

Comparison between anteroposterior and oblique “Scotty dog” approach during S1 transforaminal epidural steroid injection

A randomized controlled trial

Ryung A. Kang, MD, PhD, Woo Seog Sim, MD, PhD, Ji Won Choi, MD, PhD*, Sehee Kang, MD, Seungwon Lee, MD, Hyeon Sook Jee, MD, Eun Jung Oh, MD, Yunghun Kim, MD, Justin Sangwook Ko, MD, PhD

Abstract

Background: Traditionally, S1 transforaminal epidural steroid injection (TFESI) has been performed using an anteroposterior (AP) fluoroscopic view. In 2007, the oblique “Scotty dog” (OS) approach was introduced as an alternative technique. We compared passage time of the needle into S1 foramen (T_f) between the anteroposterior (AP) and oblique “Scotty dog” (OS) approach during S1 TFESI.

Methods: In this prospective randomized controlled trial, seventy patients scheduled S1 TFESI were randomly allocated into AP or OS groups. In the AP group, a slight cephalad-caudad tilt was used. In the OS group, the C-arm was rotated ipsilateral oblique degrees to view the S1 Scotty dog. Both groups received injection of steroid mixed with local anesthetics. We measured the passage time of the needle into S1 foramen (T_f), primary outcome, and total procedure time (T_t) between the groups. We also recorded presence of intravascular injection, patients-assessed pain relief for one month and complications.

Results: The T_f and T_t were shorter in the OS than in the AP group (24.4 ± 24.0 s vs 47.8 ± 53.2 seconds; 93.3 ± 35.0 seconds vs 160.0 ± 98.7 seconds, $P < .001$, both). Incidence of intravascular injection (AP, 8 [22.8%]; OS, 4 [11.4%], $P = .205$), pain score, and complication rates were not statistically different between the two groups. In logistic regression analysis, the body mass index (BMI) was a risk factor for longer T_f (odds ratio [OR]=1.27, 95% CI: 1.02–1.58, $P = .030$).

Conclusion: The passage time of the needle into S1 foramen was shorter in OS approach and the OS approach reduced the procedure time compared with the AP approach during S1 TFESI. The practitioners should note that procedure time can be prolonged in obese patients.

Abbreviations: AP = anteroposterior, BMI = body mass index, LESI = lumbar epidural steroid injection, NRS = numerical rating scale, OS = oblique “Scotty dog”, RAS = Random Allocation Software, TFESI = transforaminal epidural steroid injection.

Keywords: anteroposterior, approach, oblique, procedure time, S1 transforaminal epidural steroid injection

Editor: Somchai Amorniyotin.

RAK and WSS co-first authors

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Department of Anesthesiology and Pain Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea.

* Correspondence: Ji Won Choi, Department of Anesthesiology and Pain Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, South Korea (e-mail: jiwon0715.choi@samsung.com).

Copyright © 2020 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: Kang RA, Sim WS, Choi JW, Kang S, Lee S, Jee HS, Oh EJ, Kim Y, Ko JS. Comparison between anteroposterior and oblique “Scotty dog” approach during S1 transforaminal epidural steroid injection: a randomized controlled trial. *Medicine* 2020;99:43(e22895).

Received: 22 March 2020 / Received in final form: 22 August 2020 / Accepted: 20 September 2020

<http://dx.doi.org/10.1097/MD.00000000000022895>

1. Introduction

Lumbosacral transforaminal epidural steroid injection (TFESI) is a useful treatment modality for management of lower back pain and radiculopathy of lower limbs.^[1–3] S1 TFESI has been classically performed using an anteroposterior (AP) view with caudal tilt by fluoroscopic images to superimpose dorsal and ventral foramina. However, the AP view of the S1 foramen is not always predictable, therefore time for the needle to pass through the S1 foramen is an important factor in determining total procedure time.

In 2007, Fish et al reported that a technique using the bony landmark of the “Scotty dog” on an oblique (OS) view was predictable and effective for finding the S1 foramen. This approach reduced procedure length and radiation exposure, especially when simultaneous L5 and S1 TFESI were performed. They also proposed that misplacement of the needle tip anterior to the ventral foramen could be avoided using an OS approach.^[4] Moreover, in 2015, Kim et al. found that the incidence of intravascular injection in the OS view was significantly lower than that in the AP view during S1 TFESI.^[5] However, there were no studies comparing procedure time or pain reduction between the two approaches.

Therefore, we aimed to compare the passage time of the needle into the S1 foramen (T_f) between the AP and OS approaches during S1 TFESI. We hypothesized that this passage time would be shorter in the OS approach than in the AP approach during S1 TFESI. The secondary outcomes included total procedure time, incidence of vascular injection, change in NRS (numerical rating scale; 0=no pain, 10=worst pain imaginable) pain score from the day of the procedure (day 0) to 7, 14, and 28 days after the procedure, and possible risk factors for longer procedure time between the two approaches in S1 TFESI.

