Novel Method for S1 Transforaminal Epidural Steroid Injection

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BACKGROUND: **S1 transforaminal epidural steroid injection (S1-TFESI) results in positive clinical outcomes for the treatment of pain associated with the S1 nerve root. S1-TFESI via the transforaminal approach is commonly performed under fluoroscopic guidance. Ultrasound guidance is an alternative to mitigate radiation exposure. However, performing spinal procedures under ultrasound guidance has some limitations in confirming the position of the needle tip and vascular uptake. New techniques are therefore needed to make ultrasound and fluoroscopy complementary. Our objective was to describe a novel technique for S1-TFESI and confirm its reproducibility.**

METHODS: **Records of patients with S1 radiculopathy were reviewed retrospectively; those treated using the new S1-TFESI technique were selected. Initially, ultrasound was used to distinguish anatomy of the sacral foramen and guide initial placement of the needle entry point. Fluoroscopy was subsequently used to confirm needle tip position and vascular injection. The number of times the needle required reinsertion was recorded, and ultrasound and C-arm images were stored.**

RESULTS: **Sixty-seven S1-TFESIs were performed in 56 patients. All injections exhibited epidural spread of contrast media, not only to the S1 nerve. The cephalad angle was 16.25 ± 6.75° (range, 5–27°), the oblique angle was 2.48 ± 2.62° (range, 0–7°), and the mean number of attempts was 1.24 ± 1.25.**

CONCLUSIONS: **The new technique, involving the use of ultrasound to guide initial placement of the needle entry point, followed by confirmatory imaging and any needed adjustment with the use of fluoroscopy, can be a technique to complement the shortcomings of using ultrasound or fluoroscopy alone.**

INTRODUCTION

Lumbosacral transforaminal epidural steroid injection (TFESI) is a reliable therapeutic tool for the treatment of lumbosacral radicular pain. S1-TFESI is an effective nerve block used to treat pain associated with the S1 nerve root. This target-specific approach offers a better effect than other forms of epidural injection by delivering a high concentration of drug to the pathologic site and dorsal root ganglion.[1-4] S1-TFESI is usually performed under x-ray fluoroscopic guidance. The important point for successful block is to visualize the first dorsal sacral foramen. The target needle destination is at the dorsal S1 foramen. The delivered drug flow through the needle should outline the spinal nerve and the nerve root sheath and subsequently flow into the epidural space medial to the S1 pedicle to the suspected site of pathology.[5] For the needle to be properly positioned, it is important to distinguish the dorsal foramen and ventral foramen. Furthermore, overlapping the ventral foramen with the dorsal foramen helps the needle to advance without scratching bone structure. The angle of the C-arm should be adjusted to overlap the 2 foramens.[6,7] Approaching the first sacral foramen, however, can be difficult, because of variations in the sacrum and its components, particularly features on its dorsal surface. In addition, it is often difficult to distinguish radiographically between the anterior first sacral foramen and posterior foramen. The anterior foramen is larger in diameter than the posterior foramen.[8-10] In particular, when bowel gas patterns overlap the first sacral foramen, or the bony structure is ambiguous due to

Key words
- Fluoroscopy
- Radiation
- S1 transforaminal epidural steroid injection
- Ultrasound

Abbreviations and Acronyms
S1-TFESI: S1-transforaminal epidural steroid injection

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severe osteoporosis, approaching the first sacral foramen can be difficult. During determination of the proper C-arm angle, the practitioner and patient are exposed to radiation. To overcome these disadvantages, performing S1-TFESI using ultrasound can be considered. Previous studies have reported performing S1-TFESIs using ultrasound and color Doppler imaging.[11,12] It is difficult to recognize vessel intake of the injectate under ultrasound. In this article, we describe a new method for performing S1-TFESI using both ultrasound and x-ray fluoroscopic guidance to compensate for the disadvantages of using only 1 tool each.

METHODS

Study Population

The protocol for this retrospective study was approved by the Institutional Review Board of Kang Buk Samsung Hospital, Seoul, Korea. A retrospective review of medical records of patients who were diagnosed with S1 radiculopathy between February 2018 and May 2019 was conducted. All subjects were outpatients at a pain clinic of this hospital. Patients 20–85 years of age, who were diagnosed with S1 radiculopathy on the basis of S1 root compression on magnetic resonance imaging, and those with symptoms that had persisted for at least 3 months were included. Patients with radiculopathy in whom symptoms did not correlate with magnetic resonance imaging findings; those who underwent previous back surgery involving L5/S1 inserting metallic materials, such as pedicle screw fixation or posterior lumbar interbody fusion; individuals with anatomic sacral abnormalities (lumbarization or sacralization); or those with systemic infection or any active injection site infection were excluded.

