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Diagnostic Value of Bone SPECT/CT in Chronic Axial Neck Pain: A Guide for Injection Therapy

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Abstract

Diagnostic Value of Bone SPECT/CT in Chronic Axial Neck Pain: A Guide for Injection Therapy

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Background: Identification of the anatomical source of axial neck pain is often difficult. The results of previous studies on non-invasive diagnostic methods in the identification of the pain source have been inconsistent. Furthermore, diagnostic injections are invasive and therefore their use is limited as a screening tool. As an alternative, bone single photon emission computed tomography combined with conventional computed tomography (SPECT/CT) can be utilized to localize the pain source and guide percutaneous injection therapy.

Methods: The current study included 61 patients with chronic axial neck pain and no radicular pain for more than 6 weeks, who had no prior conclusive imaging study. Following the SPECT/CT, all patients were stratified into three groups according to the site of increased radiotracer uptake. Percutaneous steroid injection was performed at the location of the highest radiotracer uptake with three different methods. The visual analogue scale of neck pain was recorded before, 6 weeks and 6 months post-injection. Improvement of pain scales following injection therapy was statistically analyzed after stratification into the location of increased uptake and injection methods.

Results: 56 of 61 patients (91.8%) had increased radiotracer uptake in the cervical spine: 28 (50.0%) had the highest uptake in the facet joint, 22 (39.3%) in endplates, 6 (10.7%) in uncovertebral joint. Of 56 patients with a positive scan, 39 received injection therapy: 18 intraarticular facet joint injections, 15 intradiscal injections, and 6 interlaminar epidural injections. Average pain scale for 39 patients improved from 6.90 ± 0.85 (mean ± standard deviation) to 3.38 ± 2.16

at 6 weeks (p=0.001) and 4.41 ± 2.09 at 6 months (p=0.001). The proportion of patients with more than 50% improvement of pain were 51.3% at 6 weeks and 25.6% at 6 months post-injection.

Conclusion: SPECT/CT localized the source of chronic axial neck pain in 91.2% of patients who had no prior conclusive imaging studies. Short-term improvement of axial neck pain was observed after percutaneous injection therapy, guided by SPECT/CT.

Keywords: chronic axial neck pain; single photon emission computed tomography; percutaneous injection therapy

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SPECT	single photon emission computed tomography
CT	computed tomography
MRI	magnetic resonance imaging
VAS	visual analogue scale

Introduction

Chronic axial neck pain is a common problem, with an estimated lifetime prevalence reported up to 86.8% and point prevalence up to 41.5% [1-6]. Patients with chronic axial neck pain can present with a severe degree of pain and disability [1, 2], which is associated with a significant socioeconomic burden [3, 7-9]. Although the identification of the pain source seems to be essential in the treatment of axial neck pain, there is little evidence regarding the anatomical origin of the axial neck pain in the literature, with most of the studies focused on cervical facet joint pain [10-13].

Various non-invasive diagnostic modalities have been used to localize the source of axial neck pain, but the results have been inconsistent. There is little evidence that the findings of physical examinations, such as local tenderness, and structural imaging studies, such as magnetic resonance imaging (MRI) and computed tomography (CT), are diagnostic of facet joint pain in the cervical spine [14-19]. Likewise, physical examinations and imaging studies are also incapable of diagnosing cervical discogenic pain, which is another possible source of pain in patients with axial neck pain [18, 20, 21].

As an alternative, functional imaging using bone single photon emission computed tomography (SPECT) combined with

conventional CT: SPECT/CT can be used to identify the source of chronic axial neck pain. SPECT/CT is a hybrid imaging technique that combines the high spatial resolution of CT and the high sensitivity of SPECT [22–24], which is used not only for cancer patients but also for the detection of infection, trauma and degenerative diseases. Previous studies have reported the clinical value of the bone SPECT or SPECT/CT in the identification of the pain source and selection of percutaneous treatment for chronic spinal pain [22, 25–32]. However, most of these studies have focused on facet joint pain of the lumbar spine, and little evidence is present regarding the value of SPECT/CT on chronic axial neck pain.

The author of the current study postulated that the functional imaging using bone SPECT/CT could localize the source of chronic axial neck pain, and percutaneous injection therapy based on this localization can provide short–term benefits. Therefore, the objective of this study was to 1) describe the distribution of increased radiotracer uptake on SPECT/CT in patients with chronic axial neck pain, 2) evaluate the short–term clinical results of percutaneous injection treatment when guided by the results of SPECT/CT, and 3) assess the results of percutaneous injection treatment after stratification according to the different sources of the axial neck pain.

