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Fluoroscopic Angles in S1 Transforaminal Epidural Steroid Injections: Effects on Procedure Time

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Abstract

Objectives

To evaluate the average fluoroscopic angles used in S1 TESI and to assess their effect on procedure time.

Patients and methods::

This observational study included patients who underwent unilateral, single-level S1 TESI between July 2024 and January 2025. Demographic data, procedure time, and fluoroscopic cranio-caudal and oblique angles were analyzed to assess their association with procedure duration.

Results

A total of 51 patients were included in the study. The mean cranial and oblique angles at which the procedures were performed were 13.2 (± 5.19) and 9.2 (± 5.58), respectively. The mean procedure time of the patients were 28.46 seconds (16–93). Cranial angle demonstrated a moderate correlation with procedure time, whereas oblique angle, age, and sex had no significant effect. Furthermore, it was found that the procedure time was significantly shorter in the group where the procedure was performed at lower cranial angles.

Conclusion

In the present study, the average fluoroscopic angles used during S1 TESI were evaluated, and it was determined that excessive cranial angles cause the procedure time to be prolonged.

Introduction

Low back pain (LBP) is one of the most common reasons for seeking medical attention. According to epidemiological studies, 84% of adults experience LBP during their life (1). Moreover, approximately 3 to 5% of patients with LBP experience radicular symptoms (2). These represent a distinct clinical entity characterized by nerve root compression or irritation, typically resulting in pain, numbness or weakness radiating along the distribution of the affected spinal nerve. The majority of these radiculopathies involve the L5 and S1 nerve roots, which are particularly vulnerable due to their anatomical location and the risk of compression from adjacent degenerative musculoskeletal structures (2, 3).

Transforaminal epidural steroid injection (TESI) is applied in cases of lumbosacral radiculopathy that are resistant to conservative treatment (4–6). Indications for the procedure include radicular pain secondary to disc herniation, neurogenic claudication due to central spinal stenosis, and radicular pain associated

with post-lumbar surgery syndrome (7, 8). However, difficulties are encountered, particularly when performing S1 TESI. The main challenges of this interventional procedure relate to anatomical variability, such as the depth and orientation of the posterior S1 foramen, potential obstruction by the iliac crest in certain pelvic morphologies, and the proximity of vascular structures that may increase the risk of intravascular contrast uptake (9). For the procedure, the patient is positioned prone. Using a C-arm fluoroscopy device, cephalocaudal and oblique angles are used to align the anterior and posterior foramina. If the ideal oblique and cranial angles are not achieved, insertion of the needle into the foramen becomes more difficult, and the procedure cannot be performed, or the procedure duration may be prolonged.

Previous studies have involved heterogeneous populations, varying fluoroscopy settings, and differing levels of operator experience (10–12).In present study, we aimed to determine the mean angles used for S1 TESI and to evaluate the effect of these angles on procedure time.

Patients and methods

Design and study population

The study was conducted in accordance with the principles of the Declaration of Helsinki. After receiving approval from the institutional ethics committee (Ethics number:4710), patients who underwent S1 TESI between July 2024 and January 2025 were included in the study. Written informed consent was obtained from all participants prior to their enrollment in the study. Data were collected exclusively from patients for whom the procedures were successfully performed in compliance with the guidelines (12).

Inclusion criteria were: age over 18 years, presence of radicular symptoms for more than 3 months, MRI-confirmed S1 root compression, and having undergone unilateral, single-level TESI. Patients with a history of previous lumbar surgery, no images of the procedure, or no demographic data were excluded from the study.

Measures

The age, sex, height, weight, body mass index (BMI), procedure time (seconds) of all patients were recorded. Procedure time refers to the duration of active fluoroscopic exposure, as recorded by the C-arm system (13, 14). During the procedure was performed by the physician, the cranio-caudal and oblique angles were noted by the another pain medicine specialist. The angles were recorded based on the values shown on the fluoroscopy C-arm during the procedure.

