Cervical Spine Biopsy

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Learning Objectives

1. To understand the value and importance of radiologic anatomy as it pertains to cervical spine biopsy
2. To review the indications and contraindications for cervical spine biopsy
3. To learn image-guided coaxial cervical spine biopsy approaches and techniques

4.1 Introduction

Of all the percutaneous image-guided biopsy procedures that can be performed along the spinal axis, cervical spine biopsy remains the most challenging of these procedures. Indeed, many operators are reluctant to perform cervical spine procedures due to the perceived risk of the procedure in an area where the anatomy may present barriers to safe lesion access. The relatively small size of the cervical vertebrae pedicles limits the traditional "shielded" transpedicular pathway to the vertebral body for tissue sampling. The critical vascular structures of the neck, the carotid and vertebral arteries and the internal and external jugular veins, surround the anterior and lateral aspects of the cervical spine. These vascular structures, at initial inspection, may appear to prevent direct access to a vertebrae or intervertebral disk. Close proximity to other critical structures such as the lung apices, trachea, esophagus, thyroid gland and submandibular glands raises appropriate concerns for injury to these structures. The aerodigestive tract and adjacent glandular structures may also limit the access to the target lesion(s) within the cervical spine. The prominent cervical spinal cord and exiting nerve roots may also discourage attempts at sampling nearby lesions. Some operators are more comfortable with single access bone biopsy needles which make repeat passes in the neck somewhat precarious. Other operators have tried to improve their targeting using tandem needle techniques in which the biopsy needle is passed alongside a previously placed smaller gauge guide needle, but this requires a minimum of two needle passes in an area that contains numerous critical structures and, therefore, is a rarely utilized technique in the cervical spine. Cervical spine biopsy is an infrequently performed procedure when compared to thoracic or lumbar spine biopsy, hence many operators lack experience with the tools and techniques that are required to make cervical spine biopsy an effective, efficient and low risk procedure. In a single institution experience 22 cervical spine biopsies out of 703 total spine biopsies (3.1%) were performed over a period of 18 years whereas at another institution 9 out of 410 (2.2%) spine biopsies performed to assess for neoplasm, over an 8-year period, were performed in the cervical spine (Rimondi et al. 2011; Lis et al. 2004) . When a procedure is performed infrequently, the comfort level with performing it decreases. The objective of this chapter is to introduce the reader

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to the approaches and techniques that will assist them in the performance of percutaneous image-guided cervical spine biopsy.

4.2 Anatomic Considerations

While the cervical spine consists of seven cervical vertebrae and the intervening intervertebral disks, the overall smaller size of these structures compared to the remainder of the spinal axis is associated with a relatively lower incidence of suspicious lesions in this location. The neck is bordered superiorly by the skull base and foramen magnum. Inferiorly, the neck is separated from the thoracic cavity by the thoracic inlet, including the lung apices, brachial plexus and brachiocephalic vasculature. From a biopsy perspective, with respect to approach, the neck can be divided into anterior and posterior compartments. Anterior compartment lesions will involve either the cervical vertebral bodies, intervertebral disks or the adjacent paraspinal soft tissues. Posterior compartment lesions will involve the articular masses or facet joints, the posterior elements (pedicle, laminae or spinous processes) or the adjacent paraspinal soft tissues within the perivertebral space – paraspinal component. The anterior compartment can be further subdivided into suprahyoid and infrahyoid compartments. The pertinent suprahyoid compartments include the masticator space, parapharyngeal space, perivertebral space – prevertebral component, submandibular space, retropharyngeal space and carotid space. The oropharynx and hypopharynx are located within the suprahyoid neck and are quite prominent; a breach of these structures could contaminate the spine and biopsy specimen with adverse consequences in either situation. The carotid space contains the carotid artery and the internal jugular vein, and these critical vascular structures determine the choice of approaches when considering an anterior compartment biopsy procedure (Fig. 4.1). The vertebral arteries, likewise critical vascular structures, influence the types of approaches that can be used to access the posterior compartment (Fig. 4.1). The proximity of visceral and carotid space in the infrahyoid neck will constrain the types of approaches that can be used to access the anterior cervical spine.

> The carotid space is the key anatomic landmark for determining the majority of anterior-lateral or posterior-lateral approaches for image-guided percutaneous cervical spine biopsy.

Essentially, all needle passes within the anterior compartment will be made either anterior or posterior to the carotid space (Fig. 4.2). For fluoroscopy-guided procedures, the carotid space is a palpable structure – in other words, the operator can palpate the carotid pulse and use a manual displacement technique to move the carotid space out of the way prior to needle insertion. For computed tomography (CT) – guided procedures, the carotid space is readily identified, even on non-contrast CT studies of the neck. The primary objective is to determine a trajectory towards a lesion that avoids puncturing the carotid artery or jugular vein.

The posterior compartment of the neck includes the posterior cervical space. This includes the posterior neck muscles and the posterior elements of the cervical vertebrae. The critical anatomic structures to be aware of when attempting to biopsy lesions in this compartment are the vertebral arteries and the spinal cord. The vertebral arteries are particularly exposed in the upper cervical spine near the craniocervical junction; hence a detailed knowledge of the size and course of these vessels is mandatory when considering upper cervical spine biopsy (Fig. 4.1). The presence of a dominant vertebral artery or a hypoplastic or absent vertebral artery should be noted on the initial diagnostic studies as this will help to prevent a potential major complication. Given the small size and thickness of the posterior elements it is

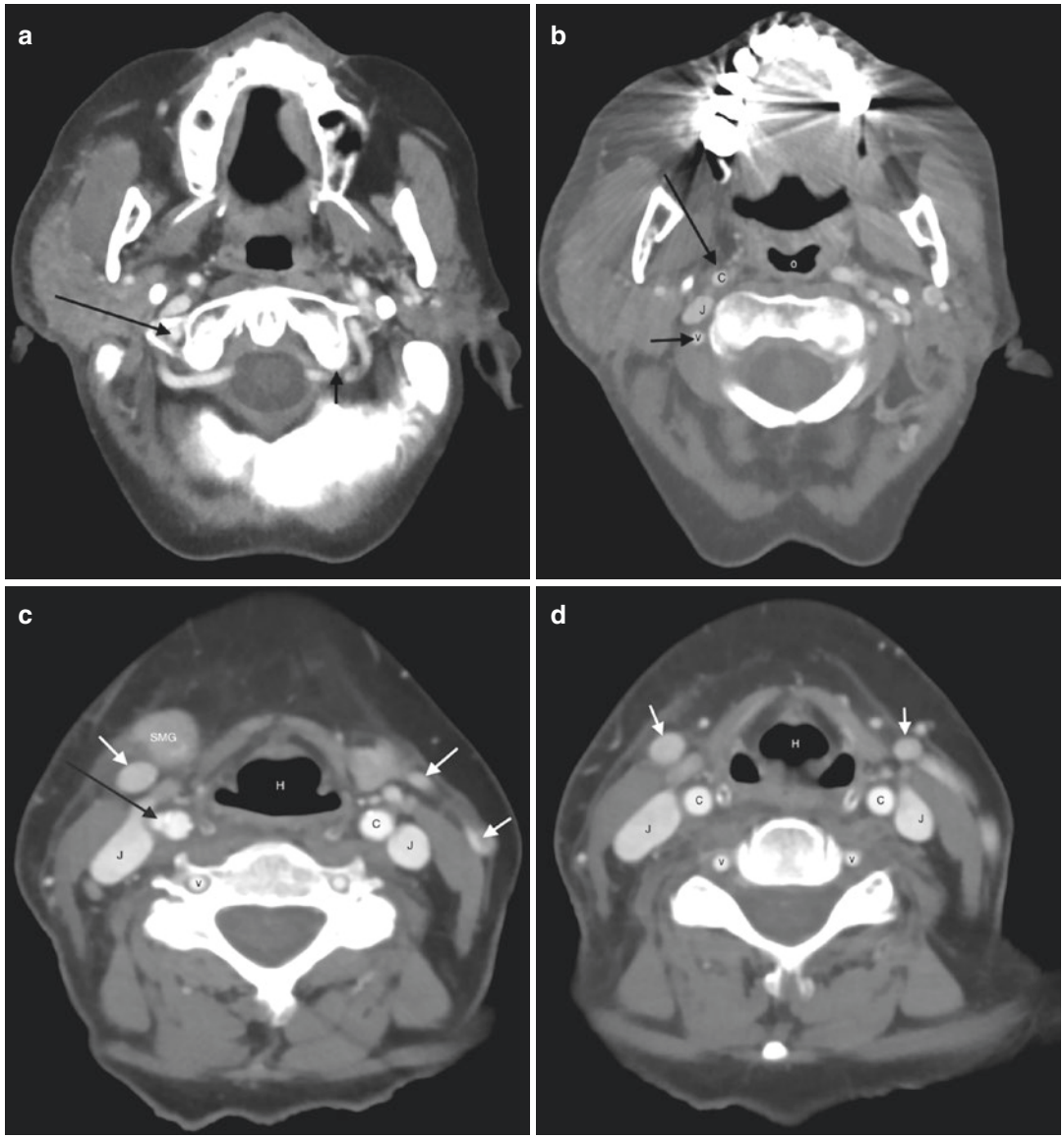


Fig. 4.1 Axial contrast-enhanced CT image (**a**) at C1 level shows course of vertebral arteries as they emerge from the C1 transverse foramen (*large arrow*) to course posterior to the lateral mass (*small arrow*), along a groove on the superior surface of the C1 neural arch, and then enter the spinal canal. Axial contrast-enhanced CT image (**b**) at C2 level shows enhancing vascular structures adjacent to lateral aspect of C2 (internal carotid artery (*c*; *large arrow*), internal jugular vein (*J*) and vertebral artery (*V*; *small arrow*)). If this were a biopsy case, this vascular anatomy effectively forms a barrier to biopsy needle access from these directions. The oropharynx (*O*) forms the anterior relation of the C2 vertebral body. Axial contrast-enhanced image (**c**) at C5 level shows external jugular vein branches (*small arrows*), internal jugular vein (*J*), carotid artery bifurcation on the right (*large arrow*) and common carotid artery (*c*). The vertebral artery (*V*) is located within the foramen transversarium. The submandibular gland (SMG) is seen anteriorly while the hypopharynx (*H*) forms the anterior relation at this level. Axial contrast-enhanced image (**d**) at the C5–6 disk space level shows external jugular vein branches (*small arrows*), internal jugular veins (*J*), common carotid arteries (*C*) and vertebral arteries (*v*). The hypopharynx (*H*) forms the anterior relation at this level

