Interventional Pain Medicine 2 (2023) 100261

Contents lists available at ScienceDirect

Interventional Pain Medicine

journal homepage: www.journals.elsevier.com/interventional-pain-medicine

Intracept technique at adjacent levels to fusions with pedicle screws

Dear Editor:

Intraosseous basivertebral nerve ablation (Intracept) is indicated for the treatment of chronic vertebrogenic low back pain with failure of at least 6 months of conservative treatment. The standard technique involves *trans*-pedicular access, which is generally not possible in the presence of pedicle screws. The article details an alternate technique to access the vertebral body for Intracept at a level with pedicle screws for patients with adjacent segment disease and vertebrogenic pain.

Intraosseous basivertebral nerve ablation (BVNA, Intracept) is indicated for the treatment of chronic, axial low back pain attributed to pathologically degenerated vertebral endplates evidenced by Modic Type 1 and/or 2 changes on magnetic resonance imaging (MRI) between L3-S1. Intracept is a valid treatment option for low back pain that is clinically consistent with anterior column pain lasting greater than 6 months despite at least 6 months of conservative treatment. Two multicenter and multiyear randomized controlled trials showed statistically and clinically significant improvement in pain and function in patients who underwent Intracept as compared to sham and standard care [1,2].

Intracept is typically performed using a *trans*-pedicular approach, by which the introducer cannula assembly (ICA) is placed via an oblique approach through the pedicle into the vertebral body. This standard approach may, however, be technically difficult or impossible in the setting of previous posterior spinal fusion with pedicle screws.

In recent years, accessing the vertebral body via an extra-pedicular (EP) approach has been well-described in the context of vertebral augmentation. Beall et al. treated 102 compression fractures using a “parapedicular” approach based on cadaveric studies that revealed a fairly avascular and aneural region of the vertebral body along the superior margin of the vertebral body-pedicle junction [3]. Zhuo et al. demonstrated that 101 compression fractures could be treated using an EP approach, mostly at the L1 through L3 levels, without complication [4], and Jiang et al. described a “modified superior pedicle notch” approach in 47 patients and noted that this technique avoids lumbar artery trauma [5]. Importantly, Xu et al. retrospectively analyzed computed angiography (CTA) in 30 patients and 300 lumbar arteries [6]. The authors found that from the L1 to L3 levels, the posterosuperior region of the vertebral body was relatively avascular, while there was significant variability in the locations of lumbar arteries at the L4 and L5 levels [6]. It should be noted, though, that bleeding complications due to lumbar artery injury requiring intervention (micro-coils, embolization, and retroperitoneal hematoma drainage) have been noted in case reports in as high as the L2 vertebral body [7]. Zhang et al. reviewed various EP approaches and noted that although the majority of arteries were located along the midline of the lateral vertebral body, a small percentage were located in the posterior-superior aspect at L4 and L5, potentially leading to a relatively higher risk of lumbar artery injury with extra-pedicular access at the L4 and L5 levels [8]. Fig. 1 shows the typical location of the lumbar artery near the midpoint of the lateral vertebral body on MRI and Fig. 2 depicts the artery overlying the target zone in the posterolateral vertebral body, which would be a contra-indication to the procedure at this level and side.

Adjacent segment pathology is a well-known sequela of spinal fusion, with 27.8% of patients demonstrating radiographic evidence and 7.6% being symptomatic [9]. Thus, it is not uncommon to see Modic changes at levels adjacent to a fusion. If BVNA is clinically indicated in the setting of adjacent segment disease, it can be accomplished in one of two ways: 1) pedicle screw removal followed by *trans*-pedicular approach; 2) the modified EP approach presented here. Given the surgical risks associated with screw removal, navigating around the screw can be the more reasonable option.

This extra-pedicular approach differs from previously published EP techniques for vertebral augmentation and has several unique challenges to overcome. Not only must one access to the vertebral body occur around a pedicle screw, but one must navigate the J-stylet over the pedicle screw inside the vertebral body before the J-stylet starts to turn abruptly inferiorly, while still remaining in the posterior half of the vertebral body and reaching a midline target medial-to-lateral and superior-to-inferior. We present step-by-step instructions for this alternate BVNA technique.