Study Protocol

All of the procedures were performed at a university hospital in a fluoroscopy suite by a single interventional spine physician with 6 years' experience. A single radiology technologist with >10 years' experience in spinal procedures operated the C-arm of the fluoroscopy unit (OEC 9900 Elite C-arm, GE Healthcare, Waukesha, Wisconsin, USA). Initially, the procedures were performed using ultrasound (Sonosite X-porte, FujiFilm Sonosite Inc., Bothell, Washington, USA). The patients were placed prone with a pillow under the lower abdomen to decrease lordosis of the lumbar spine for optimal visualization. A low-frequency (2–5 MHz) curvilinear-array transducer was used to acquire sufficient sonographic penetration. The transducer was placed over the midline in a sagittal plane at the lumbosacral junction to visualize the lumbar spinous processes. The lumbosacral junction was a reference point for counting the levels of the lumbar spine. The scan was performed from the L5 spinous process to the S1 spinous process (Figure 1). At the level of the S1 spinous process, the probe was moved slightly to the left or right, according to which direction was targeted. The posterior foramen of S1 was identified as breaks in bone contours. Tilting the probe toward cephalad enables the posterior foramen to overlap the anterior foramen. When the 2 foramens overlap well, an image of the sono beam from the posterior to anterior foramen can be acquired (Figure 2). The tilt angle of the probe was verified, and the angle of the C-arm fluoroscope was adjusted accordingly (Figure 3). The indicator was placed on the S1 foramen identified on ultrasound imaging and confirmed using a radiograph Video 1. A 22-gauge, 80-mm disposable nerve block needle was inserted in the S1 foramen pointed by the indicator. Needle tip position was confirmed on the anteroposterior and lateral views. The C-arm was returned to the anteroposterior position for injection of 2.0 cc contrast material (iohexol). After checking the image of the contrast agent, 5 cc of a solution containing 2.5 mg of dexamethasone in 0.4% lidocaine and hyaluronidase 1500 IU (Kuhnil Pharm, Seoul, South Korea) were injected. Data including patient characteristics, foramen side, cephalad and caudad angles, epidural spread pattern of contrast media, and the number of reinsertion attempts were recorded.

Video

Video available at www.sciencedirect.com

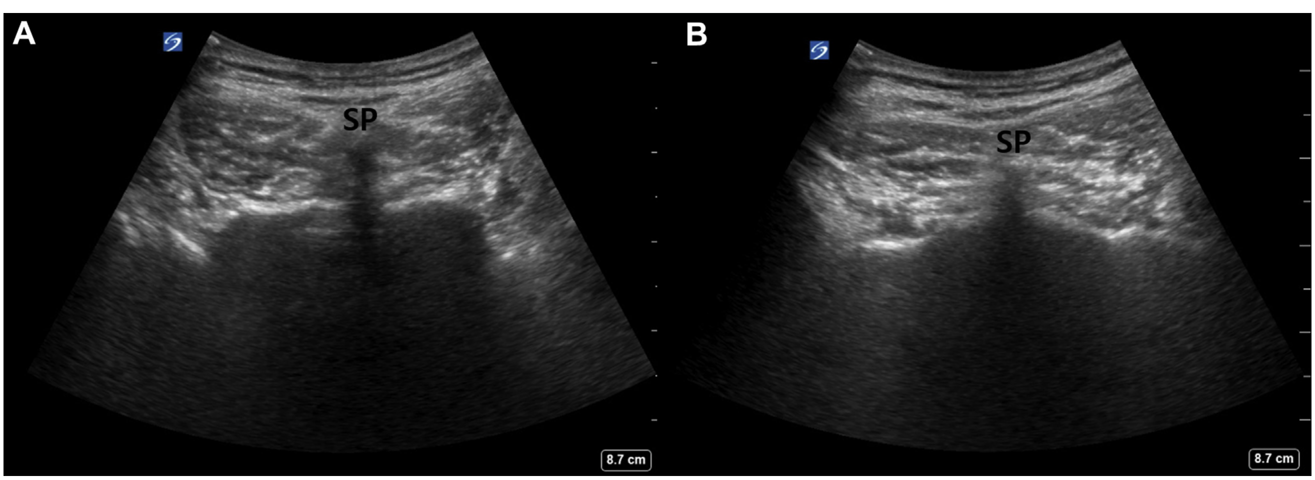

Figure 1. Images scanned from the L5 spinous process (*SP*) to the S1 SP. (**A**) L5. (**B**) S1.

