Percutaneous Imaging-Guided versus Open Musculoskeletal Biopsy: Concepts and Controversies

Violeta Vasilevska Nikodinovska, MD, PhD, MSc[1] Slavcho Ivanoski, MD[2]
Milan Samardziski, MD, PhD, MSc[3] Vesna Janevska, MD, PhD, MSc[4]

[1] Department of Radiology, Faculty of Medicine, University Surgical Clinic, St. Naum Ohridski Skopje, Ss. Cyril and Methodius University of Skopje, Skopje, North Macedonia
[2] Department of Radiology, Special Hospital for Orthopedic Surgery and Traumatology, St. Erazmo – Ohrid, Macedonia, Ss. Cyril and Methodius University of Skopje, Skopje, North Macedonia
[3] University Clinic for Orthopedic Surgery, Ss. Cyril and Methodius University of Skopje, Skopje, North Macedonia
[4] Institute of Pathology, Faculty of Medicine, Ss. Cyril and Methodius University of Skopje, Skopje, North Macedonia

Address for correspondence Slavcho Ivanoski, MD, Department of Radiology, Special Hospital for Orthopedic Surgery and Traumatology, St. Erazmo – Ohrid, Ss. Cyril and Methodius, University of Skopje, Bul. Mak. Prosvetiteli 9, Ohrid 6000, R. North Macedonia (e-mail: slavcoivanoski@gmail.com).

Semin Musculoskelet Radiol 2020;24:667–675.

Abstract

Bone and soft tissue tumors are a largely heterogeneous group of tumors. Biopsy of musculoskeletal (MSK) tumors is sometimes a challenging procedure. Although the open biopsy is still considered the gold standard for the biopsy of MSK lesions, core needle biopsy can replace it in most cases, with similar accuracy and a low complication rate. The biopsy should be performed in a tertiary sarcoma center where the multidisciplinary team consists of at minimum a tumor surgeon, an MSK pathologist, and an MSK radiologist who can assess all steps of the procedure. Several factors can influence the success of the biopsy including the lesion characteristics, the equipment, and the method used for the procedure. This review highlights some of the important aspects regarding the biopsy of the MSK tumors, with special attention to imaging a guided core needle biopsy and highlighting some of the recent advancements and controversies in the field.

Keywords
- bone
- soft tissue
- biopsy
- core needle
- accuracy

The biopsy is a procedure to obtain an adequate, feasible, and representative tissue specimen that can lead to an accurate diagnosis.[1] Bone and soft tissue tumors are a largely heterogeneous group. More than 50 subtypes of sarcoma exist.[2] In addition, they have to be differentiated from metastases and benign tumors as well as tumor mimickers.

Because of the heterogeneity of musculoskeletal (MSK) tumors and different anatomical locations that can complicate the biopsy procedure, obtaining adequate diagnostic material for further evaluation from MSK tumors can be very challenging. Moreover, a biopsy that is not performed efficiently can eventually alter the surgical management, jeopardize the limb-sparing surgery plan, and lower patient survival rate.[1–3]

A properly planned and technically perfectly performed biopsy procedure is key for the diagnosis and management of MSK tumors. Based on our personal experience, this review of the recent literature highlights the important aspects of biopsy of bone and soft tissue tumors, with special attention to imaging guided core needle biopsy, emphasizes some of the recent advancements but also the inconsistencies and controversies that still exist in the field.

Open versus Percutaneous Imaging-Guided Biopsy

Surgical or open biopsy has traditionally been considered the gold diagnostic standard for the biopsy of MSK lesions.[4] It has

Issue Theme Bone and Soft Tissue Tumors: Part 2; Guest Editors, Radhesh Lalam, MBBS, MRCS, FRCR and Marc-André Weber, MD, MSc

DOI https://doi.org/10.1055/s-0040-1717113.
ISSN 1089-7860.

several important benefits, such as obtaining large tissue specimens that are sufficient for all cytological and histopathologic analyses, and a high diagnostic accuracy approaching almost 100% in selected groups of patients.[2,5,6] Nevertheless, some difficulties and disadvantages are associated with open biopsy including a higher rate of complications in up to 16% that can modify the treatment strategy in ~ 8% of the cases, more severe complications, possibility of infection, dehiscence of the wound, possibility of profuse bleeding, and formation of hematoma that can facilitate tumor seeding.[2,7–9] The errors in diagnosis associated with open biopsy can jeopardize limb-sparing surgery and lead to otherwise unnecessary limb amputations in 1.2% of the cases.[9]

Probably the most important weakness of the open biopsy procedure is the high risk of seeding the neoplastic lesion along the excision tract. Barrientos-Ruiz et al[10] compared the tract seeding differences between core needle ultrasound (US) or computed tomography (CT)-guided biopsies and open biopsies of MSK sarcomas, by pathologic examination of the resected biopsy tract, and they found statistically significant differences (32% of the open biopsy tracts and only 0.8% of the percutaneous biopsy tracts were contaminated with tumor cells).

Percutaneous imaging-guided MSK biopsy, in contrast, has shown a comparable accuracy with open biopsy, ranging from 74 to 96%[3,4] for core needle biopsy, with fewer and generally minor complications.[2,7]

The complication rate of imaging-guided biopsy was shown to be low (0–7.5%),[7] with a negligible rate of clinically significant complications (0–1%),[5,11,12] in contrast to up to a 19% complication rate for open surgical biopsies.[13] Several articles illustrated the low rate of complications for imaging-guided biopsy in adult and pediatric populations.[5,14,15] A study examining CT-guided MSK biopsies performed by Trieu et al,[5] including a large cohort of 1,201 patients, reported a complication rate of 0.7%. Qi et al[14] reported only two mild complications (1.4%) in a study examining the percutaneous biopsy of 139 extremity soft tissue lesions. Mitton et al[15] evaluated imaging-guided biopsies in 122 MSK lesions in children and reported zero complications.

The costs have proven to be significantly higher for open biopsy compared with imaging-guided biopsies, with three to four times lower costs for the latter because of the shorter hospital stay, savings related to operation room use, medications, laboratory tests, and the costs of personnel and medical equipment.[16,17] The imaging-guided biopsy is also much better tolerated, less painful, has a lower risk of biopsy tract seeding, and can potentially lead to an earlier application of chemotherapy.[9,13,18,19]

However, not all studies show significant difference in complication rates between the different biopsy methods. Kiatisevi et al[8] in a study including CT-guided biopsies of MSK tumors found that the difference in complication rate between incisional biopsy and CT-guided biopsy was not statistically significant, although there were fewer complications with the percutaneous procedure. Furthermore, there was no statistically significant difference in accuracy between the two methods.

