Introduction

Prior to the development of image-guided percutaneous spine biopsy techniques, an open biopsy procedure was required for definitive diagnosis. The advantage of the open biopsy procedure is twofold. First, under direct visualization, multiple and larger tissue samples can be obtained and made available for frozen histopathological analysis. Second, the open biopsy can be performed as part of a surgical decompression and/or stabilization procedure of the spine. The first report of percutaneous spine biopsy was in 1935 by Robertson and Ball.\(^1\) Their procedures, however, did not utilize imaging guidance. Siffert and Arkin utilized a posterolateral approach for spine biopsy using radiographic guidance.\(^2\) Fluoroscopy-guided spine biopsy was subsequently reported in 1969, and CT-guided spine biopsy was reported in 1981.\(^3,4\)

Percutaneous spine biopsy has several advantages over an open biopsy procedure. The percutaneous image-guided procedure is faster and more cost-effective and has an overall lower risk of complications.\(^5\)

Image-guided spine biopsy procedures are usually performed to diagnose suspected primary or secondary neoplastic processes or to evaluate for the presence of infectious spondylitis.\(^6\) These procedures are less frequently performed to assess for other noninfectious inflammatory conditions that can affect the spine.

The decision to perform a spine biopsy procedure is made after close communication between the radiologist and the referring clinician. Both individuals must be convinced that the benefit to be gained from the biopsy results firmly outweighs the risks of the procedure. To this end, as a prerequisite, there must be a thorough medical history and a physical examination, combined with a complete review of all prior imaging and laboratory examinations. This consultation will avoid unnecessary spine biopsies (when they are not indicated or when a more accessible bone biopsy site, such as the iliac bone, is available),
ensure patient safety, and identify the optimal location and level for performing the biopsy procedure.

Spine biopsy is often performed to evaluate destructive or space-occupying lesions within the spinal axis (Table 5.1). Abnormal foci of marrow replacement within the vertebral column that are detected with noninvasive imaging modalities, such as Computed Tomography (CT) or Magnetic Resonance Imaging (MRI), also are often referred for spine biopsy. In every instance, the decision to proceed with a biopsy procedure is based upon a thorough analysis of risks and benefits. The overall benefit of the information gained by the procedure should always favor its performance. The results of the biopsy will affect the subsequent clinical management of the patient and influence treatment decisions in such areas as surgery, chemotherapy, radiation therapy, and antibiotic therapy.

The immediate contraindication to percutaneous biopsy is coagulopathy. Yet, even this condition, when properly anticipated and managed, can be corrected long enough to permit a surgeon to perform the procedure. When a vascular tumor such as a renal metastasis is suspected, a catheter angiogram should be considered in the diagnostic workup. These vascular lesions, however, can be carefully sampled with smaller gauge-core needle biopsy systems and with fine-needle aspiration techniques (Figure 5.1). Informed consent must be obtained prior to the procedure after the patient has received an explanation of the benefits and risks of image-guided percutaneous spine biopsy. The procedure offers the benefit of supplying diagnostic information that will guide subsequent treatment decisions. The alternative procedure is an open spine biopsy. The general risks of percutaneous spine biopsy include bleeding at or deep to the puncture site manifested as active hemorrhage or hematoma formation (Tables 5.2). Infection is another potential complication associated with spine biopsy, hence the requirement for strict aseptic technique when the procedure is performed. The spread of disease by the biopsy procedure, an extremely rare complication that has been described, is related to tumor implantation or spread of infection along the biopsy tract. The development of coaxial biopsy techniques and transcortical approaches with shorter needle

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**Table 5.1. Indications for spine biopsy**

1. Suspected secondary spine tumor (i.e., metastasis) with either a known or an unknown primary tumor
2. Suspected secondary spine tumor with a history of two or more preexisting primary tumors
3. Suspected primary spine or paraspinal tumor
4. Pathological compression fracture
5. Suspected infectious spondylitis
6. Suspected inflammatory condition that involves the spine

trajectories has decreased the incidence of these complications. Site-specific biopsy complications that have been reported are related to the spine level (cervical, thoracic, or lumbar spine) that was sampled and the proximity to critical structures. Pneumothorax can occur not only during thoracic spine biopsy, but also during the attempted biopsy of thoracolumbar or cervicothoracic lesions. Neural injury, particularly to the spinal cord, is a devastating complication that has been reported. Nevertheless, the incidence of reported complications

\textbf{Table 5.2. Complications associated with spine biopsy}

\begin{itemize}
  \item 1. Active hemorrhage
  \item 2. Hematoma
  \item 3. Vascular injury
  \item 4. Neural injury (spinal cord or nerve) resulting in transient or permanent paralysis
  \item 5. Pneumothorax
  \item 6. Infection, including meningitis
\end{itemize}

in percutaneous skeletal biopsy is low, estimated at less than 0.2%. The combination of image guidance, small-gauge biopsy needle systems, and operator experience should result in an overall major complication rate that is much less than 1%.

