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Original Contribution

Electrical Stimulation Induced Lumbar Medial Branch Referral Patterns

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Study design: Fluoroscopically guided, minimum threshold electrical stimulation of the right first, second, third, and fourth lumbar medial branches and the fifth lumbar dorsal ramus in each of eight healthy test subjects was performed. The stimulation thresholds and referral patterns were recorded. A composite drawing of the referral patterns was created. The composite drawings were compared to documented referral patterns already published by other authors.

Objective: To determine the referral patterns of the lumbar medial branches and the fifth lumbar dorsal ramus.

Hypothesis: The lumbar medial branch referral patterns created by minimum threshold electrical stimulation may differ from those obtained after zygapophysial joint (Z-joint) injections.

Summary of background data: Lumbar Z-joint referral patterns have been identified following provocative Z-joint injections. There are no reports of lumbar medial branch referral patterns.

Methods: The right L1 through L4 medial branch of the posterior primary ramus and the right L5 dorsal ramus in each of eight healthy volunteer males (n=40), without a history of back pain, were electrically stimulated under fluoroscopic imaging. All subjects were blinded to the level of stimulation, and each individual mapped out the referral area on a human line drawing at the time of each stimulus. The referral patterns after electrical stimulation and the stimulation thresholds were recorded. These referral patterns were compared to referral patterns recorded during provocative Z-joint injections by other authors.

Conclusion: All of the subjects' mapped referral sites coincided with each other, creating a well defined composite drawing. These referral zones are different than those reported after injection of the lumbar Z-joint, which may have clinical and therapeutic implications. These referral maps may provide the clinician with additional insight when evaluating a patient with lumbar, flank, or gluteal pain of undetermined etiology.

Key words: Zygapophysial joint, facet joint, medial branch, lumbago, referral pattern

Low back pain represents a major health problem across the globe. Billions of dollars are spent in the United States alone each year in the diagnosis and treatment of low back pain (1, 2). The disability that results from chronic back pain gives rise to an even greater economic burden (3). Identifying the pain generator should be an important goal of the treating physician, especially when confronted with a challenging back pain syndrome.

The lumbar zygapophysial joints (Z-joints) were first described as a source of pain by Goldthwait (4) in 1911. In 1933, Ghormely (5) used the term "facet syndrome" to describe a symptom complex characterized by pain that originated in the Z-joints and was referred to the low back. Kellegren (6) reported his observations of referred pain arising from deep somatic structures in 1939, and in 1941, Badgley (7) postulated that damage to the Z-joint capsule produced firing of the capsule nerve endings, thus transmitting nociceptive stimuli to the dorsal root ganglia via the posterior primary rami. Awareness that the Z-joint may be a source of low back pain was temporarily obscured by the "disc era" until 1963 when Hirsch et al (8) demonstrated that the injection of 10% hypertonic saline

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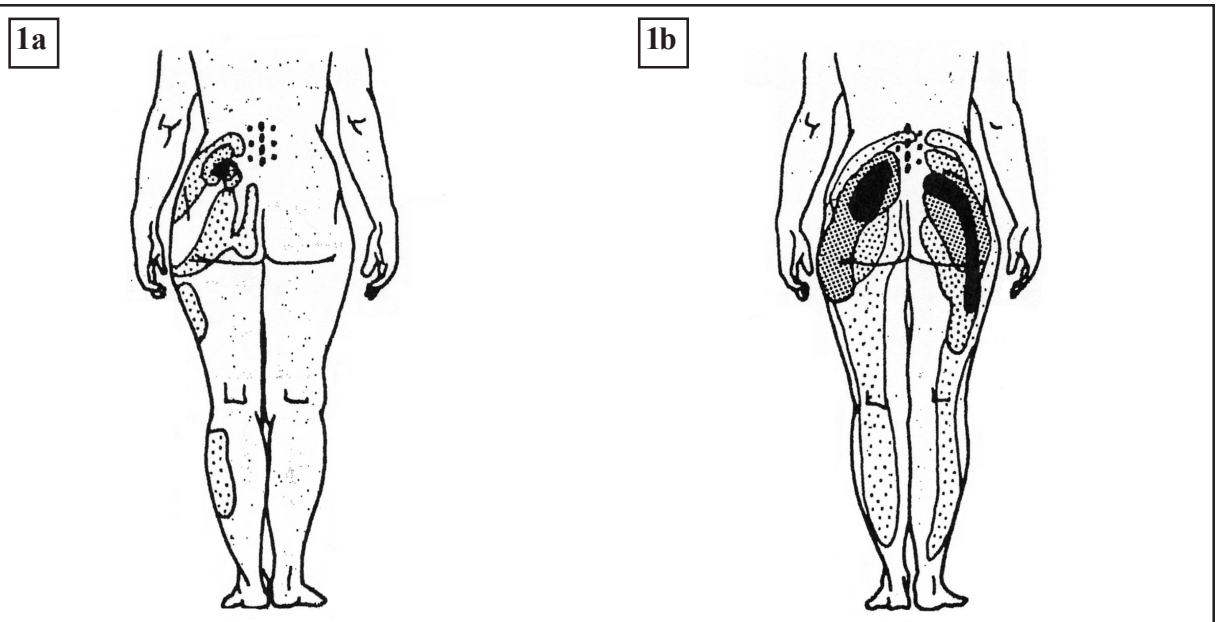

