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ORIGINAL ARTICLE

Comparison of radiation doses of fluoroscopy-guided transforaminal epidural steroid injections and dorsal root ganglia pulsed-radiofrequency applications

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SUMMARY

Objectives: The study aims to determine procedure times and estimate the radiation doses for fluoroscopy-guided transforaminal epidural steroid injection (TFESI) and dorsal root ganglion pulsed radiofrequency (DRG RF) per intervention. The goal is to postulate radiation doses for potential utilization in plans to reduce radiation doses in future interventions.

Methods: An observational study was conducted on six hundred ninety-six patients with low back pain who underwent fluoroscopy-guided TFESI or DRG RF at an algology clinic of a training and research hospital. Procedure time and radiation dose per procedure were recorded.

Results: One hundred eighty-nine of the patients underwent DRG RF, and 507 of them underwent TFESI. A total of 1,069 procedures were performed. Procedure time and radiation dose per procedure were found to be 25.68 seconds (7–94) and 4.99 mGy (0.66–49.4), respectively. There was no difference between the DRG RF and TFESI groups in terms of diagnosis, age, gender, BMI, procedure level, and radiation dose. It was found that the procedure time was significantly lower in the DRG group.

Conclusion: Although no difference was detected between TFESI and DRG RF in terms of radiation dose, the procedure time was found to be significantly shorter in the DRG RF group. Pulsed radiofrequency may be preferred in necessary patients, considering the cost.

Keywords: Dorsal root ganglia; epidural; fluoroscopy; radiation döşe; radiofrequency; transforaminal.

Introduction

Spinal interventions under fluoroscopy guidance are frequently used to ensure accurate injection into the target area. While it positively affects treatment outcomes, it can also prevent intravascular injections, dural tears, spinal cord infarction, and even death.[1] However, concerns about radiation exposure have come to the fore with the increasing frequency of use. Lumbar transforaminal epidural steroid injections (TFESI) and dorsal root ganglia (DRG) radiofrequency (RF) procedures are efficient techniques for patients suffering from low back radicular pain, and fluoroscopy guidance is required.

Epidural steroid injections are offered to deliver steroids or local anesthetics to the target area. TFESI is one of the most frequent epidural injections performed fluoroscopy-guided. The DRG plays a key role in the development of chronic pain, and DRG interventions for chronic pain management are an important part of its treatment. The DRG includes sensory neurons that are essential for the transmission of sensory information and non-neuronal cells such as macrophages and immune cells that are responsible for the modulation of neuronal function.[2] Cellular interactions between macrophages and neurons have been shown to regulate the pain signaling.[3] The recent study also showed that there was

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a decrease in serum TNF levels that continued until the 3rd month after combined DRG RF and TFESI.[4]

Both TFESI and DRG RF are performed by clinicians for low back and radicular pain. Some studies have shown that both procedures have similar effects in the short and long term.[5,6] But to our knowledge, the radiation dose and procedure time of these two procedures have not been compared yet. Therefore, the study aims to find out procedure times and estimate the radiation doses for two particular approaches of fluoroscopy-guided injections per intervention to postulate radiation doses for potential utilization for plans to reduce radiation dose in future interventions.

Materials and Methods

Design and Study Population

The research project protocol has been approved by the Ethics Committee at Health Sciences University Şişli Hamidiye Etfal Training and Research Hospital and is carried out in accordance with the ethical standards specified in the Helsinki Declaration (ethics approval number 4075). All individuals gave their informed consent before being included in the study. After receiving institutional ethics committee approval, patients who underwent lumbar TFESI or DRG RF under fluoroscopy were included. The primary outcome of the study is to calculate radiation dose per level and procedure time for fluoroscopy-guided TFESI and DRG-RF performed by experienced interventionists and to establish preliminary reference values for potential use.

After applying the exclusion and inclusion criteria, this study was conducted with 696 patients who had lumbar TFESI or DRG RF injections. A total of 1,069 interventional procedures between January 2022 and January 2023 were scanned from the hospital database system. Inclusion criteria were patients ≥18 years of age. Patients with a history of lumbar spine surgery and scoliosis, patients without procedure time, and radiation dose were excluded from the study. The procedure levels were determined as L4, L5, and S1, which are the most common hernia levels. Patients were divided into two groups as DRG RF or TFESI so that comparison could be made.

Procedures

Patients were placed prone, and a pillow was placed under their bellies to flatten lumbar lordosis. The injection site was cleaned three times with a povidone-iodine solution and covered with a sterile drape. The fluoroscopy device was given adequate angles to visualize the relevant 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 or 10 cm 22-gauge radiofrequency needle under intermittent fluoroscopic guidance. When the epidural space was approached, for the Quincke needle, the lateral view confirmed whether the needle was in the target point. For the radiofrequency needle, the correct location was determined by sensory and motor stimulation in the AP view.

