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Ultrasound-Guided Cervical Periradicular Steroid Injection for Cervical Radicular Pain: Relevance of Spread Pattern and Degree of Penetration of Contrast Medium

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Abstract

Background and Objectives. Ultrasound-guided cervical periradicular steroid injection (US-CPSI) is an attractive alternate to conventional C-arm guided transforaminal epidural injection for treatment of cervical radicular pain. We compared the technical differences and clinical outcomes between these two techniques.

Methods. Following ultrasound-guided needle placement, the extent of contrast media spread and the degree of tissue penetration were monitored by real-time fluoroscopy at the time of cervical periradicular injection in 59 patients. The spread pattern was judged to be medial foramen (medial bisector of foramen), lateral foramen (lateral bisector of foramen), or extraforaminal. The degree of tissue penetration was classified into periradicular, pararadicular, and intramuscular based on the penetration characteristics. Ultrasonographic images were categorized into crescent, perineuronal protruding, and intramuscular types. These groups were then correlated with clinical outcomes.

Results. The actual distance between the ultrasound-guided needle position and fluoroscopic target point was 1.9 and 2.3 cm in the oblique and anteroposterior view, respectively. Despite a difference in ultrasound and fluoroscopic end points, contrast dye spread was found to reach lateral foramen in 53%, medial foramen in 34%, and extraforaminal in 13% of the subjects. Analysis of postprocedural pain reduction (PPPR) showed significantly the better outcomes in periradicular and pararadicular penetration, medial and lateral, and crescent and perineural protruding type without subgroup differences than intramuscular penetration, extraforaminal spread, and ultrasonographic images of intramuscular type ($P < 0.001$). Analysis of clinical overall outcome showed favorable outcome in the groups with better results of PPPR.

Conclusion. Our preliminary data suggest that the technique of UP-CPSI can provide an adequate local spread pattern, tissue penetration for treatment of cervical radicular pain.

Key Words. Ultrasound; Selective Nerve Root Injection; Spinal Stenosis; Cervical; Chronic Pain; Radiating

Introduction

Recently, cervical transforaminal epidural steroid injection has been increasingly used for alleviating cervical radicular pain resulted from acute disk protrusion or chronic degenerative foraminal stenosis [1,2]. Based on the evidence that the pain is generated by inflammation, targeted delivery of a maximal dose of steroid to or near the site of pathology through transforaminal routes guided by fluoroscopy or computerized tomography is considered appropriate [3,4]. However, reports of devastating postprocedure neurological complications, including brain stem and spinal cord infarction, as a result of accidental radicular artery injection, call into question the safety of this procedure [5,6]. Recently, high-resolution ultrasound (US) has been used successfully to identify the target nerves, neighboring blood vessels, and anatomical planes, and to advance a needle under real-time guidance without exposure to radiation hazards [7,8]. Therefore, US-guided cervical periradicular steroid injection (US-CPSI) may emerge as a promising modality to replace fluoroscopic transforaminal (FL-TF) approach in clinical practice [9,10].

However, ultrasonographic technique has its inherent technical limitations. US fails to visualize anatomical structure underneath the bony surface. For US-CPSI, a needle is intended to target the nerve lying in the intertubercular neural groove between the anterior and posterior tubercles of the cervical vertebra outside the foramen. This is quite different from the fluoroscopic approach where the targeted site is near to the intervertebral foramen during fluoroscopy-guided cervical transforaminal injection (FL-TF). Further, it is difficult to observe the dispersion of injectate through the foramen into the epidural space under US guidance [7,11]. Presumably, the difference in steroid spread pattern and the degree of tissue penetration may lead to different clinical outcomes between FL-TF and US-CPSI. There is a paucity of clinical studies that correlate the difference in injection techniques: injectate spread pattern and tissue penetration with postprocedure pain relief. In this prospective study, clinical outcomes following US-CPSI were evaluated, and the pattern of injectate dispersion determined by direct C-arm fluoroscopy was correlated with clinical outcomes as an effort to determine a better strategy for US-CPSI.

