

## Randomized Trial

# Comparison of Intravascular Injection Incidences and Technical Easiness Between Anteroposterior and Oblique Approaches During S1 Transforaminal Epidural Injection

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**Background:** Transforaminal epidural injection (TFEI) is a useful intervention for radicular leg pain. Compared to TFEI in lumbar level, S1 TFEI is reported to have higher incidence rates of intravascular injection as well as technical difficulties.

**Objective:** The purpose of this study is to compare the incidence rates of intravascular injection and foramen passage time between anteroposterior (AP) and oblique (OB) approaches.

**Study Design:** Prospective randomized trial.

**Setting:** An interventional pain management practice in South Korea.

**Methods:** One hundred forty-seven patients receiving S1 TFEI for radicular leg pain were randomly assigned to one of 2 approach methods (AP view vs OB view). For S1 TFEI in the OB view group, lineup of the L5-S1 endplate was performed by adjusting the cephalad-caudad tilt. Then C-arm was rotated at an ipsilateral oblique angle, approximately 10° to 15°. After final confirmation of intravascular injection with real time fluoroscopy, the foramen passage time and amount of radiation exposure during S1 TFEI were measured.

**Results:** The incidence rate of intravascular injection in the AP view group was 24.2% (24/99), whereas that of intravascular injection in the OB view group was 10.1% (17/99,  $P = 0.008$ ). The radiation dose required to pass the S1 foramen was significantly higher in the AP view group than in the OB view group ( $51.3 \pm 27.2$  cGy/cm<sup>2</sup> vs  $41.0 \pm 17.0$  cGy/cm<sup>2</sup>,  $P = 0.002$ ). The foramen passage time during S1 TFEI was significantly higher in the AP view group than in the OB view group ( $103.5 \pm 44.1$  second vs  $84.9 \pm 21.0$  second,  $P = 0.001$ ). The failure rate of S1 TFEI was significantly higher in the AP view group than in the OB view group (13% vs 4%,  $P = 0.022$ ).

**Limitation:** The physicians involved in the present study were not blinded to the type of approach method (AP view vs OB view) by fluoroscopy.

**Conclusion:** Our study demonstrated reduced incidence rates of intravascular injection and reduced foramen passage time and radiation dosage with the use of OB view method during S1 TFEI.

**Key words:** Transforaminal epidural injection, intravascular incidences, anteroposterior, oblique, foramen passage time, radiation exposure

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**T**ransforaminal epidural injection (TFEI) is a useful interventional technique for low back pain or radicular leg pain resulting from spinal

stenosis, herniated intervertebral disc, and failed back surgery syndrome (1,2).

Commonly reported minor complications of TFEI

include transient weakness, pain at the injection site, vasovagal syncope, and numbness (3). Although they are rare, serious complications such as paraplegia, quadriplegia, brainstem or cerebellar infarction, and cortical blindness have been reported. Suggested mechanisms are direct mechanical needle injury of the vertebral artery or arterial embolization due to inadvertent intraarterial injection of particulate corticosteroid (4-7).

Reported incidences of inadvertent intravascular injection during lumbosacral TFEI vary from 5.4% to 30.8% (8-12). A previous study demonstrated that the highest intravascular injection was at the cervical level followed by sacral level and significantly lower incidence rates at the lumbar level (10).

The classic method to approach S1 foramen has been through an anteroposterior (AP) view with caudal tilt (13). However, there have been concerns about the unclear view of the S1 foramen with the AP approach. For S1 entry, visualization of the dorsal foramen is very important since the injection is performed at the dorsal surface of the sacrum. However, an AP view during S1 TFEI enables a better view of the ventral foramen compared to the dorsal foramen. Consequently, the needle can be misplaced on the anterior of the ventral foramen resulting in gastrointestinal penetration (13).

