SPINE

Percutaneous Access to the Vertebral Bodies: A Video and Fluoroscopic Overview of Access Techniques for Trans-, Extra-, and Infrapedicular Approaches

Andrew J. Ringer[1-3] and Sunita V. Bhamidipaty[1]

Key words
- Extrapedicular
- Infrapedicular
- Kyphoplasty
- Percutaneous
- Transpedicular
- Vertebroplasty

Abbreviations and Acronyms
AP: Anterior–posterior
VCF: Vertebral compression fracture

From the [1]Department of Neurosurgery, University of Cincinnati (UC) College of Medicine; [2]UC Neuroscience Institute; and [3]Mayfield Clinic, Cincinnati, Ohio, USA

To whom correspondence should be addressed: Andrew J. Ringer, M.D. [E-mail: editor@mayfieldclinic.com]

Citation: World Neurosurg. (2013) 80, 3/4:428-435.
http://dx.doi.org/10.1016/j.wneu.2012.09.005

Supplementary digital content available online.

Journal homepage: ***www.WORLDNEUROSURGERY.org***

Available online: ***www.sciencedirect.com***

■ OBJECTIVE: **With increasing popularity of percutaneous spinal access for minimally invasive spinal neurosurgery, the treatment paradigm has shifted from open approaches to vertebroplasty or kyphoplasty for degenerative spinal disease and vertebral compression fractures. Addressing the challenges of this shift, we integrate the fluoroscopic studies of these percutaneous approaches with the three-dimensional surgical anatomy. Step-by-step techniques are illustrated in video demonstrations that highlight the nuances of effective percutaneous access during spinal surgeries for vertebral compression fractures and pedicle screw fixation.**

■ METHODS: **Imaging guidelines, approach planning, surgical techniques, and relevant anatomical features are noted for the transpedicular, lumbar extrapedicular, and thoracic extra- and infrapedicular approaches. Video clips and accompanying fluoroscopic images highlight the critical steps. Subtle refinements unique to each percutaneous access are presented related to skin incision, needle trajectory, and cement deposition.**

■ RESULTS: **With the transpedicular approach (popular technique for vertebroplasty and pedicle screw placement), safe access requires accurate interpretation of the fluoroscopic anatomy, specifically identification of the target vertebral body in true anterior-posterior and lateral planes. The transpedicular trajectory uses the slight inferior and medial orientation of the pedicle followed anteriorly. The lumbar extrapedicular approach uses an oblique trajectory anterior to the transverse process at the level of the pedicles. A thoracic approach uses the potential space between the rib head, transverse process, and pedicle. The infrapedicular approach, which allows greater flexibility in its medial angulation but at the expense of the bony confines of the thoracic extrapedicular approach, takes advantage of the narrow-waisted thoracic laminae.**

■ CONCLUSIONS: **With an appreciation for the standard anatomical landmarks, fluoroscopic views, and avenues of approach, percutaneous access techniques can be safely and effectively applied to many spinal procedures.**

INTRODUCTION

Vertebral compression fractures (VCFs) can be caused by trauma, multiple myeloma, bony metastases, angiomas, and most often, osteoporosis. In the United States, osteoporotic VCFs account for 700,000 fractures annually (3), resulting from this systemic disease that affects more than 24 million Americans and is increasing with the demographic trend of increasing mean age (2, 9). Traditional methods of treatment for VCF and degenerative instability include bed rest, bracing, analgesics, and, in cases of neurological compromise, surgical intervention. However, osteoporotic patients often face complex surgical interventions because of poor bone quality and necessity for long constructs, anterior and posterior fixation, and segmental fixation. Undertaking this type of surgical procedure prolongs recovery time or can be impossible if other medical comorbidities are present with osteoporosis. Vertebroplasty, kyphoplasty, and percutaneous spinal instrumentation offer another alternative to conventional surgical approaches in the treatment of VCFs and spinal instability.

Traditional kyphoplasty sometimes requires a bilateral transpedicular approach to balloon and cement placement for VCF. Alternative approaches, such as a unilateral extrapedicular approach, can be appropriate, decreasing both the overall procedural costs and time under sedation and reducing the risk of damage to the vertebral body. In a study of vertebroplasty, Tomeh et al. (17) reported no asymmetric deformation with the unipedicular approach and a stiffness value comparable with that of the bilateral approach. Cotten et al. (3) noted that no directly proportional relationship exists between the percentage of lesion filling and degree of pain relief.

We report step-by-step the percutaneous techniques used in the lumbar and thoracic extrapedicular approaches and the thoracic infrapedicular approach, with depiction in accompanying video presentations. Sur-

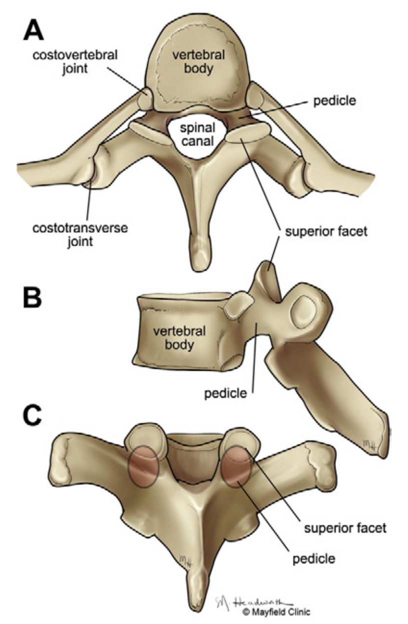

Figure 1. Anatomy of the thoracic vertebra in superior (**A**), lateral (**B**), and posterior (**C**) views. Pedicles of the thoracic vertebral body are in between the two costal demi facets, and are directed posteriorly and slightly upward. (With permission from Mayfield Clinic.)

gical nuances include the percutaneous repair of VCFs and spinal instability, accompanied by its fluoroscopic imaging. The unique anatomy of the lumbar and thoracic vertebral bodies is presented relevant to these percutaneous approaches (**Figures 1** and **2**) (8).

