



# Etiology of Lumbosacral Radiculoplexopathy: Sacral Insufficiency Fracture on Magnetic Resonance Imaging

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Received: 15 October 2019/Accepted: 5 January 2020/Published online: 6 February 2020  
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**Abstract** *Background:* Sacral insufficiency fracture (SIF) can cause lumbosacral radiculoplexopathy (LSRP) and is probably under-recognized. Symptoms may include nonspecific lumbar spine or buttock pain that is exacerbated by physical activity and alleviated with rest. The frequency of LSRP secondary to SIF has not been reported. *Questions/Purposes:* We aimed to determine the frequency of LSRP associated with SIF using magnetic resonance imaging (MRI) of the lumbar spine. *Methods:* We searched a radiology database at our institution using the keywords “sacral insufficiency fracture” and “lumbar spine MRI” for patient records from January 2014 through December 2017. We assessed for the presence of LSRP, reflected by elevated T2-weighted or short tau inversion recovery (STIR) signal intensity and enlargement of the nerve on noncontrast lumbar spine MRI. An incompletely healed vertically oriented SIF was confirmed if there was a persistent bone marrow edema pattern adjacent to the fracture site; we did not include purely transverse SIFs. The final cohort comprised 57 patients (48 female; age range, 14 to 89 years). *Results:* Abnormalities of the extraforaminal L5 nerve root or the combined L4 and L5 nerve roots (the lumbosacral trunk) were identified in 19 (33%) of 57 patients, with a total of 23 sites (bilateral involvement in four cases). Of the 23 abnormal nerves, 19 (82.6%) had corresponding, clinically documented radicular symptoms and 16 (69.6%) had no other explanation on MRI for their radicular symptoms other than

SIF. *Conclusions:* LSRP caused by SIF is an entity all radiologists should be cognizant of, especially in cases of otherwise unexplained radicular symptoms. The diagnosis of SIF can be helpful in cases involving concomitant multi-level lumbar spondylosis and neural foraminal stenosis.

**Keywords** radiculoplexopathy · magnetic resonance imaging · spine · lumbosacral plexus

## Introduction

Sciatica is characterized by symptoms of pain, paresthesia, or both in the distribution of the sciatic nerve and is a very common pathology, occurring in as many as 40% of adults at some point in their lives [16]. The sciatic nerve is formed from the L4–S3 nerve root branches, including the lumbosacral trunk, which includes a branch of L4 and the ventral ramus of L5. Symptoms referable to the L5 nerve root include pain along the lateral aspect of the lower leg and foot.

The cause of lumbosacral radiculoplexopathy (LSRP) involving the L5 nerve root is most frequently a disc herniation or neural foraminal stenosis [9, 13]. However, periostitis secondary to a sacral insufficiency fracture (SIF) causing direct nerve root impingement has been described in a few case reports [2, 3, 6, 7, 10, 12] and is likely under-recognized, particularly on “standard” lumbar spine magnetic resonance imaging (MRI) scans. SIFs are most common in women 55 years or older (mean age, 70–75 years) and in those with osteoporosis [7]. Typically, there is either little or even no history of trauma. Rather, repetitive, low-energy stress on osteoporotic, abnormal bone is the cause of the fracture [15]. Symptoms may include nonspecific lumbar spine or buttock pain exacerbated by physical activity and alleviated with rest. Periosteal impingement can be of the L5 nerve root alone or the lumbosacral trunk, which can form either proximal or just distal to the level of the first sacral segment.

Level of Evidence: Level II: Retrospective study

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s11420-020-09750-y>) contains supplementary material, which is available to authorized users.

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This study aimed to describe the frequency of LSRP secondary to vertically oriented SIF on standard lumbar spine MRI exams, which to our knowledge has not been previously reported.

## Patients and Methods

This study was approved by our institutional review board. We performed a search of our radiology report database from January 2014 through December 2017 using the key words “sacral insufficiency fracture” and “lumbar spine MRI.” A cohort of 57 patients (48 female; age range, 14 to 89 years) was generated. Medical charts were reviewed for history of radicular symptoms. As this was a retrospective analysis of observational data, informed consent was waived.

All patients underwent noncontrast lumbar spine MRI on either a 1.5- or 3.0-Tesla system (GE Medical Systems, Waukesha, WI, USA), using a standardized institutional protocol, which comprises sagittal T1- and T2-weighted sagittal inversion recovery and coronal T2-weighted sequences. In addition, three sets of axial T2-weighted stacks, without a slice gap, were plotted parallel to the intervertebral discs.

Two fellowship-trained musculoskeletal radiologists independently reviewed the MRI studies of each subject. The studies were presented in random order, and the readers were blinded to symptomatology.

SIF was confirmed by the presence of marrow edema pattern in the sacral ala and an underlying vertically oriented fracture line (Fig. 1). Healed, chronic SIFs without marrow edema pattern were excluded from the study. SIFs of a purely transverse orientation were also excluded as we found that no transverse fractures resulted in LSRP.