Recent studies showed that using an oblique "Scotty dog" approach can enable clear visualization of S1 foramen with reduced incidence of intravascular injection (13,14). However, such "Scotty dog" approach requires a fluoroscopic guided ipsilateral oblique angle of at least 30°. A potential disadvantage of this approach is that, in such an oblique angle, the iliac crest can block the pathway of the needle toward S1 foramen. According to our past experiences with S1 TFEI, using an ipsilateral oblique angle of 15°, which is a lesser oblique angle compared to the angle for "Scotty dog," enabled better visualization of S1 foramen than AP approach without blocking the pathway of the needle toward the S1 foramen.

The primary endpoint of this study was to compare the intravascular injection incidence and failure rates between the AP and oblique (OB) view methods during the first attempt of S1 TFEI. The secondary endpoint of this study was to compare the passage time of the needle into the S1 foramen and the amount of radiation dose between the AP and the OB view methods.

## METHODS

### Patients and Randomization

The Institutional Review Board (IRB #20-08-022-03) of our institution approved this prospective, randomized trial. This study was registered at clinical trial. gov (NCT04634955). Before enrollment, written informed consent was obtained from each patient after explaining the potential benefits and risks of this study.

We enrolled 149 patients who received 203 C-arm guided TFEIs from November 2020 to April 2021. Inclusion criteria were patients aged between 21 to 85 years who were diagnosed with S1 radiculopathy resulting from S1 root compression by herniated intervertebral disc or spinal stenosis confirmed with magnetic resonance imaging, and patients with a lower lumbar compression fracture and failed back surgery syndrome. Exclusion criteria were patients who were allergic to contrast medium, steroids or local anesthetics, anatomical sacral bone anomaly due to lumbarization or sacralization, pregnant woman, and laboratory findings suggesting infection, inflammatory disease, or coagulopathy. Patients were required to have stopped taking an anticoagulant for a specific time duration before TFEI. Finally, 147 patients of 198 cases of S1 TFEI were enrolled in this study (Fig. 1).

These 147 patients were randomly assigned to one of 2 groups (anteroposterior approach: AP view group vs Oblique approach: OB view group) using a concealed random number table. In case TFEI was to be performed at any other spinal levels simultaneously with S1, S1 injection was done first.

### Study Interventions

The patient was placed on a C-arm table in a prone position, and sterile preparation with draping was done.

For TFEI of S1 in the AP view group, a slight angle of cephalad-caudad tilt was used to make the dorsal foramen superimposed on the ventral foramen and to maximize the opening of the neural foramen of S1. After skin infiltration with 1% lidocaine, a spinal needle (25G, Quincke type, Taechang, Korea) was inserted toward the S1 foramen under intermittent C-arm guidance (Fig. 2A). After the physician estimated that the needle had already passed through the S1 foramen, then, a lateral image was obtained to confirm that the needle tip was within the sacral canal (Fig. 2B) and was repositioned slightly with an AP view (Fig. 2C).

For TFEI of S1 in the OB view group, a lineup of the L5-S1 endplate was done by adjusting the cephalad-