Materials and Methods

Study subjects

Current prospective case series study was approved by the institutional board review of the author's center, and informed consent was obtained from all participants. The inclusion criteria of the study were 1) chronic (more than 6 weeks) axial neck pain with intensity greater than visual analogue scale (VAS) of 6.0 and without upper extremity radiating pain, 2) no previous cervical spine MRI or MRI with insufficient findings to determine further management, and 3) failure of conservative pain management in the primary care setting. Regarding the pain location, pain in the occiput and the interscapular area was also considered as axial neck pain. Patients who presented with an apparent cause of neck pain, such as fracture or tumor, prior neck surgery, and who were not able to receive percutaneous injection therapy for other medical reasons, such as coagulopathies or uncontrolled diabetes, were excluded from the study.

At the initial visit, thorough history taking and physical examination were completed, including pain assessment using VAS and pain mapping. As for the pain mapping, patients were asked to indicate the location of their pain by drawing on an empty body diagram.

Laboratory screening including complete blood count, serum C-reactive protein and coagulation profile was done, and any abnormalities were evaluated before patient enrollment.

SPECT/CT acquisition protocol

A SPECT/CT imaging study was performed using a hybrid SPECT/CT scanner (NM/CT670, GE Healthcare), 3 hours after the injection of 750MBq Tc-99m methylene diphosphonate. First, a CT scan was acquired, followed by image reconstruction using an adaptive statistical iterative reconstruction algorithm (ASiRTM, GE Healthcare) with a slice thickness of 1.25 mm. Sequentially, SPECT images were obtained with the patient maintaining the same position, using dual-headed 360° rotating gamma camera operating at the energy peak of 140.5 KeV and producing 128 projections at 15 seconds per frame. SPECT images were then reconstructed using an iterative ordered subset expectation maximization (OSEM) algorithm with CT-based attenuation and scatter correction, and resolution recovery. After an independent nuclear medicine specialist interpreted SPECT/CT images, the locations of increased radiotracer uptake in the cervical spines were recorded and categorized into three different groups: 1) facet joints, 2) endplates, and 3)

uncovertebral joints (Figure 1). Increased uptake of the radiotracer in structures other than the cervical spine, such as shoulder joints and sternoclavicular joints were also recorded.

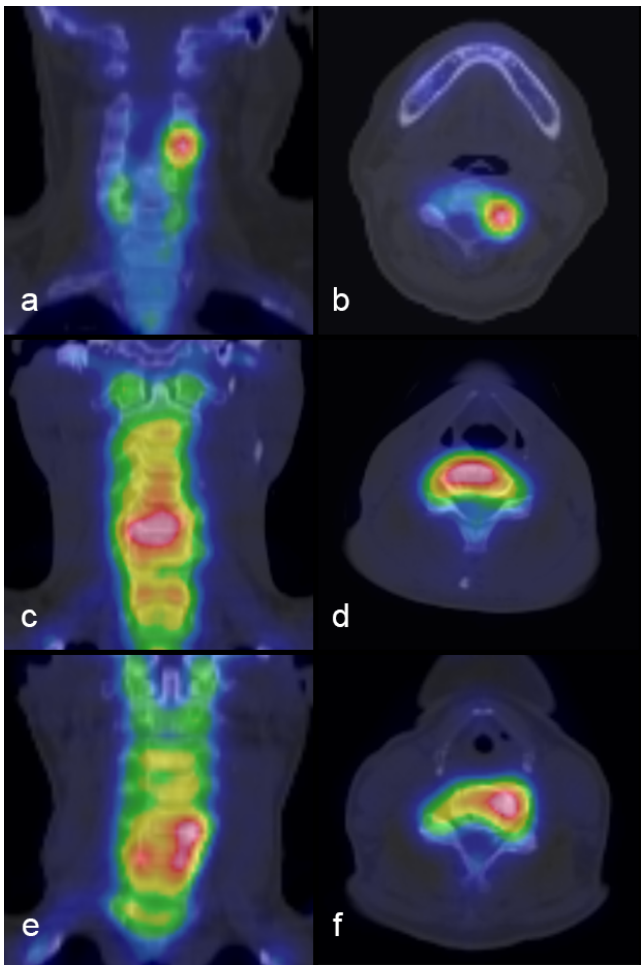

Fig. 1. Three different locations of increased radiotracer uptake in coronal and axial view of SPECT/CT. (a,b) The facet joint. (c,d) The endplates. (e,f) The uncovertebral joint.

