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MUSCULOSKELETAL IMAGING

ORIGINAL ARTICLE

Increased ^{99m}Tc MDP activity in the costovertebral and costotransverse joints on SPECT-CT: is it predictive of associated back pain or response to percutaneous treatment?

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PURPOSE
Pain related to costovertebral and costotransverse joints is likely an underrecognized and potentially important cause of thoracic back pain. On combined single-photon emission computed tomography and computed tomography (SPECT-CT), increased technetium-99m methylene diphosphonate (99mTc MDP) activity at these articulations is not uncommon. We evaluated whether this activity corresponds with thoracic back pain and whether it predicts response to percutaneous injection.

METHODS
All 99mTc MDP SPECT-CT spine examinations completed at our institution from March 2008 to March 2014 were retrospectively reviewed to identify those with increased 99mTc MDP activity in the costovertebral or costotransverse joints. The presence of corresponding thoracic back pain, percutaneous injection performed at the relevant joint(s), and response to injection were recorded.

RESULTS
A total of 724 99mTc MDP SPECT-CT examinations were identified. Increased 99mTc MDP activity at costovertebral or costotransverse joints was reported in the examinations of 55 patients (8%). Of these, 25 (45%) had corresponding thoracic back pain, and nine of 25 patients (36%) underwent percutaneous injection of the joint(s) with increased activity. At clinical follow-up two days to 12 weeks after injection, one patient (11%) had complete pain relief, two (22%) had partial pain relief, and six (67%) had no pain relief.

CONCLUSION
The findings suggest that increased activity in costovertebral and costotransverse joints on 99mTc MDP SPECT-CT is only variably associated with the presence and location of thoracic back pain; it does not predict pain response to percutaneous injection.

Back pain is a prevalent and costly medical problem in the United States that often presents a diagnostic and therapeutic challenge (1). In the thoracic spine, many potential pain generators exist, and the source of pain is frequently difficult to determine. Two of these potentially underrecognized pain generators are the costovertebral and costotransverse joints.

Approximately 9% of technetium-99m methylene diphosphonate (^{99m}Tc MDP) single-photon emission computed tomography (SPECT) combined with computed tomography (CT) studies ordered for an indication of back pain show increased ^{99m}Tc MDP activity at costovertebral or costotransverse joints (2). The relationship of ^{99m}Tc MDP activity to pain and the utility in directing percutaneous injection seems to vary at different sites throughout the axial skeleton (2). Therefore, it is important to evaluate each articulation independently. Several studies have evaluated the utility of ^{99m}Tc MDP activity at facet joints (2–6), at sacroiliac joints (7), and in the pars interarticularis (8, 9), but the utility of this activity in the costovertebral and costotransverse joints needs further study. We evaluated whether increased ^{99m}Tc MDP activity at the costovertebral and costotransverse joints corresponds with thoracic back pain and whether it predicts response to percutaneous injection.

Methods

Patient identification and retrospective clinical evaluation

Institutional review board approval was obtained for this Health Insurance Portability and Accountability Act–compliant study. All ^{99m}Tc MDP SPECT-CT reports completed at our

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institution between March 2008 and March 2014 were retrospectively reviewed. All examinations in which the interpreting nuclear medicine physician reported increased activity within one or multiple costovertebral or costotransverse joints were identified and the joints with reported increased activity were documented.

The subset of patients with these examinations was further evaluated to determine whether there was corresponding thoracic back pain. Corresponding thoracic back pain was defined as ipsilateral or midline pain within two vertebral levels of the costovertebral or costotransverse joints that had increased ^{99m}Tc MDP activity (e.g., from T7–T11 for the T9 joints). The level of each patient's back pain was determined by reviewing the electronically documented history and physical examination of the physician who ordered the ^{99m}Tc MDP SPECT-CT study, typically a pain specialist.

Patients who underwent percutaneous image-guided injections of costovertebral or costotransverse joints that had increased ^{99m}Tc MDP activity were identified. Patients who had injections at joints different from those that had ^{99m}Tc MDP activity were excluded from further analysis. The interval between the ^{99m}Tc MDP SPECT-CT examination and the injection was determined. Administration of anesthetic as part of the injection was confirmed for each patient. The type and dose of corticosteroid, when administered, and the joints into which it was injected were recorded.

