Randomized Controlled Trial

Comparative Effectiveness of Parasagittal Interlaminar and Transforaminal Cervical Epidural Steroid Injection in Patients with Cervical Radicular Pain: A Randomized Clinical Trial

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Background: Cervical epidural steroid injections (ESI) are performed either by interlaminar (IL) or transforaminal (TF) approaches; however, there is controversy over which is better for safety and efficacy.

Objectives: This clinical trial aimed to compare the effectiveness of the parasagittal IL and TF approaches for cervical ESI in patients who were suffering from cervical radicular pain.

Study Design: A prospective randomized assessor-blind study.

Setting: The study took place at a single pain clinic within a tertiary medical center in Seoul, Republic of Korea.

Methods: This prospective randomized, assessor-blind trial included 80 patients with cervical radicular pain. We randomly assigned patients to the TF or parasagittal IL approach for cervical ESI. The effectiveness of the 2 groups was compared based on pain intensity using the Numeric Rating Scale (NRS-11) at 1 and 3 months. The Neck Disability Index (NDI), Medication Quantification Scale (MQS), and responders at 1 and 3 months between the 2 groups were compared.

Results: The pain intensity of both groups significantly reduced after 1 and 3 months after each procedure ($P < 0.001$). Two-way repeated measures of analysis of variance showed no significant interaction between group and time for cervical radicular pain ($P = 0.266$), although NRS-11 pain score was lower in the TF group than the parasagittal IL group after 1 month ($P = 0.010$). NDI, MQS, and successful responders were not different between the 2 groups at 1 and 3 months after the procedure. We observed 7 cases (18.4%) of vascular visualization in the TF group, although no serious complications were found in either group.

Limitations: This study had no placebo control group and limited follow-up time.

Conclusions: Parasagittal IL ESI may be recommended over the TF ESI in reducing cervical radicular pain, considering both clinical effectiveness and safety.

Key words: Chronic pain, cervical radicular pain, fluoroscopy, epidural steroid injection, parasagittal, interlaminar, transforaminal, pain management

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One of the most common health problems is cervical radicular pain with an annual incidence of 83 per 100,000 people (1). Cervical radicular pain is described as pain perceived in the upper limb and/or neck caused by irritation and/or injury of the cervical spinal nerve (2,3). The most common causes of cervical radicular pain are disc protrusion, cervical spondylosis, and cervical spinal stenosis (4). Other than mechanical

compression, multiple mechanisms have been considered to induce cervical radicular pain (5). Of these, the inflammatory reaction that stimulates the spinal nerve is the theoretical basis for epidural steroid injection (ESI) (6). If there is no improvement with conservative treatment, such as activity modification, drug therapy, and physical therapy, cervical ESIs can be helpful (7).

Cervical ESIs are mainly performed either by fluoroscopically guided interlaminar (IL) or transforaminal (TF) approaches (3,6). Theoretically, the TF approach of epidural injection has the benefit of being able to place the injected drugs directly around the dorsal root ganglion. This is particularly useful for the cases due to spondylotic stenosis and herniated disc (8). However, cervical TF ESIs can cause significant complications, such as vascular injection, embolism, and resulting infarction (3,6,9). Meanwhile, the IL approach has fewer side effects by intravascular injection than the TF approach, but the dorsal, not ventral, epidural space is used to administer the drug (6). The cervical parasagittal IL approach is technically more accurate than the midline approach (10), and it is believed that relatively large amounts of injections are delivered directly to the affected nerve roots, providing better treatment results. There is a report that the parasagittal IL and TF approaches did not significantly differ in clinical efficacy in patients with axial neck pain due to cervical disc herniation (11).

However, to the best of our knowledge regarding cervical radicular pain, there have not been any randomized controlled trials on the comparative effectiveness between the IL and TF cervical epidural injections using fluoroscopy (3). Therefore this study aimed to compare the effectiveness between the parasagittal IL and TF approaches for cervical ESI in patients with cervical radicular pain.