Percutaneous injection therapy

After the SPECT/CT examination, patients revisited outpatient clinics for re-evaluation and to determine further treatment plans. After being informed of the risks and benefits of percutaneous injection therapy, the patient was given a choice to receive the treatment. The method and level of the injection therapy were decided according to the location of the increased uptake of the radiotracer in the SPECT/CT study: 1) intraarticular facet joint injection was done for patients with increased uptake in the facet joint, 2) intradiscal injection for the endplates, and 3) interlaminar epidural injection for the uncovertebral joint (Table 1). For patients with multiple regions showing increased radiotracer uptake in SPECT/CT, injection therapy was performed on the area with the highest indicated uptake. As for other treatments besides injection therapy, pain medications were not prescribed during the study period. However, adjuvant therapies given to patients outside the author's center, such as physiotherapy and acupuncture, were not controlled.

Method	Medication and dosage*	Equipment
Intraarticular facet	triamcinolone 40mg/mL, 0.5mL + 2% lidocaine 0.5mL	22 gauge
Intradiscal	triamcinolone 40mg/mL, 0.5mL + 2% lidocaine 0.5mL	25 gauge
Interlaminar epidural	dexamethasone 5mg/mL, 2mL	22 gauge

*For all methods, contrast material (iohexol, 300mg/mL) was used to confirm the placement of the needle

Table 1. Protocols for percutaneous injection therapy

Outcome assessment

Patients were scheduled to visit the outpatient clinic 6 weeks and 6 months after receiving percutaneous injection therapy. Pain assessment using pain mapping and VAS was undertaken using the same method as the initial evaluation. Patients who showed more than 50% reduction in pain VAS were deemed as “responders”.

Statistical analysis

The size of the study sample was determined to achieve a desired statistical power of 80% to detect a 50% VAS change, with a two-

sided alpha of 0.05 and a 20% dropout rate. The change of pain VAS from initial to 6 weeks and 6 months was assessed using paired t-test and repeated measures ANOVA with the post hoc Bonferroni adjustments. One-way ANOVA with post hoc Tukey test, Chi-square test and Fisher's exact test were applied to compare the results of percutaneous injection after stratification according to the different sources of axial neck pain. A p-value of <0.05 was considered statistically significant, and SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

Results

Study subjects

The current study enrolled 66 patients following the result of the sample size determination. A total of 61 patients (25 males and 36 females, mean age of 63 years old) were included in the current study following the exclusion of patients who did not comply with the 6 months follow up. All 61 patients underwent a cervical spine SPECT/CT examination, and 39 of these 61 patients received percutaneous injection therapy (Figure 2).

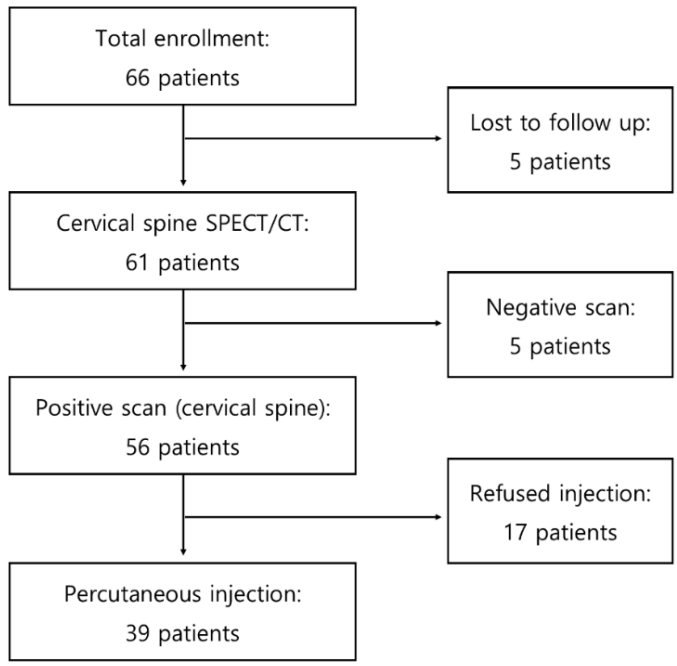

Fig. 2. Study flowchart

Findings of SPECT/CT

Of the 61 patients, 56 (91.8%) had increased radiotracer uptakes in the cervical spine, which were considered as the source of axial neck pain. 20 of 61 (32.8%) patients had increased uptake in areas outside the cervical spine, such as the acromioclavicular joints and the glenohumeral joints, including 2 of 5 patients who had no increased uptakes in the cervical spines. As a result, only 3 patients were left with a completely negative scan (no increased radiotracer uptake across the entirety of the examined field).

