Bone and Soft-Tissue Biopsies: What You Need to Know

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Abstract

Percutaneous, image-guided musculoskeletal biopsy, due to its minimal invasive nature, when compared with open surgical biopsy, is a safe and effective technique which is widely used in many institutions as the primary method to acquire tissue and bone samples. Indications include histopathologic and molecular assessment of a musculoskeletal lesion, exclusion of malignancy in a bone/vertebral fracture, examination of bone marrow, and infection investigation. Preprocedural workup should include both imaging (for lesion assessment and staging) and laboratory (including coagulation tests and platelet count) studies. In selected cases, antibiotic prophylaxis should be administered before the biopsy. Core needle biopsy of musculoskeletal lesions has a diagnostic accuracy that ranges from 66 to 98% with higher diagnostic yield for lytic, large-size, malignant lesions and when multiple and long specimens are obtained. Reported complication rates range between 0 and 10% and usually do not exceed 5%, with a suggested threshold of 2%. The purpose of this review article is to illustrate the technical aspects, the indications, and the methodology of percutaneous image-guided bone biopsy that will assist the interventional radiologist to perform these minimal invasive techniques.

Keywords

- musculoskeletal lesion
- percutaneous biopsy
- Imaging guidance
- interventional radiology

Objectives: Upon completion of this article, the reader will be able to describe indications, contraindications, and the methodology for accessing bone lesions for needle biopsy via imaging guidance.

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Musculoskeletal lesions are frequently encountered in clinical practice presenting as painless masses, pain sources, or as incidental findings in imaging studies. Axial imaging can be used in the diagnosis of primary and secondary musculoskeletal lesions; however, the histopathologic verification is lacking. Percutaneous, image-guided musculoskeletal biopsy, due to its minimal invasive nature when compared with open surgical biopsy, is a safe and effective technique which is widely used in many institutions as the primary method to acquire tissue and bone samples for histopathological and molecular analysis of a lesion, for recurrence prediction in curative cases (which can assist in the treatment stratification, identification, and validation of new targets), or for culturing and antibiogram testing (in cases of infection).^{1–5} Percutaneous biopsies obviate the risk of destabilizing an already diseased spinal or peripheral skeleton segment (which can occur with open biopsies),

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while imaging guidance additionally provides immediate confirmation of the correct needle location inside the target area/lesion.

The purpose of this article is to illustrate the technical aspects, the indications, and the methodology of percutaneous image-guided bone biopsy that will assist the interventional radiologist to perform these minimal invasive techniques.

Indications and Contraindications

Indications for image-guided percutaneous biopsy of a bone lesion include assessment of the nature of a bone lesion with nonspecific or aggressive imaging findings, confirmation of bone metastasis in a patient with known primary tumor, exclusion of malignancy in a bone/vertebral fracture, examination of bone marrow for hematologic disease diagnosis, and investigation of infection obtaining sample for microbiological analysis and antibiogram test (—Figs. 1–3).^{1–4} Additionally, molecular analysis of malignant tumors is very important for personalized cancer treatment.⁵ Absolute contraindications of image-guided percutaneous bone biopsies are rare and include incomplete imaging of the lesion prior to biopsy, inaccessible

sites, lack of a safe biopsy path, soft-tissue infection that poses the underlying bone to a high risk of contamination, incomplete information regarding definite surgical excision route, uncooperative or unwilling/unable to provide consent patient, and uncorrected bleeding diathesis.^{1,6} However, bleeding complications from musculoskeletal biopsies are reported to be low, even when coagulation assessment is omitted prior to biopsy.⁷

Preprocedural Workup

Preprocedural workup consists of the review of patient's clinical data including coagulation tests and platelet count, as well as of all diagnostic and functional tests that should provide a definite regional assessment and also staging of the lesion.^{1,2} Depending on the clinical scenario, the imaging studies could include computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography/CT (PET/CT), and bone scans. Information obtained from the aforementioned studies should lead to the selection of the appropriate biopsy route and the imaging guidance modality and also to the selection of the appropriate biopsy needle. Surgical consultation may be required especially in the case

Fig. 1 (a) Computed tomography (CT) axial scan illustrating a lytic lesion in the right pedicle of T8 vertebral body (arrow). (b) CT axial scan (same patient)—biopsy needle is placed inside the lesion (transpedicular approach) (arrow). (c) CT axial scan (different patient from a, b)—biopsy needle is placed inside T9 vertebral body (costovertebral approach). (d) CT axial scan (different patient from a, b, c)—biopsy needle is placed inside the L1 lesion (posterolateral approach).