Method

After Institutional Review Board approval from the Presbyterian Medical Center and written informed consents, patients with cervical radicular pain were recruited in the study to undergo US-CPSI. These patients had a history of chronic radicular pain (>3 months) that was refractory to medical and physical therapy, pain intensity >5 on the numerical rating scale (NRS, 0 = no pain, 10 = worst pain), and pain presumably originating from a single cervical level. The nature of radicular pain was confirmed by clinical examination (motor, sensory, and reflex evaluation), provocation tests, e.g., the Spurling's maneuver and upper extremity root tension sign, and radiographic examinations. Magnetic resonance imaging (MRI) examinations were further performed, if necessary, when pain levels were not settled by physical and radiographic examinations. Prior to study, all patients were interviewed by a pain specialist nurse, who recorded pain distribution pattern, NRS, and pain-related dynamic factors. Excluded were patients with musculoskeletal pain, e.g., cervical zygapophyseal joint pain, shoulder joint pain, peripheral neuropathy, contrast media allergy, local skin infection, bleeding diathesis, and rheumatologic diseases. To avoid the diagnostic confusion with zygapophyseal joint pain, medial branch block was performed if neck pain is combined.

US-CPSI was performed using a modified Narouze technique [7], i.e., patient-positioned oblique supine decubitus with a frame support under the shoulder and the hip, with the head turned approximately 15° to the opposite side. After aseptic skin preparation, a 12 MHz linear transducer of a US machine (Venue 40 unit, GE Healthcare, Milwaukee, WI, USA) was applied to the symptomatic side of the neck. A C-arm fluoroscopic unit was adjusted to obtain the anteroposterior (AP) and oblique view without hindering the US-guided procedure. To prevent inadvertent needle penetration into the vertebral artery, the ascending cervical artery, the deep cervical artery, and V1 segment of the vertebral artery were identified with color Doppler. First, the C7 transverse process was located by recognizing the shape of its rudimentary anterior tubercle and prominent posterior tubercle. Then, the transducer was moved cephalad to identify the C6 transverse process with its characteristic anterior and posterior tubercles that were asymmetrical, described as the "2-humped camel" sign [7]. Thereafter, the targeted hypoechoic nerve was identified within the intertubercular groove of the corresponding transverse process with its underlying bony acoustic shadow. Once the needle tip was positioned in the posterior circumneural sheath between the nerve and posterior tubercle outside the intervertebral foramen under real-time US guidance (Figure 1), 1 mL of contrast dye (Iopamiro, Ilsung Pharmaceuticals, Seoul, Korea) was slowly injected. While keeping the needle in the same position, the pattern and shape of contrast medium spread were simultaneously visualized with fluoroscopy. After ruling out intravascular injection by fluoroscopy, an admixture containing 0.5 mL of 0.5% bupivacaine, 0.5 mL of saline, and 1 mL of dexamethasone palmitate (4 mg/mL, Welfide Korea, Seoul, Korea) was injected slowly under real-time US guidance. The images of US and C-arm were taken and saved for later analysis.

To objectively characterize the shape and the spread pattern of contrast medium flow, the saved C-arm and ultrasonographic images were analyzed by three independent experienced observers. The spread pattern of contrast medium was classified as: (1) "extraforaminal" indicated by dye dispersion not reaching the articular pillars, (2) "lateral foramen" indicated by dye filling the lateral bisector of the articular pillars, and (3) "medial foramen" indicated by dye filling the medial bisector of articular pillars (Figure 2). The degree of dye penetration

