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SCIENTIFIC ARTICLE

Ultrasound versus fluoroscopy-guided cervical medial branch block for the treatment of chronic cervical facet joint pain: a retrospective comparative study

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Abstract
Objective To compare the mid-term effects and advantages of the ultrasound (US)-guided with fluoroscopy(FL)-guided cervical medial branch blocks (CMBBs) for chronic cervical facet joint pain through assessment of pain relief, functional improvement, and injection efficiency.
Methods Patients with chronic cervical facet joint pain who received US- ($n = 68$) or FL-guided CMBBs ($n = 58$) were included in this retrospective study. All procedures were performed using a FL or US. The complication frequencies, treatment effects, functional improvement, and injection efficiency of CMBBs were compared at 1, 3, and 6 months after the last injection.
Results Both the NDI and VNS scores showed improvements at 1, 3, and 6 months after the last injection in both groups, with no significant differences between groups ($p < 0.05$). Furthermore, the treatment success rate at all time points was not significantly different between groups. Logistic regression analysis revealed that the injection method (US- or FL-guided), the number of injections, sex, analgesic use, and age were not independent predictors of treatment success. Compared with FL-guided CMBB, US-guided CMBB was associated with a shorter administration duration and fewer needle passes.
Conclusions Our results suggest that, compared with FL-guided CMBBs, US-guided CMBBs require a shorter administration duration and fewer needle passes, while providing similar pain relief and functional improvements. Therefore, US-guided CMBBs can be considered as an effective alternative for the conservative management of chronic cervical facet joint pain.

Keywords Cervical facet joint pain · Ultrasound · Fluoroscopy · Medial branch block

Introduction

Cervical facet joints have been implicated as a source of chronic pain in 54–67 % patients with chronic posterior neck pain [1–6]. Therapeutic benefit for facet joint pain has been reported with three types of interventions. These include intraarticular injections, medial branch nerve blocks (MBBs), and neurolysis of medial branch nerves by means of radiofrequency [7]. Significant debate surrounds the appropriate management of cervical facet joint pain [7–10]. The long-term therapeutic benefit of intraarticular injections of facet joints has been poor [11, 12]. However, they showed moderate evidence for cervical medial branch blocks (CMBBs) and radiofrequency neurotomy, which has also been echoed in other reports [9, 10, 13–15]. Thus, MBBs may be utilized as an alternative to radiofrequency neurotomy [16].

A CMBB is conventionally administered under fluoroscopic guidance [17]. Because CMBBs are often required to identify the symptomatic joint or rule out facet joint pain, the procedure may expose patients to considerable radiation doses without thyroid protection [17]. Moreover, cervical medial

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branch nerve is radiolucent like all other nerves and cannot be identified directly by fluoroscopy (FL) [18]. Therefore, interest in the application of ultrasound (US) guidance for CMBBs has been rapidly increasing, as evidenced by previous published reports [17–20]. The main advantage of US, in addition to no radiation exposure, is direct real-time visualization of vessels and nerves, which is particularly beneficial for CMBBs considering the multitude of blood vessels and other vital soft tissue structures that increase the vulnerability of the target area to injury under FL guidance [17–23]. Furthermore, real-time visualization of needle advancement can decrease the number of passes and trauma to adjacent structures [19]. Finally, the ability to visualize blood vessels can prevent unintentional intravascular injection [19].

In a study by Eichenberger et al. [17], nine of ten healthy volunteers who received a US-guided third occipital nerve block (TONB) achieved confirmatory numbness in the suboccipital region. Siegenthaler et al. [18], conducted a study involving 50 patients suffering from chronic neck pain and reported that successful visualization of the nerves varied from 96 % for the third occipital nerve (TON) to 84 % for the medial branch of C6. In another prospective observational study by Siegenthaler et al. [21], 60 healthy volunteers received CMBBs using US as the primary imaging tool, with fluoroscopic confirmation. They reported that US-guided CMBBs allowed the needle to reach the target location in 82 of 107 (77 %) attempts at correct placement, as assessed by radiography. Meanwhile, Finlayson reported that FL and US guidance provide similar success rates for TONB, although US-guided techniques are associated with improved efficiency with regard to the administration duration and number of needle passes [22].

However, the previous studies had several limitations in that they only reported limited topics such as technical reports, accuracy, efficiency, and short-term pain improvement in comparison with FL-guided techniques. Therefore, comparisons of mid-term effectiveness and safety between US-guided and FL-guided CMBBs techniques seemed necessary to elucidate the clinical significance of US-guided CMBBs. Accordingly, we conducted this retrospective study to evaluate mid-term pain relief and functional improvements after US-guided CMBBs and compare the findings with those for FL-guided CMBBs. In addition, we assessed the injection efficiency with regard to the administration duration and number of needle passes as a secondary outcome.

Materials and methods

Study design

This study is a retrospective comparative review of chart data. Patient privacy and data confidentiality were maintained throughout the research process. The institutional review board of the corresponding author's affiliated university approved the study. The approval included a waiver of informed consent, because the study did not include direct contact with the study population, and all patient identifiers were removed from the dataset on initial collection.

Subjects

Potential study participants were patients who received US- or FL-guided CMBBs at our outpatient rehabilitation department between January 2013 and December 2014. On the day of the procedure, before injection, patients were requested to fill out self-assessment questionnaires regarding their baseline information (e.g., pain level, functional status). The electronic clinical records and questionnaire responses were retrospectively reviewed to gather data and determine compliance with the inclusion criteria.

