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The role of radiocontrast agents in the pulsed radiofrequency treatment of lumbar dorsal root ganglion

Serdar KOKAR[1], Ozgur Emre POLAT[2]

[1] Division of Pain Management, Department of Physical Medicine and Rehabilitation, School of Medicine, Marmara University, Istanbul, Turkey
[2] Pain Management Clinic, Memorial Sisli Hospital, Istanbul, Turkey

Corresponding Author: Serdar KOKAR
E-mail: srdrkkr@hotmail.com

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ABSTRACT

Objective: The aim of this study was to investigate the effect of contrast agent use on procedure time and accuracy in pulsed radiofrequency treatment of the lumbar dorsal root ganglion.

Patients and Methods: Patients aged 23–79 years with lumbar radicular pain due to disc herniation for at least 3 months were randomized into two groups of 35 patients each. Patients in both groups underwent fluoroscopy-guided pulsed radiofrequency treatment of the dorsal root ganglion at the level of the L5 foramen. In the radiocontrast group, unlike the control group, the location of the ganglion was determined by administering the contrast agent before the radiofrequency treatment.

Results: Procedure time in the radiocontrast group was significantly longer than in the control group ($P< 0.05$). In 50 cases ganglion was detected in the extraforaminal or intraforaminal location, the excitation of the ganglion in the range of 0.4–0.6 V was significantly higher in the radiocontrast group (95.8%) than in the control group (69.2%) ($P< 0.05$).

Conclusion: The use of radiocontrast material in pulsed radiofrequency application on the dorsal root ganglion prolongs the procedure time. However, for ganglia that cannot be detected by stimulation, contrast injection is useful on procedural accuracy.

Keywords: Dorsal root ganglion, Pulsed radiofrequency therapy, Contrast agent, Lumbar radicular pain

1. INTRODUCTION

Low back pain is a leading cause of disability, with a lifetime prevalence of 40%–70% [1]. Although, there are many causes of low back pain, radicular pain secondary to lumbar disc herniation is one of the most common pathologies [2, 3]. Pulsed radiofrequency (pRF) therapy applied to the dorsal root ganglion (DRG) is an alternative interventional modality in the treatment of lumbar radicular pain not responding to conservative methods and epidural injection treatments [4].

The DRG contains the cell bodies of primary sensory neurons, which transmit sensory information to the spinal cord. The modulation of sensory processing, its role in pain development, and its anatomical accessibility make the DRG an important target for interventional pain management [5]. The pRF technique developed by Sluijter in 1998 prevents tissue damage by ensuring that the temperature does not rise above 42 °C [6]. The electrical field generated by pRF alters the cellular activity in DRG neurons, reduces nociceptive transmission by polarizing cell membranes, and contributes to analgesia [7]. In order to achieve these effects, it has been suggested that the electrode be placed 1–2 cm peripheral to the DRG [8]. However, although, these are minimally invasive procedures, complications can occur. The duration and accuracy of the procedure are important to reduce the radiation dose and the risk of complications and to improve treatment success.

In lumbar dorsal root ganglion pRF applications, when the targeted point is reached, the position is verified by providing motor and sensory stimuli, followed by pRF application [9]. However, because the DRG is not always located in the same place, time is often wasted searching for it with stimulation, and sometimes the ganglion cannot be found. To prevent these issues, the location of the ganglion can be determined primarily by injecting a contrast agent into the spinal nerve

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root and epidural area while using intermittent fluoroscopic imaging [8]. The aim of this study was to investigate the effect of using a contrast agent for procedure time and accuracy in pRF treatments of lumbar DRG.

2. PATIENTS and METHODS

Study Design

The present study was designed as a prospective randomized controlled trial and was approved by the Harran University, School of Medicine, Clinical Researches Ethics Committee (Date: 18.01.2021, No: 21.02.29). The study included patients between the ages of 18–80 years with lumbar radicular pain not responding to conservative treatment for at least 3 months. The reason for radicular pain was L5 nerve root compression due to disc herniation. Patients with L5 nerve root compression due to causes other than disc herniation, the presence of spondylolisthesis, transitional vertebrae, active infection, bleeding diathesis, renal insufficiency, and pregnants were excluded from the study. A total of 70 patients who applied to pain outpatient clinics between March 2021 and December 2022 were included in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki. All patients were informed about the nature of the study and written informed consent was obtained.