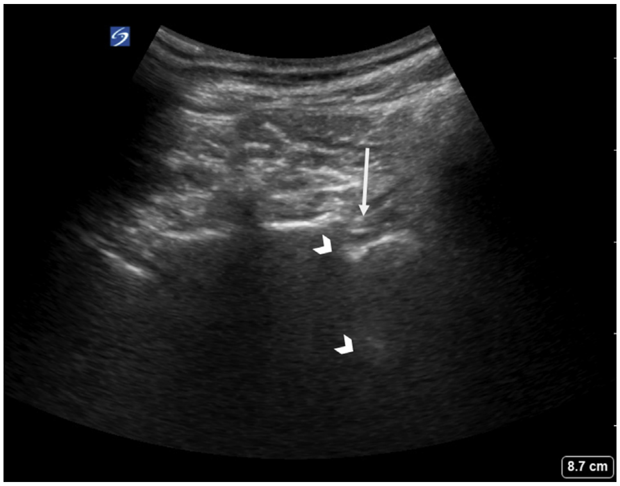

Figure 2. Ultrasound images demonstrating that the ultrasound beam is not blocked by the bone shadow (*arrow*) when the ventral foramen (*arrowhead*) and posterior foramen (*arrowhead*) are adequately overlapped.

RESULTS

Sixty-seven S1-TSEFIs were performed in 56 patients, which included 30 on the right and 37 on the left side. All injections exhibited epidural spread of contrast media and not only to the S1 nerve. The epidural spread patterns of contrast media were to the superior pedicle of S1 ($n = 41$) and the superior aspect of the L5-S1 intervertebral disk ($n = 26$) (**Figure 4**). The cephalad angle was $16.25 \pm 6.75°$ (range, 5–27°), and the oblique angle was $2.48 \pm 2.62°$ (range, 0–7°), with no caudad angle in any injections. The mean number of attempts was 1.24 ± 1.25.

DISCUSSION

The S1 nerve root transits past the L5-S1 disk in a slightly sideways manner in the center location, descends inferiorly, and then exits at the foramen at S1, where it can be compressed foraminally or extraforaminally. Therefore there are various potential sources of S1 radiculopathy as the nerve descends and exits the foramen. L5-S1 stenosis or a right central L5-S1 herniated nucleus pulposus may encroach along the S1 nerve as it transits inferiorly. When patients complain of S1 radiculopathy, 1 therapeutic option is S1-TFESI. Therapeutic S1-TFESI results in a satisfactory effect

