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Original Contribution

Alternative Approach for Lumbar Transforaminal Epidural Steroid Injections

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The traditional superoanterior approach for transforaminal epidural steroid injection (TFESI) carries a risk of complication by obstructing arterial flow to the anterior portion of the spinal cord by puncturing the spinal radicular artery that passes through the superoanterior foraminal zone or "safe triangle" zone, which does not describe vascular safety, but rather describes neural safety. Consequently, multiple disasters have been described in recent years with transforaminal epidural injections. They are utilized extensively even though their effectiveness has been debated.

Here we describe a dorsal technique through transforaminal epidural injections to place the tip of the needle immediately dorsal to the dorsal root ganglion. Multiple different techniques have been discussed and described in recent years, the majority of them to avoid the radicular artery injection.

The primary goal of this paper is to describe another posterior approach to place the tip of spinal needle directly toward the posterior epidural space to avoid puncturing the spinal radicular artery and minimize nerve root penetrations while delivering medication into the epidural space through the foramen.

Key words: transforaminal epidural injection, selective nerve root block, safe triangle zone, radicular artery, radiculomedullary artery, lumbar spinal artery, lumbar vein, intervertebral vein

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The traditional superoanterior approach for transforaminal epidural steroid injection (TFESI) carries a risk of complication by obstructing arterial flow to the anterior portion of the spinal cord by puncturing the spinal radicular artery that passes through the superoanterior foraminal zone or "safe triangle" zone (1) which is the neural safe triangle rather than overall or vascular safe triangle (2-20).

The radicular artery and artery of Adamkiewicz (21-24) are most commonly located along the superoanterior aspect of the foramen (Fig. 1); however it can be located at any location within the neural foramen. The traditional superoanterior approach places a spinal needle tip in the anterior and superior aspects of the foramen, which predisposes to the risk of puncturing a spinal radicular artery placing the patient at risk of complication, which may include paraplegia (2-20). Even so, epidural injections, including transforaminal epidurals, are utilized extensively even though their effectiveness has been debated (25-51).

The objective of the "dorsal technique" to TFESIs has been described to place the tip of the needle "immediately dorsal to the dorsal root ganglion (DRG)" .There have been many new articles published discussing the issues (15,16) and many new technique approaches also have been developed or used by many interventionalists to minimize the serious complications from the traditional superoanterior approach for TFESIs (15-21).

The goal of this article is to provide a preliminary report which objectively describes an alternative posterior approach technique.

Technique

In this alternative approach, a curved spinal needle is placed posterior or posteroinferior within the foramen, and relatively parallel to the DRG or nerve root in the anteroposterior (AP) position. It should wrap around the upper half of the superior articular process (SAP) and the line formed between the lateral border and the midpoint of the superior and inferior pedicles (Fig. 1).