We selected patients older than 18 years who received US- or FL-guided CMBBs for the treatment of cervical facet joint pain that lasted for at least 3 months. Cervical facet joint pain was diagnosed by comparative local anesthetic blocks [24]. All patients had not responded to conservative management, including analgesic use (NSAIDs or opioids) and physical therapy, performed for at least 4 weeks. Self-reported neck pain was at least 5 points on a Verbal Numeric Scale (VNS), with symptoms present on most days for at least 3 months. The exclusion criteria included a diagnosis of symptomatic cervical disc herniation or spinal stenosis, psychiatric disorders, neurological deficits, and laboratory results suggestive of inflammatory disease or rheumatoid disorders. We also excluded patients who had undergone cervical spine surgeries. Finally, we excluded patients whose body mass index (BMI) was over 22 because it is very difficult to have a clear ultrasound window for those obese patients.

Injection methods

In patients who do not desire radiofrequency ablation but do realize sustained relief with medial branch blockade, FL-guided or US-guided CMBBs is a common practice for treating symptomatic cervical facet joint pain at our institution. The patient is provided detailed information about the procedure and the expected benefits and risks, following which consent is obtained. The choice of FL or US guidance is made by the patient.

The procedures were performed by a physician (Y. Park) with more than 7 years of experience with US- and FL-guided procedures. All treatments were performed on an outpatient basis. The patients were placed in the lateral decubitus position, with the side requiring treatment facing upwards. Generally, a US examination is performed to identify all important structures prior to skin disinfection and wrapping of

the US transducer with a sterile cover. Accuvix XQ® (Samsung Medison, Seoul, Korea) with a linear probe at 6–12 MHz was used as the US instrument.

The cervical facet joints were identified by US examination. The lateral aspect of the neck was scanned in the region of the mastoid process in a long-axis view. The transducer was caudally moved to visualize the drop-off corresponding to the bony contour at the C2–C3 level [19, 22]. Scanning was performed caudally from the C2–C3 junction, and each level was determined by simply counting the "hills" (joints) and "grooves" (articular pillars) in a downward direction [21, 23]. The unique shape of the articular pillar of C7 with a transverse process served as a reference for accurate level determination. US identification of the bony target point for conventional facet joint nerve blocks was assessed. The target points are the facet joint cleft between C2 and C3 for blockade of TON and the deepest point ("groove") of the articular pillar from C3 to C6 for blockade of the medial branches of the C3 to C6 dorsal rami (Fig. 1a, b) [17–23]. The bony target for blockade of the medial branch of C7 lies at the junction of the transverse process of C7 and the superior articular process of C7 (Fig. 1c) [18].

Once an overview of the anatomy and target points was achieved, the skin was disinfected with Betadine and an aseptic dressing was applied. The needle was placed at all target levels in the short-axis view. Scanning was initiated posteriorly, where the spinous process and lamina were visualized, and moved anteriorly, where the contour of the articular pillar was identified [19, 20, 22]. The probe was then repositioned slightly cephalad or caudad to obtain the flattest and most echogenic linear image [19, 20, 22]. At this point, the probe was rotated along the short axis of the articular pillar to provide a slight posterior tilt and maximize the length of the linear echogenic image (Fig. 2a) [19, 20, 22]. To detect possible blood vessels in the proposed path of the needle or those overlying the articular pillar, the US probe was subsequently rotated to obtain a short-axis view. The color Doppler mode was used to detect vascular structures and determine the safest needle trajectory (Fig. 2b) [18–20, 22]. Finally, the needle was advanced until it contacted the periosteum using a posterolateral approach with a short-axis view and an in-plane (IP) freehand technique (Fig. 2c) [19, 20, 22].

Before injection, a long-axis view was assessed to ensure that the needle tip was close to the medial branch or the bony target point if the medial branch could not be precisely identified [19, 22]. Following negative aspiration for blood, 1 ml of a mixture of 1 % lidocaine (0.5 ml) and dexamethasone (5 mg/ml; 0.5 ml) was injected under real-time US guidance with a short-axis view (Fig. 2d). With regard to a C7 block, if the C7 superior articular process (SAP) could not be visualized, a point on the transverse process immediately caudal to the C6–C7 facet joint was selected [19]. Because of variations in the course of the medial branch of C7, which is occasionally found lateral to SAP along the cephalad aspect of the proximal TP, the needle was slightly withdrawn and repositioned 2 mm lateral to the initial target [25]. If the C7 TP (assessed in the long-axis view) was particularly prominent, this distance was increased to 4 mm [25]. A second 0.5-ml bolus of the mixture was injected before needle withdrawal; the total injectate did not exceed 1 ml.

FL-guided CMBBs were administered using the lateral approach, wherein the patients lie on their side with the painful side facing upward [25]. For blockade at C3–C6, the target points are the centroid of the articular pillar with the same segment number as the target nerve [25]. Under fluoroscopic visualization, after identification of the waists of the articular pillars at the desired levels, each medial branch block was administered with a 25-gauge, 3.5-inch spinal needle. Therapeutic facet joint nerve blocks were administered by injecting 1 ml of the mixture as assigned by grouping at each level. For TON, three target points were used to ensure adequate infiltration because this nerve is thicker than the medial branches of typical cervical dormi, it is embedded in the pericapsular fascia of C2–C3, and it has a variable location in relation to this joint [25]. For blockade at C7, the target point lies on the apex of SAP. Similar to the process during US-guided CMBB, the needle was withdrawn approximately 4 mm, 0.5 ml of a mixture of 1 % lidocaine (0.25 ml) and dexamethasone (5 mg/ml; 0.25 ml) was injected at the target point, and a further 0.5 ml was injected because of variations in the path of the medial branch (Fig. 3) [25].