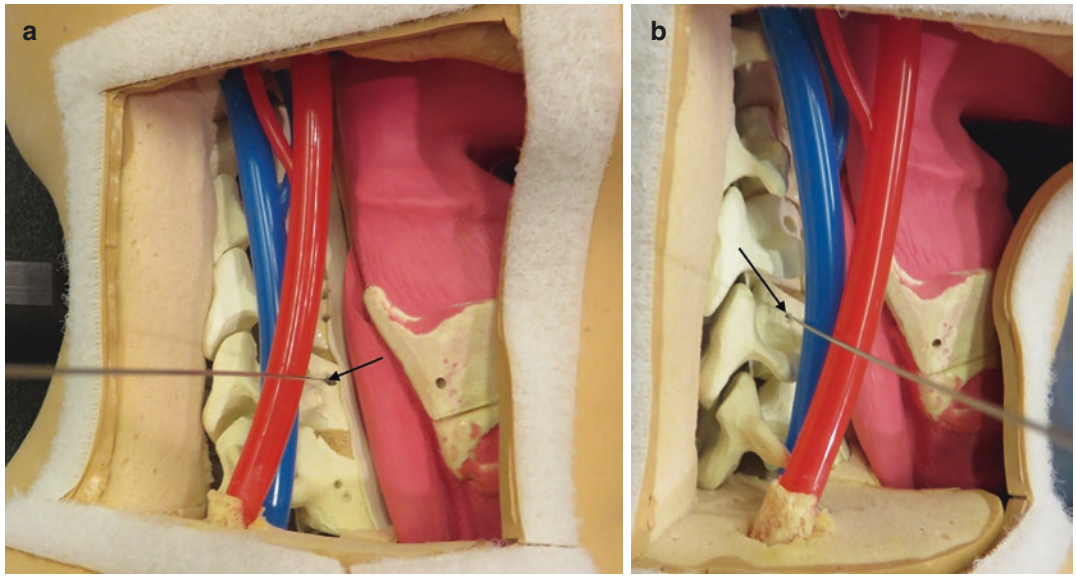


Fig. 4.2 Photographs of neck model showing a spinal needle inserted into a cervical vertebral body (**a**) anterior (*arrow*) and (**b**) posterior (*arrow*) to the carotid space

important to be aware of the location of the spinal cord and exiting nerve roots relative to the lesion.

> A constant awareness and vigilance of the important neck compartments and critical anatomic structures is required before, during and even after the cervical spine biopsy procedure.

This is an important principle that must be adhered to when performing image-guided percutaneous spine biopsies (Ortiz et al. 2010). A detailed review of pertinent imaging studies, such as magnetic resonance imaging (MRI) studies of the cervical spine or positron emission tomography (PET) – CT examinations, is therefore mandatory prior to considering and planning a biopsy procedure. The prior study or studies should be readily available for immediate consultation during the biopsy procedure.

4.3 Indications

Image-guided percutaneous cervical spine biopsy is performed to obtain tissue samples from the cervical vertebrae (including the vertebral bodies, articular masses and posterior elements) intervertebral disks and surrounding paraspinal soft tissues. The two most common indications for performing percutaneous image-guided cervical spine biopsy include the evaluation of a neoplastic process or the assessment for possible spine infection (Table 4.1). Secondary or primary neoplastic lesions of the spine may be considered for biopsy when their histopathologic identification impacts the subsequent management of the patient. Secondary neoplastic lesions of the cervical spine include metastases, myeloma, lymphoma and leukemia; these may occur in patients with a known primary malignancy, or be the first presentation of an unknown primary tumor. Alternatively, a patient may be afflicted with two or more neoplastic conditions, and further characterization

Table 4.1 Indications for image-guided percutaneous cervical spine biopsy

1. Secondary neoplastic involvement
Metastasis
Known primary neoplasm
Two or more known primary neoplasms
Unknown primary neoplasm
Extension from systemic neoplasm (myeloma, lymphoma, leukemia)
2. Primary neoplastic involvement
3. Spine infection
4. Spine infection mimics
Inflammatory spondyloarthropathy (chronic hemodialysis, gout)
5. Other
Pathologic vertebral compression fracture
Langerhans Cell Histiocytosis
Evaluate recurrence of neoplasm after surgical, medical and/or radiation treatment
Distinguishing radiation change from neoplasm

of a cervical spine mass will determine which of these processes is responsible. Primary spine tumors, though rare, do occur and may require a biopsy in order to optimize the subsequent management. Now that tailored immune-modulating therapies are available and that an analysis of cellular genomics is readily feasible, biopsies for tissue acquisition and detailed characterization are critical for both treatment planning and prognosis. A pathologic cervical vertebral compression fracture may also require a biopsy.

It must be emphasized that when a neoplastic process is identified within the cervical spine, the remainder of the spinal axis and body should be evaluated for the possible presence of a more readily accessible lesion for biopsy sampling (Fig. 4.3)

In patients in whom there is an infectious or inflammatory process that involves the cervical disk space and adjacent vertebral endplate(s) a biopsy may be necessary in order to confirm the diagnosis and guide subsequent therapeutic interventions.

4.4 Contraindications

The major contraindication to performing percutaneous image-guided cervical spine biopsy is uncorrected coagulopathy (Table 4.2). Given the increased modern day use of anticoagulants and anti-platelet agents, it is imperative that the operator be aware of whether or not a patient is being treated with one or more of these medications (Refer to Chap. 2). A discussion with the referring clinician and patient is often required in order to determine the necessary steps in either holding or reversing the effects of these medications in order to perform the biopsy procedure. The focus of the conversation should include a risk-benefit analysis in order to ascertain the absolute need for the cervical spine biopsy procedure. The rationale for the both the cervical spine biopsy procedure and the temporary management of the coagulation status should be documented by the operator. In specific situations the patient may need to be admitted for in-hospital management of their coagulation status prior to performance of the biopsy. It must be kept in mind that the majority of these cervical spine biopsy procedures are elective or semi-urgent procedures that by default provide sufficient opportunity for adequate evaluation and communication in order to maximize the chances for a safe and effective procedure. If patient, custodial agent or administrative consent cannot be obtained then the procedure should not be performed.

The other contraindications to image-guided percutaneous cervical spine biopsy are relative, that is, the procedure can be performed provided that the specific management steps are taken. For example, pre-procedure

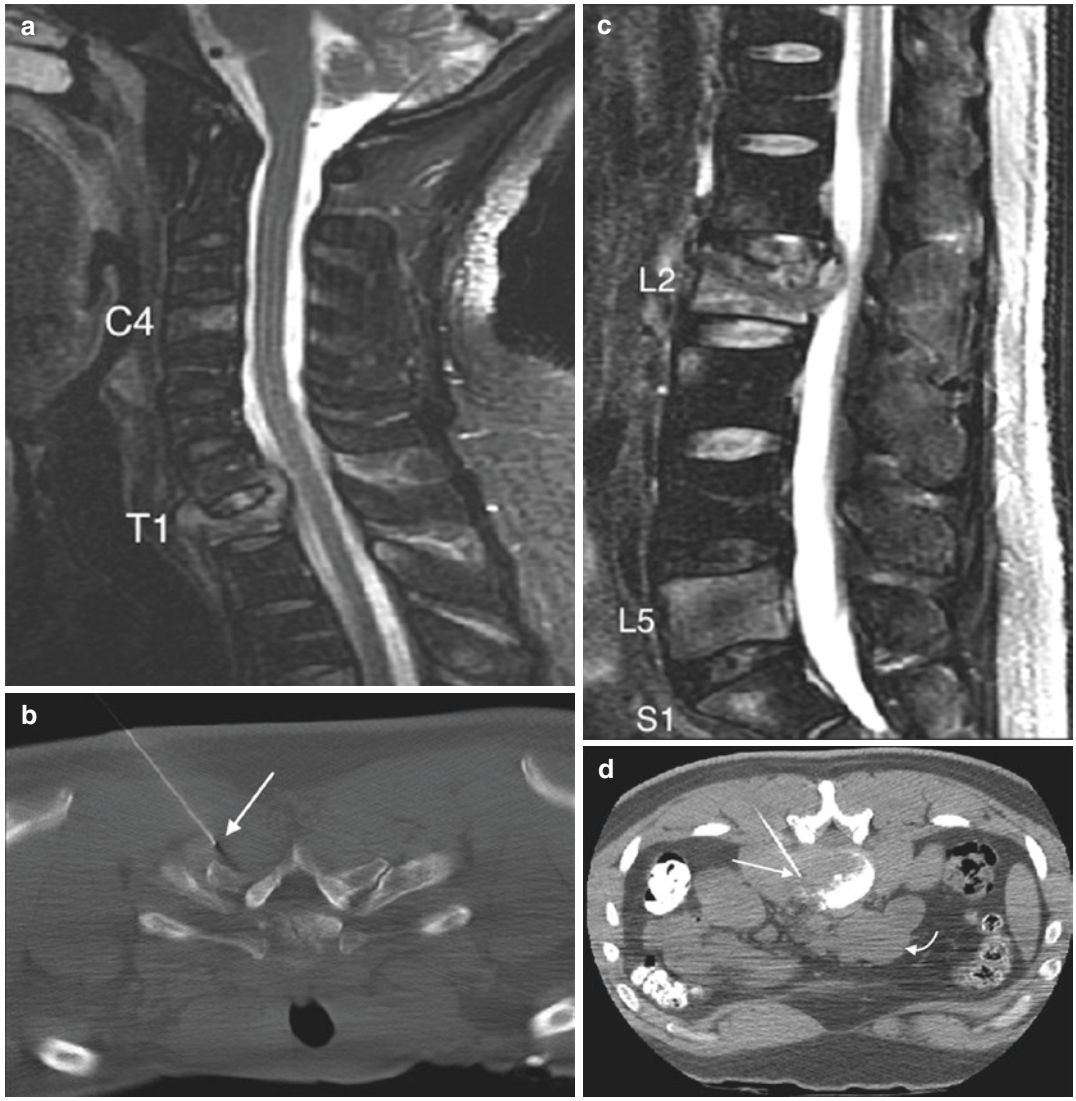


Fig. 4.3 30 year-old male with multiple spine lesions. Fat-suppressedT2 sagittal MR image of cervical spine (**a**) shows a C4 and T1 vertebral body lesions. The operator attempted to biopsy T1 via a posterior approach (*arrow*) without success (**b**). STIR sagittal MRI image of lumbar spine (**c**) shows L2 and L5 and S1 lesions. CT-guided biopsy (**d**) of the L2 lesion via a posterior approach (*arrow*) confirmed the presence of lymphoma; note the extensive retroperitoneal adenopathy (*curved arrow*)

Table 4.2 Contraindications to image-guided percutaneous cervical spine biopsy

Absolute
Uncorrected coagulopathy
Unable to obtain consent for the procedure
Relative
Uncooperative patient
Unstable patient
Suspected vascular lesion
Small (<5 mm diameter) lesion located adjacent to critical structure

catheter angiography with our without embolization may be required prior to performing a biopsy of a suspected vascular tumor such as a renal or thyroid metastasis, aneurysmal bone cyst, or aggressive hemangioma. Alternatively, a very small (<5 mm diameter) if not tiny lesion may just not be amenable to tissue sampling, especially if it is located in close proximity to the spinal cord or a vascular structure.

