

Imaging-guided Bone Biopsy

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Abstract

Imaging-guided percutaneous bone biopsy can be rapidly performed under local anaesthesia with little patient discomfort. It has a useful role in the diagnosis and management of patients with bone lesions. The indications, contraindications, general principles, technique and possible complications of bone biopsy, performed using computed tomography guidance, are highlighted in this update.

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Introduction

Biopsy may be performed at surgery (open biopsy) or percutaneously (closed biopsy). Percutaneous bone biopsies are usually performed under imaging guidance using a variety of modalities, such as fluoroscopy¹ and computed tomography (CT),²⁻⁴ and less commonly, ultrasonography (US)^{5,6} and magnetic resonance (MR) imaging.^{7,8} Compared to open biopsy, the advantages of imaging-guided closed biopsy are lower cost, time saving, no need for hospitalisation, lower morbidity (including avoidance of general anaesthesia-related problems), less risk of postoperative wound infection, decreased likelihood of a pathological fracture, earlier commencement of radiation therapy and biopsy of surgically inaccessible or multiple sites.^{9,10}

Imaging Techniques

Imaging-guided biopsy is safe, with major complications being uncommonly reported. When properly performed, accuracy rates of 68% to 97% have been reported.^{1,4,11,12} Open biopsy is still widely regarded as the “gold standard” for obtaining adequate and representative bone samples, with a reported accuracy rate of up to 98%.¹³ Biplane fluoroscopy is often used to guide biopsy of superficial lesions located in long bones. Fluoroscopy is relatively inexpensive and widely available. The disadvantages of fluoroscopic-guided biopsy include poor visualisation of small intramedullary lesions, the soft tissue component of bone lesions, and small lesions located in complex-shaped bones such as the pelvis and spine. US can be used for

surface bony lesions and if there is a soft tissue mass or cortical destruction accompanying aggressive bony lesions.^{5,6} The advantages of US are its lack of ionising radiation hazard, real-time imaging capability and reasonable visualisation of soft tissues. However, it is operator-dependent and is not suitable in the majority of intramedullary and deep-seated bone tumours.

MR imaging has been found to be feasible for biopsy of musculoskeletal lesions, particularly for those that are not well visualised on fluoroscopy or CT.^{7,8} The advantages of MR imaging are its superior soft tissue contrast, tissue characterisation ability, lack of ionising radiation hazard and high sensitivity for delineation of intramedullary lesions. However, an open MR unit and a host of MR-compatible equipment and accessories are required. The choice of imaging guidance is also determined, to a certain extent, by operator preference. Percutaneous biopsy performed under CT guidance will be highlighted in this update as it is currently the procedure of choice for bone lesions.

Indications¹⁴⁻¹⁶

- Confirm metastasis in patients with known primary tumour (Fig. 1).
- Determine the nature of a solitary bone lesion, particularly primary bone tumour.
- Evaluate for tumour recurrence.
- Determine if chemotherapy has been effective.
- Assess for multiple myelomas or other round cell lesions.
- Exclude metastases or myelomas in vertebral body compression.

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- Investigation for infection (Fig. 2).
- Confirm benignity of lesion to facilitate correct treatment (such as osteoporosis and renal osteodystrophy)
- Assessment of a lesion in poor surgical risk patients.

Contraindications¹⁴⁻¹⁶

- Bleeding diathesis.
- Decreased platelet count.
- Suspected vascular lesion in the thoracic vertebra as haemorrhage causing cord compression may potentially occur.
- Infected soft tissues surrounding the bone to be biopsied.
- Inaccessible sites, such as C1 vertebra and odontoid lesions.
- Unco-operative patient.

General Principles

A well-planned biopsy provides an accurate diagnosis and facilitates treatment. Biopsy of a suspected primary tumour should be performed at centres specialising in the treatment of bone tumours, with adoption of a multidisciplinary team approach. All imaging, particularly MR imaging, should be completed prior to biopsy. The radiologist should review the clinical history and all pertinent imaging studies to ensure that a biopsy is indicated and to locate the most appropriate biopsy site. Radiographs provide an overview of the lesion and its morphological characteristics. Bone scintigraphy is helpful in determining the extent and distribution of the disease. CT and MR imaging are best for defining the local extent and further disease characterisation, particularly for radiographically occult or subtle lesions and associated soft tissue components (Fig. 2).