Methods

Study Design and Patients

This prospective study was conducted as a randomized, assessor-blind, equivalent trial. This study was approved by the institutional review board of the Asan Medical Center (protocol number 2015-1114) and also registered in the Clinical Research Information Service (KCT0002989). Patients who underwent cervical epidural injection from November 2015 to April 2017 for radiating unilateral upper extremity pain with or without neck pain that did not respond to conservative managements, such as oral medication and physical therapy, at least for 4 weeks were included in this clinical trial. Among them, patients with cervical radicular pain from the C5-T1 level pathology on magnetic resonance imaging (MRI) were included. Patients with shoulder problems, neck pain greater than upper arm pain, nonradicular pain, previous cervical spine surgery, red flag signs (infection, malignancy, spinal fracture, progressive neurologic deficits, and cauda equina syndrome, etc.), or yellow flag signs (inappropriate attitudes or beliefs for pain, inappropriate behavior for pain, emotional problems, and legal issue related pain, etc.) were excluded. Additionally, the exclusion criteria for this study included patients with previous cervical ESI within the previous 3 months, nonavailability of MRI before the procedure, coagulopathy, pregnancy, breastfeeding, and hypersensitivity to the contrast medium. Patients who could not express pain and functional abnormalities as on the Numeric Rating Scale (NRS-11) and Neck Disability Index (NDI), respectively, were also excluded. Finally, patients who did not want to participate in the study and did not provide written informed consent were also excluded. To report this study, we followed the CONSORT guidelines. Written informed consent was obtained from all patients, and the study was conducted following the Declaration of Helsinki.

Randomization and Blinding

Patients who met the inclusion criteria were allocated to the TF group or parasagittal IL group in a 1:1 ratio by randomization without risk stratification. To allocate equal numbers of patients in each group, we used block randomization. Block sizes were randomly permuted to make the allocation process unpredictable. A clinical instructor who was not involved in patient diagnosis performed randomization using a web-based program (www.randomization.com). The attending physicians and patients were only blinded to the treatment allocation just before the procedure.

ESI Procedures

ESIs were performed with a pulse oximeter and a blood pressure monitor in an operating room under fluoroscopic guidance. For the TF approach, a patient was in a supine position on the table. The C-arm was ipsilaterally rotated 45° to 60° to the injection site to secure the largest cross-sectional area of the foramen at 6 o'clock in the foraminal direction as shown in Fig. 1A (12). The tip of the needle was not advanced beyond the mid-portion of the pedicle in a true anteroposterior view to avoid passing the needle through the spinal canal. After 0.5 mL

of contrast medium was slowly administered to confirm the epidural space (Fig. 1B), a 3-mL mixture of 5 mg of dexamethasone and 1% lidocaine was slowly injected. A parasagittal IL approach was performed underneath one segment of the target segment in patients in the prone position. Accessing for epidural space for cervical parasagittal IL ESIs, we followed the previously described contralateral oblique method with modification. As shown in Figs. 1C and 1D, if the needle touched the ligamentum flavum parasagittally and resistance was obtained, the C-arm was turned to the opposite side of the target at approximately 50º to adjust the needle tip to be positioned at the ventral IL line, and the epidural space was confirmed by resistance dissipation method (13). If loss of resistance was felt, 0.5 to 1.0 mL of contrast medium Omnipaque 300 (iohexol injection, iodine content 300 mg/mL, NDC 0407-1413-86; GE Healthcare, Chicago, IL) was contrasted for confirming epidural space followed by an injection of a 5-mL mixture of 5-mg dexamethasone and 1% lidocaine.

Demographic Data and Outcome Assessments

The demographic characteristics of the patients and the neck MRI findings were recorded. The primary outcome was to evaluate the effectiveness of the IL and TF ESI based on NRS-11 at 1 and 3 months after the procedure. The secondary outcome was to compare the NDI, Medication Quantification Scale (MQS), and successful responders between the 2 groups. A clinical instructor who was unaware of the group assignment of the patients evaluated the outcome variables after the procedure. A postprocedural evaluation was performed at 1 and 3 months after the procedure. The intensity of pain and functional status before injection and 1 and 3 months after injection were measured using NRS-11 and NDI, respectively (14,15). The NRS-11 was used as a numeric scale from 0 (no pain) to 10 (extreme pain). Functional evaluation was performed using the Korean version of NDI (16). Decreases in MQS compared with baseline at the 1- and 3-month follow-up examination were also determined and compared between the 2 groups (17). A successful response was determined based on previous studies with some modifications (18-20). We defined a successful response as follows: (1) ≥ 50% (or ≥ 4 points) reduction in the NRS-11 pain intensity from baseline without a corresponding increase in NDI or MQS; (2) ≥ 30% (or ≥ 2 points) in the NRS-11 pain intensity from baseline with a simultaneous ≥ 30% (or ≥ 10 points) reduction from baseline in NDI or ≥ 25% reduction from baseline in MQS. Any patient with an increase in NDI or MQS during the follow-up period was excluded as a successful responder. Additionally, complications related to the procedure were reported.

