Percutaneous CT-Guided Vertebral Biopsy: A Technical Overview (anatomy, techniques, and clinical outcomes)

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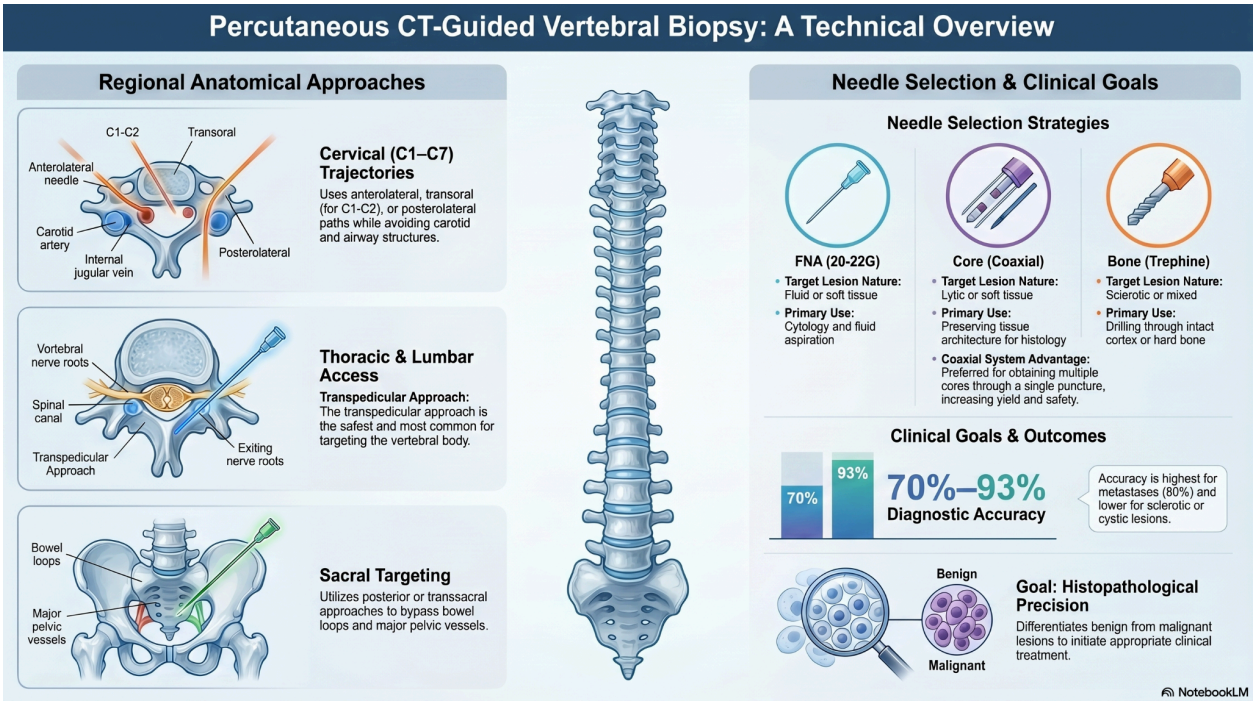
***Abstract*—Percutaneous CT-guided vertebral biopsy has become the gold standard for the minimally invasive diagnosis of spinal lesions, offering a safe and effective alternative to open surgical biopsy. This procedure is essential for differentiating between primary bone malignancies, metastatic disease, and spondylodiscitis. Literature consistently demonstrates a high diagnostic accuracy range of 70% to 93%, which is heavily dependent on lesion type, needle selection, and proceduralist expertise. The primary clinical advantage of this technique lies in its significantly lower morbidity profile, reduced cost, and the ability to perform the procedure in an outpatient setting, often under local anesthesia. By utilizing the precision of computed tomography (CT), the interventionalist can navigate complex regional anatomy—such as the carotid sheath in the cervical region or the pleura in the thoracic region—while maintaining a direct path to the pathology. This review provides a technical roadmap for the spine interventionist, detailing anatomical safe zones, specific instrumentation mechanics, and level-specific procedural approaches required to maximize tissue yield and minimize complications.**

Graphical abstract



***Index Terms*—spine biopsy, percutaneous biopsy, vertebral lesions, interventional radiology, tomography, x-ray computed.**

I. Introduction : The Landscape of Spinal Diagnostics

The management of spinal pathologies depends entirely on definitive histological or cytological diagnosis. Differentiating between primary spinal malignancies (e.g., chordoma, myeloma), metastatic disease from visceral primaries, and infectious processes is a frequent challenge in clinical practice. While open surgical biopsy was once the standard, it is associated with significant surgical risks, longer recovery times, and higher costs.