**Patient Preparation**

Percutaneous spine biopsy can be performed either on an inpatient or outpatient basis. The patient must not eat or drink for a minimum of 8 h prior to the procedure. The following laboratory parameters are assessed at the authors’ institution: hematocrit, hemoglobin, platelet count, Prothrombin Time (PT), Partial Thromboplastin Time (PTT), International Normalized Ratio (INR), Blood Urea Nitrogen (BUN), and creatinine. Patient allergies are recorded, with particular attention to anesthetic agents and imaging contrast agents. Prior to performing the biopsy procedure, the operator should carefully scrutinize all pertinent imaging studies. This will help identify the optimal lesion(s) for biopsy and the safest approach to access the lesion(s). Furthermore, this pre-procedure evaluation can assist in the selection of the appropriate needles and imaging modality.

Percutaneous spine biopsy can be performed with local anesthesia, with local anesthesia and conscious sedation, or under general anesthesia. The procedure is often performed with a combination of local anesthesia and intravenous conscious sedation using a short-acting benzodiazepine (Versed®, Hoffmann–La Roche, Nutley, NJ) and an analgesic such as fentanyl or morphine. While general endotracheal anesthesia often is not utilized owing to the requirement for prone positioning of the patient, general intravenous anesthesia can be performed with propofol. To minimize the possibility of infection, the study should be performed with strict aseptic technique.

Patient positioning depends upon the spine level (cervical, thoracic, or lumbosacral) of the lesion and its location (vertebral body versus posterior elements). The prone position is optimal for accessing lesions in the thoracic or lumbosacral spine or, rarely, within the posterior aspect of the cervical spine. The supine position is usually required to access the cervical spine. In certain instances – for example, when a patient cannot lie completely prone – the lateral decubitus or prone oblique position can be helpful (Figure 5.2). Patient monitoring is performed with the help of a pulse oximeter, continuous electrocardiography, and an automated blood pressure cuff. Appropriate placement of the monitoring equipment is required so that it does not obscure the field of view during the procedure and does not contaminate the sterile field. An intravenous catheter should also be in place prior to the procedure to facilitate the intravenous administration of medications, contrast agents, or hydration. The antecubital fossa should be avoided in situations that require prone positioning of the patient: the patient’s elbows are often flexed in this position, and the intravenous catheter function can be compromised.
Equipment Requirements

Image guidance can be accomplished with several different modalities. These include fluoroscopy, computed tomography, computed tomography combined with a multidirectional fluoroscope, computed tomographic fluoroscopy, and magnetic resonance imaging. The choice of equipment is determined by its availability, operator preference, and by the location and size of the suspected lesion. A CT-guided spine biopsy can be performed without or with the use of a stereotactic apparatus to guide the insertion of the biopsy needle. The use of MRI requires the simultaneous use of MR-compatible equipment, both for patient monitoring and for performing the biopsy procedure.

The modality selected depends upon its availability and the training and experience of the operator. The cross-sectional modalities afford the advantage not only of precise lesion localization, but also of “critical” structure (e.g., lung, aorta, and carotid artery) identification. In experienced hands, however, fluoroscopy-guided biopsies tend to be performed more quickly and with good patient safety. For cervical spine biopsy, CT, fluoroscopy, or CT with fluoroscopy facilitates the selection of an optimal biopsy trajectory that yields access to the...
lesion but avoids critical neck structures. Numerous factors influence the total procedure time, but the average time using local anesthesia is approximately 30 min. This assumes that the patient is cooperative and that the radiologist and the radiology technologist are experienced in biopsy procedures.