Fig. 2 Percutaneous biopsy for spondylodiscitis. (a) Lateral fluoroscopic view—needle is inside L4–L5 intervertebral disc (arrow)—biopsy is performed for culture in a patient with suspected spondylodiscitis. (b) Cone beam CT axial reconstruction (same patient)—needle is inside L4–L5 intervertebral disc (posterolateral approach). (c) Lateral fluoroscopic view (different patient from a, b)—biopsy needle (arrow) is placed inside L2–L3 intervertebral disc through a transpedicular access crossing the end plate. Sampling is performed both from the end plate and the intervertebral disc. (d) Computed tomography axial scan (different patient from a, b, c)—biopsy needle is placed inside the lesion located anterior to the L5–S1 intervertebral disc (transsacral approach).

Fig. 3 (a) Computed tomography (CT) axial scan illustrating a large-size soft-tissue mass of the right iliac bone (arrows)—soft-tissue semiautomatic biopsy needle is placed in the periphery of the mass. (b) CT axial scan illustrating a hyperdense intraosseous lesion of the femoral bone. (c) CT axial scan (same patient with b)—after consulting with the surgeon, a lateral approach was performed; using a coaxial system, needle is located inside the lesion.

of limb-salvage surgery where avoidance of crossing of more than one anatomic compartment is crucial as there is risk of tumor cells seeding across the needle trajectory; needle track staining with methylene blue following biopsy facilitates its subsequent surgical excision.^{8–11}

Preprocedurally, there are additional issues that have to be decided, including administration of sedation and/or analgesia, patient positioning, number of samples, and assessment of contraindications and complication risks.¹ Informed consent is mandatory for any interventional

procedure following a full explanation of indications and complication risks and has to be obtained directly by the interventional radiologist who will carry out the biopsy.¹ Patients should be on nil per os for 4 to 6 hours prior to the procedure especially when sedation is planned. A peripheral venous access (18–20 gauge) should be placed prior to biopsy and monitoring of vital signs is needed during the procedure.¹ Antibiotic prophylaxis is not routinely used, but, when indicated, should be administered before the biopsy.¹

Technical Factors

Patient positioning is very important for percutaneous biopsy of musculoskeletal lesions; the patient should be placed in a comfortable position depending on the decided access route which will allow optimal access to the biopsy site.^{1,2,12} The most common imaging-guided methods used are ultrasound, CT, and fluoroscopy.¹³ MRI and PET/CT are used more rarely for biopsy guidance but frequently they reveal lesions that are CT occult.¹³ Ultrasound can be used for bone lesions with extraosseous component or for soft-tissue lesions.^{2,14} Choice of imaging guidance modality depends on many parameters including availability and operator's preferences but should provide proper visualization of both relevant anatomy and biopsy equipment during the interventional procedure and also assessment of possible complications exposing the patient to as low ionizing radiation as possible. Contemporary equipment allows fusing of images from different imaging modalities facilitating needle tracking.¹ Ultrasound image guidance provides real-time imaging without ionizing radiation exposure, but it is an operator-dependent method with a limited field of view and suboptimal visualization of deep lesions, especially in obesity.^{1,14} MRI provides near real-time imaging with a large field of view with multiplanar detailed visualization of the region of interest without ionizing radiation exposure; how-

ever, MRI-compatible instruments are required, and the procedure time is longer in comparison to other methods.^{1,2,12} Availability issues and high cost are additional disadvantages of MRI that have to be mentioned.¹² CT is the most common method for image guidance, as it provides excellent and rapid visualization of the instruments, the lesion, and the regional compartmental anatomy but at the cost of ionizing radiation exposure.^{1,2,12} CT fluoroscopy can be used for real-time imaging and using intermittent fluoroscopy, radiation exposure is greatly reduced.¹ Musculoskeletal biopsies should be core biopsies and a variety of different needles exist; so, the selection of the appropriate needle depends on the location and type of the lesion and the operator's preference.^{1,2} A trocar should be used for coaxial biopsy, in the case of an intact cortical bone, allowing for multiple samples to be obtained using the same access site¹⁵ (► Fig. 4). In the case of densely sclerotic lesions, increased bone thickness, and excessive periosteal reaction, the use of a drill (manual or electric) may improve diagnostic yield and be technically easier.^{16–20}