Patients are scheduled to received two consecutive injections at a 2-week interval. The patient satisfactory scores were measured with a 5-grade scale (<0, no effect at all; 1, bad; 2, fair, 3, good; ≥4, excellent), 2 weeks after first injection. 'Excellent' means 'satisfied with the treatment result as expected', 'good' means 'not as much as expected but willing to try this treatment next time when pain redevelops,' 'fair' means 'had some effect but not enough to choose the same treatment next time when pain re-develops', and finally, 'bad' means 'same effect as the prior treatment or worse.'

The second injection was omitted with the patient followed up only if the initial injection resulted in a significant symptom alleviation [≥50 % improvement by the Verbal Numerical Scale (VNS) score for pain]. The second injection or re-evaluation was not considered if there was an aggravation of pain, no relief of pain, or the patient satisfaction score equal to or below 'fair' grade. If the patient satisfaction score was 'good' in spite of the VNS score improvement < 50 %, a second injection was scheduled. Because none of the patients had shown any improvement with medications such as analgesic use (NSAID or opioid) and physical therapy for 4 weeks, we did not set any limit for continuation of the previous exercise programs and drug therapy and return to work. No specific physical therapy, occupational therapy, bracing, or other specific interventions were utilized.

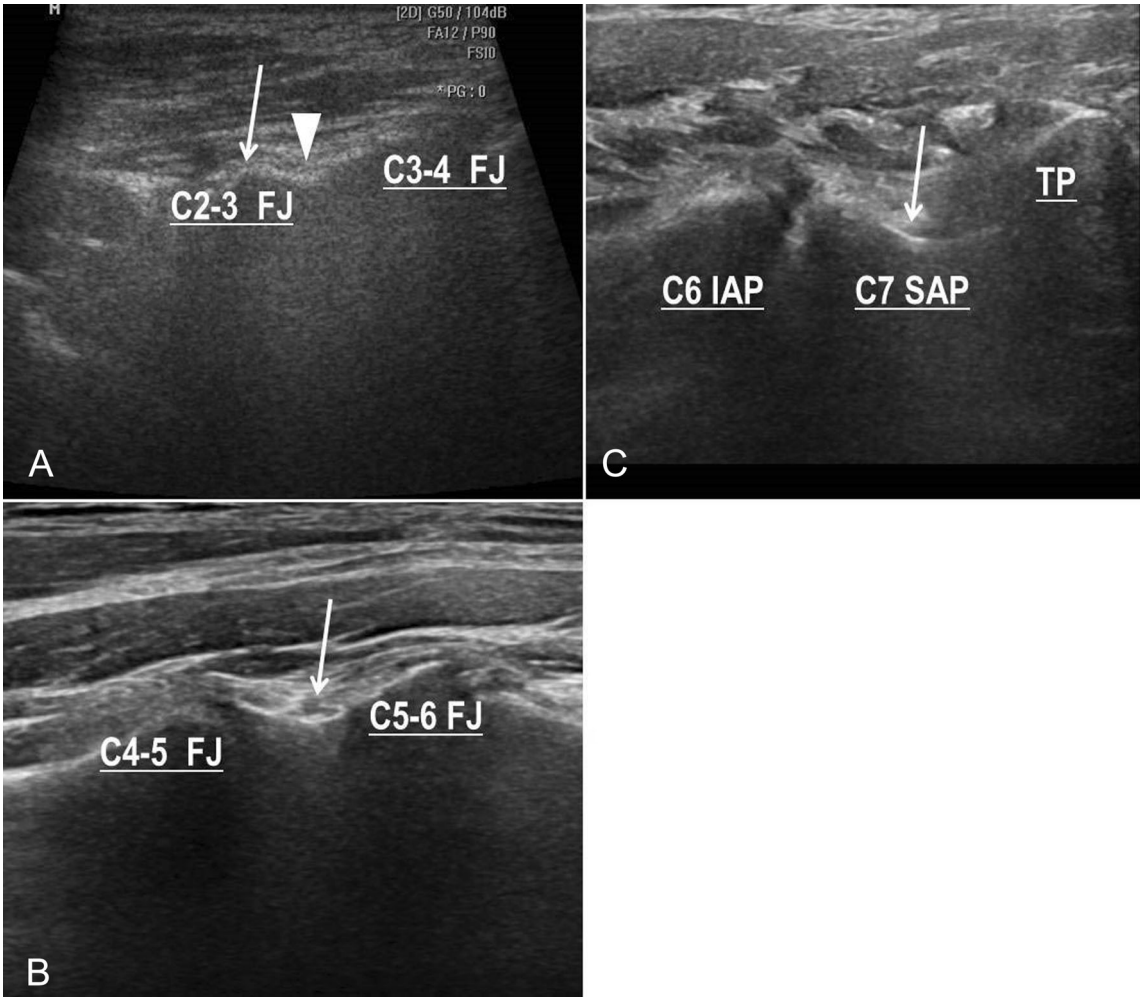

Fig. 1 Ultrasound-guided medial branch block of target lesion. a Long-axis view at the level of C2-C3, used as target for TON block (*arrow*) and C3 medial branch block (*arrowhead*), TON third occipital nerve, FJ facet joint. b Long-axis view at the level of C5, used as target for C5 medial branch block (*arrow*), FJ facet joint. c Long-axis view at the level of C7, used as target for C7 medial branch block (*arrow*). TP C7 transverse process, SAP superior articular process, IAP inferior articular process

Review of clinical data

A standardized chart abstraction form was used to extract data on demographics, treatments, pain severity, analgesic use, and functional assessments. Follow-up interviews were conducted by nursing personnel not involved in the procedure during a hospital visit at 1, 3, and 6 months after the last injection.