CT-guided percutaneous biopsy has revolutionized this landscape. The high spatial resolution of CT allows for the identification of the most viable portion of a lesion, such as the lytic component or the aggressive cortical breach, while avoiding vital neurovascular structures. Compared to open biopsy, the percutaneous approach minimizes tissue trauma, eliminates the need for hospitalization in many cases, and provides a cost-effective pathway for patients who may be poor surgical candidates.

II. Relevant Regional Anatomy

Successful biopsy requires meticulous planning to navigate regional "no-fly zones."

- **Cervical Region:** The primary concern is the protection of the carotid sheath (containing the carotid artery, internal jugular vein, and vagus nerve) and the aerodigestive tract (esophagus and trachea). A safe corridor must be identified between these structures to reach the anterior or lateral vertebral body.
- **Thoracic Region:** The pleura and lungs are in close proximity to the vertebral bodies. Transcostovertebral or transpedicular paths are utilized to avoid pleural transgression and subsequent pneumothorax. The intercostal neurovascular bundle, located at the inferior margin of each rib, must also be avoided.
- **Lumbar Region:** The psoas muscle houses the lumbosacral plexus. Accessing the vertebral body laterally requires an understanding of the "safe zone" in the anterior and middle thirds of the psoas to avoid the femoral nerve and other branches of the plexus.
- **Sacral Region:** Biopsies must be planned to avoid the sacral foramina (nerve roots) and the pelvic viscera (rectum, bladder, and iliac vessels).

III. Pre-Procedural and Peri-Procedural Details

Patient Preparation

A thorough review of all prior imaging (MRI and CT) is mandatory to select the target lesion. Patients must be screened for anticoagulation therapy and antiplatelet use. Written informed consent must detail the risks of nerve injury and bleeding.

Contraindications

The primary absolute contraindication is an uncorrectable coagulopathy. A platelet count <50,000/μL or an INR >1.5 are generally considered thresholds requiring correction prior to intervention to prevent epidural hematoma.

Anesthesia

Local anesthesia (LA) with 1% lidocaine is usually sufficient for most cooperative patients, especially for lumbar and sacral levels. However, general anesthesia (GA) or monitored anesthesia care (MAC) is often preferred for complex cervical biopsies, patients with high anxiety, or when the lesion is near the spinal canal where any patient movement could lead to catastrophic cord injury.

IV. Instrumentation and Needle Systems

Fine Needle Aspiration (FNA)

FNA utilizes 20–22G thin-walled needles. This system is optimized for cytological sampling, particularly in suspected metastatic disease where cellular morphology is sufficient for diagnosis.

Core Biopsy Systems

For primary bone tumors, histological architecture is required. Automatic or semiautomatic core systems (e.g., side-notch needles) allow for the acquisition of high-quality tissue strips while maintaining the structural integrity of the specimen.

Bone Biopsy Systems

Breaching the dense vertebral cortex requires specialized hardware:

- **Murphy's System:** This system features a sharp trocar and a cannula with a serrated edge. It is designed for manual "corkscrew" advancement through hard cortical bone, allowing for the extraction of a solid bone core.
- **Ackerman System:** A heavy-duty trephine-style system specifically used for sclerotic or hard lesions. It provides superior torque for sampling the medullary space after a cortical breach.

Coaxial Technique

The coaxial technique involves placing a larger outer cannula (the "introducer") against the target cortex. This provides several benefits:

- **Multiple Samples:** Multiple biopsy passes can be made through a single cortical breach.
- **Reduced Track Seeding:** The outer cannula protects the soft tissues from direct contact with potentially malignant cells during needle withdrawal.
- **Precision:** It allows for stable repositioning of the inner needle to sample different areas of a single lesion.

V. Level-Specific Procedural Approaches

Cervical Level

- **Anterolateral Approach:**
    - Place patient in the supine position with slight neck extension.

    - Use CT or ultrasound to identify the gap between the carotid sheath and the trachea/esophagus.
    - Manually displace the carotid artery laterally and the aerodigestive tract medially if the corridor is narrow.
    - Advance the needle toward the anterior or lateral aspect of the vertebral body.
- **Transoral Approach (C1-C2):**
    - Perform under GA with the mouth held open by a retractor.
    - Advance the needle through the posterior pharyngeal wall under CT-fluoroscopic guidance.
    - Target the midline of the dens or the C1 atlas directly.

Thoracic Level

- **Transpedicular Approach:**
    - Place patient in the prone position.
    - Target the superior-lateral aspect of the pedicle ("the eye").
    - Advance through the pedicle into the vertebral body, maintaining a medial-caudal trajectory to stay within the bony margins and away from the spinal canal.
- **Transcostovertebral Approach:**
    - Position the patient prone.
    - Target the space between the rib head and the pedicle.
    - The needle stays extra-pleural, entering the lateral aspect of the vertebral body directly.