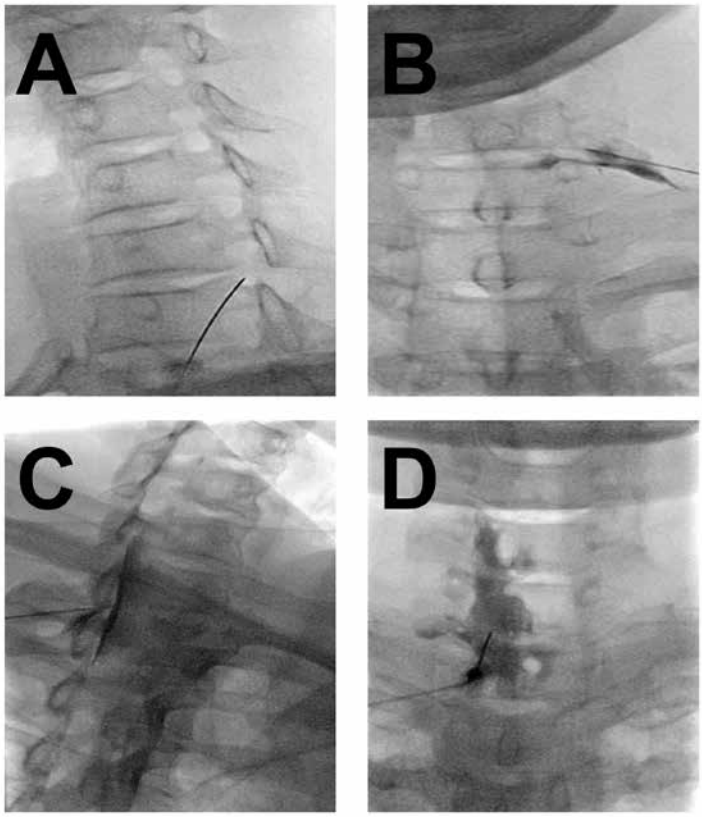

Fig. 1. *A fluoroscopic image of cervical TF and parasagittal IL epidural blocks in patients with cervical radicular pain. (A) Ipsilateral oblique fluoroscopic view showing the largest cross-sectional area of the foramen at 6 o'clock in the direction of the foramen in cervical TF approach. (B) The needle tip is not advanced beyond the mid-portion of the pedicle in a true anteroposterior view showing the spread of contrast medium along the dural sleeve. (C) Contralateral oblique fluoroscopic view showing the spread of contrast medium along the spinolaminar line. (D) Anteroposterior view showing the parasagittally located needle and the unilateral spread of contrast medium.*

Statistical Analysis

The effect size was estimated in a previous study comparing contrast medium flow and clinical effectiveness between a modified parasagittal IL approach and TF approach in cervical ESI (21). Based on this previous study, we calculated the sample size to achieve the assumption of a type I error of 0.05 (2-tailed) and a desired power of 80%. At least 35 patients in each group were consequently required. Assuming a dropout rate of 10%, a total of 80 patients were considered as ideal and allocated to each group equally.

The independent t-test or the Mann-Whitney U test was used to compare quantitative variables, and the χ^2 or the Fisher exact test was performed to analyze qualitative data, as appropriate. Quantitative data are reported as mean ± standard deviation or median with interquartile range, and qualitative data are presented as frequency and percentage. Two-way repeated measures of analysis of variance (ANOVA) with Bonferroni test for multiple comparisons were used to compare the changes from baseline values of each variable at 1 and 3 months. Data were analyzed with IBM SPSS Version 22 (IBM Corp., Armonk, NY), and *P* value less than 0.05 was considered statistically significant.