The distribution of increased radiotracer uptakes in the cervical spine is described in Figure 3. After the stratification into three groups by the location of highest radiotracer uptake, it was found that patients with the highest uptake in the facet joints were significantly older than patients in the other two groups (p=0.001 in one-way ANOVA test) (Table 2). According to the pain maps of the three different groups, patients with increased uptake in the endplates tended to have more pain in the interscapular and trapezius area, compared to the patients with increased uptake in other sites. (Figure 4).

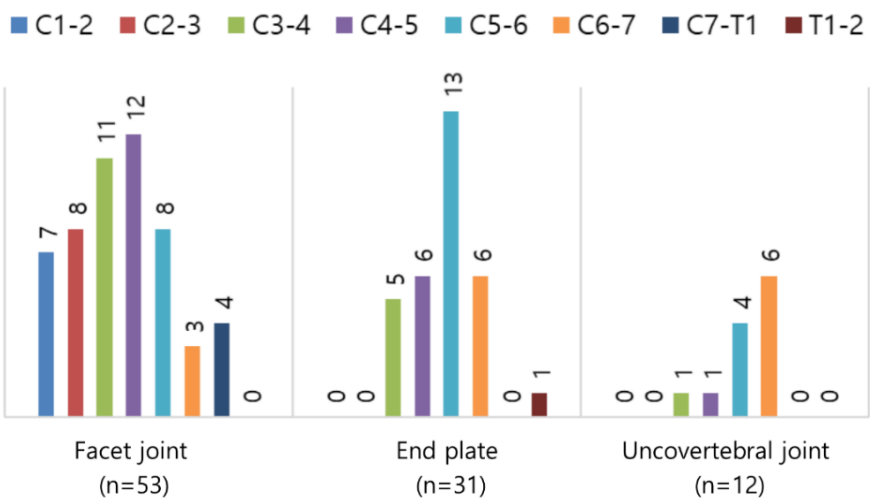

Fig. 3. Distribution of increased radiotracer uptakes in SPECT/CT.

(The numbers above the bars indicate the number of levels with increased radiotracer uptake.)

	Facet joint	Endplate	Uncoverte-bral joint	p-value
Patients (n)	28	22	6	
Age (years)	70.6±9.2	56.7±6.6	56.4±12.9	0.001*
Sex (M:F)	10:18	10:12	2:4	0.732**
Body mass index	23.1±2.2	23.7±3.9	23.4±1.4	0.355*

Values of age and body mass index are described as mean ± standard deviation.

* p-value derived from one-way ANOVA with post hoc Tukey test.

** p-value derived from Fisher exact test (two-tailed).

Table 2. Demographic data of three groups stratified by the location of the highest radiotracer uptake in SPECT/CT

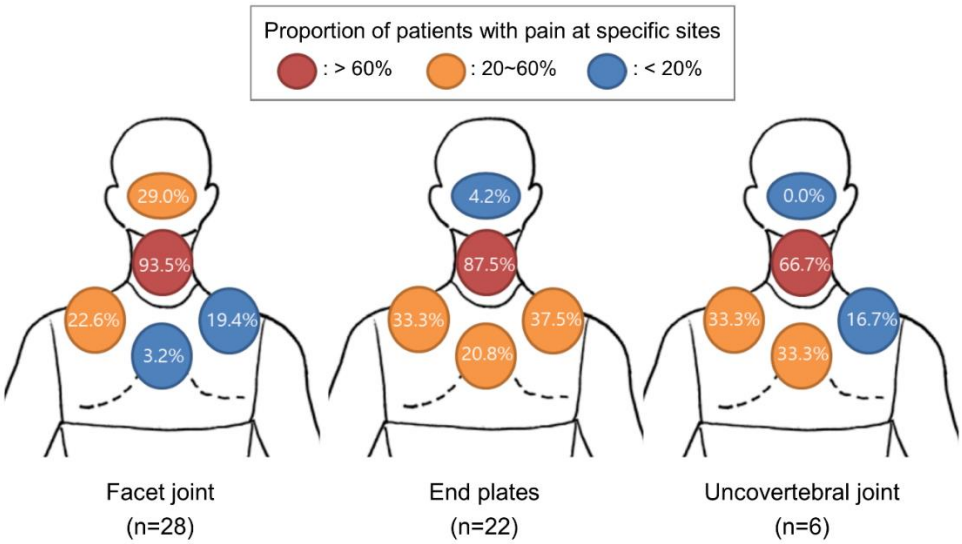

Fig. 4. Pain maps stratified by the highest radiotracer uptake.

(The numbers in the circles indicate the proportion of patients presenting with pain at respective regions.)