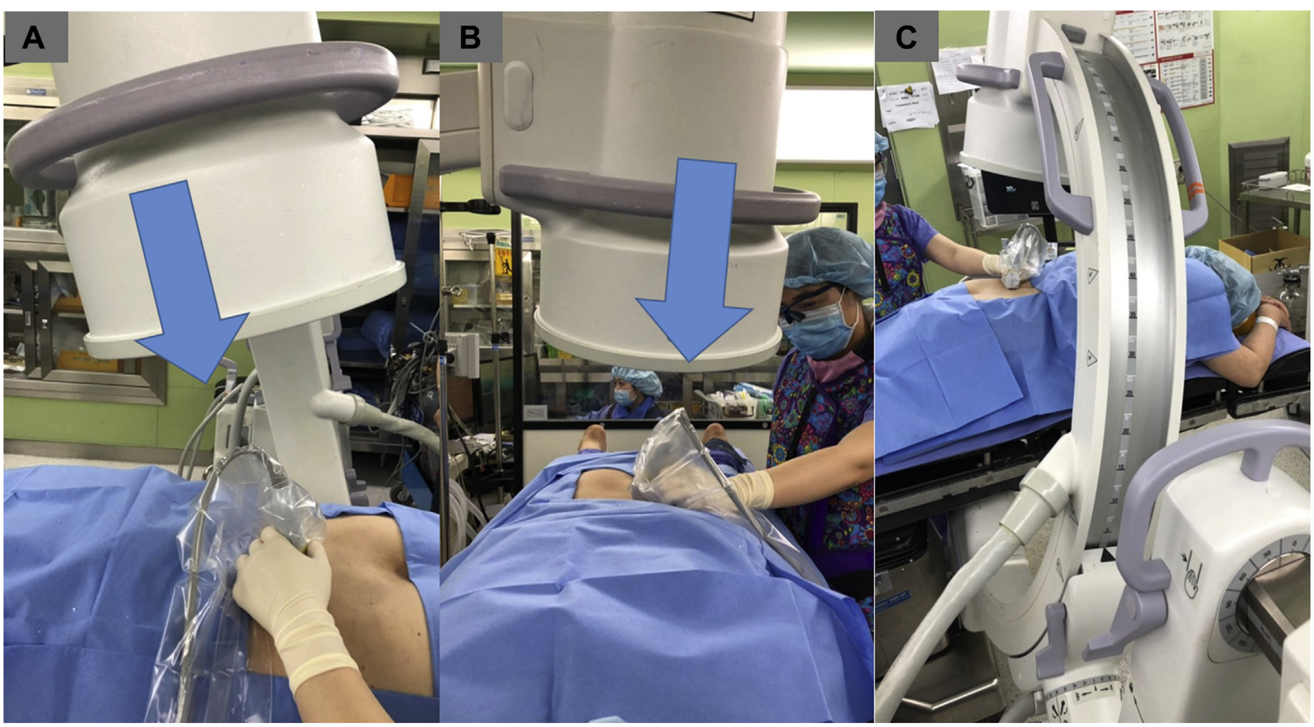

Figure 3. The reliability of the procedure can be improved by combining 2 commonly used devices. The process is described in detail. (**A**) The tilt angle of the probe was aligned. (**B**) The oblique angle of the probe was aligned. (**C**) Overall picture of the procedure. *Arrow* indicates the axis of the probe and C-arm.