2. Materials and methods

2.1. Study population and randomization

This prospective, randomized controlled trial was approved by the Institutional Review Board (IRB) of Samsung Medical Center, Seoul, Republic of Korea (IRB no. 2018–08–119–005). The study was registered with the Clinical Research Information Service (registration no. KCT0003697). Before enrollment in the study, informed written consent was obtained from each patient who received S1 TFESI in the outpatient department for pain management at a university hospital from April 2019 to September 2019. Patients 20 to 80 years of age who were diagnosed with S1 radiculopathy related to issues such as herniated intervertebral disc (HIVD) or spinal stenosis on the basis of S1 root compression on magnetic resonance imaging and symptoms persisting for at least 3 months were included. A patient was excluded if any of the following were present: pregnancy, anatomical sacral abnormality (lumbarization or sacralization), known or suspected coagulopathy, tumor or systemic infection, active infection of injection site, a history of spine surgery, or allergy to TFESI injectates (e.g., contrast media, local anesthetics, or corticosteroids).

Patients were blinded to group enrollment, but were informed that they would be in one of the two groups (anteroposterior vs oblique “Scotty dog”). Patients were allocated randomly to one of the two groups (anteroposterior approach: group AP or oblique “Scotty dog” approach: group OS) by an author (JH) using restricted randomization via Random Allocation Software (RAS),^[6] with random permuted blocks of four and an allocation ratio of 1:1.

2.2. Study intervention and clinical data measures

Two pain physicians (SW and CJ) were involved in this study. They had more than 15 years of working experience in the department of pain medicine. The S1 transforaminal epidural steroid injections were performed by one and simultaneously observed by the other. The physicians could not be blinded to the type of fluoroscopic view.

Patients were placed on a bed in the prone position, a pillow placed under the lower abdomen, and sterile preparation and draping commenced. For TFESIs in the group AP, the S1 sacral dorsal foramen was superimposed on the ventral foramen with a slight cephalad-caudad tilt, about 10° to 20°, to maximize the fluoroscopic anatomy opening of the neuroforamen in the anteroposterior view (Fig. 1A) using a fluoroscope (SERIES 9800 Mobile C-Arm, General Electric, USA). After the overlying skin around the needle entry point was infiltrated using 1% lidocaine, a spinal needle (23G, Quincke, Taechang, Korea) was inserted into the respective S1 neuroforamen (Arrow head of Fig. 1A) using intermittent fluoroscopic guidance. Once the needle passed through S1 foramen, then, the needle tip was confirmed to be adjacent to the sacral canal with a lateral image (Fig. 1B) and was repositioned as appropriate with an AP view.

For TFESIs in the group OS, the cephalad-caudad tilt was first adjusted to line-up the L5-S1 endplate using a fluoroscope. Then the fluoroscope was rotated in an ipsilateral oblique fashion, about 10° to 15°, until a ‘Scotty dog’ was seen at the L5 vertebral segment. When the L5 Scotty dog was visualized, the operator should view the S1 segment, and the dog’s “neck” and “forelimb” were identified as the superomedial landmarks of the S1 foramen. The S1 superior articular process represents the ear of a S1 dog (Fig. 2A). If a “Scotty dog” was not seen clearly at the S1 vertebral segment, the tilt was adjusted slightly and the angle of oblique projection modified if necessary. To determine the skin entry point, the operator first confirmed the 6’o’clock position below L5 pedicle in oblique “Scotty dog” view, then, could find the superomedial landmark of the S1 foramen (Arrow head of Fig. 2A) by drawing an imaginary line down from the position. After injection of 1% lidocaine at the skin entry point, a spinal needle (23G, Quincke, Taechang, Korea) was inserted into the respective S1 neuroforamen using intermittent fluoroscopic guidance. Once the needle passed through S1 foramen, then, the

