SPINE Volume 19, Number 7, pp 807–811

Thoracic Zygapophyseal Joint Pain Patterns

A Study in Normal Volunteers

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Study Design. Nine asymptomatic volunteers underwent 40 provocative intra-articular injections of the thoracic zygapophyseal joints.

Objective. The purpose of the study was to isolate and stimulate the thoracic zygapophyseal joints via fluoroscopically guided intra-articular injections to determine whether they are potential pain generators.

Summary of Background Data. Experimentally, the cervical and lumbar zygapophyseal joints have been shown to produce pain, and tentative referral patterns have been established. Referral patterns based on stimulation of the thoracic zygapophyseal joints have not been previously reported.

Methods. Four subjects underwent right-sided T3–T4, T5–T6, T7–T8, and T9–T10 joint injections, and four subjects underwent left-sided T4–T5, T6–T7, T8–T9, and T10–T11 joint injections. One subject underwent both the right- and left-sided joint injections. The zygapophyseal joints were injected with contrast medium only, and the quality, intensity, and distribution of evoked pain was recorded.

Results. In this asymptomatic population, 72.5% of joints injected produced a sensation/pain that was different from the sensation of needle advancement through the soft tissues. In 27.5% of joints injected, there was no evoked pain despite adequate capsular distension. Evoked referral patterns were consistent in all subjects. Significant overlap occurred in the referral patterns, with most thoracic regions sharing 3–5 different joint referral zones.

Conclusions. This study provides preliminary confirmation that the thoracic zygapophyseal joints can cause both local and referred pain. A referral pain diagram has been constructed. [Key words: injection, referred pain, thoracic facet joints, thoracic pain, thoracic zygapophyseal joints] **Spine 1994;19:807–811**

Thoracic pain, although less common, can be as disabling as cervical and lumbar pain. The role of the thoracic zygapophyseal joint in thoracic pain syndromes has received little attention because only a few sources discuss these joints as sites of pain production.[4,15,18] Instead, the focus has been on other structures capable of causing thoracic pain: the disc, nerve roots, regional myofascial structures, and the costotransverse and costovertebral joints.[15] The cervical and lumbar zygapophyseal joints have received considerable attention and now are accepted as potential pain generators.[2] The thoracic zygapophyseal joint has not gained equal attention. Previous literature addressing the thoracic zygapophyseal joint has appeared largely in manual medicine or chiropractic texts and journals.[8,9,14]

Experimentally, the cervical and lumbar zygapophyseal joints have been isolated and stimulated via intra-articular joint injections under fluoroscopic guidance.[6,11,13] Such injections cause capsular distention and activate nociceptors, causing local and distal (referred) pain. Furthermore, tentative referral patterns for the cervical and lumbar zygapophyseal joints have been presented based on the results of these injections. Stimulation of the thoracic zygapophyseal joints in a similar manner has not been performed. These joints cannot be assumed to cause pain simply because of similar findings in the cervical and lumbar spine. Furthermore, documentation of a nerve supply (nociception ability) to the joint or capsule is not available in gross or histologic preparations. Based upon preliminary thoracic dissections in humans,[3] the medial branch of the dorsal rami is believed to innervate the joint. Definitive proof of this innervation pattern, however, has been confirmed only in monkeys.[16]

The present study isolated and stimulated the third through tenth thoracic zygapophyseal joints and mapped the referral patterns. It is hoped these referral patterns will initiate further research regarding the thoracic zygapophyseal joints and provide the clinician with useful information complimentary to that available for the cervical and lumbar spine.

Methods

Similar to previous provocative studies in the cervical and lumbar spine,[6,11,13] normal, asymptomatic volunteers were used to eliminate the potential for pain from multiple structures, placebo responses, and confounding psychologic problems. Thus, any pain noted with injection was attributed to the thoracic zygapophyseal joints.

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Accepted for publication October 18, 1993.

Informed consent was obtained from all subjects before injection. Potential risks included allergic reactions to the contrast medium or anesthetic, rupture of the joint capsule, penetration of the needle into the epidural or subarachnoid space with subsequent injection of contrast medium into these spaces, epidural leakage of contrast from intra-articular injection, exposure to radiation, and temporary irritation of the joint, regional muscles, and periosteum.

Nine asymptomatic volunteers, seven men and two women, without history of thoracic pain participated in the study. Their ages ranged from 21–36 with a mean age of 30. Subjects included physicians, chiropractors, a physical therapist, exercise physiologists, and other health professionals involved in the care of those with spinal disorders. They were familiar with the importance of the study and understood the potential risks. At the time of injection, they were unaware of the exact level stimulated.