The biopsy route should be planned so that it does not compromise the definitive surgical procedure to be performed. The neurovascular bundles should be avoided, unaffected compartments should not be crossed and biopsy should be done in consultation with the surgeon who will be performing the definitive surgery. Ideally, the pathologist who will be examining the specimen should also be involved early in the management pathway. One should aim to obtain at least 3 specimens, particularly if a cytopathologist is not present during the procedure to confirm adequacy of the biopsy specimen. Anticoagulants should be discontinued prior to biopsy; for assessment of infection, antibiotics should be discontinued at least 48 hours prior to biopsy. Other pre-biopsy considerations include blood tests to check for coagulopathy and platelet counts, sedation or anti-anxiety premedication and written informed consent.

CT Technique

A large number of our bone biopsies are performed using CT fluoroscopy (or real-time CT). The development of CT

fluoroscopy resulted from recent advances in CT scanner technology, such as slip-ring scanning, sub-second rotation time and greater computing power. These advances allow rapid reconstruction of CT data such that continuous update and provision of cross-sectional images in near real-time is now possible. In CT fluoroscopy, the person performing the biopsy is located at the patient's side in the CT suite. During CT fluoroscopic scanning, the musculoskeletal radiologist is able to manipulate the needle either continuously or intermittently. Besides real-time imaging, time saving is the other main advantage of CT fluoroscopy as, unlike conventional CT scanning, the periods between scanning and adjustment of needle position are eliminated or greatly shortened.¹⁷ However, compared to conventional CT scanning, where the operator is usually located in a separate room during scanning and hence receives a negligible radiation dose, the operator receives considerable radiation dosage during CT fluoroscopy. The amount of radiation received depends on the level of operator experience and degree of complexity of the individual procedure.¹⁷ Compared to standard radiographic fluoroscopy, CT fluoroscopy employs higher radiation dose rates. The radiation dose to both operator and patient should be minimised by limiting the imaging time, employing lower mA settings and using appropriate radiation protection measures.¹⁸

The patient is positioned to facilitate needle access to the lesion and, ideally, also for comfort. Vital signs are monitored during the procedure. Following preliminary axial CT scanning, the most appropriate slice is selected to plan the most appropriate route for directing the needle into the lesion. Generally, if there are multiple lesions, the largest and most superficial lesion is chosen. Any soft tissue component related to the bone lesion should also be biopsied (Fig. 3). In planning the needle route, vital anatomical structures, such as the major blood vessels, nerves, pleura, peritoneal cavity and spinal canal, should be avoided (Fig. 4). The skin to lesion length and the angle of the chosen route should be estimated or measured. The selected slice is surface marked and the skin, cleaned and draped. After administration of local anaesthesia, a small skin incision is made and the biopsy needle is directed into the lesion under intermittent imaging guidance.

The type of needle used depends on the nature of the lesion and the operator's personal preference. There are a large variety of needles available. They can be classified into aspiration (such as spinal), cutting (such as Trucut or Quickcore) and trephine or bone-cutting (such as Ostycut) needles. They range in size from 11G to 22G. In general, the needle should have the appropriate size bore for obtaining an adequate amount of specimen, with larger needles giving better accuracy (Fig. 5). Aspiration needles are fine-gauge and are used to aspirate fluid or soft tissue lesions for

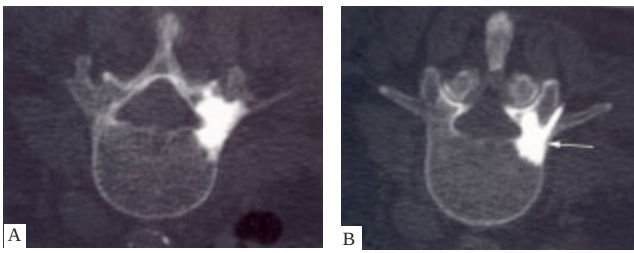


Fig. 1. A 67-year-old man with prostatic carcinoma and incidental finding of a solitary sclerotic vertebral lesion. (A) Axial CT scan taken with the patient lying prone shows a sclerotic focus in the right L4 pedicle that extends slightly into the adjacent vertebral body. (B) Axial CT fluoroscopic image taken with the patient lying prone shows the tip of the trephine biopsy needle (arrow) within the sclerotic lesion.