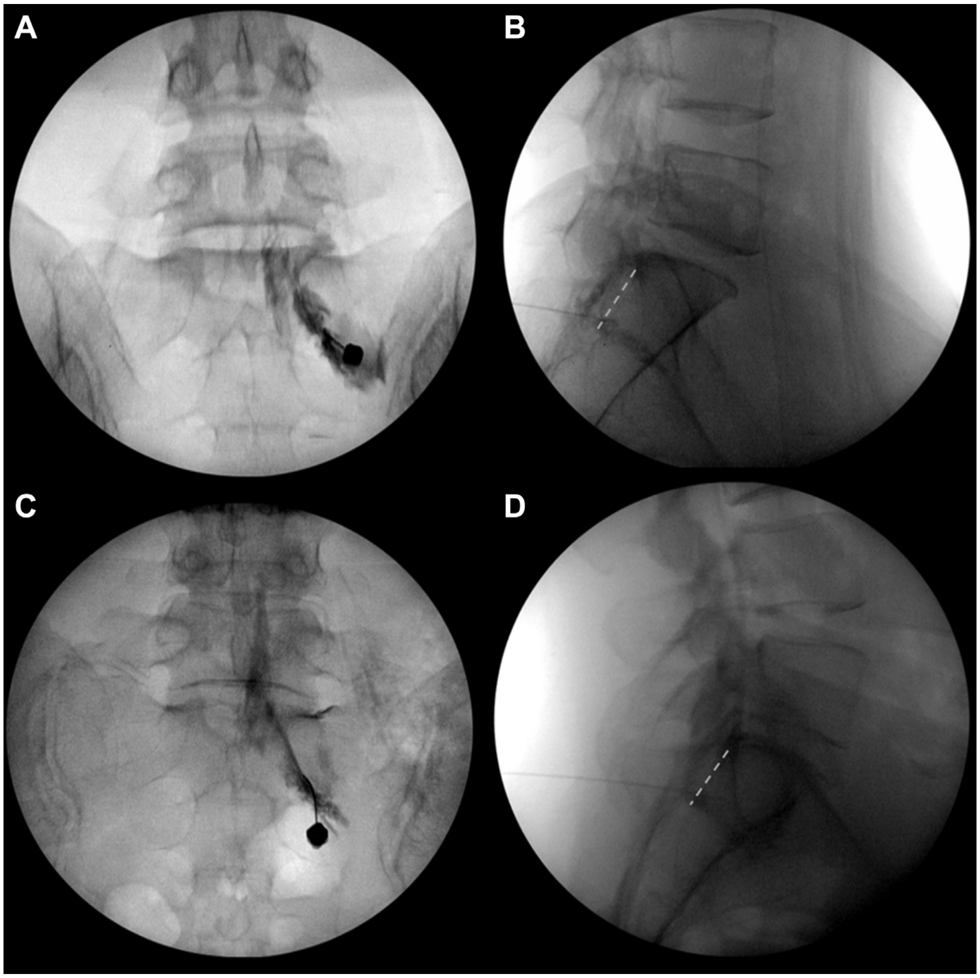

Figure 4. Epidural contrast spread patterns during S1 transforaminal injection. (**A**) Anteroposterior view: The contrast flowing along the medial aspect of the superior pedicle of S1. (**B**) Lateral view: The contrast flowing along the medial aspect of the superior pedicle of S1, *dotted line:* needle tip position. (**C**) Anteroposterior view: the contrast flowing along the superior aspect of the L5-S1 intervertebral disk. (**D**) Lateral view: the contrast flowing along the medial aspect of the superior pedicle of S1, *dotted line:* needle tip position.

when medication is delivered from the needle tip to the dorsal root ganglion, medial to the pedicle, and into the epidural space. The proposed mechanism of pain relief is believed to be the decrease or dilution of inflammatory mediators, thus reducing edema and disturbing excitatory afferent nerve impulses caused by irritation of nerve root.[5,13-15] The standard method of S1-TFESI is under fluoroscopic block. Fluoroscopically guided S1-TFESI uses specific C-arm angle settings to accurately visualize target structures. A trajectory view is used to accurately visualize anatomic structures before needle insertion. However, the incorporation of C-arm fluoroscopic imaging to visualize the needle trajectory for S1 TFEI has been operator and patient dependent. Multiple images are required to determine the appropriate trajectory view because there are no precisely appropriate angles. In acquiring multiple images, the amount of radiation exposure to the patient and practitioner(s) increases. By using ultrasound for S1-TFESI, radiation exposure can be mitigated, if not eliminated. Several techniques of ultrasound-guided injection have been described in previous studies.[11,12,16] However, the depth of the needle position is not visible in ultrasound-guided injection. Therefore the needle may pass too deeply into the ventral foramen and cause visceral injury. The drug may be delivered merely to the S1 nerve, not into the epidural space when the needle passes through the ventral foramen. The practitioner may sometimes not recognize vascular uptake. Furthermore, the incidence of intravascular injection of injectates during S1-TFESI has been reported to be 16.5%–27.8% higher than TFESI in the lumbar spine.[17] The aim of the present study was to assess and describe a new method for performing S1-TFESI using both ultrasound and C-arm together to compensate for the limitations of each of the 2 devices used alone.

The posterior foramen of S1 can be distinguished using ultrasound. The posterior and ventral foramen can be overlapped by changing the angle of probe, tilting, and turning it oblique. An ultrasonic probe is used to determine the appropriate angle of the C-arm to obviate the need for multiple image captures to find the trajectory view. After identifying the needle entry point using ultrasound, needle position can be verified using C-arm. When the needle is positioned in a trajectory view toward the dorsal foramen and confirmed in the anteroposterior view, then a lateral image is obtained to verify needle depth. Contrast injection can be confirmed by vascular uptake.

One limitation of the new technique is that the practitioner is required to have some level of proficiency to distinguish the anatomy of the sacrum. In addition, it takes more time to perform the procedure because 2 devices must be prepared. In future studies, we plan to compare the difference in the time required for the procedures and differences in radiation exposure by performing the procedure using fluoroscopically guided S1-TFESI and using the new technique.

CONCLUSION

To mitigate the risks associated with radiation exposure from fluoroscopy during the S1-TFESI procedure, ultrasound guidance may be an alternative. However, ultrasound has several limitations in confirming needle tip position and vascular uptake. The new technique described herein, using ultrasound to guide initial placement of the needle entry point, followed by confirmatory imaging and any needed adjustment using fluoroscopy, appears to be a viable alternative.

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