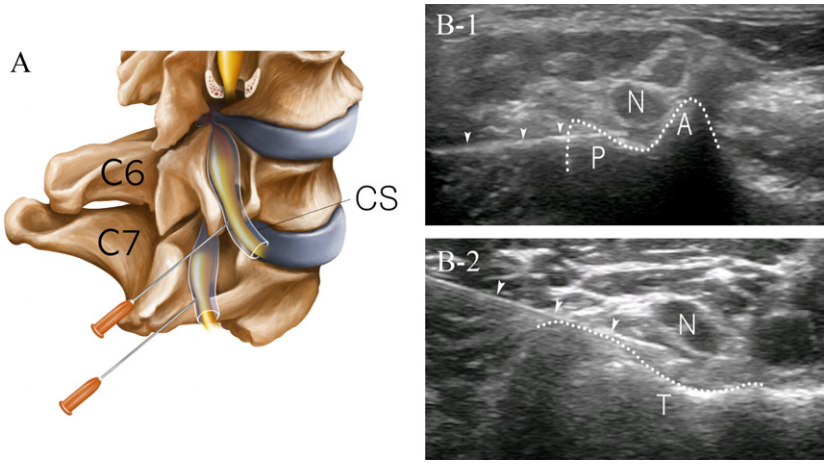

Figure 1 (A) Illustration of the lower cervical vertebrae showing the circumneural sheath covering the cervical nerves and intended targets of steroid injection at the posterior circumneural sheath between anterior and posterior tubercles. (B) Ultrasonographic image showing the C6 prominent anterior tubercle (B-1) and C7 flat transverse process (B-2). Arrow heads are pointing to the needle placed just beneath the nerves. A = anterior tubercle; P = posterior tubercle; T = transverse process, N = spinal nerve.

as judged by fluoroscopy was classified as: (1) "periradicular" type when the dye filled the periradicular space outlining the contour of the spinal nerve; (2) "pararadicular" type when the dye filled the periradicular space and partially spilled into neighboring muscular tissue, and (3) "intramuscular" type when the dye accumulated locally in the muscles without periradicular filling (Figure 3). Ultrasonographic images were categorized as follows: (1) "crescent pattern" (e.g., hypoechoic expansion of perineural outline) indicating that injectate is contained within circumneural sheath, (2) "perineural protruding pattern" (e.g., hypoechoic protruding expansion from the perineural outline) indicating that part of injectate is spilled out from the circumneural sheath, and 3) "intramuscular pattern" showing the swelling of the scalenus medius muscle without a perineural hypoechoic rim (Figure 3).

To determine the difference in target difference between US-CPSI and FL-TF, the AP and oblique fluoroscopic views were obtained to measure the distance between the US target (distal intertubercular grove) and the fluoroscopic target (the anterior surface of the superior articular process in the oblique view and the intersecting point between medial and lateral border in the articular pillar and the center of the upper and lower pedicles in AP view), as shown in Figure 4. Displacement of US target from the fluoroscopic target was quantified after correcting for fluoroscopic magnification effect.

Postprocedure pain severity (NRS) was assessed 3 months later. The postprocedural pain reduction (PPPR) was evaluated using the following formula [11]:

$$(\text{pretreatment score} - \text{post-treatment score}) \times 100/\text{pretreatment score}$$

For evaluation of clinical treatment outcome, patients who showed more than 50% pain reduction following US-CPSI were considered as overall favorable outcome group.

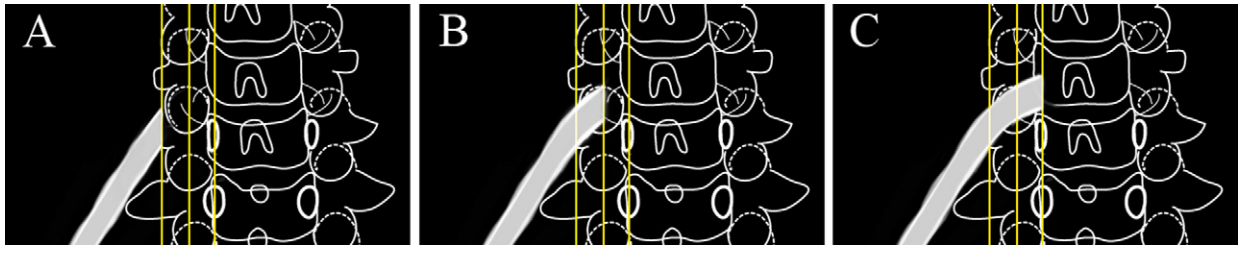

Figure 2 Schematic illustration showing the spread patterns of contrast medium depending on extent of contrast spread. (A) Extraforaminal pattern, (B) lateral foramen pattern, (C) medial foramen pattern.