Several biopsy needle systems are commercially available (Table 5.3). The system that is utilized depends upon the lesion type (soft tissue or osseous), the lesion location (vertebra, disc space, and paraspinal soft tissues), and the method of specimen acquisition (aspiration biopsy versus core biopsy). Aspiration biopsy can be performed with a 22- or 20-gauge stylet-bearing needle. Core biopsy can be performed with a trephine or beveled tip (usually 11-, 12-, or 14-gauge) bone biopsy needle or a soft tissue-cutting needle (usually 18-gauge) (Figure 5.3). These core biopsy needles can be used as part of either a tandem needle system or a coaxial system. In the tandem technique, the needle that is used in the initial application of local anesthesia both localizes the lesion and serves as a visual guide. In a simultaneous tandem system, the biopsy needle is placed alongside a thin needle that was previously placed to anesthetize the biopsy tract. In a sequential tandem system, the biopsy needle is advanced along a tract previously created by the smaller anesthetizing needle.

Coaxial needle systems have increased in popularity. The biopsy needle is advanced over the anesthetizing and localizing needle (22-gauge). The localizing needle has a removable hub and serves as a mechanical guide for the biopsy needle. A guiding cannula, through which multiple biopsy needle passes can be made, is left in place. Coaxial biopsy needle systems are particularly helpful for cervical spine biopsies. The major advantages of the coaxial system, therefore, are a decreased procedure time, resulting from better accuracy, and decreased procedure complications. Only a single biopsy tract is used with the coaxial system, thus avoiding the risk of additional soft

<table>
<thead>
<tr>
<th>System</th>
<th>Manufacturer or city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration</td>
<td>Becton–Dickinson, Rutherford, NJ</td>
</tr>
<tr>
<td>3.5-6 in. 18- to 22-gauge spinal needles</td>
<td></td>
</tr>
<tr>
<td>10-20 cm 22-gauge Chiba needles</td>
<td>Cook Co., Bloomington, IN</td>
</tr>
<tr>
<td>Cutting</td>
<td></td>
</tr>
<tr>
<td>Tru-cut</td>
<td></td>
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<tr>
<td>Trephine</td>
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<td>Craig</td>
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<td>Ackermann</td>
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<td>Parallax</td>
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</tr>
</tbody>
</table>

tissue structure injury associated with a second pass. Additionally, the
guiding cannula can serve as a guide for fine-needle aspiration prior
to core biopsy, or for obtaining multiple core biopsy samples with a
soft tissue-cutting needle. An 18-gauge spring-loaded biopsy needle is
used to obtain soft tissue cores. Accessory guidance systems have been
developed to facilitate needle localization. These vary in complexity
and are infrequently used in routine practice.

Biopsy Techniques

An important decision that is made before and during spine biopsy is
the choice of approach. The determinants for the approach are lesion
location and lesion size (Table 5.4). A posterior approach is used
for thoracic, lumbosacral, and posterior cervical lesions. An anterior
approach is used for most cervical spine biopsies. The location of “criti-
cal” normal anatomical structures also will modify the approach. Unless
the lesion is clearly localized to the left side of the spine, for example, a
right-sided approach is preferable to a left-sided approach for accessing
thoracic spine tumors without damaging the aorta. In the cervical spine,
the critical structures include the great vessels of the neck, the pharynx
and hypopharynx, the trachea, the esophagus, the thyroid gland,
the lung apices, and the spinal cord. In the thoracic spine, the critical
structures are the lungs and the aorta. In the lumbar spine, the critical

Figure 5.3. An 18-gauge soft tissue-cutting needle (arrow) is used to obtain
a core of soft tissue from this large paraspinal mass that erodes the lat-
eral margin of the vertebral body. (Reprinted with the kind permission of
Springer Science+Business Media from Mathis JM ed. Image-Guided Spine
Table 5.4. Biopsy approaches

<table>
<thead>
<tr>
<th>Location</th>
<th>Approach</th>
<th>Spine level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone</td>
<td>Paraspinal oblique</td>
<td>Thoracic or lumbar</td>
</tr>
<tr>
<td></td>
<td>Transpedicular</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transcostovertebral</td>
<td>Thoracic</td>
</tr>
<tr>
<td></td>
<td>Posterolateral</td>
<td>Lumbar&gt; thoracic&gt;cervical</td>
</tr>
<tr>
<td></td>
<td>Anterolateral</td>
<td>Cervical</td>
</tr>
<tr>
<td>Disc</td>
<td>Paraspinal oblique</td>
<td>Thoracic or lumbar</td>
</tr>
<tr>
<td></td>
<td>Posterolateral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anterolateral</td>
<td>Cervical</td>
</tr>
<tr>
<td>Paraspinal</td>
<td>Paraspinal oblique</td>
<td></td>
</tr>
<tr>
<td>Soft tissues</td>
<td>Posterolateral</td>
<td>Thoracic or lumbar</td>
</tr>
<tr>
<td></td>
<td>Anterolateral</td>
<td>Cervical</td>
</tr>
</tbody>
</table>