Lumbar Level

- **Lateral Approach:**
    - Position patient prone or in lateral decubitus.
    - Select an entry point approximately 8–10 cm from the midline.
    - Advance the needle through the psoas muscle toward the mid-portion of the vertebral body.
    - Ensure the trajectory remains in the anterior two-thirds of the psoas to avoid the lumbar plexus roots.

Sacral Level

- **Transsacral Approach:**
    - Place patient in the prone position.
    - Use a posterior-to-anterior trajectory through the dorsal sacral cortex.
    - Carefully steer the needle to avoid the neural foramina and target the lesion within the sacral ala or body.

Figure depicting the vertebral biopsy approaches.

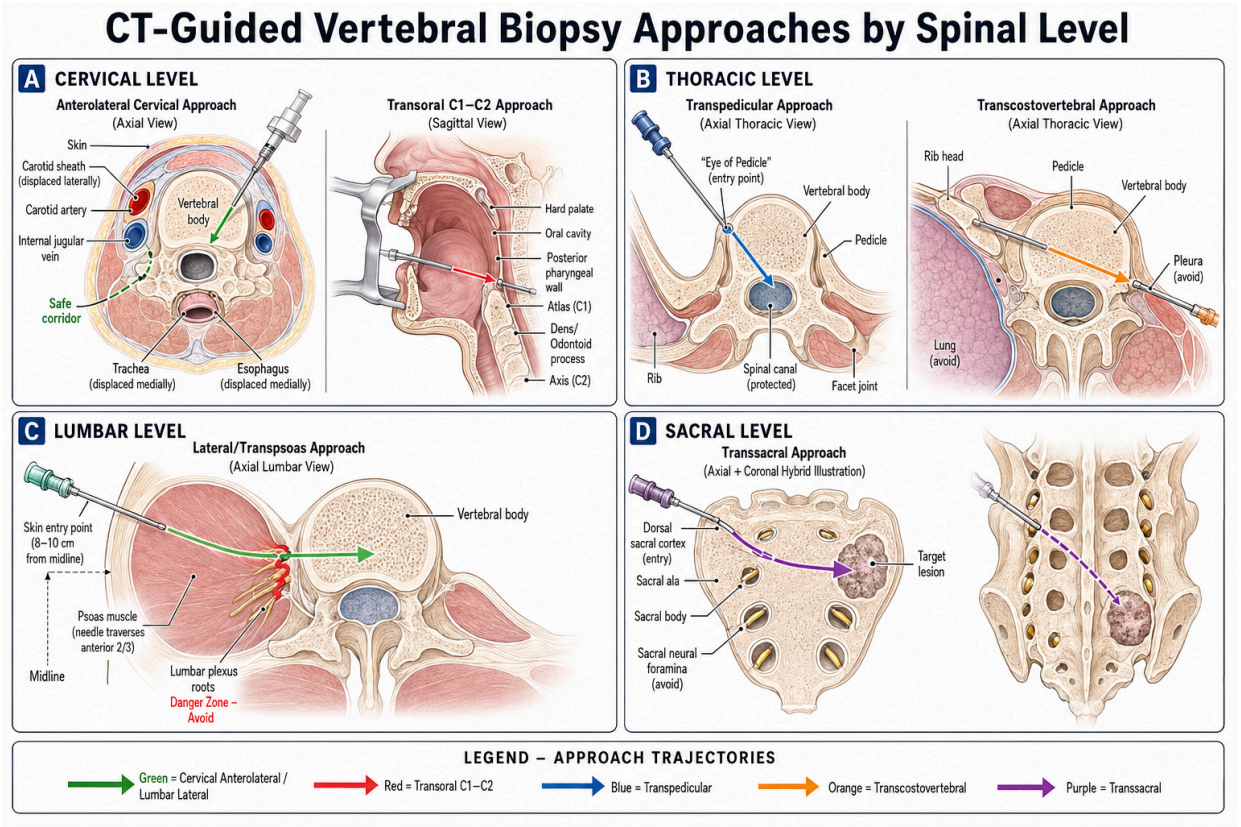
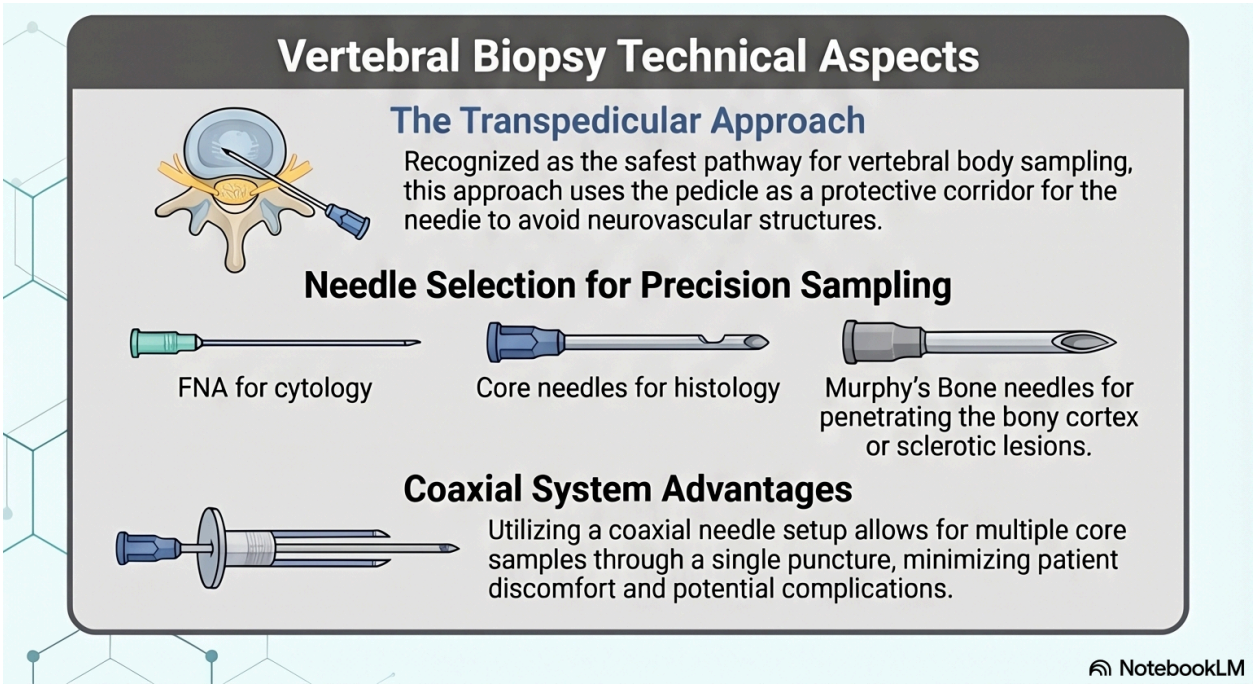