FLUOROSCOPIC ALIGNMENT

Safe access for percutaneous approaches to the vertebral body requires accurate fluoroscopic appreciation of the anatomy, which is best accomplished by observing the target vertebral body in the true anterior–posterior (AP) and lateral planes. Back-and-forth manipulation of the C-arms (or image intensifiers if performed in a radiology suite) or biplanar fluoroscopy with two C-arms that obviates the need for this manipulation can be used. We confirm these views before the sterile preparation and draping of the patient. Beginning with the AP view, the C-arm is rotated left or right until the spinous process is centered between the pedicles of the target vertebral body (**Video 1**). Next, the C-arm is rotated superiorly or inferiorly until the superior and inferior endplates appear flat. Before the correct superior-inferior orientation is achieved, these endplates may appear elliptical. The inferior endplate of the next superior vertebral body can be used for reference because the target vertebral body is deformed by fracture (particularly at the superior endplate). When the lateral view is obtained, rotation of the C-arm superiorly or inferiorly (to the patient's head or the foot, respectively) flattens the appearance of the endplates. The C-arm is then rotated left or right until the posterior cortical margin appears flat. If neither the AP nor lateral view is true, discrepancies in the apparent trajectory between the two views may disorient the surgeon's view to the target.

Video

Video available at WORLDNEUROSURGERY.org

TRANSPEDICULAR APPROACH

The transpedicular approach, the most often used technique for vertebroplasty and kyphoplasty, can be performed unilaterally or bilaterally for vertebroplasty; a bilateral approach is typically recommended for kyphoplasty. Safety of the transpedicular approach relies on restricting the instruments to the bony confines of the pedicle until the vertebral body is entered, with a trajectory to the vertebral body that is relatively restricted. Convergence to midline can be difficult in the thoracic spine because of the sagittal orientation of the thoracic vertebral bodies. Familiarity with this anatomy makes this approach attractive for surgeons accustomed to placing pedicle screws. However, the senior author (AJR) has observed (during multiple practical courses) that translating open navigation of the pedicles for screw fixation to a closed, percutaneous approach is difficult and that the learning curve is steep.

Planning the Approach

With AP and lateral views of the target vertebral body, the approach follows the slightly inferior and medial orientation of the pedicle followed anteriorly; this trajectory is also used through the back's soft tissues and maintained in the pedicle. Accordingly, the skin entry point should be slightly superior and lateral to the radiographic appearance of the pedicle. From a true AP view, a radio-opaque instrument marks the skin incision over the superior-lateral margin of the pedicle. A second mark is made 1–2 cm superior and lateral to the first (**Figure 3**, point 1). Variance in the measurement allows for adjustments to the patient's body habitus (i.e., 1 cm for thin patients). This measurement is repeated for the contralateral pedicle.

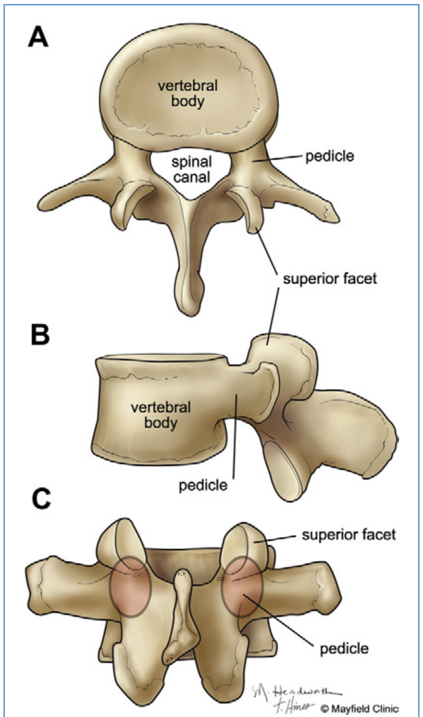

Figure 2. Anatomy of the lumbar vertebra in superior (**A**), lateral (**B**) and posterior (**C**) views. Note that the facets on the superior processes are concave, as well as posteriorly and medially oriented. Facets of the inferior processes are convex and anterolaterally oriented. Pedicles are directed posteriorly and laterally from the upper part of the body. (With permission from Mayfield Clinic.)

A small stab incision is made at the skin entry point. If the patient is under conscious sedation, local anesthetic is topically applied and a spinal needle is inserted through the soft tissues to the periosteum at the bony entry point. Accurate positioning can be confirmed fluoroscopically.

Surgical Technique

Surgical technique is demonstrated in **Video 2**. An 11-gauge Jamshidi needle is