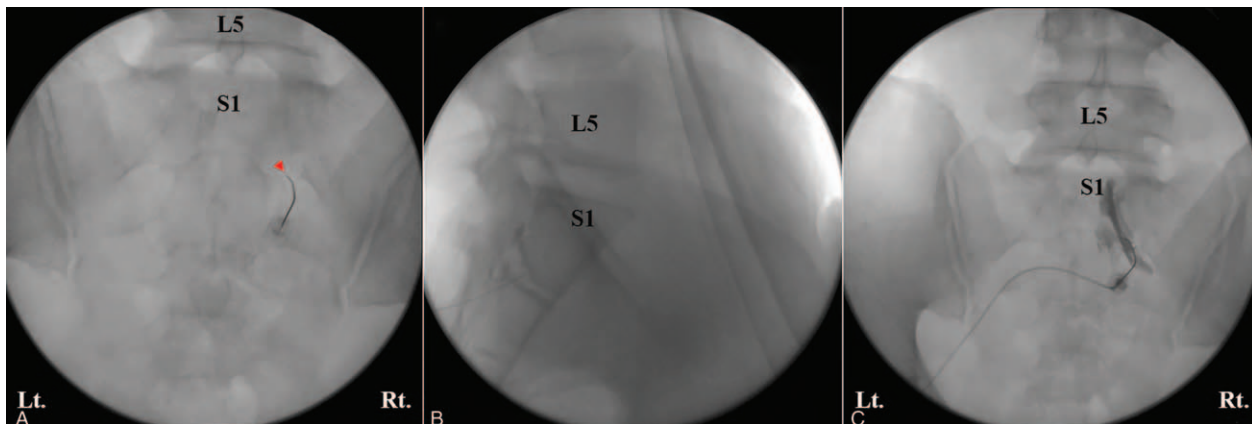


Figure 1. Anteroposterior (AP) approach for S1 transforaminal epidural steroid injection. (A) Placement of needle into S1 foramen in AP view (The arrow head indicates the respective S1 foramen). (B) The lateral view. The needle tip was confirmed to be adjacent to the sacral canal. The contrast flowing along the medial aspect of the superior pedicle of S1. (C) Anteroposterior view with contrast for checking whether intravascular injection occurred.

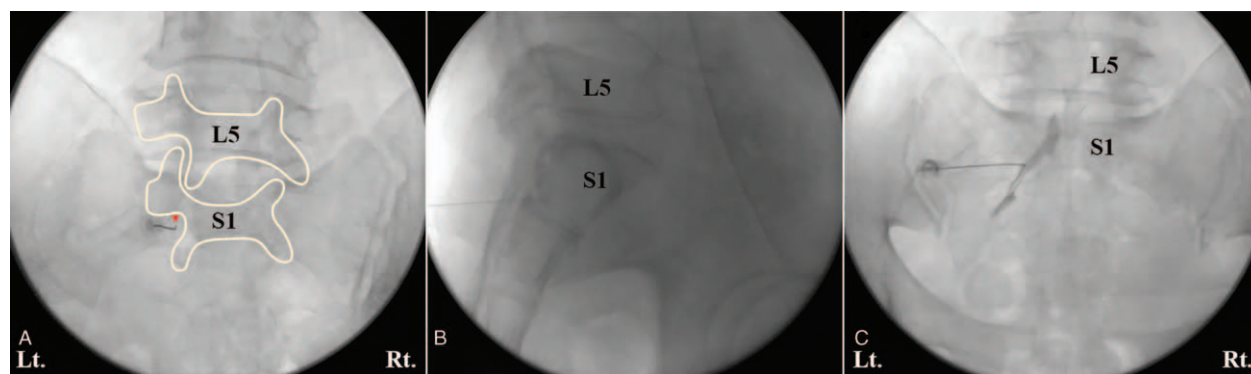


Figure 2. Oblique “Scotty dog” (OS) approach for S1 transforaminal epidural steroid injection. (A) Placement of needle into S1 foramen in oblique view with highlights of the ‘Scotty dog’ formation at L5 and S1 vertebra (The arrow head indicates superomedial landmark of the S1 foramen). (B) The lateral view. The needle tip was confirmed to be adjacent to the sacral canal. The contrast flowing along the medial aspect of the superior pedicle of S1. (C) Anteroposterior view with contrast for checking whether intravascular injection occurred.

needle tip was confirmed to be adjacent to the sacral canal with a lateral image (Fig. 2B) and the procedure continued as for transforaminal epidural steroid injection in the AP view.

In both approaches, if the needle could not pass the S1 neural foramen at once, the physician found an appropriate view again using fluoroscopic guidance. Subsequently, contrast media was injected during real-time fluoroscopy to determine whether intravascular injection occurred (Figs. 1C and 2C). Intravascular injection was confirmed based on a characteristic fleeting pattern of contrast media that immediately disappeared. The spread pattern was assigned to one of three categories (i.e., epidural only, epidural and vascular, or vascular only).^[7] If vascular spread of the contrast media was observed, the needle was relocated, and lack of vascular uptake was confirmed. Then the injectate (a total of 1.5 mL of 0.75% ropivacaine mixed with 5 mg of dexamethasone and 1,500 iu of hyaluronidase) was administered.

T_f , foramen passage time, was defined as time from the start of the procedure until the needle passed through the S1 neural foramen. T_t , total procedure time, was defined as time from the start of the procedure until the end of the procedure. Patients were allowed to continue taking their regular medications, but were prohibited from taking new medications for four weeks.