Radiopaque substances (1 cc iohexol) were used to confirm whether the needle was in the epidural area in both procedures. Patients were discharged one hour after the injection in case of any adverse effects.

All procedures were performed by a pain medicine specialist with at least 5 years of experience, with the same fluoroscopy unit (Ziehm Vision R) performing intermittent imaging. Collimation was used in all procedures to minimize radiation exposure according to ALARA rules.

Data Collection

Radiation doses and procedure times were obtained from the fluoroscopy device after the procedure. Procedure time was calculated as fluoro-time only during the entire procedure. Bringing the patient into the room, positioning him/her, or applying stimulation were not added to the total time. For multiple-level procedures or bilateral procedures, time and radiation dose were divided by the number of levels. Demographic data of the TFESI and DRG RF groups were compared. Additionally, the patient's diagnoses and procedure levels were compared.

Statistical Analysis

Based on the study conducted by Suresh et al.[7] to examine the radiation dose difference between the two groups, the number of patients was found to be 640, with a 95% confidence interval and 80% power. SPSS 22.0 software (IBM Corp., Armonk, NY) was used

Table 1. Demographic and procedural characteristics

Variable	Value (n=696)
Age (years)	52.22 (19–91)
BMI (kg/m^2)	28.54±4.92
Radiation dose	4.99 (0.66–49.4)
Procedure time (s)	25.68 (7–94)
Gender, n (%)	
Male	301 (42.4)
Female	395 (57.6)
Procedure	
TFESI	507 (72.8%)
	236 (47%) single-level
	271 (53%) multiple-level
DRG	189 (27.2%)
	87 (46%) single-level
	102 (54%) multiple-level
Diagnosis	
LDH	465 (66.9%)
LSS	231 (33.1%)
Procedure level (n=1069)	
L4	206 (19.3%)
L5	588 (55.1%)
S1	273 (25.6%)

BMI: Body mass index; LDH: Lumbar disc herniation; LSS: Lumbar spinal stenosis; TFESI: Transforaminal epidural steroid injection; DRG: Dorsal root ganglion.

for statistics. Continuous variables are 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 Mann-Whitney U test was used to compare non-normally distributed data, and the independent t-test was used to compare normally distributed data. The chi-square test was used for categorical variables. The $p<0.05$ was considered statistically significant.

Results

A total of 696 patients were included in the study. Demographic and procedural characteristics have been given in Table 1. One hundred eighty-nine of these were patients who underwent DRG-RF, and 507 were patients who underwent TFESI. The average age of the patients was 52.22 (19–91). The average BMI of all patients was 28.54±4.92. In terms of gender, there was female dominance (57.6%). A total of 1,069 procedures were performed. The most frequently performed procedure level was determined to be L5, with 55.1%. Procedure time and radiation dose per procedure were found to be 25.68 (seconds) (7–94) and 4.99 (mGy) (0.66–49.4), respectively.

Table 2. Comparison of the characteristics of the both groups

	TFESI (n=507)	DRG (n=189)	p
Age (years)	51.95±20.42	52.77±23.83	0.233
BMI (kg/m^2)	28.48±4.77	28.97±5.78	0.436
Radiation dose	4.90±4.71	5.24±3.95	0.383
Procedure time	26.60±11.04	23.22±10.09	<0.001
Gender			0.541
Male	217 (42.8%)	86 (45.5%)	
Female	290 (47.2%)	103 (54.5%)	
Diagnosis			0.246
LDH	356 (70.1%)	124 (65.5%)	
LSS	151 (29.9%)	65 (34.5%)	
Procedure level			0.116
L4	161 (20.7%)	48 (16.5%)	
L5	415 (53.5%)	169 (58.0%)	
S1	202 (25.8%)	74 (25.5%)	

BMI: Body mass index; LDH: Lumbar disc herniation; LSS: Lumbar spinal stenosis; TFESI: Transforaminal epidural steroid injection; DRG: Dorsal root ganglion.

There was no difference between DRG RF and TFESI groups in terms of diagnosis, age, gender, BMI, procedure level, and radiation dose. It was found that the procedure time was significantly lower in the DRG group (Table 2).

Discussion

Fluoroscopy assists in applying the needle to the accurate target by imaging bony landmarks, but the radiation exposure causes concerns. It is a well-known fact that radiation can impair the functioning of organs and generate acute and chronic side effects such as hair loss, local radiation injuries, and particular types of cancers. For these reasons, it is of great importance to find out the radiation dose exposed during the procedure. In the present study, there was no difference between radiation doses exposed during TFESI and DRG RF. However, the procedure time was found to be significantly lower in the DRG RF group. Therefore, the short procedure time may be a reason for preference in lumbar interventional procedures.