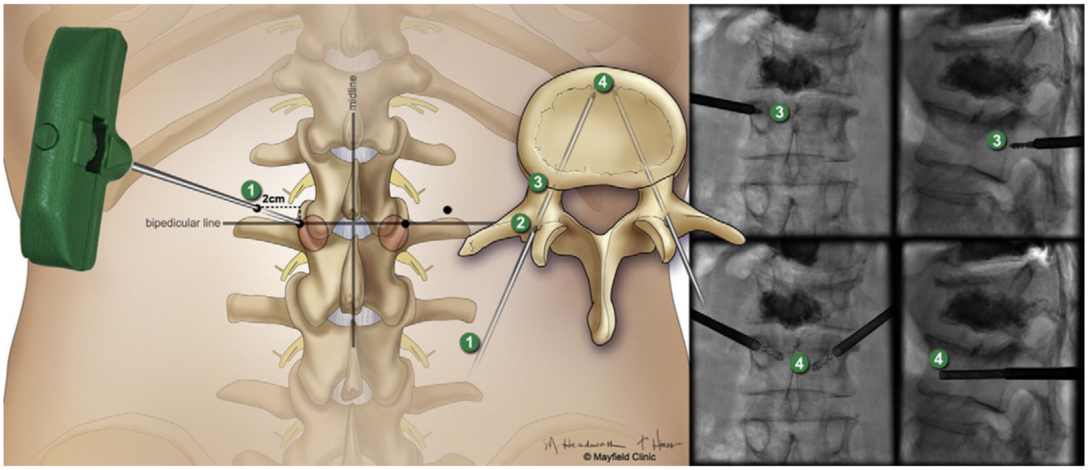

Figure 3. Transpedicular approach. The superior-lateral border of both pedicles is marked on the skin and a bipedicular line is drawn. Approximately 1 to 2 cm superior and lateral to the first mark, a second mark is made for skin incision (point 1). Measurements are repeated for the contralateral pedicle. A Jamshidi needle is passed through the trajectory of the two skin marks until it meets the bone (point 2). By palpation, the tip will appear to be on the "uphill slope" of the facet joint. The needle is lightly tapped with a mallet 1 to 2 mm into the bone. Fluoroscopy views are taken to confirm trajectory. The needle tip should appear aligned with the medial wall of the pedicle on anterior–posterior (AP) fluoroscopy, and appear just anterior to the posterior cortical margin of the vertebral body on lateral fluoroscopy (point 3). Subsequently, the needle is advanced to a point between the medial pedicle border and spinous process on AP fluoroscopy and to a point within the anterior one third of the vertebral body on lateral fluoroscopy (point 4). (With permission from Mayfield Clinic.)

passed through the same trajectory to the bone of the posterior spinal elements. On AP fluoroscopy, the Jamshidi tip appears to be in the superior-lateral quadrant of the pedicle. By palpation, the tip will appear to be on the coronally oriented lateral surface of the facet joint, slightly posterior to the transverse process (the "uphill slope") (**Figure 3**, point 2). After palpation of this entry point, the Jamshidi is lightly tapped 1 to 2 mm into the bone using a mallet. Anchoring the Jamshidi needle to the transpedicular–lamina slope (i.e., medial to lateral orientation) and then reversing its trajectory so it does not slide off the slope is sometimes necessary. At this time, the superior–inferior trajectory of the instrument should be checked on lateral fluoroscopy; the line of the Jamshidi should extrapolate through the pedicle, preferably in its superior half. A trajectory too inferior poses a risk of fracture to the inferior pedicle with injury of the exiting nerve root immediately below the pedicle. A trajectory too superior may fracture through the collapsed superior endplate of the vertebral body.

With confirmation of the entry point on AP view and the trajectory on lateral view, the Jamshidi is gradually driven through the pedicle. Although it is best to periodically check both views, the AP view is critical at this point. The instrument tip must be lateral to the medial border of the pedicle on AP view until it appears anterior to the posterior border of the vertebral body on lateral view (**Figure 3**, point 3). If at any time the instrument appears medial to the pedicle on AP view before it has entered the vertebral body on lateral view, the instrument is in the spinal canal; the surgeon should then consider backing the instrument out slightly and redirecting if it approaches the medial pedicle border at a point too posterior to the vertebral body. Some redirection can be achieved by rotating the tip of a beveled Jamshidi, torquing the handle in the direction opposite the desired trajectory. That is, lateral tip redirection requires medial deviation of the Jamshidi handle. Once the Jamshidi needle is safely within the vertebral body, it may be advanced further (**Figure 3**, point 4) to allow methylmethacrylate injection for vertebroplasty, or it may be exchanged over a Kirschner wire for an osteointroducer cannula for kyphoplasty.

Additional Considerations

The coaxial view is an alternative to the standard AP and lateral views during the transpedicular approach. Along with the lateral view, the surgeon may prefer to oblique the AP view to match the trajectory of the pedicle (1). On this lateral view, the instrument is positioned in the center of the pedicle on the oblique view and is maintained while advancing the instrument until it has entered the vertebral body on the lateral view. An advantage of this technique is that the surgeon can immediately recognize any deviation from the center of the pedicle whereas a disadvantage may be poor visualization in patients with severe osteoporosis. Accurate recognition of the obliquity of the pedicle may prove quite difficult, potentially compromising the accuracy of instrument placement.

LUMBAR EXTRAPEDICULAR APPROACH

The lumbar extrapedicular approach uses an oblique trajectory, anterior to the transverse process, at the level of the pedicles. This trajectory facilitates the access to the contralateral half of the vertebral body from a unilateral approach, obviating the need for access to the bilateral vertebral body. The exiting nerve root is easily avoided because the entire approach is made in the axial plane of the pedicles. The more lateral approach also makes entry into the spinal canal difficult. As with the transpedicular approach, accurate fluoroscopic visualization of the vertebral anatomy is paramount.