Figure depicting the tools for vertebral body biopsy



VI. Clinical Outcomes and Procedural Safety

Diagnostic Yield

The diagnostic yield of percutaneous CT-guided biopsy is reported between 70% and 93%. Higher yields are associated with lytic lesions and the use of core biopsy needles, whereas sclerotic (blastic) lesions or small-gauge FNA-only samples may result in lower diagnostic accuracy.

Complications and Mitigation

The close proximity of spinal structures necessitates careful monitoring.

- **Bleeding and Hematoma:** Connects to anatomical proximity of epidural veins. Mitigated by checking coagulation and using a coaxial system to tamponade the track.
- **Nerve Root Injury:** Risk is highest in the lumbar psoas or sacral foramina. Mitigated by utilizing CT-fluoroscopy to track the needle tip in real-time.
- **Pneumothorax:** Associated with thoracic levels. Mitigated by using a transpedicular path which is entirely intra-osseous and avoids the pleura.
- **Infection:** Standard sterile technique and prophylactic antibiotics (when indicated for spondylodiscitis) reduce risk.

References

[1] Gala KB, Shetty NS, Janu AK, Shetty N, Kulkarni SS. Percutaneous CT guided vertebral biopsy: Anatomy and technical considerations. J Clin Interv Radiol ISVIR. 2021;5:150-157.
[2] Rimondi E, Staals EL, Errani C, et al. Percutaneous CT-guided biopsy of the spine: results of 430 biopsies. Eur Spine J. 2008;17(7):975-981.
[3] Yang SY, Oh E, Kwon JW, Kim HS. Percutaneous image-guided spinal lesion biopsies: Factors affecting higher diagnostic yield. AJR Am J Roentgenol. 2018;211(5):1068-1074.
[4] Lis E, Bilsky MH, Pisinski L, et al. Percutaneous CT-guided biopsy of osseous lesion of the spine in patients with known or suspected malignancy. AJNR Am J Neuroradiol. 2004;25(9):1583-1588.
[5] Nourbakhsh A, Grady JJ, Garges KJ. Percutaneous spine biopsy: a meta-analysis. J Bone Joint Surg Am. 2008;90(8):1722-1725.