Step 1

The patient is positioned on the table in an anterior

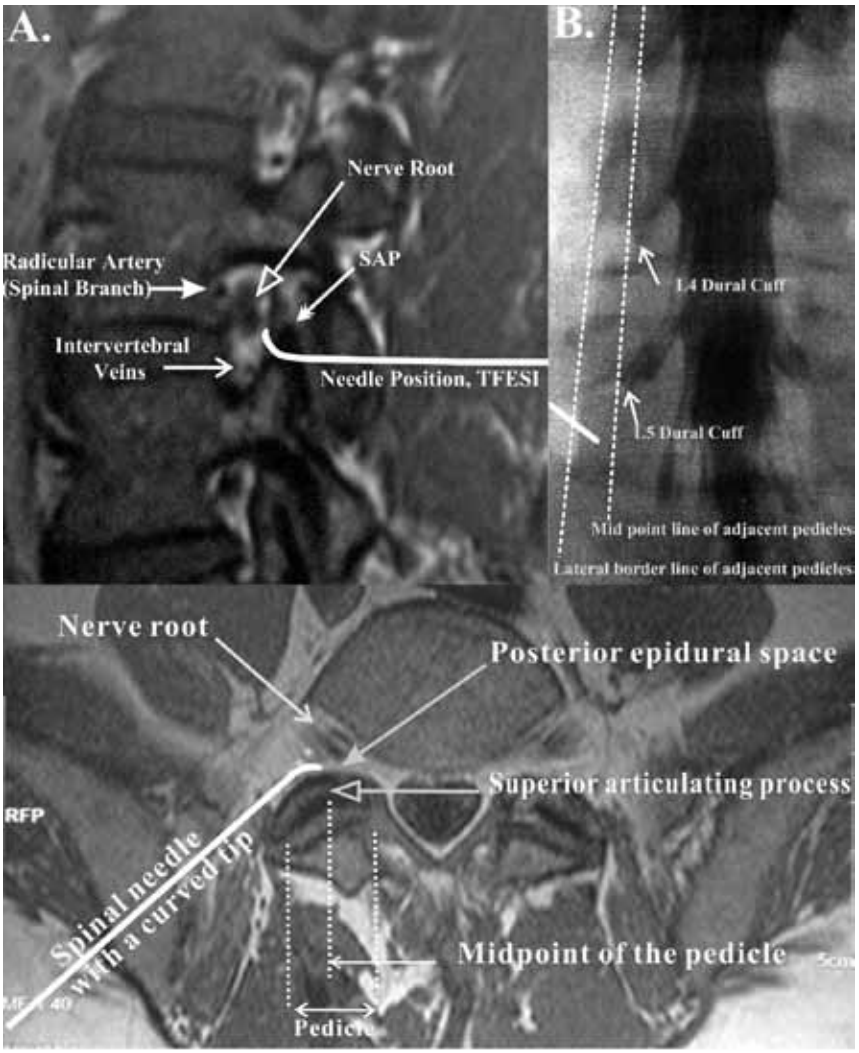

Fig. 1. *The final needle position at L5-S1 foramen for L5 TFESI. (A) Sagittal view of lumbar MRI. Needle: Radicular artery (or the branch of spinal artery) is commonly located superoanterior to the nerve root. White solid arrow: Radicular artery. (B) AP view of lumbar myelogram: The dural cuff may end medial to the midline of adjacent superior and inferior pedicles. (C) Axial view of lumbar MRI. The spinal needle tip wrapped around the SAP.*

oblique or lateral recumbent position with the effected side up. The injection area is prepared and draped in a sterile fashion.

The SAP below the nerve root level is identified using fluoroscopic guidance. The C-arm is adjusted until the superior and inferior vertebral bodies are square and angled around 45° in the oblique view, or until the upper tip of the target SAP is located just directly medial to the midpoint of the vertebral body above the target foramen (Fig. 2).

Step 2

A spinal needle with a curved tip is inserted and advanced under fluoroscopic guidance until contact is made at the upper portion of the SAP, closer to its lateral edge (Fig. 3).

Step 3

The needle is rotated until the curved tip is directed laterally; then, the needle is advanced about 1-2 mm away from the SAP (Fig. 4).

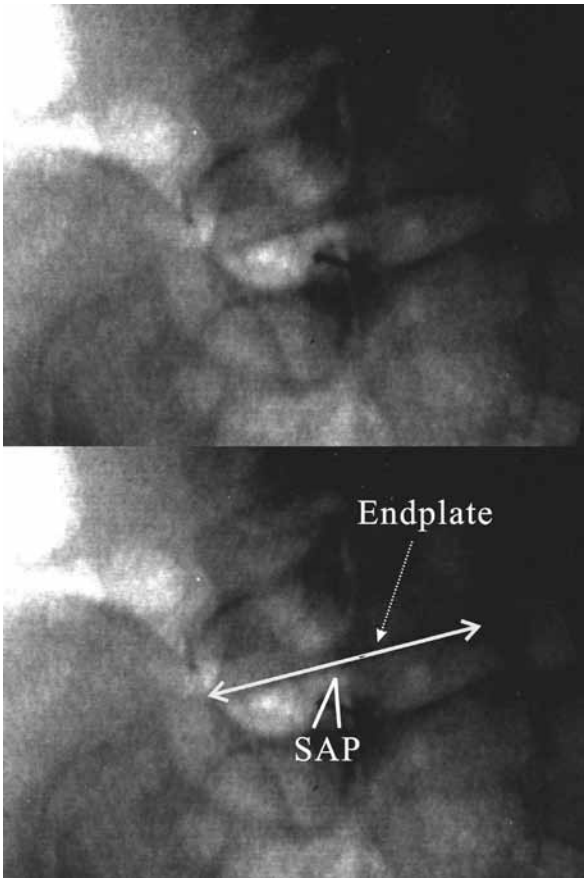

Fig. 2. *The C-arm is tilted until the adjacent vertebral endplates are square and angled around 45° in the oblique view or until the upper tip of the subject SAP is pointing medial to the midpoint of the above vertebral body.*