4.5 Risks and Complications Associated with Cervical Spine Biopsy and How to Minimize Them

The risks and complications that occur as a result of image-guided percutaneous cervical spine biopsy are uncommon and can be kept to a minimum (Wu et al. 2014). Complications that occur as a result of cervical spine biopsy include hemorrhage. As previously stated, this risk can be reduced by temporarily correcting a pre-existing coagulopathy. Identifying critical vascular structures when planning an approach to the lesion and determining an optimal trajectory will also reduce the likelihood of a hemorrhagic complication. Use of coaxial biopsy needle technology, with one needle pass and placement of a guiding cannula through the biopsy trajectory, also reduces the chances of hemorrhage. The occasional, but necessary use of intravenous contrast enhancement with CT guidance may identify subtle vascular structures that can subsequently be avoided. Pre- and peri-procedure management of suspected vascular lesions will also help to reduce the possibility of hematoma formation. Some vascular lesions may require an embolization procedure (pre-procedure endovascular embolization or post-procedure biopsy tract embolization with a small amount of surgifoam), while others can be safely sampled with fine needle aspiration techniques. Adequate blood pressure management and control during and after the biopsy procedure will also help to reduce the likelihood of hemorrhage (Fig. 4.4). There is no substitute for appropriate hand compression techniques following removal of the biopsy needle system at the puncture site, as this will help to stop bleeding at the puncture site. A few minutes (2–5 min) of manual compression will help to stabilize the biopsy tract. Bleeding into one of the neck spaces can lead to hematoma formation and possible airway compromise. Therefore, it is important to monitor the patient during and after the procedure (Fig. 4.4). Patients with hematoma formation can be imaged with CT in order to assess for stability of the hematoma and the airway.

Other procedural risks are related to needle puncture and include vascular injury, spinal cord puncture and, with lower cervical spine biopsy, lung perforation with pneumothorax formation. Fortunately with careful planning and meticulous technique, injury to these critical structures can usually be prevented. Spine infection is a potential complication of any biopsy procedure. This applies to situations where the cervical

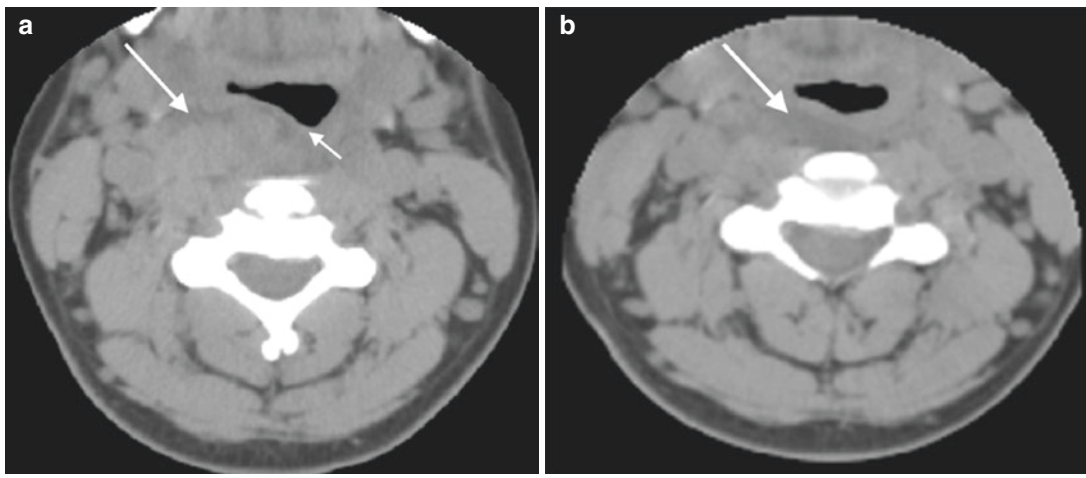


Fig. 4.4 48F for fluoroscopy guided disk aspiration at C4–5 (**a**). The patient's blood pressure increased significantly during the procedure (240/120 mmHg) and she complained of difficulty swallowing. Axial CT image (**a**) shows acute soft swelling with hematoma formation (*large arrow*) and mass effect on oropharnyx (*small arrow*). This responded to conservative management including blood pressure control. A follow-up limited CT (**b**) at 1 week shows partial resolution of the swelling and residual retropharyngeal fluid (*arrow*)

spine biopsy is being performed to evaluate for non-infectious conditions, such as neoplastic lesions of the cervical spine. The use of strict aseptic technique including shaving and hair removal at the biopsy puncture site will help to reduce the chance of infection. The use of coaxial technique, by reducing the number of times that the skin is breached, will also help to reduce the inadvertent introduction of cutaneous microbes into the deep tissues of the cervical spine. The routine use of pre-procedure intravenous antibiotic prophylaxis for the performance of cervical spine biopsy is not required unless there is a specific clinical concern that might warrant their use such as a patient that is immunocompromised. Seeding of tumor along a biopsy tract is an extremely rare complication of biopsy procedures and theoretically is even less likely to occur with coaxial biopsy techniques (Saghieh et al. 2010).

The types of complications that can occur or have been reported with cervical spine biopsy are listed in Table 4.3. It must be kept in mind that these are potential complications, many of which can be avoided if careful steps are taken to minimize the chances of their occurrence. The overall incidence of complications that can occur with skeletal biopsy is less than 0.2% (Murphy et al. 1981). The overall complication rate for percutaneous spine biopsy ranges from less than 1% to 3% (Tehranzadeh et al. 2007). A review of the literature shows that the overall incidence of complications that can occur with image-guided percutaneous cervical spine biopsy is rare (Brugieres et al. 1992; Kattapuram and Rosenthal 1987; Rimondi et al. 2008; Wu et al. 2014). The other important risk that can occur with cervical spine biopsy procedures is the possibility of a "non-diagnostic" biopsy. In this situation, tissue is obtained from the sampled lesion; nevertheless the histopathologic analysis is not able to arrive at a conclusive diagnosis. This potential outcome should always be discussed with the patient at the time of the informed consent process in order to clarify expectations and to make them aware that another biopsy procedure, percutaneous or open, might be required.

Table 4.3 Cervical spine biopsy procedure risks and complications

Hemorrhage
Superficial – at puncture site
Deep – potential hematoma formation – airway compromise
Needle injury
Artery or vein puncture
Spinal cord puncture
Cervical nerve root puncture
Lung puncture – pneumothorax
Glandular injury: thyroid gland, parathyroid gland, submandibular gland, parotid gland
Aerodigestive tract perforation
Other
Non-diagnostic biopsy
Wrong level or wrong side biopsied
Infection (cellulitis, infectious spondylitis)
Tumor seeding along the biopsy tract
Transient paresis of lower extremities
Transient recurrent laryngeal nerve palsy
Systemic – anesthesia complication, contrast agent reaction
Increased pain
Radiation exposure
Death
Equipment failure – broken needle

4.6 Imaging Guidance

While there are a few sporadic case reports of image-guided percutaneous spine biopsy performed with ultrasound or magnetic resonance imaging guidance the principal imaging modalities that are used for cervical spine biopsy include CT and fluoroscopy (Ortiz et al. 2010). Each of these modalities possesses advantages and disadvantages. Both modalities allow for ease of access to the cervical spine, variable patient positioning and ready access to the patient for continuous monitoring and management, and the ability to use any number of tools or instruments for the biopsy procedure. CT provides good axial spatial resolution and a thorough view of all anatomic and critical structures within the cervical spine as well as localizing the target lesion. The major vascular structures within the neck can usually

be visualized on unenhanced axial images and intravenous contrast agents are not routinely required. The axial CT images can be compared to the pre-biopsy studies in order to plan the optimal approach and trajectory for the biopsy procedure. The precise location of the biopsy needle tip relative to the lesion and adjacent critical structures can readily be monitored with CT. CT-guided cervical spine biopsies were first performed with conventional stepwise advancement of needles with intermittent acquisitions of a small number of images through the area of interest between needle advancements or repositioning (Brugieres et al. 1992; Kattapuram and Rosenthal 1987). This technique facilitated procedure safety, but was associated with a longer procedure time. CT fluoroscopy improves the efficiency of the procedure by keeping the operator in the procedure room and allowing for immediate image acquisition through the area of interest. CT does have limited longitudinal or Z-axis visualization, which can be a challenge if the patient moves during the procedure or if needle angulation is required. These challenges are partially mitigated by using CT fluoroscopy with the trade-off being a slight increase in radiation dose. Nevertheless, the use of CT fluoroscopy increases the efficiency and safety of the procedure as it combines the real time benefits of fluoroscopy with the axial resolution of CT (Wu et al. 2014).

Fluoroscopy can be used to perform anterior cervical spine biopsy. The advantages of this modality include real time, instantaneous feedback on needle trajectory and depth of the needle tip. The operator's hands, however, are often within the fluoroscopy field during the procedure and this increases radiation exposure to the operator. The absence of soft tissue contrast limits the anatomic detail and subtle or small lesions may not be visualized with fluoroscopy. Fluoroscopic guidance is helpful in performing intervertebral disk biopsies using an anterolateral approach with manual displacement of the carotid space by the operator (the operator uses his/her hand to pull the carotid out of the way) and efficient prompt insertion of the biopsy needle into the abnormal disk.

4.7 Approaches

The objective of any biopsy is to obtain as much tissue as possible to improve the chances of obtaining an accurate diagnosis and to perform this safely without injuring critical structures. The choice of a percutaneous approach to a lesion is paramount to determining the optimal biopsy needle trajectory or trajectories (Table 4.4) (Gupta et al. 2007). The approach for cervical spine biopsy is determined by several factors (Ortiz et al. 2010). First, the location of the lesion – is it within the anterior compartment or the posterior compartment? Second, the level of the lesion – is the lesion at the level of the suprahyoid neck or the infrahyoid neck? Is the lesion located within the upper cervical spine at C1 or C2 or is it located in the mid to lower cervical spine (C3-C7) (Sun et al. 2009)?