Results

Study Population

We screened a total of 131 patients for eligibility to participate in this study. Fifty-one patients who did not meet the criteria were excluded. A total of 80 patients fulfilled the inclusion criteria and were randomized to each group. However, 7 patients did not receive the allocated treatment because of improved symptoms or refusal of participation. Finally, the data of 35 patients in the parasagittal IL group and 38 patients in the TF group were analyzed (Fig. 2). Table 1 shows the baseline demographic characteristics of

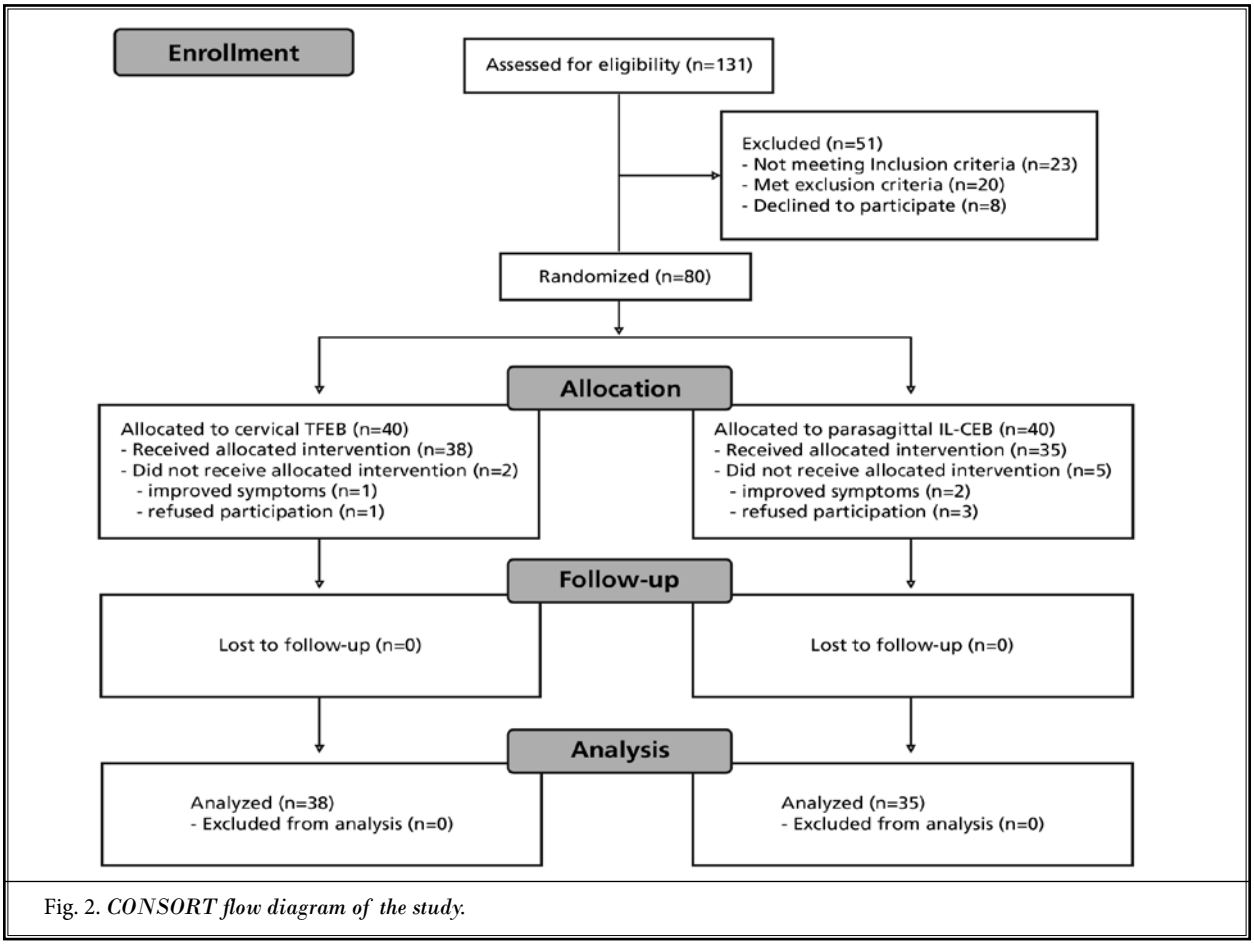

Fig. 2. *CONSORT flow diagram of the study.*

each group. There were no statistically significant differences between the 2 groups. Similarly, the 2 groups did not show a significant difference in interventional characteristics, such as the number of target locations and levels (Table 1).