Because percutaneous treatment of these joints is relatively uncommon, uniform follow-up with a visual analog scale (VAS) pain score (0–10) at standardized postinjection times was not available. Clinical response had been recorded in the electronic medical record on a VAS, by percentage pain relief, or with completely subjective terminology (e.g., moderately improved). Therefore, the response documented in the clinical notes by the ordering clinician was stratified into four categories: 1) complete relief, 2) near-complete relief, 3) partial relief, and 4) no relief or increased pain. Complete relief was defined as a VAS of zero, 100% pain relief, or a subjective documentation of complete resolution of pain. Near-complete relief was defined as a VAS of 1, 80% or greater pain relief, or a subjective documentation of near-complete resolution of pain. Partial relief was defined as any degree of decrease of VAS greater than 1, 1%–79% pain relief, or a subjective documentation of mild or moderate pain relief. No relief or increased pain was defined as a VAS equal to or more than the initial VAS, 0% pain relief, or subjective documentation of no pain improvement or worsened pain.

The above-described responses were determined immediately after injection when available and between two days and 12 weeks after injection. The interval between the injection and postinjection clinical follow-up was recorded. If multiple clinical follow-up evaluations occurred during the follow-up interval, the first available follow-up was used to evaluate response to injection.

In patients with thoracic back pain corresponding to costovertebral or costotransverse joints with ^{99m}Tc MDP activity, whether or not an injection was performed, the ^{99m}Tc MDP SPECT-CT reports were reviewed to determine whether any potential alternative pain generators were present. Potential alternative pain generators were defined as being present if there were any additional areas of ipsilateral or midline increased ^{99m}Tc bone tracer activity described in the spine within two vertebral levels of the costovertebral or costotransverse joints that had ^{99m}Tc MDP activity. Areas of increased contralateral activity were excluded as potential alternative pain generators because referred pain in the spine is unlikely to arise from a contralateral pain generator (10). Percutaneous injection of potential alternative pain generators during the interval between the injection and postinjection clinical follow-up, if present, was also documented.

^{99m}Tc MDP SPECT-CT parameters

SPECT-CT examinations of the spine were performed 3–4 hours after injection of 740 MBq (±10%) ^{99m}Tc MDP. Examinations were all performed on either a 6-slice or 16-slice Precedence scanner (SKYLight SPECT system with a Brilliance CT scanner; Philips Healthcare). SPECT parameters were as follows: 128×128-word mode matrix, 64 views at 20 seconds per view, 1.46 zoom factor, step and shoot angular step of 3, body contouring, and low-energy all-purpose collimator. CT parameters were as follows: 120 kVp, 60 mAs per slice, 3 mm slice thickness, and 3 mm increments. The extent of coverage of the spine is variable at our institution and is tailored to each specific case. The area of pain was covered in all patients, but some patients had coverage of only a portion of the thoracic spine.

Main points

- Costovertebral and costotransverse joints are potential pain generators in the thoracic spine.
- ^{99m}Tc MDP activity at the costovertebral and costotransverse joints on SPECT-CT is not uncommon.
- ^{99m}Tc MDP activity at the costovertebral and costotransverse joints on SPECT-CT is not highly predictive of corresponding pain.
- Even if corresponding pain is present, pain often does not improve and only infrequently resolves or nearly resolves following percutaneous injection.

Results

A total of 724 ^{99m}Tc MDP SPECT-CT examinations were performed at our institution between March 2008 and March 2014. Increased ^{99m}Tc MDP activity at costovertebral or costotransverse joints was reported on 55 (8%) of these examinations (35 involving a single joint, seven with multiple joints unilaterally, and 13 with multiple joints bilaterally). Of 55 patients, 25 (45%) had corresponding thoracic back pain, and 11 of these 25 (44%) proceeded to percutaneous injection. Two of these 11 patients were excluded from the analysis because they underwent percutaneous injection of different joints than those that had increased ^{99m}Tc MDP activity. Despite having corresponding thoracic back pain, these patients received injections at different joints than those with reported increased activity on the SPECT-CT scan because their location of maximal pain was clinically thought to be at a different anatomic location than the joints with increased ^{99m}Tc MDP activity on SPECT-CT. Given these two exclusions, only nine of 25 patients (36%) with increased activity at costovertebral or costotransverse joints and corresponding thoracic back pain went on to receive percutaneous injection of costovertebral or costotransverse joints with increased activity (Table).