2.3. Pain assessments

Another investigator (OE) who evaluated the treatment efficacy was blinded to group enrollment as she was not involved in performing the procedure. Before injection, radiculopathy-related pain score for areas such as the lower back and legs was assessed using the NRS (0=no pain, 10=worst pain imaginable). To evaluate pain after injection, face-to-face interviews were conducted on days 0, 14, and 28, while telephone interviews were conducted on day 7 for patient convenience. Complications or discomfort associated with the procedure were also recorded.

2.4. Statistical analysis

The primary outcome of this study was the passage time of the needle into S1 foramen (T_f) between the AP and the OS approaches. The number of patients was calculated based on a pilot study conducted in 15 patients. In the pilot study, the mean time of the AP and OS approaches were 31.35 seconds and 22.92

seconds, respectively. The common standard deviation (SD) was 12.04 seconds. With a power of 80% to detect differences and a significance level of 0.05, 34 patients in each group were required. Assuming a 5% dropout rate, we planned to enroll at least 70 patients (35 individuals for each group).

Independent *t* test or the Wilcoxon rank-sum test was used to determine significant differences in continuous variables. The chi-squared test or Fisher exact test was used to compare categorical variables. Patient demographic and clinical data were summarized as a frequency (percentage) for categorical variables and mean \pm standard deviation or median (interquartile range) for continuous variables. The normality of the continuous variable was evaluated with the Shapiro–Wilk test.

Multi-variable logistic regression was used to assess possible factors for longer procedure time (T_f and T_t) than the median time. Each median time of T_f (23 seconds) and T_t (98 seconds), a binary outcome variable, was defined as the cutoff value. The view type used during S1 TFESI as well as patient’s characteristics such as sex, age, body mass index (BMI), pain duration, diagnosis, and side of procedure were entered into analysis. Collinearity was examined using VIF (variance inflation factor).

The reported *P* values were two-tailed, and $P < .05$ was considered statistically significant. All statistical analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC).

3. Results

As we needed 70 participants, 78 patients were recruited. Among them, three patients who did not meet the inclusion criteria and two who withdrew from the study were excluded; the remaining 73 patients were randomly assigned to two groups. Three patients were subsequently excluded because of changes in approach (AP to OS or OS to AP) in 2 cases, and complaint of paresthesia during the procedure in one case. Thus, 70 patients were finally analyzed (Fig. 3). Patient characteristics and clinical data are shown in Table 1.

Foramen passage time (T_f) and total procedure time (T_t) were shorter in the OS than in the AP group (24.4 ± 24.0 s vs 47.8 ± 53.2 s; 93.3 ± 35.0 s vs 160.0 ± 98.7 seconds, respectively; $P < .001$, both). Overall rate of intravascular injection in both groups was 17% (12/70). Incidence of intravascular injection was higher in the AP group than OS group, however the difference was not statistically different between the two groups (8 [22.8%]