Structures are the aorta, inferior vena cava, kidneys, large and small bowel, conus, and exiting spinal nerves. The objective is to choose a trajectory that enables access to the lesion without compromising normal, critical structures (Figure 5.4).

The specific location of the lesion within the spine also will influence the approach that is selected. A vertebral body lesion and a posterior element lesion (Figure 5.5) will be approached differently.

Figure 5.4. Axial CT image shows a localizing needle adjacent to the right pedicle (long arrow) of a lumbar vertebra. A transpedicular approach was chosen to access the most proximal (small arrow) of three sclerotic lesions in a patient with a history of breast cancer. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
Biopsy Techniques

Figure 5.5. Axial CT image shows an expansile lytic lesion within the right transverse process and posterior vertebral body of this thoracic vertebra. Fine-needle aspiration of the right transverse process (arrow) was therefore performed with a 22-gauge Chiba needle. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).

The type of posterior approach (posterolateral, transpedicular, or transcostovertebral) can be tailored to the specific location of the lesion (Figure 5.6). The posterolateral approach can be used to access lesions located within the vertebral body, disc, or paraspinal soft tissues of the lumbar spine (Figures 5.7 and 5.8). The transpedicular

Figure 5.6. Diagram of vertebra indicating the biopsy routes for the posterolateral, transpedicular, and transcostovertebral approaches. (Drawing modified with permission from Dr. Bernadette Stallmeyer; Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
Figure 5.7. Axial CT image obtained during a disc and vertebral endplate biopsy (arrow) shows a bone biopsy needle inserted via a left posterolateral approach. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).

Figure 5.8. Axial CT image shows a left parapedicular approach (arrow) used to sample this destructive vertebral body lesion. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
Biopsy Techniques

approach can be used to safely access lesions within the thoracic or lumbar vertebrae. A transcostovertebral approach can be used for thoracic disc space lesions, thoracic paraspinal soft tissue masses, or vertebral body lesions (Figure 5.9).

The selected imaging modality is used to identify the lesion level (Figure 5.10). Once a safe path to the target lesion has been chosen, the entry site on the skin surface is marked with an indelible ink marker. The region of interest is then prepped and draped in sterile fashion. A 1 cm wheal is raised at the skin entry site by using a 25-gauge needle and a local anesthetic agent (e.g., 1% lidocaine, 0.25% bupivacaine). A #11 scalpel blade is used to make a dermatotomy incision at the skin entry site. A stylet-bearing thin needle is then advanced by means of image guidance, and the local anesthetic is then administered into the deeper soft tissues. If a vertebra is to be entered, infiltration of the anesthetic agent into the periosteum is extremely helpful in minimizing patient discomfort. With coaxial technique, the position of the needle tip relative to the lesion is adjusted and confirmed by means of image guidance. When the needle tip is in satisfactory position, the needle hub is removed and the needle then essentially serves as a stiff guide wire. A guiding cannula is inserted over the hubless needle and advanced to the desired level under image guidance. Aspiration or core needles can be passed through this guiding cannula to obtain specimens.

The needle tip must always be accounted for with respect to the target lesion and to all pertinent critical structures (Figure 5.11). This rule

![Figure 5.9. Axial CT image shows a right transcostovertebral approach (arrow) used to sample this destructive vertebral body lesion (fungal osteomyelitis). (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).](image-url)
FIGURE 5.10. Steps in a CT-guided biopsy. (A) To use a right transpedicular approach (*long black arrow*), the skin entry site must be located near the second skin marker (*white arrow*). (B) The guide needle is advanced to the posterior margin of the pedicle (*arrow*).

applies especially to cutting needles; their biopsy chamber requires additional exposure and excursion within the lesion matrix to enable the cutting portion of the needle mechanism to slide over the biopsy
Figure 5.10. Continued. (C) The bone biopsy needle is advanced through the pedicle to sample the right-sided lytic lesion (arrow). (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).