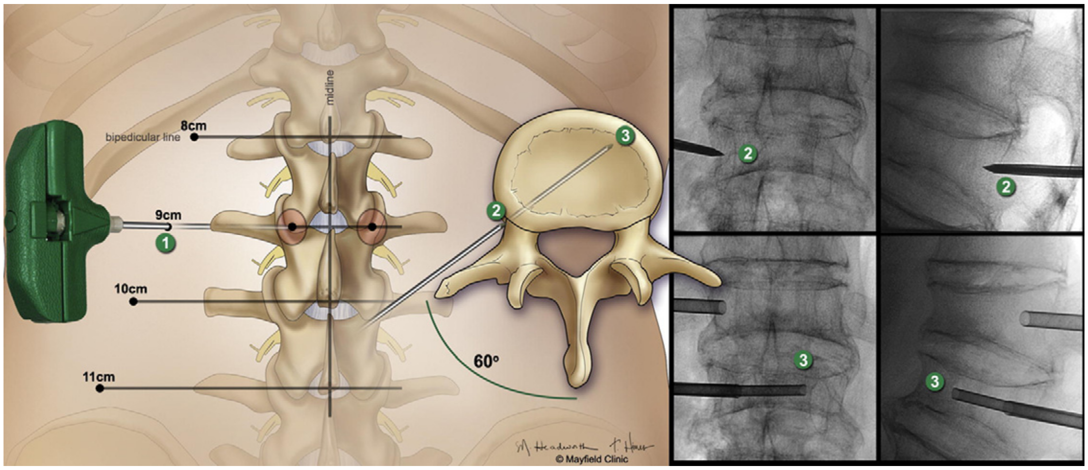

Figure 4. Lumbar extrapedicular approach. The center of each pedicle is marked on the skin with a pen and a bipedicular line is drawn. Skin entry is marked 9 cm off midline at L2 (point 1). With a trajectory approximately 60° to the vertical plane, the Jamshidi needle is advanced along the bipedicular line, anterior to the transverse process, until it meets the bone at the junction of the ipsilateral pedicle and vertebral body. With fluoroscopy views taken to confirm trajectory, the needle tip should appear aligned with the lateral wall of the pedicle on anterior–posterior (AP) views, and appear just anterior to the posterior cortical margin of the vertebral body on lateral views (point 2). The biopsy cannula, shown in the inferior vertebral body, is an extension of the trajectory reaching the contralateral pedicle on AP fluoroscopy (point 3) at the instrument's most anterior position within the anterior third of the vertebral body on lateral view (point 3). (With permission from Mayfield Clinic.)

Planning the Approach

After establishing the true AP and lateral views for the target vertebral body, the surgeon marks each pedicle's center with a radio-opaque instrument and draws a bipedicular line. Next, a mark is made 8 to 12 cm lateral to midline along the bipedicular line (**Figure 4**, point 1). An entry point is chosen 8 cm off midline at L1, 9 cm off midline at L2, 10 cm off midline at L3, or 11 cm off midline at L4 or L5. Access to L5 may be difficult because of the iliac crest: given the extreme medial angulations of the L5 pedicles and the largeness of the vertebral body, there may be less reason to use an extrapedicular approach at L5.

Surgical Technique

Surgical technique is demonstrated in **Video 3**. With a trajectory approximately 60° to the vertical plane, a spinal needle is advanced along the bipedicular line on AP fluoroscopy, anterior to the transverse process, to the junction of the ipsilateral pedicle and the posterior vertebral body at their lateral walls (**Figure 4**, point 2). An initial trajectory that is too ventral or too dorsal can be corrected easily by slight adjustments in their trajectory. After periosteal anesthesia is administered, the spinal needle is withdrawn and the 11-gauge Jamshidi is advanced along the same trajectory to the same entry point. From this entry point, an instrument can easily be advanced through the vertebral body obliquely toward the plane of the contralateral pedicle on AP fluoroscopy while reaching the anterior one third of the vertebral body on lateral fluoroscopy (**Figure 4**, point 3). Care is taken to avoid violation of the anterior cortical margin of the vertebral body.

Additional Considerations

Unique to the lumbar extrapedicular approach is the security of vertebral body access during subsequent maneuvers. Unlike an instrument advanced through the pedicle, very little bony purchase is obtained at the point of vertebral body entry. Care is taken to avoid dislodging the Jamshidi needle or osteointroducer cannula from the vertebral body because reaccess may prove difficult. Clearing the instruments of any residual methacrylate before their removal from the vertebral body avoids the problem of the polymer escaping into the surrounding soft tissues. Such leakage, although unlikely to cause symptoms, is undesirable. Conversely, methylmethacrylate dragged back during instrument removal after a transpedicular approach will remain within a bony compartment. Despite these potential difficulties, we prefer the lumbar extrapedicular approach for its ease and ability to achieve dramatic bone tamp inflation during kyphoplasty.

THORACIC EXTRAPEDICULAR APPROACH

The far lateral entry point necessary for the lumbar extrapedicular approach is not possible in the thoracic spine because of the ribs and pleura. Instead, a thoracic approach uses the potential space between the rib head, transverse process, and pedicle (7).

Planning the Approach

With true AP and lateral fluoroscopic views of the target vertebral body established, the AP view is used as the surgeon marks the top of each pedicle and measures its distance from the spinous process. The skin entry is then marked at 1.5 times the spinous-pedicle distance, lateral to the pedicle, along the bipedicular line (**Figure 5**, point 1). With local anesthetic, a small stab incision is made in the skin.