Indications and Contraindications

The main indications for MSK imaging-guided biopsy are confirmation or exclusion of a primary or metastatic bone or soft tissue tumor, for instance in a case of examination of a pathologic fracture (►**Fig. 1**) or a vertebral compression fracture, and confirmation or elimination of infection of the MSK system.[20]

There are several contraindications for imaging-guided biopsy of the MSK system. An absolute contraindication is a confidently diagnosed benign lesion with the noninvasive imaging modalities[21] or a situation when the biopsy does not change the therapeutic outcome.[20] Several MSK lesions exist with characteristic imaging features that exclude further unnecessary procedures, also called do-not-touch lesions. Such benign tumors, pseudotumors, inflammatory processes, and normal anatomical variants include but are not limited to a subchondral cyst, simple (unicameral) bone cyst, synovial cyst, fibrous dysplasia and nonossifying fibroma, cortical desmoid, enostosis (bone island), bone infarction, vertebral hemangioma, myositis ossificans, and Tietze's costochondritis.[22] Other relative contraindications include a lesion that is inaccessible or poorly visualized, the preprocedural cross-sectional imaging is lacking or incomplete, there is significant coagulopathy that cannot be corrected, cases of spinal hypervascular lesions, or the patient is uncooperative.[10,21]

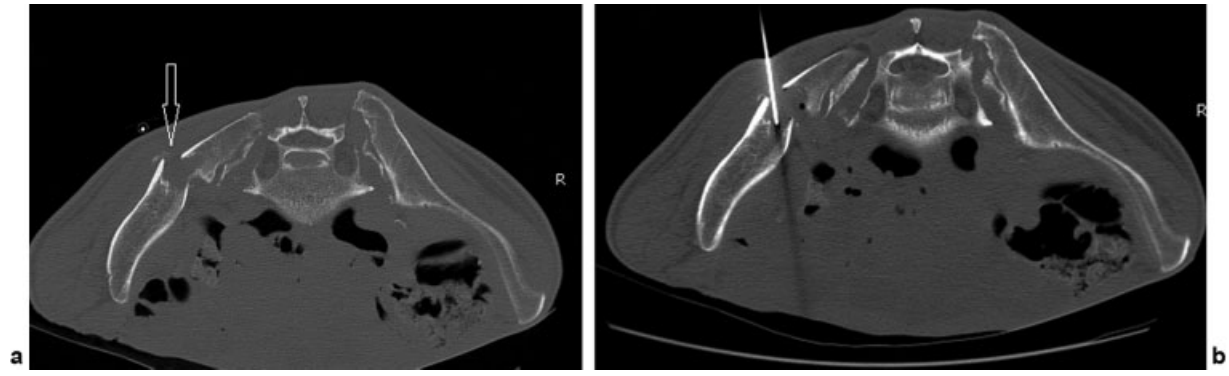

Fig. 1 Evaluation of a pathologic fracture is an indication for percutaneous biopsy. (**a**) Core needle biopsy of an osteolytic lesion of the right iliac bone presented with a pathologic fracture (arrow). (**b**) The core needle for obtaining biopsy material is placed within the lesion.

Although an open biopsy can cause more profuse and clinically significant bleeding, bleeding diathesis was also reported as an important contraindication for percutaneous biopsy,[10,20,21] and a coagulation test is proposed as mandatory before the percutaneous biopsy. However, two studies showed that the significant bleeding in imaging-guided biopsies is a rare and unusual complication even in cases of thrombocytopenia.[23,24] Liu et al[23] performed a retrospective study including an imaging-guided biopsy of bone marrow in 981 patients with normal and low platelet count, focusing on the postprocedural hemorrhage. There was a hemorrhagic complication rate of 0% in the group with the low platelet count. The authors concluded that the method in thrombocytopenic patients is safe to perform in those with a platelet count ranging between 20,000 and 50,000/μL. Shif et al[24] compared the CT- and US-guided biopsy in patients with or without a preprocedural platelet test and international normalized ratio (INR) testing. The results of their retrospective study showed that the imaging-guided biopsy is a safe method even if a preprocedural coagulation test is not performed.

In our center, the guidelines for the coagulation status and the risk of hemostasis management recommended by the Cardiovascular and Interventional Radiological Society of Europe are respected.[25] Because almost all imaging-guided biopsies of the MSK system are procedures with a low or intermediate risk of bleeding,[25] a platelet count $> 50{,}000/\mu L$ is considered safe, and lower values are corrected with platelet transfusion. An INR value of 2 is considered a threshold for imaging-guided biopsies with low bleeding risk, but high INR has to be corrected to ≤ 1.5 for medium risk procedures, such as vertebral biopsies.

Preparation for Biopsy

It is generally agreed that the management of MSK tumors, including the biopsy procedure, should be performed in a tertiary sarcoma center where all aspects of the management of the lesion are considered and the presence of a multidisciplinary team can offer the best possible diagnosis and treatment options.[26–28] Proper diagnosis and treatment at a tertiary sarcoma center significantly reduces the time to diagnosis of the lesion,[26,28] decreases the rate of local recurrence of the lesion, and improves the patient's survival rate.[27,29]

Sinha et al[26] retrospectively evaluated the benefits of diagnostic US-guided biopsy performed in a one-stop sarcoma center (a regional tertiary bone and soft tissue sarcoma service) in the United Kingdom in 524 patients with soft tissue sarcomas. The results showed that early referral to a tertiary sarcoma center reduces the waiting time for additional diagnostic imaging, such as magnetic resonance imaging (MRI), and decreases the time to the final diagnosis.

Dyrop et al[28] investigated 545 patients with MSK sarcomas referred to a tertiary center in Denmark. The authors compared the time between the appearance of the symptoms and establishing the final diagnosis in patients referred with previous CT or MRI examination from local clinics versus patients with diagnostic examinations obtained at the sarcoma center. There was at least a 1-month delay of obtaining the diagnosis in half of the patients who had previous diagnostic investigations at local hospitals, and the tumor size in the same group tended to be greater.

