CT-Guided Biopsy of Bone: A Radiologist's Perspective

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OBJECTIVE. We present an overview of approaches for bone biopsy used to minimize potential tumor seeding of adjacent soft-tissue structures and compartments. We discuss a variety of approaches related to specific anatomic parts and review pertinent anatomy.

CONCLUSION. We provide important guidelines and key examples that will help readers perform percutaneous needle bone biopsy safely.

Percutaneous needle bone biopsy is a safe and accurate method [1–5] for obtaining a tissue diagnosis. In general, superior results are obtained with lesions in the extremities or pelvis compared with those in the spine [6]. Percutaneous needle biopsies have a very low complication rate (1.1%), whereas open biopsy has a complication rate of up to 16% [7]. A concerning complication of percutaneous biopsy is the risk of seeding malignant cells along the needle track, particularly if the lesion is a sarcoma, which would necessitate resection of the needle track en bloc with the tumor at limb-sparing reconstructive surgery [8]. Thus, choosing the appropriate needle path is critical for limb-salvage procedures.

We discuss our general approach to percutaneous biopsy of bone and focus on specific topographic approaches used for various anatomic areas of the skeletal system. We describe our preferred biopsy route to complement limb-sparing surgical resection in the event of malignant seeding along the needle track. In addition, we describe other techniques, such as CT gantry angling, periosteal sampling, and extrapleural saline infiltration for biopsy of paraspinal lesions.

General Points

Thorough prebiopsy imaging review is essential, and further imaging may be necessary. Close attention should be paid to evaluating the extent of the lesion and whether skip lesions are present because these factors determine the extent of resection and the feasibility of limb-salvage surgery. The imaging findings should be correlated with patient symptoms and findings on functional studies, such as PET and bone scanning, if indicated. In patients with multiple lesions, the lesion that is most amenable to biopsy, allowing the highest yield with the lowest risk of complications, is selected.

The presence of multiple lesions is also important because biopsy of a potential metastasis has different considerations compared with biopsy of a primary bone tumor. Fine-needle aspiration (FNA) can differentiate a metastasis from a benign lesion; however, core biopsy is superior to FNA in determining cell type and tumor grade, which is necessary for the diagnosis of primary bone tumor. Primary bone tumors necessitate thoughtful percutaneous track planning with limb-sparing resection and rehabilitation in mind, whereas for metastases, the route is less important because seeding is of questionable concern and the shortest and most direct route is usually used. As a general rule, if the lesion is not metastatic—that is, if it is a primary bone tumor or there is uncertainty about metastatic disease, we treat it as if seeding of the biopsy track may occur and an appropriate percutaneous route is used.

At the University of Michigan Hospitals, we use three different needles (Fig. 1) of a variety that are available for bone biopsy [9]. A 14-gauge coaxial bone biopsy system with an eccentric drill tip (Bonopty bone biopsy system, C. R. Bard, Inc.) is used to obtain tissue from sclerotic lesions and lesions with an intact cortex. The excentric bit allows a channel to be drilled just wider than the external diameter of the cannula of the coaxial system, so the cannula can be advanced and can act as a coaxial introducer. Through this introducer, the bone

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biopsy component of this system may be used, but also a soft-tissue "gun" or a fine-needle aspirate may be obtained [10]. A 16-gauge biopsy needle (Quick-Core, Cook) is used to sample a soft-tissue mass external to bone, but it also works well through the 14-gauge Bonopty coaxial system to biopsy a soft-tissue mass within bone. An 11-gauge needle system (InterV Traplok, Medical Device Technologies, Inc.) provides a large specimen core and is used for lesions containing cystic and necrotic components, but in our experience, it is not as effective as the Bonopty coaxial system for sclerotic lesions and where a normal (or thickened) cortex of bone needs to be traversed. Also, once the biopsy sample has been taken with the InterV Traplok system, if a second core is required, the entire system must be repositioned.

In general, we perform all bone biopsies with the patient under conscious sedation using local anesthesia; however, general anesthesia may be necessary in children or uncooperative patients. Painful lesions, such as neurogenic tumors, or lesions in the hand and foot may require a regional nerve block. Liberal periosteal anesthetic infiltration is often helpful to minimize pain.

If a soft-tissue mass is associated with a destructive bone lesion, the biopsy may be taken from the soft-tissue component and, if possible, a biopsy of an intraosseous part of the mass should also be obtained. The enhancing regions of a soft-tissue mass as seen on contrast-enhanced CT or MRI should be sampled, as should the center and periphery of the lesion. In addition, if a mass is calcified or ossified, sampling the least mineralized portion often shows the highest atypia. Biopsy samples from two or three different locations in a single lesion, especially a large lesion, may be obtained.