Pre-operative imaging review for procedure planning is critical. It is recommended to have both MRI and CT of the lumbar spine. The general trajectory of this EP approach consists of docking the ICA at the pedicle-vertebral body junction between the pedicle screw and superior endplate (SEP), advancing it medially over the top of the screw, then driving it caudally to reach the target position, as depicted in Figs. 3–14. Imaging must be reviewed to ensure that such a path is feasible and safe.

Sagittal MRI/CT images must show that at least one foramen directly above each targeted vertebral body is capacious enough inferiorly to allow for docking below the exiting nerve root (Fig. 3). Severe foraminal stenosis preventing the 4 mm ICA from safely entering below the nerve root is a contraindication to this technique.

The anticipated final probe location should be at least 1 cm from any screw to minimize the risk of thermal energy transfer to the screw and adjoining hardware. This should be measured pre-operatively on cross-sectional imaging. Inferiorly or very medially placed pedicle screws inside the vertebral body may not allow for this. This 1 cm distance is extrapolated from the guideline that the ablation probe be at least 1 cm from the posterior cortex of the vertebral body to avoid thermal transmission to the spinal canal.

For each vertebral body, the better side for entry should be predetermined. Typically, this is the side with screw placement that is lower within the pedicle and less oblique in orientation, allowing for more caudal docking and with less obstruction by the screw head. Anatomic

https://doi.org/10.1016/j.inpm.2023.100261
Received 22 April 2023; Received in revised form 29 May 2023; Accepted 30 May 2023

Fig. 1. Sagittal T2 weighted MRI depicting the lumbar artery in the typical location in the midpoint of the lateral vertebral body (white arrows).

Fig. 2. Sagittal STIR MRI showing an atypical location of the lumbar artery overlying the superior posterolateral aspect of the vertebral body (white arrow).

impediments, especially if asymmetric, should also be considered when choosing the optimal side, including foraminal stenosis, high iliac crest, medial/dorsal kidney location, ipsilateral scoliotic rotation, facet hypertrophy, and bony fusion mass.

Once the optimal side of access is chosen for a given vertebral body, the angle of entry is measured. The angle is measured on axial images in the plane of the discs at the pedicle level. One line is drawn from a point lateral to the pedicle screw head and/or superior articular process (SAP), through the lateral aspect of the pedicle-vertebral body junction, and to the midline of the vertebral body. The second is a sagittal line from the spinous process through the midline of the vertebral body where it will intersect with the first line. This intersection typically occurs 50–75% anterior to the posterior aspect of the vertebral body, yielding an angle of about 40–50° in most cases (Fig. 4).

The c-arm is tilted to square the SEP and obliqued ipsilaterally to the premeasured angle. The image intensifier is then tilted slightly cephalad to visualize a landing area on the vertebral body below the SEP and just lateral to the junction of the superior articular process (SAP) medially and transverse process (TP) inferiorly (Fig. 5).

The ICA, with the bevel-tip stylet in place, is inserted slightly lateral to the target and advanced until bone is contacted on the vertebral body, just superolateral to the pedicle, below the SEP (Fig. 6). An AP image is taken to ensure the tip is not entering medially into the foramen before entering the cortex of the vertebral body [Fig. 7]. A lateral image should confirm that the tip is at the pedicle-body junction (Fig. 8).

Upon docking on bone, the ICA should have the bevel-tip oriented to travel medially/dorsally to prevent skiving ventrally on initial malleting, which can potentially cause vascular injury. This also helps maintain a more medial trajectory as the ICA enters the vertebral body. Depressing

Fig. 3. Sagittal T1 weighted MRI demonstrating adequate room for the introducer cannula assembly (ICA) below the exiting nerve root. The target point for entry into bone is marked with the white asterisk.

