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What's Old Is New Again: The Sacroiliac Joint as a Cause of Lateralizing Low Back Pain

Jennifer Saunders[1], **Mel Cusi**[1], **and Hans Van der Wall**[1,2]

[1]Sydney School of Medicine, University of Notre Dame, Sydney, Australia; and [2]CNI Molecular Imaging, Sydney, Australia

Corresponding Author:
Hans Van der Wall, PhD
CNI Molecular Imaging, 4 Hospital Road,
Concord West, NSW 2138, Australia;
E-mail: hvanderwall@gmail.com

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Abbreviations: Sacroiliac joint (SIJ), Single-photon emission computed tomography (SPECT), computed tomography (CT), low back pain (LBP), nonspecific low back pain (NSLBP), magnetic resonance imaging (MRI)

ABSTRACT

It has not been easy to identify mechanical failure of the sacroiliac joint (SIJ) with traditional imaging. The integrated model of function (Lee and Vleeming, 1998) suggests that under normal circumstances, form and force closure combined contribute to sacral nutation and "locking" the SIJ for optimal load transfer. This model is supported by clinical evidence and scintigraphic findings that contribute to successful therapy in 80% of cases. Single-photon emission computed tomography and x-ray computed tomography (SPECT-CT), a hybrid device, was used in a study of 1200 patients (64% female and 36% male patients with an average age of 42 years; range, 15–78 years) with a clinical diagnosis of SIJ incompetence (pelvic girdle pain syndrome). Standard clinical testing and an alternate series of tests were used as a reference standard for imaging. Symptoms were present for a mean of 43 months. Imaging finding were of increased uptake in the upper SIJ (S1–S2), with extension into the dorsal interosseous ligament and measurable by count profile. Associated findings of tendon enthesopathy reflected altered biomechanics around the pelvis. Ipsilateral adductor enthesopathy was found in 70% and contralateral hamstring enthesopathy in 60% of patients. SPECT-CT criteria for the diagnosis of SIJ incompetence were developed and validated. SPECT-CT is a valid and reproducible technique for the diagnosis of SIJ incompetence with high concordance and specificity compared to the reference standards. Findings are supportive of the integrated model of SIJ function proposed by Lee and Vleeming.

INTRODUCTION

Low back pain (LBP), a common ailment, afflicts 85% of people at one time or another, with a high proportion reporting chronicity (>12-week duration) or frequent recurrences that are disabling (1). Epidemiological studies indicate that ~15% of chronic LBP is caused by an intervertebral disc pathology and the remaining 85% of LBP is classified as nonspecific low back pain (NSLBP) (1). NSLBP is a term of convenience that hides ignorance of the actual pathophysiology in the vast bulk of patients with the condition. It is a descriptor, not a diagnosis. It may include a complex collection of physical and psychosocial pathologies that cannot be addressed by the current imaging paradigm.

One typical and common scenario is patients presenting with lateralizing LBP that radiates into the buttock and often the groin and may include a history of onset in the peripartum period or after trauma to the lower back or buttocks. The clinical presentation is often thought to be "sciatica" and an intervertebral disc lesion is sought by x-ray computed tomography (CT) or magnetic resonance imaging (MRI). A high proportion of these patients will have essentially normal finding or "disc bulges" without neural compromise. This group is invariably labeled as NSLBP in a nihilistic exercise that raises unresolvable and often damaging questions of psychological or psychiatric overlays and may result in secondary depression.

This situation exists despite a vast body of Northern European literature that indicates that 15%–30% of such patients (2-7) may have the sacroiliac joint (SIJ) identified as the cause of their symptoms. Ironically, such patients may be treated with specific physiotherapy that yields a significant improvement in 80% of cases. These patients can be identified by a specialized battery of physical tests that have been established as the diagnostic reference standard on the basis of good evidence (8). We have developed and validated a bone scintigraphic technique with the use of single-photon emission CT (SPECT) with fused CT images (SPECT/CT) to identify this condition (9). The major cause of the dysfunction in this series was trauma, largely related to either discrete or repetitive sporting trauma. We describe the specific scintigraphic findings in 1200 cases together with illustrations of the primary abnormality in the SIJ and the secondary findings around the pelvis. We hypothesize that these findings agree with and provide physical imaging evidence to support the integrated model of SIJ function proposed by Lee and Vleeming

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(10). Accurate diagnosis will provide significant clinical improvement with targeted therapy in 80% of cases (9, 11).