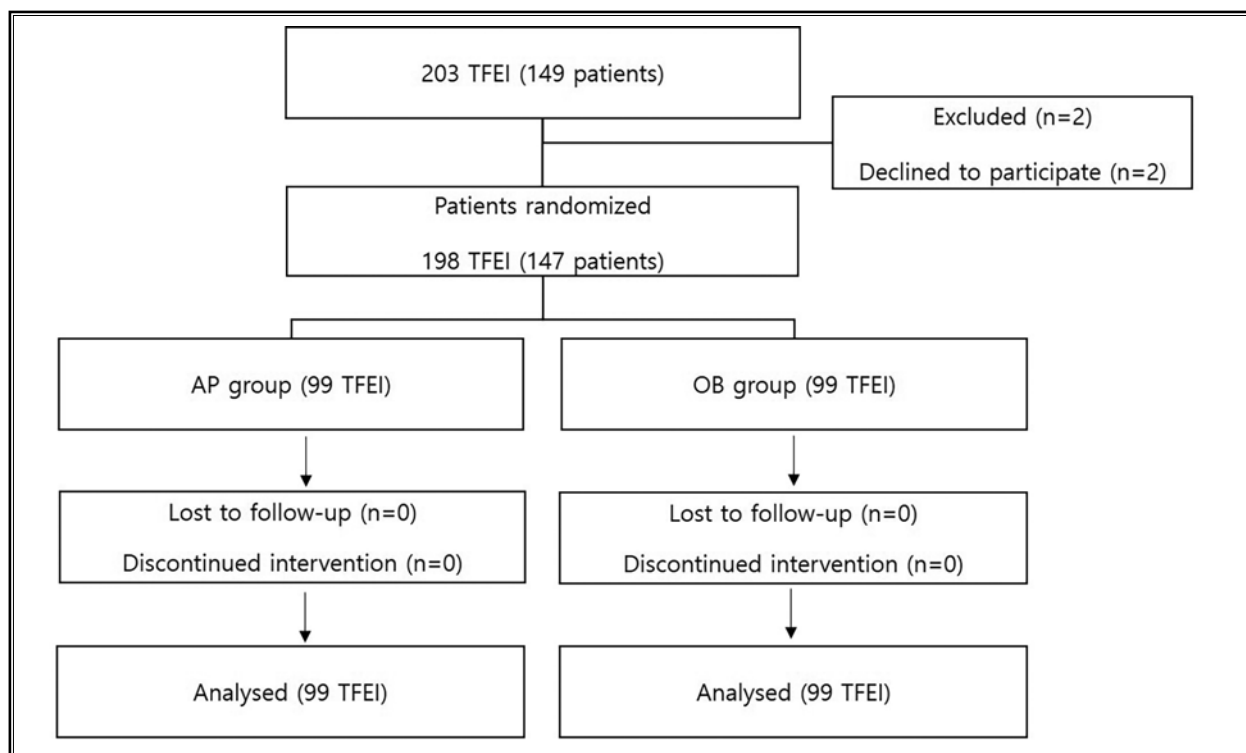


Fig. 1. Flow chart showing patients who participated in this study.

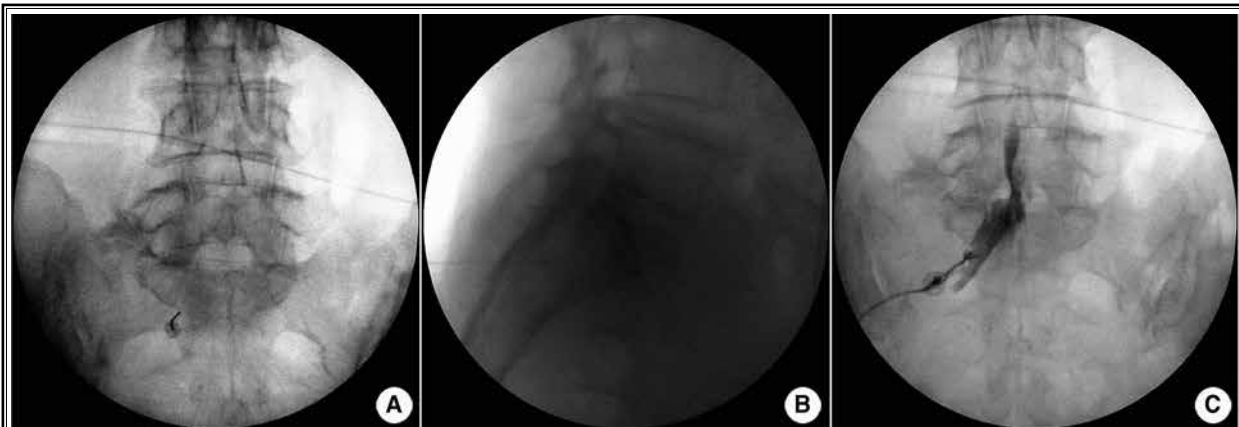


Fig. 2. Anteroposterior (AP) approach for S1 transforaminal injection. (A) Placement of needle into S1 foramen in AP view. (B) The needle was confirmed to be located within the sacral canal in lateral view. (C) AP view with injection of contrast medium to check the presence of intravascular injection.