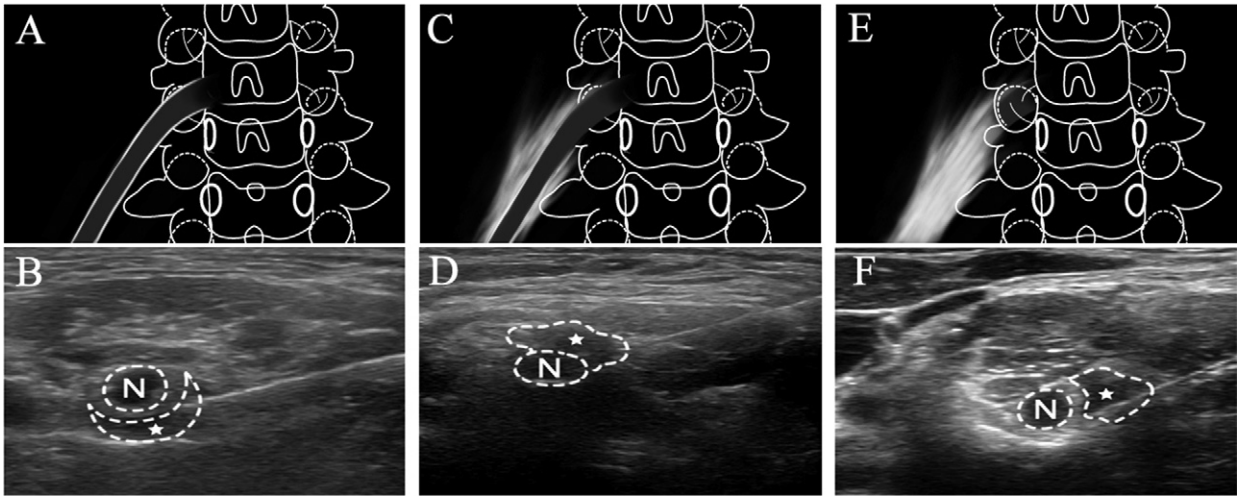

Figure 3 Schematic illustration of degree of dye penetration and corresponding ultrasonographic images. (A,B) Periradicular spread and crescent pattern; (C,D) pararadicular spread and perineural protruding pattern; (E,F) intramuscular spread and intramuscular pattern. N = spinal nerve. *indicates the infiltrated portion with contrast medium.

Patients who achieved response more than 80% did not receive further injections, while patients with <80% response were offered another injection if they agreed. No patient received more than two injections in 6 months.

All statistical analyses were performed using a SPSS 12.0 (SPSS, Chicago, IL, USA). The spread pattern, degree of dye penetration, and ultrasonographic images were compared using paired *t*-test. PPPR vs degree of penetration and dye spread were analyzed using one-way analysis of