Four subjects underwent consecutive right-sided T3–T4, T5–T6, T7–T8, and T9–T10 thoracic zygapophyseal joint injections, and four subjects underwent consecutive left-sided T4–T5, T6–T7, T8–T9, and T10–T11 joint injections. Each of these eight subjects had four joints stimulated, for a total of 32 joints. One subject, on separate days, had both the right- and left-sided joints stimulated for a total of eight joint injections. In total, 40 thoracic zygapophyseal joints divided equally over eight separate segmental levels were injected. To minimize the effect of referred pain overlap, every other ipsilateral segment was stimulated.

Injection was performed as previously described.[4] The subject was prone and the appropriate area was prepped with betadine followed by chlorhexidine and alcohol. No sedation or analgesia was provided. Under posterior to anterior fluoroscopy, the target joint was isolated and the skin (point of needle entry) overlying the superior margin of the pedicle below that joint was marked. For example, for the T7/8 joint, the skin overlying the superior margin of the T9 pedicle was marked. A skin wheel was raised with 1.5% lidocaine, and a 25 gauge 3½ inch spinal needle was inserted at approximately a 60° cephalad angle. Higher segments required an approach more tangential to the skin. Using intermittent imaging, the needle was advanced superiorly while a position lateral to the interlaminar zone was maintained, thus minimizing inadvertent epidural or subarachnoid penetration. The needle was directed toward the medial aspect of the joint to facilitate joint entry, because the medial aspect of the joint is located more posterior and superficial.[5] Typically, the needle was advanced 5–6 cm through the soft tissues unless periosteum was contacted first. The C arm then was rotated away from the side being injected until the outline of the joint was clearly visible. This required almost full lateral imaging. Minor rotational changes were made to align the x-ray beam along the plane of the joint. Because the joint is small, at times this was difficult.

With the joint line (lucency) visualized, the needle was directed toward the inferior aspect of the joint through the capsule into the most inferior aspect of the joint where the needle tip abuts the periosteum of the superior articular facet. The joint was injected with contrast medium (Iothalamate meglumine [Conray] Mallinckrodt, St. Louis, MO) under constant imaging. Injection was continued until 1) pain occurred; 2) the joint felt pressurized and no further contrast could be safely injected without potentially rupturing the capsule; or 3) epidural spread was noted.

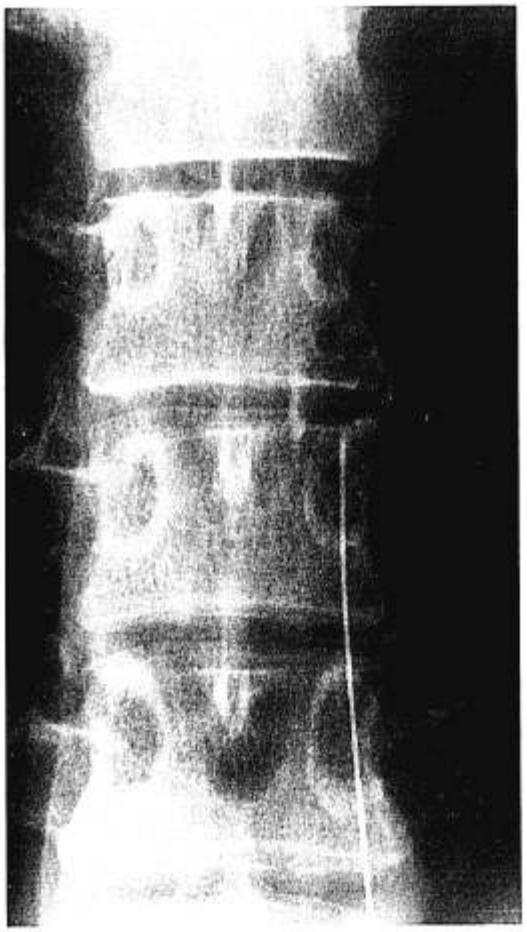

Figure 1. Posterior to anterior radiograph of a thoracic zygapophyseal joint arthrogram.