Figure 5.11. Axial CT image obtained during a bone biopsy shows a guide needle that reaches the anterior vertebral body cortex (large arrow). Note the proximity of this needle to the aorta (arrowhead). The guide needle had been advanced far beyond the target lesion (small arrow). (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
chamber and retrieve the specimen. Moreover, specimen retrieval by means of fine-needle aspiration requires an in-and-out motion within the lesion matrix. Failure to completely account for the position of the needle tip may result in an unsuccessful biopsy and may also injure a critical structure. To access bone marrow or a lytic lesion with an aspiration or cutting needle, a pre-existing bone window must be present within the vertebral cortex, as occurs with a lytic focus, or a cortical window must first be cut with a bone needle. Neither aspiration nor cutting needles will penetrate normal or near normal bone cortex.

Cervical spine biopsy often requires an anterolateral approach. The neck can be separated into suprahyoid and infrahyoid compartments (Figure 5.12). The location of the carotid space contents within these compartments and the location of the spinal lesion will determine the skin entry site for the biopsy (Figure 5.13). Other important structures that are to be avoided include oropharynx, hypopharynx, and visceral space contents (esophagus, trachea, and thyroid gland). In approaching lower cervical spine lesions, care must be taken to avoid the pulmonary apex. In addition to being constantly aware of the location of the carotid artery and jugular vein, the operator must be cognizant of the location of the vertebral artery. When in doubt about the location or identity of a potentially important vascular structure, administer an intravenous contrast agent to clarify the situation.

The trajectory can be anterior or posterior to the carotid space, depending on the location of the great vessels. A 22-gauge needle can be used to go safely beside these structures with CT guidance. Alternatively, some operators prefer to use palpation and carotid displacement during the initial needle placement, to bypass the carotid artery. This maneuver is often performed with fluoroscopy-guided biopsy procedures. Once the needle tip has passed beyond the carotid space and is near the target, a coaxial technique can be used to safely obtain multiple biopsy specimens. A posterior approach is occasionally required for accessing posterior element lesions. Given the relatively small size of the posterior elements and the proximity to the spinal cord, it is advisable to utilize CT for safely approaching and sampling lesions in this location.

For thoracic or lumbar spine lesions, a transpedicular approach is optimal for accessing centrally located vertebral body lesions (Figure 5.14). The pedicle provides a safe passageway to the vertebral body. Special care must be taken to avoid fracturing the pedicular cortex. This complication can cause either direct injury to the spinal cord or exiting nerve root, or can indirectly injure these structures by leading to hematoma formation. The margins of the pedicle should be visualized at all times while the biopsy needle courses through the pedicle.

A potential pitfall of the transpedicular approach, which occurs when the pedicle is not involved by tumor, is the possibility of obtaining a false-negative biopsy result. The solution in such cases is to take deeper and multiple samples.

The transcostovertebral approach is useful in accessing laterally located thoracic vertebral lesions or in sampling the thoracic disc. The posterolateral approach is ideal for accessing laterally located vertebral
FIGURE 5.12. Location of the prevertebral and paravertebral spaces within the suprahyoid (A) and infrahyoid neck (B). Note the anterolateral position of the carotid space (arrows) relative to the prevertebral space. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
Figure 5.13. Steps in a CT-guided biopsy of the cervical spine. (A) Skin markers (a set of 4 taped 18-gauge 1 in. needles) are placed for an anterolateral approach with the patient in the supine position. The soft tissue window algorithm is used to identify the carotid artery (arrow) and internal jugular vein (arrowhead). (B) Coaxial technique is used to advance a needle with a removable hub, through a short 18-gauge needle, past the carotid artery (white arrow) and adjacent to the abnormal cervical vertebra (black arrow).
Biopsy Techniques

body lesions or their paraspinal soft tissue components or the intervening disc space within the lumbar spine. Two or preferably three core specimens are obtained and placed in 10% formalin. When bone biopsy cores are obtained, they must undergo a period (approximately 48 h) of decalcification in 7% formic acid, whereupon the specimens are embedded in paraffin for subsequent histological sectioning and staining. The reported diagnostic accuracy of core biopsy ranges from 77 to 97%.

If the clinical concern is infection, the specimens are placed in sterile containers and immediately brought to the microbiology laboratory for appropriate processing.