Table 4.4 Approaches used to perform cervical spine biopsy

Lesion	Level	Location	Approach
Osseous	C1	Lateral mass	Posterior or lateral
		Posterior arch	Posterior or lateral
Osseous	C2	Dens/body	Infra-maxillary, transoral, transpedicular
		Posterior arch	Posterior or lateral
Osseous	C3 – C7	Vertebral body	Anterolateral
		Facet joint	Posterior or lateral
		Posterior arch	Posterior or lateral
		Spinous process	Posterior or lateral
Intervertebral disk			Anterolateral
Prevertebral soft tissues			Anterolateral
Paraspinal soft tissues			Posterior or lateral

Third, what is the specific anatomic location of the lesion – vertebral body, intervertebral disk, articular mass or facet joint, laminae, spinous process or paravertebral soft tissues? Lesion size will also influence the approach. In general, when sampling a lesion it is desirable to have the needle pass through the greatest diameter of the lesion. This allows for both more sampling and for a margin of safety in that the needle stays within the lesion and does not extend beyond into a possible critical structure. Larger lesions provide a large diameter for sampling whereas smaller lesions may have limited areas for needle excursion thereby resulting in fewer and/or smaller samples. Larger lesions, especially those that involve the paraspinal soft tissues, may displace critical structures out of the path of the intended needle trajectory. Of equal importance is the identification of all critical structures, from skin surface to spinal cord, along all possible trajectories to the lesion. These factors will not only contribute towards determining the approach to lesion, but will also influence the patient's position within the operative field. In addition to supine and prone patient positions for standard anterior and posterior approaches, respectively, it may be necessary to place a patient in oblique or decubitus positions to facilitate access to specific lesions or cause slight displacement of critical structures such that the intended trajectory becomes more feasible.

4.8 The Cervical Spine Biopsy Procedure

4.8.1 General Considerations

4.8.1.1 Patient Factors

Cervical spine biopsy procedures can be performed on inpatients or outpatients and should only be performed on cooperative patients. Therefore, whenever and as much as possible it is important to evaluate and examine the patient. This objective can be accomplished at the time of the informed consent process. This consultation serves several purposes as it allows the operator to assess the patient's mental status and to establish a doctor – patient relationship with the patient and the patient's family and healthcare proxies. It also enables the operator to examine the neck for any possible wounds, scars, tattoos and hair, to assess the patient's ability to flex, extend or rotate the head and neck, to assess shoulder mobility and to determine ahead of time, which positions the patient can or cannot tolerate. These factors along with the intended approach will influence the patient position. The patient should be as comfortable as possible just before and throughout the procedure as this will improve their ability to cooperate during the biopsy procedure. An informed and comfortable patient will tend to be a cooperative and less anxious patient. The upfront opportunity to clarify expectations with the patient and the patient's representatives cannot be understated. Patients should also be informed that the other diagnostic alternative to a percutaneous biopsy procedure is an open biopsy procedure. Open biopsy procedures are performed in the operating room under general anesthesia, require a somewhat longer recovery period and carry the risks (bleeding, infection, tissue damage) associated with open surgical procedures (Mankin et al. 1996).

In addition to obtaining a thorough medical and surgical history, the operator should also be aware of the patient's medications, especially antiplatelet and anticoagulant medications, any concurrent antibiotic therapy and any herbal or vitamin supplements. Patient allergies should be documented and recent laboratory parameters for hematologic status (serum hematocrit, hemoglobin, platelet count), coagulation status (serum Prothrombin Time, Partial Thromboplastin Time, International Normalized Ratio), and renal function (serum Blood Urea Nitrogen, Creatinine, Glomerular Filtration Rate) should be available. In those patients with a suspected spine infection, consideration ought to be given to obtaining a white blood cell count with differential, an erythrocyte sedimentation rate and a C-reactive protein. Patients should be instructed to not eat or drink, in other words, remain in NPO status after midnight on the day of the procedure.

4.8.1.2 Staff Factors

It is helpful to discuss the procedure ahead of time with the procedural staff, including the radi-

ology technologist, nurse(s), anesthesiologist (if consulted), pathologist and/or microbiologist. These communications maximize the chances for a smoother, more successful procedure. They facilitate specimen collection, handling and analysis. For example, if a fine needle aspiration procedure is performed, then a cytopathologist or cytotechnologist may be present on site to evaluate the tissue samples and determine if there is adequate diagnostic tissue.

4.8.1.3 Anesthesia

The choice of anesthesia is influenced by the type of biopsy, the patient's preference, the patient's medical condition, the patient's position and the operator's discretion. If an anesthesiologist is assisting in the case, then they will help to decide the preferred method of anesthesia. The options for anesthesia range from the use of local anesthetics, to intravenous sedation and analgesia to the use of intravenous anesthesia. It is strongly advised to avoid the antecubital fossa for securing intravenous access as the arms are often flexed during the procedure, impeding the efficacy of intravenous medications.

4.8.1.4 Patient Preparation

The patient is placed on the procedure table in the desired position and monitoring equipment (pulse oximeter, electrocardiogram and blood pressure monitor) is placed on the patient. Cervical spine biopsy is performed with strict aseptic technique. The skin should be shaved in order to remove hair from the sterile field. It is important to discuss the need for hair removal at the craniocervical junction ahead of time with patients. Once the patient is positioned, the skin is shaved and the patient is on the procedure table, then a time-out protocol is exercised in order to confirm patient, procedure, site and side.

4.8.2 Technique

4.8.2.1 CT Guidance

Scout images are obtained in both the frontal and lateral projections with a radiopaque skin grid in place covering the side and area of the intended approach (Fig. 4.5). The intended skin puncture site is marked with a skin marker. The skin is then prepped with a sterile solution and draped. In patient's that are receiving intravenous sedation/analgesia or anesthesia, this can be initiated at this time or just after the time out process. The skin is anesthetized with a local anesthetic agent (such as 1 or 2% lidocaine or 0.25% bupivacaine) using a 25 gauge needle. A small cross hair incision is made at the skin insertion site using a #11 scalpel blade.

Cervical spine biopsies were first performed with tandem needle techniques; a biopsy needle was maneuvered alongside and parallel to an initially placed small gauge (20 gauge) spinal needle, but these entailed a minimum of 2 skin punctures (Kattapuram and Rosenthal 1987). Coaxial needle technique is well suited for performing cervical spine biopsy (Geremia et al. 1992; Wu et al. 2014;). With a coaxial needle technique, a 15 cm long, 20 gauge guide needle with a removable hub is slowly advanced under CT fluoroscopic guidance towards the target lesion, carefully avoiding critical structures. When the needle tip approaches the margin of the lesion or an osseous surface, additional local anesthetic (approximately 1 mL volume) can be administered in order to minimize patient discomfort. Once the optimal trajectory and needle position are established with imaging guidance and the periosteal or lesion surface have been anesthetized, then the needle hub is removed (Fig. 4.5). The needle then serves as a guidewire or guidepin for subsequent coaxial insertion of a guiding cannula. The guiding cannula provides a safe access port to the target lesion, reducing if not obviating the requirement for repeat needle passes in the vicinity of critical structures (Figs. 4.6 and 4.7). For bone biopsy, a removable blunt dissector is inserted into the guiding cannula; this facilitates safe passage of the guiding cannula through the deep soft tissues over the hub-less guide needle. For any type of soft tissue biopsy (disk or paraspinal) a guiding cannula and blunt dissector can be advanced over the guide needle or, alternatively, a soft guide needle can be advanced using its own stylet (Fig. 4.8). In the anterior neck, the platysma can present as a stubborn barrier to advancement of the blunt dissec-

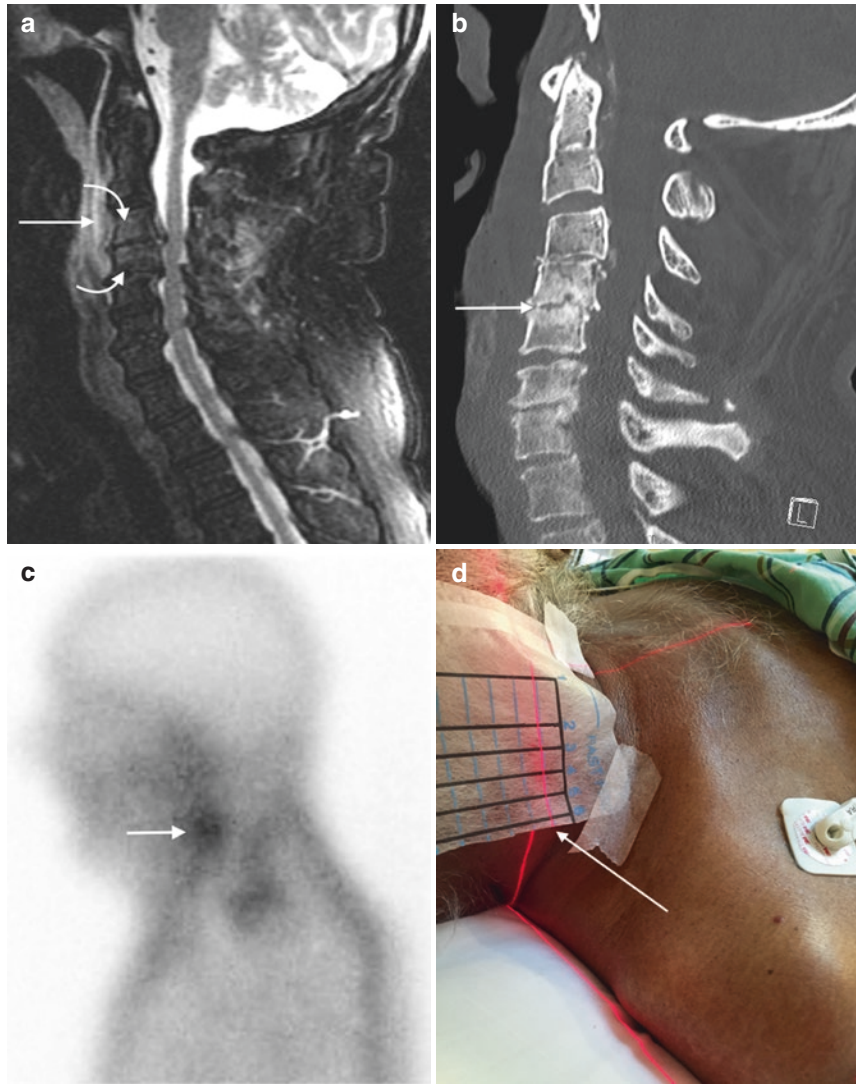
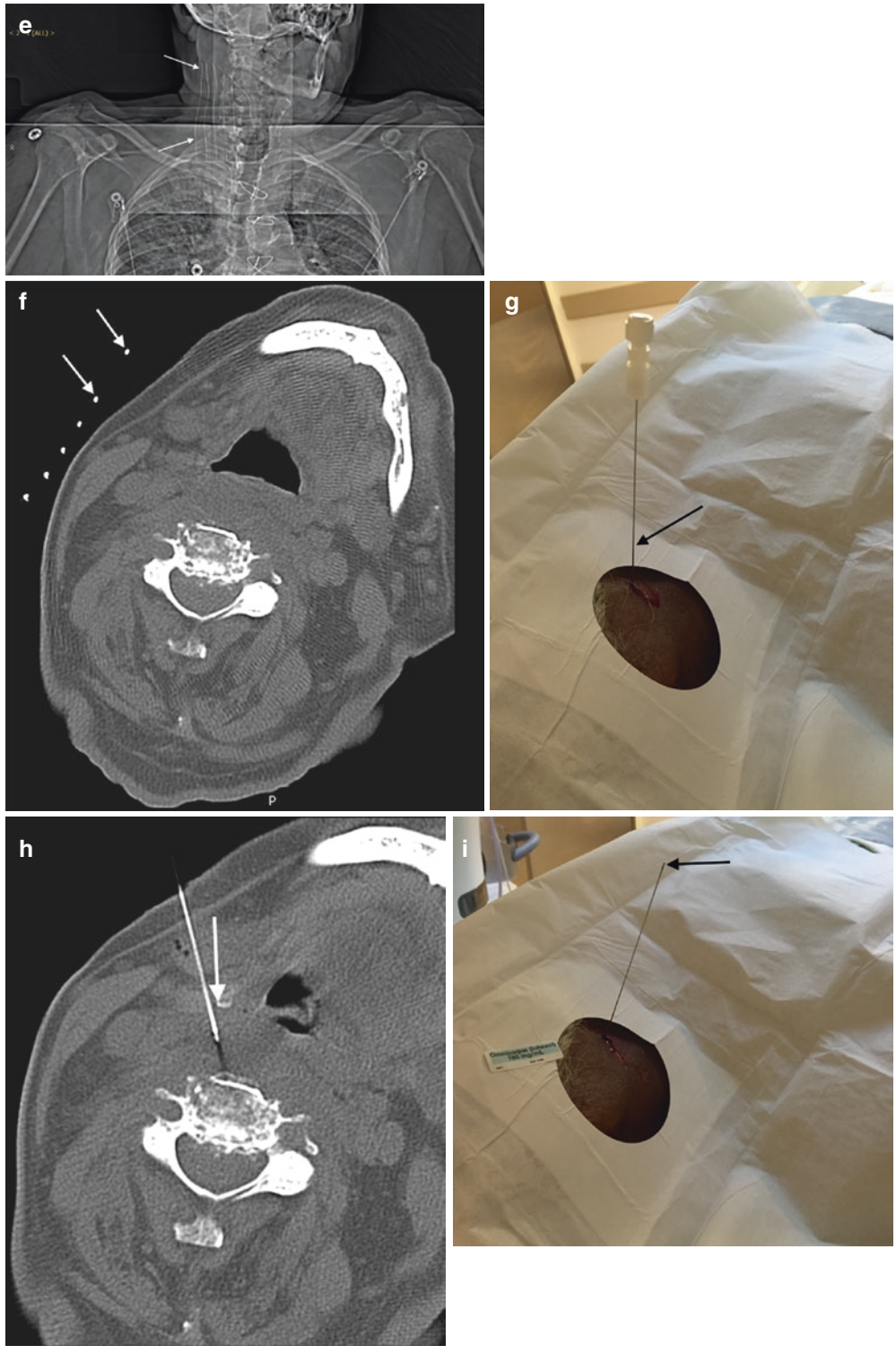