Surgical Technique

Surgical technique is demonstrated in **Video 4**. The instrument is advanced obliquely until the rib head is felt. Following the posterior wall of the rib, the instrument

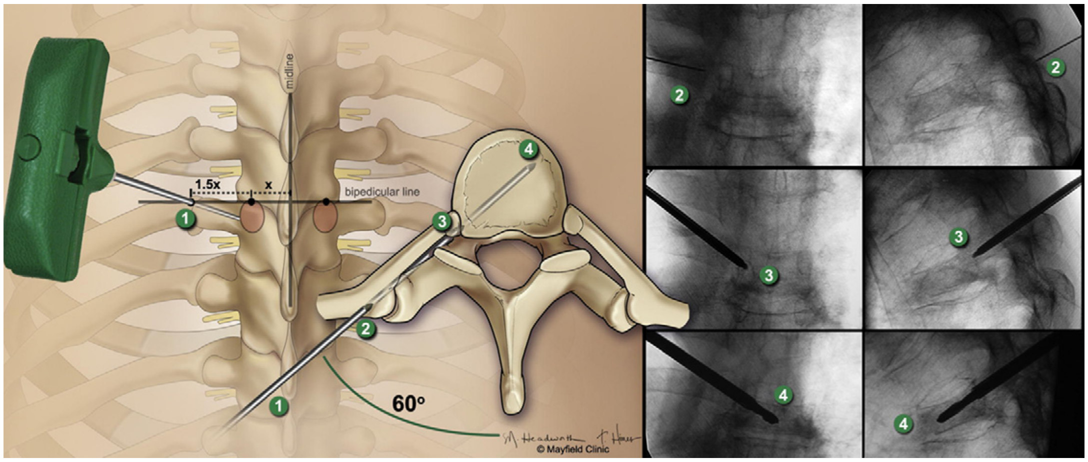

Figure 5. Thoracic extrapedicular approach. After each pedicle top is marked on the skin, the distance from the spinous process to the pedicle is measured. Skin entry is marked approximately 1.5 times the spinous-pedicle distance, lateral to the pedicle, along the bipedicular line (point 1). The needle is advanced obliquely at a 60° angle until the junction of the rib head and the transverse process is felt (point 2). Following the posterior wall of the rib, the needle is advanced until it is aligned with the medial wall of the pedicle on anterior–posterior fluoroscopy and appears just anterior to the posterior cortical margin of the vertebral body on lateral fluoroscopy (point 3). Final position is obtained by further advancing the instrument to the anterior one third of the vertebral body (point 4). (With permission from Mayfield Clinic.)

must be advanced anterior to the transverse process (**Figure 5**, point 2). The trajectory is relatively fixed once it is between the rib and transverse process, and then it is confirmed on lateral fluoroscopy. After confirmation of the cranial–caudal trajectory, the instrument is then advanced into the vertebral body by entry into the lateral wall of the pedicle, crossing it as the instrument is advanced. Confirmation of the instrument position is critical at this step: its tip must remain lateral to the medial border of the pedicle on AP view until the tip is anterior to the posterior vertebral body border on lateral view (**Figure 5**, point 3). Failure to maintain this relationship risks entry into the spinal canal. Unlike the transpedicular approach, this is relatively easy to avoid in the extrapedicular approach.

Once within the vertebral body, certain attempts may accentuate the instrument's medial course to achieve access across midline within the vertebral body. Tips for redirecting a Jamshidi needle or other instrument are discussed in the section on transpedicular approach. Similar to all approaches at this point, the surgeon must recognize the anterior cortical margin of the vertebral body (**Figure 5**, point 4). The cortex may actually be posterior to the apparent position on lateral fluoroscopy.

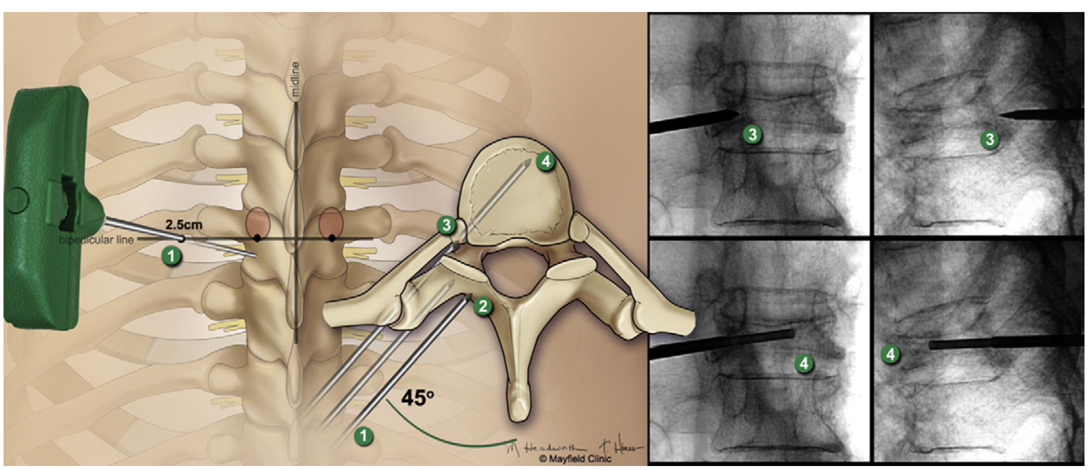

Figure 6. Thoracic infrapedicular approach. The inferior border of each pedicle is marked on the skin. Skin entry is marked 2.5 cm lateral to the pedicle on the approach side, along the bipedicular line (point 1). The needle is advanced at a 45° angle until it meets the bony lamina (point 2), posterior to the canal. Maintaining approximately the same angle, the surgeon slides the entire needle laterally until it advances beyond the lateral edge of the lamina and falls off, landing on the vertebral body below the pedicle (point 3). The trajectory allows access to the plane of the contralateral pedicle within the vertebral body (point 4). (With permission from Mayfield Clinic.)