When conservative treatments have failed, TFESI and DRG RF are widely used as an option to surgery. Comparative studies on the effectiveness of TFESI and DRG RF have shown that both procedures cause similar outcomes in pain improvement and functionality in patients with low back pain.[4–6] According to our results, the amount of radiation exposure was similar in both interventions. This is probably because both procedures were performed at similar anatomical locations in the lumbar region. In both interventions, the C-arm is positioned around 20–30 degrees lateral oblique in order to visualize the intervertebral foramen while the patient lies supine. The accurate position is confirmed with two-way imaging after contrast injection. In both interventional methods, the intervertebral foramen is targeted and the images of the needle's movement are taken in order to reach the correct target. Since they are similar procedures that image similar areas, the amount of radiation exposure of both procedures is thought to be similar.

The dorsal root ganglia houses the cell bodies of neurons that transmit sensory data and have considerable importance in pain development.[2] Applications of radiofrequency to the DRG have been practiced for more than 40 years, and DRG RF is an alternative and widely accepted procedure in lumbar interventions. Pulsed RF is a non-ablative method that provides pain control without the destructive effect of high temperature and has a neuromodulation effect on synapses.[8] In the DRG RF approach, the needle is positioned close to the dorsal root ganglion by giving motor and sensory stimulation. The possibility of nerve root damage decreases as the progress is made by providing stimulation.[4] In the present study, when TFESI and DRG RF procedure times were compared, the procedure time of DRG RF was found to be shorter. The procedure may be completed in a shorter time due to the confidence created by progressing with motor and sensory stimulation. In this way, unnecessary shots may not be taken by advancing the needle until stimulation is received.

With the increasing use of fluoroscopy-guided spinal interventions, the radiation dose exposure raises concern, and many methods have been proposed to mitigate potential radiation hazards. The harmful effects of radiation on multiple organs range from mild changes to severe destructions, and it may even cause death.[9] Shielding with lead aprons, thyroid collars, gloves, and glasses, increasing the distance from the radioactive source, decreasing procedure time, avoiding magnification, and utilizing collimation and pulsed fluoroscopy are the essential approaches in order to lessen the amount of radiation exposure, concerning ALARA radiation safety recommendations. In a recent study, a C-arm tube covered with a lead apron was found to decrease the total amount of radiation exposure.[10–12]

Computed tomography (CT) is another reliable and safe alternative guide for lumbar spinal interventions. Although it has been shown that the radiation exposure was lower for patients and higher for interventionists, in a recent study, the radiation exposure of lumbar epidural injections under fluoroscopy and ultralow-dose CT was compared, and it has been shown that ultralow-dose CT can be a safer option for these interventions.[13,14] In the future, after technological developments, CT may replace fluoroscopy in spinal interventions and become a more reliable tool that causes less radiation exposure. However, for now, physicians need to be more careful about CT-guided interventional pain procedures.[15]

In a study about the comparison of radiation doses and duration of procedure in lumbar epidural steroid injection methods, no differences were found between contralateral oblique view and lateral view.[16] Cohen et al.[17] obtained reference radiation doses for lumbar transforaminal epidural (13 mGy, 30 s) and radiofrequency interventions (7 mGy, 17 s). In that study, a reference time and dose were specified rather than comparing them in both interventions. When we evaluate the results, similar to ours, the procedure time of radiofrequency was shorter, but differently, the radiation exposure dose was found to be less. Although the duration of DRG RF interventions in our study was short, this result may have occurred because we could not perform standardized collimation during each procedure and eliminate radiation-reducing factors.

Body mass index is one of the modifiable associated factors with the depth of the epidural space. A higher body mass index leads to a higher amount of radiation dose and procedure time.[18] Radiation doses need to be adjusted according to BMI, or doses per

BMI must be provided for each procedure to obtain a more precise approach.[9] In the present study, since BMI did not differ between groups, it did not require additional calculations.

Limitations

This study has some limitations. First of all, the procedure time and radiation dose of each level were not calculated separately; the cumulative radiation dose and radiation exposure were divided by the number of procedures. However, due to its high blood supply and difficult positioning, procedures performed at the S1 level may take longer procedure time and may generate more radiation exposure. Additionally, the procedures were not performed under sedation, and the patient's movement during the procedure may have caused the procedure time to be prolonged or extra images to be taken. Although the amount of radiation dose in the fluoroscopy was recorded, the radiation doses to which the physician was exposed were not separately reported. To calculate it, measuring the dosimeters on the performer following each procedure would have provided us with sufficient information.

Conclusion

Fluoroscopy-guided TFESI and DRG RF interventions have been found to cause similar radiation exposure, although the procedure time of DRG RF applications was shorter. It is essential to take adequate precautions to avoid side effects that may be caused by radiation exposure.

Ethics Committee Approval: The Health Sciences University Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee granted approval for this study (date: 29.08.2023, number: 4075).

Informed Consent: All individuals gave their informed consent before being included in the study.

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