Patients were randomized into two groups of 35 patients each. Patients in both groups underwent fluoroscopy-guided pRF treatment of the DRG at the level of nerve root compression due to disc herniation (L5 foramen level). All procedures were performed by a pain specialist with 5 years of experience in interventional pain management. Unlike the control group, a contrast material was administered before the intervention and the location of the DRG was initially determined in the radiocontrast group. In the control group, the location of the DRG was determined by sensory and motor stimuli, as detailed below. After the procedure was terminated, the location of the DRG was also determined in the control group via contrast injection.

Interventional Procedure

Patients were placed in the operating room in the prone position, the skin was sterilized, and a pillow was placed under the abdomen to correct the lumbar lordosis. The vertebral endplates were flattened by angling the C-arm in the cephalic or caudal direction. The needle entry site was then determined by adjusting the scope to the ipsilateral oblique position. The needle insertion site was chosen based on intraforaminal localization, which is the most common location of DRG. After achieving skin and subcutaneous anesthesia, a 22-G radiofrequency (RF) hybrid cannula was advanced toward the target under coaxial imaging. When the targeted point (the dorsocranial part of the intervertebral foramen) was reached, contrast material was injected in the radiocontrast group, C-arm was switched to the anteroposterior (AP) position, and the electrode was directed toward the area where the ganglion was stained on the epidurogram. In the control group, DRG location was confirmed by providing motor and sensory stimuli without the contrast agent at this stage. For this purpose, sensory stimulation was given at 50 Hz and motor stimulation at 2 Hz. Attempts were made to provide stimuli at levels higher than 0.4 V to avoid intraganglionic localization. Paresthesia below 0.6 V was considered close to the DRG [9]. Within this range, the ganglion was searched in four quadrants of the foramen, namely ventrocranial, dorsocranial, ventroinferior, and dorsoinferior, without deviating from the intraforaminal (IF) direction. If paresthesia was not achieved, the electrode was directed toward the extraforaminal (EF) region. If the ganglion could not be stimulated, a response up to 1 V was sought with 0.1 V increments, first in the IF and then in the EF region. After the stimulus was provided, motor stimulation was given by increasing the volts at which paresthesia was achieved with sensory stimulation by up to twofold. No response confirmed that the location was far enough from the motor nerve. After the position was confirmed following the stimulations, pRF was applied at 2 Hz over 6 minutes. Meanwhile, the temperature was not allowed to rise above 42 ^{0}C. In the control group, after the PRF procedure was completed, a contrast agent was administered and the location of the DRG was determined.

A stopwatch was started when the needle was inserted into the skin and stopped when the position of the DRG was confirmed by stimulation, and the time was recorded. Whether the ganglion could be distinguished by a contrast agent was noted. If so, the location of the DRG was classified by drawing a line from the medial and lateral borders of the pedicle. Accordingly, intraspinal (IS), intraforaminal (IF), and extraforaminal (EF) location of the ganglion based on the location of its center was recorded (Figure 1A-B). In addition, after the location of the DRG was confirmed by stimulation, the quadrant of the intervertebral foramen where the needle tip was located was identified on lateral imaging. Cases in which DRG localization could not be confirmed after stimulation were recorded separately.