Subjects were asked to distinguish the sensation produced from the penetration of the needle through skin and muscle from the sensation or pain produced from distention of the joint capsule. No subject had difficulty making this distinction. Once the joint was injected, the subject was asked to report 1) the level of pain/sensation induced on a 0–10 analog pain scale; 2) a description of the pain/sensation induced; and 3) any referred pain. The distribution of pain/sensation produced from the injection was outlined and marked on the skin of the subject by the injectionist via palpation and verbal interaction with the subject. A separate investigator mapped these areas onto a body diagram.

■ Results

No complications occurred in any subject during the study. Penetration into all 40 joints was confirmed by obtaining an arthrogram (Figures 1 and 2). Eleven of 40 joints injected (27.5%) did not produce pain despite adequate capsular distention. At the T6–T7, T7–T8, T8–T9, and T9–T10 joints, two out of five injections produced no sensation with capsular distension. With injection of the T10–T11 joint, three out of five injections produced no sensation with capsular distension. For any one subject, no more than two out of four joints were nonpainful upon injection. The remaining 29

joints produced a pain/sensation described as distinctly different from the sensation noted upon advancement of the needle through the soft tissues. In these joints, pain/sensation was felt within 10 seconds of injection and was most intense upon capsular distention. Most subjects reported a deep, dull ache. Other descriptive terms included "nauseating," "boring," "cramp-like," or similar to delayed muscle soreness. It was difficult for all subjects to define an exact margin of perceived pain. No subject reported pain as sharp, electric, burning, tingling, or localized to a specific point.

On the 0–10 analog pain scale, pain responses ranged from 0 to 7. Excluding the joints that were nonpainful, the mean response for all levels was 3. The mean response, including the 11 joints without painful responses, was 2.2. The segmental mean response for all joint injections was 3.1 for T3–T4, 3.8 for T4–T5, 2.0 for T5–T6, 2.7 for T6–T7, 1.3 for T7–T8, 1.4 for T8–T9, 2.0 for T9–T10, and 1.6 for T10–T11. Thus, there was a slight trend for the more cephalad joints to be more painful. Furthermore, only the three most cephalad joints (T3–T4, T4–T5, and T5–T6) produced painful responses upon joint injection in each case.

Twenty-seven joints held 0.4 ml, 11 held 0.5 ml, and 2 held 0.6 ml of contrast medium. In two of 40 joint injections, epidural spread occurred. Upon this observation, injection was immediately discontinued. Evoked referral patterns were consistent in all subjects for each joint studied. No subject was privy to the referral patterns of the previous subjects.

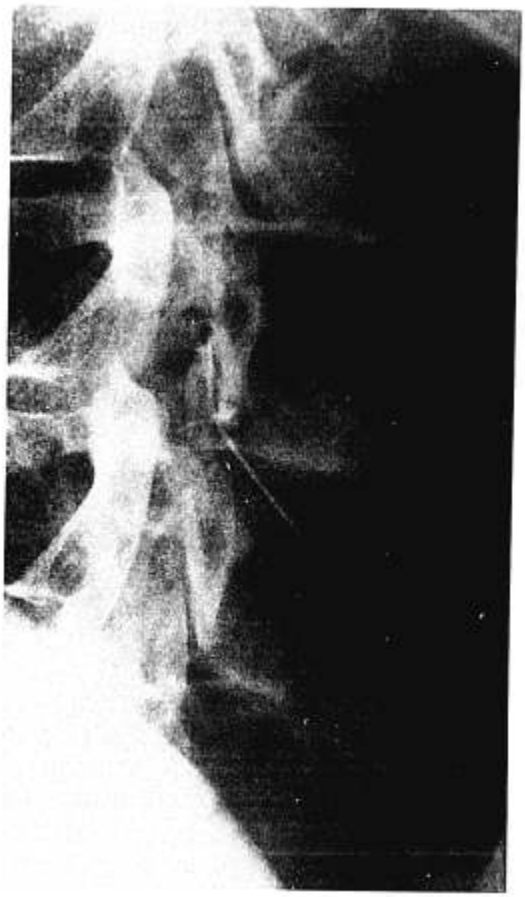

Figure 2. Lateral radiograph of thoracic zygapophyseal joint arthrogram. The needle is placed in the inferior aspect of the joint.