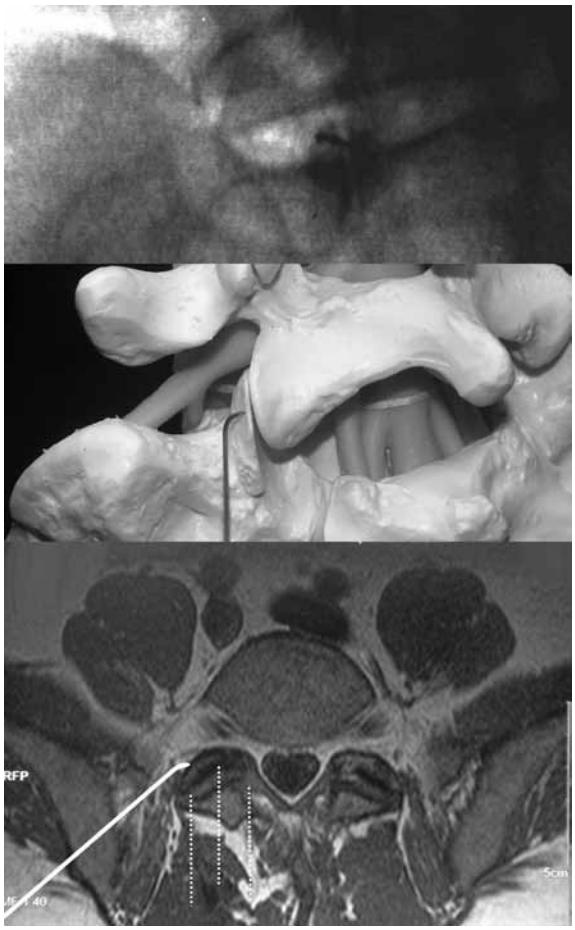

Fig. 3. *A spinal needle with a curved tip is inserted and advanced under fluoroscopic guidance until contact is made at the upper portion of the SAP, closer to its lateral edge.*

Step 4

The needle is then rotated back toward the SAP and advanced another 1-2 mm (Fig. 5).

Step 5

Steps 3 and 4 are repeated under fluoroscopic guidance until the spinal needle tip is wrapped around the SAP between the lateral borderline of the adjacently superior and posterior pedicles and close to the midpoint line of the adjacently superior and posterior pedicles in the AP view of fluoroscopy (Figs. 6 and 7).

Step 6

A lateral fluoroscopic view is then checked to ensure that the needle tip is located within the posterior aspect of the neuroforamen (Fig. 8).

The ideal needle tip position is posterior or posteroinferior and relatively parallel to the DRG or nerve root on the lateral view of fluoroscopy. On the AP

Fig. 5. *The needle is then turned back toward the SAP and advanced another 1-2 mm.*

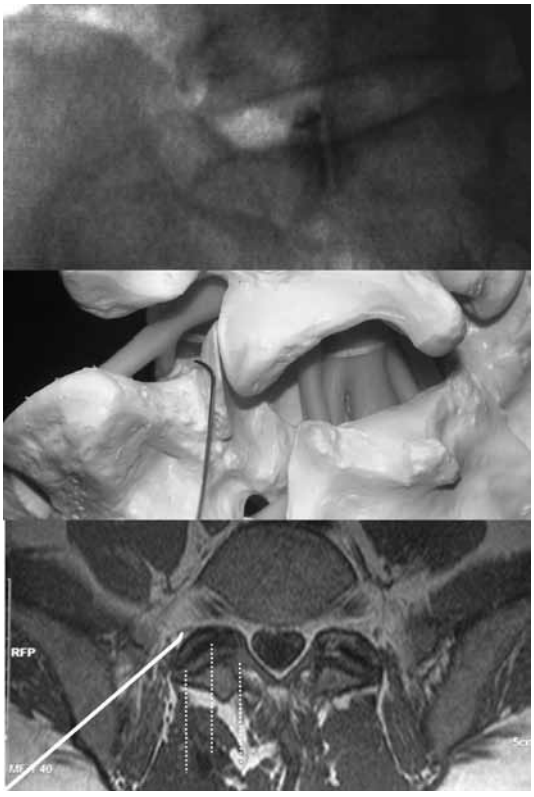

Fig. 4. *The needle is turned until the curved tip is directed laterally, then advanced about 1-2 mm away from the SAP.*