METHODOLOGY

Clinical

Patients were either referred from private clinical practice for the evaluation of lateralizing LBP or prospectively recruited into an open-label trial of prolotherapy for physiotherapy-resistant disease of the SIJ (11). Approval for patient studies was given by the Ethics Committee of the University of Notre Dame Australia, Sydney Campus. All patients met the clinical conditions for the diagnosis of SIJ incompetence/pelvic girdle pain syndrome (3/4 positive clinical tests) according to the European guidelines (8). These patients either complained of pain in the peripartum period or sustained significant lower back/buttock trauma or repeated microtrauma in a sports setting. Patients were tested if symptoms remained unresolved after a 6-week duration. All patients were referred from 6 sports medicine practices after initial screening by qualified staff. Two trial-based specialized sports medicine physicians (JS and MC) then undertook definitive clinical screening tests and documented histories and quality-of-life assessments.

Clinical tests

These were selected according to the validated European guidelines for pelvic girdle pain (8). The following four tests are evidence-based: Stork test (Gillet test), tender palpation of the long dorsal sacroiliac ligament (12, 13), posterior pelvic pain provocation test (14), and active straight leg raise test (15-18). Results following therapy were available in 891 patients. The remainder of the patients who underwent therapy were either lost to follow-up or refused follow-up, often because their symptoms and functional capabilities had improved.

Scintigraphy

Patients were imaged using standardized protocols published in detail elsewhere (9). Following the intravenous injection of 900-1000 MBq of 99m-Tc hydroxydiphosphonate (HDP), blood-pool images of the anterior and posterior pelvis were obtained. Planar images of the same views were obtained at 2 h after injection followed by SPECT/CT on a Hawkeye 4 hybrid gamma camera (General Electric, Milwaukee). Images were viewed as SPECT, CT, and SPECT with fused CT images in 3 standard projections. A semiquantitative analysis was performed by obtaining counts from a standard circular region of interest over the soft tissues posterior to the SIJ at the level of the S2 segment.

A number of SPECT/CT abnormalities were sought: SIJ uptake (S1/S2 level), posterior soft tissue uptake/ligamentous uptake at insertion into the ilium, and CT grading of sclerosis/erosive disease in the upper SIJ. Increased uptake around the pubic symphysis and/or adductor/hamstring/gluteus medius/psoas tendon insertions and the CT appearances of these sites were reported. Lumbar zygoapophyseal joint uptake or intervertebral disc space abnormalities were reported. Abnormal scintigraphy and CT appearances of the hips were commented on.

RESULTS

Clinical

The study cohort comprised 1200 patients (64% female and 36% male patients with an average age of 42 years; range, 15–78 years) with a clinical diagnosis of SIJ incompetence (pelvic girdle pain syndrome) (8). Clinical history revealed that 88% of cases were because of acute trauma or repetitive microtrauma, 8% were postpregnancy, and 4% without a clear-cut cause. Standard clinical testing and an alternate series of a tests were used as a reference standard for imaging (8). Symptoms were present for a mean of 43 months (range, 6 weeks to 26 years). A cohort of young athletic patients (n = 23) presented with symptoms predominantly indicating either adductor or hamstring dysfunction, which was often recurrent.

Results following targeted physiotherapy, prolotherapy or surgery of the SIJ were available in 891 patients with pain-free return to normal function as the end point. Of the 891 patients, 145 (16%) did not respond completely to therapy or were lost to follow-up. Complete response with loss of pain and functional improvement with physiotherapy and ongoing exercise programs was reported in 665 (75%). Incomplete responses were found in 83 (7%) with successful response to hypertonic dextrose injections into the dorsal sacroiliac ligament under CT control (11). The remaining 2% of patients responded to operative fusion of the involved SIJ.

Scintigraphy

The blood-pool image showed hyperemia in the affected SIJ in 11% of patients, with the delayed study showing increased uptake in the affected joint in 22%. Uptake around the pubic symphysis and in the ipsilateral hip was present in 27% of patients in the planar images.