An adequate biopsy sample is one that provides enough abnormal tissue for a pathologist to comfortably make a diagnosis. We have found that with an 11-gauge needle, a single long core of abnormal tissue has been enough, and we frequently divide this core into two pieces, one piece each for histology and bacteriology. If the lesion is large, two or three cores obtained with a 14- or 16-gauge needle have proved adequate, but five to eight or more cores may be necessary if the cores are obtained with a small-gauge needle; we rarely obtain such small cores of tissue. Two or three partial cores count as a "single" core, and all fluid aspirated is sent routinely for evaluation. With cystic lesions or lesions in which the majority of the lesion is necrotic, we obtain multiple cores through both the superficial and deep margins of the lesion. If blood is aspirated from the lesion, the clotted blood should be sent for pathologic evaluation.

Differentiating infection from tumor is difficult because infection often appears aggressive at imaging and may simulate malignancy. For this reason, we suggest that at the time of biopsy the specimens be sent for both pathologic and bacteriologic evaluations. In hemorrhagic lesions, postbiopsy embolization of the needle track using a hemostatic agent, such as an absorbable collagen hemostatic sponge (Helitene, Integra LifeSciences Corporation), may limit bleeding.

The shortest path between skin and lesion that avoids neurovascular and joint structures, lung, bowel, and other organs is optimal. For primary bone lesions for which limb-sparing surgery is contemplated, every effort must be made not to contaminate a disease-free compartment. If a sarcoma or a primary tumor is suspected, seeding is a concern, and further specific principles are followed: First, the needle path must be close to the incision for the definitive limb-sparing surgery so that the needle path can be resected. Second, the needle should not traverse an uninvolved compartment, joint, or neurovascular bundle. This is particularly relevant if these structures are needed for reconstruction. Third, avoiding the physes will allow the option of physis-sparing surgery in the skeletally immature. The biopsy should be considered part of the surgical therapy, and a team approach with the surgical oncology team is critical for a positive outcome. We recommend that the biopsy route should always be discussed with the surgeon treating the patient before biopsy of a suspected primary bone tumor [8, 11].

The Upper Limb

The Shoulder

The deltoid and pectoral muscles are typically used for reconstruction at the shoulder. Because the deltoid muscle is innervated by the axillary nerve from posterior to anterior, en bloc resection of a posterior needle track may denervate and leave functionless the more anterior muscle (Fig. 2). A proximal humeral lesion should be approached through the anterior third of the deltoid (Fig. 3). The deltopectoral groove is to be avoided because this approach may compromise the use of pectoral muscle for reconstruction and may contaminate the main neurovascular bundle of the upper limb.

The Forearm

The interosseous membrane between the radius and ulna forms a natural barrier to the spread of tumor. When sampling lesions through the extensor compartment, the flexor compartment should not be traversed and vice versa (Figs. 4 and 5). It is optimal to biopsy the ulna at its subcutaneous border; if this approach is not possible, contamination of the extensor carpi ulnaris or flexor carpi ulnaris is associated with the least morbidity after resection.

The Pelvis and Lower Limb

The Pelvis

For primary lesions of bone, if at all possible, avoid traversing the gluteal muscles posteriorly and the rectus femoris muscle anteriorly (Fig. 6). Resection of the gluteal muscles is associated with a poor outcome after limb-sparing surgery because these muscles provide a significant proportion of functionality after surgery. An anterior or posterior approach through the ilium avoids the gluteal musculature (Fig. 7). If the lesion is a suspected metastasis, stabilization with hardware rather than resection may be used; therefore, the shortest path may be chosen (Fig. 8).

The Thigh

An anterior approach through the rectus femoris muscle should be avoided (Fig. 9). Resection of these extensor muscles—in particular, the rectus femoris muscle—provides suboptimal results during limb-sparing surgery. If a lesion is closely apposed to the femoral vessels, a medial approach is preferred because a medial incision facilitates vessel exploration. The lateral approach is often more ergonomically feasible and avoids the medial neurovascular structures, especially if the vastus lateralis muscle is involved without vascular involvement (Fig. 10). In the distal thigh, the suprapatellar recess may extend for a varying distance proximally and should be avoided along with the remainder of the knee joint. For a medial approach, we may either elevate the leg to be biopsied or flex and externally rotate the contralateral hip to provide easy access to the medial thigh.

The Leg

The interosseous membrane between the tibia and fibula is a natural barrier to tumor spread. Because the anterior medial tibia is subcutaneous, both compartments may be avoided (Figs. 11 and 12).