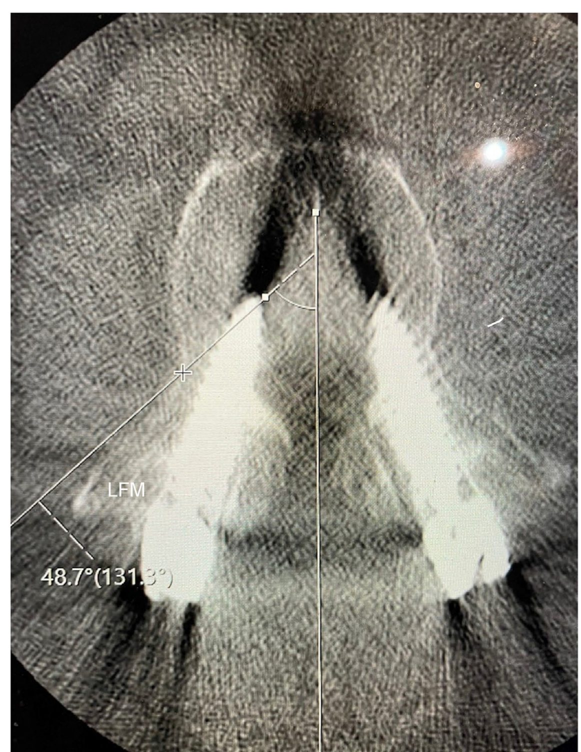

Fig. 4. Axial CT with the measured angle of entry around pedicle screw head, superior articular process, lateral fusion mass (LFM) or other obstructions. The target point for entry into bone is marked with the black cross.

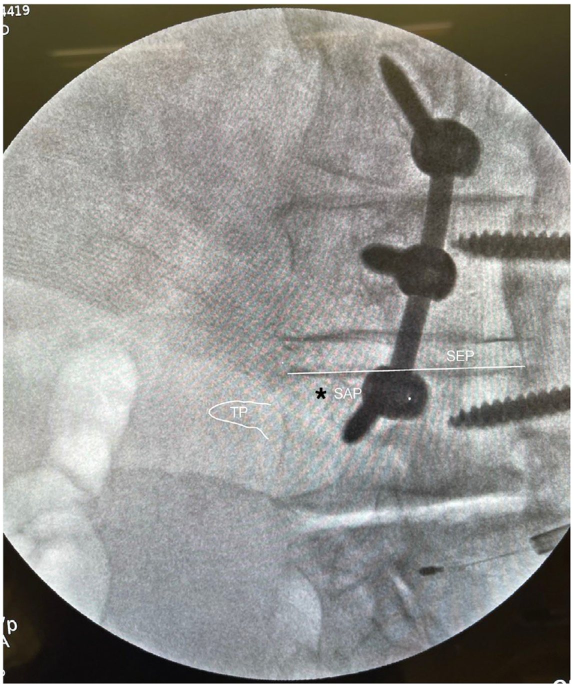

Fig. 5. Oblique fluoroscopic view with starting point marked with a black asterisk, inferior to superior endplate (SEP), superior to transverse process (TP) and lateral to superior articular process (SAP).