caudad tilt. Then C-arm was rotated at an ipsilateral oblique angle, about 10° to 15°. After this, we evaluated whether a “Scotty dog” was seen at the L5 and checked the 6 o’clock position below the L5 pedicle in an oblique view. An imaginary line was drawn down from the 6 o’clock position of the L5 pedicle toward

sacral foramen, and this enabled easier access of the S1 foramen through the skin entry point (Fig. 3A). Before needle insertion, the hindrance of needle pathway by the appearance of iliac crest was checked. After skin infiltration with 1% lidocaine, a spinal needle (25G, Quincke type, Taechang, Korea) was inserted toward

the S1 foramen under intermittent C-arm guidance. After the physician estimated that the needle passed through the S1 foramen, then, a lateral image was obtained to confirm that the needle tip was within the sacral canal (Fig. 3B) and was reconfirmed after injection of contrast medium with an AP view (Fig. 3C).

Intravascular injection incidences were determined based on the characteristic fleeting pattern of the contrast medium, which disappeared rapidly. A 3-mL syringe filled with contrast medium was attached to the extension tube and subsequently connected to a needle hub. Two mL of contrast medium was injected slowly using a real time image. The contrast spread pattern after S1 TFEI was divided into 3 categories: epidural only, epidural and vascular, and vascular only. If a vascular spread was confirmed after injection of the contrast medium, the needle was repositioned until the vascular spread was confirmed to have cleared by C-arm. After such confirmation, the injectate (a total of 4 mL of 0.2% ropivacaine mixed with 0.9% normal saline) was administered.

Two pain physicians with more than 15 years of experience in C-arm guided injections were involved in this study. One physician performed the S1 TFEI, and the other physician who was not involved in performing the procedure determined the incidences of intravascular injection, failure rate of the first attempt of S1 TFEI, foramen passage time, and the amount of radiation exposure. Those physicians were not blinded to the type of approach. The physician who performed S1 TFEI did not make any decision about those issues.

In both groups, if the needle could not pass the S1

neural foramen at once, such a case was considered as a failure of the first attempt of S1 TFEI. Then, the angle of the cephalad-caudad tilt was adjusted slightly to enhance visualization of the S1 foramen, and the needle was reinserted into the S1 foramen.

Foramen passage time was measured using a stopwatch (Dretec, Japan). It was defined as the time from the skin infiltration with lidocaine until the needle passed through the S1 foramen successfully, and the S1 root was seen clearly when 2 mL of contrast medium was injected. The total amount of radiation was automatically measured in the C-arm and was analyzed.

The patient's data collected during the study included sex, age, body mass index, side of the injection, diagnosis, and underlying medical illness.

### Statistics

This study was powered to detect a difference in the incidence of intravascular injection between the AP and the OB view groups. According to a previous study, the intravascular injection incidence rate of AP and the OB view groups was 29% and 11%, respectively (14). Assuming the difference of intravascular incidence rate between the AP and the OB view groups as 0.08 and an  $\alpha$  error level of 0.05, a  $\beta$  error level of 0.02, dropout rate of 15%, 95 cases of TFEI were required in each group with a power of 80%.