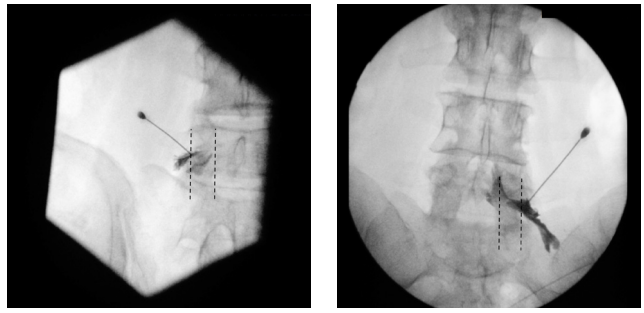

Figure 1. *The dorsal root ganglion is classified by drawing dotted lines from the medial and lateral borders of the pedicle.* ***A)*** *Intraforaminal location of the ganglion.* ***B)*** *Ekstraforaminal location of the ganglion.*

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Statistical Analysis

The IBM SPSS Statistics 22 program was used for statistical analyses. The conformity of variables to a normal distribution was evaluated by the Kolmogorov–Smirnov and Shapiro–Wilks tests. In addition to descriptive statistical methods (mean, standard deviation, and frequency), the Student's t-test was used to compare normally distributed quantitative variables between the groups and the Mann–Whitney U test was used to compare non-normally distributed variables between two groups. The chi-square test, Fisher's exact test, and continuity (Yates's) correction were used to compare qualitative variables. $P < 0.05$ was accepted as statistically significant in all analyses.

3. RESULTS

The present study was conducted with 70 patients, of whom 36 (52.4%) were males and 34 (48.6%) were females. The patients were aged between 23 and 79 years. There was no statistically significant difference between the groups in terms of age, gender, and educational level ($P > 0.05$) (Table I). The parameters evaluated in the study are presented in Table II.

Table I. *Evaluation of the groups in terms of demographic characteristics*

	Radiocontrast	Control	*Total*	p
Age $_{\text{Mean} \pm \text{SD}}$	44.74 ± 13.54	45.66 ± 12.7	*45.2 ± 1.04*	[1]0.772
Gender $_{\text{n (\%)}}$				
Male	16 (45.7%)	20 (57.1%)	*36 (51.4%)*	[2]0.473
Female	19 (54.3%)	15 (42.9%)	*34 (48.6%)*	
Educational Status $_{\text{n (\%)}}$				
Illiterate	9 (25.7%)	5 (14.3%)	*14 (20%)*	[3]0.384
Literate	5 (14.3%)	4 (11.4%)	*9 (12.9%)*	
Primary education	11 (31.4%)	10 (28.6%)	*21 (30%)*	
High School	9 (25.7%)	11 (31.4%)	*20 (28.6%)*	
University	1 (2.9%)	5 (14.3%)	*6 (8.6%)*	

[1]*Student's t-test* [2]*Continuity (Yates's) correction* [3]*Chi-square test*

Table II. *Distributions of procedural parameters*

		n	%
*pRF-treated dorsal root ganglion	Right L5	37	52.9
	Left L5	33	47.1
Level and localization of disc herniation causing L5 root compression	L4–L5 (paracentral)	57	81.4
	L4–L5 and L5–S1 (pc and ef)	9	12.9
	L5–S1 (extraforaminal)	4	5.7
Excitability of **DRG in the range 0.4–0.6 V	Yes	47	67.1
	No	23	32.9
Voltage at which DRG can be stimulated (n = 61)	0.4	5	7.1
	0.5	18	25.7
	0.6	24	34.3
	0.7	4	5.7
	0.8	4	5.7
	0.9	6	8.6
Cases where DRG cannot be stimulated below 1 V	Extraforaminal (control group)	2	2.9
	Intraforaminal (control group)	1	1.4
	Intraspinal (control group)	1	1.4
	Intraspinal (radiocontrast group)	2	2.9
	Unidentified	3	4.3
Recognition of DRG localization by contrast agent injection	Yes	62	88.6
	No	8	11.4
DRG Localization (According to contrast agent staining)	Extraforaminal	12	17.1
	Intraforaminal	38	54.3
	Intraspinal	12	17.1
	Unidentified	8	11.4
Localization of the needle tip relative to the foramen on lateral fluoroscopic imaging when DRG position was confirmed by stimulation (n = 61)	Dorsocranial	46	75.4
	Ventrocranial	15	24.6

**pRF: pulsed radiofrequency; **DRG: Dorsal root ganglion*

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The procedure time was significantly longer in the radiocontrast group than in the control group (P= 0.000; P < 0.05). The excitation rate of DRG at 0.4–0.6 V was 74.3% in the radiocontrast group and 60% in the control group, and the difference between the groups was not statistically significant (P > 0.05) (Table III).