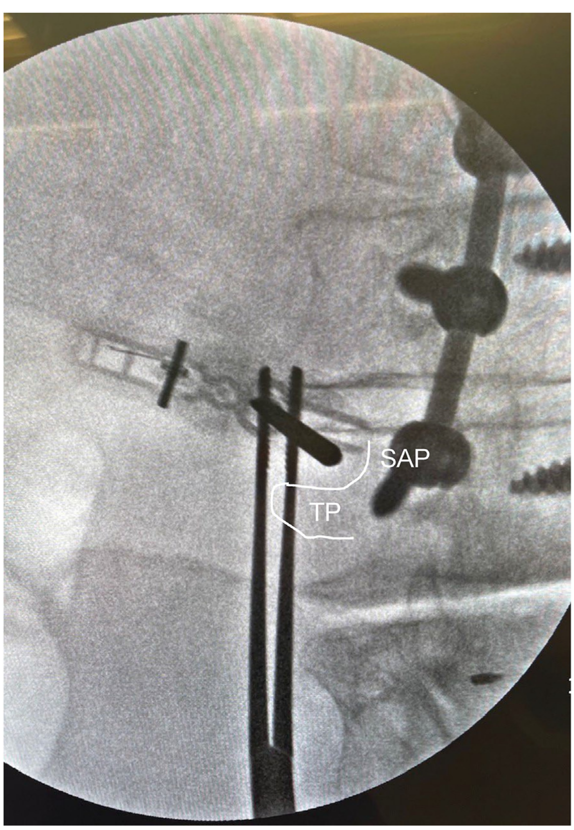

Fig. 6. Oblique fluoroscopic view with the ICA contacting the target on the vertebral body.

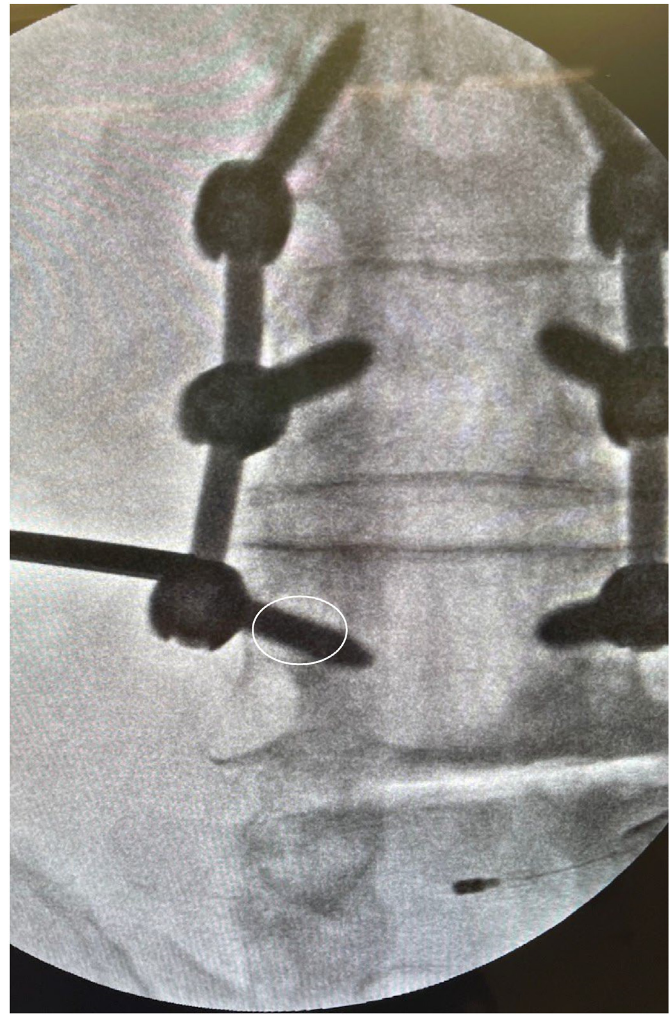

Fig. 7. AP fluoroscopic view with ICA at docking point on bone at the junction of superolateral pedicle and vertebral body (white ellipse outlining pedicle).

the ICA handle ventrally during malleting can further accentuate the lateral-to-medial trajectory.

Once the leading edge of ICA is through the cortex of the vertebral body on the lateral view (Fig. 9), an ipsilateral oblique view in same plane as the pedicle screw is then obtained. The ICA is slowly advanced in this view until it begins to cross above the pedicle screw (Fig. 10). This will ensure that the curved cannula assembly (CCA) does not start curving caudally/medially until it passes over the screw.

Before switching to the CCA, an AP view is obtained to confirm that the leading edge of ICA is fully through the cortex on this view as well; typically, it will be at approximately mid-pedicle on AP view at this point. If the ICA is not far enough into the vertebral body, the J-stylet may get stuck and kink as it attempts to enter the cortex.

When removing the bevel-tip stylet and inserting the J-stylet to create the CCA, care should be taken to not dislodge the introducer cannula, as there is much less purchase of cannula in bone compared to the transpedicular approach.