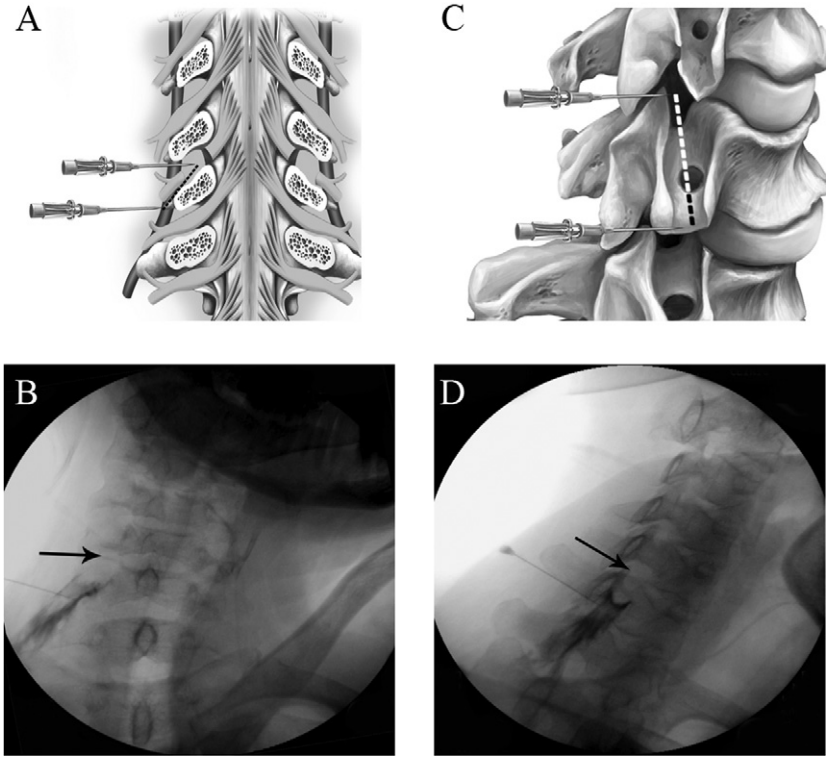

Figure 4 Measurement of distance between ultrasound-guided needle position (needle) and fluoroscopic target (arrow) in a patient who showed periradicular and lateral foraminal spread pattern. (A,B) Illustration (dotted line) and C-arm anteroposterior view showing the distance between two targets; (C,D) illustration (dotted line) and C-arm oblique view showing the distance between two targets.

Table 1 Demographic and clinical features of patients undergoing ultrasound-guided periradicular steroid injection

Category		Spondylosis	HCD	*P*-Value
Age		58.31	43.22	<0.001
Sex	Male	18 (50%)	11 (48%)	0.542
	Female	18 (50%)	12 (52%)	
Duration of pain (weeks)		21.94	24.70	0.612
Initial NRS		6.75	6.78	0.895
Motor weakness		10	8	0.577
Level of block	C5	4	5	0.088
	C6	14	13	
	C7	18	5	
Number of blocks	One time	16	14	0.168
	Two times	20	9	

HCD = herniated cervical disk; NRS = numerical rating scale.

variance (ANOVA), and comparison among different groups were further made using Tukey's HSD (honestly significant difference) post-hoc test. In addition, postprocedural outcome scores were compared with several variables such as age, sex, pain duration, pre-intervention NRS, level, and number of blocks using one-way ANOVA test. Statistical significance was accepted for *P*-values of <0.05.

Results

Table 1 summarizes the demographic data and clinical characteristics of 29 male and 30 female patients. Pain was secondary to cervical spondylosis in 36 patients and herniated cervical disk (HCD) in 23 patients. Average age was higher in the patients with spondylosis (58.3) than those with HCD (43.2) ($P < 0.001$). Duration of pain in cervical spondylosis and HCD was 18 and 20.5 weeks, respectively. Pain severity prior to intervention was same in both groups; mean NRS was 6.8 in cervical spondylosis and 6.8 in herniated disk. MRI examinations were additionally performed in 27 patients (45%) to confirm the single-level pathology. The US-CPSI was most commonly performed at C6 (N = 27, 46%) followed by C7 (N = 23, 39%) and C5 (N = 9, 15%). One injection was performed in 16 patients with spondylosis and 14 with HCD, whereas two injections were performed in 20 with cervical spondylosis and in 9 with HCD.

The distance measurements between the US-CPSI and fluoroscopic target are summarized in Table 2. The distance between the two targets measured in the AP view was 2.0 ± 0.5 cm in C5, 2.3 ± 0.4 cm in C6, and 1.9 ± 0.4 cm in C7. The distance measured in the oblique view was 1.4 ± 0.2 cm in C5, 1.4 ± 0.2 cm in C6, and 1.2 ± 0.3 cm in C7. The distance measurements in the AP view are considered more accurate, for the distance in oblique view appears shorter than the actual distance because of X-ray beam characteristics.

The data for dye spread in the US-CPSI group showed that injection of contrast medium showed most commonly medial foramen (N = 31, 53%) and lateral foramen spread (N = 20, 34%), while extraforaminal (N = 8, 13%) was significantly less common. Analysis of dye penetration showed that periradicular spread was most common (N = 31, 53%), followed by pararadicular spread (N = 25, 42%) and intramuscular spread (N = 3, 5%) in this study.