In 50 cases the DRG was found to be in IF or EF location based on contrast staining, the rate of excitation of the DRG in the range of 0.4–0.6 V was significantly higher in the radiocontrast group (95.8%) than in the control group (69.2%) (P = 0.024; pP< 0.05) (Table IV).

Table III. *Evaluation of groups in terms of procedure times and excitability of DRG at 0.4–0.6 V (n = 70)*

		Radiocontrast	Control	p
Procedure time (sec) Mean±SD (median)		265.97 ± 103.29 (245.5)	168.24 ± 65.38 (160)	[1]0.000*
Excitability of DRG at 0.4–0.6 V	Yes	26 (74.3%)	21 (60%)	[3]0.309
	No	9 (25.7%)	14 (40%)	

*[1]Mann–Whitney U Test [2]Fisher's Exact Test [3] Continuity (Yates's) correction *P < 0.05*

Table IV. *Comparison of groups in terms of excitability rates of dorsal root ganglion at 0.4–0.6 V in patients with intraforaminal and extraforaminal localization (n = 50)*

Dorsal root ganglion excitation at 0.4-0.6 V	Radiocontrast n (%)	Control n (%)	P
Yes	23 (95.8%)	18 (69.2%)	0.024*
No.	1 (4.2%)	8 (30.8%)	

*Fisher's Exact Test *P< 0.05*

4. DISCUSSION

The lumbar DRG can be radiologically divided into three locations [8, 10-12]. In addition to the medial border of the vertebral pedicle, the locations of the ganglion can be defined by vertical lines drawn from the central [8, 10] or lateral border [11, 12] of the pedicle. There are radiologic and cadaveric studies investigating the location of the L5 DRG in the literature [8, 10, 12-15]. These studies reported IS, IF, and EF localization of L5 DRG as 66.7%–94.3%, 0%–33.3%, and 0%–19.2%, respectively [8, 10, 12-15]. In the present study, IS, IF, and EF localization rates after contrast injection were 17.1%, 54.3%, and 17.1%, respectively. In 11.4% of the cases, the ganglion could not be identified based on the spread of the contrast agent (Table II). In the present study, IF localization was found at a slightly lower rate compared to that in the previously mentioned studies. Nevertheless, our location findings are consistent with other studies. In addition, the inability to distinguish the ganglion in some cases after contrast staining may be responsible for this to some extent. Because the aforementioned studies were mostly MRIs and cadaveric studies or unidentified ganglions were excluded from those studies, this disadvantage was not observed in them [10, 12-15].

In the lower lumbar region, the DRG is localized in the foramen, below and just exterior to the vertebral pedicle [8]. In cases where we were able to confirm the location of the DRG with sensory and motor stimulation, we found that the ganglion was located in the upper part of the foramen. DRG was located in the posterior part of the foramen in 24.6% of cases and in the anterior part of the foramen in 75.6% of cases (Table II). It has been reported in the literature that the ganglion moves toward the anterior of the foramen as it approaches the inferior lumbar area [8].

Paresthesia with sensory stimulation at 0.4–0.6 V was considered ideal proximity to the DRG in the present study. Accordingly, the ganglion could be appropriately stimulated in 47 patients (67.1%). In patients with no response in the ideal range, the ganglion was located intraspinally in 10 patients and it could not be distinguished with a contrast agent in 4 patients. In five cases, the ganglion was located EF and these patients were in the control group. In the control group, we believe that the lack of contrast agent injection before pRF application resulted in an inability to direct the needle toward the EF area. In cases with IF and EF DRG localization, a significant difference was found in favor of the radiocontrast group in terms of ganglion excitability in the ideal voltage range (P< 0.05) (Table IV). No paresthesia response was obtained in four patients despite stimulation in the appropriate range and the electrode being in the location identified by the contrast agent. In these patients, this barrier was overcome below 1 V when the stimulus voltage was increased. We believe that this may be due to altered nociception caused by neuropathy or chronic pain. The patients were not questioned about additional diseases that could cause polyneuropathy and this could be a limitation of the study.