Percutaneous injection therapy

Of the 56 patients with increased radiotracer uptake in the cervical spine, 39 received one of three types of percutaneous injection therapy: 1) 18 intraarticular facet joint injections, 2) 15 intradiscal injections and 3) 6 interlaminar epidural injections. (Figure 5) All interlaminar epidural injections were administered through the C6–7 interlaminar space. Besides the two patients who received facet joint injections at two separate levels with equivalent radiotracer uptakes on SPECT/CT, all other patients received an injection at a single level with the highest uptake. All study patients received injection therapy for only once during the study period of 6 months. No complication associated with the injection therapy was reported during the study period.

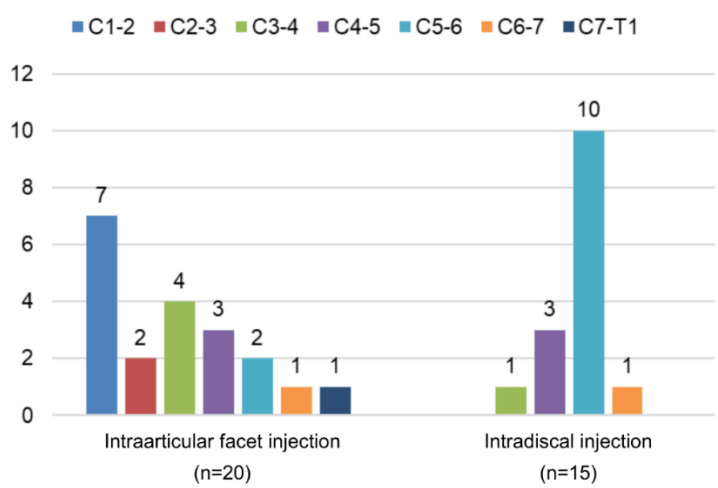

Fig. 5. Levels of percutaneous injection therapy.

Outcome assessment

For all 39 patients who received percutaneous injection therapy, the average pain VAS before treatment (6.90 ± 0.85, mean ± standard deviation) showed statistically significant improvement at 6 weeks (3.38 ± 2.16, p=0.001) and 6 months (4.41 ± 2.09, p=0.001) after the injection. However, the average pain VAS at 6 months after the injection was significantly higher than the pain VAS at 6 weeks post-injection (p=0.001). The proportion of responders (patients with more than 50% improvement of pain VAS) at 6 weeks and 6 months after injection were 51.3% (20/39) and 25.6% (10/39), respectively. When stratified by the location of highest uptake in SPECT/CT and the corresponding methods of injection therapy, the changes of pain scales over time between groups did not show a significant difference in repeated measures ANOVA test (p=0.895) (Figure 6). The proportion of responders were also not statistically different between the stratified groups (Figure 7).

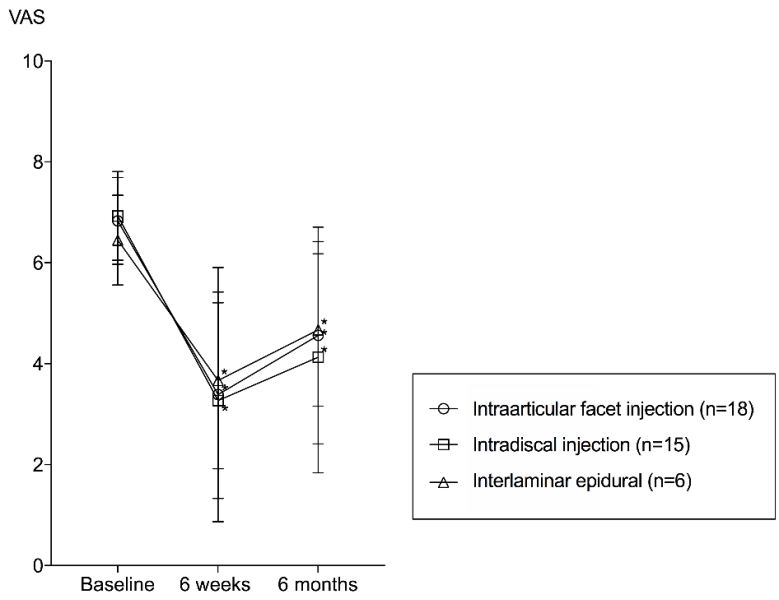

Fig. 6. Changes of pain scales following injection therapy.

(The error bars represent the standard deviation of measurements.
*p<0.05 in intragroup comparison of pain scales at baseline, 6 weeks and 6 months following injection therapy.)