Procedure

The patients were placed prone, and a pillow was placed under their abdomens to flatten lumbar lordosis. The injection site was cleaned three times with a povidone-iodine solution and covered with a

sterile drape. The C-arm is adjusted to obtain an optimal cranio-caudal and oblique view that clearly outlines the sacral foramen. The skin area at the needle entry point was anesthetized (5 cc 2% prilocaine) before advancing the tip of a 22-gauge, 10-cm Quincke needle under intermittent fluoroscopic guidance. When the epidural space was approached, 1–2 ml of contrast material was injected to confirm epidural and transforaminal spread, ensuring no vascular uptake (Fig. 1). Then, 3 cc of drug mixture (8 mg of dexamethasone, 1 cc of 2% lidocaine) was injected. Patients were monitored for adverse effects for 1 hour before discharge. All procedures were performed by a pain medicine specialist with at least 10 years of experience with the same fluoroscopy unit (Ziehm Vision R) performing intermittent imaging.

Statistical analysis

Using G*Power software with an effect size of 0.50, a significance level of 0.05, and a desired power of 0.80, the required sample size was calculated to be 50 patients (10).

SPSS 22.0 software (IBM Corp., Armonk, NY) was used for the statistics. Continuous variables were expressed as mean and median. Categorical variables were defined as number and frequency. The Shapiro-Wilk test was used to determine the normal distribution of the data. The relationship between continuous variables was assessed using Pearson’s correlation analysis. To determine the independent predictors of procedure time, a multiple linear regression analysis was performed. An independent samples t-test was used to compare cranial angle groups. A p-value of less than 0.05 was considered statistically significant.

Results

All 51 patients included in the study had their procedures performed using the cranial angle. No patient underwent the procedure using the caudal angle. Twenty-six (50.9%) of the patients were male, and the mean age of all patients was 43.66 (18–78) years. The mean procedure time of the patients was 28.46 seconds (16–93). The mean cranial and oblique angles at which the procedures were performed were 13.2 (0–25) and 9.2 (0–20), respectively (Table 1).

Table 1
Demographic and procedural characteristics.

Variable		Value (n:51)
Age (years)		43.66 (18–78)
BMI (kg/m2)		27.51 ± 4.01
Procedure time (s)		28.46 (16–93)
Gender (n)	Male	26 (50.9%)
	Female	25 (49.1%)
Cranial angle		13.2 (0–25)
Oblique angle		9.2 (0–20)
BMI: Body mass index,		

Correlation analysis revealed a no effect of the oblique angle on the procedure time was detected, a moderate positive correlation was found between the given cranial angle and the procedure time (correlation coefficients 0.335). It was also determined that age and sex had no effect on procedure time (Table 2).

Table 2
Correlation coefficient between the procedure time and health status measurements

Age (years)	Procedure time (s)
	0.251
Gender	0.179
BMI (kg/m2)	0.239
Cranial angle	0.335*
Oblique angle	0.095
* p < 0.05	

Multiple linear regression analyses were performed to determine the factors associated with procedure time. Age was also significantly associated with procedure time (B = 0.267, β = 0.252, t = 2.103, p = 0.044). Although BMI showed a negative association, it did not reach statistical significance (B = -0.977, β = -0.277, t = -1.808, p = 0.081). Sex, cranial angle, and oblique angle were not significant predictors of procedure time (p > 0.05) (Table 3).

Tbale 3. Multiple linear regression analysis of factors affecting procedure time

	Procedure time			
	B	Beta	t value	p
Age (years)	0.267	0.252	2.103	0.044
Gender	0.470	0.017	0.137	0.892
BMI (kg/m2)	-0.977	-0.277	-1.808	0.081
Cranial angle	0.465	0.170	1.157	0.257
Oblique angle	0.064	0.025	0.202	0.841

BMI: Body mass index,

Cranial angle was dichotomized based on the median value. It was found that the procedure times were significantly longer in the group with angles greater than 13 degrees (Fig. 2).

Discussion

Visualizing the sacral foramen can be difficult in some patients. Therefore, knowing the optimal fluoroscopic angles to start with is of critical importance. In the present study, the average cranial and oblique angles at which procedures were performed were evaluated. Furthermore, a positive correlation was found between the cranial angle and procedure time. Moreover, it was determined that excessive cranial angles cause the procedure time to be prolonged.