Primary Outcome

Changes of median pain intensity in NRS-11 at 1 and 3 months after each intervention are shown in Fig. 3A. The pain intensity in NRS-11 of both groups had significantly reduced at 1 and 3 months following each procedure ($P < 0.001$). One month after procedure, the NRS-11 pain score decreased more in the TF group than the parasagittal IL group (difference between groups = 1.3, 95% confidence interval [CI], 0.3–2.2, $P = 0.010$). However, at the 3-month follow-up visit, we did not observe a significant difference in pain intensity between the 2 groups (difference between groups = 0.4, 95% CI, –0.6 to 1.3, $P = 0.470$). Two-way repeated measures of ANOVA showed no significant interaction between group and time for cervical radicular pain ($P = 0.266$). Table 2 shows detailed changes in pain scores after cervical TF ESI or parasagittal IL ESI in patients with cervical radicular pain.

Secondary Outcomes

Changes of the NDI at 1 and 3 months after each intervention are shown in Fig. 3B and Table 3. The NDI decreased significantly compared with baseline until 3 months after the procedure in both groups ($P < 0.001$). As shown in Table 3, we did not observe a significant difference in NDI between the 2 groups at 1 and 3 months after the intervention ($P = 0.080$ and $P = 0.182$, respectively). Two-way repeated measures of ANOVA also showed no significant interaction between group and time for NDI ($P = 0.311$).

Changes of MQS at 1 and 3 months from baseline in TF group were not significant (1.471, 95% CI, –0.336 to 3.278, $P = 0.110$, and 1.297, 95% CI, –0.509 to 3.104, $P = 0.158$, respectively). Similarly, in parasagittal IL group, changes of MQS at 1 and 3 months from baseline were not significant (0.574, 95% CI, –1.308 to 2.457, $P = 0.547$, and 1.171, 95% CI, –0.711 to 3.054, $P = 0.221$, respectively). These changes between groups were also not different at 1 and 3 months after the interventions ($P = 0.498$ and $P = 0.924$, respectively). In addition, we did not observe a significant interaction between group and time for MQS ($P = 0.902$) by 2-way repeated measures of ANOVA. Table 4 shows detailed changes in MQS after cervical TF ESI or parasagittal IL ESI in patients with cervical radicular pain.

Table 1. *Baseline and interventional characteristics of the study patients.*

	TF (n = 38)	Parasagittal (n = 35)	*P* Value
Age (years)	55.4 ± 11.5	55.7 ± 9.9	0.899
Gender (n, %)			0.903
Male	19 (50.0)	17 (48.6)	
Female	19 (50.0)	18 (51.4)	
Body mass index (kg/m^2)	24.37 ± 2.82	24.65 ± 3.43	0.191
Diabetes (n, %)	6 (15.8)	6 (17.1)	0.876
Hypertension (n, %)	14 (36.8)	8 (22.9)	0.213
Symptoms (n, %)			0.243
Arm	21 (55.3)	14 (40.0)	
Arm and neck	17 (44.7)	21 (60.0)	
Lesion site			0.161
Right	19 (50.0)	11 (34.1)	
Left	16 (42.1)	17 (48.6)	
Bilateral	3 (7.9)	7 (20.0)	
Duration of pain (month)	4.0 (3.0–7.0)	4.0 (3.0–12.0)	0.861
Basal pain intensity (NRS-11)	6.0 (5.8–8.0)	7.0 (6.0–8.0)	0.738
NDI (0–50)	16.5 ± 7.0	16.1 ± 6.1	0.130
MQS	8.1 (4.0–16.4)	4.8 (0.0–12.0)	0.075
Target level (n, %)			0.335
C4-5-6	1 (2.6)	1 (2.9)	
C5-6	13 (34.2)	9 (25.7)	
C5-6-7	8 (21.1)	3 (8.6)	
C6-7	16 (42.1)	21 (60.0)	
C6-7-T1	0 (0.0)	1 (2.9)	
Target location (n, %)			0.642
Right	20 (52.6)	16 (45.7)	
Left	18 (47.4)	19 (54.3)	

Data are expressed as numbers (%), means ± standard deviation, or medians (interquartile range).