The multidisciplinary team should be included in management of the biopsy and always consist of at least an MSK radiologist, orthopaedic sarcoma surgeon, and pathologist.[6,30] Previous imaging has to be obtained and discussed at the oncology conference. US is an initial imaging method of choice for soft tissue tumor evaluation, as long as the lesion is assessable,[31] whereas plain radiograph is the primary imaging modality for bone lesion assessment.[32] In complex locations, such as the shoulder, the ribs, the pelvis, or vertebrae, CT is often required.[32] If the nature of the lesion requires further evaluation, CT and MRI are the imaging modalities of choice before biopsy of MSK tumors.[10,31,32]

MRI is a preferred imaging modality for MSK tumor evaluation and local staging because it can offer answers to important questions such as the extent of the lesion and possible infiltration of a nearby joint, the safest biopsy tract to avoid neurovascular structures and not breach the compartment, and the best imaging modality for guidance.[31–33] CT can help in the search for distant metastases in cases of MSK malignancy. Nuclear imaging can further supplement the conventional imaging modalities and help determine the tumor viability, the metabolic activity, the response to therapy, and the exploration for metastases.[31–33] The biopsy needle should be aimed at the most viable spot of the lesion, avoiding the cystic and necrotic parts of the tumor, which in difficult cases can be clarified with the help of dynamic contrast-enhanced MRI or positron emission tomography-CT with CT fusion.[1,32,34]

The presence of MSK radiologists in a multidisciplinary sarcoma team is valuable. In a study performed by Rozenberg et al,[35] the secondary interpretation of MRI examinations by an MSK radiologist involved in an orthopaedic sarcoma conference made a clinically significant change to the primary diagnosis and changed the treatment plan in 22% of the patients. A meta-analysis performed by Kubo et al[2] showed that a core needle biopsy performed by an MSK radiologist has significantly higher accuracy for the final histologic subtype prediction compared with the core needle biopsy performed by an orthopaedic surgeon, possibly because of the former's more extensive knowledge of different interventional radiology procedures.

Almost all percutaneous biopsies can be performed under local anesthesia, with an addition of periosteal anesthetic for bone tumors or with conscious sedation.[36,37] The exceptions of these recommendations are small children who are too young to cooperate and in some circumstances pathologic fractures that are too painful.[33]

The path of the biopsy needle and the part of the tumor that should be aimed at is a question that also has to be discussed at a sarcoma conference, with close correlation to the orthopaedic oncology team that performs the surgery and pathologists.[7,30,38] Although the shortest possible route should be chosen, the closest skin-to-lesion distance is not always the best possible option.[6] Several other rules have to be appreciated including avoidance of the neurovascular bundles, joints, tendons, and bursae[37] (►**Fig. 2**). There is an agreement among clinicians that both imaging-guided and open biopsy must be

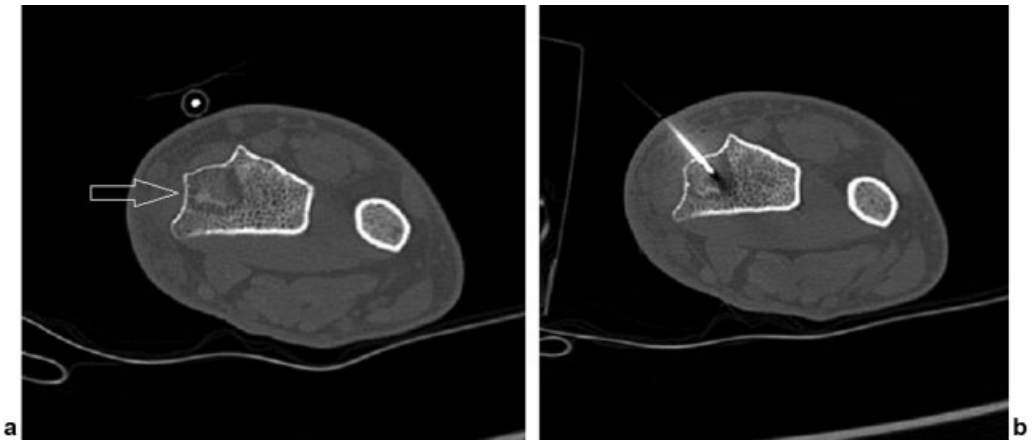

Fig. 2 (**a**) Core needle biopsy of an osteolytic lesion of the distal radius (arrow). (**b**) The needle is placed in the lesion, through a lateral approach, avoiding the vital structures.

performed with full respect for the compartmental anatomy, and the biopsy tract should not breach more than one anatomical compartment of the region or the nearby joints[39,40] (►**Fig. 3**). In addition, the biopsy tract has to be properly marked and removed with the final surgical procedure because it is potentially seeded with tumor cells.[38]

In a systematic review examining the tract seeding of biopsy of MSK tumors, Oliveira et al[18] included 11 articles (7 case reports and 4 cohort studies). Most of the case reports and all cohort studies involved percutaneous biopsies, with or without imaging guidance. The authors concluded that tract seeding occurs in both percutaneous and open biopsy, and the resection of the biopsy tract may decrease the chance of a local recurrence of the tumor.

However, some authors pointed out that the guidelines to respect the compartmental anatomy in percutaneous biopsies are based on the empirical sense and only on several case reports in the literature, rather than on strong clinical evidence that can support them.[18,41]

In a retrospective study by UyBico et al[42] including 363 imaging-guided biopsies of bone and soft tissue lesions, there were no cases of local recurrence because of breaching the anatomical compartments, vital structures, or biopsy tract seeding.

Siddiqi et al[43] evaluated the influence of resection of the biopsy tract on local recurrence in 72 patients with a soft tissue sarcoma. Half of the patients had resection of the biopsy tract. The results showed no significant difference of the resection of the tract on local tumor recurrence. Saghieh et al[44] retrospectively evaluated the local recurrence of a skeletal sarcoma in 10 patients who underwent core needle biopsy, and the biopsy tract was not surgically removed. None of the procedures was associated with local recurrence.