SPECT/CT findings were of increased uptake in the upper SIJ (S1-S2) with extension into the dorsal interosseous ligament and measurable by count profile in 100% of patients. A significant difference in count profile between the affected and unaffected side was found. Mean counts on the affected side were 168 (SD: 91) and those on the unaffected side were 109 (SD, 60). Analysis with the Student *t* test yielded a mean difference of 59 counts (95% CI, 42–89 counts). The specific SPECT/CT criteria for the diagnosis of SIJ incompetence have been validated in previous work (9).

Ancillary finding reflecting altered abdominopelvic muscle functional. Ipsilateral adductor enthesopathy was present in 70% of cases and contralateral hamstring enthesopathy in 60%. A number of patients (n = 41) also demonstrated gluteus medius and psoas tendon enthesopathy. Osteitis pubis was found in 7%. Ipsilateral femoroacetabular hip impingement was present in 72% of patients.

Unrelated incidental findings. Approximately 57% had other pathological conditions. These included pars fractures (2% of patients), chronic sacroiliitis (0.3% of patients), old fractures of the coccyx or sacrum (0.5%), osteitis condensans ilii (0.5%), bilateral hip impingement (7%), degenerative changes of the intervertebral discs or facet joints in the lumbar spine and SIJs (44%), and other minor changes (2.7%).

DISCUSSION

The problem of SIJ "dysfunction" is not new. It was described in the medical literature as far back as 1905 (19). The concept was however lost following the 1934 publication of the citation classic by Mixter and Barr (20), which ascribed rupture of the intervertebral disc with compromise of the spinal canal as a cause of lateralizing LBP. SIJ "dysfunction" was however resurrected in the northern European literature by a number of workers who reported the clinical presentation of lateralizing LBP (pseudosciatica) in women in the peripartum period (2-5, 21, 22), where up to 8% would be left with a permanent disability. The syndrome was described as the pelvic girdle pain syndrome, with the principal site of pathology being the SIJ rather than the intervertebral disc. This has been described as a similar clinical entity arising from either discrete or repetitive trauma to the buttock or lower back. Therefore, the term SIJ incompetence has been coined to cover both the posttraumatic and the postpartum variants (9).

Unfortunately, the majority of patients with lateralizing LBP, which is clinically identical to "sciatica" (23-25), are not recognized as suffering from anything other than intervertebral disc disease with rupture and neural compromise by the vast majority of the medical community. Under these circumstances, a natural progression is to perform an MRI, which shows a significant intervertebral disc abnormality in ~15% of patients, with the remainder being classified as nonspecific LBP (1). The northern European literature is however replete with numerous patients in whom mechanical "dysfunction" of the SIJ may account for 15%–20% of NSLBP. The importance of this diagnosis lies in the successful resolution of a failed load transfer of the SIJ to appropriate physiotherapy in >80% in this series. To ignore the SIJ as a cause of significant symptoms in such a large proportion of patients with LBP is to engender diagnostic nihilism that disadvantages the optimal care of such patients. These patients are invariably young, as in this series. Furthermore, the average time to an accurate diagnosis was 43 months, which is an unacceptable delay in any parlance. These patients invariably have an essentially noncontributory MRI study that fails to identify significant pathology as we have described previously, with the result that psychological issues are raised as an explanation in ~75% of patients (9).

The inability to image mechanical "dysfunction" of the SIJ has been reported for plain film, MRI (22), and scintigraphy (26). The inability of MRI to diagnose injury to the dorsal interosseous ligament stems from the fact that the ligament is avascular. Ligaments that reside outside synovial joints are avascular, as they are not covered by a synovial layer derived from the joint as in the knee (27). Hence repair is by calcification, and there is no oedematous signal for MRI to detect. This calcification is what allows uptake of the scintigraphic bone agent, which has a high conspicuity with SPECT/CT, unlike in the past where SPECT alone did not allow accurate interrogation of the deep ligamentous structures.

The previous failure of imaging to delineate mechanical SIJ issues led to the adoption of a battery of reproducible physical examination tests that are the reference standard for the diagnosis (8). Our group has validated a number of findings by SPECT/CT that is both sensitive and specific for the diagnosis of SIJ incompetence and has good reproducibility (κ = 0.85) (9). The region of interest (ROI) analysis found that of the hypothesized criteria for the diagnosis, increased soft tissue uptake in the dorsal interosseous ligament of the SIJ and at the site of ligament entheses yielded a score of 1.0 compared with joint uptake and sclerosis, which yielded a score of 0.41. These findings and the approach to the scintigraphic diagnosis can best be appreciated by understanding the integrated model of load transfer through the SIJ proposed by Lee and Vleeming (28). SPECT/CT is in the unique position to provide an accurate diagnostic system for SIJ incompetence that is unavailable by any other imaging modality.