The CCA is oriented to curve inferiorly as it is advanced Figs. 11 and 12. Frequent toggling between AP and lateral views, as well as small taps and directional corrections, are used to maintain an appropriate trajectory, as there will be simultaneous movements in lateral-to-medial, posterior-to-anterior, and superior-to-inferior planes with each tap. On a squared AP view, the trajectory should be that the J-stylet aims toward the contralateral inferior corner of the vertebral body until the standard target is reached and confirmed in AP and lateral views (Fig. 12–13).

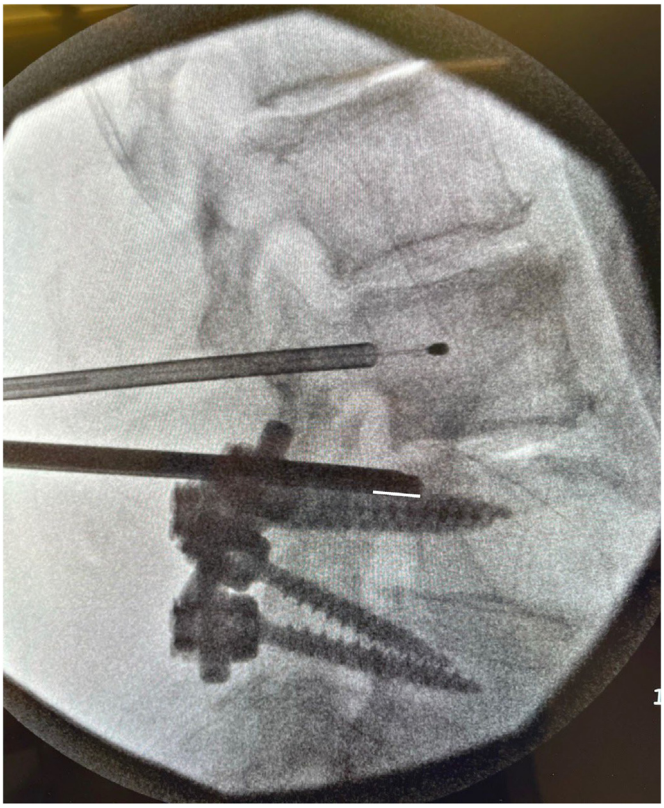

Fig. 8. Lateral fluoroscopic view with ICA contacting bone at the junction of superolateral pedicle and vertebral body (white line indicating superior pedicle).

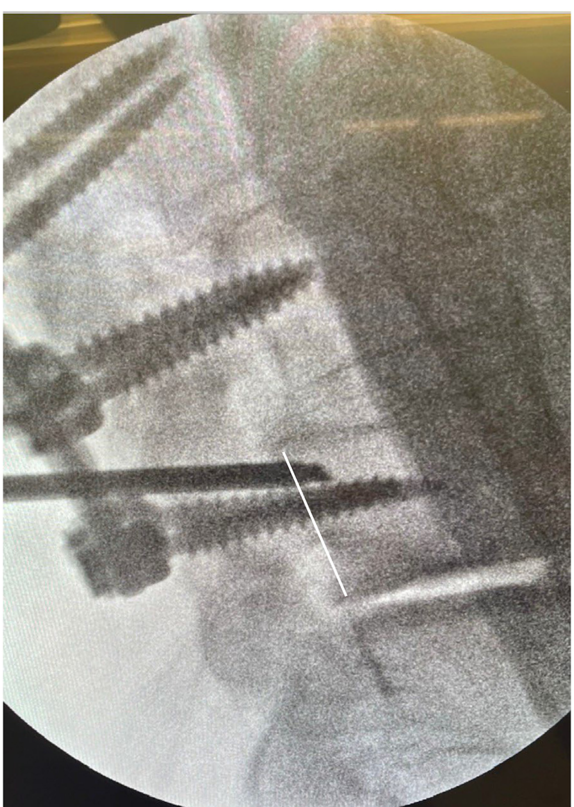

Fig. 9. Lateral fluoroscopic view with the stylet tip and leading edge of ICA through cortex of the vertebral body (white line depicting posterior vertebral body).