The stimulation voltage was increased in cases with no response in the ideal range (0.4–0.6 V). Paresthesia occurred below 1 V in 14 patients. As a result, 87.1% of all patients responded to sensory stimuli below 1 V. In the present study, the ganglia of nine patients could not be stimulated below 1 V. When these cases were analyzed, it was observed that the ganglion could not be differentiated even with a contrast agent in three patients. In three of the other six cases, the DRG was located intraspinally, which is probably why we could not get close enough to the ganglion. The remaining three patients were in the control group, and prior injection of a contrast agent could have served as a guide for appropriate stimulation in these patients.

When all cases were considered, the procedure time was significantly longer in the radiocontrast group than in the control group (Table III). In addition, no difference was found between the groups regarding the ganglion's excitability in 0.4–0.6 V (Table III). However, when intraspinal cases were excluded, there was a significant difference in ganglion excitability in favor of the radiocontrast group (Table IV). The ganglion could not be stimulated in the ideal voltage range (0.4–0.6 V) in 10 of the 12 cases with IS localization (83.3%). In conclusion, IS localization of DRG appears to be the most difficult challenge in pRF applications.

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One patient in each group developed a vasovagal reaction during the procedure, but pulse and blood pressure were controlled with atropine 0.5 mg/iv. Although, prolonged procedure time is a factor that increases the risk of complications, in the present study, the longer procedure time in the radiocontrast group (Table III) did not create a difference in terms of complications.

In a cadaveric study, Silverstein et al., determined the position of the DRG using MR imaging before dissection [16]. Subsequently, they determined the anatomical location by dissection. Accordingly, MR imaging and anatomical evaluation were 86.3% compatible. In the present study, the DRG localization assumed after contrast injection and confirmed after stimulation coincides with 82.1%. Because this is not a cadaveric study, the inability to confirm the anatomical location is one of the limitations of the study. Nevertheless, the data obtained, leads to certain conclusions. In 46 of 70 patients, radiological and stimulation localization were consistent, whereas in 10 patients, they were not. The DRG could not be identified by contrast injection in 5 of the 70 patients and could not be stimulated below 1 V in 6 patients; these patients were not included in the analysis. In three cases, the ganglion could neither be stimulated nor differentiated with a contrast agent. All 10 patients with discordance between contrast agent and stimulation-mediated localization were in the control group. In this group of patients, it is possible to position the needle closer to the DRG and achieve stimulation with a lower voltage if the radiofrequency needle is directed to the target after contrast agent injection.

The present study examined the L5 foramen level, where pRF applications are most commonly performed. The fact that other lumbar foraminal levels were not evaluated can be considered another limitation of the study.

Conclusion

The use of radiocontrast agents in pRF applications for the DRG prolongs the procedure time. In addition, ganglion location can be determined using sensory and motor stimulations without the use of radiocontrast in most cases. Therefore, we do not routinely recommend contrast agents in these procedures. However, contrast injection is helpful regarding procedural accuracy for ganglia that cannot be detected by stimulation, especially in cases with EF localization. It can also detect IS localization, thereby revealing why the ganglion is not stimulated in the ideal voltage range and preventing prolonged procedures. In conclusion, the use of contrast agents in pRF treatment for lumbar DRG should be considered as an adjunct modality, but not the primary component of the procedure.

Compliance with the Ethical Standards

Ethics Committee Approval: The present study was approved by the Harran University, School of Medicine, Clinical Researches Ethics Committee (Date: 18.01.2021, Approval No: 21.02.29). The study was conducted in accordance with the principles of the Declaration of Helsinki. All patients were informed about the nature of the study and written informed consent was obtained.

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