Fig 1a. Normal Z-joint referral patterns in asymptomatic subjects.
Fig 1b. Abnormal lumbar Z-joint referral patterns in symptomatic subjects. Adapted from Mooney and Robertson (9)

into the region of the Z-joint could induce pain in the lower back and upper thigh. In 1976, Mooney and Robertson (9) published the referral patterns created by fluoroscopically guided intra-articular lumbar Z-joint injections using hypertonic saline in both symptomatic and asymptomatic volunteers. A confirmatory study was published by McCall et al (10) in 1979.

Since that time, diagnostic intracapsular injections and more recently, Z-joint nerve blocks have been used to determine the role of these joints in the production of low back pain (11-19). The referral patterns described by various authors were obtained by direct injection into the Z-joints (figure 1). We are unaware of any reports where fluoroscopically guided electrical stimulation of the medial branch was used to determine the referral patterns of the lumbar medial branch and L5 dorsal ramus.

Our goal was to determine the referral patterns of the lumbar medial branch and L5 dorsal ramus after fluoroscopically guided electrical stimulation and to compare our results with referral patterns obtained by other authors after intracapsular injections.

METHODS

Eight healthy male subjects with no history of back pain volunteered for the study. The ages of the subjects ranged from 31 – 42 with a mean age of 35.1 years. The principal author performed the procedures on all subjects. The individuals were placed in the prone position on a radiolucent procedure table. The thoracolumbosacral area was adequately prepped with povidone iodine solution and sterilely draped. The lumbar spine was fluoroscopically surveyed. The position of the lumbar medial branch was identified using either an AP view or an oblique view with a right oblique rotation of 15 to 25 degrees from the sagittal plane and a caudal tilt of 10 to 15 degrees. Buffered 1% lidocaine was used to anesthetize the skin and fascia only. Specifically, care was taken to avoid anesthetizing the Z-joint or lumbar medial branch. A Radionics RFG 3C Plus® unit (Radionics, 22 Terry Avenue, Burlington, MA 01803) was utilized for the procedure and each test subject was appropriately grounded with a disposable grounding pad. Using an "en pointe" approach, either a 22 G 100.5 mm SMK probe with a 5mm active tip or a 20 G 145 mm SMK probe with a 5mm active tip was placed down to the cephalad border of the

Table 1. *Description of the minimum stimulation thresholds (mV) at the L1 through L5 levels for each subject.*

SUBJECT	L1	L2	L3	L4	L5
A	0.15	0.20	0.08	0.10	0.10
B	0.10	0.05	0.05	0.22	0.10
C	0.05	0.06	0.05	0.18	0.12
D	0.15	0.15	0.15	0.10	0.05
E	0.07	0.08	0.05	0.08	0.07
F	0.08	0.07	0.07	0.03	0.08
G	0.07	0.13	0.10	0.20	0.23
H	0.25	0.20	0.20	0.10	0.08

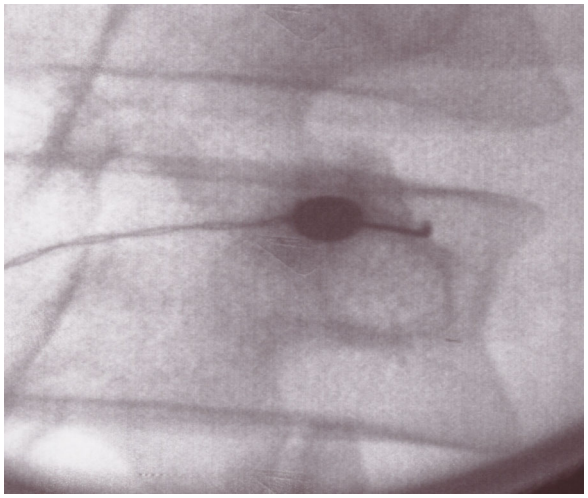

Fig 2. A typical probe placement at the right L2 medial branch. The fluoroscopic image intensifier is angled 25 degrees ipsilaterally in the axial plane and 20 degrees caudally. The SMK probe is positioned at the cephalad aspect of the transverse process at the junction of the superior articular process. The long axis of the exposed tip of the probe is parallel to the course of the medial branch.