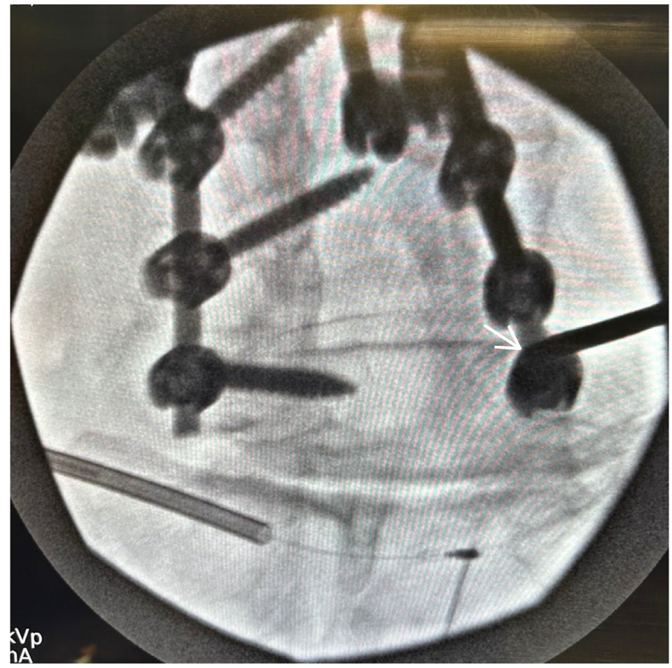

Fig. 10. Oblique fluoroscopic view in the plane of right L5 pedicle screw, confirming the ICA has started to cross over the screw (white arrow indicating tip of ICA).

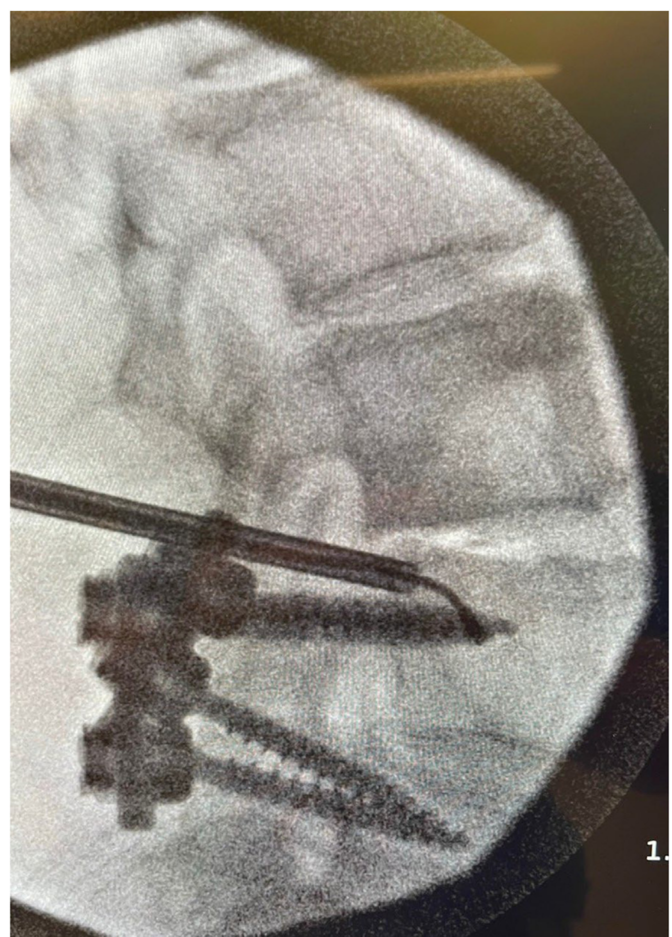

Fig. 11. Lateral fluoroscopic view demonstrating the J stylet starting to curve inferiorly over the pedicle screw.