Difficult Anatomic Regions

The Hand and Foot

The complex anatomy of the hand and foot necessitates discussion with a surgeon in planning a biopsy route. Patients undergoing biopsy of these sensitive areas may benefit from a regional nerve block. We try to avoid traversing the sole of the foot or the palm of the hand (Fig. 13) because these areas are more sensitive to pain. Initial needle stabilization in a structure with little subcutaneous tissue at CT-guided biopsy may be challenging (Fig. 14) and often requires sterile towels around the needle for support.

The Ribs

The diagnostic yield from a rib biopsy is higher if there is an associated soft-tissue mass (Fig. 15). The convex superficial surface, small size, and adjacent lung make these biopsies challenging. A tangential approach rather than one perpendicular to the pleura is favored to minimize risk of pneumothorax.

The Spine

Typically, vertebral body lesions are biopsied using an approach through the pedicles (Fig. 16). However, if the epicenter of the lesion is not accessible through the pedicles, a costovertebral approach may be considered (Fig. 17). Injection of saline into the soft tissues may be used to displace tissue away from the spine and displace the adjacent lung away from the needle path (Fig. 18).

Periosteal Sampling

Infrequently, the anatomy or the density of a bone may make obtaining a bone sample difficult. If periosteal bone apposition is present, a sample obtained here may yield a diagnosis (Fig. 19).

Gantry Angling

This technique is useful when trying to avoid traversing a compartment, as in the pelvis. The axial plane may not include both the optimal entry point of the needle and the target. By angling the gantry, the entry point and the target may be on a single image or, more commonly, on a smaller number of images, facilitating more accurate needle alignment and a less complicated biopsy (Fig. 20).

Conclusion

In conclusion, by communicating with the surgical team and following some basic principles, we can obtain adequate samples of tissue and minimize the surgical implications of seeding the needle track in the biopsy of primary tumors of bone.

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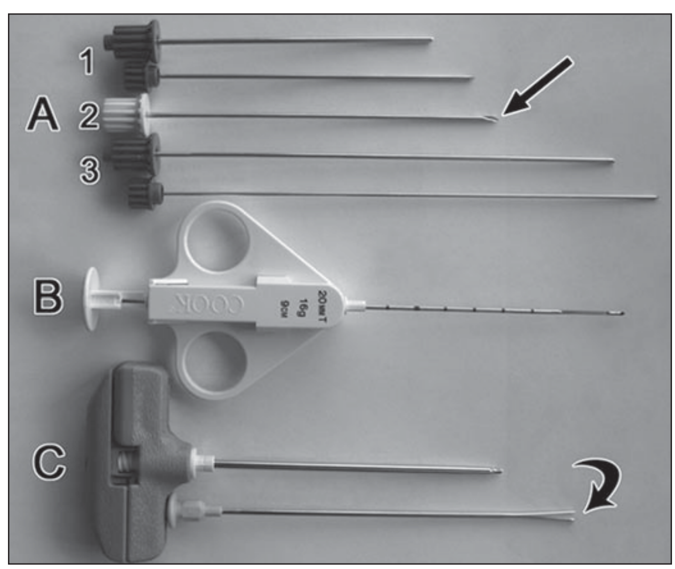
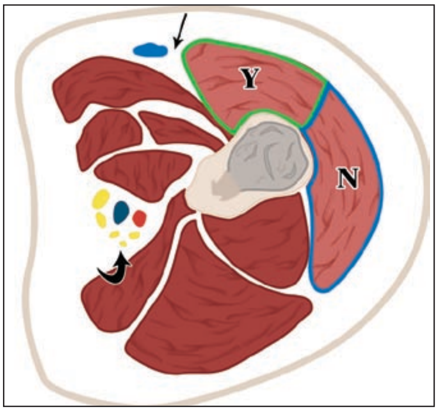


Fig. 1—Photograph shows three needle types for biopsy of bone lesions. First type is Bonopty coaxial system (C. R. Bard, Inc.) (A). Introducer (1) with trocar (below) traverses soft tissue. Trocar is removed to allow drill bit (2) to replace it and traverse bone. Note cutting portion of drill bit (*straight arrow*). Once in position, bit is removed to allow bone biopsy needle (3) with trocar (below) to be positioned. Once positioned, biopsy needle trocar is removed and biopsy sample is obtained. Second type is Quick-Core biopsy "gun" (B) (Cook) for soft-tissue cores only. Note illustrated needle is 9 cm long; a longer needle is required to fit through Bonopty coaxial system. Third type of needle is 11-gauge InterV Traplok system (C) (Medical Device Technologies, Inc.). Note detail of trap device (*curved arrow*) to help retain biopsy tissue core within needle.