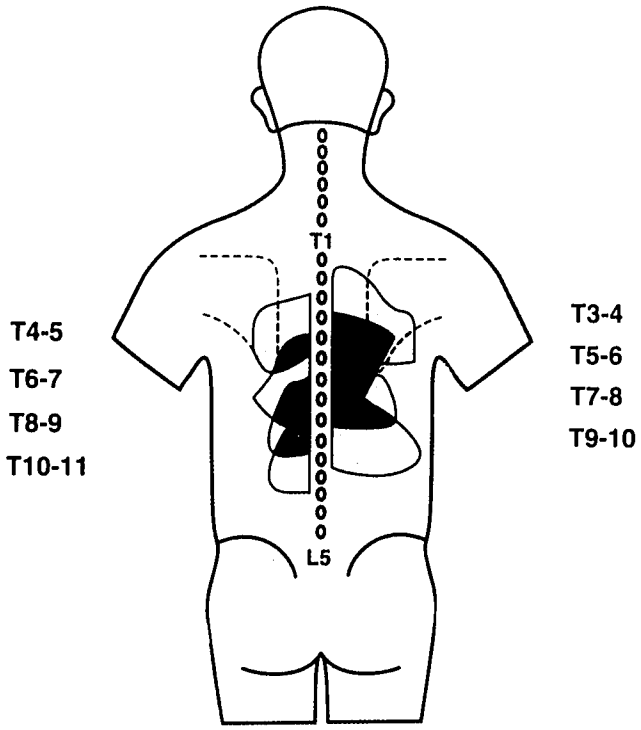

Figure 3. A composite map of the results in all volunteers showing referral patterns from the T3–T4 to T10–T11 thoracic zygapophyseal joints.

In all subjects, each joint caused the most intense area of evoked pain one segment inferior and slightly lateral to the joint injected. No joint referred pain more superior than one-half the vertical height of that vertebral segment. All joints referred pain inferiorly and all joint injections caused unilateral pain only (Figure 3). Referral zones approached but did not cross midline. No midline pain occurred in isolation. The more inferior and lateral the referral zone extended, the less intense the evoked pain. Maximum inferior referral was 2.5 segments, whereas maximum lateral referral approached but did not reach the posterior axillary line (Figure 3). Radicular pain or pain evoked in the anterior or lateral chest wall was not seen. Nevertheless, two subjects reported interesting referral patterns. In one subject, upon a T3–T4 joint injection, pain was produced in the back, but it also was stated that "pain went into my lung behind my sternum." In another subject, upon a T4–T5 injection, pain was evoked in the back, but the subject also stated that pain "like a quarter-sized cylinder went toward my breast bone."

Significant overlap of the evoked referral patterns occurred with most regions lateral to the spine, encompassing three and up to five shared joint referral zones

(Figure 3). Essentially no referral zones could be attributed solely to one thoracic zygapophyseal joint.

Discussion

Based on the results obtained in this study, thoracic zygapophyseal joints can produce pain in a reproducible manner. Pain referral patterns are best established based on a large cohort of subjects. However, because of the invasive nature of provocative thoracic facet injections and potential risks, we believed a pilot study with nine individuals would provide adequate preliminary information. Previous provocative joint injection studies in the cervical and lumbar spines have included only 4–6 subjects and have been widely accepted.[6,11,13]

A study involving anesthetizing symptomatic thoracic zygapophyseal joints would help validate our experimentally induced pain patterns. This has been done for cervical zygapophyseal pain, and results have shown the referred pain patterns to be clinically accurate.[1] The authors state that experimentally induced pain referrals likely represented the "critical or core area characteristic of the segment stimulated," but with symptomatic joint disease the referral zones may be broader with "secondary extensions."[1]

As noted in previous provocative injection studies,[6] no pain is typically evoked until capsular distention occurs. Pain produced with experimental injection of iothalamate meglumine is believed to result from the development of capsular tension rather than from chemical irritation.[6]

No obvious explanation exists for why 27.5% of injections produced no sensation with capsular distension. This lack of provocation cannot be attributed to individual pain tolerance because the same subject appreciated strong sensations two segments superior or inferior. Nor were there any procedural variations or obvious anatomic factors to explain this phenomenon. Similar experimental studies in other regions of the spine have not reported similar completely asymptomatic segments.[11,13] However, in one study, two out of 11 (18%) joints did not produce direct pain, but caused minimal referral tenderness in the soft tissues.[6]

Comparing the experimental design of the present study with similar studies in the cervical and lumbar spine[6,11,13] reveals two important differences: 1) the use of contrast versus hypertonic saline; and 2) the region of spine studied. Although a less noxious stimulus (iothalamate meglumine) was used, any decrease in pain experienced should affect all joints equally. There may be less inherent potential for the thoracic versus lumbar zygapophyseal joints to produce pain. An unsubstantiated hypothesis is that there is a diminished density of nociceptors in the joint capsules of the thoracic spine compared to other spinal regions.