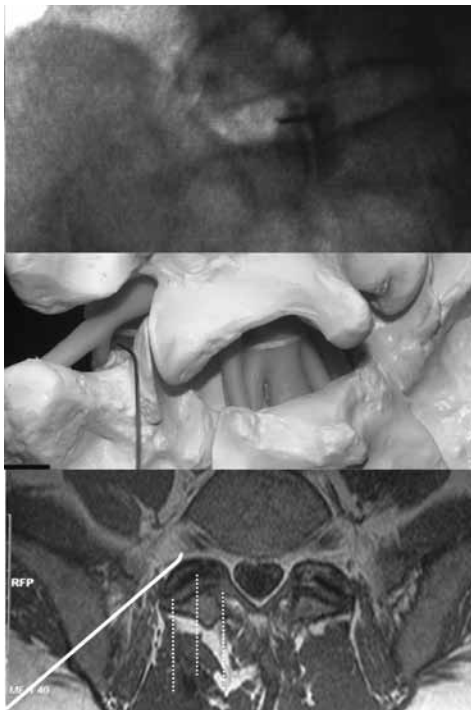

Fig. 6. *The needle is rotated until the curved tip is directed laterally, then advanced another 1-2 mm away from the SAP.*

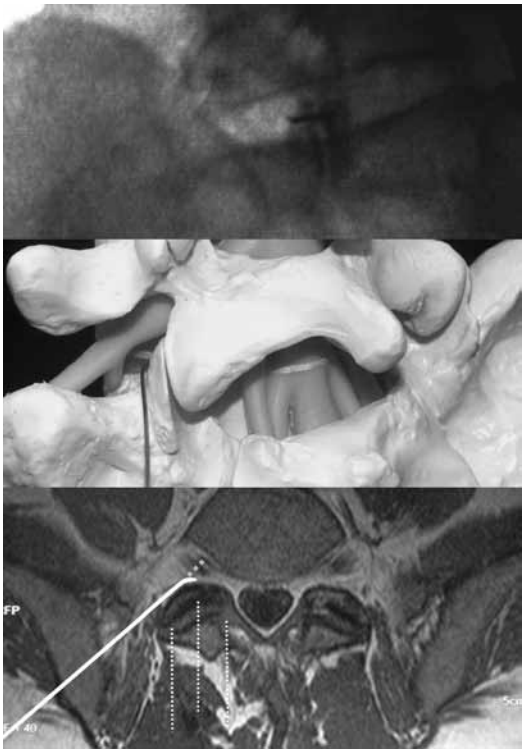

Fig. 7. The needle is then turned back toward the SAP and advanced another 1-2 mm. The above steps are repeated until, under fluoroscopic guidance, the spinal needle tip is wrapped around the SAP between the lateral borderline of adjacent superior and inferior pedicles and the midpoint line of the adjacent superior and inferior pedicles.

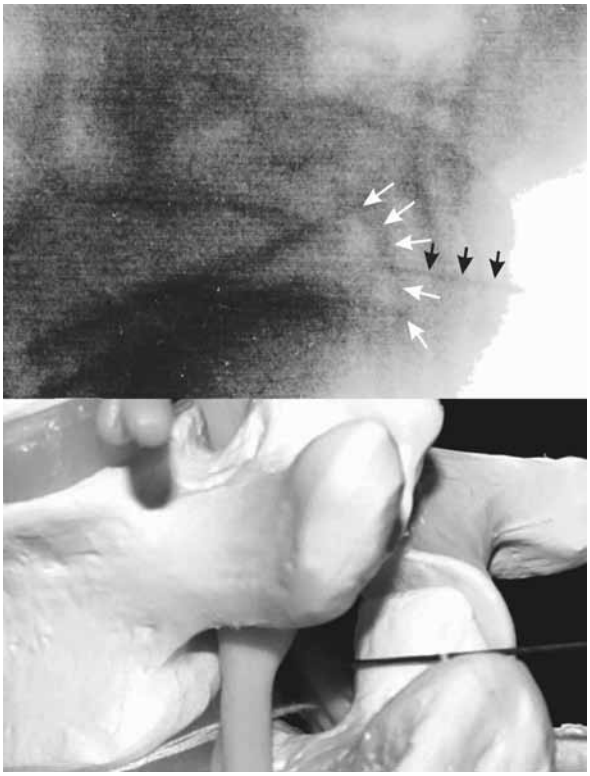

Fig. 8. *A lateral fluoroscopic view shows that the needle tip is located within the posterior aspect of neuroforamen. White arrows are pointing at the posterior border of the neuroforamen. The black arrows indicate the spinal needle.*

view of fluoroscopy the ideal needle tip position is lateral to the midpoint line of the adjacently superior and posterior pedicles at the upper portion of the SAP (Fig. 9).

Step 7:

Contrast medium is injected during live fluoroscopic monitoring to confirm an epidural diffusion pattern that should spread smoothly and equally from the foramen to the midline of the epidural space (Figs. 10 and 11). If vascular uptake is obtained with live fluoroscopy, the needle should be withdrawn and redirected.