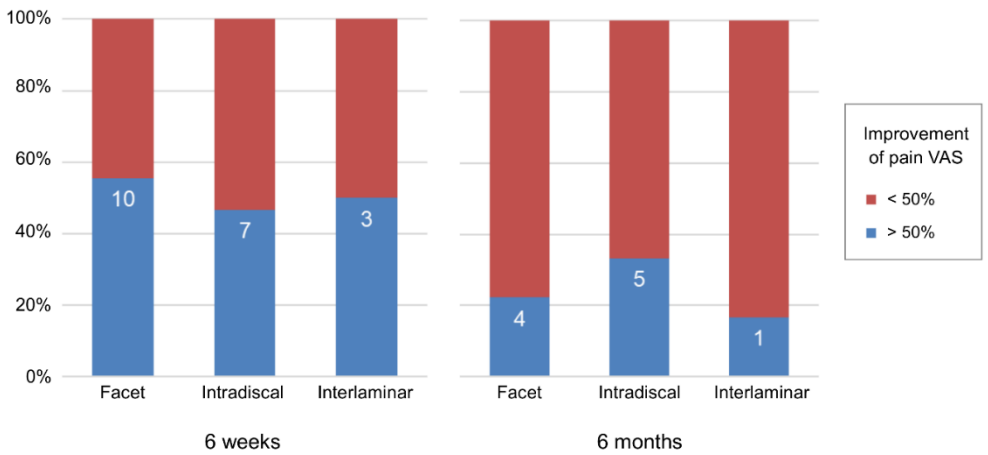

Fig. 7. Proportion of responders following injection therapy.

(The numbers in the bars indicate number of responders.)

Discussion

Study design and inclusion criteria

In daily practice, spine specialists frequently encounter patients who have chronic axial neck pain with no definitive evidence of the anatomical source. In general, these patients have not undergone recent diagnostic radiologic examinations including CT and MRI or have no conclusive findings on such tests to determine the anatomical source. Additional diagnostic measures would be required for these patients to identify the origin of pain and further treatment. The objective of the current study was to evaluate the clinical value of SPECT/CT in the diagnosis and treatment of these clinically difficult patients.

Localization of the anatomical source of axial neck pain

Previous literature examined various non-invasive measures, including structural imaging studies and physical examinations, for the diagnosis of chronic axial neck pain, but the results were both inaccurate and unreliable [16-18]. Methods utilizing fluoroscopy assisted percutaneous injections, such as controlled comparative local anesthetic block and provocation discography, are often considered as diagnostically adequate in cervical degenerative

diseases [33, 34]. However, these methods are invasive, and therefore their use is limited as a screening tool. Furthermore, a previous study has shown that a large subset of patients is still left without a definitive diagnosis even after these invasive diagnostic tests [10]. Therefore, as an alternative, non-invasive functional imaging can be considered useful for the identification of the pain source in patients with chronic axial neck pain.

Few previous studies have utilized the SPECT or SPECT/CT to localize the source of pain in chronic axial neck pain [22, 25]. In these studies, pain generator was identified in 81~92% of the patients, with facet joint being the most common site of increased radiotracer uptake (37.5-52.0%). These findings are similar to those of the current study, where the pain generator was identified in 91.8%, and facet joint was the most common site of the highest radiotracer uptake (50.0%). Prevalence of the pain source identified by SPECT/CT in this study is also comparable to those of previous studies, in which the pain generator was identified using other diagnostic measures including invasive methods, such as controlled comparative local anesthetic block and provocative discography [10-13].

Value of SPECT/CT in the cervical facet joint pain

Several previous studies have examined the role of SPECT in the prediction of outcomes following percutaneous injection therapy, most reporting a favorable outcome of injection therapy in SPECT positive patients [27–29, 31]. Some studies also suggested that the high sensitivity and negative predictive value of SPECT examination can reduce the number of unnecessary injections [26, 28, 29]. However, these studies focused only on the lumbar facet arthroplasty and used SPECT and not SPECT/CT, except for a single study which examined SPECT/CT in the lumbar spine [29]. In 2013, a study by Matar reported that 8 out of 13 patients who were diagnosed with cervical facet joint arthropathy by SPECT/CT received steroid injections [22], but did not describe the procedure specifically or evaluate the effectiveness of these interventions. To the best of my knowledge, the current study is the first to evaluate the efficacy of percutaneous injection therapy based on the results of cervical spine SPECT/CT.