The percentage of patients with a successful response was similar in the TF and parasagittal IL groups at 1 month (63.2% vs. 57.1%, respectively, $P = 0.600$) and 3 months (60.5% vs. 57.1%, respectively, $P = 0.815$) (Table 5). Table 6 summarizes the number of observed patients who satisfied the individual parameters of the multidimensional responder analysis at each follow-up period.

Adverse Events

Any severe complications of ESI, such as spinal cord trauma, subdural or subarachnoid injection, intraarterial injection, vascular embolism, and cerebral infarction, were not found in either group. However, we observed 7 (18.4%) cases of vascular visualization with contrast medium flow in the TF group. In these cases, the procedure was successfully completed by repositioning the needle. In the parasagittal IL group, we did not observe vessel visualization during the procedure. In addition, 5 patients (13.2%) in the TF group and 2 patients (5.7%) in the parasagittal IL group complained of temporary pain and paresthesia during the procedure, which was tolerable and did not require additional medications or discontinuation of the procedure. As shown in Table 7, these adverse events during the procedures showed a significant difference between groups (P = 0.011). Other adverse events that were presented throughout the entire study period were minor, temporary, and without the need for additional treatment.

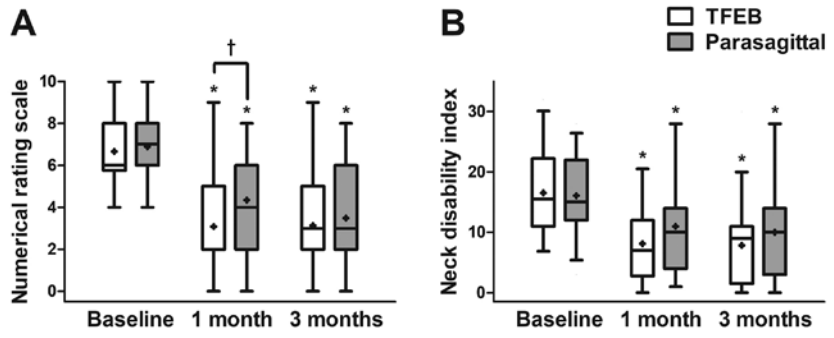

Fig. 3. *Pain intensities and NDI at baseline, 1, and 3 months after cervical epidural block. NRS-11 of cervical radicular pain (A), and NDI (B) at baseline, 1, and 3 months after cervical TF epidural block (TFEB, white columns) and cervical parasagittal IL epidural block (parasagittal, gray columns). The solid line shows the median, the box edges, the interquartile range, and the whiskers at the 5th–95th percentile. The plus sign shows the mean. P values for interactions between group and time for radicular pain (NRS-11) and NDI were 0.266 and 0.311, respectively. *P <0.01 vs. baseline in each group. †P = 0.010 between groups.*

Discussion

This study showed that cervical parasagittal IL ESI may be comparable with cervical TF

Table 2. *Changes in pain scores after cervical TF epidural block or cervical parasagittal IL block in patients with cervical radicular pain.*

Variables	Time	Groups		Differences	*P* Value
		TF	Parasagittal		
Pain (NRS-11)	Baseline	6.7 (6.0–7.3)	6.9 (6.2–7.6)	0.2 (–0.7 to 1.2)	0.642
	1 month	3.1 (2.4–3.7)	4.3 (3.6–5.0)	1.3 (0.3–2.2)	0.010
	3 month	3.1 (2.5–3.8)	3.5 (2.8–4.2)	0.4 (–0.6 to 1.3)	0.470

NRS-11 of cervical radicular pain at baseline, 1, and 3 months after cervical TF epidural block and cervical parasagittal IL epidural block. Data are presented as mean ± 95% CI. *P* value for the interactions between group and time for radicular pain (NRS-11) = 0.266.