There was a significant correlation between the degree of dye penetration and spread pattern ($P < 0.001$). Periradicular spread (N = 31) resulted in dye extension commonly to the medial (N = 20, 65%) and lateral foramen areas (N = 11, 35%), and not into the extraforaminal region. Pararadicular spread (N = 25) resulted in dye extension commonly to the medial (N = 11, 44%) and lateral foramen areas (N = 9, 36%), less commonly into the extraforaminal region (N = 5, 20%). Intramuscular spread (N = 3) produced exclusively an extraforaminal spread pattern (N = 3, 100%). The underlying spine pathology (cervical spondylosis and/or HCD) did not affect the pattern or degree of dye spread in this study.

The degree of dye penetration was significantly related with different ultrasonographic characteristics depending on the injectate locations ($P < 0.001$). Periradicular spread produced the crescent pattern (N = 31, 100%) of ultrasonographic image. However, pararadicular spread

Table 2 The oblique distances between ultrasound-guided and C-arm-guided transforaminal selective nerve block in anteroposterior (AP) and oblique view

Level	AP View (cm)	Oblique View (cm)
C5	2.0 ± 0.5	1.4 ± 0.2
C6	2.3 ± 0.4	1.4 ± 0.2
C7	1.9 ± 0.4	1.2 ± 0.3

Table 3 PPPR depending on the degree of dye penetration, spread pattern, and ultrasonographic images at 3 months following cervical periradicular steroid injection

Outcome Groups	Classifications	Pre-NRS	Post-NRS	Difference in NRS	PPPR	*P*-Value	95% CI Lower Bound	95% CI Upper Bound
Outcome vs degree of penetration	Periradicular (N = 31)	6.8	3.0	3.8 ± 0.2	55.7	<0.001	3.3	4.2
	Pararadicular (N = 25)	6.8	2.7	4.1 ± 0.3	60.6	<0.001	3.6	4.7
	Intramuscular (N = 3)	6.3	5.3	1.0 ± 0.6	15.8	0.225	–1.5	3.5
Outcome vs dye spread pattern	Medial (N = 31)	6.8	3.1	3.7 ± 0.3	54.8	<0.001	3.2	4.2
	Lateral (N = 20)	7.0	2.4	4.6 ± 0.2	65.5	<0.001	4.2	4.9
	Extraforaminal (N = 8)	6.3	4.1	2.13 ± 0.4	33.9	<0.01	1.2	3.0
Outcome vs ultrasonographic images	Crescent (N = 39)	6.9	2.7	4.1 ± 0.2	60.3	<0.001	3.7	4.5
	Perineural protruding (N = 17)	6.7	3.2	3.5 ± 0.3	52.2	<0.001	2.8	4.2
	Intramuscular (N = 3)	6.3	5.3	1.0 ± 0.6	15.8	0.225	–1.5	3.5

CI = confidence interval; NRS = numerical rating scale; PPPR = postprocedural pain reduction, which is calculated as (pre-NRS – post-NRS)/(pre-NRS) × 100.

produced the perineural protruding pattern (N = 17, 68%) or crescent pattern (N = 8, 32%). Intramuscular spread produced the intramuscular pattern (N = 3,100%) (Figure 3).

The postprocedure outcome vs degree of dye penetration is summarized in Table 3. There were significant reductions of pain in periradicular and pararadicular penetration ($P < 0.001$), whereas intramuscular penetration failed to produce the significant pain reduction. PPPR results showed that pararadicular penetration showed the greatest degree of pain reduction (61%), followed by periradicular penetration (56%) and intramuscular penetration (16%); periradicular and pararadicular penetration are not statistically significantly different from each other, whereas intramuscular penetration results are significantly different from those of the former two ($P < 0.001$).

The postprocedure outcome vs dye spread pattern is summarized in Table 3. There was a significant reduction of pain in all of the dye patterns ($P < 0.01$); there was a greatest reduction in lateral (65%), followed by medial (55%) and extraforaminal dye spread pattern (34%). Lateral and medial dye pattern did not show the statistical difference outcomes with each other but showed the significant difference with those of extraforaminal dye pattern.