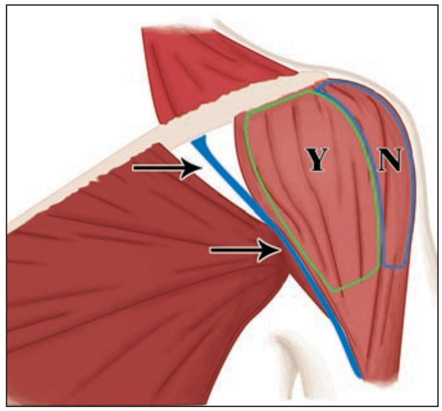


Fig. 2—Shoulder illustrations.
A and **B,** Axial (**A**) and coronal (**B**) shoulder illustrations show zones permissible for biopsy (*green*) including anterior deltoid (Y). Areas outlined in blue should be avoided, such as posterior deltoid (N). Note deltopectoral groove (*straight arrows*), neurovascular structures (*curved arrow*, **A**), and cephalic vein (*blue,* **B**).

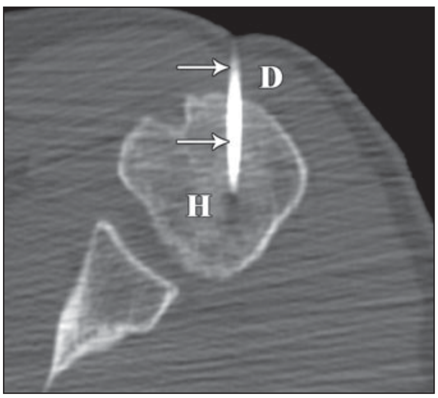


Fig. 3—63-year-old man with grade I chondroblastoma. Axial CT section of left shoulder shows 11-gauge biopsy needle (*arrows*) with tip within sclerotic lesion in humeral head (H). Anterior approach through anterior portion of deltoid muscle (D) was used.

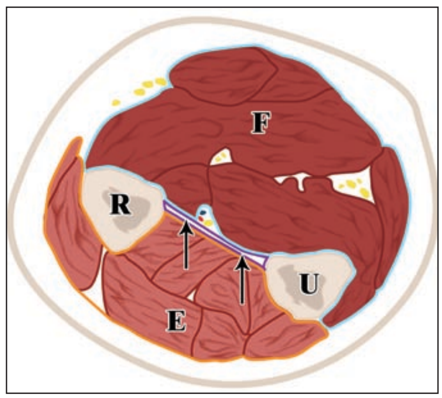


Fig. 4—Illustration of forearm in axial plane. Interosseous membrane (*arrows*) separates extensor (E) and flexor (F) compartments. Special care should be taken not to violate interosseous membrane, thus avoiding contamination of multiple compartments. R = radius, U = ulna.

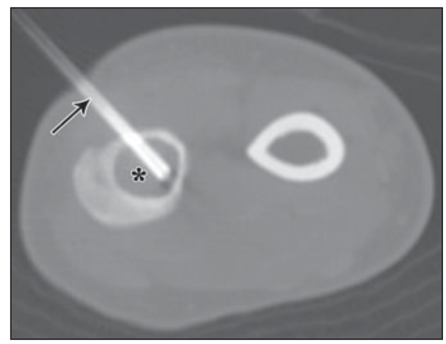


Fig. 5—20-year-old woman with enchondroma of radius. Axial CT image through forearm shows 11-gauge needle (*arrow*) with tip in radius (*asterisk*). Care is taken not to traverse interosseous membrane.

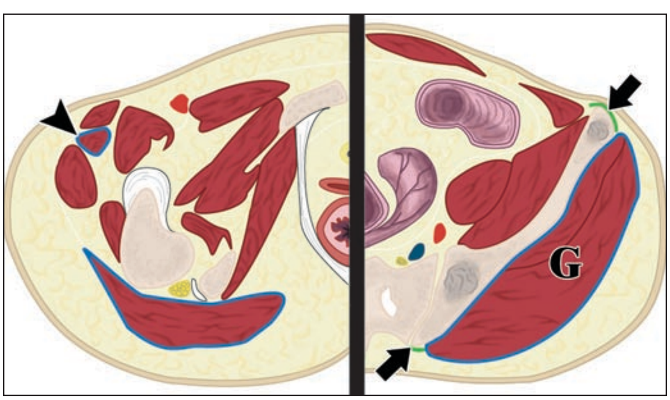


Fig. 6—Illustrations of pelvis at level of iliac bone (*right*) and inferior pubic ramus (*left*). Gluteus muscle group (G) and rectus femoris muscle (*arrowhead*) must be avoided. Ideal approach is directly into iliac bone (*arrows*), either anterior or posterior.