If the desired contrast medium pattern is not achieved, the needle can be adjusted with small movements until the pattern is achieved under fluoroscopic views. Caution must be used to ensure that the needle tip does not pass medial to the midline of the adjacently superior and inferior pedicles. A digital subtraction angiography view may be coupled with live contrast-medium-enhanced fluoroscopy to detect the presence or absence of vascular uptake. A lateral view can be used to complement the AP view for the final needle placement (Fig. 9).

Needle Requirement

Figure 12 shows the different types of needles used for epidural injections. A spinal needle with a pencil tip (a blunted tip) should be bent 3-5 mm from the tip away from the bevel side. The longer the bent portion of the needle tip is, the more difficult it is to manipulate in deep tissue. The angle of the bent tip should be between 30-45°. The use of a straight needle makes this technique impossible, as it cannot be wrapped around the SAP to point in the direction of the posterior epidural space. A straight needle also has a high potential risk of being advanced into the anterior aspect of the

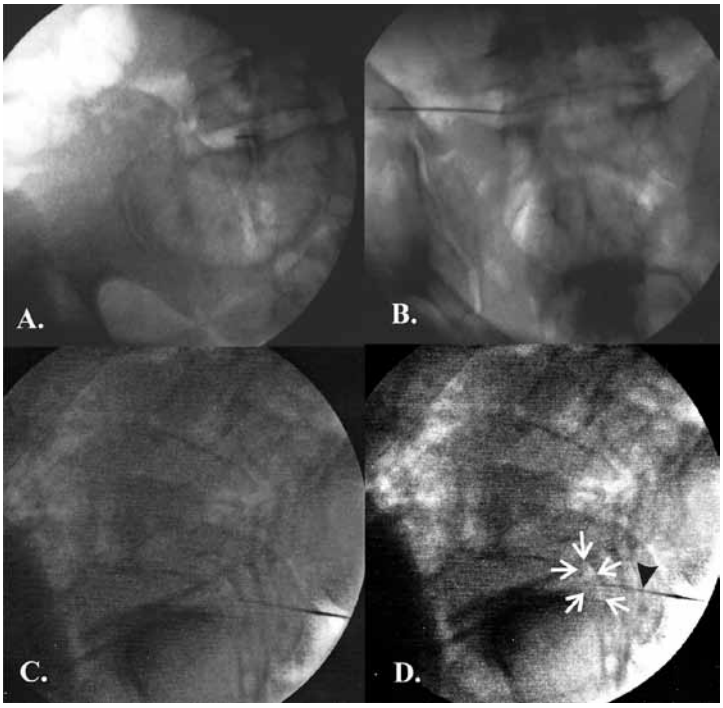

Fig. 9. *Final needle position before injecting contrast medium (A) Final needle position in an oblique view (B) Final needle position in an AP view (C) Final needle position in a lateral view (D) Final needle position in a lateral view; the white arrow shows the foramen; the black arrow shows the spinal needle.*

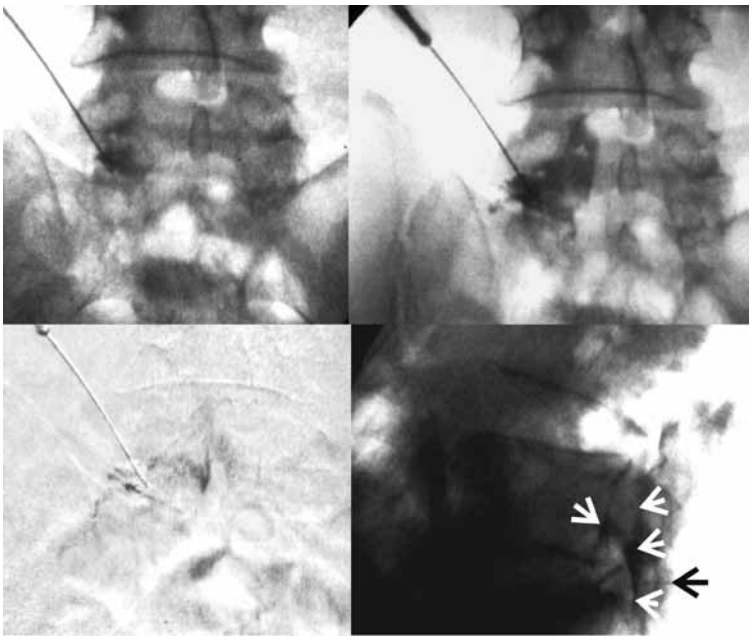

Fig. 10. *Contrast medium is injected to confirm an epidural diffusion pattern that should spread smoothly and equally from the foramen to the midline of the epidural space. The subsequent digital subtraction angiography (DSA) showed no vascular uptake. The white arrows show that the contrast medium spread into the neuroforamen along the posterior border of the foramen. The black arrow demonstrates the spinal needle position.*