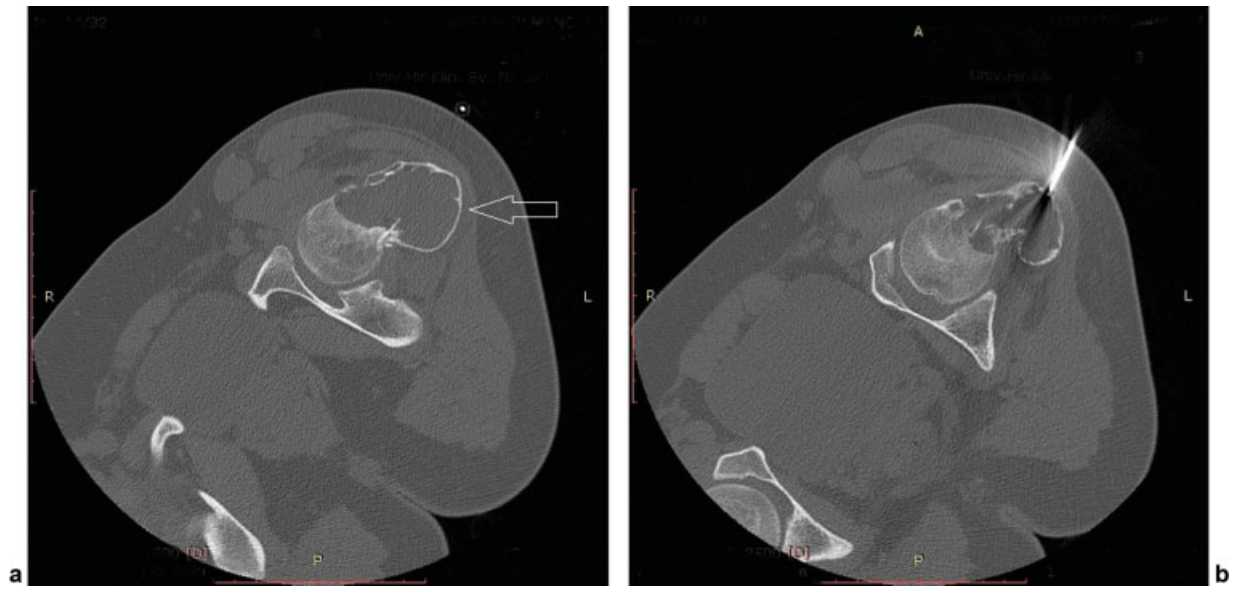

Fig. 3 (**a**) Core needle biopsy of an osteolytic lesion in the left major trochanter (arrow). (**b**) A lateral needle approach is used to avoid vital structures. The biopsy result was osteofibrous dysplasia with secondary aneurismal bone cyst.

Factors Associated with Success of the Imaging-Guided Biopsy

The successful imaging-guided biopsy depends on several factors including the needle type, the imaging modality used for guidance, the number and the length of cores obtained, the type and characteristics of the lesion, and the size and location of the lesion.

Percutaneous imaging-guided biopsy can be subdivided into a fine-needle aspiration (FNA) biopsy using a thin needle (18–25G), and a core needle biopsy using a thicker needle (9–20G) and a cutting mechanism that can obtain a larger tissue specimen.[36]

Although it has several advantages, such as the cost, speed, and ease of performing, and it has already shown high sensitivity in the biopsy of several other organs, FNA is not often used for the biopsy of MSK tumors.[45,46] The main reason is the structure and heterogeneity of the mesenchymal tumors that have similarities and can overlap cytomorphologically, and the low quantity of obtained material that is insufficient for various morphological, immunohistochemical, or molecular analyses.[45,46] Several studies showed low accuracy of FNA in the biopsy of MSK tumors compared with core needle biopsy, whereas others claimed a high sensitivity.[45,46] Therefore FNA is usually reserved for the diagnosis of metastases or recurrent tumors that were previously documented,[47] and some centers do not perform it at all. However, other authors reported high sensitivity of FNA. A retrospective study performed by Yu et al[46] showed that FNA has high sensitivity, and the combination of FNA followed by core needle biopsy might decrease the rate of false-negative core needle biopsies. The high sensitivity of FNA in the study was partly attributed to the high percentage of metastases and hematopoietic tumors that have high cellularity compared with primary mesenchymal tumors.

The core needle biopsy with CT or US guidance is a standard and preferred procedure over open biopsy in most the majority of MSK biopsies in most sarcoma centers (►**Fig. 4**). The core needle biopsy allows preservation of the architecture of the tissue.[48] It can yield sufficient and adequate material for most histopathology analyses including the subtyping of a sarcoma.[17] It has a high diagnostic yield and accuracy, comparable with open biopsy results.[7,8]

Pohlig et al[7] retrospectively evaluated the diagnostic accuracy of core needle biopsy in comparison with open biopsy in 77 patients with bone and soft tissue lesions. The results showed the difference in diagnostic accuracy for core needle biopsy (92.9%) was not statistically significant compared with the open biopsy result (98%).

Traina et al[3] compared percutaneous biopsy of bone or soft tissue MSK tumors with open biopsy in their review of 17 articles including biopsies guided by CT, US, and MRI, but also percutaneous biopsies without imaging guidance. The difference in accuracy between the two biopsy types was not statistically significant. The authors proposed percutaneous biopsies of MSK tumors as the first biopsy choice and the incisional biopsy for failed or inconclusive results.

Kubo et al[2] performed a systematic review and meta-analysis of 32 articles for imaging-guided core needle biopsy of MSK lesions, comparing the diagnostic accuracy of the needle biopsy with the final histologic diagnosis. The difference between the histologic diagnosis and the needle biopsy result was statistically significant, with a more accurate result for open biopsy. Nevertheless, the authors proposed the needle biopsy as a first-line method, due to its many advantages, and the surgical biopsy for doubtful cases when imaging and clinical results contradict the histopathology.

Kasraeian et al[17] examined the results of FNA, core needle, and open biopsy performed on the same soft tissue lesion. The authors found that specimens obtained with open biopsy had significantly higher diagnostic accuracy for establishing the exact histopathologic diagnosis (100%), compared with both FNA and core needle biopsy (33.3% and 45.6%, respectively), and they recommended the open biopsy as the best method for indeterminate soft tissue lesions.

FNA is not performed for MSK lesions in our center at all because our pathologists prefer and strongly suggest core needle biopsy over FNA. Core needle biopsy is the first method of choice for almost all biopsies of MSK lesions in our center. Open surgical biopsy is reserved for technically difficult cases, unsuccessful core needle biopsies, or if the biopsy result conflicts with the clinical symptoms and radiology reports.