Of nine patients who had injection, five (56%) were female; mean age was 45 years (range, 17–76 years). A total of 14 costovertebral and costotransverse joints had injections, ranging from one to three per patient. Of the 14 injections, 10 (71%) were

Table. Characteristics of nine patients who had increased ^{99m}Tc-MDP activity and underwent percutaneous injection

Case	Sex, Age (years)	Joints with ^{99m}Tc MDP activity	Joints injected	Days between SPECT-CT and injection	Immediate response[a]	Pain improvement	Days between injection and follow-up	Alternative pain generator
1	M, 51	Right T6 costovertebral	Right T6 costovertebral	4	NA	No	49	Yes
2	F, 76	Left T11 and T12 costovertebral	Left T11-12 costovertebral	7	0/10 pre, 0/10 post	No	40	Yes
3	F, 43	Right T1 costotransverse, left costotransverse T9-10	Right T1 costotransverse	13	NA	Yes	49	Yes
4	M, 63	Right T10-12 costovertebral	Right T10-11 costovertebral	25	NA	Yes	34	Yes
5	M, 36	Left T12 costotransverse	Left T12 costotransverse	14	7/10 pre, 2/10 post	No	21	Yes
6	F, 38	Right T9 costotransverse, bilateral T11 costovertebral	Bilateral T11 costovertebral	10	NA	No	10	No
7	F, 17	Left T11 costovertebral	Left T11 costotransverse	3	5/10 pre, 5/10 post	No	19	No
8	F, 23	Left T9 costovertebral	Left T9 costotransverse	4	7/10 pre, 4/10 post	Yes	2	No
9	M, 57	Multiple bilateral costovertebral	Left T7-T9 costotransverse	1	3/10 pre, 0/10 post	No	16	Yes

^{99m}Tc MDP, technetium-99m methylene diphosphonate; SPECT-CT, single-photon emission computed tomography-computed tomography; M, male; NA, not applicable; F, female; pre, pre-injection; post, post-injection.
[a]Visual analog scale pain score (0–10) immediately before and after injection.

performed in the lower third of the thoracic spine (T9–T12). Injections were performed by either a neuroskeletal or musculoskeletal fellowship-trained radiologist or another interventional pain physician. With the exception of a single injection that was performed for diagnostic purposes with local anesthetic only (case 8), all injections included a combination of local anesthetic and corticosteroid. Corticosteroid types and doses used were variable and included betamethasone (n=7; dose range, 2–6 mg per joint), dexamethasone (n=1; dose, 4 mg per joint), and triamcinolone (n=5; dose range, 10–20 mg per joint). Injections were performed under CT (n=5), fluoroscopic (n=8), or combined dynaCT-fluoroscopic guidance (n=1). The mean interval between the ^{99m}Tc MDP SPECT-CT examination and the injection was 12 days (range, 1–25 days). At clinical follow-up between two days and 12 weeks after injection, one patient (11%) had complete pain relief, two (22%) had partial pain relief, and six (67%) had no pain relief or increased pain. The patient with complete pain relief (case 8) was the only patient to receive anesthetic only. This patient was assessed two days after the injection, at which time she underwent resection of the left ninth rib head and associated joints. Therefore, none of the eight patients who received percutaneous anesthetic and corticosteroid injection as the primary treatment of presumptively painful costovertebral or costotransverse joints had complete or near-complete pain relief.

Potential alternative pain generators were present in 17 of 25 patients (68%) with increased ^{99m}Tc MDP activity at costovertebral or costotransverse joints and corresponding thoracic back pain. They were present in six of nine patients (67%) with corresponding thoracic back pain who received injections of costovertebral or costotransverse joint(s) with increased ^{99m}Tc MDP activity. Of six patients who underwent injection and had potential alternative pain generators present, two (33%) had partial pain relief and the others had no relief. Of three patients who underwent injection but did not have potential alternative pain generators present, one (33%) had complete relief and the others had no relief. None of the patients with potential alternative pain generators present underwent percutaneous injection of any of those potential alternative pain generators during the interval between the costovertebral or costotransverse joint injections and postinjection clinical follow-up.

Examples of ^{99m}Tc MDP SPECT-CT images from select patients are shown in Fig. 1–3.