In addition, thoracic zygapophyseal joints are intrinsically smaller and hold less volume than their cervical and lumbar counterparts. Because of their smaller size, even if the nociceptive density is similar, there is less surface area available capable of transmitting painful responses. Again, such factors would be expected to exert a more uniform effect on the ability of the thoracic facet to produce pain. Despite the possibility that thoracic zygapophyseal joints may not be as uniformly capable of causing pain as the lumbar or cervical joints, this study's conclusion that they are a potential source of thoracic pain is not de-emphasized.

The referral patterns for thoracic zygapophyseal pain are less diffuse than other zygapophyseal joint pain diagrams generated for the cervical and lumbar spine. Thoracic zygapophyseal pain did not refer more than 2.5 segments inferior to the joint injected. In the cervical spine, referral can be seen up to six segments inferiorly for the C6–C7 joint and into the thigh and leg in the lumbar spine with L4–L5 joint injection.[6,11] Thus, it appears thoracic zygapophyseal joint pain is more localized and appreciated closer to its origin than zygapophyseal pain in other spinal regions.

With unilateral stimulation, no abdominal wall pain, bilateral thoracic pain, pleuritic pain, paresthesias, dermatomal pain, or true anterior chest wall pain was seen. These symptoms have been reported in those with clinical thoracic zygapophyseal joint pain.[9] Description of a "T4 syndrome" with unilateral glove paresthesias of the upper limbs and headaches has been described when there is articular restriction and pain emanating from the T3–T4 or T4–T5 joints.[12] These symptoms were not evoked with stimulation of these joints. Referred pain over the iliac crests or into the anterolateral abdominal wall or inguinal area with pathology from the T10–T11, T11–T12, and T12–L1 segments has been described.[10] Although only the T10–T11 segment was stimulated in the present study, these symptoms were not seen.

Failure to reproduce these reported clinical symptoms may reflect an asymptomatic versus a symptomatic state. Additional symptoms not evoked in this study may fall into the category of secondary extension zones rather than core referral zones. In two separate joint injections in two separate subjects, there was referral into the chest toward, but not reaching the anterior chest wall. With a more noxious stimulus, referral might have continued onto the anterior chest wall. If a more noxious stimulus had been used, other clinically reported but not evoked referral patterns may have been seen.

It is not suggested that referred pain maps replace a thorough history and physical examination of the patient with thoracic pain. Referred pain into the regions experimentally generated by this study can occur from other thoracic structures. Thus, referred pain into the regions demonstrated by this study cannot be assumed to occur solely from symptomatic thoracic zygapophyseal joints. These joints, however, must be included in the differential of thoracic pain. Referral patterns gen-

erated from this study overlap with reported referral patterns from a variety of other thoracic structures, including, but not limited to the intervertebral discs, costotransverse and costovertebral articulations, ligaments, posterior primary rami, and dorsal musculature.[7,14,15,17] Obviously, additional diagnostic tools will be required to distinguish a symptomatic thoracic facet joint from other structures that can refer pain in a similar fashion.

Even after the thoracic zygapophyseal joints are considered the presumptive pain generators, the referral maps generated in this study still have limitations. Because of the substantial overlap in the referral patterns of the thoracic zygapophyseal joints, the preliminary referral maps will not isolate the symptomatic thoracic joint to a single level, but will implicate only an area of four to five segments. Relying on the most intense area of pain may help further isolate the symptomatic joint. The most intense pain was felt within the core referral zone at or approximately one segment below the stimulated joint. The referral map generated in this study may help to better define the symptomatic region of thoracic zygapophyseal joint pathology, but ancillary physical examination still will be required to more precisely localize the pain source.

Hopefully, the pain diagram for the thoracic zygapophyseal joints can be used in a manner analogous to the well accepted cervical zygapophyseal pain diagram.[6] The clinical usefulness of the cervical zygapophyseal pain diagram was confirmed in a study on 24 patients.[1] Further research is required to validate the clinical utility of our thoracic zygapophyseal pain diagram.

■ Summary

This report provides preliminary confirmation that thoracic zygapophyseal joints can cause both local and referred pain. Pain emanating from these joints must be included in the differential of pain sources in the thoracic spine. A thoracic zygapophyseal joint referral pain diagram has been constructed that hopefully will help the clinician isolate the symptomatic joint in those with thoracic zygapophyseal joint pathology.

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