Primary outcomes included the Neck Disability Index (NDI) scores and VNS scores for pain, which were recorded before injection and at 1, 3, and 6 months after the last injection. The degree of physical disability was measured using NDI, which is the most widely used questionnaire survey assessing cervical spine abnormalities. NDI was first developed to evaluate the degree of limitations in the daily lives of patients with severe cervical pains, particularly those with whiplash trauma [26]. It includes ten questions related to functional activity (seven questions), symptoms (two questions), and concentration (one question) [26]. The final score is obtained by adding the scores for all questions. A higher NDI score indicates increased functional disability related to cervical abnormality. The original developer, Vernon, suggested score interpretation as follows: ≤4 or lower = no disability, 5–14 = mild disability, 15–24 = moderate disability, 25–34 = severe disability, and ≥35 = complete disability [26]. To obtain VNS scores, the patients were asked to rate their pain on a scale from 0 to 10, where 0 and 10 represented no pain and the worst pain possible, respectively. Scores were assigned as whole numbers with 11 integers, including zero [27].

Responder of CMBBs wad defined as more than 50 percent improvement of VNS score and more than 40 percent improvement of NDI score [27, 28]. CMBBs of not responder was considered when patients failed to meet these criteria or underwent invasive procedures (radiofrequency) during the follow-up period after injection. Their VNS and NDI scores were recorded for statistical analysis and subsequently

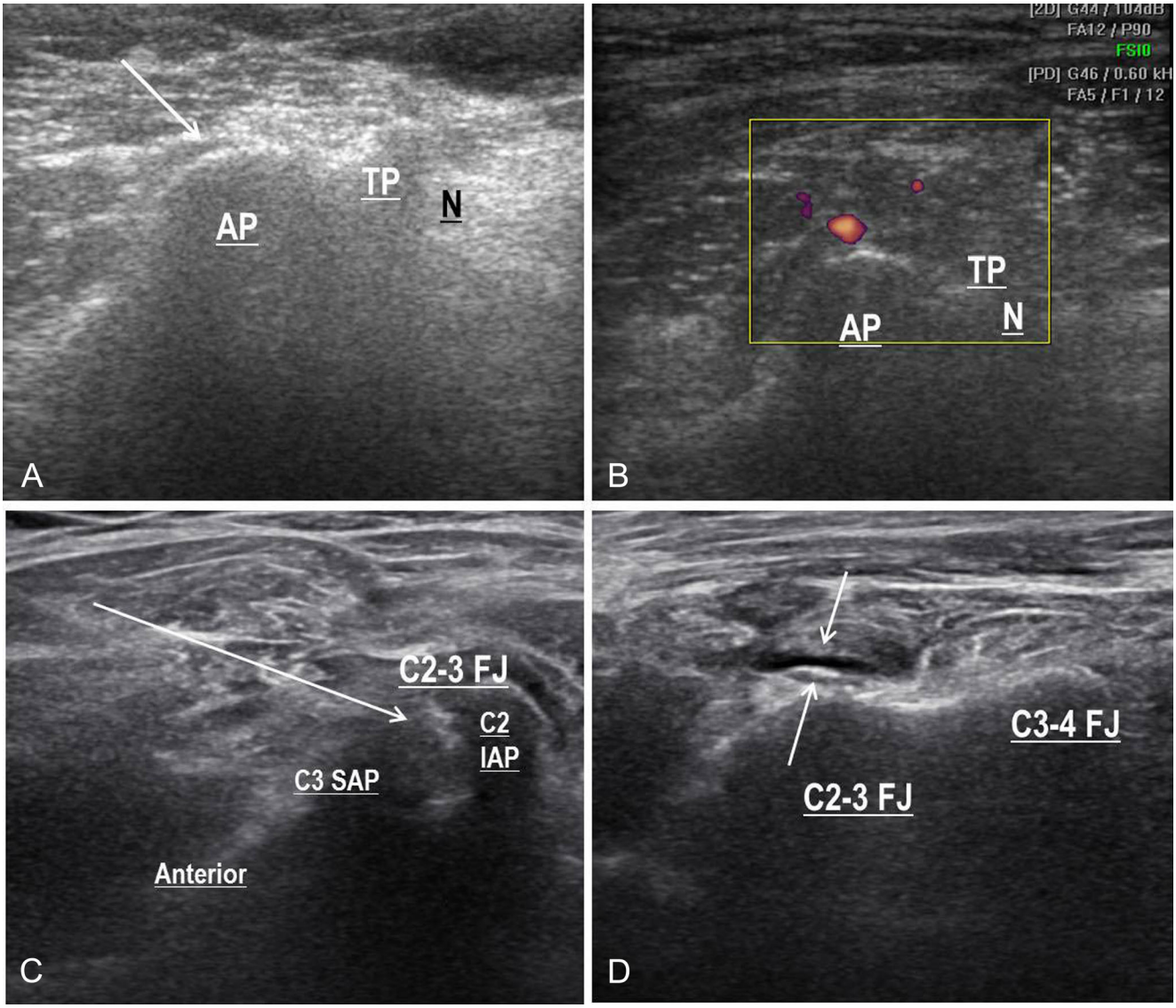

Fig. 2 Ultrasound-guided medial branch block by a posterolateral approach with short-axis view and an in-plane free-hand technique. **a** Short-axis view of the C5 articular pillar demonstrating target position for a medial branch block; transverse process of C5 (TP); articular pillar (AP) of C5 (C5); lamina (Lam). A similar approach was used for the C6 level. **b** Short-axis view at the level of the C5 articular pillar. Note the artery (*arrows*) coursing anteriorly over the articular pillar (AP). *N* nerve root, *Tp* transverse process. **c** Short-axis view of the C2–3 facet joint demonstrating a needle (*arrow*) in position for a TON block. **d** Long-axis view of the C2–3 facet joint showing injectate volume expansion (*arrow*)