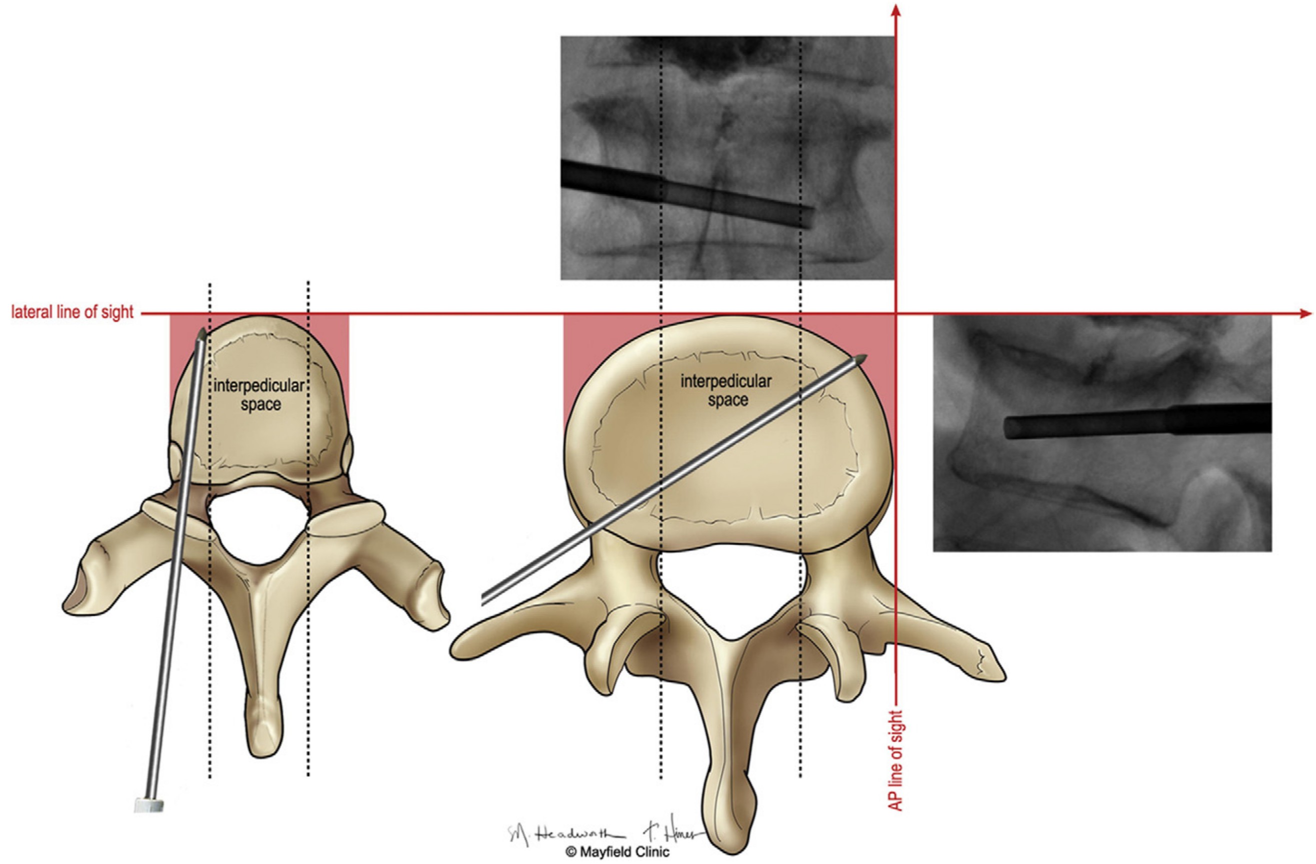

Figure 7. Danger zones at the anterior border of the vertebral bodies. Instruments within the red areas may appear to be within the vertebral body on both anterior–posterior (AP) and lateral fluoroscopy, yet have perforated the anterior cortical margin. To avoid entering the danger zone, the surgeon should advance an instrument no more than three fourth of the vertebral bodies in AP dimension (on lateral view) unless it is nearly centered between the pedicles on AP view. (With permission from Mayfield Clinic.)

THORACIC INFRAPEDICULAR APPROACH

During the thoracic extrapedicular approach, a difficulty is the inability to alter instrument trajectory in the axial plane. That is, it is relatively fixed after it enters the space between the rib head and transverse process. When compared with the transpedicular approach, the infrapedicular approach allows greater flexibility because of its medial angulation, lacks the usual safety of a bony canal, and has the advantage that the thoracic laminae are slightly wider than the vertebral body itself.

Planning the Approach

With true AP and lateral fluoroscopic views to the target vertebral body, the surgeon uses the AP view to mark each pedicle's inferior border. Skin entry is then marked 2.5 cm lateral to the pedicle on the side of the approach, along the bipedicular line (**Figure 6**, point 1).

Surgical Technique

Surgical technique is demonstrated in **Video 5**. After injection of local anesthetic, a spinal needle is advanced at a 45° angle until it meets bone. Lateral fluoroscopy will confirm the needle tip is on the lamina, posterior to the canal (**Figure 6**, point 2). Maintaining approximately the same angle, the surgeon slides the entire needle laterally until it advances beyond the lateral edge of the lamina. Although the sensation can be startling for those unaccustomed to this approach, AP fluoroscopy confirms that the needle tip is located between the lateral edge of the vertebral body and the lateral border of the pedicle; the lateral view confirms the needle is positioned at the posterior border of the vertebral body (**Figure 6**, point 3). The periosteum is then anesthetized.

The Jamshidi needle or K-wire is inserted into the skin incision, matching the trajectory of the spinal needle at this point. Injection of local anesthetic is continued as the spinal needle is withdrawn and the next instrument is advanced. Despite this step, the surgeon does not often reach the vertebral body with the Jamshidi or K-wire on the first attempt and the procedure for the spinal needle must be repeated. Like the lumbar extrapedicular approach, the instrument is entirely within soft tissue until reaching the vertebral body. Once the vertebral body is reached, the surgeon can easily adjust the trajectory to suit the desired target.