However, a limitation of the current study in assessing the clinical effectiveness of SPECT/CT is the absence of a control group. This study did not compare the outcome of injection therapy between the SPECT/CT–positive and negative patients. In the current study, an

injection therapy was not considered in the SPECT/CT-negative patients, because these patients failed to have the source of pain localized. Applying injection therapy to these patients was not feasible and considered unethical. The current study also did not compare the outcomes between the patients who received an injection and those who received other conservative treatments after the SPECT/CT examination. Since the short-term benefit of injection therapy has been highlighted in previous literature [34, 35], a comparison of the outcomes of injection therapy and other treatment in the SPECT/CT-positive patients was considered unnecessary.

As an alternative, to assess the effectiveness of percutaneous injection therapy in the SPECT/CT positive patients, the results of this study can be indirectly compared to other previously published studies on cervical injection therapy not utilizing SPECT/CT, but invasive methods such as diagnostic controlled comparative block for the localization. Most recently, Lim et al. conducted a prospective, randomized study comparing intraarticular pulsed radiofrequency and intraarticular corticosteroid injection for the management of cervical facet joint pain [36]. The study reported that 20 patients who received intraarticular cervical facet joint injection showed 70.7% and 58.6% pain reduction at one-, 6 months post-injection, respectively. The study also reported that 60.0% of patients showed

more than 50% of pain reduction at 6 months after injection, which is better than the results of the current study (Figure 6). A low response rate in the current study can be the result of a high false positive rate of the SPECT/CT and detection rate of 91.2% by the SPECT/CT can be an overestimation. Therefore, prospective randomized controlled trials with high quality comparing the outcomes of injection therapy following the localization by SPECT/CT and diagnostic controlled comparative block are required for more clarity on the clinical usefulness of SPECT/CT in guiding the therapeutic facet joint injections.

An intraarticular facet joint injection was applied rather than the medial branch block as the treatment for the patients with the highest uptake in the cervical facet joint in this study. Since SPECT/CT detects synovial joint inflammation [37, 38] and the intraarticular corticosteroid injection reduces synovial joint inflammation [39], the intraarticular injection seemed to be more appropriate for the treatment of the SPECT-positive patients. In the same context, a randomized double-blind clinical trial comparing the intraarticular and medial branch nerve blocks in patients with positive lumbar facet joint SPECT imaging reported that the intraarticular group showed a significantly higher percentage of pain relief and disability reduction [30].

Value of SPECT/CT in the cervical discogenic pain

Regarding the 15 patients who received a therapeutic intradiscal injection on the level with highest radiotracer uptake in SPECT/CT, only one patient had discordant provocation during the discography, suggesting the high sensitivity of SPECT/CT on discogenic pain (Table 3). Because the diagnostic discography was not performed according to the recommended guidelines, such as International Association for the Study of Pain (IASP) criteria, and discography was not performed in SPECT/CT−negative patients, other predictive values of SPECT/CT in diagnosing the discogenic pain cannot be derived. To the best of my knowledge, there are no studies on the predictive value of SPECT/CT for the identification of cervical discogenic pain that used diagnostic provocative discography with proper standards, such as the IASP criteria; future studies on this subject are necessary.

Pain concordance	Pain scales (mean ± standard deviation)		
	Baseline	6 weeks	6 months
Concordance* (n=9)	6.89 ± 1.05	2.67 ± 2.18	3.11 ± 2.32
Partial concordance** (n=5)	7.00 ± 0.71	3.80 ± 0.84	5.80 ± 1.30
Discordance*** (n=1)	7.2	6.1	5.2
All (n=15)	6.93 ± 0.88	3.27 ± 1.94	4.13 ± 2.29

*Provoked pain covers the same area of the patient's usual pain

**Provoked pain partially covers the area of the patient's usual pain

***Pain provoked in a different area compared to the patient's usual pain

Table 3. Pain provocation and change of pain scale following intradiscal injection

Value of SPECT/CT in the uncovertebral joint pain

According to cadaveric studies, an uncovertebral joint of the cervical spine is a synovial joint and possesses somatic and autonomic nerve endings, and therefore, can be considered as the pain generator in the cervical spine [40]. However, limited evidence is present regarding the clinical significance of uncovertebral joint

degeneration in patients with chronic axial neck pain. Furthermore, evidence on the clinical effectiveness of interlaminar epidural steroid injections in these patients (axial neck pain without disc herniation and radiculopathy) is even more scare [41]. In this study, 6 patients had the highest radiotracer uptake in the uncovertebral joints on SPECT/CT examination and showed similar clinical results following the interlaminar epidural injection when compared to other injection groups. This result can suggest that SPECT/CT can be used in the diagnosis of the axial neck pain originated from the uncovertebral joint and the guidance for further treatment. However, because of the small sample size and the limited study design of the study, a statistically significant and meaningful result cannot be elicited from the current study.