excluded. Independent variables, including the injection method, the number of injections, sex, and age were documented in the medical charts. Age was classified into five groups as follows: <39, 40–49, 50–59, 60–69, and >70 years.

The administration duration and number of needle passes were also recorded. For US-guided CMBB, the administration duration was defined as the time interval between the contact of the US probe with the patient's skin and completion of injection [20, 22]. For FL-guided CMBB, the administration duration was defined as the temporal interval between the first radiographic image and the end of the second injection [20, 22]. In both groups, the initial needle insertion was counted as one pass; any subsequent needle advancement that was preceded by withdrawal of more than 1 cm was counted as an additional pass [20, 22]. Finally, we reviewed the charts for immediate adverse events such as vasovagal reaction, facial flushing, and brief severe neck pain within a few minutes after injection. Each patient was handed a questionnaire at the end of the procedure, which they had to complete within 48 h after the procedure and return at the 2-week follow-up visit.

Statistical analysis

Pearson's Chi-square and Wilcoxon's rank-sum test were used to compare the characteristics of the two groups with regard to variables such as sex, age, body mass index (BMI), number of

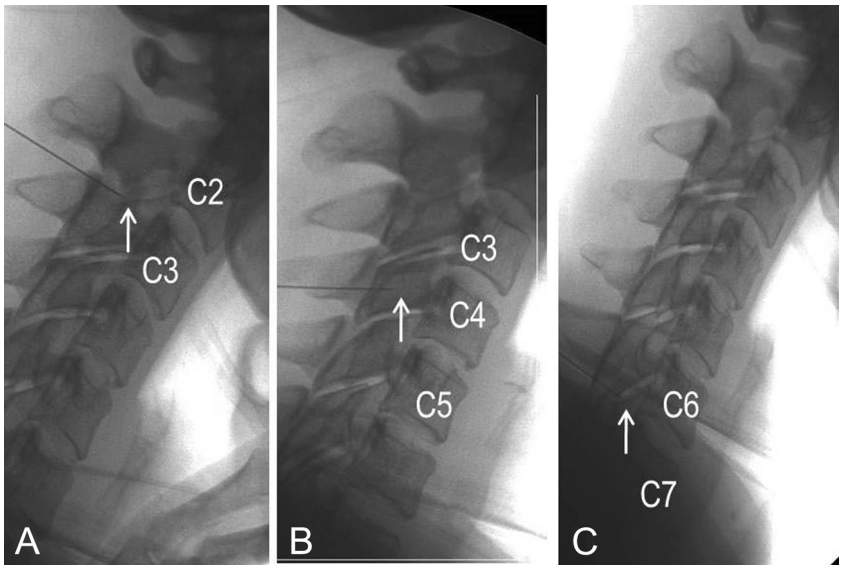

Fig. 3 Fluoroscopy-guided medial branch block. **a** Lateral view of the upper cervical spine showing the needle resting on the subchondral plate of superior articular process of C3. **b** Lateral view of the cervical spine showing a needle in correct position for C4 medial branch block. A similar approach was used for the C5, 6 level. **c** Lateral view of the cervical spine showing a needle in correct position for C7 medial branch block

injections, analgesic use, and pain duration. At each time point (before injection and 3, 6, and 12 months after the last injection), the VNS and NDI scores were compared by repeated measures analysis of variance (ANOVA) with Bonferroni's correction for post hoc comparisons. Pearson's Chi-square tests were used to test the differences in proportions. Wilcoxon's rank-sum test was used to compare the two groups with regard to the administration duration and number of needle passes. Univariate and multivariate logistic regression analyses with Pearson's Chi-square were performed to assess whether the injection method, age, sex, analgesic use and the number of injections were independent predictors of treatment success. All statistical analyses were performed using SAS Enterprise Guide 4.1 (4.1.0.471). A p value of <0.05 was considered statistically significant.

Results

Of the 186 CMBBs, including 104 US-guided CMBBs and 82 FL-guided CMBBs, administered during the study period, a total of 126 (68 %) met the inclusion criteria. Forty-five (24 %) injections were excluded because the patients did not complete and return the follow-up surveys. Another 15 (8 %) were excluded because of the exclusion criteria. Twelve patients were excluded for previous operation and three patients for underlying rheumatoid arthritis (RA). Finally, 68 patients received US-guided CMBBs and 58 received FL-guided CMBBs. In total, 214 blocks, including 52 TON, six C3, 12 C4, 48 C5, 64 C6, and 32 C7, were administered in the US-guided group and 191 blocks, including 46 TON, four C3, 10 C4, 49 C5, six C6, and 22 C7, were administered in the FL-guided group.

The average age of patients in the US-guided and FL-guided groups was 53.1 ± 11.7 and 55.3 ± 10.0 years, respectively, with no significant differences between groups. Moreover, there were no significant differences in sex, BMI, pain duration, analgesic use, and number of injections between groups (Table 1).