Additional Considerations

In the infrapedicular approach, particular attention is paid to the instrument's angu-

Table 1. Comparison of Percutaneous Approaches

Approach	Trajectory	Fluoroscopy View	Landmarks	Pearls
Transpedicular	Inferior and medial orientation of pedicle	AP: align inferior endplate of superior vertebral body and spinous process centered between pedicles Lateral: align endplates to eliminate ellipse and posterior cortical margin to eliminate duplication	Begin in upper, outer quadrant Stay lateral to medial pedicle border until anterior to posterior cortical margin	Skin incision 1–2 cm superior and lateral to pedicle Bone entry on "slope" of facet behind transverse process
Lumbar extrapedicular	Oblique, anterior to transverse processes	Same	Central bipedicular line Pedicle–vertebral body junction for bone entry	Extra care to ensure introducer cannula security because of shorter bone purchase More lateral entry will flatten trajectory past transverse process
Thoracic extrapedicular	Potential space between rib head, transverse process, pedicle	Same	Superior bipedicular line Palpable junction of transverse process and rib head	Palpate rib as moving medial to step off with transverse process
Thoracic infrapedicular		Same	Inferior bipedicular line Parallel to inferior endplate	Palpate lamina as moving lateral to drop-off to posterior vertebral body

AP, anterior–posterior.

lation during the initial approach to the vertebral body. Do not alter the angle of approach when attempting to pass lateral to the lamina. Rather, move the instrument laterally while maintaining a 45° angle to horizontal. If oriented too vertically with respect to the floor, the instrument may simply pass along the lateral wall of the vertebral body rather than enter with an appropriate trajectory. Similarly, the warnings described above should be heeded regarding the actual position of the anterior cortex of the vertebral body. Unless the skin entry point is too far lateral, it is difficult to enter the spinal canal using this approach. Careful monitoring on lateral fluoroscopy reveals an appropriate approach appearing parallel to and just superior to the inferior endplate of the vertebral body. If the approach is more superior, near the inferior border of the pedicle, injury to the nerve root may occur. Using the guidelines above, we have found this approach very safe and effective in achieving bilateral vertebral body access with a unilateral approach.

SAFETY CONSIDERATIONS

An anatomical consideration important for safety within the vertebral body is its anterior border, which is curvilinear on the axial view (**Figure 7**, **Video 6**). As such, the anterior cortical margin between the pedicles on AP view reaches farther anterior than the cortical margins lateral to the pedicles. This more posterior cortical margin cannot be appreciated on lateral fluoroscopy. Therefore, an instrument that appears to be within the vertebral body on both AP and lateral images could in fact extend anterior to the vertebral body. As a general guideline, we recommend an instrument be advanced anteriorly no more than three fourth of the AP dimension (on lateral view) of the vertebral bodies unless it is nearly centered between the pedicles on AP view.

After the needle insertion into the vertebral body, a single injection of contrast medium is often advocated to identify paraspinal veins where cement might leak during injection (vertebrogram) (10). This may help predict or prevent transvenous cement embolus resulting in pulmonary embolus. This practice is not uniform and may obscure cement visualization if injected contrast remains in the bone (6, 18).

DISCUSSION

Accurate interpretation of the fluoroscopic anatomy and refinement of the percutaneous trajectories ensure safe access to the target vertebral body. Traditional percutaneous approaches to the thoracic and lumbar vertebral bodies offer the security of a bony canal; their significant advantages minimize damage to the nerve root or the dura because the surgeon stays within the bony canal (11, 12). Although protective for the neural elements, this approach is confining, often prevents the instruments' passage beyond midline, and in turn, does not promote the important symmetric deposition of cement (13). Without proper cement deposition, a bilateral approach must be used, which increases the operative time and all its concordant risks. Occasionally, prior intervention may preclude this transpedicular access (14). In addition, placement of the needle and cement on the opposite side can be complicated by the poor visualization because of the cement already injected (11). Lastly, instrumentation of the pedicle always carries the risk of fracture to the pedicle; this risk is doubled with a bipedicular approach.

In a study of percutaneously placed pedicle screws, percutaneous transpedicular navigation can prove challenging, with cortical violation occurring in 80% of patients (16). However, Kim et al. described that a unilateral extrapedicular approach to kyphoplasty or vertebroplasty offers several benefits, including shorter operative time, which in turn reduces perioperative risks that are considerable in seniors with multiple medical issues (11). This approach also reduces postoperative pain because there is a single incision. Because of its extrapedicular approach, the risk of pedicle fracture, and thus vertebral body instability, is usually negligible. A unilateral approach also uses fewer injections of cement, thus decreasing the risk of cement extravasation.

Because a unilateral extrapedicular approach is unfamiliar to many neurosurgeons, the learning curve is steep as noted by the senior author (AJR). The usual bony boundaries are not present, and the surgeon must rely on the fluoroscopic imaging and develop a three-dimensional visualization of the vertebral anatomy (**Table 1**). Several important questions are raised in perusal of this approach, including the adequacy of the cement amount injected and the importance of crossing midline in cement placement. Our experience of injection of 3–10 mL of methylmethacrylate through this unilateral approach without difficulty is comparable to other authors' reported injection amounts for kyphoplasty or vertebroplasty (5). Peters et al. (15) have reported that with experience one can advance the cement past midline using the conventional transpedicular approach. Although we agree that this can be true in experienced hands, the extrapedicular approach makes bilateral placement of cement significantly easier. Additionally, a logical assumption would be that maximal filling of the vertebral body with cement would lead to maximal benefit; however, no such direct proportional relationship has been shown between the amount of cement deposited and the extent of pain relief (3, 4). Moreover, neither the biomechanical strength nor stability of the vertebral body appears to depend on the amount of cement placed (17). With regards to the importance of symmetrical cement placement in the vertebral body, at least one study has shown that this affects postprocedural strength and stability of the vertebral body (13).