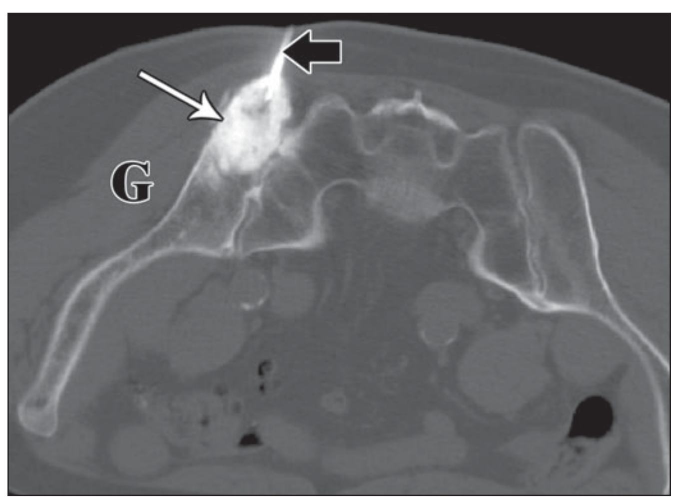


Fig. 7—74-year-old man with osteoblastic osteosarcoma. Axial CT image of pelvis with patient prone shows 14-gauge needle (*black arrow*) with tip within lesion (*white arrow*). Posterior approach through iliac bone, thus avoiding gluteal muscles (G), was used.

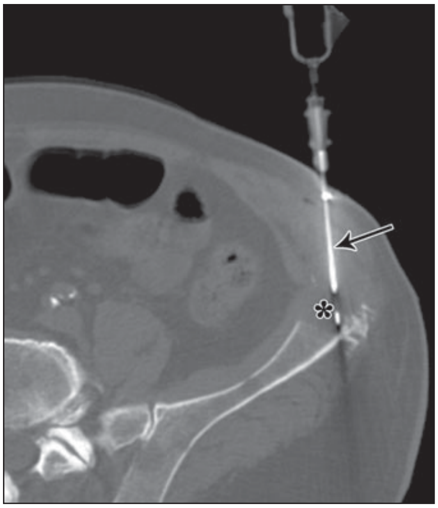


Fig. 8—70-year-old man with metastatic lung cancer. Axial CT scan through pelvis shows lytic metastasis in left anterior iliac bone (*asterisk*); 18-gauge needle (*arrow*) (Quick-Core, Cook) is seen traversing lytic lesion.

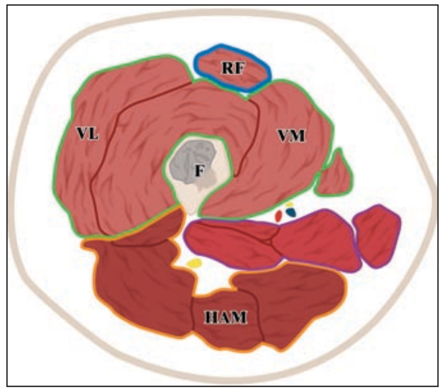


Fig. 9—Illustration of axial thigh. Rectus femoris muscle (RF) and hamstrings (HAM) are to be avoided. Medial or lateral approach through vastus medius (VM) and vastus lateralis (VL) is preferred. F = femur.