The NDI and VNS scores showed a significant improvement at 1, 3, and 6 months after the last injection in both groups, with no significant differences between groups at baseline and at 1, 3, and 6 months after the last injection (Table 2). At 1 month, 14 patients had received repeat injections and one had undergone surgery in the US-guided group. Thus, the 1-month treatment success rate was 77.9 % (n = 53) in the US-guided group. Meanwhile, 12 patients had received repeat injections and two had undergone surgery by 1 month in the FL-guided group. Thus, the 1-month treatment success rate was 75.9 % (n = 44) in the FL-guided group. At 3 months,

Table 1 General characteristics of the patients

	Ultrasound-guided medial branch block (n = 68)	Fluoroscopy- medial branch block (n = 58)	p value
Age (years)	53.1 ± 11.7	55.3 ± 10.0	0.300
Sex, n (%)			
Female	48 (70.6 %)	41 (70.7 %)	
Male	20 (29.4 %)	17 (29.3 %)	0.990
BMI (kg/m^2)	23.99 ± 2.52	24.59 ± 2.97	0.258
Number of injections	1.43 ± 0.498	1.48 ± 0.504	0.531
Analgesic use, n (%)			
NSAID usage	42 (61.8)	31 (53.4)	0.346
Opioid usage	48 (70.5)	41 (70.7)	0.990
Pain duration (months)	6.51 ± 2.29	6.62 ± 2.23	0.791

Values are mean ± standard deviation

BMI body mass index

Table 2 Comparison of VNS and NDI from baseline to 1, 3, and 6 months after last injection

		Baseline	1 month	3 month	6 month
VNS	Ultrasound	6.46 ± 1.06	2.54 ± 1.4*	2.72 ± 1.70*	2.74 ± 1.36*
	Fluoroscopy	6.40 ± 0.96	2.76 ± 1.95*	2.67 ± 1.35*	2.71 ± 1.66*
NDI	Ultrasound	24.25 ± 5.39	12.35 ± 5.50*	12.43 ± 6.39*	12.68 ± 4.06*
	Fluoroscopy	23.95 ± 4.45	12.55 ± 6.63*	11.91 ± 4.98*	12.75 ± 4.01*

Values are mean ± standard deviation

*$p < 0.05$: Comparison before and after the injection

VNS verbal numeric pain scale, *ODI* Neck Disability Index

nine and eight patients had received repeat injections in the US-guided and FL-guided groups, respectively, resulting in treatment success rates of 64.7 % ($n = 44$) and 62.1 % ($n = 36$), respectively. Finally, at 6 months, six patients each had received repeat injections in the US-guided and FL-guided groups, resulting in treatment of responders rates of 55.9 % ($n = 38$) and 51.7 % ($n = 30$), respectively (Fig. 4). There were no significant differences in the success rate at any time point between the two groups. There was not a clinically significant reduction in the percentage of analgesic (NSAID and opioid) users in the between the two groups at 6 months after therapeutic injections.

The proportions of patients with >50 % improvement in the VNS score and >40 % improvement in the NDI score are illustrated in Fig. 2. The respective rates at 6 months were 55.9 and 51.7 % in the US-guided and FL-guided groups. There were no significant differences at any time point between the two groups.

Univariate and multiple logistic regression analyses revealed that the injection method, sex, age, analgesic use and number of injections were not independent predictors of treatment success ($p > 0.05$). The results are summarized in Tables 3 and 4.

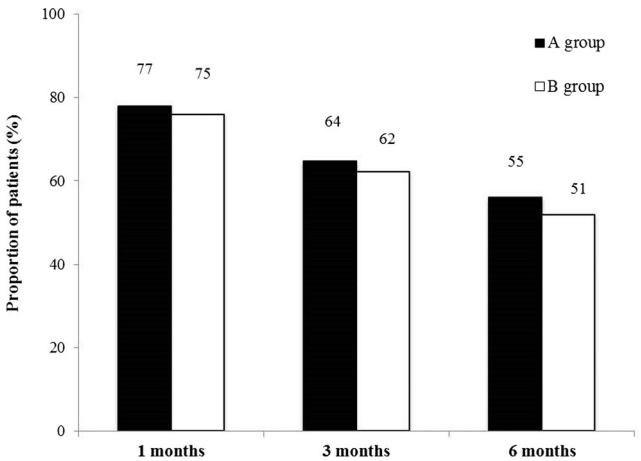

Fig. 4 Illustration of significant pain relief (≥50 % reduction in verbal numeric pain scale from baseline), functional improvement (≥40 % reduction in Neck Disability Index from baseline). A group: Ultrasound-guided cervical medial branch block, B group: fluoroscopy-guided cervical medial branch block

The administration duration (221 vs. 383 s) and number of needle passes (two vs. five) were significantly smaller in the US-guided group than in the FL-guided group (both $p < 0.001$).

Immediately after the procedure, four patients in the US-guided group and three in the FL-guided group experienced a vasovagal reaction, while four and three patients, respectively, developed a transient headache ($p > 0.05$). Overall, at the 2-week follow-up session, three patients in the US-guided group and four in the FL-guided group reported transient pain exacerbation (in the head or upper limbs) 48 h after the procedure. No patient reported headache suggestive of postpuncture syndrome, decompensated heart disease, or diabetes. No cases of infection or hematoma were recorded during the 2-week period after the procedure.