Clinical overall outcome presented against the degree of penetration, spread pattern, and ultrasonographic images is shown in Table 4. Out of 59 patients, 46 (78%) of them showed overall favorable outcomes, and 13 (22%) patients showed overall unfavorable outcomes. For those patients with favorable outcome, periradicular injection produced highest positive outcome (90%), followed by pararadicular injection (72%), whereas intramuscular injection did not result in favorable outcome. Small portions of patients who underwent either periradicular and pararadicular injections also expressed unfavorable outcomes (10% and 28%, respectively). Similar result can be drawn with the spread pattern of injection; highest positive outcomes were resulted from medial pattern (87%), followed by lateral pattern (85%), and extraforaminal resulted in least number of favorable outcome (25%). In outcome analysis based on the ultrasonographic image, among patients with crescent pattern, favorable outcome was shown in 84% and unfavorable outcome in 16% of patients. For patients showing perineuronal protruding shape, favorable outcome was shown in 76% and unfavorable outcome in 24% of the patients. Lastly, all patients with intramuscular shape showed unfavorable outcome.

Serious complications such as spinal cord or brain stem infarction, motor deficit, long-lasting paresthesia, visible hematoma, or edema in the neck did not happen. Minor complications occurred infrequently: skin bruises in the neck (4%), local tenderness (3%), itchiness (5%), hiccup (1%), and sleep disturbances (7%). Elevated glucose level was observed in nine diabetic patients (12%), but there was no sign of aggravation of diabetic symptoms.

Discussion

Inflammation of the spinal nerve and dorsal root ganglion can generate neck and arm pain, and targeted steroid injection near or to the ganglia and spinal nerve through FL-TF can provide effective pain relief [12–14]. Recently, high-resolution US imaging has been applied to visualize nerve and vascular structures, and guide selective nerve blocks [7,11,15]. US-CPSI can be an alternate to FL-TF steroid injection, but the major drawback of US-CPSI is needle placement, with the needle tip placed in the peripheral intertubercular grove and not at the intervertebral foramen due to technical limitation of the US beam. Further, as the spinal nerve courses down obliquely from the neural foramen, intertubercular groove is located at the level of

Table 4 Clinical overall outcome depending on the degree of penetration, spread patterns, ultrasonographic images at 3 months following cervical periradicular steroid injection

		Degree of Penetration			Spread Pattern			Ultrasonographic Images		
Outcome	No. of Patients	Periradicular	Pararadicular	Intramuscular	Medial	Lateral	Extraforaminal	Crescent	Perineural Protruding	Intramuscular
Favorable,	46 (78%)	28 (90%)	18 (72%)	0 (0%)	27 (87%)	17 (85%)	2 (25%)	33 (84%)	13 (76%)	0 (0%)
Unfavorable	13 (22%)	3 (10%)	7 (28%)	3 (100%)	4 (13%)	3 (15%)	6 (75%)	6 (16%)	4 (24%)	3 (100%)
Total	59 (100%)	31 (100%)	25 (100%)	3 (100%)	31 (100%)	20 (100%)	8 (100%)	39 (100%)	17 (100%)	3 (100%)

caudal vertebral body, leading to widening the distance between fluoroscopic and US targets. In essence, US-CPSI results in an extraforaminal injection that may not guarantee direct drug delivery into the site of lesion. Our distance measurements between US-CPSI and fluoroscopic targets (FL-TF) were 1.9~2.3 cm in the AP and oblique views. Although Narouze and Eichenberger et al. reported placing the needle within 5 mm from the fluoroscopic target to ensure adequate spread, our findings showed that even needles placed at >1.5 cm from the fluoroscopic target had good clinical outcome [7,16]. Good postinjection response in our patients suggests that correct needle placement near the target is not the only factor that determined the clinical effect of US-CPSI.