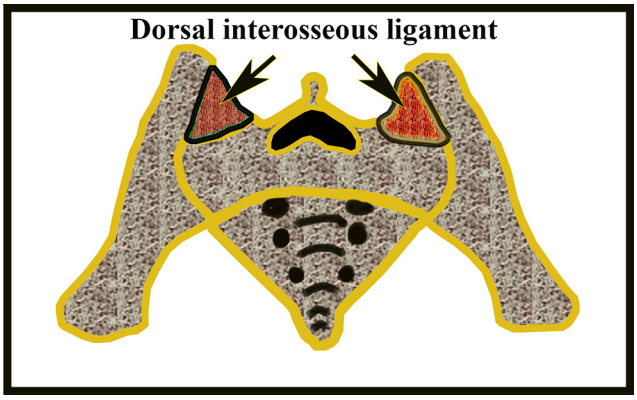

Figure 1. Graphical illustration of the dorsal interosseous ligament of the sacroiliac joint from the posterior view of the pelvis and in the cross section. The ligament reaches deep into the sacroiliac joint (arrows) and has more extensive coverage at the level of the S1 and S2 segments.

The concept of load transfer through the SIJ postulates 2 mechanisms for a stable load transfer. The first is form closure, where the irregularities on the joint surface of the sacrum and innominate and the "L" shape of the articulation effectively lock the SIJ into the pelvic ring. When this articulation is under load, the sacrum moves anteriorly into the ring (nutation) in a stable configuration. The second mechanism is force closure, in which there is a coordinated contraction of the abdominal musculature that compresses the pelvic ring and locks the sacrum into the pelvis in a stable configuration. When there is significant injury to the SIJ, this mechanism is disrupted, usually because of an injury to the dorsal interosseous ligament of the SIJ (Figure 1). This ligament is structurally important, as there is no capsule around the posterior aspect of the joint and ligamentous disruption can result in the sacrum moving posteriorly and out of the stable configuration of the pelvic ring (23). This painful process leads to a loss of sequencing of the contractions of the abdominal musculature, leading to loss of the compressive mechanism that helps lock the pelvic ring. It was initially believed that the principal pain generator was the SIJ itself. However, more recent work has shown that this group of patients with mechanical SIJ "dysfunction" respond more completely to local anesthetic injection into the dorsal ligaments rather than into the SIJ itself

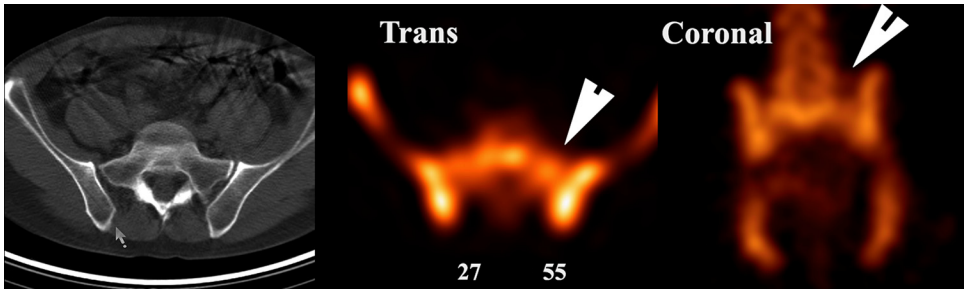

Figure 2. Patient with left sacroiliac joint incompetence. The single-photon emission computed tomography (SPECT) images show increased uptake of tracer in the dorsal interosseous ligament of left sacroiliac joint (arrowhead). Compare the absence of such an uptake on the right side. This is often well demonstrated in the coronal images as shown by the arrowhead. The differential counts are indicated in the transaxial image.

(96% vs 62% improvement in pain scores) (29). This suggests that the principal site of the pathophysiology in mechanical "dysfunction" of the SIJ is the dorsal interosseous ligament with loss of abdominal muscle synchronization being a secondary phenomenon.