Fig. 4.5 83 M with neck pain. Fat suppressed T2 sagittal MR image (**a**) shows a small prevertebral fluid collection (*arrow*) with subtle increased signal within the adjacent vertebral bodies at C3 and C4 (*curved arrows*). A sagittal reconstructed CT image (**b**) shows multi-level disk space height loss with endplate irregularity (*arrow*) at C4–5. Lateral static image from a gallium scan (**c**) shows intense uptake within the cervical spine (*arrow*). An erythrocyte sedimentation level and C reactive protein level were noted to be elevated and the patient was referred for an image-guided biopsy. A grid line sheet (*arrow*) was placed on the right side of the patient's neck (**d**). A CT scout frontal radiograph (**e**) shows the radiopaque lines (*arrows*) which aid in marking the skin entry site with an indelible ink marker pen. An axial CT image in bone algorithm (**f**) shows the grid points (*arrows*) relative to the C4–5 disk space. The skin was then prepped and draped with strict aseptic technique, the skin anesthetized with 0.5 mL 2% lidocaine, and a 20 gauge guide needle (*arrow*) was advanced into the skin (**g**) and passed along the lateral margin of the thyroid ala (*arrow*) as shown on the axial image (**h**). Photograph of guide needle (**i**) after removal of the hub (*arrow*). An 18 gauge spinal needle (*large arrow*) was subsequently passed over what is now essentially a firm guidewire (*medium arrow*) in order to adequately penetrate the platysma (*small arrow*) as shown on the axial image (**j**). Axial CT (K) shows advancement of the spinal needle over the hub-less guide needle to the anterior aspect of the C4–5 disk (*arrow*). The 18 gauge spinal needle is removed, but the 22 gauge hub-less guide needle (guidewire) is kept in place in order to maintain safe access for subsequent placement of the blunt dissector. Axial CT image (**l**) shows advancement of the blunt dissector over the guide needle (*arrow*). The blunt dissector was removed and then inserted into the guide cannula such that this coaxial system was subsequently advanced over the guide needle to the anterior aspect of the C4–5 disk (*arrow*) as shown in the axial CT image (**m**). The blunt dissector was exchanged for a trephine bone biopsy needle (*arrow*) which was advanced through the guide cannula and into the disk and endplate as shown on the axial CT image (**n**). The microbiology specimens were positive for enterococcus species and the pathology specimens showed inflammatory changes consistent with osteomyelitis



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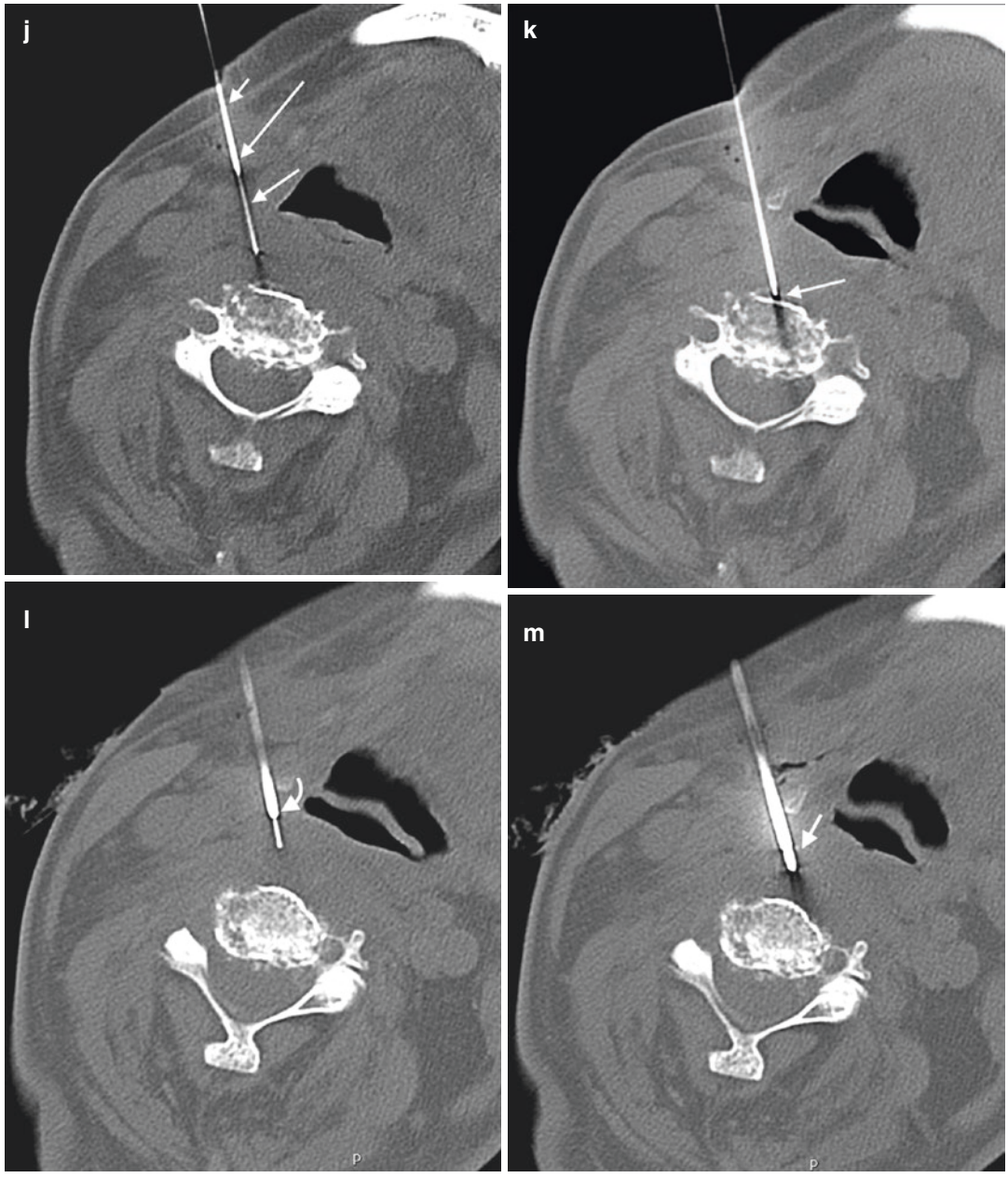

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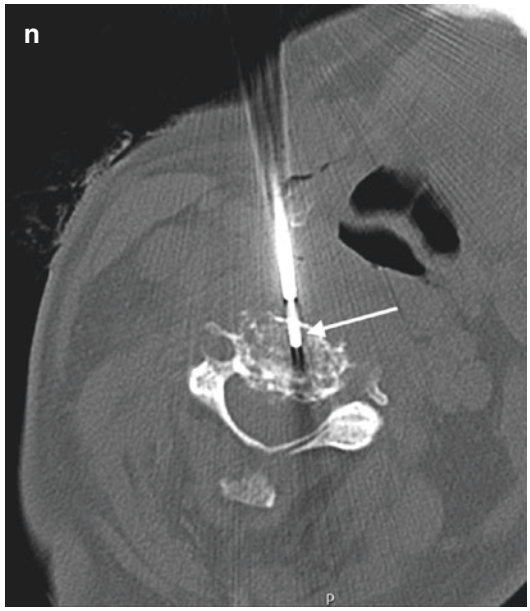