The present study demonstrates that spread pattern and degree of dye penetration are determinants of pain relief following US-CPSI. Yamauchi et al. reported that US-CPSI injection mainly spreads in the extraforaminal direction compared with the conventional transforaminal injection [11]. Nonetheless, this technique could provide satisfactory relief of radicular pain [11]. Although it is not possible to determine the spread pattern and degree of penetration with US imaging, combined use with fluoroscopy demonstrated that steroid can reach the dorsal root ganglia and even the dura if they have medial and lateral foramen pattern. It is known that the "circumneural sheath" outside the epineurium of the spinal nerve is the main route for contrast to reach the epidural space [17]. It starts where the nerve enters the intervertebral foramen and extended to the posterior longitudinal ligament of the vertebral body. The circumneural sheath forms a channel between it and epineurium and is strong enough to hold the contrast flow. It is assumed that circumneural sheath maintains the open channel for the dispersion of contrast even under the conditions of foraminal narrowing such as spondylosis and herniated disk. Therefore, good pain relief is expected if contrast spreads into the circumneural sheath and reaches the epidural space, and the medial and lateral foramen areas but poor response when the contrast medium remains extraforaminal.

This study also demonstrates that the degree of dye penetration influences the spread pattern. If the contrast injection shows periradicular or pararadicular penetration, it commonly showed the medial and lateral foramen spread pattern, which likely allows the contrast or steroid to spread into pain-producing structures, including dorsal root ganglia or spinal nerve. In contrast, the intramuscular type exclusively produces extraforaminal pattern in which contrast flow does not reach these structures easily. Consequently, the degree of dye penetration is significantly related with clinical outcomes like the spread pattern. The significant lower pain reduction with intramuscular penetration is likely to result from paucity of injection into the nerves compared with other two penetrations. The pararadicular penetration resulted in higher pain reduction level; despite of spillover of contrast than periradicular penetration, it is assumed that small amount of loss in steroid injectate does

not influence the final outcome of the procedure in this study.

The degree of dye penetration is often linked to their characteristic US imaging features: periradicular type with crescent expansion of perineural hypoechoic rim, pararadicular type with mushroom-like protruding expansion of hypoechoic rim from the perineural outline or with crescent pattern, and intramuscular type with the swelling of scalenius medius without perineural hypoechoic rim. Although US image alone cannot visualize the foramen like as fluoroscopy, it can show the characteristic images to judge the spread pattern and degree of penetration. Therefore, creation of appropriate US image during injection is a critical technical component for a successful US-CPSI procedure [18]. Especially, when we consider that periradicular spread always shows the crescent pattern, US-guided technique can be used as stand-alone method in treating for cervical radicular pain.

The present study shows that US-CPSI can be a promising tool for the control of pain caused by cervical spondylosis and HCD. Seventy-eight percent of patients who received US-CPSI showed favorable response (defined as more than 50% diminution of pain at 3 months following periradicular steroid injection in this study). Although this result cannot exclude placebo effect or reduction of pain by natural history, it is comparable with those of FL-TF steroid injection. Vallee et al. [19] reported greater than 75% diminution or complete resolution of pain in 53% of the patients at 6 months. Slipman et al. [12] also reported similar results in which overall good or excellent results were observed in 60% of the patients at an average of 21 months of follow-up. Considering that the quality of pain reduction is better in FL-TR approach and efficacy of the epidural steroid injection decreases along the time, clinical outcome of FL-TR steroid injection is likely to be better [20]. However, US-CPSI has quite reasonable outcome in the short-term follow-up, as shown in this study. To ensure the validity of long-term clinical efficacy of US-CPSI, a double-blind, controlled study eliminating the false-positive response is mandatory. Despite the preliminary apprehension of complications, we did not observe any major complications. Minor complications such as skin bruises, itching sensation, hiccup, and sleep disturbances could be easily managed. Therefore, US-CPSI is considered to be a safe procedure with reasonable outcome in the patients with cervical radicular pain if the interventionists understand the high technical complexity of US-CPSI and have enough training [18].

In summary, US-CPSI has technical differences compared with C-arm-guided transforaminal epidural injection. Our study shows that correct placement of a needle in the periradicular space to produce lateral or medial foramen spread pattern coupled with periradicular or pararadicular dye penetration is a critical component of successful practice. Observation of characteristic US images corresponding to periradicular and pararadicular shape is relevant technical elements.

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