When performing S1 TESI, angles were evaluated during the procedure, and average angles were suggested in some studies (10–12). Plastaras et al. observed the ideal angles during the procedure to be an oblique angle of 5° ± 5° in 73% of patients and a cephalad tilt angle of 15° ± 5° in 69% of cases (12). Chang et al., using computed tomography, evaluated the ideal oblique angle for the S1 foramen as 25° ± 1.36 (11). Park et al. performed ultrasound-guided s1 TESI and confirmed it with fluoroscopy and found the cephalad angle to be 16.25 ± 6.75° and the oblique angle to be 2.48 ± 2.62°(10). In the present study, the oblique and cranial angles were found to be 9.2 (0–20) and 13.2 (0–25), respectively. These findings, in conjunction with previous literature, suggest that a relatively low oblique angle is optimal for the procedure. The reason for not providing a higher oblique angle is likely due to the iliac crest obscuring the foramen at higher angles.

Various studies have shown that the procedure time varies in epidural procedures (14, 15). Studies on TESI have shown that procedure time vary depending on the level (16, 17). In the present study, a positive correlation was found between cranial angle and procedure time. This suggests that working with larger cranial angles during injection increases the duration of fluoroscopy. However, multiple regression analysis revealed that cranial angle was not an independent predictor of procedure time. When the cranial angle was categorized as low or high, it was found that the procedure time was shortened at

angles less than 13 degrees. We believe that high cranial angles, especially those with very high oblique angles, prevent the anterior and posterior S1 foramina from aligning, thus prolonging the procedure.

In the present study, age was also found to be a factor affecting procedure time. With increasing age, spinal degeneration, disc size reduction, and foraminal formation increase. This can increase procedure time, create anatomical challenges during TESI, and adjust the fluoroscopy angles may be adjusted (18, 19). Consequently, increasing aging can lead to increased procedure time and radiation exposure during TESI; therefore, age-specific dose planning and careful planning are necessary.

This study has several limitations. First, the study was conducted at a single center, which may limit the generalizability of the findings. All procedures were performed by highly experienced physicians, potentially reducing the variability in technique and minimizing the influence of imaging angles on radiation dose and procedure time. Anatomical variations, such as sacral slope, iliac crest height, and foramen size, were not quantitatively assessed, which may have influenced the required imaging angles. Technical parameters of the fluoroscopy device, such as frame rate and dose settings, were not standardized across all procedures. Nevertheless, a major strength of this study is that it demonstrates the potential imaging angles for S1 TESI and evaluates their effects on procedure time.

In conclusion, the mean cranial and oblique angles used for the S1 TESI were identified. Additionally, the study demonstrated that excessive cranial angles cause the procedure time to be prolonged. Moreover, multicenter studies are needed to achieve standardization.

Declarations

Conflict of interest: The authors declare that they have no potential conflicts of interest regarding the investigation, authorship, and/or publication of this article.

Ethical Approval and consent to participate: This study was approved by the Şişli Hamidiye Etfal Hospital Ethics Committee with approval no: 4710. The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their enrollment in the study.

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Clinical trial number: Not applicable

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Author contributions: This study was designed by RS, TS, HK,GE. The data were analyzed by RS , and the results were critically examined by all authors. RS and HG had a primary role in preparing the manuscript, which was edited by RS. All authors have approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Data availability statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Figures