Comparisons of clinical characteristics were made using the independent t test, chi-square, or Fisher's exact test as appropriate. The incidence of intravascular injection was analyzed using the chi-squared test. The radiation dose and foramen passage time were

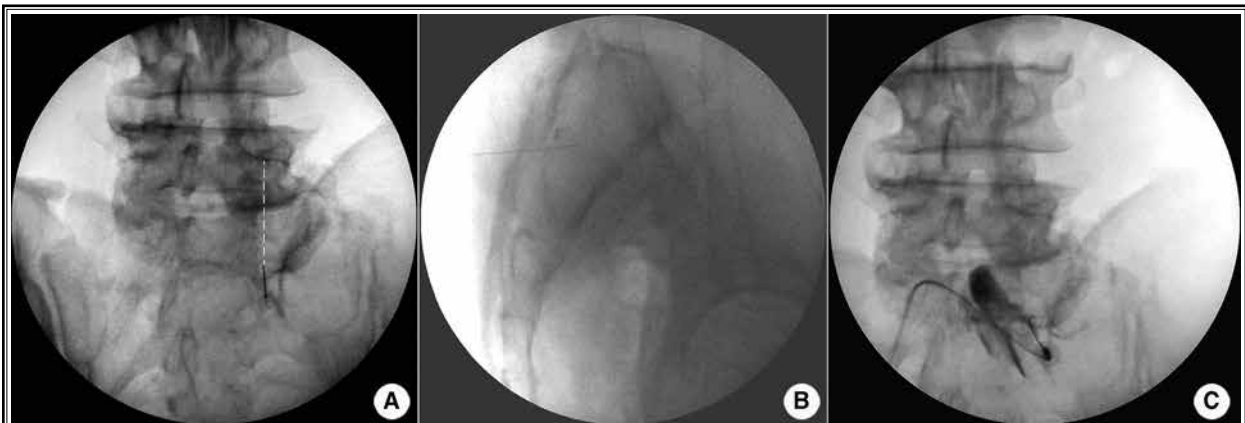


Fig. 3. Oblique (OB) approach for S1 transforaminal injection. (A) Placement of needle into S1 foramen in OB view (The imaginary line from L5 pedicle indicates the respective S1 foramen). (B) The needle was confirmed to be located within the sacral canal in lateral view. (C) OB view with injection of contrast medium to check the presence of intravascular injection.

analyzed using the independent t test (SPSS Version 20, Chicago IL). A *P* value of < 0.05 was considered statistically significant.

## RESULTS

A total of 149 patients who received 203 C-arm guided S1 TFEIs were assessed for eligibility. Among them, 2 patients were excluded because they refused to participate in this study. Finally, 147 patients with a total of 198 S1 TFEIs were enrolled in this study (Fig. 1).

There were no significant differences in the patient's age, gender, body mass index, side of injections, and diagnosis (Table 1).

The overall incidence rate of intravascular injection was analyzed according to the 2 different approach methods (AP view group vs. OB view group). The incidence of intravascular injection in the AP view group was 24.2% (24/99), whereas that of the intravascular injection in the OB view group was 10.1% (17/99). The incidence of intravascular injection was more than 2 times higher in the AP view group than in the OB view group (*P* = 0.008, Table 2). The contrast spread pat-

tern was more common in simultaneous epidural and vascular spread than in the vascular spread only. The intravascular injection rate was not significantly different between the simultaneous epidural and vascular spread, and vascular spread only (Table 2).

The amount of radiation dose required to pass the S1 foramen was significantly higher in the AP view group than in the OB view group ( $51.3 \pm 27.2$  cGy/cm<sup>2</sup> vs  $41.0 \pm 17.0$  cGy/cm<sup>2</sup>, *P* = 0.002, Table 3). The foramen passage time during S1 TFEI was significantly higher in the AP view group than in the OB view group ( $103.5 \pm 44.1$  seconds vs  $84.9 \pm 21.0$  seconds, *P* = 0.001, Table 3).

The first attempt failure rate of the S1 TFEI was significantly higher in the AP view group than in the OB view group (13% vs. 4%, *P* = 0.022, Fig. 4). In both groups, there were no cases of needle passage to S1 foramen blockage by the iliac crest.