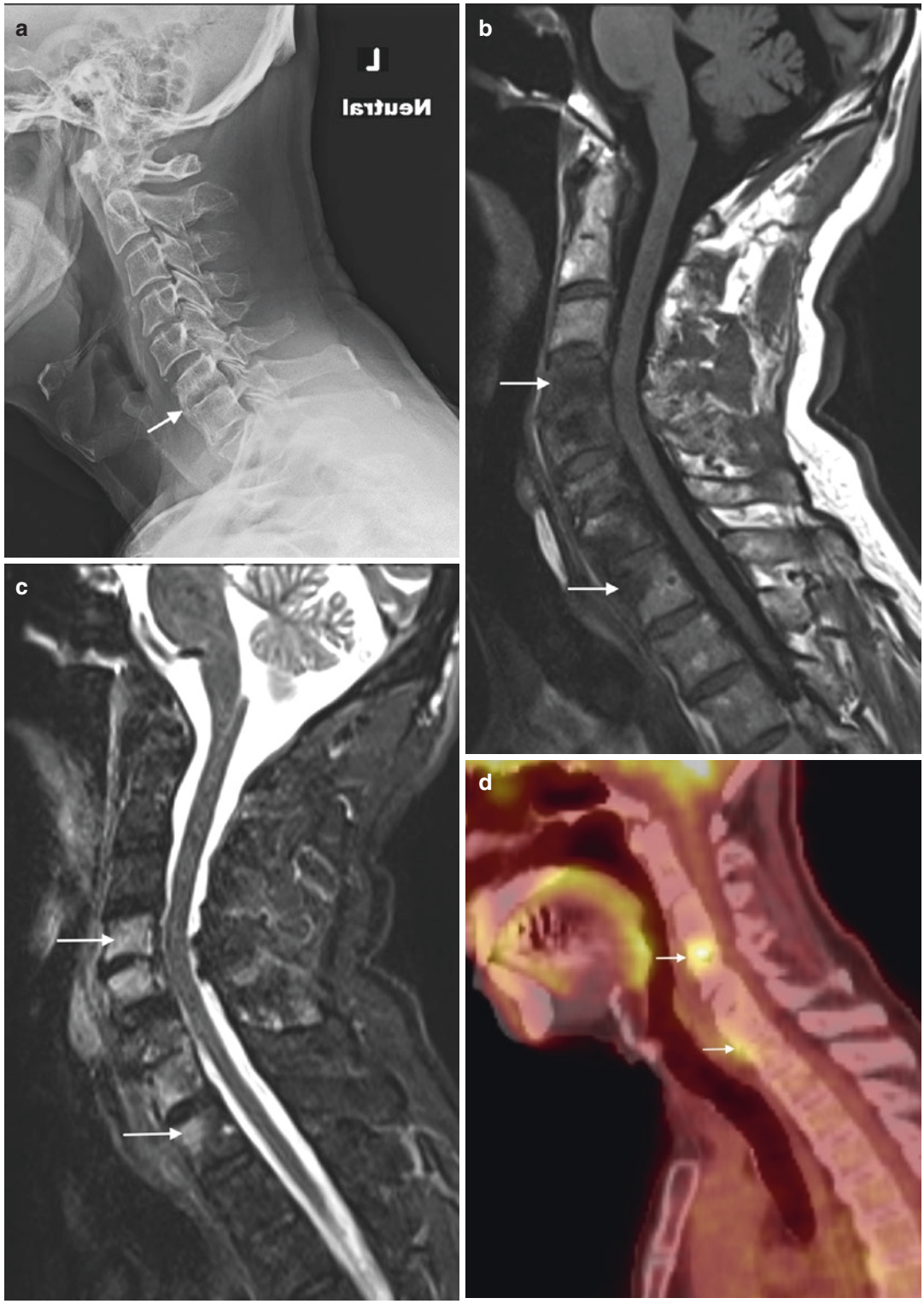
Fig. 4.5 (continued)

tor and/or guiding cannula. If this occurs, then the operator should first advance an 18 gauge spinal needle over the guide needle in order to make a small perforation in the platysma (Fig. 4.5). This maneuver will allow the blunt dissector, initially without, and then with the guiding cannula to readily pass through the platysma.

Once the guiding cannula reaches the margin of the bone or the lesion then the guide needle and blunt dissector are removed after satisfactory positioning is confirmed with CT. Other needles can now be safely inserted through this working cannula. The biopsy sample can be obtained using fine needle (1 mm diameter or less) aspiration or core needle (diameter greater 1.5 mm) biopsy via this coaxial technique. In some situations, the guiding cannula is not supported by the soft tissues of the neck and tends to move. When this occurs it is helpful to hold the guiding cannula and insert the biopsy needle in order to gain purchase within the structure to be sampled. A trephine needle, which has a serrated cutting edge, or other bone cutting needle can be inserted into osseous structures while a soft tissue cutting needle or a fine needle can be inserted into a soft tissue lesion. The guiding cannula can also be stabilized at the skin surface with either sterile towels or a small stack of sterile gauze. The position of the guiding cannula and biopsy needle, relative to the lesion and other critical structures, can be confirmed with the acquisition of sequential CT images (Figs. 4.6 and 4.7).

For soft tissue masses, fine needle aspiration should be performed prior to core biopsy in order to minimize hemorrhage into the needle tract (Fig. 4.8) (Ayala et al. 1995). The latter adversely impacts on the utility of the fine needle aspiration procedure by contaminating the biopsy specimen with blood. Sequential needle passes can be made into the soft tissue mass with slight angulations in order to sample areas of "fresh" tissue. CT image acquisition should be used to monitor the direction and depth of the biopsy needle and assess its proximity to other critical structures. Fine needle aspiration and soft tissue biopsy needles can be used to obtain tissue samples from osteolytic lesions provided that the peripheral cortex, if very thin, can be penetrated by these needles or a bone needle is used to create a tract for subsequent soft tissue needle use. Many soft tissue biopsy needle systems possess a sampling chamber that must be exposed within the substance of the lesion; the needle tip therefore must travel a short distance further (often 1 or 2 cm) in order for the cutting mechanism to work within the lesion matrix. It is important to account for the excursion distance of the soft tissue cutting needle when deploying this instrument in order to avoid injury to a critical structure. The number of passes that can be made will be determined by the size of the lesion and its location relative to critical structures; small, less than 1 cm diameter, lesions will yield only a small sample volume. If the fine needle aspiration shows diagnostic tissue then, at the operator's discretion, the procedure can be stopped. If the situation permits an attempt should be made to obtain at least 3 soft tissue cores (Ortiz et al. 2010).

Bone biopsy needles are used to obtain osseous matrix from bone lesions. Trephine needles are manually rotated with alternating short clockwise and counterclockwise motions, with slight downward pressure, in order to be advanced into the bone. A similar maneuver can be used with other bone cutting needles. The gradual advance-


a
Neutral
b
c
d

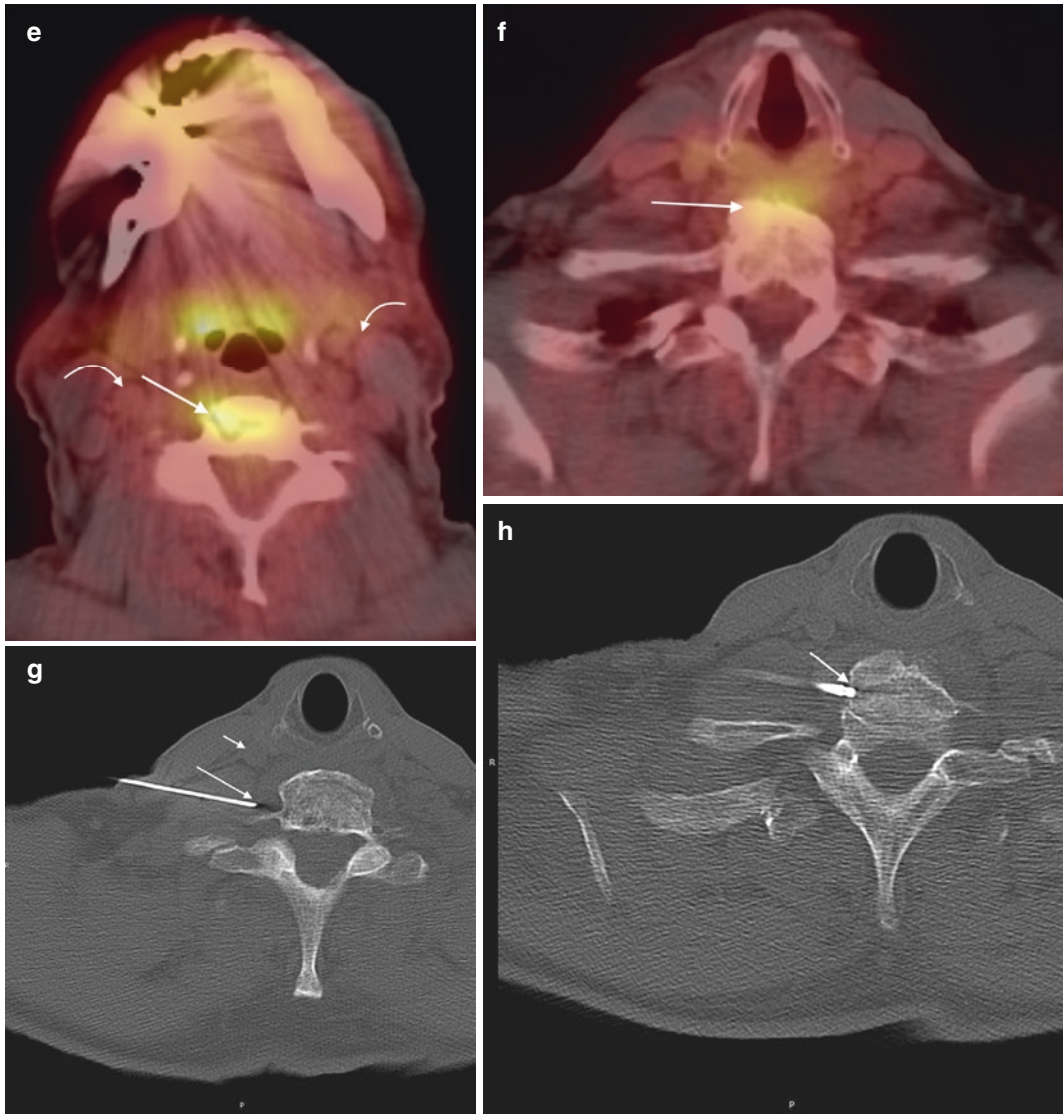
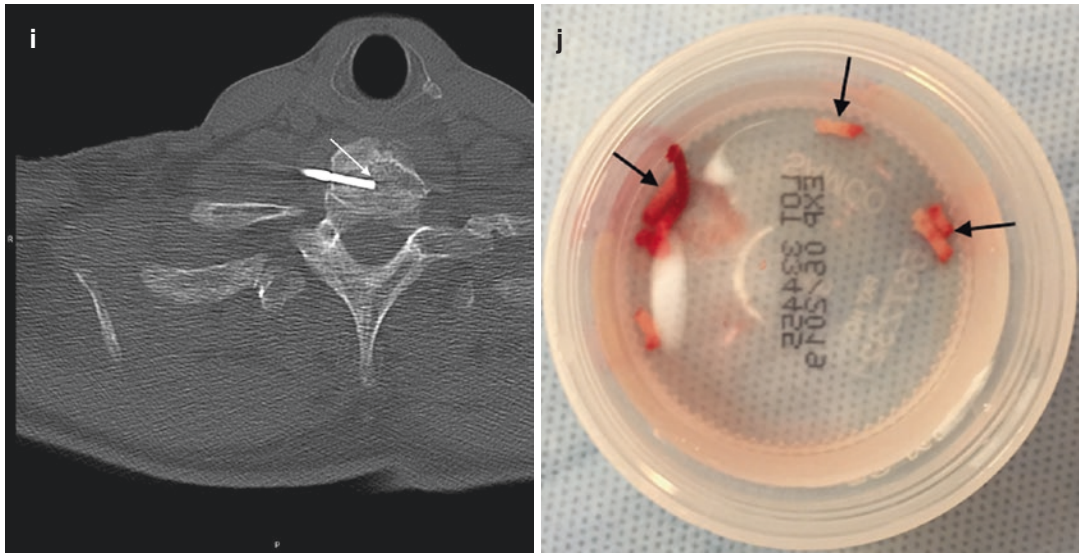