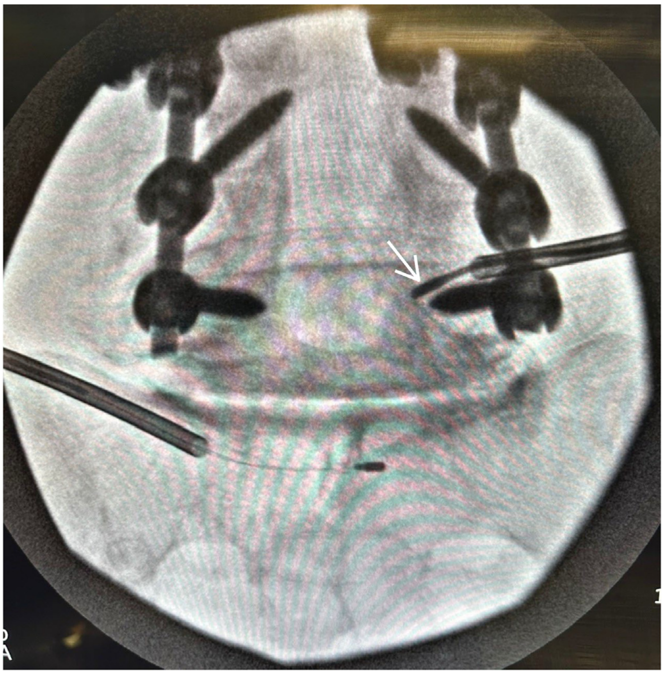

Fig. 12. AP fluoroscopic view showing the J stylet starting to curve inferomedially over the right L5 pedicle screw (white arrow).

This technique article demonstrates the feasibility of performing Intracept for a level adjacent to a spinal fusion with pedicle screws via EP access. The safety profile of this technique is extrapolated from published literature on EP access for vertebral augmentation [3–8]. Patients need to be made aware that this technique may have an increased risk of vascular injury compared to standard *trans*-pedicular access, despite proper pre-operative planning. Consideration should be given to obtaining CTA prior to performing Intracept via the EP approach, particularly when targeting the L4 and/or L5 levels when the lumbar artery is not clearly visualized on MRI. Larger studies are warranted to evaluate the safety and efficacy of this technique.

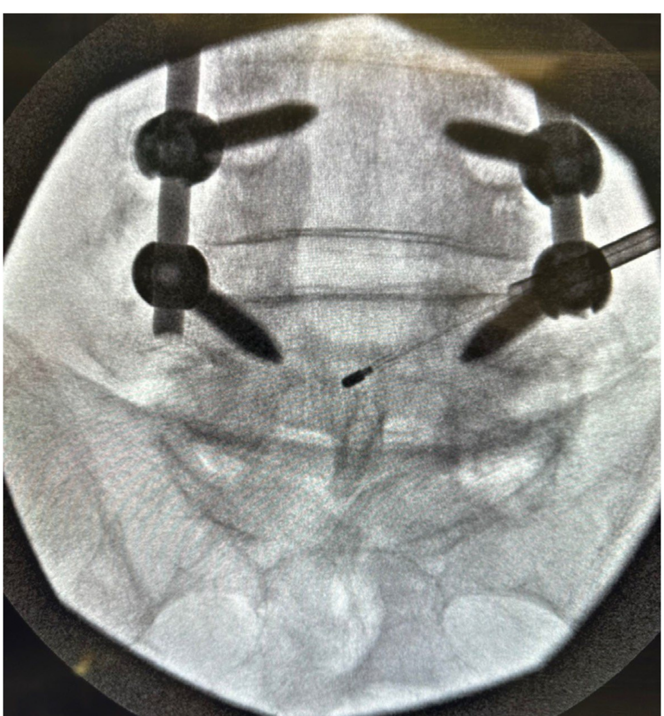

Fig. 13. AP fluoroscopic view showing the final electrode position halfway between the endplates and lateral borders of the vertebral body.