There is no universal needle gauge for performing a core needle biopsy because every case is specific, and the biopsy should be planned individually.[6] According to some authors, because of the nature of MSK tumors, larger gauge needles

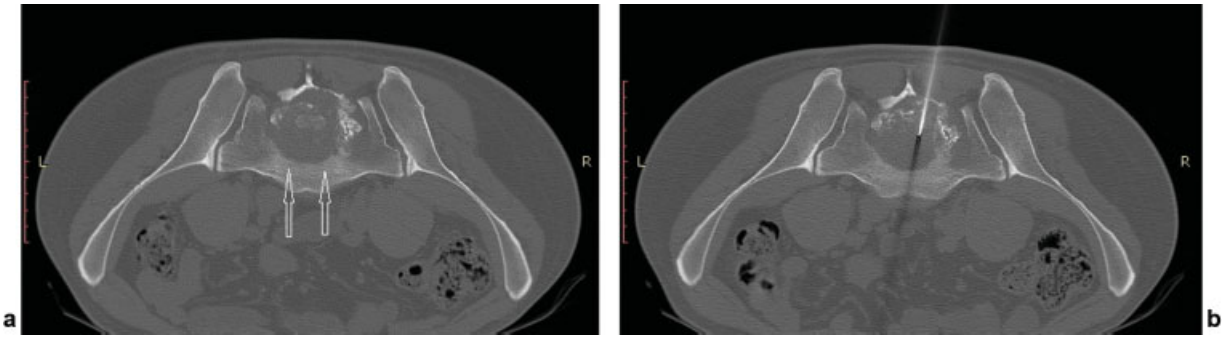

Fig. 4 (**a**) Core needle biopsy of a large lytic soft tissue lesion of the sacral body with destruction of surrounding bone (arrows). (**b**) The core needle is correctly placed within the lesion. The histopathology result confirmed the diagnosis of peripheral primitive neuroectodermal tumor.

are needed for such biopsies, ranging from 9 to 17G for bone biopsies and somewhat thinner needles for soft tissue lesions (14–18G).[37] In deep-seated lesions, guidewire or using a coaxial biopsy set can be beneficial.[6]

The number of the core samples can influence the diagnostic yield of the core needle biopsy. Due to the relatively deficient material obtained with core needle biopsies in MSK lesions compared with open biopsy, that characteristic can restrict its diagnostic value and its use for various histopathologic examinations.[49] There is usually a need for multiple passes to obtain sufficient specimens. Wu et al[50] examined the diagnostic performance of core needle biopsies of bone and soft tissue tumors in 151 patients, and they proposed a minimum of four samples for soft tissue tumors and three samples for skeletal tumors to achieve an ideal diagnostic yield. However, obtaining multiple samples is not always possible with a core needle biopsy. Of note, the location of the lesion can influence the number of acquired cores. In some difficult-to-approach locations, such as in the cervical or thoracic spine, obtaining even one appropriate cylinder can be challenging due to the difficult approach and the vertebral size.[20]

The type of lesion also influences the number of the cores that should be obtained during the procedure. Bone metastases are usually homogeneous tumors, with uniform structure, so a high diagnostic yield can be achieved with fewer samples. Chira et al[51] evaluated the diagnostic performance of US-guided biopsy of bone metastases in 16 patients, and they concluded that one to two cores are enough for obtaining high diagnostic accuracy and yield, if specimens are $\geq$ 10 mm long and visually satisfactory.

The size of the lesion can also be an important factor for imaging-guided biopsy success. Most authors agree that 2 cm is a minimal lesion size that should be targeted with imaging guidance to obtain optimal biopsy success. Wu et al[50] showed the diagnostic yield of the MSK core needle biopsy was significantly lower for lesions $<$ 2 cm than in the groups of larger lesions. Rimondi et al[20] reported significantly lower diagnostic accuracy for lesions $<$ 2.5 cm than larger lesions. Li et al[48] investigated the outcome of CT-guided biopsies for bone lesions in 155 patients. Biopsies of lesions that were $\geq$ 3 cm had a significantly higher diagnostic yield than lesions $<$ 3 cm. However, in a 2016 study performed by Kim et al,[52] evaluating the diagnostic yield of US-guided core needle biopsy in soft tissue tumors, the lesions between 1 and 2 cm had a comparable diagnostic yield to larger lesions, but lesions $\leq$ 1 cm had a significantly lower yield. The authors recognized the technical difficulties in performing the biopsy, targeting the lesion, and obtaining an adequate specimen, which can contain some normal tissue that can alter the histologic diagnosis, as causes for the low diagnostic yield in small lesions.

The location and the depth of the lesion influences the selected method of biopsy and the overall success of the procedure. Lesions of the spine and deep-seated MSK tumors like paraspinal soft tissue tumors have a lower diagnostic accuracy compared with other sites.[2,53]

Percutaneous biopsy of bone and soft tissue lymphoma has a higher nondiagnostic rate compared with biopsy of other malignant lesions.[54,55] In a study examining the nondiagnostic rate of CT-guided bone and soft tissue biopsies, Chang et al[54] concluded that biopsy of lymphoma had a significantly lower diagnostic rate (nondiagnostic rate of 21%) compared with myeloma, metastases, and sarcomas. Similarly, Yang et al[55] evaluated the nondiagnostic biopsy results of 508 MSK lesions, and they found a nondiagnostic rate for imaging-guided biopsy of lymphomas of 19%.

Low-grade liposarcomas are occasionally difficult to diagnose based on specimens obtained with percutaneous biopsy. Their possible heterogeneity and the size of the specimen that might miss the most characteristic tumor area do not always permit the correct histopathologic diagnosis.[13,56] Ferguson et al[56] described higher nondiagnostic results for US-guided biopsy of low-grade lipomatous lesions compared with other soft tissue tumors. Qi et al[14] found that all five false-negative cases of 139 soft tissue CT- or US-guided core needle biopsies in their study were liposarcomas. The solution of the problem might be treating the low-grade lipomatous lesions with open surgical biopsy, marginal incision, or eventually obtaining more tissue specimens from different parts of the tumor.[13,56]

Low diagnostic performance of imaging-guided biopsy is reported for sclerotic bone lesions compared with lytic and mixed lesions, due to various procedural difficulties such as the inability to penetrate the dense cortex and reach the lesion, absence of a soft tissue component, and low tumor cellularity[48] (►**Fig. 5**). Some authors advise that open biopsy should be chosen for sclerotic bone lesions.[57] Li et al[48] reported a diagnostic yield of 48.5% for CT-guided biopsy of sclerotic bone lesions, compared with almost 90% for lytic bone lesions. Rimondi et al[20] examined the diagnostic accuracy of $>$ 2,000 CT-guided MSK biopsies. The accuracy was higher in mixed and lytic lesions (97% and 94%, respectively) compared with sclerotic lesions (87.6%).