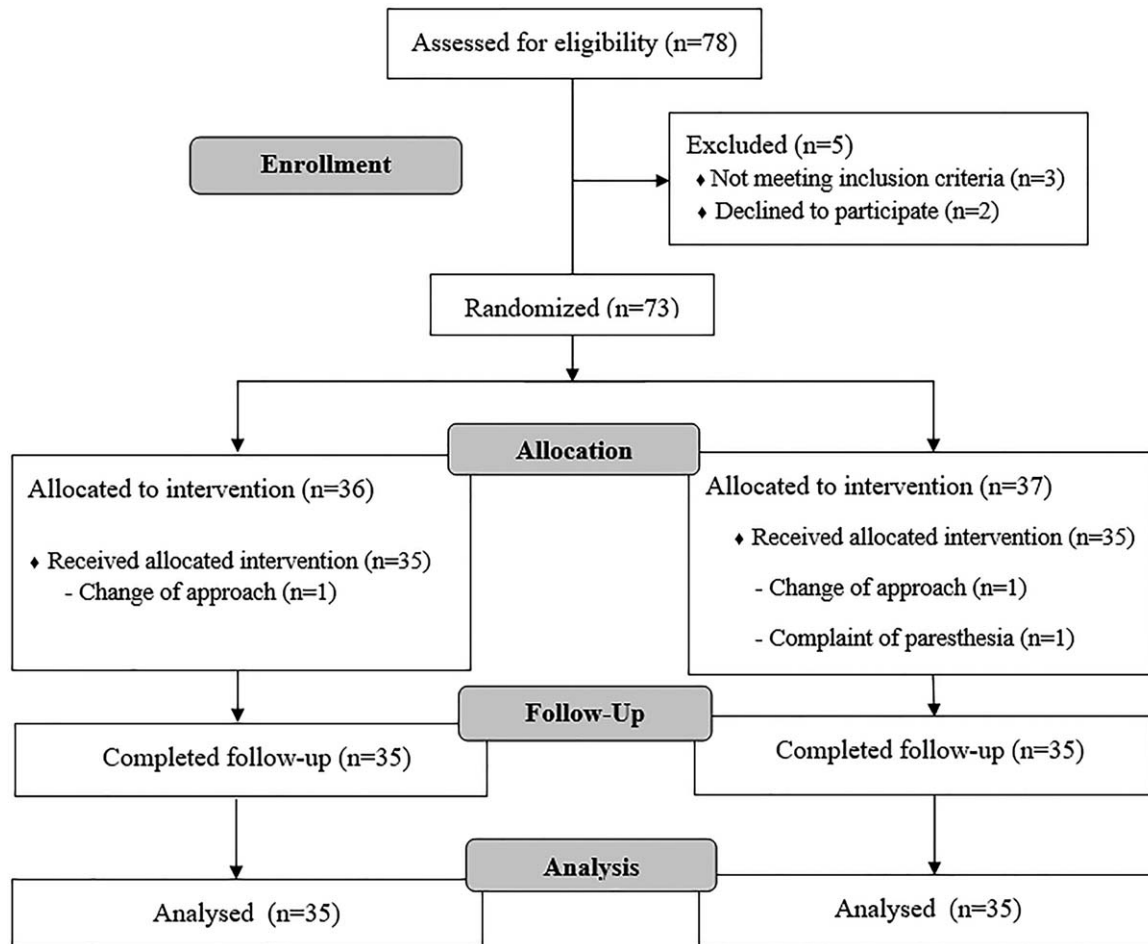


Figure 3. Consolidated Standards of Reporting Trials (CONSORT) flow diagram showing the patients progress through the study phases.

vs 4 [11.4%]; $P = .205$, Table 2). Among cases involving intravascular injection, the rates of simultaneous epidural injections in the AP and OS groups were 75% (6/8) and 50% (2/4), respectively. There were no significant differences in pain score pre- and post-procedure on days 0, 7, 14, and 28 between the 2 groups (Table 2).

Table 1
Patients characteristics and clinical data.

Parameter	Anteroposterior (AP, n = 35)	Oblique "Scotty dog" (OS, n = 35)	P value
Sex (male/female)	14/21 (40/60)	18/17 (51.4/48.6)	.337
Age (yr)	63.4 ± 12.7	66.6 ± 8.9	.424
Height (cm)	159.1 ± 8.8	160.5 ± 7.1	.497
Weight (kg)	61.9 ± 12.0	63.4 ± 9.1	.554
Body mass index (kg/m ²)	24.2 ± 3.5	24.5 ± 2.8	.647
Pain duration (month)	10.2 ± 8.2	11.8 ± 10.7	.501
Diagnosis			
Spinal stenosis	18 (51.4)	21 (60.0)	.232
HIVD	12 (34.3)	6 (17.1)	
Others	5 (14.3)	8 (22.9)	
Side			
Right	12 (34.3)	23 (65.7)	.009
Left	23 (65.7)	12 (34.3)	

Values are mean ± standard deviation or number (%). HIVD = herniated of intervertebral disc.

In multi-variable logistic regression analysis after defining each median time as the cutoff value, the AP approach was the risk factor for longer T_f and T_r (odds ratio [OR] = 8.68, 95% CI: 2.36–31.92, $P = .001$; odds ratio [OR] = 3.89, 95% CI: 1.16–13.02, $P = .027$, respectively). Thus, the BMI was the only risk factor for longer total procedure time (T_r) (odds ratio [OR] = 1.27, 95% CI: 1.02–1.58, $P = .030$). Other variables such as patient's sex, age, pain duration, diagnosis, and side of procedure (right or left) did not have statistically significant association with the longer procedure time (Table 3). There were no serious adverse events associated with the procedure.

4. Discussion

We found that the passage time of the needle into S1 foramen in the oblique "Scotty dog" approach was shorter than that in the anteroposterior approach during S1 TFESI. And the oblique "Scotty dog" approach also reduced the total procedure time compared with anteroposterior approach during S1 TFESI. However, there were no significant differences in pain reduction pre- and post-procedure for 1 month between the 2 groups. Thus, patient's body mass index was associated with prolonged total procedure time. The strength of this study is that it was the first research to evaluate the degree of pain reduction between the 2 groups after the procedure.

Table 2**Comparison between anteroposterior (group AP) and oblique “Scotty dog” (group OS) approach during S1 transforaminal epidural steroid injection.**

Parameters	Anteroposterior (AP, n=35)	Oblique “Scotty dog” (OS, n=35)	P value
Foramen passage time, T_f (s)	47.8±53.2	24.4±24.0	<.001
Total procedure time, T_t (s)	160.0±98.7	93.3±35.0	<.001
Contrast spread pattern, n (%)			.343
Epidural only	27 (77.2)	31 (88.6)	
Epidural and vascular	6 (17.1)	2 (5.7)	
Vascular only	2 (5.7)	2 (5.7)	
Intravascular injection, n (%)	8 (22.8)	4 (11.4)	.205
Numeric rating scale (0–10)			
Pre- procedure	5.7±1.3	5.9±1.2	.595
Post-procedure, day 0	2.9±2.7	3.7±2.5	.254
Post-procedure, day 7	4.0±1.8	3.8±1.8	.663
Post-procedure, day 14	4.2±1.9	4.1±1.9	.780
Post-procedure, day 28	4.4±2.0	4.2±2.1	.706

Values are mean ± standard deviation or number (%). T_f , time from the start of the procedure until the needle passed through the S1 neural foramen; T_t , time from the start of the procedure until the end of the procedure.