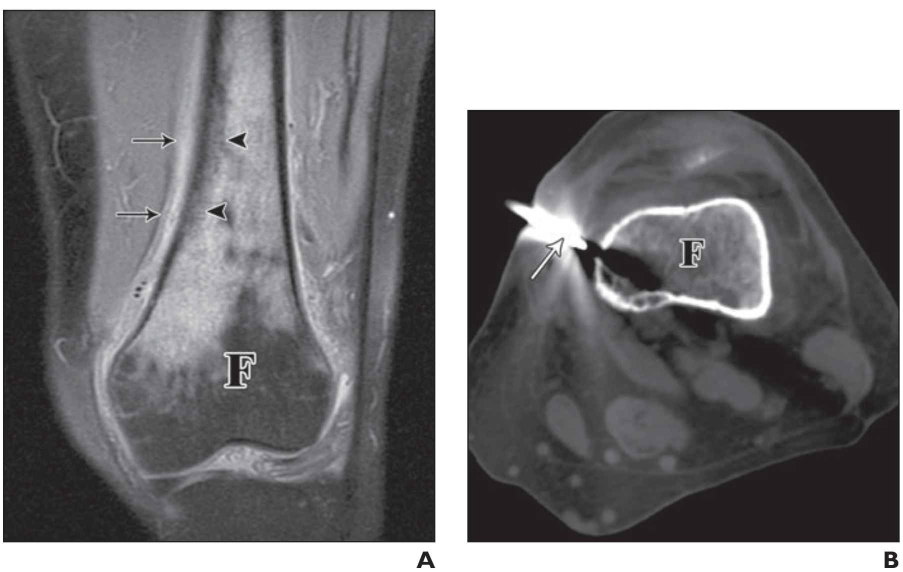


Fig. 10—58-year-old man with metastatic adenocarcinoma.
A, Coronal T2-weighted MR image shows marrow replacement in distal femur (F), soft-tissue signal abnormality (*arrows*) surrounding medial distal femur, and adjacent intramedullary low signal (*arrowheads*).
B, Axial CT image of distal femur shows 11-gauge needle (*arrow*) used to obtain core biopsy of femoral lesion (F).

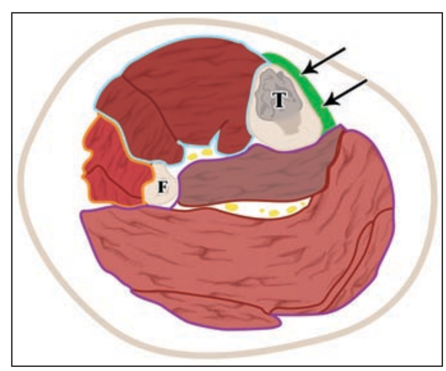


Fig. 11—Illustration of lower leg. Axial image shows optimal entry site for tibial biopsy (*green* and *arrows*) that avoids muscle compartments. T = tibia, F = fibula.

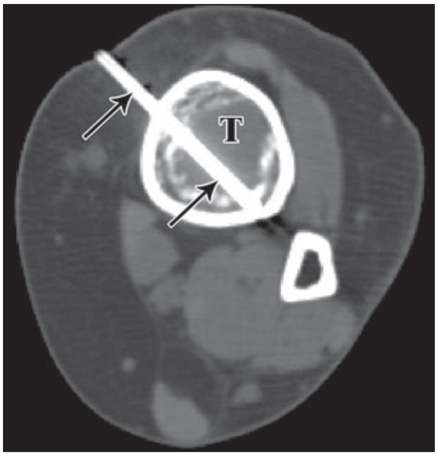


Fig. 12—52-year-old woman with enchondroma. Axial CT scan of left leg shows 14-gauge core biopsy needle (*arrows*) traversing tibia (T) through anteromedial approach. Note marrow replacement of tibia.

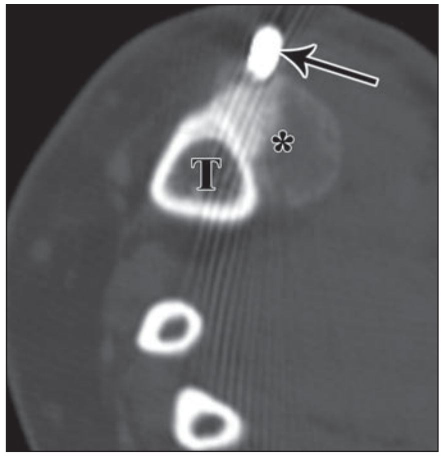


Fig. 13—34-year-old woman with right first metatarsal osteoma. Axial CT scan of right foot shows 11-gauge biopsy needle (*arrow*) sampling osteoma (*asterisk*) in medial aspect of first metatarsal (T).

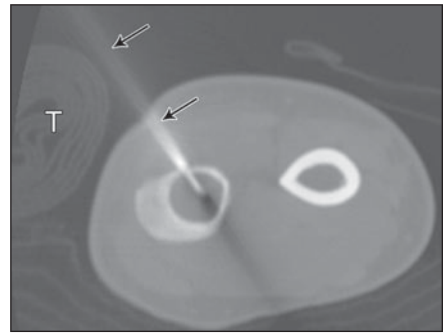


Fig. 14—20-year-old woman with enchondroma of radius. Axial CT scan of right forearm shows biopsy needle (*arrows*). Because of little surrounding tissue in distal extremity to stabilize needle during imaging-guided placement, sterile towel (T) was rolled and used to support needle.