base of the transverse process as it joins the superior articular process. The tip of the probe was then deflected off the cephalad border of the transverse process by 1-2 mm such that the long axis of the active tip lay alongside and parallel to the lumbar medial branch (Figure 2). With the Radionics unit set at 50Hz stimulation mode, the right first, second, third, and fourth lumbar medial branches and the right fifth dorsal ramus were stimulated and the thresholds were recorded (Table 1). The subjects' lumbar medial branches were stimulated in a variable pattern to further blind the subjects and each lumbar medial branch was stimulated repeatedly in order to confirm the reproducibility of the data and to make sure that a minimum stimulation threshold had truly been obtained. In no case was radicular stimulation obtained. Each subject was asked to mark the drawing corresponding to the referred sensation during stimulation. This procedure was performed on each individual, at each level.

RESULTS

Each subject received perceptible and reproducible stimulation between 0.05 and 0.25 volts at all levels. Each subject mapped a localized referral pattern to a region several centimeters caudal and lateral to the actual stimulation site (Figure 3). In two subjects, there was referral into the superolateral hip region, one was with stimulation of the right L4 lumbar medial branch and the

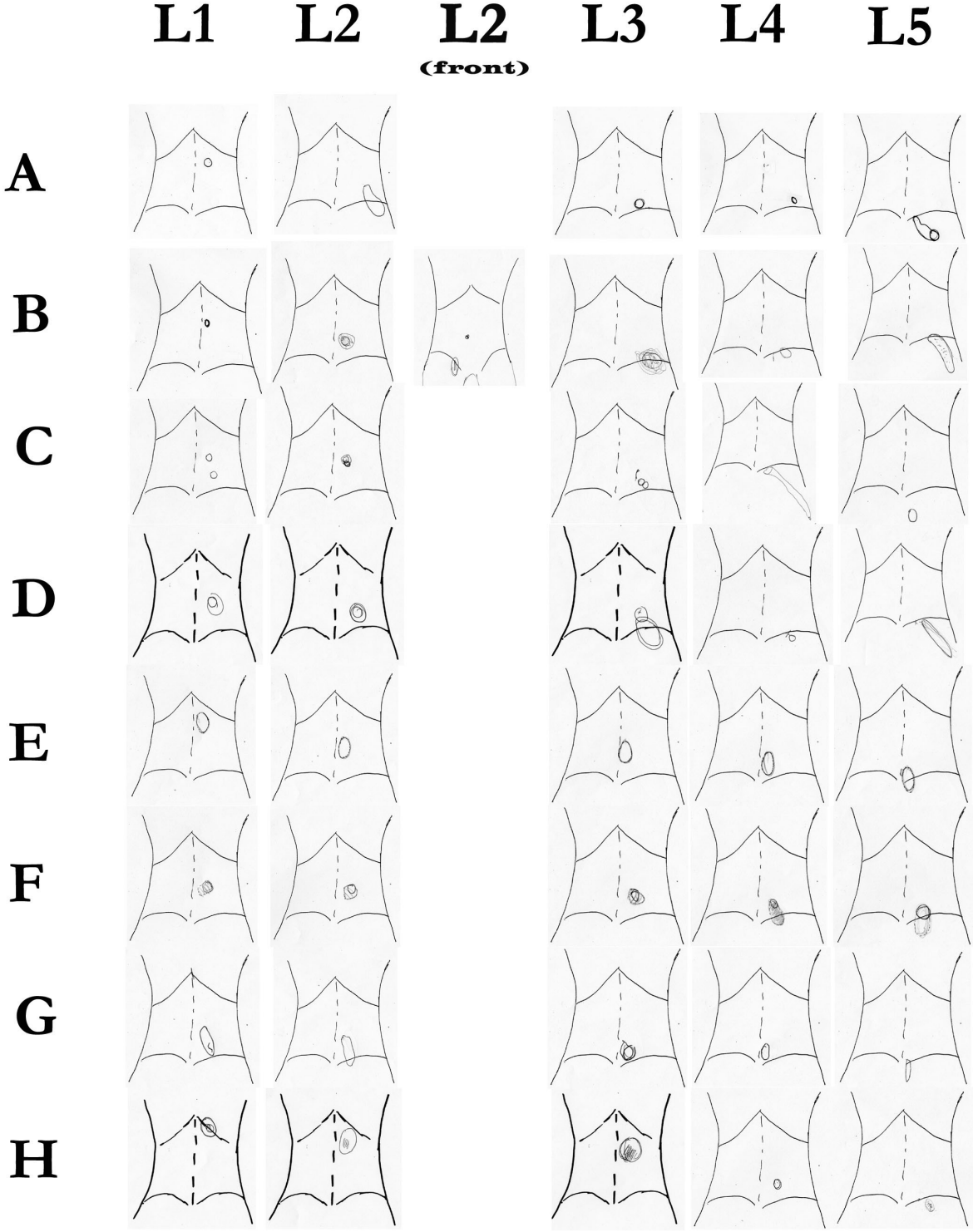

Fig 3. Thumbnail sketches of all subjects at all levels

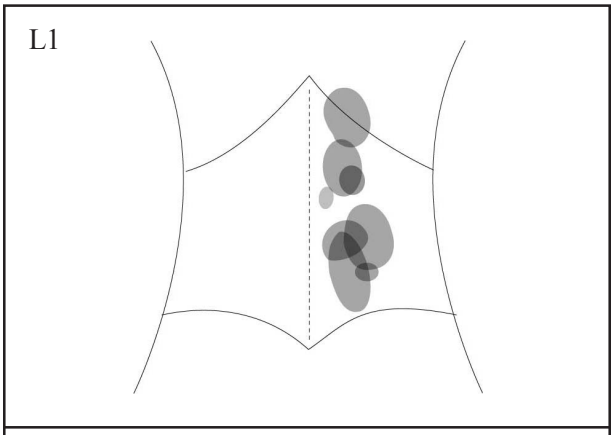

Fig 4a. Composite drawing of the referral zones of all eight subjects derived from the minimal threshold stimulation of their right L1 medial branch

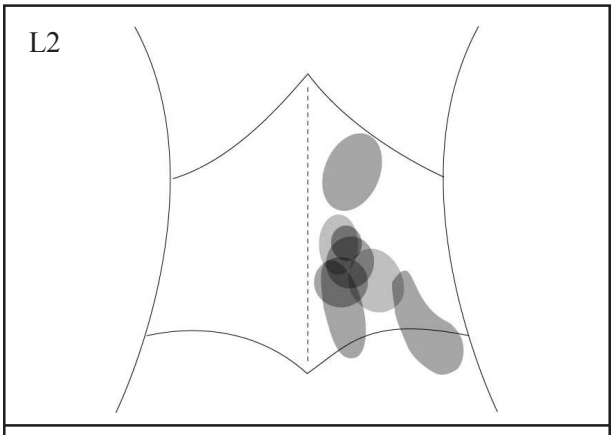

Fig 4b. Composite drawing of the referral zones of all eight subjects derived from the minimal threshold stimulation of their right L2 medial branch

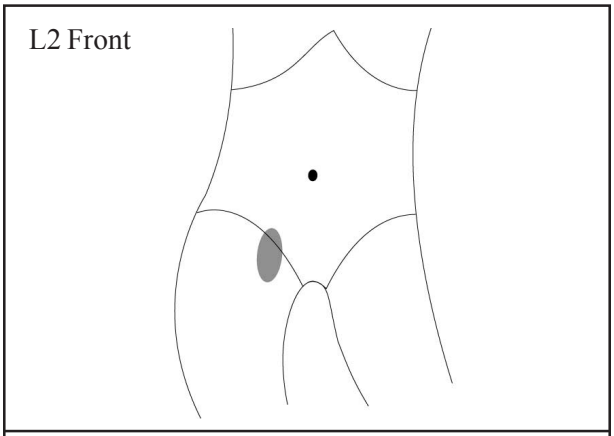

Fig 4c. Drawing of one volunteer who obtained anterior right inguinal stimulation from the minimal threshold stimulation of his right L2 medial branch.

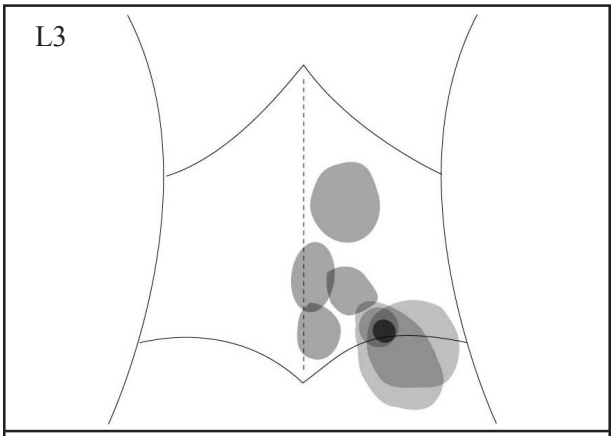

Fig 4d. Composite drawing of the referral zones of all eight subjects derived from the minimal threshold stimulation of their right L3 medial branch.