There have been some studies of S1 TFESI, mainly for the incidences of intravascular injection, comparing the 2 approaches or needle insertion site.^[5,8] However, there were no studies comparing the procedure time or the degree of pain reduction between AP and OS approaches. The foramen from which the S1 nerve root exits is classically accessed with an approach that differs from the lumbar foraminal approach. Mostly, an AP view with caudal tilt is used for S1 TFESI, because of the anatomical characteristics of the sacrum. The operator should superimpose the dorsal and ventral foramina to find the S1 neural foramen accurately. Thus, passing the needle through the S1 foramen determines the time and difficulty of the procedure.

One possible reason for the shorter procedure time with the OS approach is the wide range of angles for visualizing the S1 foramen in the AP approach. In other words, the OS approach can shorten “ T_f ”. An important aspect of successful S1 TFESI is to visualize the first dorsal sacral foramen. In an anteroposterior approach, the angle of the C-arm should be adjusted to overlap the ventral and dorsal foramina. In some studies,^[9,10] the range of cephalad angle was wide (ranges, 5–27° or 0–40°; mean ± standard deviation, 16.25 ± 6.75 or 15 ± 5 degrees, respectively);

often, several C-arm manipulations are needed to achieve this view. On the other hand, visualization of the lumbar vertebral segment in the “Scotty dog” approach using an oblique view is very familiar to pain physicians. After confirming the 6 o’clock position under the L5 pedicle in the oblique “Scotty dog” approach, the operator can easily find the superomedial landmark of the S1 foramen by drawing an imaginary line down from this position.

The differences in the 2 techniques might not be significant in experienced clinicians. In other words, whether to use the AP or OS approach depends on a physician’s preference. However, approaching the first sacral foramen can be difficult, because of variations in the sacrum and its components, particularly features on its dorsal surface. Furthermore, if a patient has severe foraminal stenosis or herniation of a disc, even a skilled practitioner may have difficulty finding the S1 neural foramen from the anteroposterior view.^[11,12] In another advantage of the OS approach performing two-level L5 and S1 TFESI, both foramina can be visualized with the same oblique view. This allows for initial needle advancement for a L5 and S1 TFESI using the same fluoroscopic view, which reduces procedure time and

Table 3**Logistic regression analysis of risk factors associated with longer procedure time than each median value during S1 transforaminal epidural steroid injection.**

Variables	Foramen passage time ($T_f \geq 23$ s [*])		Total procedure time ($T_t \geq 98$ s [*])	
	OR [95% CI]	P value	OR [95% CI]	P value
AP approach (OS approach [†])	8.68 [2.36, 31.92]	.001	3.89 [1.16, 13.02]	.027
Sex (Female [†])	2.55 [0.72, 9.00]	.146	1.29 [0.41, 4.02]	.664
Age	1.04 [0.98, 1.11]	.152	0.96 [0.90, 1.02]	.199
BMI	0.98 [0.81, 1.19]	.844	1.27 [1.02, 1.58]	.030
Pain duration	0.97 [0.91, 1.03]	.347	1.02 [0.96, 1.09]	.483
Diagnosis (Spinal stenosis [†])		.610		.457
HIVD	0.55 [0.09, 3.43]	.936	0.52 [0.10, 2.81]	.768
Others	1.48 [0.25, 8.73]	1.000	0.30 [0.04, 2.60]	.425
Right side (Left side [†])	2.80 [0.83, 9.52]	.098	2.30 [0.72, 7.38]	.160

All relevant variables underwent univariable analysis and multivariable analysis. AP approach = anteroposterior approach, BMI = body mass index, CI = confidence interval, HIVD = herniated of intervertebral disc, OR = odds ratio, T_f = time from the start of the procedure until the needle passed through the S1 neural foramen, T_t = time from the start of the procedure until the end of the procedure.

^{*} median value.