Discussion

The results of this study suggest that ^{99m}Tc MDP activity at the costovertebral and costotransverse joints on SPECT-CT is not highly predictive of pain or positive response to percutaneous injection. Patients may have corresponding thoracic back pain, but more than half in this study did not. In patients with corresponding pain, the utility of targeting these joints for percutaneous injection is questionable. In this study, pain often did not improve and only infrequently resolved or nearly resolved. These results are important because there is little to no prior report in the English literature of the utility of ^{99m}Tc MDP activity for direction of percutaneous injection of the costovertebral and costotransverse joints. With increasing use of combined imaging such as SPECT-CT, specific localization of activity to these articulations may become more common. Therefore, it is important to retrospectively study and report these findings to help establish the prevalence and significance of ^{99m}Tc MDP activity at these joints.

^{99m}Tc MDP SPECT is often performed for the purpose of identifying the cause of back pain, but its utility in degenerative conditions remains unclear (11). Previous reports addressing the significance of SPECT-CT ac-

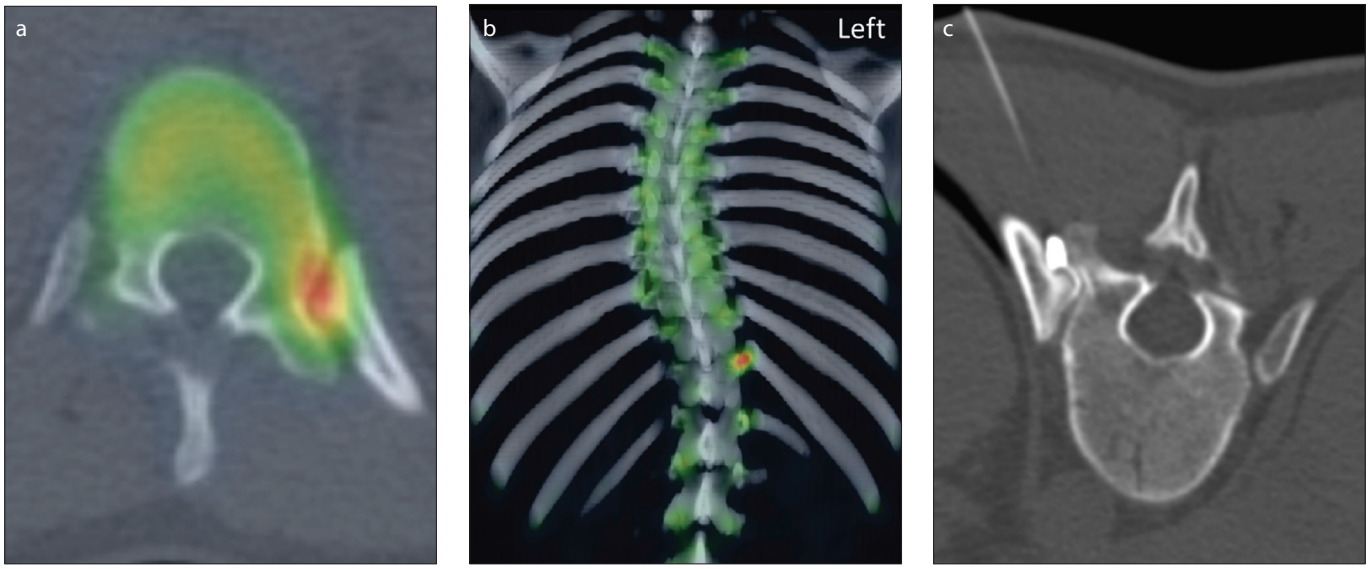

Figure 1. a–c. SPECT-CT images of a 17-year-old girl (case 7) with left lower thoracic back pain and increased technetium-99m methylene diphosphonate (^{99m}Tc MDP) activity. Panel **(a)** shows increased bone tracer activity at the left 11th costovertebral joint. Posterior volume-rendered reformatted image **(b)** shows that no alternative pain generator with increased ^{99m}Tc MDP activity is present. Note the presence of scoliosis without associated increased ^{99m}Tc MDP activity. The joint was injected with 4.5 mg betamethasone and local anesthetic **(c)**. The patient had no pain relief after injection.