When aspiration biopsy is anticipated, it should be performed prior to obtaining any core specimens, since the core biopsy can create a hemorrhagic tract that prevents successful aspiration of the desired abnormal tissue. Otherwise, a different tract to the lesion must be utilized. Successful aspiration biopsy requires a secure fit between the aspirating syringe and the needle hub to facilitate forceful suction. Full negative pressure is generated by using a 20-mL syringe while the needle is being advanced and retracted within the lesion. The distance of the needle excursions depends upon the lesion size; large lesions permit safer, longer excursions, and short excursions are required for small lesions adjacent to critical structures (Figure 5.15). Needle excursions extending...
Figure 5.14. Steps in a CT-guided biopsy of the thoracic spine. (A) The patient is in the prone position and skin markers (arrow) are placed to determine the optimal skin entry site. (B) A 1.5 in. 22-gauge needle is used to administer local anesthetic along the biopsy tract to the periosteal surface (arrow).
Figure 5.14. Continued. (C) The sequential tandem technique is used to replace the 22-gauge needle with a 12-gauge bone needle, which is gradually advanced through the pedicle (arrow) and into the vertebral body under imaging guidance. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).

Figure 5.15. Axial CT image shows a large right paraspinal mass (arrows) that erodes into the lumbar vertebra. The size of this mass permits long excursions of the biopsy needle during fine-needle aspiration. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
more than 3–4 mm are required to obtain a specimen. Slight adjustments in angulation, when possible, are made with each needle pass to increase the yield of pathological tissue.

A flash of hemorrhagic fluid within the needle hub usually signals the end point of aspiration. In the ideal situation, the needle and syringe are withdrawn from the spinal lesion, and this ensemble is immediately handed to a cytotechnologist, who prepares slide smears of the specimen. The technologist or a pathologist looks at the slides under a microscope and determines whether abnormal cells are present within the specimen. Alternatively, the biopsy specimen can be placed in 95% ethanol before being sent for cytological analysis. The published accuracy of aspiration biopsy is series dependent and ranges from 23 to 97%.

When infection is the working clinical diagnosis, the aspirates are not placed in ethanol but instead are submitted in sterile containers to the microbiology laboratory. If fluid cannot be aspirated, a few milliliters of sterile, nonbacteriostatic normal saline can be injected through the biopsy needle and reaspirated for subsequent microbiological analysis. Aspirates obtained following core biopsies also can be sent for microbiological analysis: there is always bleeding at the core biopsy site, so that blood can be aspirated and placed in a sterile container.

Alternatively, the aspiration biopsy can be performed prior to the core biopsy procedure. These two techniques have been shown to be complementary and to increase the diagnostic accuracy of the percutaneous biopsy procedure. The histological features of cell structure and microarchitecture may provide a specific cytological diagnosis. A positive fine-needle aspirate can obviate a more aggressive biopsy procedure, thereby reducing the likelihood of a procedure-related complication (Figure 5.16). Furthermore, the core biopsy also can be used to produce a touch preparation for immediate cytological analysis.

These procedures in combination can minimize the possibility of obtaining a specimen that is too small for analysis. A spine biopsy procedure may be discontinued when a positive aspirate is identified by the cytopathologist, or when a set of three fine-needle aspirations and three bone and/or soft tissue cores has been obtained. Other factors, such as small lesion size, limited lesion access, or the occurrence of a complication may require discontinuation of the biopsy procedure at the discretion of the operator.

Specific instances do occur in which percutaneous biopsy may be unsuccessful, yielding either no specimen or one that proves to be nondiagnostic. The bony elements of the vertebrae consist of round, hard surfaces. Securing purchase on their normal hard cortex can be difficult when the target lesion lies deep into normal bone. Sclerotic or osteoblastic lesions can be quite difficult to sample (Figure 5.17). At the other end of the lesion spectrum are heterogeneous lesions that are predominantly either cystic or necrotic. Despite multiple attempts, it may not be possible to harvest a satisfactory specimen from these lesions.

Lesions with variable histology from one area to another, such as cartilaginous tumors, also can cause a diagnostic dilemma. Fortunately, these diagnostic challenges are infrequent. More often, one is unable to retain a specimen within the bone biopsy needle chamber after successful entry into the substance of an osseous lesion. Several maneuvers
can be attempted to obtain a specimen. Slight, gentle rocking of the needle may allow separation of the specimen from the parent bone. If the lesion is large enough and there is a margin of safety, then advancing the biopsy needle slightly may enable retention of the bone core.