However, in a 2018 study by Chang et al[57] examining the performance of CT-guided biopsy of 37 sclerotic lesions, the diagnostic yield and accuracy were high (78.4% and 94.6%, respectively). The authors attributed the higher results for the accuracy and yield to the thick core needles (11G) and the battery-powered drill system that was used for almost half of the biopsies. In a recent meta-analysis performed by Suh et al[58] examining the diagnostic outcome of imaging-guided biopsy of sclerotic lesions in 15 different studies, the use of a battery-powered drill significantly increased the diagnostic outcome of the biopsy compared with manual drilling systems.

Obtaining satisfactory specimens from predominantly cystic lesions with little or no solid parts can be difficult with core needle biopsy. The main reason for the nondiagnostic biopsies is the presence of mainly fluid, blood, or liquid necrotic material within the lesion and less soft tissue that can complicate obtaining a sufficient sample.[19] Jelinek et al[19] evaluated the diagnostic accuracy of CT or fluoroscopy-guided biopsy in 110 primary bone tumors. The accuracy for exact diagnosis was lowest in tumors presenting as cysts, mainly composed of fluid or blood on CT and MRI (71%).

Several authors pointed out that the diagnostic accuracy and diagnostic yield of imaging-guided biopsy is significantly

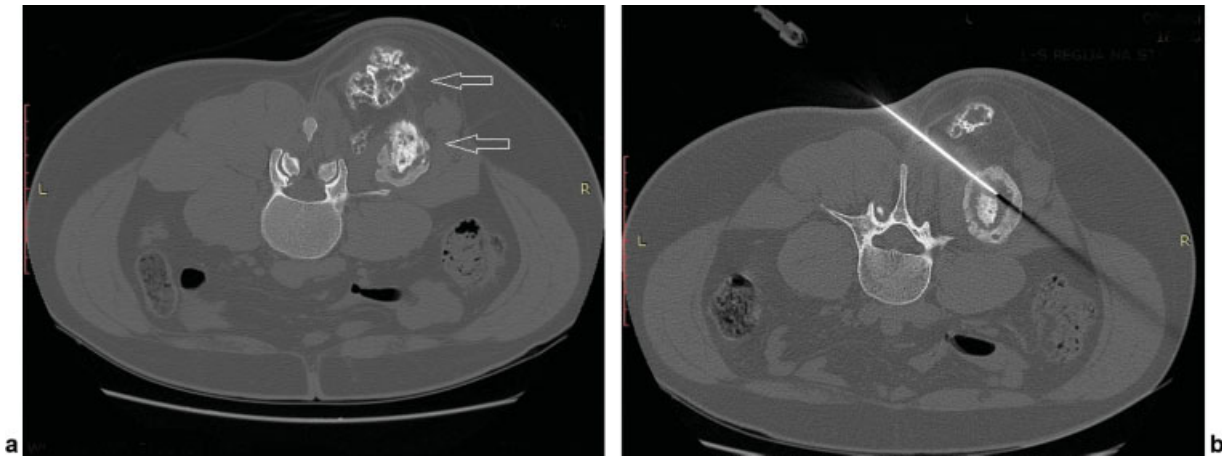

Fig. 5 (**a**) Core needle biopsy of a mixed, dominantly sclerotic lesion originating from the left iliac wing (not shown) presenting in the left paraspinal muscle (arrows). (**b**) The needle is placed within the soft tissue part of the lesion. The result of core needle biopsy was exostosis.

lower for benign tumors compared with malignant lesions.[4,59] Omura et al[4] evaluated the diagnostic success of CT-guided biopsy of MSK tumors and presented a significantly lower diagnostic yield in benign and low-grade MSK tumors compared with malignant ones. The authors attributed the difference in the diagnostic yield to the sampling error, an inability to differentiate certain benign lesions from similar malignancies, such as lipoma from liposarcoma, based on the tissue sample acquired with needle biopsy.[4]

However, even nondiagnostic needle biopsies are not completely unusable. In certain circumstances, specimens that are not diagnostic can still help the clinician and moderate the further management of the lesion. A study performed by Didolkar et al[60] evaluated the clinical usefulness of the nondiagnostic lesions in 778 MSK core needle biopsies. More than half of nondiagnostic biopsy results eventually helped the orthopaedic oncologist in decision making and further management of the lesion. In particular, a combination of a nondiagnostic biopsy with a nonaggressive clinical and imaging appearance was supportive of a benign lesion or process. Most of the nondiagnostic results in the study were ganglion cysts for the soft tissue group and histiocytosis and simple bone cysts for the bone lesion group.[60]

Conclusions

Because of the nature of the MSK tumor and localization, obtaining adequate tissue and avoiding a delay in diagnosis can sometimes be a challenging task. Today, CT- or US-guided core needle biopsy is widely considered a standard diagnostic procedure that can obviate the use of open biopsy in most cases. It has a high diagnostic yield with a low complication rate. It can replace the open biopsy in the majority of cases of bone and soft tissue tumors. Percutaneous imaging-guided biopsy has to be performed in a tertiary tumor center, where all previous imaging, planning that includes the best imaging modality, the safest biopsy tract, and the portion of the tumor that should be investigated are discussed at a sarcoma conference. The sarcoma conference should consist of an MSK radiologist, orthopaedic oncology surgeon, and pathologist. An experienced clinician, preferably a trained MSK radiologist who is familiar with interventional radiology procedures, should perform the biopsy.

The success of needle biopsy can be influenced by several factors including the lesion size, localization, lesion nature, the needle diameter, and the number and length of the specimens that are obtained. Needle biopsy of certain histologic types of tumors can be challenging, so different imaging guidance, equipment, biopsy method, or strategy is necessary in specific cases. The clinician should be aware of all the potential difficulties and pitfalls that can occur and lead to an unsuccessful biopsy, possible solutions to the problems, and how to avoid unnecessary procedures and postponements to establish the diagnosis in a safe and timely manner.

Conflict of Interest
None declared.