Table 3. *Changes in physical function after cervical TF epidural block or cervical parasagittal IL block in patients with cervical radicular pain.*

Variables	Time	Groups		Differences	*P* Value
		TF	Parasagittal		
NDI (0-50)	Baseline	16.5 (14.3–18.7)	16.1 (13.8–18.4)	-0.5 (-3.6 to 2.7)	0.771
	1 month	8.1 (5.9–10.3)	11.0 (8.7–13.3)	2.8 (-0.3 to 6.0)	0.080
	3 month	7.8 (5.6–10.0)	10.0 (7.7–12.3)	2.2 (-1.0 to 5.3)	0.182

NDI at baseline, 1, and 3 months after cervical TF epidural block and cervical parasagittal IL epidural block. Data are presented as mean ± 95% CI. *P* value for the interactions between group and time for NDI = 0.311.

Table 4. *Changes in MQS after cervical TF epidural block or cervical parasagittal IL block in patients with cervical radicular pain.*

Variables	Time	Groups		Differences	*P* Value
		TF	Parasagittal		
MQS	Baseline	9.5 (7.4–11.6)	6.6 (4.4–8.7)	-2.9 (-5.9 to 0.0)	0.053
	1 month	8.0 (6.0–10.1)	6.0 (3.8–8.1)	-2.0 (-5.0 to 0.9)	0.178
	3 month	8.2 (6.1–10.3)	5.4 (3.2–7.5)	-2.8 (-5.8 to 0.2)	0.064

MQS at baseline, 1, and 3 months after cervical TF epidural block and cervical parasagittal IL epidural block. Data are presented as mean ± 95% CI. *P* value for the interactions between group and time for MQS = 0.902.

Table 5. *Proportions of successful responders 1 and 3 months after cervical epidural block.*

	TF (n = 38)	Parasagittal (n = 35)	*P* Value
Responder (n, %)			
1 month	24 (63.2)	20 (57.1)	0.600
3 months	23 (60.5)	20 (57.1)	0.815

Successful response was defined as follows: (1) ≥ 50% (or ≥ 4 points) reduction in the NRS-11 pain intensity from baseline without a corresponding increase in NDI or MQS; or (2) ≥ 30% (or ≥ 2 points) in the NRS-11 pain intensity from baseline with a simultaneous ≥ 30% (or ≥ 10 point) reduction from baseline in NDI, or ≥ 25% reduction from baseline in MQS. Any patient with an increase in NDI or MQS during the follow-up period was excluded from the successful responders.

ESI for pain reduction and functional improvement in patients with unilateral cervical radicular pain during the 3-month follow-up. However, adverse effects were more common with the TF approach than with the parasagittal IL approach.

There are 2 main methods to implement ESI for the cervical region: the IL and TF approaches. Previous reports have separately shown the effectiveness of cervical IL ESI (22,23) or TF ESI (24,25) in cervical radicular pain. In general, it has been suggested that TF ESI is more effective than IL ESI because the TF approach has the advantage of being able to place drugs directly to the site of pathology by targeting the posterior side of the intervertebral foramen, whereas in the IL approach, ventral epidural spread was found in only 28% of cases (26). However, in other studies, the cervical region has a narrower epidural space than the lumbar spine (27), and thus the drug spreads well to the ventral epidural space, which is mainly the site of the lesion. Therefore the factor that the drug spreads to the anterior epidural space is strongly related to the dose of the drug (28).

Surprisingly, there are few randomized trials comparing the effectiveness of IL ESI and TF ESI in cervical radicular pain; hence there is still controversy over which approach is the superior technique considering both the effectiveness and safety in patients with cervical radicular pain. Recently, Choi et al (21) reported a contrast medium dispersion pattern of parasagittal IL ESI and TF ESI in patients with cervical radicular pain. They found that contrast medium dispersion to the anterior epidural space in the modified parasagittal IL approach was significantly greater than in the TF approach for cervical ESI. They also found no difference in the degree of pain reduction between the 2 approaches, similar to this study. In another study, they showed a comparison of computed tomography epidurogram

Table 6. *Observed number of patients who satisfied the individual parameters for a successful response at each follow-up visit.*