Blood was aspirated before injection in 12 and 0 % patients in the FL-guided and US-guided groups, respectively. No

Table 3 Univariable analysis for possible outcome predictors for injection effectiveness at follow-up

Characteristic	Responders ($n = 68$)	Not responders ($n = 58$)	p value
Injection method			
US (%)	38 (55.9)	30 (51.7)	
Fluoroscopy (%)	30 (44.1)	28 (48.3)	0.641
Gender			
Female	51 (75.0)	38 (65.5)	
Male	17 (25.0)	20 (34.5)	0.244
Age			
≤ 39	6 (8.8)	8 (13.8)	
40–49	15 (22.1)	15 (25.9)	
50–59	21 (30.9)	18 (31.0)	
60–69	19 (27.9)	13 (22.4)	
> 70	7 (10.3)	4 (6.9)	0.795
Number of injections			
1	36 (52.9 %)	33 (56.9 %)	
2	32 (47.1 %)	25 (43.1 %)	0.721
Analgesic use, *n* (%)			
NSAID usage	43 (63.2 %)	30 (51.7 %)	0.192
Opioid usage	50 (73.5 %)	39 (67.2 %)	0.440

Table 4 Multiple logistic regression analysis for possible outcome predictors for injection effectiveness at follow-up

Factor	OR	95 % CI	*p* value
US- vs. FL-guided method	1.242	0.607–2.543	0.553
Sex	1.629	0.745–3.564	0.221
Age group	1.247	0.903–1.722	0.873
Number of injections	0.942	0.455–1.952	0.624
Opioid	0.925	0.385–2.219	0.861
NSAID	0.645	0.287–1.447	0.287

OR odds ratio, *95 % CI* 95 % confidence interval, *US* ultrasound, *FL* fluoroscopy

intravascular contrast spread was noted during injection in the FL-guided group. In the US-guided group, vascular structures were found to overlie the articular pillar in 9, 16, 16, 12, 32, and 46 % of the C2–C3, C3, C4, C5, C6, and C7 levels, respectively.

Discussion

This retrospective study assessing the treatment effects of CMBBs with US or FL guidance showed clinically meaningful and significant improvements in all parameters at the end of a mid-term period of 6 months after the last injection, when the treatment success rates were 55.9 and 51.7 % in the US-guided and FL-guided groups, respectively. The treatment success rates showed no significant differences between groups at 1, 3, and 6 months after the last injection. However, the US-guided technique required fewer needle passes and a shorter administration duration compared with the FL-guided technique. We speculate that the greater efficiency conferred by US guidance stems from the inherent difficulties related to FL. Pain control and functional improvements were similar with US-guided and FL-guided CMBBs. To the best of our knowledge, this study is the first to compare the treatment efficacy and the injection efficiency with regard to the administration duration and number of needle passes between US-guided and FL-guided CMBBs over a 6-month follow-up period in patients with chronic posterior neck pain.

A systematic review by Falco et al. [7] showed moderate evidence for CMBBs that has also been echoed in other reports [13, 15]. Manchikanti et al. published an observational study and a randomized double-blind trial of medial branch blocks performed with or without steroids [29, 30], which documented positive results in 85 and 92 % patients at the 1-year follow-up, respectively. The equal effectiveness of local anesthetics with and without corticosteroids for CMBBs indicates that there is no significant role of the corticosteroid in CMBBs [29, 30]. However, most studies mention that corticosteroids provide a certain level of efficacy by their anti-inflammatory, immunosuppressive, and anti-edema effects and the inhibition of neurotransmission within C-fibers [31–34]. Therefore, we used a mixture of dexamethasone and lidocaine in the present study and derived good treatment success rates at 6 months in both groups.

CMBBs are conventionally administered under FL guidance. Because several blocks are often necessary to identify the symptomatic joint or rule out facet joint pain, the procedure may expose patients and personnel to considerable radiation doses [23, 35]. On the other hand, US-guided CMBB is not associated with radiation Exposure [23]. The main advantage of US guidance, in addition to no radiation exposure, is direct real-time visualization of vessels and nerves. This is particularly beneficial for cervical spine procedures, where a multitude of vulnerable vessels and other vital soft tissue structures are compactly arranged in a small area and often in the path of the projected needle trajectory [36]. Cohen et al. [37] reported a 7 % incidence of unintentional intravascular injections during FL-guided CMBBs. Narouze et al. [38] published a report on two major vessels identified with color Doppler in the frontal area and posterior side of the foramen in 64 patients during a prospective study on US-guided spinal procedures. These vessels were located in regions vulnerable to needle-related damage under FL guidance. They reported that the application of a US-guided approach would prevent intravascular injections [38]. A different study reported the presence of the ascending or deep cervical artery or a large branch in the needle path in >20 % (21/95) patients undergoing cervical spinal procedures [39]. Furthermore, a third of these vessels were spinal branches that entered the foramen posteriorly, potentially forming a radicular or a segmental feeder vessel to the spinal cord [39]. In the present study, vascular structures were found to overlie the articular pillar in 9, 16, 16, 12, 32, and 46 % of the C2–C3, C3, C4, C5, C6, and C7 levels, respectively, in the US-guided group. These findings are similar with those of previous studies, where rates of 30, 12.5, 10, and 40 % were found for the C6, C5, C2–C3, and C7 levels, respectively [20, 22, 40]. In all cases, the vessels were located in areas vulnerable to needle-related damage under FL guidance.