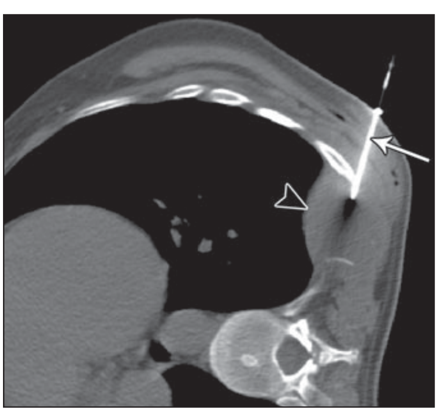


Fig. 15—35-year-old woman with metastatic renal cell cancer. Axial CT scan of chest shows 18-gauge soft-tissue biopsy needle (*arrow*) sampling chest wall mass (*arrowhead*).

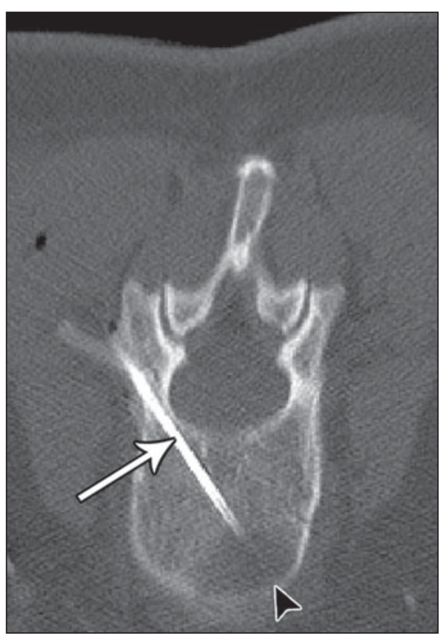


Fig. 16—55-year-old woman with metastatic breast cancer. Axial image of spine shows core biopsy needle (*arrow*) through vertebral lytic lesion (*arrowhead*) using transpedicular approach.

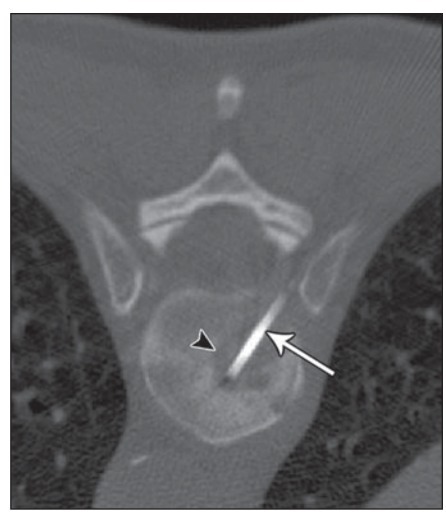
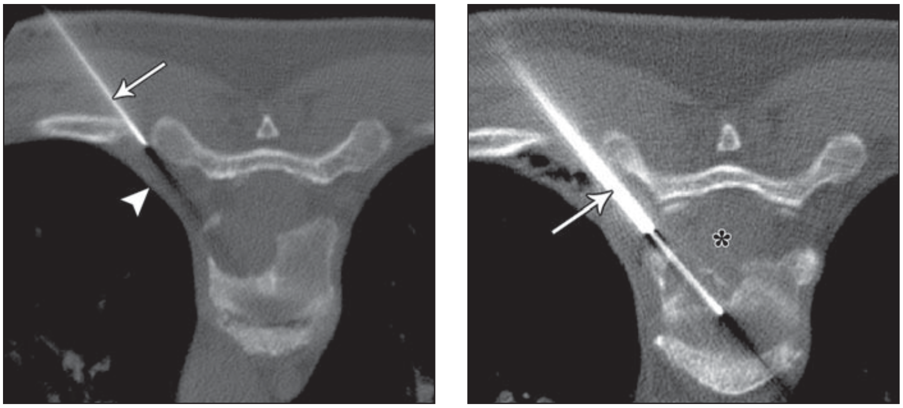


Fig. 17—61-year-old woman with nodular sclerosing Hodgkin's disease treated with radiation. Axial image of spine shows 16-gauge core biopsy needle (*arrow*) through lytic vertebral lesion (*arrowhead*) using costovertebral approach.



A B

Fig. 18—56-year-old woman with metastatic lung cancer.
A, Axial image of spine shows 22-gauge spinal needle (*arrow*) in posterior paraspinal soft tissues (*arrowhead*), through which saline was injected to displace lung away from biopsy needle path.
B, Axial image shows coaxial needle and introducer (*arrow*) with tip within vertebral lytic lesion. Note adjacent spinal canal (*asterisk*).