[†] reference.

radiation exposure. Then, the AP view can also be obtained to visualize the S1 foramen. For beginners, using an OS approach or both OS and AP approaches can help them find the S1 foramen quickly and accurately. In one study of residents' learning curve with lumbar TFESI, residents took more time and required more fluoroscopy in TFESI of S1 than for the upper lumbar nerve roots.^[13] In our study, an OS approach to the S1 foramen was effective, easy, and faster than the AP approach. In the report that first introduced the oblique approach, researchers mentioned potential advantages of it, including reduced procedure time and radiation exposure.^[4]

The incidence of accidental intravascular injection during lumbosacral TFESI is reported as from 9.9% to 30.8%.^[14–17] Moreover, the incidence of intravascular injection during S1 TFESI in the AP view was reported as from 16.5% to 19%.^[7,16] In this study, the overall rate of intravascular injection during the procedure in both groups was 17%. In a previous study, S1 TFESI in the OS view rather than the AP view reduced the risk of intravascular injection, decreasing the incidence to 11%.^[5] These researchers thought that the S1 TFESI in the OS approach might have lower risk of contact with the posterolateral longitudinal veins.

However, in the present study, the rate of intravascular uptake was not statistically different between the two groups, although the incidence was higher in the AP group (group AP, 8 [22.8%]; group OS, 4 [11.4%]; $P = .205$). This difference might be explained by the sample size difference between the two studies. In a previous study, 104 cases were estimated per group, assuming that the difference in intravascular injection rate between the two approaches was greater than three times. On the other hand, in our study, 70 cases were analyzed with the primary objective of comparing the procedure time between the two groups. The second reason for the difference was probably the angle of the OS approach. We applied the OS approach used in the report by Fish et al, who mentioned that one potential disadvantage of the oblique view was possible obstruction of the pathway to the S1 foramen by the iliac crest.^[4] Therefore, we utilized an angle of 10° to 20°, which was smaller than the commonly used angle of L5 TFESI.^[18] Then, in many cases, the block needle arrived in the sacral epidural space with less inward angle.

We already confirmed correlation between the AP/OS approach and the procedure time using Wilcoxon rank sum test. Further, we also analyzed the factors influencing longer procedure time than the median value (Tf: 23 seconds, Tt: 98 seconds). In an analysis of factors affecting foramen passage time (T_f) and total procedure time (T_t) using the logistic regression method after defining each median time as the cutoff value, the AP approach was significantly associated with longer Tf and Tt. And, the BMI was only associated with longer Tt. Some studies have shown longer fluoroscopy times with increasing BMI during interventional and surgical procedures.^[19–22] According to one study that assessed the relationship between BMI and fluoroscopy time during lumbar epidural steroid injection (LESI) for lumbosacral radiculopathy, obese patients required the longest fluoroscopy times, and trainees involved in TFESI needed longer time with increasing BMI classes. This is likely due to a combination of a greater depth of tissue traversed to reach the epidural space of patients with increased BMI and reduced radiographic image quality in patients with higher BMI. However, BMI was not significantly associated with the passage time of the needle into the S1 foramen (T_f). This means that a proper view to find the S1 foramen is a very important factor in

reducing the procedure time. In the case of procedure side, there was statistically different results between the two groups. However, approach side was not associated with long procedure time in logistic regression analysis.

There were some limitations in this study. First, during the procedure, the physician performing the procedure and the physician viewing the epidurogram could not be blinded to the type of fluoroscopic view (anteroposterior vs oblique “Scotty dog”). However, the clinician performed transforaminal epidural steroid injections only with given information as to which view should be applied. Furthermore, another researcher who was not involved in performing the procedure followed up the patients' treatment efficacy so as to minimize the confirmation bias. Second, we excluded patients with a history of spine surgery. Our results may not be applicable to the patients with a history of spine surgery. In previous studies, spine surgery history was unrelated to intravascular injection during S1 TFESI.^[5,8] Regarding procedure time, further research will be needed.

In conclusion, the passage time of the needle into the S1 foramen via an OS approach was shorter than that using an AP approach during S1 TFESI. Thus, the OS approach reduced the total procedure time compared with the AP approach. Moreover, the body mass index of patients was associated with longer total procedure time. There were no significant differences in pain reduction during the first month after the procedure. Therefore, the OS approach may be an easy and safe alternative for physicians, especially beginners, who fail the procedure via an AP approach during S1 TFESI.

Author contributions

Conceptualization: Woo Seog Sim, Ji Won Choi

Data curation: RyungA Kang, Ji Won Choi, Sehee Kang, Seungwon Lee, Yunghun Kim

Formal analysis: Ji Won Choi, Sehee Kang, Seungwon Lee

Investigation: Woo Seog Sim, Ji Won Choi, Seungwon Lee, Hyeon Sook Jee, Eun Jung Oh

Methodology: RyungA Kang, Woo Seog Sim, Ji Won Choi, Sehee Kang, Hyeon Sook Jee

Project administration: RyungA Kang, Ji Won Choi

Resources: Woo Seog Sim, Ji Won Choi, Justin Sangwook Ko

Software: Eun Jung Oh, Yunghun Kim

Supervision: Woo Seog Sim, Ji Won Choi, Justin Sangwook Ko

Validation: Woo Seog Sim, Ji Won Choi, Justin Sangwook Ko

Visualization: RyungA Kang, Ji Won Choi, Eun Jung Oh

Writing – original draft: RyungA Kang, Ji Won Choi, Justin Sangwook Ko

Writing – review & editing: RyungA Kang, Woo Seog Sim, Ji Won Choi, Justin Sangwook Ko