Sedation and analgesia provide patient comfort and cooperation during and after the biopsy and most bone biopsies are performed under conscious sedation or using local and cutaneous anesthesia.¹ A 22-gauge spinal needle can be used to deliver local anesthetic from the entry site up to the lesion or the periosteum. General anesthesia is usually recommended when patient cooperation is suboptimal (e.g., children) or for patients with high narcotic tolerance levels.^{1,12,21,22} Bone biopsy should be performed under strict sterile conditions and on completion of biopsy and removal of the needle, the biopsy site is evaluated with imaging to rule out hemorrhage. Patients are usually kept for evaluation of immediate complications and prior to discharge a full explanation, or more preferably printed advice, about potential complications and appropriate postprocedural care must be provided to the patient.²³

Fig. 4 Coaxial approach offers the advantage of multiple bone sampling with a single puncture. Through the initial trocar, either a bone or a soft-tissue biopsy needle can be inserted depending on the lesion.

Efficacy and Complications

Core needle biopsy of musculoskeletal lesions has a diagnostic accuracy that ranges from 66 to 98%,^{24–28} but it is lower for spinal lesions²⁹ and infectious disease,³⁰ as well as in the case of benign lesions or low-grade tumors (in contrast with malignant tumors).^{25,31} Diagnostic yield is reported to be higher in lytic lesions,^{29,32} in large targets, and when multiple and long specimens are obtained.³² Sclerotic lesions, such as prostate cancer bone metastases, are more challenging to biopsy and often the sample obtained is inadequate for diagnosis and molecular analysis but drill-assisted systems increase accuracy and improve diagnostic yield,³³ and even blood clots obtained through drilling can be used for next-generation sequencing with favorable results.³³ Concerning acquisition of cellular and molecular material, imaging modality and multiple samples are associated with higher diagnostic yield, which is also positively affected when bone lesions contain radiolucent areas, have ill-defined margins, and exhibit recent interval growth.^{4,34} In initially nondiagnostic findings, repeat core biopsy can be useful as an alternative to open biopsy, but it may be underutilized.³⁵

Mukherjee et al performed spine biopsy in patients with presumed osteoporosis and no prior cancer as well as known cancer patients presumed to be in remission reporting an overall cancer diagnosis rate of 5.5% when combined the results of routine vertebral biopsy in both groups.³⁶ Image-guided spinal biopsy for spondylodiscitis has a reported sensitivity of 52.2% and a specificity of 99.9%, while the microbiological yield varies from 36 to 91%.³⁷ According to de Lucas et al, diagnostic rates obtained in patients with previous antibiotic treatment are significantly lower (23 vs. 60%, $p = 0.013$) than in those with discontinuation of antibiotics prior to biopsy.³⁸ As far as spinal infection is concerned, percutaneous biopsy can lead to a change in decision management in 35% of the cases.³⁹

Complication risk for percutaneous bone biopsy is lower than for open biopsy and reported complication rates range between 0 and 10% and usually do not exceed 5%, with a suggested threshold of 2%.^{1,12,21,40} Clinically significant complications occur in less than 1% of cases^{2,40} and procedure-related mortality rate does not exceed 0.05%.^{1,21} Risk factors for delayed minor complications following percutaneous biopsy of musculoskeletal lesions are patient age, female gender, and lesion location.⁴¹ Reported complications include bleeding and hematoma, infection, neural injury, bone fracture, needle tip breakage, surrounding organ damage, and needle tract seeding.^{1,42} Significant bleeding is rare,¹ fracture risk is higher in very lytic lesions⁴² and needle tract seeding may be affected by needle size, number of needle passes, tumor type, and location of the lesion.²¹ Careful planning of the biopsy route is very important. For grading and classification of complications, international systems can be used combining outcome, presence of complication, effect upon hospitalization, and severity of a specific complication and sequelae in patient's everyday life.^{43,44}

Conclusion

Percutaneous, image-guided musculoskeletal biopsy is a safe (2% suggested threshold of complications rate) and effective (diagnostic accuracy ranging from 66 to 98%) technique widely used for tissue and bone sampling. Percutaneous musculoskeletal biopsies as opposed to open surgical approaches obviate the risk of destabilizing an already diseased spinal or peripheral skeleton segment, while imaging guidance additionally provides immediate confirmation of the correct needle location inside the target area/lesion.

Note

The reader is referred to a prior article in *Seminars in Interventional Radiology* that also covers musculoskeletal biopsies.¹²

Conflict of Interest

Authors have no conflict of interest to disclose.

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