## DISCUSSION

Our study demonstrated markedly low intravascular injection rates in the OB view group as compared to the AP view group. Specifically, the intravascular

Table 1. Clinical characteristics of patients assigned to the anteroposterior (AP) or the oblique (OB) view group for S1 transforaminal injection.

	AP view group (n = 99)	OB view group (n = 99)	P value
Age (years)	67.4 ± 12.1	63.9 ± 14.6	0.05
Female	54 (54.5%)	57 (57.6%)	0.67
Injection side (left)	54 (54.5%)	50 (50.5%)	0.57
BMI (kg/m <sup>2</sup> )	24.6 ± 3.5	24.0 ± 3.0	0.21
Diagnosis			
Spinal stenosis	46 (46.5%)	38 (38.4%)	
Herniated intervertebral disc	45 (45.5%)	54 (54.5%)	
Lumbar compression fracture	0 (0%)	2 (2%)	
Failed back surgery syndrome	8 (8.1%)	5 (5.1%)	

Values are mean ± SD or number of patients.

Table 2. Incidence of intravascular injection for S1 transforaminal epidural injection in the anteroposterior (AP) or the oblique (OB) view group.

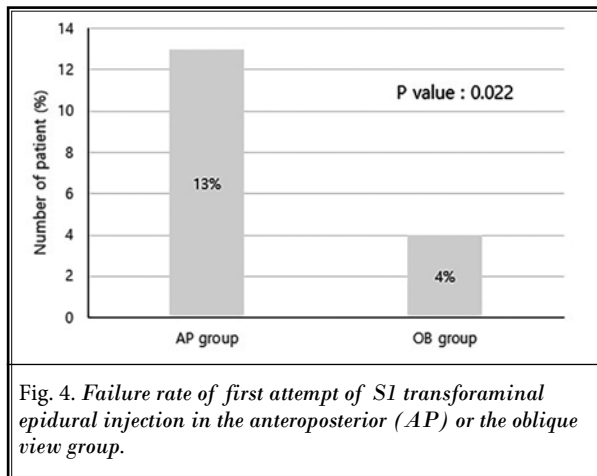
	AP view group (n = 99)	OB view group (n = 99)	P value
Epidural only	75 (75.8%)	82 (89.9%)	
All vascular	24 (24.2%)	17 (10.1%)	0.008
Epidural and vascular	16 (16.2%)	8 (8.1%)	0.082
Vascular only	8 (8.1%)	2 (2.0%)	0.053

Values are number (%) of intravascular injection.

Table 3. Radiation dose and foramen passage time required for S1 transforaminal epidural injection in the anteroposterior (AP) or the oblique (OB) view group.

	AP view group (n = 99)	OB view group (n = 99)	P value
Radiation dose (cGy/cm <sup>2</sup> )	51.3 ± 27.2	41.0 ± 17.0	0.002
Foramen passage time (seconds)	103.5 ± 44.1	84.9 ± 21.0	0.001

Values are mean ± SD.



injection rate of the AP view group was more than 2 times higher than that of the OB view group. A previous study demonstrated that the incidence of intravascular injection was high, especially at cervical and sacral levels during C-arm guided TFEI (10). This study showed an incidence rate of 24.2% in the AP view group. The incidence of intravascular injection during S1 TFEI using the AP view has been studied frequently. When the S1 intravascular injection rate was analyzed using real time fluoroscopy, the reported incidence rates were between 19% and 29% (11,14-16). Our result of intravascular incidence in the AP view group shows similarity with previous studies (11,14-16). A previous study by Kim et al (14) demonstrated the incidence rates of intravascular injection as 29% and 11% in the AP view and the OB view groups, respectively. The incidence rate of intravascular injection in the OB view group was similar to that of the present study. However, the incidence of intravascular injection in the AP view group was higher than that of our study; this could be attributed to the differences in the technology used to assess the intravascular injection. They used the digital subtraction angiography (DSA) technology to assess the intravascular injection. DSA images were more distinguished among epidurograms and intravascular spread (17,18). However, there should be an evaluation of the benefit and risk of using DSA to identify intravascular injection alone since increased radiation exposure to the medical staff and patient is always required (19).