Findings on the SPECT/CT reflect these mechanisms. There is significant dorsal ligamentous uptake of tracer that is optimally assessed at the S2 segment level and is best visualized in the coronal and transaxial sections. A standardized region of interest (eg, circular) may then be placed over this area of soft tissue uptake with the generation of a comparative count profile between the affected and nonaffected sides (Figure 2). This can be problematic when the injury is serious enough to affect both SIJs, making visual analysis critical. Repeated traction on the ligament also leads to a periosteal reaction where the normal "dumbell" configuration of the joint is lost. Over time, the increased motion of the joint leads to sclerosis and increased joint uptake. Loss of synchronization of the abdominal core musculature triggers a number of disadvantageous compensatory mechanisms that manifest as muscle spasm. These can be clinically detected and is part of the battery of physical diagnostic tests for the condition (8). These compensations lead to enthesopathic changes around the pelvis and hips and the subsequent loss of the compressive mechanism on the pelvic ring. Such muscle changes have been elegantly demonstrated by electromyographic studies, particularly in the biceps femoris muscle (30).

Enthesopathic changes were apparent at the hamstring origin in 70% of patients and invariably on the side contralateral to the affected SIJ (Figure 3). The adductor origin uptake was evident around the pubic symphysis, either bilaterally or on the ipsilateral side in 60%. Other sites of enthesopathy that are less frequently visualized involved the ipsilateral gluteus medius and iliopsoas origins. An indirect result of the associated muscle compensatory changes, particularly of the gluteus medius (30) on the ipsilateral side, is the occurrence of femoroacetabular hip impingement as the femoral head is rotated anteriorly and impinges on the acetabulum (Figure 4).

The location of the principal abnormality of the dorsal interosseous ligament uptake at the S2 level distinguishes SIJ incompetence from sacroiliitis, osteitis condensans ilii, degenerative disease, and sacral fractures. No other condition of the lumbar spine, SIJs, or pelvis has the same conglomeration of signs that distinguish SIJ incompetence. We have found many of these conditions to coexist with SIJ incompetence and to be clearly distinguishable (9).

A number of referrals for suspected SIJ incompetence were triggered by recurrent tears of the hamstring tendons in a small but physically active group of patients (n = 23) who gave a history

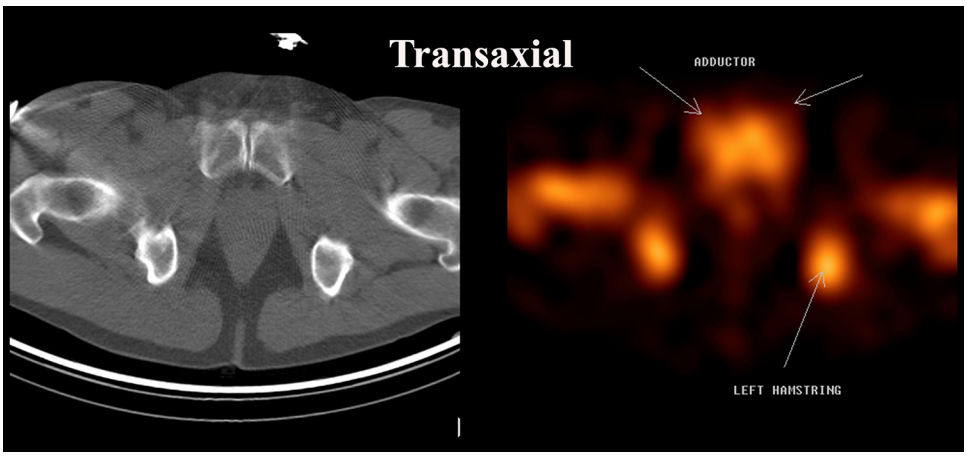

Figure 3. Enthesopathy. Uptake at sites of tendon insertion for the adductors and hamstring tendons (arrows) in the transaxial SPECT image.