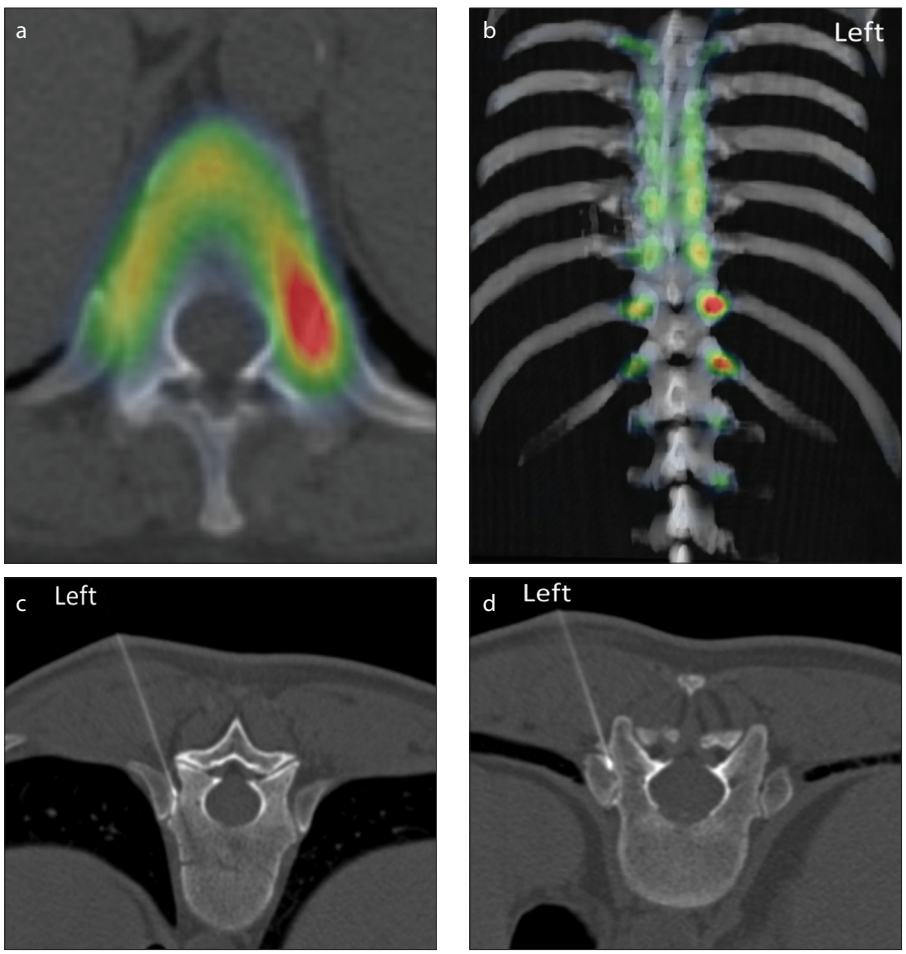

Figure 2. a–d. SPECT-CT images of a 76-year-old woman (case 2) with left lower thoracic back pain and increased ^{99m}Tc MDP activity. Panel **(a)** shows increased bone tracer activity at the left 11th and 12th (not shown) costovertebral joints. Posterior volume-rendered reformatted image **(b)** shows increased activity relative to the adjacent costovertebral joints. An alternative pain generator was present at the left L2 facet (not shown). The left 11th **(c)** and 12th **(d)** costovertebral joints were each injected with 3 mg of betamethasone and local anesthetic.
The patient had no pain relief after injection.

tivity in the costovertebral and costotransverse joints are limited, but studies have been performed to evaluate the significance of radiotracer activity in facet joints. Prior studies suggest that injection of facet joints with increased ^{99m}Tc MDP activity results in clinical improvement (3, 6, 12). However, a recent study by Lehman et al. (13) found that facet joints targeted for injection often differ from those with reported activity on ^{99m}Tc MDP SPECT-CT. This discrepancy occurred most commonly because pain was not clinically thought to correspond with the anatomic location of activity on the ^{99m}Tc MDP SPECT-CT study. The same phenomenon was present in our study, in which two patients were excluded because they received injections at different levels than those at which increased activity was reported. This approach calls into question the effectiveness of ^{99m}Tc MDP SPECT-CT versus clinical examination in determining potential injection targets.