The reason why the incidence rate of intravascular injection during S1 TFEI was lower in the OB view group than in the AP view group is unclear. The anterior and posterior internal vertebral venous plexus consists of paired anterolateral and posterolateral longitudinal veins. Both veins drain into the radicular

veins, which accompany the radicular artery and spinal nerve through the sacral foramen (20). A previous study suggested that intravascular injection occurs when the needle is placed along the pathway of the longitudinal vein during S1 TFEI in the AP view (14). Considering the vascular anatomy and needle pathway in the AP view, we think that the needle in the OB view passes outside the pathway of the longitudinal vein. Therefore, the OB view group might have reduced the chances of rupturing the longitudinal vein. Ultimately, we could lower the intravascular injection in the OB view group to as low as the lumbar level.

In this study, we measured the foramen passage time and failure rate of the first attempt of S1 TFEI to compare the technical easiness between the 2 approach methods. The foramen passage time in the OB view group was shorter than in the AP view group. Shorter foramen passage time and a lower rate of the failure of the first attempt of S1 injection in the OB view group represent the technical easiness during S1 TFEI.

Besides the high intravascular injection rate of S1 TFEI, many pain physicians encounter difficulties in finding the S1 foramen using the classic approach of AP view. Sometimes, even after needle insertion toward sacral foramen, it is uncertain whether it is inserted at the S1 or the S2 level. However, using the OB view approach, we could ascertain that S1 foramen was visualized more clearly than when using in the AP view method. Such clear visualization of S1 foramen in the OB view group resulted in a shorter passage time of foramen and a lower rate of failure of the first attempt of S1 injection as compared to the AP view group. For easier location of S1 foramen, one should check the 6 o'clock position of the L5 pedicle before identifying the S1 foramen. The S1 foramen in the OB view group was always located in the imaginary line down from the 6 o'clock position of the L5 pedicle toward sacral foramen (13,14). Clear visualization of S1 foramen is an important factor in enhancing technical easiness and safety. A previous study demonstrated that pain beginners who are practicing the C-arm guided injections required more fluoroscopy time in S1 TFEI than for the upper lumbar level TFEI (21).

In this study, we used an oblique angle of 10° to 15° in the OB group. With such an oblique angle, the appearance of "Scotty dog," which is seen at the L5, may not be as clear as the "Scotty dog" under an oblique angle of 30°. However, by using such an oblique angle, we could avoid the hindrance of iliac crest during S1 TFEI with better visualization of S1 fora-

men. In addition, if a pain physician is planning 2-level L5 and S1 TFEI, both foramen can be visualized with the same oblique angle. Therefore, one can advance an initial needle for an L5 and S1 TFEI without switching to a different angle, which would ultimately reduce the procedure time and radiation exposure.

This study presents the advantages of reducing the incidence rates of intravascular injection and enhancing the technical easiness of S1 TFEI with the use of the OB approach. In spite of many advantages of the OB approach, the decision of whether to use the AP or the OB approach depends on a physician's preference. However, if an S1 TFEI should be performed in a patient with severe foraminal stenosis or large disc herniation, even an experienced physician might have difficulty finding the S1 foramen from the AP view.

This study includes several limitations. First, the physicians in the present study were not blinded to the type of approach method (AP view vs OB view) by fluoroscopy. Second, this study did not evaluate the treatment efficacy between the 2 groups. However, we do not think that the efficacy of S1 TFEI would be affected by the oblique approach method.

## CONCLUSION

In conclusion, S1 TFEI in the OB group had a benefit of reducing the incidence of intravascular injection with reduced foramen passage time and radiation dosage. Therefore, if a pain physician encounters failure of S1 TFEI using an AP approach, the OB approach may be a useful alternative.

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