**Figure 5.16.** Intraspinal biopsy. Fine-needle aspiration technique was used to sample (A) a cystic astrocytoma (arrow) of the spinal cord and (B) a solid astrocytoma drop metastasis within the lumbar spinal canal (arrow). (Reprinted with the kind permission of Springer Science + Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
Chapter 5 Image-Guided Percutaneous Spine Biopsy

Figure 5.17. (A) Axial CT image obtained during a cervical spine biopsy of a sclerotic vertebral body lesion (arrow) shows a guide needle in place. (B) The bone needle deflected across the hard surface of this sclerotic lesion and was advanced into the opposite side of the vertebral body. The needle tip is located just medial to the foramen transversarium (arrow) and anterior to the right neural foramen. The patient did not experience any adverse sequelae despite this suboptimal needle placement. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
within the chamber of the biopsy needle. Applying suction to the biopsy needle with a 20-mL syringe may also facilitate a successful biopsy. Some single-pass bone biopsy needles come with an inner cannula that is partially truncated near its tip to trap the bone core within the parent needle chamber. Alternatively, if the sample size remains unsatisfactory for diagnostic purposes, a larger gauge needle system such as the Craig system can be used to obtain a specimen (Figure 5.18).

Other reasons for a nondiagnostic result include biopsies that are limited either by small lesion size or because too few passes were made with the biopsy needle. Hypervascular lesions can be difficult to sample, since the brisk bleeding that can potentially occur with the initial access to the lesion can terminate the procedure. The intraosseous blood that is often aspirated during bone biopsy is sometimes erroneously discarded. This osseous blood should be considered to be a biopsy specimen and should be submitted for pathological analysis, since it is possible to diagnose malignancy from this tissue. Occasionally, a discrepancy in accounting for vertebral levels between different modalities causes the wrong vertebral levels to be sampled. Many spine lesions are identified on MRI, yet the percutaneous biopsy procedure is performed either with fluoroscopy or with CT. In certain situations, lesion conspicuity may be so much decreased with the latter modalities that optimal sampling is compromised. With respect to infectious spondylitis, the common reason for a nondiagnostic biopsy

Figure 5.18. Axial CT image demonstrates a Craig bone biopsy needle with its tip located in the substance of a lytic endplate lesion (arrow). Smaller gauge needles were unable to provide satisfactory amounts of tissue. (Reprinted with the kind permission of Springer Science+Business Media from Mathis JM ed. Image-Guided Spine Interventions. New York: Springer Science+Business Media, 2004).
result is that patients are already being treated with antibiotics at the time of the procedure. Other reasons for a nondiagnostic biopsy result in spine infection include a failure to perform the correct microbiological testing (such as not performing an acid-fast bacillus stain or culture), dismissing as contaminants unusual microbes that may in fact be the causative agents, improper specimen handling or transport (e.g., not using anaerobic culture media when these organisms are suspected), or failing to follow specific cultures (e.g., *Mycobacterium tuberculosis*) for an extended period of observation.

To optimize the success of the biopsy procedure, the radiologist must communicate his or her clinical concerns to either the pathologist or the microbiologist. In the case of a suspected neoplasm, the clinical information and the radiological differential diagnosis should be communicated to the interpreting pathologist. The more useful the data shared with the pathologist and/or the microbiologist, the greater the likelihood of arriving at the correct diagnosis. This is the equivalent of a radiologist’s request for the appropriate clinical history from the referring clinician whenever imaging studies are to be performed or interpreted. For instance, if a patient is undergoing a biopsy to test for possible metastatic breast cancer, it is helpful to inform the pathologist that the woman had a mastectomy last year at the same institution. Similarly, it is important to inform the microbiologist whether the patient is already on intravenous antibiotics or that a specific organism, such as *Mycobacterium tuberculosis*, is causing concern.