Fig. 4.6 (continued)

Fig. 4.6 73M with history of prostate cancer complains of neck pain. Lateral radiograph of the cervical spine (**a**) shows endplate irregularity and a bridging osteophyte at C6–7 (*arrow*) and no gross lytic or blastic bone lesions. T1 (**b**) and T2 (**c**) weighted sagittal MR images show a diffuse marrow replacement process that extends from C4 to T1 (*arrows*). Sagittal fused PET-CT image (**d**) shows hypermetabolic activity at the C4–5 level and the C7 level (*arrows*). Fused axial PET-CT images at C4–5 (**e**) and C7-T1 (**f**) levels confirm the areas of hypermetabolism (*arrow* in **e**), but also show multiple vascular structures preventing access to the C4–5 level (*curved arrows* in **e**). A more feasible approach posterior to the carotid space (*large arrow* in **f**) is possible at C7-T1. A lateral approach commencing with an 18 gauge spinal needle (*large arrow*) posterior to the carotid space (*small arrow*) was used (**g**). This enabled the bone needle (*arrow*) to be advanced across the C7 vertebra (**h**, **i**). Photograph of specimen container (**j**) shows multiple bone cores (*arrows*)



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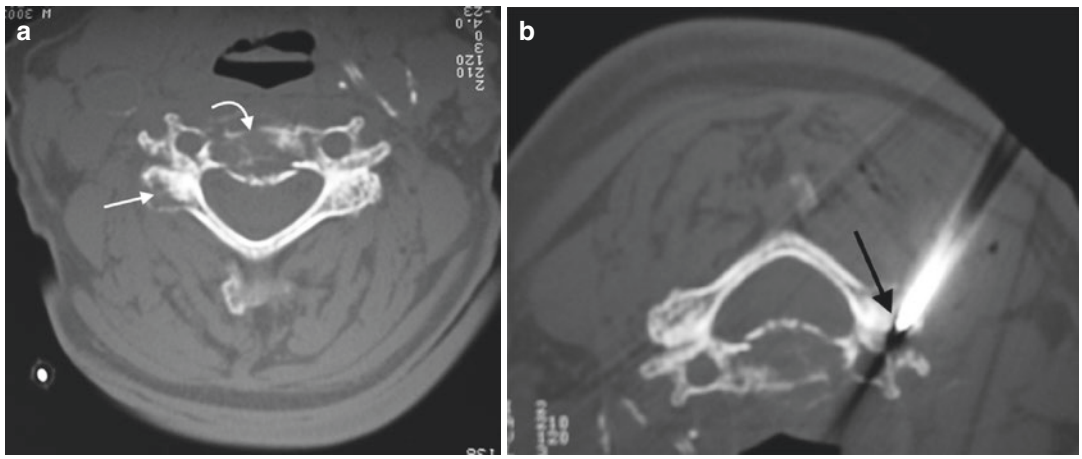

Fig. 4.7 Axial CT image in bone window algorithm (**a**) shows lytic lesions within the vertebral body (*curved arrow*) and the right articular pillar (*arrow*). Axial CT image with patient prone (**b**) shows that the articular pillar was biopsied (*arrow*) with a posterior approach in this patient with biopsy proven multiple myeloma

ment of the needle should be monitored with serial CT scans. Extreme caution should be observed in elderly patients with osteoporosis, or patients with very osteolytic lesions as the bone needle may advance briskly in these situations. It is helpful to sample as much tissue as safely as possible, scanning and checking needle position, between and during biopsy attempts. Since the bone tissue will require de-calcification prior to histopathologic analysis, whenever possible the operator should attempt obtain at least three bone cores (Fig. 4.6).

4.8.2.2 Fluoroscopic Guidance

Fluoroscopic guidance can be used to biopsy large or diffuse osseous lesions when CT is not available. This modality is particularly useful in providing prompt access to the intervertebral disk

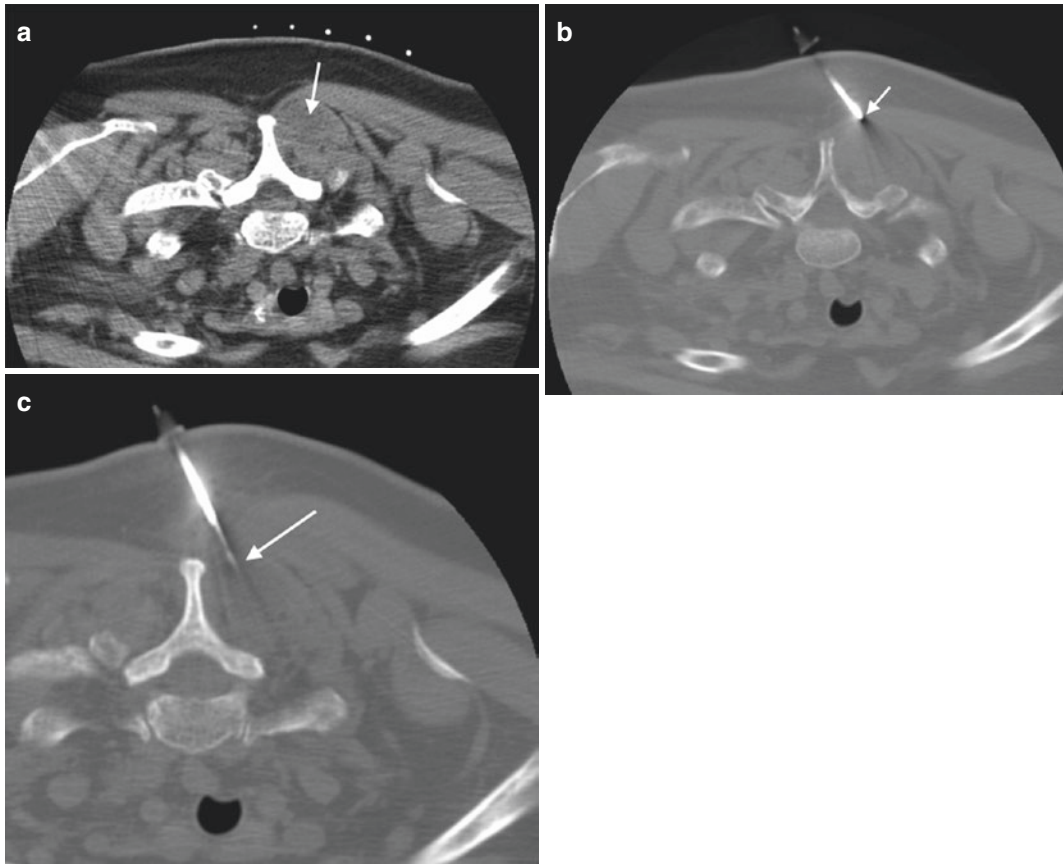

Fig. 4.8 63F with palpable posterior neck mass. Axial CT image in soft tissue algorithm (**a**) shows skin markers placed above a slightly hypodense mass that is located beneath the trapezius muscle (*arrow*). Axial CT image in bone window algorithm (**b**) shows guide needle placement just superficial to the lesion (*arrow*). Note that the guide needle is obliquely angled away from the spinal canal in order to (1) prevent spinal canal access and spinal cord injury and, (2) to maximize biopsy needle excursion through the greatest diameter of the lesion. Axial CT image in bone window algorithm (**c**) shows deployment of a cutting needle within the matrix of this biopsy proven schwannoma

space using an anterolateral approach with manual posterior displacement, by the operator, of the carotid artery and jugular vein. With the patient supine and the neck extended, an oblique approach with the cervical vertebral endplates aligned at the level of interest, the intervertebral disk is accessed at a minimum of a few millimeters anterior to the uncovertebral joint (Fig. 4.9). The extent and depth of needle insertion is monitored with frontal, lateral and contralateral oblique projections. Coaxial approaches with a guide needle/cannula and smaller gauge aspiration needles can be used to attempt to obtain tissue from the disk. Alternatively, automated percutaneous aspiration systems are available and can be used to obtain disk material for microbiologic and pathologic analysis (Ortiz et al. 2010; Wattamwar and Ortiz 2010). As the majority of these disk biopsy procedures are being performed to evaluate for infection, additional coaxial passes with bone biopsy needles, angling them toward the endplate, may help to yield more tissue (Michel et al. 2006). The number of passes that can be made with these approaches will be limited by the final location of the biopsy needle tip, which should be maintained within the confines of the disk space throughout the procedure. Performing disk biopsies prior to the initiation of