Although we established that US guidance can aid in avoiding intravascular injection, it remains unclear whether it aids in detecting intravascular injection [36]. The present retrospective observational study with a small sample size is inadequate to validate the safety of US guidance compared with that of FL guidance. Furthermore, the technique requires a highly experienced sinologist [32]. It is worth mentioning that the lack of detection of a small critical vessel on US images does not necessarily mean that it does not exist [41]. Also, visualization of small nerves such as CMMBs and TON can be very challenging, particularly in obese patients and patients with advanced cervical facet arthritis, and requires special training and experience [41]. Also, no particular

corticosteroid is recommended to ensure safety, because the microvessels that can promote neurological damage cannot be identified with US alone. Tiso et al. [42] recommended the use of dexamethasone or betamethasone, which are small particles, because the particles of methylprednisolone or triamcinolone flocculate may block smaller arteries by forming large coagulations measuring ≥100 μm in diameter. Derby et al. [43] also reported that arterial or capillary obstruction caused by inadvertent injection into an artery can be avoided with the use of dexamethasone sodium phosphate particles, which measure one-tenth the size of red blood cells.

Currently, two techniques are available for US-guided CMBBs, and both are free-hand techniques. Finlayson et al. [19] used the short-axis IP approach and Siegenthaler et al. [23] used the long-axis out-of-plane (OOP) approach. The short-axis view over the long-axis view to better identify the AP; they did not seek to visualize the medial branch itself [36]. Each technique has its advantages and limitations, although the advantages of the long-axis view are two-fold. The presence of only one cervical level in the view minimizes the risk of erroneous counting of the cervical level and facilitates the placement of more than one needle for multiple-level injections [36]. More importantly, in the long-axis view, one can better identify the nerves because they appear oval in the cross section, with a typical US appearance of a small peripheral nerve [23]. The short-axis view offers better visualization of critical blood vessels as they course anteriorly across the articular pillar toward the neuroforamen [36]. Therefore, Finlayson et al. [20, 22] and Narouze [36] recommend a preinjection scan in the short-axis view to identify any blood vessels near the target area, following which the needle can be placed in the same view to avoid these blood vessels. Then, a long-axis view should be obtained to identify the actual medial branches, and the needle can be slightly adjusted as required. This should add to the specificity of the block by minimizing the injectate volume.

The OOP approach involves insertion of the needle such that it crosses the plane of imaging near the target. With this approach, the target is typically centered within the field of view and the depth is noted [44]. With the IP approach, the needle can be inserted within the plane of imaging to visualize the entire shaft and the tip. Therefore, the imaged needle path should be maximized by placing the target on the side of the imaging field of view away from the approaching needle [45]. We used the short-axis IP approach in the present study. However, critics of the IP approach are concerned that it is time consuming and that the partial line-ups of the needle and transducer create a false sense of security [44]. Another potential disadvantage of the IP approach is the associated reverberation created by the long axis of the needle shaft, which may impair the detection of structures below the imaged procedural needle shaft [44]. Also, the IP approach requires longer needle insertion paths compared with the OOP approach and can consequently cause greater discomfort for the patient [46]. On the other hand, critics of the OOP approach are concerned about complications due to the lack of needle tip visibility during the procedure. Finding an echogenic dot within a bright background can be difficult [40]. In addition, the OOP approach poses difficulty in accurately following the procedural needle for target selection and does not allow physicians to determine whether the hyperechoic dot observed on the US image is an approximation of the procedural needle tip or the needle shaft. Further studies on comparisons of these US-guided techniques are necessary.

The administration duration and number of needle passes were significantly smaller with US-guided CMBB than with FL-guided CMBB. These results can be explained as follows. In previous studies, US-guided TONB necessitated injection at a single site instead of the three common fluoroscopic targets, and the greater efficiency conferred by US guidance stems from the inherent difficulties related to fluoroscopic imaging [22, 40]. Acquiring a true radiographic lateral view, a critical step for safe needle advancement and accurate identification of the targeted SAP, can be time consuming in the lower cervical spine [22, 40]. Furthermore, correct assessment of the needle depth necessitates at least one additional anteroposterior view before the needle tip is positioned. In contrast, US allows visualization of the contours of the articular pillar and the zygapophyseal joints; these are immediately identifiable in transverse or coronal planes and are less affected by the patient's position [22, 40].

The present study has several limitations; first is the retrospective design. Although we selected patients using extensive inclusion and exclusion criteria, heterogeneity and randomization of subjects were inevitable. However, this shortcoming was compensated by the standardization of demographic, clinical, and imaging data recordings before treatment and at each follow-up visit in the case records of patients who received CMBBs at our institution. Second, we could not entirely exclude other treatments such as medication or physical therapy during the follow-up periods. Third, both procedures were performed by a single physician, reflecting the experience of only one practitioner and limiting generalization of the study results. Fourth, we did not confirm if US-guided CMBBs were administered precisely at the site targeted by FL. Thus, multi-center prospective studies are necessary to resolve these issues.

Conclusions

In conclusion, the results of our study suggest that, compared with FL-guided CMBBs, US-guided CMBBs require a shorter administration duration and fewer needle passes, while providing similar pain relief and functional improvements. Therefore, within the limitations of this retrospective study,

we believe that US-guided CMBBs should be considered as an effective alternative for the conservative management of chronic cervical facet joint pain.

Compliance with ethical standards

Ethics approval and consent to participate The institutional review board of the corresponding author's affiliated university approved the study. The approval included a waiver of informed consent, because the study did not include direct contact with the study population, and all patient identifiers were removed from the dataset on initial collection.

Conflict of interest The authors declare that they have no conflicts of interest.

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