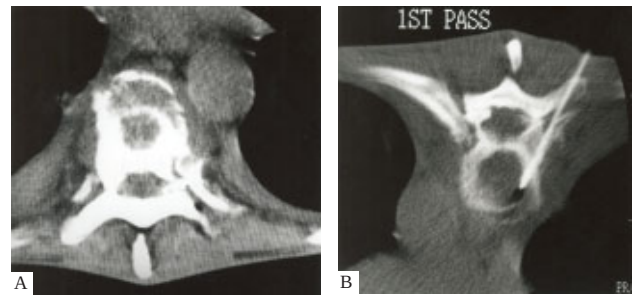


Fig. 4. A 59-year-old man with a destructive lesion involving the T9/10 disc and adjacent vertebra. (A) Axial CT scan shows osteolytic involvement of the upper T10 vertebral body, with a surrounding paravertebral soft tissue mass. (B) Axial CT fluoroscopic image taken with the patient lying prone shows passage of the trephine biopsy needle using the right costovertebral approach. The needle tip is optimally positioned to avoid the spinal canal, lung and thoracic great vessels.

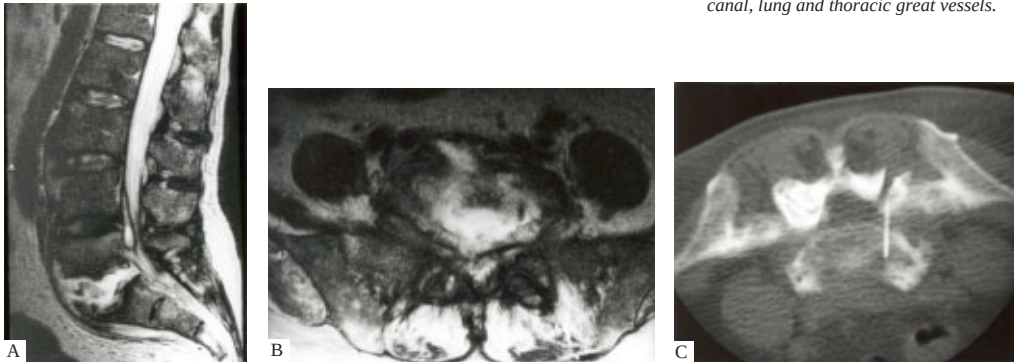


Fig. 2. A 73-year-old man with L5/S1 infective discitis due to *Staphylococcus aureus*. (A) Sagittal FSE T2-W MR image shows increased signal in the L5/S1 disc. (B) Axial FSE T2-W MR image shows increased signal in the L5/S1 disc with a small epidural component. (C) Axial CT fluoroscopic image taken with the patient lying prone shows passage of the trephine biopsy needle through the right L5 pedicle into the L5/S1 disc.

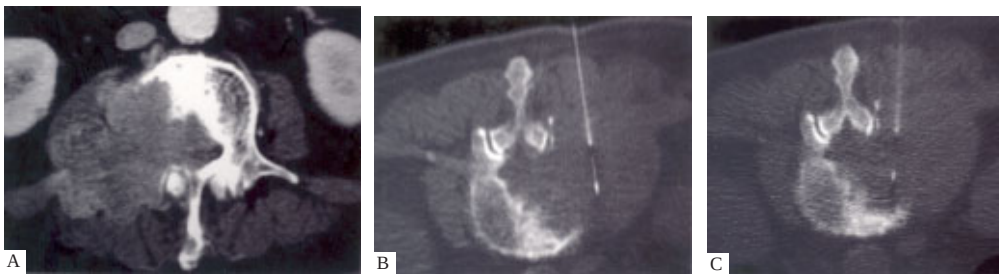


Fig. 3. A 79-year-old man with hepatocellular carcinoma. (A) Enhanced axial CT scan shows osteolytic destruction of the right L4 vertebral body and pedicle, with a heterogeneously-enhancing soft tissue mass that extends into the right psoas muscle. (B, C) Axial CT fluoroscopic images taken with the patient lying prone show different positions of the cutting biopsy needle in the medial and lateral aspects of the right paravertebral mass.

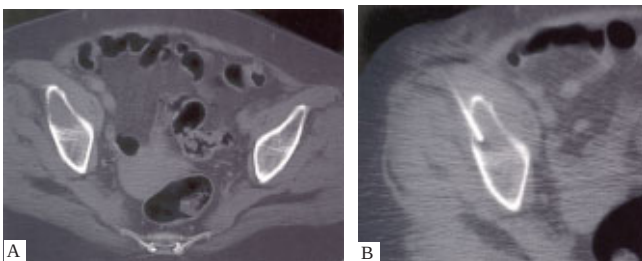


Fig. 5. A 73-year-old woman with right iliac metastasis. (A) Axial CT scan shows an osteolytic lesion with mild lateral cortical destruction and thinning of the medial cortex. (B) Biopsy was performed with the patient lying supine. Unlike the patients in Figures 1 to 4, where a 17G needle was used, a 13G trephine biopsy needle was employed for this relatively large lesion.

culture or cytology. Cutting needles may be used to obtain solid specimens, usually soft tissue. Both aspiration and cutting needles may also be used in lesions with overlying cortical destruction. Trephine needles have a serrated cutting tip and are usually used to obtain bone specimens for histopathology, particularly if the lesion is sclerotic. A coaxial technique may also be used.