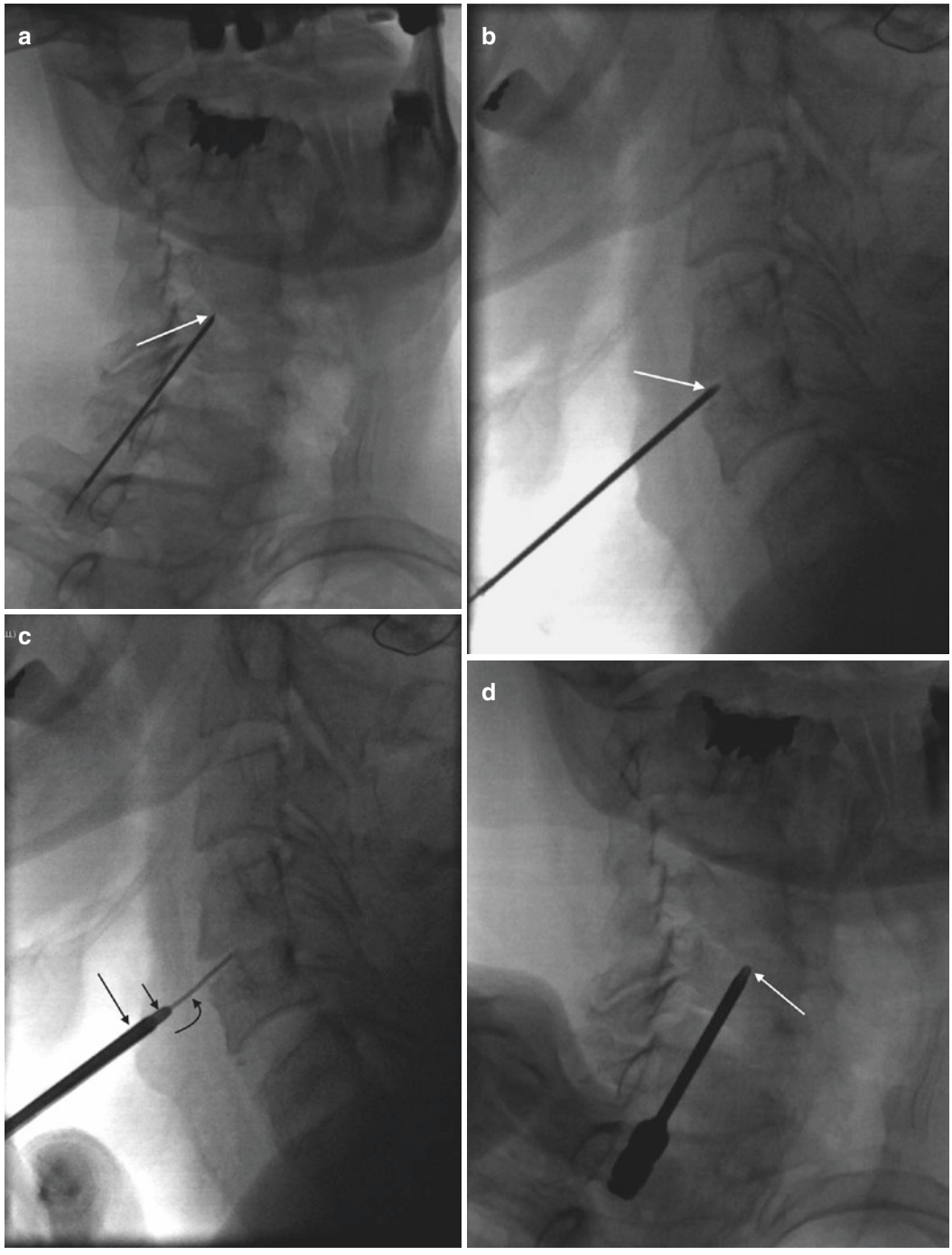

Fig. 4.9 Fluoroscopic images showing oblique approach (**a**) to disk space with an 18 gauge spinal needle; note the position of the spinal needle anterior to the uncovertebral joint adjacent to the lateral margin of the disk space (*arrow*). A lateral projection (**b**) shows the tip of the needle within the disk space (*arrow*). After disk aspiration is performed through the spinal needle, a hub-less long 22 gauge exchange (*insert*) needle is inserted into the spinal needle using coaxial technique and the spinal needle is exchanged for a12 gauge bone biopsy guide cannula (*large arrow*) and introducer (*small arrow*) which are then advanced over the guide needle (*curved arrow*) as shown on the lateral projection (**c**). The insert needle is removed and the guide cannula is stabilized and slightly re-positioned within the disk (*arrow*) as shown of the oblique projection (**d**). Frontal projection (**e**) shows replacement of the introducer with a bone biopsy needle (*arrow*) as the guide cannula is held firmly in place. The bone biopsy needle is carefully advanced with to and fro clockwise/counterclockwise rotations; the position of the biopsy needle tip is monitored with frontal, oblique and lateral (**f**) fluoroscopic images

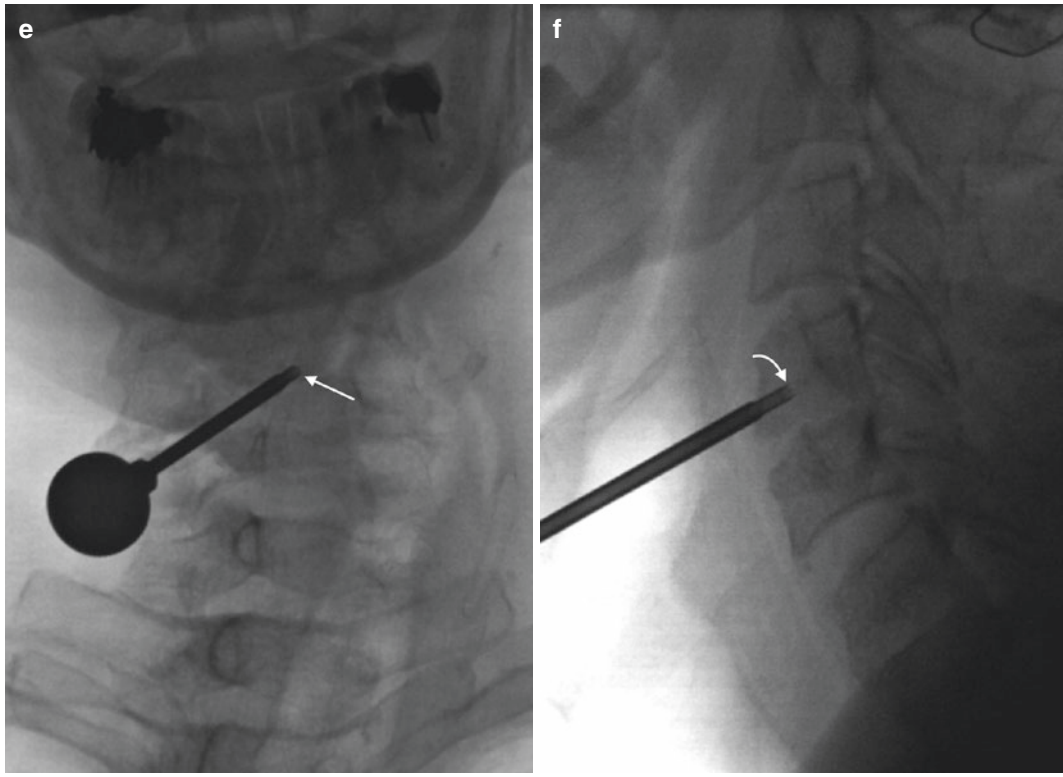

Fig. 4.9 (continued)

antibiotic therapy will help to increase the likelihood of a positive diagnostic yield (Howard et al. 1994; Rankine et al. 2004).

Once biopsy specimens are obtained, they should be labeled and processed immediately. Microbiology specimens should be placed in sterile containers and immediately transported to the microbiology laboratory with the appropriately completed requisition. Pathology specimens should be placed in 10% formalin (bone and soft tissue cores) or a cytology compatible ethanol mixture for fine needle aspirates, labeled, and brought to the pathology laboratory with the appropriately completed requisitions. If there is a clinical concern for specific clinical conditions, such as lymphoma or leukemia, special measures for specimen handling will be necessary, and this should be discussed with a pathologist as flow cytometry and/or other special stains will be performed. Specimen transport should be performed by responsible personnel as part of an organized process; unfortunately, not a year goes by when at some institution or facility, that after a biopsy procedure is performed, the specimen is lost. It is highly recommended that the operator provide as much detailed information about the case and the imaging findings along with their specific clinical concerns in order to improve the chances of obtaining an accurate diagnosis.

The diagnostic accuracy of image-guided percutaneous cervical spine biopsy has improved with the use of CT fluoroscopy and coaxial needle techniques (Wu et al. 2014). Factors that impact on the diagnostic accuracy of the spine biopsy procedure include the lesion location, lesion type, size and matrix, needle size (gauge) and type, sample volume and the experience of the operator and pathologist (Kreula 1990; Ortiz et al. 2010; Rimondi et al. 2011). Small and difficult to access lesions will yield less volume of tissue as compared to other lesions; this is not an infrequent scenario in the cervical spine. Malignant neoplastic lesions are more readily detected as compared to some benign tumors or other benign, non-neoplastic processes (Rimondi et al. 2011). The diagnostic accuracy is lower for sclerotic lesions (76%),

which are technically more difficult to sample, as compared to lytic lesions (93%) (Lis et al. 2004). A review of the literature shows that the accuracy of image-guided percutaneous spine biopsy with core sampling ranges from 70 to 97% (Hau et al. 2002; Issakov et al. 2003; Madhavan et al. 2002; Schweitzer et al. 1996). A few reports have shown 100% accuracy, but these are small case series (Wu et al. 2014). With CT-guidance the diagnostic accuracy of coaxial core biopsy techniques is in the range of 90%, especially when sampling a neoplastic process (Lis et al. 2004). The diagnostic accuracy of fine needle aspiration is 60% (Rimondi et al. 2008; Gupta et al. 2002; Yang and Damron 2004). This lower accuracy rate reflects the smaller sampling volume that is obtained with smaller gauge needles as well as sample contamination by hemorrhage. When performing an image-guided percutaneous spine biopsy for infection the diagnostic accuracy is lower, in the range of 50–60% (Rimondi et al. 2008). Antibiotic therapy decreases the diagnostic yield for spine biopsies intended to assess for the presence of infection and antibiotics either should ideally not be administered until the biopsy is performed or should be held for 48 h prior to the performance of the procedure.

4.9 Post-procedure Care

Following cervical spine biopsy, the patient should be monitored and recovered for at least 2 h. The biopsy skin puncture site should be immediately covered with a sterile bandage and monitored for signs of bleeding or expanding hematoma. Pain medication can be given if necessary. An ice-pack can be placed over the area of the puncture site in order to reduce swelling and irritation. Once stable the patient can be discharged home or transported back to their hospital room. The patient should be reminded that the biopsy specimen(s) may take several days to process prior to analysis and that the biopsy results, especially with bone biopsies, will not be immediately available. The patient is instructed to follow up with the referring clinician for the biopsy results. Outpatients are also instructed to call the operator's office and/or staff if they notice any increased swelling, irritation, or increased difficulties with breathing or swallowing.

After the procedure, the operator can contact the referring clinician and update them on the procedure and the patient's status. A day after the procedure, a courtesy follow-up telephone call to the patient (for outpatients) or a direct visit with an inpatient is very helpful in terms of clarifying any post-procedure concerns, identifying delayed complications and reassuring the patient. The operator and/or a staff designee should follow up with the appropriate laboratories in order to obtain the biopsy results and ascertain that the referring clinician also has the biopsy results.

Key Review Points

1. A primary objective of image-guided percutaneous cervical spine biopsy is to determine a trajectory towards a lesion that avoids injury to a critical structure while at the same time yielding access to the target lesion.
2. A constant awareness and vigilance of the important neck compartments and critical structures is required before, during and even after the cervical spine biopsy procedure.
3. When a cervical spine neoplasm is detected, always evaluate the remainder of the axial skeleton and body for the possibility of a more accessible lesion.
4. An absolute contraindication to cervical spine biopsy is uncorrected coagulopathy.
5. The risks and complications that can occur as a result of image-guided percutaneous cervical spine biopsy are uncommon and can be kept to a minimum.
6. CT fluoroscopy is a useful modality for performing cervical spine biopsy.
7. Coaxial techniques improve the sampling rate and safety margin of the cervical spine biopsy procedure.
8. Another important objective of cervical spine biopsy is to obtain as much tissue as possible in order to improve the chances of obtaining an accurate diagnosis and to perform the procedure safely without injuring the patient.

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