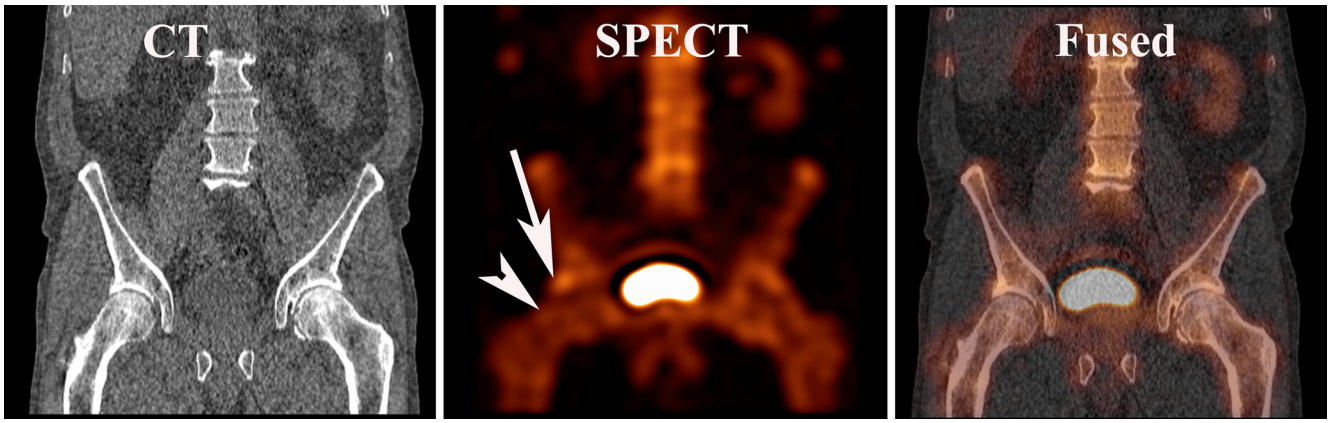

Figure 4. Femeroacetabular hip impingement in a patient with right sacroiliac joint incompetence. The patient presented with right buttock pain and sudden onset of worsening groin pain while running. Intense uptake is apparent in the superior lip of the right acetabulum (arrow), which was subsequently shown to be an acetabular labral tear. A cam-shaped femoral head is apparent on both sides, being more marked on the right, with increased uptake at the head and neck junction (arrowhead) on the right.

of either repetitive trauma or discrete traumatic injuries to the buttocks or lower back. These were often in high-level athletes who engaged in soccer or football. Invariably, patients had evidence of both SIJ incompetence and significant enthesopathy of the adductor or hamstring insertions around the pelvis. SIJ-related issues and kinematic alterations in core muscle contractions have been reported by others in such patients (31, 32). A high index of clinical suspicion in these patients can provide a diagnosis that is effectively treated by appropriate physiotherapy.

What is the point of the imaging test if the reference standard up to now is a group of clinical tests? The imaging finding are used by physical therapists to target sites of muscle spasm to recoordinate sequential abdominopelvic muscle contraction. It also helps the physicians to understand the pathophysiology arising from injury to the dorsal interosseous ligament. For example, the finding of secondary femeroacetabular hip impingement on the side ipsilateral to the SIJ dysfunction is crucially important, as experience has shown that surgical intervention, particularly for injuries to the acetabular labrum, will lead to rapid degeneration of the joint and the requirement for hip replacement surgery. If detected early, this can be avoided by effective treatment of the affected SIJ.

Physical examination is a difficult prospect for general physicians, orthopedic surgeons, and general practitioners who do not undertake these assessments on a regular basis. Reproducibility suffers for the occasional user of the test. The imaging findings are crucial for this group of medical practitioners and for orthopedic surgeons who will encounter secondary manifestations such as femeroacetabular hip impingement or even recurrent hamstring tendon tears. Furthermore, when physical therapy fails to address the problem, uptake in the dorsal interosseous ligament is a specific target for either prolotherapy or the injection of platelet-rich plasma. The operator can be certain that the correct side is being injected.

CONCLUSION

SPECT and x-ray CT (SPECT-CT) is a valid and reproducible technique for the diagnosis of SIJ incompetence with high concordance and specificity compared to the reference standards. Findings are supportive of the integrated model of SIJ function proposed by Lee and Vleeming. In the athletic population, SPECT-CT may provide information on the risk factors for adductor- and hamstring-related injuries. SPECT/CT can provide an accurate diagnosis that no other imaging modality can. It should be used more frequently for a disease that may be more prevalent than intervertebral disc rupture in patients with lateralizing LBP, particularly where the MRI study is noncontributory.

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Conflict of Interest: The authors have no conflict of interest to declare.

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