References

1 Trieu J, Sinnathamby M, Di Bella C, et al. Biopsy and the diagnostic evaluation of musculoskeletal tumours: critical but often missed in the 21st century. ANZ J Surg 2016;86(03):133–138
2 Kubo T, Furuta T, Johan MP, Sakuda T, Ochi M, Adachi N. A meta-analysis supports core needle biopsy by radiologists for better histological diagnosis in soft tissue and bone sarcomas. Medicine (Baltimore) 2018;97(29):e11567
3 Traina F, Errani C, Toscano A, et al. Current concepts in the biopsy of musculoskeletal tumors: AAOS exhibit selection. J Bone Joint Surg Am 2015;97(02):e7
4 Omura MC, Motamedi K, UyBico S, Nelson SD, Seeger LL. Revisiting CT-guided percutaneous core needle biopsy of musculoskeletal lesions: contributors to biopsy success. AJR Am J Roentgenol 2011;197(02):457–461
5 Trieu J, Schlicht SM, Choong PF. Diagnosing musculoskeletal tumours: how accurate is CT-guided core needle biopsy? Eur J Surg Oncol 2016;42(07):1049–1056
6 Mavrogenis AF, Angelini A, Errani C, Rimondi E. How should musculoskeletal biopsies be performed? Orthopedics 2014;37 (09):585–588
7 Pohlig F, Kirchhoff C, Lenze U, et al. Percutaneous core needle biopsy versus open biopsy in diagnostics of bone and soft tissue sarcoma: a retrospective study. Eur J Med Res 2012;17(01):29

8 Kiatisevi P, Thanakit V, Sukunthanak B, Boonthatip M, Bumrungchart S, Witoonchart K. Computed tomography-guided core needle biopsy versus incisional biopsy in diagnosing musculoskeletal lesions. J Orthop Surg (Hong Kong) 2013;21(02):204–208
9 Welker JA, Henshaw RM, Jelinek J, Shmookler BM, Malawer MM. The percutaneous needle biopsy is safe and recommended in the diagnosis of musculoskeletal masses. Cancer 2000;89(12):2677–2686
10 Barrientos-Ruiz I, Ortiz-Cruz EJ, Serrano-Montilla J, Bernabeu-Taboada D, Pozo-Kreilinger JJ. Are biopsy tracts a concern for seeding and local recurrence in sarcomas? Clin Orthop Relat Res 2017;475(02):511–518
11 Filippiadis DK, Charalampopoulos G, Mazioti A, Keramida K, Kelekis A. Bone and soft-tissue biopsies: what you need to know. Semin Intervent Radiol 2018;35(04):215–220
12 Gogna A, Peh WC, Munk PL. Image-guided musculoskeletal biopsy. Radiol Clin North Am 2008;46(03):455–473, v
13 Adams SC, Potter BK, Pitcher DJ, Temple HT. Office-based core needle biopsy of bone and soft tissue malignancies: an accurate alternative to open biopsy with infrequent complications. Clin Orthop Relat Res 2010;468(10):2774–2780
14 Qi D, Zhao M, Hu T, Zhang G. Diagnostic yield of percutaneous core needle biopsy in suspected soft tissue lesions of extremities. J Int Med Res 2019;47(06):2598–2606
15 Mitton B, Seeger LL, Eckardt MA, et al. Image-guided percutaneous core needle biopsy of musculoskeletal tumors in children. J Pediatr Hematol Oncol 2014;36(05):337–341
16 Ceraulo A, Ouziel A, Lavergne E, et al. Percutaneous guided biopsy for diagnosing suspected primary malignant bone tumors in pediatric patients: a safe, accurate, and cost-saving procedure. Pediatr Radiol 2017;47(02):235–244
17 Kasraeian S, Allison DC, Ahlmann ER, Fedenko AN, Menendez LR. A comparison of fine-needle aspiration, core biopsy, and surgical biopsy in the diagnosis of extremity soft tissue masses. Clin Orthop Relat Res 2010;468(11):2992–3002
18 Oliveira MP, Lima PM, da Silva HJ, de Mello RJ. Neoplasm seeding in biopsy tract of the musculoskeletal system. A systematic review. Acta Ortop Bras 2014;22(02):106–110
19 Jelinek JS, Murphey MD, Welker JA, et al. Diagnosis of primary bone tumors with image-guided percutaneous biopsy: experience with 110 tumors. Radiology 2002;223(03):731–737
20 Rimondi E, Rossi G, Bartalena T, et al. Percutaneous CT-guided biopsy of the musculoskeletal system: results of 2027 cases. Eur J Radiol 2011;77(01):34–42
21 Le HB, Lee ST, Munk PL. Image-guided musculoskeletal biopsies. Semin Intervent Radiol 2010;27(02):191–198
22 Fonseca EKUN, Castro ADAE, Kubo RS, et al. Musculoskeletal "don't touch" lesions: pictorial essay. Radiol Bras 2019;52(01):48–53
23 Liu B, Limback J, Kendall M, et al. Safety of CT-guided bone marrow biopsy in thrombocytopenic patients: a retrospective review. J Vasc Interv Radiol 2017;28(12):1727–1731
24 Shif Y, Kung JW, McMahon CJ, et al. Safety of omitting routine bleeding tests prior to image-guided musculoskeletal core needle biopsy. Skeletal Radiol 2018;47(02):215–221
25 Patel IJ, Davidson JC, Nikolic BStandards of Practice Committee, with Cardiovascular and Interventional Radiological Society of Europe (CIRSE) Endorsement, et al; Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. J Vasc Interv Radiol 2012;23(06):727–736
26 Sinha R, Mohamed AM, Karsandas A. The impact of ultrasound in an integrated one-stop sarcoma clinic. Clin Radiol 2020;75(04):321.e21–321.e28
27 Bhangu AA, Beard JA, Grimer RJ. Should soft tissue sarcomas be treated at a specialist centre? Sarcoma 2004;8(01):1–6
28 Dyrop HB, Vedsted P, Rædkjær M, Safwat A, Keller J. Imaging investigations before referral to a sarcoma center delay the final diagnosis of musculoskeletal sarcoma. Acta Orthop 2017;88(02):211–216
29 Clark MA, Thomas JM. Delay in referral to a specialist soft-tissue sarcoma unit. Eur J Surg Oncol 2005;31(04):443–448
30 McCarthy EF. CT-guided needle biopsies of bone and soft tissue tumors: a pathologist's perspective. Skeletal Radiol 2007;36(03):181–182
31 Noebauer-Huhmann IM, Weber MA, Lalam RK, et al. Soft tissue tumors in adults: ESSR-approved guidelines for diagnostic imaging. Semin Musculoskelet Radiol 2015;19(05):475–482
32 Lalam R, Bloem JL, Noebauer-Huhmann IM, et al. ESSR consensus document for detection, characterization, and referral pathway for tumors and tumorlike lesions of bone. Semin Musculoskelet Radiol 2017;21(05):630–647
33 Exner GU, Kurrer MO, Mamisch-Saupe N, Cannon SR. The tactics and technique of musculoskeletal biopsy. EFORT Open Rev 2017;2(02):51–57
34 Noebauer-Huhmann I-M, Amann G, Krssak M, et al. Use of diagnostic dynamic contrast-enhanced (DCE)-MRI for targeting of soft tissue tumour biopsies at 3T: preliminary results. Eur Radiol 2015;25(07):2041–2048
35 Rozenberg A, Kenneally BE, Abraham JA, et al. Clinical impact of second-opinion musculoskeletal subspecialty interpretations during a multidisciplinary orthopedic oncology conference. J Am Coll Radiol 2017;14(07):931–936
36 Veltri A, Bargellini I, Giorgi L, Almeida PAMS, Akhan O. CIRSE guidelines on percutaneous needle biopsy (PNB). Cardiovasc Intervent Radiol 2017;40(10):1501–1513
37 Welch BT, Welch TJ. Percutaneous image-guided biopsy of the musculoskeletal system. Tech Vasc Interv Radiol 2011;14(03):110–117
38 Kim SY, Chung HW, Oh TS, Lee JS. Practical guidelines for ultrasound-guided core needle biopsy of soft-tissue lesions: transformation from beginner to specialist. Korean J Radiol 2017;18(02):361–369
39 Bancroft LW, Peterson JJ, Kransdorf MJ, Berquist TH, O'Connor MI. Compartmental anatomy relevant to biopsy planning. Semin Musculoskelet Radiol 2007;11(01):16–27
40 Liu PT, Valadez SD, Chivers FS, Roberts CC, Beauchamp CP. Anatomically based guidelines for core needle biopsy of bone tumors: implications for limb-sparing surgery. Radiographics 2007;27(01):189–205; discussion 206
41 Seeger LL. Revisiting tract seeding and compartmental anatomy for percutaneous image-guided musculoskeletal biopsies. Skeletal Radiol 2019;48(04):499–501
42 UyBico SJ, Motamedi K, Omura MC, et al. Relevance of compartmental anatomic guidelines for biopsy of musculoskeletal tumors: retrospective review of 363 biopsies over a 6-year period. J Vasc Interv Radiol 2012;23(04):511–518, 518.e1–518.e2
43 Siddiqi MA, Kim HS, Jede F, Han I. Association of core needle biopsy tract resection with local recurrence in extremity soft tissue sarcoma. Skeletal Radiol 2017;46(04):507–512
44 Saghieh S, Masrouha KZ, Musallam KM, et al. The risk of local recurrence along the core-needle biopsy tract in patients with bone sarcomas. Iowa Orthop J 2010;30:80–83
45 Khalbuss WE, Teot LA, Monaco SE. Diagnostic accuracy and limitations of fine-needle aspiration cytology of bone and soft tissue lesions: a review of 1114 cases with cytological-histological correlation. Cancer Cytopathol 2010;118(01):24–32
46 Yu GH, Maisel J, Frank R, Pukenas BA, Sebro R, Weber K. Diagnostic utility of fine-needle aspiration cytology of lesions involving bone. Diagn Cytopathol 2017;45(07):608–613
47 Rekhi B. Core needle biopsy versus fine needle aspiration cytology in bone and soft tissue tumors. J Cytol 2019;36(02):118–123
48 Li Y, Du Y, Luo TY, et al. Factors influencing diagnostic yield of CT-guided percutaneous core needle biopsy for bone lesions. Clin Radiol 2014;69(01):e43–e47
49 Mangham DC, Athanasou NA. Guidelines for histopathological specimen examination and diagnostic reporting of primary bone tumours. Clin Sarcoma Res 2011;1(01):6