**Soft Tissue Biopsy**

Percutaneous image-guided biopsy techniques are also utilized to approach and diagnose spinal and paraspinal soft tissue abnormalities. Whether aspirating a collection or obtaining tissue from a neoplasm, image guidance provides a high margin of safety and diagnostic efficacy. CT guidance is typically used to target soft tissue lesions that would be occult under fluoroscopy. CT has been shown to have a diagnostic yield of about 80% and an accuracy of over 95% for bony lesions, and 70% and 93%, respectively for soft tissue lesions. The pre-procedural evaluation and regimen are the same as for vertebral or other deep bone biopsy; pre-procedure clinical assessment and laboratory studies are obtained in the interest of safety.

The paraspinal space is large in scope and dimension, and each region poses its unique set of challenges to the approach. Coaxial techniques should be utilized when possible; reports of tract seeding from TB, sarcomas, and other etiologies have been well documented. The use of coaxial needle systems and core biopsies along with CT guidance has been shown to be safe, effective, and useful. The location of the pathology and the adjacent vital structures will dictate the trajectory of the needle or device that can be used. Innovation is often required, but patient safety should remain paramount. The cervical anatomy is particularly complex and may require a contrast-enhanced CT for planning in order to identify the major vascular structures (Figure 5.19).
FIGURE 5.19. Fifty-year-old woman with dysphagia. Carcinoid tumor. Axial CT image (A) demonstrates a well-defined prevertebral mass (arrow) deep to the trachea and between the carotid sheath and esophagus. CT-guidance allows for a direct anterior approach (B) that avoids the carotid, trachea, and esophagus.
100 Chapter 5 Image-Guided Percutaneous Spine Biopsy

Figure 5.20. Sacroiliac osteomyelitis and abscess. Posterior approach. Sixty-year-old man presenting with increasing pain 1 month after a fall that resulted in sacral fractures. Axial T1-weighted image following gadolinium administration (A) demonstrates enhancement within the left sacral ala and iliac bone consistent with osteomyelitis. A low signal pelvic fluid collection anterior to the left SI sacroiliac joint represents abscess surrounded by a thick, enhancing wall (arrow). Axial CT image (B) demonstrates CT-guided posterior transarticular approach to abscess through the SI joint. Drainage of the collection resulted in immediate improvement of symptoms. The patient was pain free at 6 month follow-up. Methacrylate sacroplasty was not required.
In the thoracic region, care must be taken to avoid a pneumothorax. In the lower thoracic and upper lumbar regions, a posterior oblique approach should take into consideration and avoid the kidneys; this is even more important when performing a fluoroscopically-guided biopsy.

The vast number of cases reported in the literature and the comprehensive vertebral review of vertebral biopsy techniques provided in this chapter preclude a consideration of all of the potential approaches to soft tissue lesions; however, some unique approaches and techniques are presented (Figures 5.20 and 5.21).

**Postoperative Care**

Immediately following the procedure, a sterile dressing is placed over the skin entry site(s). The patient is observed in recovery for 2–4 h, depending on the type of anesthesia that was used. Monitoring of the patient, including vital signs, is continued during the recovery period.

The puncture site is periodically observed for signs of active bleeding or for expanding hematoma. Strict bed rest is maintained throughout the recovery period. When the patient is judged to be stable, either by the radiologist who performed the procedure or by the anesthesiologist who sedated the patient, he or she is discharged from the recovery area: an outpatient goes home, an inpatient to a hospital room.

An instruction sheet with attention to wound care and observation should be given to all outpatients. All patients should be informed that the test results might not be available for several days owing to specimen processing requirements. More importantly, patients also should be made aware of the small, but real, possibility that the test results may be nondiagnostic, whereupon a repeat percutaneous biopsy or an open biopsy may be required. Adequate follow-up on all biopsy procedures is essential, and the final results should be communicated to the referring clinician(s).

**Conclusion**

Image-guided percutaneous spine biopsy is a procedure that can be performed safely and efficiently by radiologists. The procedure is performed to determine accurately the composition of abnormal tissue. The information obtained from the biopsy procedure can be used to guide patient management. The radiologist is part of a team that includes the patient, the referring clinician, and a pathologist. Optimal communication among the team members will increase the likelihood of a successful procedural outcome.
Figure 5.21. Presacral abscess. Sagittal (A) and axial (B) enhanced T1-weighted MR images demonstrate a large, loculated presacral pelvic abscess. Axial images (C, D, and E) acquired during CT-guided approach utilizing a curved needle to gain access to the loculated collection. Frontal (F) and lateral (G) radiographs demonstrate the trajectory of the curved needle.
Figure 5.21. Continued.
Figure 5.21. Continued.
References

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