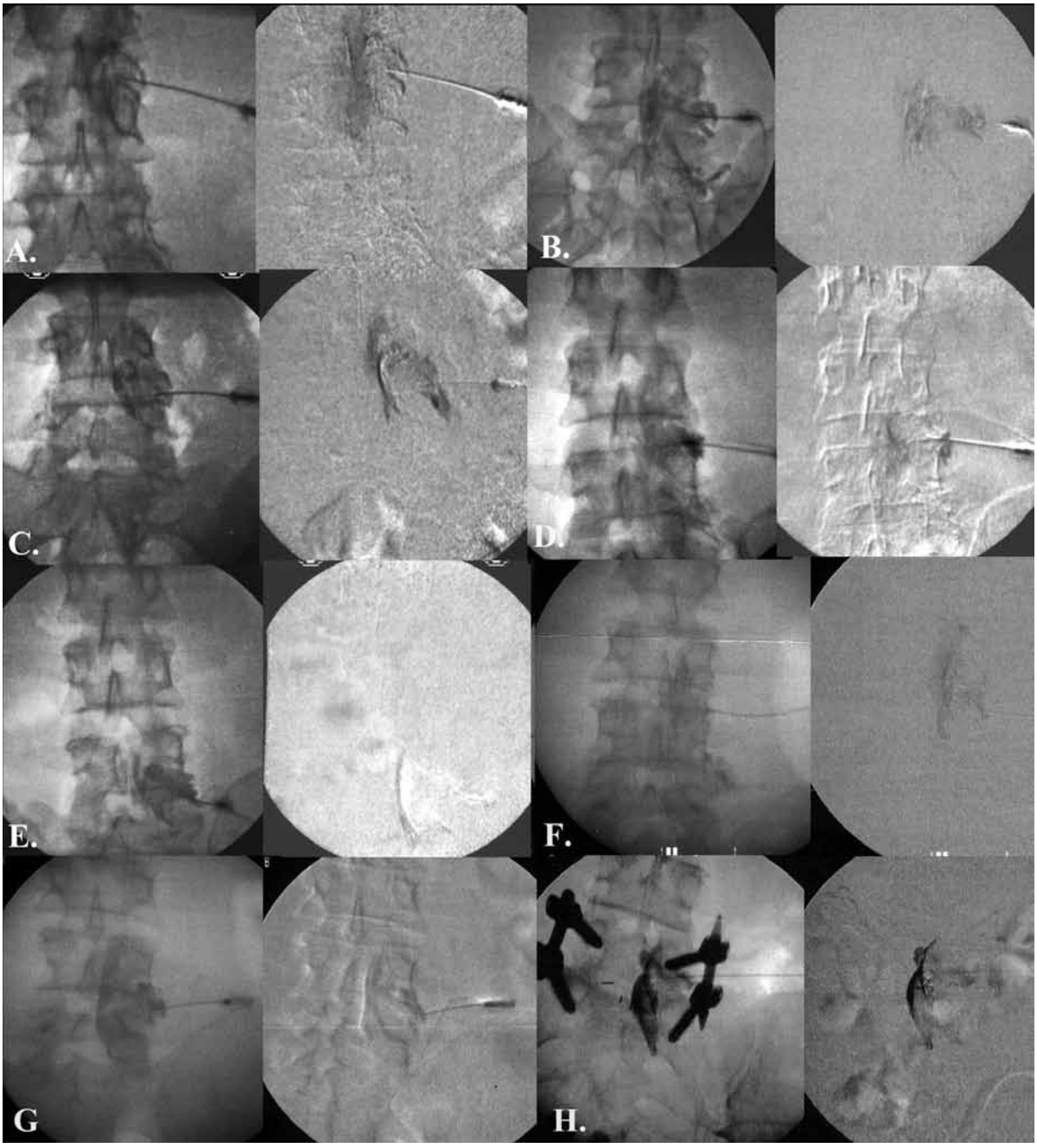

Fig. 11. *Contrast medium pattern produced by alternative TFESI approach.*
Contrast medium spread smoothly and equally from the foramen to the midline of the epidural space in different levels of transforaminal epidural injections. The subsequent Digital subtraction angiography (DSA) showed no vascular uptake. (A) Right L2 transforaminal epidural injection. (B) Right L5 transforaminal epidural injection. (C) Right L4 transforaminal epidural injection. (D) Right L4 transforaminal epidural injection. (E) Right L5 transforaminal epidural injection. (F) Right L3 transforaminal epidural injection. (G) Right L4 transforaminal epidural injection. (H) Right L5 transforaminal epidural injection.