References

- [1] Lee JH, Shin KH, Park SJ, et al. Comparison of clinical efficacy between transforaminal and interlaminar epidural injections in lumbosacral disc herniation: a systematic review and meta-analysis. *Pain Physician* 2018;21:433–48.
- [2] Vad VB, Bhat AL, Lutz GE, et al. Transforaminal epidural steroid injections in lumbosacral radiculopathy: a prospective randomized study. *Spine (Phila Pa 1976)* 2002;27:11–6.
- [3] Abdi S, Datta S, Trescot AM, et al. Epidural steroids in the management of chronic spinal pain: a systematic review. *Pain Physician* 2007;10:185–212.
- [4] Fish DE, Lee PC, Marcus DB. The S1 “Scotty dog”: report of a technique for S1 transforaminal epidural steroid injection. *Arch Phys Med Rehabil* 2007;88:1730–3.

- [5] Kim DH, Yoon DM, Yoon KB. Incidence of intravascular injection and the spread of contrast media during S1 transforaminal epidural steroid injection by two approaches: anteroposterior vs oblique. *Anaesthesia* 2015;70:975–84.
- [6] Saghaei M. Random allocation software for parallel group randomized trials. *BMC Med Res Methodol* 2004;4:26.
- [7] Smuck M, Fuller BJ, Yoder B, et al. Incidence of simultaneous epidural and vascular injection during lumbosacral transforaminal epidural injections. *Spine J* 2007;7:79–82.
- [8] Park SJ, Kim SH, Kim SJ, et al. Comparison of incidences of intravascular injection between medial and lateral side approaches during traditional S1 transforaminal epidural steroid injection. *Pain Res Manag* 2017;2017:6426802.
- [9] Park YJ, Lee SH, Ryu KH, et al. Novel method for S1 transforaminal epidural steroid injection. *World Neurosurg* 2020;133:e443–7.
- [10] Plataras CT, Popescu A, McLaughlin CA, et al. C-arm fluoroscope angle settings for fluoroscopically guided lumbar transforaminal epidural injections. *Pain Med* 2016;17:832–8.
- [11] Cheng JS, Song JK. Anatomy of the sacrum. *Neurosurg Focus* 2003;15:E3.
- [12] Povo A, Arantes M, Matzel KE, et al. Surface anatomical landmarks for the location of posterior sacral foramina in sacral nerve stimulation. *Tech Coloproctol* 2016;20:859–64.
- [13] Joswig H, Haile SR, Hildebrandt G, et al. Residents' learning curve of lumbar transforaminal epidural steroid injections. *J Neurol Surg A Cent Eur Neurosurg* 2017;78:460–6.
- [14] Furman MB, O'Brien EM, Zgleszewski TM. Incidence of intravascular penetration in transforaminal lumbosacral epidural steroid injections. *Spine (Phila Pa 1976)* 2000;25:2628–32.
- [15] Lee MH, Yang KS, Kim YH, et al. Accuracy of live fluoroscopy to detect intravascular injection during lumbar transforaminal epidural injections. *Korean J Pain* 2010;23:18–23.
- [16] Nahm FS, Lee CJ, Lee SH, et al. Risk of intravascular injection in transforaminal epidural injections. *Anaesthesia* 2010;65:917–21.
- [17] Smuck M, Yu AJ, Tang CT, et al. Influence of needle type on the incidence of intravascular injection during transforaminal epidural injections: a comparison of short-bevel and long-bevel needles. *Spine J* 2010;10:367–71.
- [18] Ra IH, Min WK. Optimal angle of needle insertion for fluoroscopy-guided transforaminal epidural injection of L5. *Pain Pract* 2015;15:393–9.
- [19] Ector J, Dragusin O, Adriaenssens B, et al. Obesity is a major determinant of radiation dose in patients undergoing pulmonary vein isolation for atrial fibrillation. *J Am Coll Cardiol* 2007;50:234–42.
- [20] Torrecilla Ortiz C, Meza Martinez AI, Vicens Morton AJ, et al. Obesity in percutaneous nephrolithotomy. Is body mass index really important? *Urology* 2014;84:538–43.
- [21] Stanic MG, Majewska N, Makalowski M, et al. Patient radiation exposure during carotid artery stenting. *Vascular* 2015;23:154–60.
- [22] Baratz MD, Hu YY, Zurakowski D, et al. The primary determinants of radiation use during fixation of proximal femur fractures. *Injury* 2014;45:1614–9.