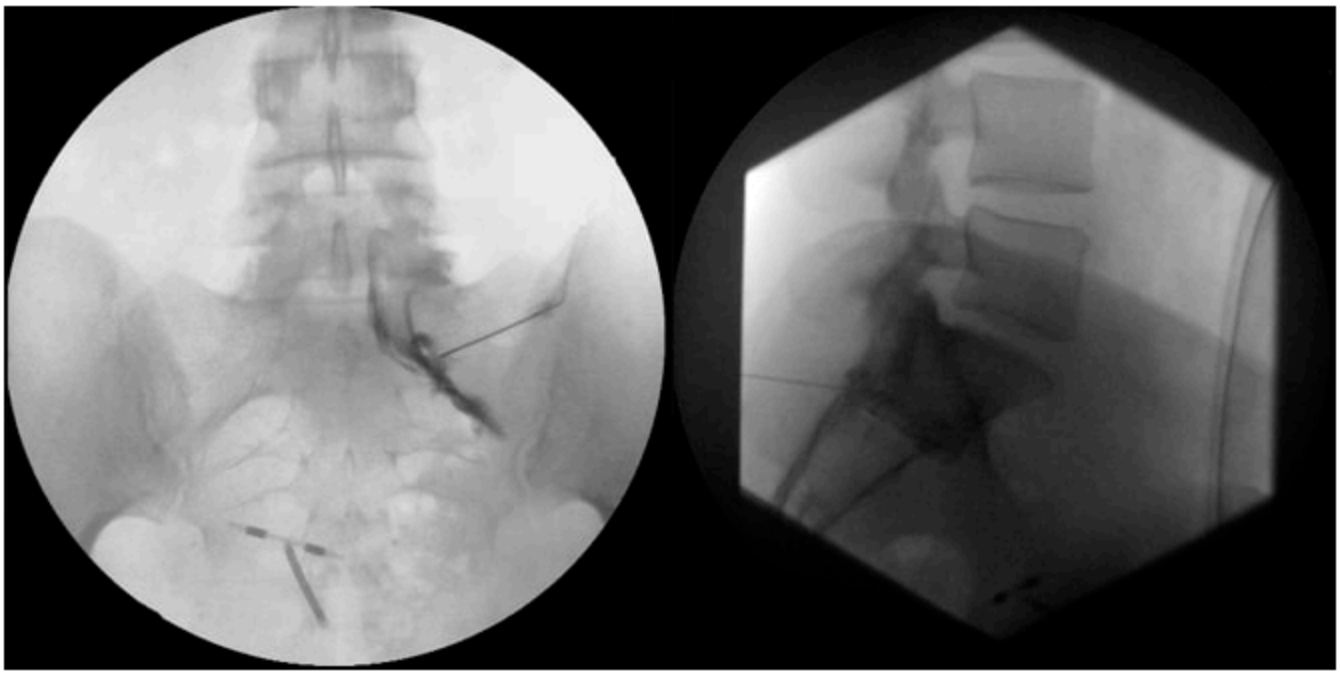


Figure 1

Anteroposterior and lateral fluoroscopic views of a right S1 transforaminal epidural steroid injection.

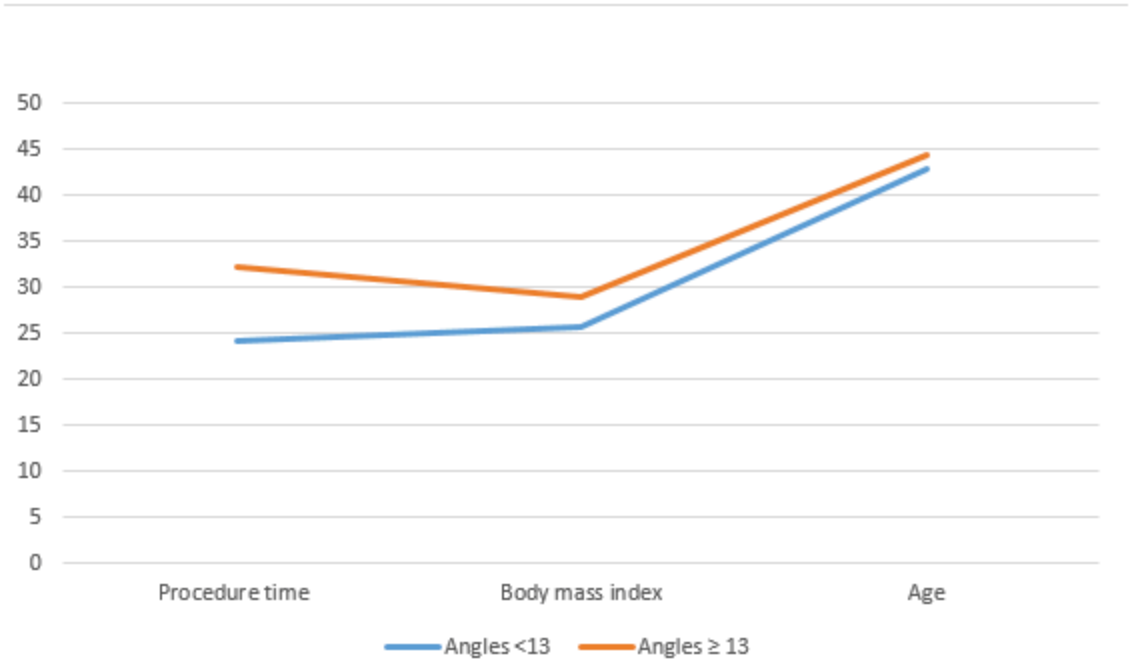


Figure 2

Comparison of procedure time, age, and body mass index between cranial angle groups (<13° and ≥13°).