An algorithmic approach for the selection of specific biopsy techniques is recommended. The use of a fine aspiration needle for small (<3 cm) soft tissue masses, a cutting needle for large (>3 cm) soft tissue masses and a trephine or bone-cutting needle for bone tumours has been shown to be safe and accurate.¹² In a study of CT-guided

biopsies of musculoskeletal lesions, Hau et al⁴ found that core biopsy is more accurate (74%) than fine needle aspiration (63%). The accuracy of the biopsy outcome is also dependent on the anatomical site and type of lesion. For example, pelvic biopsy has a higher accuracy rate (81%) compared to spine biopsy (61%). Biopsies of malignant primary and metastatic lesions have a higher accuracy rate (approximately 90%) compared to benign tumours (80%) and infection (50%).⁴

The needle should be placed into different parts of the lesion to facilitate proper sampling. Necrotic areas are avoided. The material obtained should be routinely sent for cytology, culture and histopathological examination. Blood clots may contain cells or organisms and should not be discarded.¹¹ Aspiration and core biopsy specimens have a complementary role.¹⁹ The radiologist should be familiar with smear preparation on glass slides and the types of containers to be used for culture and histopathological specimens. All these specimens should be despatched promptly to the appropriate processing laboratory under the care of a responsible person.

Post-biopsy care includes dressing the puncture site, advising the patient on the possibility of pain after local anesthesia is absorbed, and administering pain medication. The length of the post-biopsy observation period depends on whether sedation was given. The patient is sent home with pain medication, warned about possible complications and what to do if any do occur.

Complications

The incidence of complications depends on the type of needle used and on the anatomical location of the lesion. The reported incidence rates are 0% to 10%, with serious complication rates of <1%. These serious complications include excessive bleeding requiring blood transfusion, infection, neurological injury and pneumothorax. The risks for imaging-guided biopsy are acknowledged to be less than those associated with surgical open biopsy, as the risks associated with general anaesthesia are avoided.

The complications^{1,14-16,19-21} include:

- Bleeding requiring transfusion.
- Infection.
- Neurological injury with paresis or paralysis. For example, cord compression may rarely occur after biopsy of hypervascular lesions, such as metastatic renal cell carcinoma.
- Pneumothorax rates of 4% to 11% after thoracic spine biopsy have been reported.
- Fracture, particularly of weight-bearing bones.
- Tumour seeding along the needle track.
- Infection spread along the needle track, resulting in draining sinus.

Summary

Imaging-guided bone biopsy has a useful role in the diagnosis and management of patients with bone lesions. Most biopsies can be rapidly performed under local anaesthesia with little patient discomfort. Percutaneous bone biopsies are best performed by experienced musculoskeletal radiologists using CT or other appropriate forms of imaging guidance. Knowledge of the indications, contraindications, technique and possible complications are requisite for success.

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QUESTIONS

1. In performing imaging-guided biopsy of bone,
 - a) General anaesthesia is usually required.
 - b) Ultrasonography is a recognised imaging method for surface lesions.
 - c) MR imaging is the method of choice for guiding biopsy of large destructive tumours in long bones.
 - d) Biplane fluoroscopy is the ideal method for skull lesions.
2. Regarding imaging-guided biopsy of bone tumours,
 - a) It should ideally be performed in centres specialising in the treatment of bone tumours.
 - b) The radiologist should work closely with the pathologist.
 - c) Pertinent diagnostic imaging studies should be completed prior to biopsy.
 - d) Obtaining a single bone aspiration specimen usually suffices.
3. The following are indications for imaging-guided bone biopsy:
 - a) Known vascular malformation in the thoracic vertebra.
 - b) Exclusion of metastasis in a compressed vertebral body.
 - c) Evaluation for tumour recurrence.
 - d) Investigation of suspected osteomyelitis.
4. Regarding the bone biopsy needle,
 - a) The anticipated needle route can be planned during preliminary CT scanning.
 - b) The biopsy needle should ideally be directed towards the necrotic area of a tumour.
 - c) Infection spread along a needle track may result in a draining sinus.
 - d) Post-biopsy fracture risk can be decreased with the use of smaller needles.

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