50 Wu JS, Goldsmith JD, Horwich PJ, Shetty SK, Hochman MG. Bone and soft-tissue lesions: what factors affect diagnostic yield of image-guided core-needle biopsy? Radiology 2008;248(03): 962–970
51 Chira RI, Chira A, Calauz A, et al. Ultrasound-guided biopsy of osteolytic metastasis—could be less than three cores enough? Med Ultrason 2018;1(01):50–56
52 Kim SY, Chung HW. Small musculoskeletal soft-tissue lesions: US-guided core needle biopsy—comparative study of diagnostic yields according to lesion size. Radiology 2016;278(01):156–163
53 Rougraff BT, Aboulafia A, Biermann JS, Healey J. Biopsy of soft tissue masses: evidence-based medicine for the musculoskeletal tumor society. Clin Orthop Relat Res 2009;467(11):2783–2791
54 Chang CY, Huang AJ, Bredella MA, et al. Percutaneous CT-guided needle biopsies of musculoskeletal tumors: a 5-year analysis of non-diagnostic biopsies. Skeletal Radiol 2015;44(12):1795–1803
55 Yang J, Frassica FJ, Fayad L, Clark DP, Weber KL. Analysis of nondiagnostic results after image-guided needle biopsies of musculoskeletal lesions. Clin Orthop Relat Res 2010;468(11): 3103–3111
56 Ferguson KB, McGlynn J, Jane M, Ritchie D, Mahendra A. Outcome of image-guided biopsies: retrospective review of the West of Scotland musculoskeletal oncology service. Surgeon 2016;14(02):87–90
57 Chang IJ, Ilaslan H, Sundaram M, Schils J, Subhas N. CT-guided percutaneous biopsy of sclerotic bone lesions: diagnostic outcomes. Skeletal Radiol 2018;47(05):661–669
58 Suh CH, Yun SJ. Diagnostic outcome of image-guided percutaneous core needle biopsy of sclerotic bone lesions: a meta-analysis. AJR Am J Roentgenol 2019;212(03):625–631
59 Tsukushi S, Nishida Y, Yamada Y, Yoshida M, Ishiguro N. CT-guided needle biopsy for musculoskeletal lesions. Arch Orthop Trauma Surg 2010;130(05):699–703
60 Didolkar MM, Anderson ME, Hochman MG, et al. Image guided core needle biopsy of musculoskeletal lesions: are nondiagnostic results clinically useful? Clin Orthop Relat Res 2013;471(11): 3601–3609