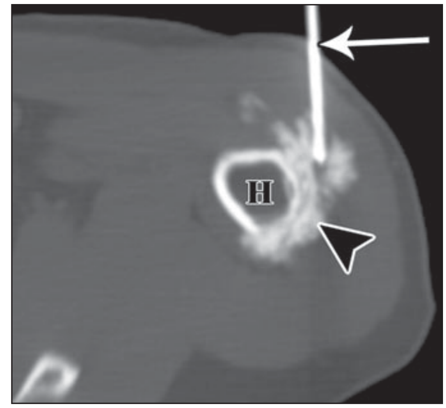
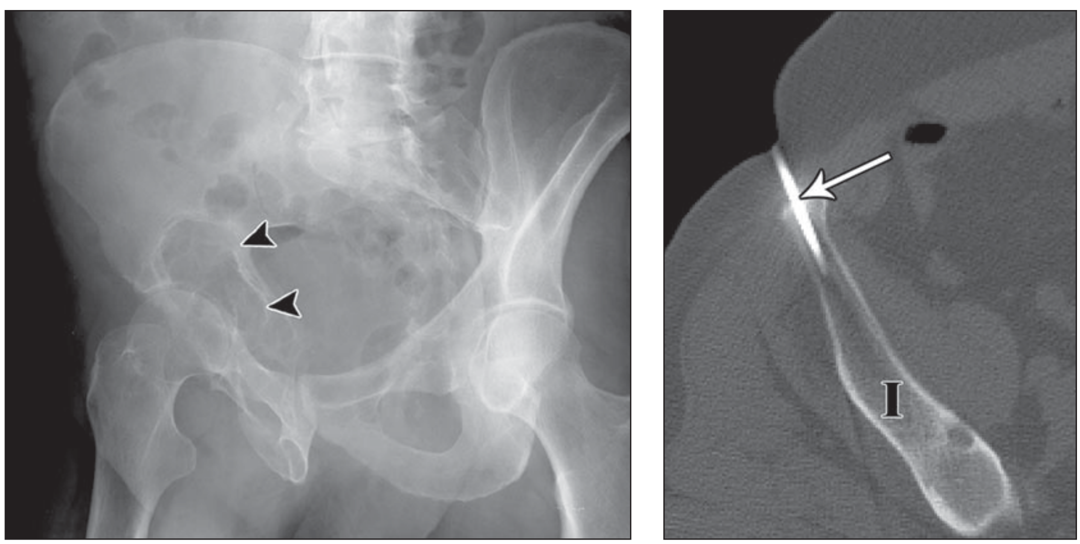


Fig. 19—45-year-old man with parosteal osteosarcoma. Axial image of left arm shows 11-gauge biopsy needle (*arrow*) sampling periosteal bone apposition (*arrowhead*) adjacent to humerus (H) via preferred anterior transdeltoid approach.



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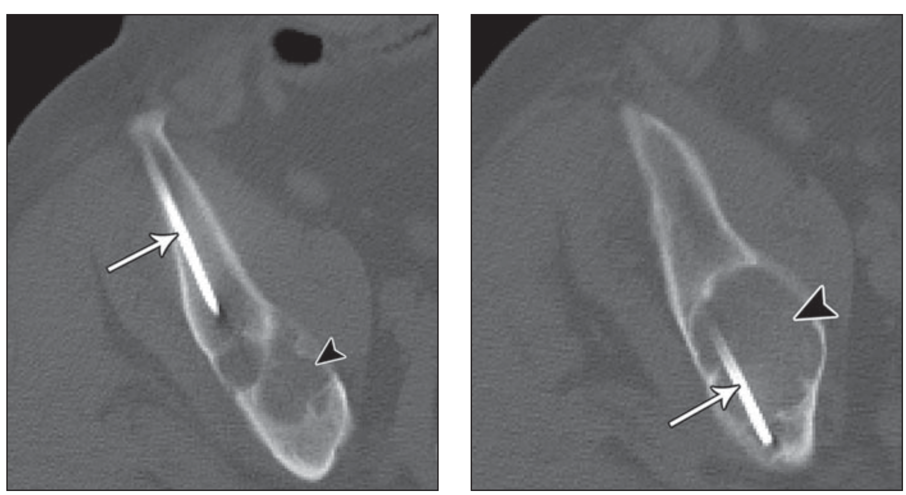

C D

Fig. 20—52-year-old man with grade II chondrosarcoma.
A, Oblique radiograph of pelvis shows expansile, radiolucent lesion (*arrowheads*) of right acetabulum extending into proximal ischium.
B, Sequential axial CT section through pelvis with gantry angled shows needle (*arrow*) entering anteriorly at iliac bone (I), path oblique to CT scan plane.
C, Sequential axial CT section through pelvis with gantry angled shows needle (*arrow*) oblique to CT scan plane with distal tip at tumor (*arrowhead*).
D, Sequential axial CT section through pelvis with gantry angled shows needle (*arrow*) oblique to CT scan plane with distal tip having traversed tumor (*arrowhead*).