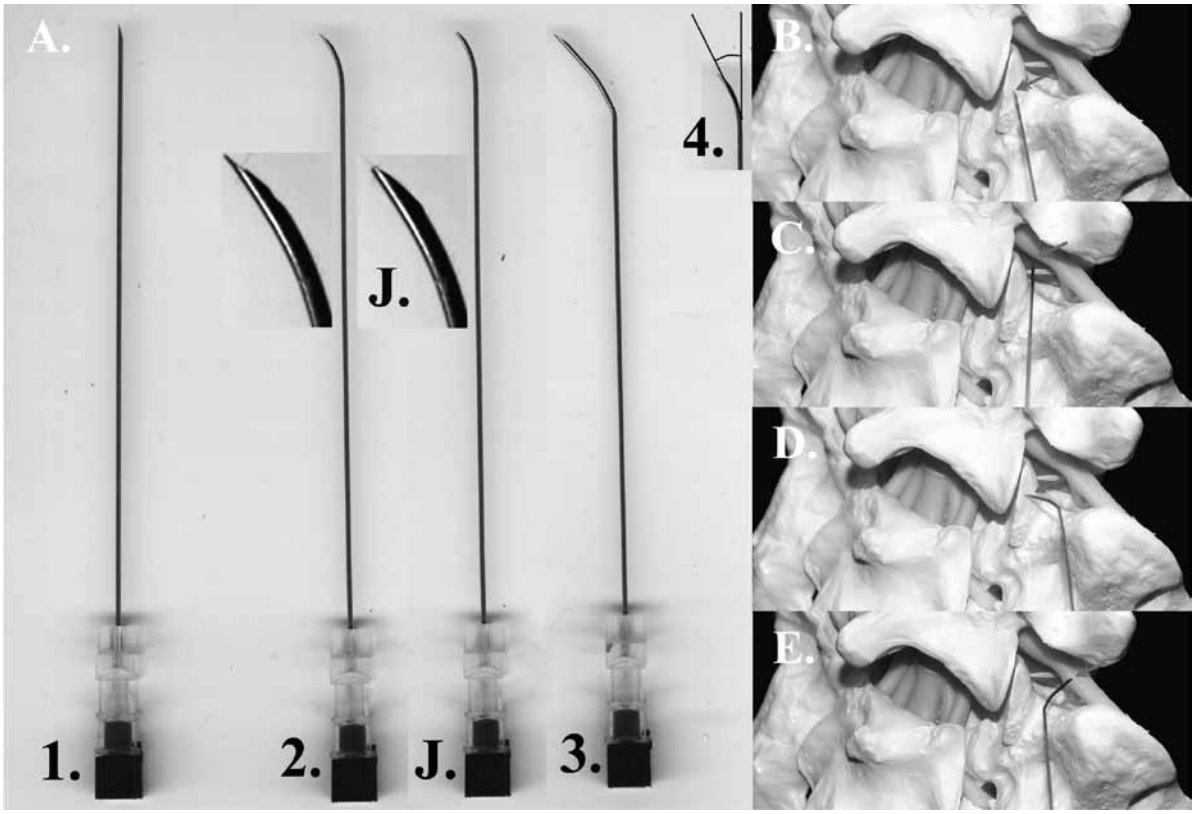

Fig. 12. *(A1) A spinal needle with a straight tip. (A2) A spinal needle with a small curved tip. (A3) A spinal needle with a large curved tip. (AJ) A spinal needle with a small blunt curved tip. (B,C) A straight needle into neuroforamen which has a risk of puncturing the nerve root. (D, E) A needle with a big bent tip. Black arrows show the needle tip locations.*

foramen, which could cause arterial injury and nerve root puncture. The use of a pencil tip (blunted tip) spinal needle is recommended because of the lower risk of injury, as it has less penetrating or cutting force when compared to a traditional needle. The blunted bevel of the curved tip may push the nerve root away and has less chance to injure the nerve root.