Fig. 14. Lateral fluoroscopic view demonstrating the final electrode position halfway between the endplates and 30 to 50% from the posterior cortex (white arrow).

Conflicts of interest and source of funding

The authors, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity for the preparation of this article. Relevant disclosures related to the topic of the article are listed on disclosure forms.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Fischgrund JS, Rhyne A, Macadaeg K, Moore G, Kamrava E, Yeung C, Truumees E, Schaufele M, Yuan P, DePalma M, Anderson DG, Buxton D, Reynolds J, Sikorsky M. Long-term outcomes following intraosseous basivertebral nerve ablation for the treatment of chronic low back pain: 5-year treatment arm results from a prospective randomized double-blind sham-controlled multi-center study. Eur Spine J 2020 Aug; 29(8):1925–34.

[2] Koreckij T, Kreiner S, Khalil JG, Smuck M, Markman J, Garfin S. INTRACEPT Trial Investigators. Prospective, randomized, multicenter study of intraosseous basivertebral nerve ablation for the treatment of chronic low back pain: 24-Month treatment arm results. N Am Spine Soc J 2021 Oct 26;8:100089.

[3] Beall D, Braswell J, Martin H, et al. Technical strategies and anatomic considerations for parapedicular access to thoracic and lumbar vertebral bodies. Skeletal Radiol 2017; Jan;36(1):47–52.

[4] Zhuo Y, Liu L, Wang H, Li P, Zhou Q, Liu Y. A modified transverse process-pedicle approach applied to unilateral extrapedicular percutaneous vertebroplasty. Pain Res Manag 2021;2021:6493712. https://doi.org/10.1155/2021/6493712. Published 2021 Oct 22.

[5] Jiang Y, Li J, Yuan S, et al. A modified trajectory of kyphoplasty via superior pedicle notch for osteoporotic vertebral compression fractures: technique note and clinical result. Front Surg 2022;9:1012160. https://doi.org/10.3389/fsurg.2022.1012160. Published 2022 Sep. 15.

[6] Xu J, Fan S, Ni Y, Ngwayi JRM, Porter DE, Guo J. An anatomical feasibility study using CTA reconstruction for modified percutaneous lumbar vertebroplasty. BMC

Muscoskel Disord 2022;23(1):693. https://doi.org/10.1186/s12891-022-05586-1. Published 2022 Jul 21.

[7] Heo DH, Cho YJ. Segmental artery injury following percutaneous vertebroplasty using extrapedicular approach. J Korean Neurosurg Soc 2011;49(2):131–3. https://doi.org/10.3340/jkns.2011.49.2.131.

[8] Zhang H, Zhao B, Luo L, Li P, Zhao C, Jiang D, Zhou Q, Liu L. The puncture methods of extrapedicular PVP (PKP): a narrative review. Interdisciplinatry Neurosurgery 2021;25. https://doi.org/10.1016/j.inat.2021.101250. Published 2021 May 11.

[9] Donnally 3rd CJ, Patel PD, Canseco JA, et al. Current incidence of adjacent segment pathology following lumbar fusion versus motion-preserving procedures: a systematic review and meta-analysis of recent projections. Spine J 2020;20(10):1554–65. https://doi.org/10.1016/j.spinee.2020.05.100.

David Stolzenberg*, Paul M. Kitei

Department of Physical Medicine & Rehabilitation, Rothman Orthopaedic Institute, Philadelphia, PA, 19107, USA

Department of Rehabilitation Medicine, Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, 19107, USA

David Tran

Axion Spine and Neurosurgery, Alpharetta, GA, 30005, USA

Ryan Pfeifer

Department of Physical Medicine & Rehabilitation, Rothman Orthopaedic Institute, Philadelphia, PA, 19107, USA

Department of Rehabilitation Medicine, Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, 19107, USA

* Corresponding author. Rothman Orthopaedic Institute at Thomas Jefferson University, 925 Chestnut St, 5th Floor, Philadelphia, PA, 19107, USA.

E-mail address: David.stolzenberg@rothmanortho.com (D. Stolzenberg).