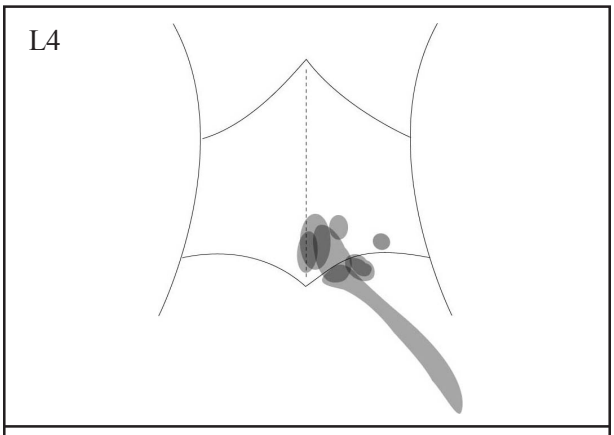

Fig 4e. Composite drawing of the referral zones of all eight subjects derived from the minimal threshold stimulation of their right L4 medial branch.

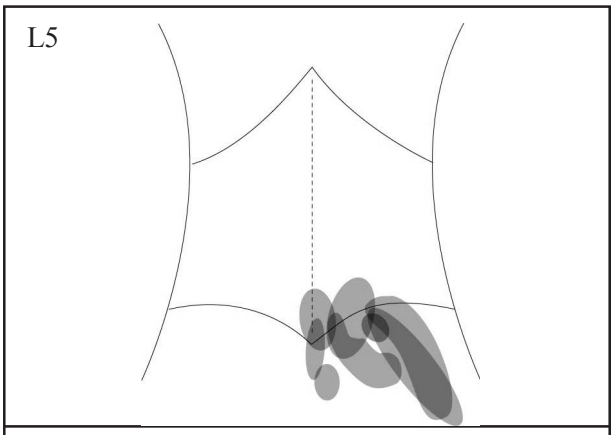

Fig 4f. Composite drawing of the referral zones of all eight subjects derived from the minimal threshold stimulation of their right L5 dorsal ramus

other was with stimulation of the right L5 dorsal ramus. One of these individuals also reported and recorded stimulation in the right inguinal region with stimulation of his right L2 medial branch. Except for these three unusual referral patterns, all of the other mapped referral sites coincided well with each other. A well-defined composite drawing for each level was obtained (Figure 4A-F). No radicular stimulation was reported by any of the test subjects. There were no complications as a result of the procedure.

DISCUSSION

Injury of the lumbar medial branch may occur as a result of entrapment under the mammilloaccessory ligament, myopathy, or metabolic conditions such as diabetes mellitus (20-24). Since the lumbar Z-joint is innervated by at least the lumbar medial branch at the same level and the level above (25-28), it seems reasonable to infer that the sensation experienced by a subject during stimulation of a Z-joint should be different than the sensation experienced during stimulation of a single lumbar medial branch as each Z-joint's afferent signal must travel through both lumbar medial branches, their associated dorsal root ganglion and then onto their respective receptive fields in the dorsal horn (29-31). As a result, an individual lumbar medial branch receptive field should be smaller and different than a Z-joint receptive field. The corresponding sensation resulting from stimulation of an individual lumbar medial branch should be more localized than that of a Z-joint under normal conditions and indeed that is what we found. Under unusual circumstances of chronic or severe pain, patients may experience "wind up" thus causing the region of referred pain to be enlarged when compared to normal subjects (31). This must be taken into account when considering this data during the treatment of pain patients.

CONCLUSION

All 40 referral patterns were meticulously mapped and well controlled. All of the subjects' referral maps correlated well with each other with the exception of the three individuals mentioned previously, two of which mapped stimulation in the superolateral thigh and one of which mapped stimulation in the inguinal region. With the exception of these three outliers, the remainder of the subjects' mapped referral patterns created a well-defined composite drawing (Figs 4A-F). While there was apparently less correlation at the L1 and L2 levels than at lower levels of the spine, this may be explained by the fact that the subjects indicated at the time of stimulation that they had a better sense for where they perceived the stimulation on the drawing as it related to the iliac crest and posterior superior iliac spine than higher up in the lumbar spine using the twelth rib as a reference point.

These referral zones are different than those reported during stimulation of the lumbar Z-joint and may have clinical implications. These referral maps may provide the clinician with additional insight when evaluating a patient with lumbar, flank, or gluteal pain of undetermined etiology.

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