Key Points

1. The radicular artery and the artery of Adamkiewicz are most commonly located along the superoanterior aspect of the foramen. However, it can be located anywhere within the foramen. Caution must be taken even with the above described approach in order to minimize the possibility of artery injury.
2. The fluoroscope should be obliquely rotated at least 45° (around 45-50°). The less oblique the fluoroscopy view is, the more difficult it is to direct the needle tip toward the posterior epidural space. It may be difficult to rotate more than 45° when targeting the L5 nerve level, as the iliac crest is in the way in some cases.
3. There is a potential risk of puncturing the dural cuff if the needle tip is extended too far medially beyond the midpoint line of the adjacently superior and posterior pedicles in an AP view (Fig. 1).
4. If there is a large lateral disc herniation causing significant narrowing of the space between the herniated disc and the posterior wall of the foramen, the needle tip should be positioned closely along the posterior wall of the foramen. Otherwise, if the needle tip is not wrapped around the SAP closely or is placed too anteriorly in the foramen, the needle tip may enter the outer layer of the disc. If the needle tip is in the outer layer of the protruding portion of a herniated disc, the dye pattern will show an irregular transverse line. The needle should be withdrawn and redirected closer to the

Table 1. *The comparison between the safe triangle zone approach with the present approach.*

	Safe triangle zone approach	This approach
Spinal needle	A spinal needle with a straight or curved tip	A spinal needle with a small curved pencil tip
The final needle tip location	Superoanterior aspect of the foramen	The curved needle tip should be wrapped around the upper half of the SAP closely, and advanced close to the midpoint line of the adjacently superior and posterior pedicles on the anteroposterior view of the fluoroscope.
Contrast medium patterns	An irregular line pattern along the nerve root which may or may not extend into the epidural space	The contrast medium spreads smoothly and evenly from the foramen to the midline of the epidural space in a fan shape
Common problems		1. The curved portion of the needle is too long. The curved portion of the spinal needle should not be more than 3-5 mm. A long curved tip will make the needle rotation more difficult. It is also difficult to wrap a long curved tip needle around the SAP closely. 2. The fluoroscope should be obliquely rotated at least 45°. The less oblique, the more difficult to direct the needle tip to the posterior epidural space. The needle may be advanced toward the anterior aspect of the foramen or enter the disc.
Less common problems		The needle may enter the outer annular layer of the protruding portion of the disc if there is no space between the disc and the posterior wall of the foramen.
Contraindications	Systemic infection or localized infection at the injection site, bleeding diathesis, weakness	1. Systemic infection or localized infection at injection site, bleeding diathesis, weakness 2. Caution must be taken for severe foraminal stenosis because the needle may damage the nerve root. 3. Do not use this technique with carelessness. 4. Abort the procedure if any difficulty is encountered.
Recommendations	Caution needed	1. The radicular artery and artery of Adamkiewicz can be located anywhere along the spinal nerve. Caution must be taken even with this approach. 2. Use a spinal needle with a small curved pencil tip or blunted tip. 3. Live contrast medium-enhanced fluoroscopy should be used to detect vascular uptake. 4. DSA (DEFINE) may play a supportive role. 5. Use liquid steroid if possible (avoid spinal infarction from the particles of the medication). 6. Lidocaine test

posterior wall of the foramen (Table 1).

5. The key for this approach is to place the tip of the spinal needle immediately dorsal to the DRG and toward the posterior epidural space. In order to achieve this goal, a spinal needle with a small curved tip should be used. A straight needle can be placed immediately dorsal to the DRG, however, the tip of the straight needle will likely be aimed toward the DRG, and not directly into the posterior epidural space. As a result, a certain amount of the medications might not be injected into the posterior epidural space.

The traditional superoanterior approach may produce a neurogram, in which the contrast medium highlights the nerve root, not only intra-foraminally but sometimes also extra-foraminally. Lesions causing lumbar radicular symptoms such as disc herniation, facet arthropathy, etc., are commonly located more proximal than the needle tip. Using this method, steroids will be delivered into the epidural space, rather than along the nerve root distal to the needle tip, to optimally achieve the therapeutic effect. There were a couple of cases where the needle was inserted into the outer annular layer of the protruding portion of a large herniated disc. This was due to severe narrowing of the space between the herniated disc and the posterior wall of the foramen. In these cases, the needle was redirected successfully, to place it closer to the posterior wall, and the desired contrast medium pattern was achieved.

Limitations include further studies to confirm its safety.

Conclusion

The primary goal of this approach is to minimize the risk of puncturing the spinal radicular artery, minimize nerve root penetrations, and effectively deliver medications into the epidural space through the neuroforamen. This modified approach is potentially safer than the traditional superoanterior ones currently in use.

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