CONCLUSIONS

Percutaneous access via vertebroplasty or kyphoplasty offers a new treatment paradigm for degenerative spinal disease and VCFs. Traditional techniques involve a transpedicular approach and cannulization of both pedicles for adequate bilateral and symmetric placement of methylmethacrylate. Compared with a bipedicular approach, an extrapedicular approach can achieve the same symmetric placement of cement without the risk of fracture/instability. Certain key anatomical and radiological landmarks are critical for each percutaneous technique used in the treatment of VCFs in the thoracic and lumbar spine, and deepen our understanding of the nuances for each in terms of skin incision, needle trajectory, and particular restrictions. Of the multiple percutaneous approaches, especially vertebroplasty or kyphoplasty, that may yield access to the vertebral bodies in patients with VCFs, their use applies to any radiographically guided percutaneous spinal procedures. With increasing popularity of minimally invasive procedures, percutaneous spinal access will become an important tool for spinal neurosurgeons. Understanding the standard anatomical landmarks, fluoroscopic views, and avenues of approach may ensure their safe, effective use in many spinal procedures.

REFERENCES

1. Appel NB, Gilula LA: Bull's-eye modification for transpedicular biopsy and vertebroplasty. AJR Am J Roentgenol 177:1387-1389, 2001.
2. Cooper C, Atkinson EJ, Jacobsen SJ, O'Fallon WM, Melton LJ, 3rd: Population-based study of survival after osteoporotic fractures. Am J Epidemiol 137: 1001-1005, 1993.
3. Cotten A, Dewatre F, Cortet B, Assaker R, Leblond D, Duquesnoy B, Chastanet P, Clarisse J: Percutaneous vertebroplasty for osteolytic metastases and myeloma: effects of the percentage of lesion filling and the leakage of methylmethacrylate at clinical follow-up. Radiology 200:525-530, 1996.
4. Deramond H, Depriester C, Galibert P, Le Gars D: Percutaneous vertebroplasty with polymethylmethacrylate: technique, indications, and results. Radiol Clin North Am 36:533-546, 1998.
5. Fourney DR, Schomer DF, Nader R, Chlan-Fourney J, Suki D, Ahrar K, Rhines LD, Gokaslan ZL: Percutaneous vertebroplasty and kyphoplasty for painful vertebral body fractures in cancer patients. J Neurosurg 98:1-30, 2003.
6. Gaughen JR Jr, Jensen ME, Schweickert PA, Kaufmann TJ, Marx WF, Kallmes DF: Relevance of antecedent venography in percutaneous vertebroplasty for the treatment of osteoporotic compression fractures. AJNR Am J Neuroradiol 23:594-600, 2002.
7. Hide IG, Gangi A: Percutaneous vertebroplasty: history, technique and current perspectives. Clin Radiol 59:461-467, 2004.
8. Lewis WH, ed.: Gray's Anatomy of the Body 20th ed.New York; Bartleby.com, 2000.
9. Melton LJ 3rd: Epidemiology of spinal osteoporosis. Spine 22:2S-11S, 1997.
10. McGraw JK, Heatwole EV, Strand BT, Silber JS, Patzilk SB, Boorstein JM: Predictive value of intraosseous venography before percutaneous vertebroplasty. J Vasc Interv Radiol 13:149-153, 2002.
11. Kim AK, Jensen ME, Dion JE, Schweickert PA, Kaufmann TJ, Kallmes DF: Unilateral transpedicular percutaneous vertebroplasty: initial experience. Radiology 222:737-741, 2002.
12. Lane JM, Johnson CE, Khan SN, Girardi FP, Cammisa FP: Minimally invasive options for the treatment of osteoporotic vertebral compression fractures. Orthop Clin N Am 33:431-438, 2002.
13. Liebschner MA, Rosenberg WS, Keaveny TM: Effects of bone cement volume and distribution on vertebral stiffness after vertebroplasty. Spine 26: 1547-1554, 2001.
14. Mehdizade A, Payer M, Somon T, Willhelm K, Kelekis A, Wetzel S, Palmesino M, Lovblad KO, Rufenacht DA, Martin JB: Percutaneous vertebroplasty through a transdiscal access route after lumbar transpedicular instrumentation. Spine J 4:475-479, 2004.
15. Peters KR, Guiot BH, Martin PA, Fessler RG: Vertebroplasty for osteoporotic compression fractures: current practice and evolving techniques. Neurosurgery 51:96-103, 2002.
16. Schizas C, Michel J, Kosmopoulos V, Theumann N: Computer tomography assessment of pedicle screw insertion in percutaneous posterior transpedicular stabilization. Eur Spine J 16:613-617, 2007.
17. Tohmeh AG, Mathis JM, Fenton DC, Levine AM, Belkoff SM: Biomechanical efficacy of unipedicular versus bipedicular vertebroplasty for the management of osteoporotic compression fractures. Spine 24:1772-1776, 1999.
18. Vasconcelos C, Gailloud P, Beauchamp NJ, Heck DV, Murphy KJ: Is percutaneous vertebroplasty without pretreatment venography safe? Evaluation of 205 consecutive procedures. AJNR Am J Neuroradiol 23:913-917, 2002.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 2 September 2011; accepted 10 September 2012; published online 23 September 2012

Citation: World Neurosurg. (2013) 80, 3/4:428-435.
http://dx.doi.org/10.1016/j.wneu.2012.09.005

*Journal homepage: **www.WORLDNEUROSURGERY.org***

*Available online: **www.sciencedirect.com***

1878-8750/$ - see front matter