric Considerations: Children may present communication challenges and often require sedation for imaging or surgical intervention. Engaging caregivers is crucial for informed decision-making and to ensure adherence to follow-up and rehabilitation plans.[55]

Comparison with Existing Literature

The investigation of epidemiological trends and diagnostic effectiveness corroborates our results.[56] Previous studies indicate that radiopaque materials such as metal and glass are more readily detectable than wood and plastic, which necessitate specialist imaging techniques.[15] Other authors have emphasized the necessity for a standardized management strategy due to the hazards associated with inadequate removal of organic materials such as wood, which decay and cause contamination.[57]

Foreign objects may penetrate the body via an air-filled orifice in soft tissue, between bone and muscle, or directly into soft tissue. The literature identifies metal, glass, wood, stone, acrylic, graphite, Bakelite, thorns, and sand as foreign substances.[57-59]

Conventional or digital radiography, computed tomography, magnetic resonance imaging, and ultrasonography are capable of identifying foreign entities.[32,34] Radiography, being cost-effective, non-invasive, and readily accessible, serves as the primary imaging modality for identifying radiopaque foreign bodies and is the initial screening instrument in any foreign body detection protocol. Radiography is two-dimensional; therefore, ultrasound, MRI, and CT scans are essential for precisely evaluating foreign body dimensions and positioning, as well as facilitating treatment planning.[35]

Ultrasonography can economically identify superficial and deep radiolucent foreign objects such as wood, sand, and plastic fibers.[21] An exhaustive patient history and understanding of the putative foreign body or incident are essential for precise detection.[26] Ultrasonography is less effective in identifying deeper foreign bodies (>3 cm) and air-filled cavities.[13] Portable, non-invasive, low-radiation ultrasonography offers real-time imaging at an economical price. This bedside method is also extensively accessible.[29] Certain ultrasound studies have attained 95% sensitivity in detecting radiolucent foreign bodies.[33,34] Radiography and CT failed to reveal low-radiopaque organic substances such as wood, fiber, plastic, and sand in the interstitial spaces between muscle and bone or inside muscle tissue.[35] Ultrasonography revealed all low-radiopaque materials, with the exception of fiber plastic and sand, near the bone/muscle interface.[36]

CT scans are a non-invasive method for detecting and identifying foreign objects, revealing their shape, size, and orientation.[54] CT is optimal for surgical planning due to its precise localization of foreign objects.[55] Nonetheless, metallic items can affect CT images, resulting in localization inaccuracies. MRI should not be employed to identify foreign bodies of unknown composition, as artifacts such as iron, glass, graphite, sand, and plastic can obstruct visibility.[42]

Additionally, MRI is costly, exhibits significant intra-observer variability, and may not be accessible in all facilities or at all times.[37] The authors encountered difficulties in locating foreign entities within muscle tissue. The presence of polytrauma patients and real-time emergency scenarios complicates this endeavor, particularly in the absence of patient history.[18,19]

Our findings support epidemiological trends and the diagnostic effectiveness literature.[44] As shown, radiopaque metal and glass are easier to identify than wood and plastic, which require specific imaging. Others have stressed the significance of continual monitoring due to the risks of inadequate clearance, especially for organic materials like wood, which degrade and harbor pathogens.[45]

Metal, glass, wood, and plastic can cause extremity foreign body injuries. Foreign object characteristics affect radiological imaging detection. Metal foreign bodies are radiopaque in conventional radiography; however, glass fragments above 2 mm can be precisely recognized. Smaller particles may be harder to diagnose. Magnetic resonance imaging shows hypointensity on T1-weighted images and hyperintensity on T2-weighted images in inflammation around a foreign substance. MRI may miss small wooden splinters without surrounding inflammation.[44]

The shape and location of prolonged foreign entities in tendon sheaths improve their mobility.[18] The organic nature of wooden foreign bodies promotes microbial growth.[19,39] Age and the site of foreign body insertion affect anesthetic choice and treatment setting (operating room vs. emergency department).[52] Local anesthesia is sufficient for removing superficial foreign bodies in adults, while general anesthesia is needed for deeper cases or pediatric patients.[40] Regardless of the cause, lacerations and puncture wounds in the emergency department must be evaluated for foreign substances.[31] Extraction of non-infected residual foreign bodies is optional.[32] Bullet fragments from gunshot wounds may remain asymptomatic unless joint involvement occurs.[37,49] Some authors recommend intraoperative fluoroscopy or needle localization before incision to identify radiopaque foreign items. Sharma and Azzopardi describe needle-filled foreign bodies, while others recommend the Trendelenburg position to reduce blood flow and enhance visibility.[1,46,50] Ultrasound-guided extraction reduces tissue injury in complex cases.[48] Low-flow irrigation and exit gate expansion help remove intra-articular fragments during arthroscopy.[41] Mahiroğulları et al. found that arthroscopy reduces tissue stress more than open surgery for gunshot fragment removal.[58] Some authors suggest that asymptomatic foreign bodies in the hand may not cause complications, while others warn of nerve damage or chronic synovitis.[10,30,32,38]

Limitations

The retrospective nature of our study introduces potential selection and documentation biases. Variations in clinician expertise, resource availability, and follow-up duration may have influenced the outcomes observed. Additionally, this single-center experience may not fully reflect regional or international variations in patient populations. Prospective, multicenter studies are needed to provide a stronger evidence base and enable broader validation and refinement of the proposed management algorithm.

CONCLUSION

Soft tissue foreign bodies (STFBs) require a systematic approach integrating clinical assessment, imaging, and tailored interventions. Radiography detects radiopaque objects, while ultrasound and CT/MRI are more effective for radiolucent or complex cases. Surgical removal is indicated for symptomatic, infected, or high-risk foreign bodies (e.g., organic materials), whereas small, inert, asymptomatic objects may be monitored.

Prophylactic antibiotics should target high-risk wounds, emphasizing stewardship to prevent resistance. Tetanus prophylaxis is mandatory in contaminated injuries. Surgical precision, aided by intraoperative imaging, minimizes neurovascular damage.

Postoperative care focuses on infection control and functional rehabilitation. Future research should refine imaging protocols and validate management strategies across diverse populations. Standardized approaches can enhance diagnostic accuracy, reduce complications, and improve outcomes in STFB injuries.

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Informed Consent: Written informed consent was not required due to the retrospective nature of the study.

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Collection and/or Processing - M.B.G., A.Ö., O.A., M.T., A.G., H.D., O.Y., M.A.C., İ.T.; Analysis and/or Interpretation - M.B.G., A.Ö., O.A., M.T., A.G., H.D., O.Y., M.A.C., İ.T.; Literature Review – M.B.G., A.Ö., O.A., M.T., A.G., H.D., O.Y., M.A.C., İ.T.; Writing – M.B.G., A.Ö., O.A., M.T., A.G., H.D., O.Y., M.A.C., İ.T.; Critical Review – M.B.G., A.Ö., O.A., M.T., A.G., H.D., O.Y., M.A.C., İ.T.

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