Parameters (n, %)	Follow-up (month)	TF (n = 38)	Parasagittal (n = 35)	*P* Value
≥ 50% or 4-point decrease in the NRS-11	1	24 (63.2)	12 (34.3)	0.019
	3	23 (60.5)	21 (60.0)	0.963
≥ 30% or 2-point decrease in the NRS-11	1	30 (78.9)	25 (71.4)	0.588
	3	28 (73.7)	27 (77.1)	0.732
≥ 30% or 10-point decrease in NDI	1	27 (71.1)	18 (51.4)	0.098
	3	28 (73.7)	20 (57.1)	0.149
Increase in NDI	1	3 (7.9)	4 (11.4)	0.703
	3	3 (7.9)	4 (11.4)	0.703
≥ 25% decrease in MQS	1	10 (26.3)	8 (22.9)	0.791
	3	11 (28.9)	10 (28.6)	1.000
Increase in MQS	1	5 (13.2)	6 (17.1)	0.748
	3	5 (13.2)	6 (17.1)	0.748

Data are expressed as numbers (%).

Table 7. *Adverse events during cervical TF epidural block or cervical parasagittal IL block in patients with cervical radicular pain.*

	TF (n = 38)	Parasagittal (n = 35)	*P* Value
			0.011
None	26 (68.4)	33 (94.3)	
Intravascular	7 (18.4)	0 (0.0)	
Paresthesia	5 (13.2)	2 (5.7)	

Data are expressed as numbers (%).

between TF ESI and parasagittal IL ESI for cervical upper limb pain (29). However, the 2 studies mentioned earlier mainly evaluated contrast medium flow as the primary outcome, and briefly compared NRS-11 change as a secondary outcome for the treatment effectiveness of the 2 groups. Distinct from previous trials, this study may be meaningful for clinical decision-making in treating cervical radicular pain because this study was evaluating the details of pain intensity, functional status, and medication profiles for the difference in treatment effect according to the 2 procedures.

In this study, we found that cervical TF ESI had significantly reduced pain intensity only at the 1-month follow-up visit than cervical IL ESI. This supports the existing general argument that the TF approach may be more effective than the IL approach in some patients with severe cervical stenosis, in which the drug may not spread well to the ventral epidural space. Nevertheless, we observed that there was no statistically significant difference in treatment effectiveness at the overall 3-month follow-up period. In cervical TF ESI, the drug tends to go more directly to the anterior epidural space and reduces inflammation and pain in the short-term, but it is assumed that there is no significant difference when viewed for at least 3 months after the procedure. More importantly, we found the frequency of vascular visualization and temporary pain or paresthesia was higher in cervical TF ESI than parasagittal IL ESI. Cervical TF ESI may be associated with serious complications such as inadvertent intravascular injection (or embolism) and spinal cord infarction. One systematic review has reported numerous catastrophic neurologic injuries including death and persistent neurologic sequelae after cervical TF ESIs (30). They concluded that the evidence for the effectiveness of cervical TF ESI is very low quality according to the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system, and the benefits of the procedure can be compromised by the risk of serious complications (30). Taken together with this study, when considering both the clinical effectiveness and risk, the parasagittal IL approach may be recommended over the TF ESI in reducing cervical radicular pain.

There are several limitations in this study. First, this study had no placebo control group. However, this study primarily aimed to compare the clinical efficacy of different approaches of cervical ESI; thus we did not establish a placebo group. Second, the 3-month follow-up period in the present study may have been insufficient to evaluate the long-term clinical effects of cervical ESI. Therefore it is necessary to further evaluate the long-term treatment effect of more than 3 months. Third, double-blind in each group was impossible. This was inevitable because the posture of the patients during the procedure was different following the approach, and the clinician performing the procedure had to know the assignment of the patients clearly. Thus we conducted this study as a prospective, randomized assessor-blind study to determine the effectiveness of procedures. Fourth, this study lacks information on adjuvant therapies, such as exercise therapy and physical therapy, for individual patients. Fifth, we did not evaluate the effects of emotional function and global satisfaction of patients. Therefore we performed an additional multidimensional responder analysis with carefully selected outcome variables to reflect treatment success, including pain intensity, NDI, and changes of analgesic medications, although the rules for deciding successful response in this study could be criticized.

Conclusions

Considering both the clinical effectiveness and adverse effects, the parasagittal IL approach should be recommended over TF ESI in reducing cervical radicular pain. The present report could help to safely perform cervical ESI in the management of patients with cervical radicular pain.

Acknowledgments

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