Limitations

This study has several limitations. First, the current study didn't utilize the diagnostic injection such as controlled comparative facet blocks for facet joint pain, which is considered as the gold-standard diagnostic method in the literature, to evaluate the diagnostic value of SPECT/CT. Second, the current study included patients with no prior cervical spine MRI, which could have been diagnostic and made SPECT/CT unnecessary if present. Third, the sample size for

individual groups is small, particularly for the uncovertebral joint group, which limits the statistical significance. Fourth, additional conservative treatments, besides prescribed medications which were not given, were not controlled during the follow-up period and may have had a confounding effect on pain improvement. Finally, the pain VAS was the only outcome measure following the injection therapy, and the scores of function and disability of the patients were not evaluated. Despite these limitations, the descriptive findings of the current study provide a new perspective on the clinical usefulness of SPECT/CT in the management of chronic axial neck pain and guidance for the future studies.

Conclusion

SPECT/CT suggested the source of chronic axial neck pain in 91.2% of patients who had no prior conclusive imaging studies. Short-term improvement of axial neck pain was observed after percutaneous injection therapy, guided by SPECT/CT.

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국문 초록

배 경: 만성 축성 목 통증을 유발하는 해부학적 구조물의 위치를 확인하는 것은 해당 환자의 치료에 있어 매우 중요하나, 이전의 여러 연구에서 기존의 비침습적 진단법들은 목 통증의 원인을 진단하는 데에 있어서 일관되지 못한 결과를 보였다. 또한 진단 목적의 주사법들은 침습적이어서 선별 검사로는 그 사용에 제한이 있다. 이에 대한 대안으로서, 단일광자 단층 촬영(single photon emission computed tomography combined with conventional computed tomography, SPECT/CT)은 만성 목 통증의 원인 구조물을 찾고, 적절한 주사 치료 결정에 도움을 줄 수 있는 유용한 비침습적 진단법이 될 수 있다.

대상 및 방법: 본 연구는 6주 이상의 상지 방사통이 없는 만성 축성 목 통증을 호소하는 환자 중에서, 이전의 영상 검사를 통해 정확한 원인 부위를 찾지 못한 61명의 환자를 대상으로 하였다. 상기 환자에서 SPECT/CT 검사를 시행하고, 방사성추적자의 섭취가 가장 많은 부위를 기준으로 세 그룹으로 분류하였다. 그 다음으로 주사 치료에 동의한 환자들을 대상으로 방사선추적자 섭취가 가장 많았던 부위에 세 가지 방법을 통해 경피적 주사 치료를 시행하였다. 시술 전과 6주, 6개월 후의 목 통증 척도(visual analogue scale)의 변화 양상을 분석하였다.

결 과: SPECT/CT 검사 결과를 보았을 때, 61명의 환자 중 56(91.8%)명에서 경추에 방사성추적자의 섭취 증가가 관찰되었다. 가장 큰 섭취 증가를 보인 해부학 구조물을 기준으로 환자들을 나누어 보면, 1) 후관절(facet joint)이 28명(50.0%), 2) 종판(endplate)이 22명 (39.3%), 3)

구추관절(uncovertebral joint)이 6명 (10.7%)의 비율을 보였다. SPECT/CT 검사에서 경추에 방사성추적자 섭취 증가를 보인 56명의 환자 중에 39명이 경피적 주사 치료를 시행 받았다. 후관절 관절내 주사를 받은 환자가 18명, 추간판내 주사 치료를 받은 환자가 15명, 마지막으로 추궁간 경막외 주사 치료를 받은 환자는 6명이었다. 주사 치료를 시행 받은 39명의 환자 전체의 평균 통증은 치료 전 6.90±0.85 (평균±표준편차)에서 치료 후 6주째에 3.38±2.16, 6개월째에 4.41±2.09로 통계적으로 유의하게 감소하였다(p=0.001). 치료 후 50% 이상의 통증 호전을 보인 환자의 비율은 치료 후 6주째에 51.3%, 6개월째에는 25.6%로 나타났다.

결 론: 기존의 영상 검사를 통해 원인 부위가 진단되지 않았던 만성 축성 목 통증 환자의 91.2%에서 단일광자 단층촬영을 통해 그 원인 부위를 확인하였다. 이에 근거하여 경피적 주사 치료를 시행하였을 때, 단기적인 통증 완화 효과가 관찰되었다.

색인 단어: 만성 축성 목 통증; 단일광자 단층촬영; 경피적 주사 치료

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