Degenerative changes of the costovertebral joints are present in approximately half of all people on postmortem examination (14). They may be asymptomatic in most instances, but there are numerous reports of both localized pain (15, 16) and referred patterns such as chest pain (17). Indeed, pain reduction with administration of local anesthetic and corticosteroid as a criterion to direct resection arthroplasty of these joints has been reported (15). Additionally, pain related to these joints reportedly can

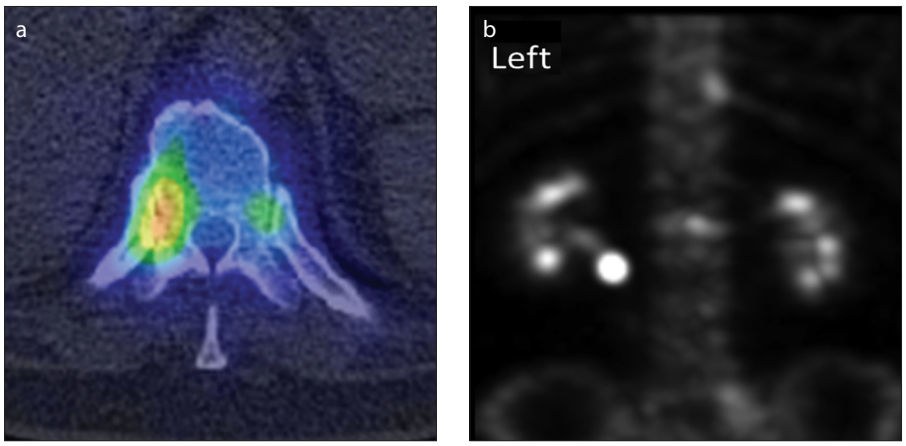

Figure 3. a, b. SPECT-CT images of a 68-year-old man with low back pain and increased ^{99m}Tc MDP activity. Panel **(a)** shows increased bone tracer activity at the right 10th costovertebral joint. The patient had midline tenderness in the lumbar spine, but no pain corresponding to the right 10th costovertebral joint. Panel **(b)** shows additional areas of increased activity including an L1-L2 anterior osteophyte and the left L5-S1 facet joint. The right 10th costovertebral joint did not undergo injection.

be present in the absence of anatomic degenerative changes (18). Identification of both an imaging marker of this pain and effective minimally invasive treatment is desirable. Physiologic imaging markers such as ^{99m}Tc MDP are attractive prospects because they may identify joints with inflammation, and presumably associated pain, that could in principle be ameliorated with local anti-inflammatory medication.

Our study was small—only 55 patients had increased costovertebral or costotransverse joint ^{99m}Tc MDP activity and nine patients received injection to joints with increased activity. The small study size precluded formal statistical analysis. Despite this limitation, the likelihood of having such a high rate of nonresponders or partial responders purely by chance seems remote. Only one of nine patients (11%) had a complete or near-complete response, which is less than the reported placebo rate for a single diagnostic facet joint anesthetic block (19). Our results question the utility of ^{99m}Tc MDP activity to direct percutaneous injection of costovertebral or costotransverse joints. If percutaneous injection is performed, the results of this study suggest a high rate of success is unlikely.

Our study has other limitations. Many of the patients in the study had potential alternative pain generators present, defined as nearby additional areas of increased ^{99m}Tc MDP activity. The retrospective design precluded standardization of clinical examinations, follow-up parameters, and treatment doses. The interval between ^{99m}Tc MDP SPECT-CT and percutaneous injection varied. The chronicity of back pain was not addressed. Finally, the definitions of the four categories of responders were arbitrary and included subjective terms of category assignment. However, this categorization should be sufficient to draw general conclusions and distinction between patients with excellent and poor clinical responses to injection.

Our study shows important preliminary findings, but it also indicates the need for further investigation as outlined by the limitations described above. A larger, prospective trial is needed. The ability to control for potential alternative pain generators will remain difficult because of the complexity of back pain and possibility that pain generators exist that do not have imaging manifestations. Future study could also evaluate potential subsets of patients who might respond more favorably to targeted treatment of costovertebral and costotransverse joints with increased ^{99m}Tc MDP activity, based on factors such as chronicity of pain.

In conclusion, our results indicate that ^{99m}Tc MDP activity at the costovertebral and costotransverse joints on SPECT-CT is not highly predictive of corresponding thoracic back pain or positive response to percutaneous injection. Patients may have corresponding thoracic back pain, but more than half did not. When corresponding thoracic back pain was present, there was often no relief with percutaneous injection. Given the retrospective design and small number of patients in the study, future prospective investigation with a larger number of patients is necessary to further define the significance of costovertebral and costotransverse joint ^{99m}Tc MDP activity on SPECT-CT.

Conflict of interest disclosure

The author declared no conflicts of interest.

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