We recorded the presence of LSRP, reflected by elevated T2-weighted or short tau inversion recovery (STIR) signal intensity and enlargement of the nerve, and the presence of nerve displacement, reflected by periosteal thickening overlying the sacral fracture site (Fig. 1). MRI scans were also evaluated for the presence of disc herniation, central or neural foraminal stenosis, or synovial cyst formation that could have resulted in nerve root impingement at each motion segment from L1–L2 to L5–S1.

## Results

The two radiologists demonstrated an excellent level of agreement in assessing enlargement of the nerve relative to the contralateral side (although in some cases there was bilateral involvement) and in assessing signal hyperintensity of the nerve, with perfect inter-observer reliability ( $\kappa = 1.0$ ).

Of the 57 patients with SIF, 19 (33%) had MRI findings suggestive of LSRP involving either the extraforaminal L5 nerve root or lumbosacral trunk, and four patients had abnormality of the L5 nerves bilaterally, for a total of 23 cases of LSRP. Of the 23 cases, 19 (82.6%) had corresponding radicular symptoms, and in 16 cases (69.6%) there was no explanation for radicular symptoms other than SIF. In three

patients, the cause of LSRP was indeterminate as the patients had an ipsilateral disc herniation, foraminal stenosis, or synovial cyst formation that could have also explained symptoms. Four of the 23 patients had MRI features of LSRP with no corresponding symptomatology.

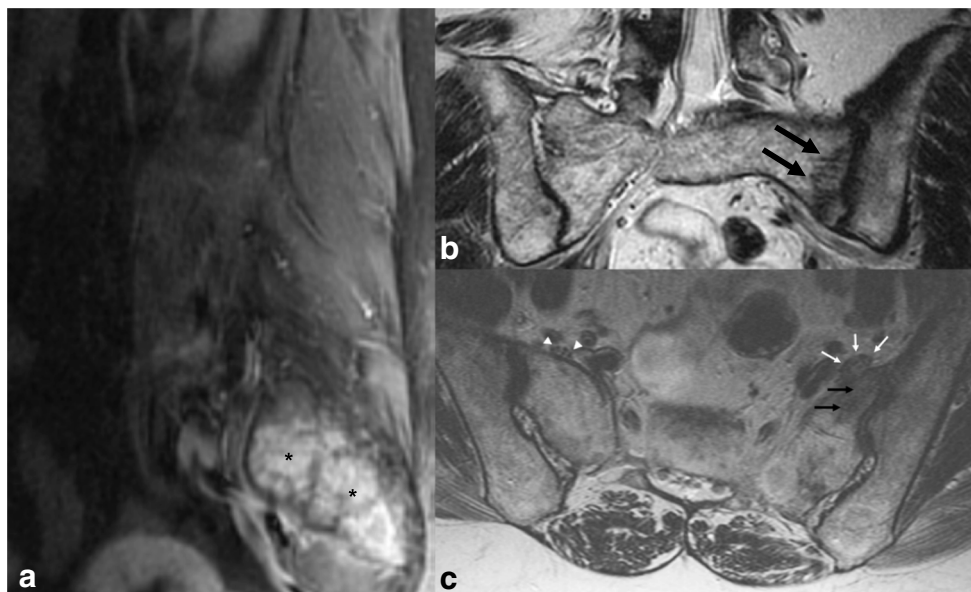
## Discussion

This study aimed to determine the frequency of LSRP associated with SIF, as seen on MRI of the lumbar spine, in a retrospective analysis of a group of patients with vertically oriented fractures. We demonstrated a high prevalence of L5 nerve root or lumbosacral trunk involvement in cases of SIF, which may be attributed to either adjacent soft tissue periosteal reaction or callus formation that impinged or ventrally displaced the nerves.

We acknowledge several study limitations. First, electrodiagnostic testing was not routinely performed to confirm patients’ radiculopathies; however, electrodiagnostic testing has been shown to have low sensitivity in the diagnosis of LSRP, and those abnormalities that are detected can often be detected on physical exam [14]. Second, among the 23 nerves that appeared abnormal on MRI in our study, in four cases there were no corresponding signs of LSRP on physical examination. Therefore, reports should be carefully worded to state that the abnormal nerve findings may suggest an underlying LSRP and are to be correlated with symptoms. Finally, the patient cohort was identified by reviewing lumbar spine MRI reports for the term “sacral insufficiency fracture.” In order to further pinpoint the frequency of LSRP related to SIF as seen on lumbar spine MRI, a review of all lumbar spine MRI exams would need to be performed over a designated time period.

Linstrom et al. classified SIFs as oriented either vertically or transversely [11]. Vertically oriented fractures involve only the sacral ala, whereas transverse fractures traverse the sacral body. Denis et al. described “zone 1” fractures in the region of the sacral ala, which were at times associated with injury to the L5 nerve root [5]. No Denis “zone 2” fractures, defined as fractures that traverse the sacral neural foramina, were included in this study. In our series, all sacral fractures with concomitant MRI findings of LSRP had a purely vertical orientation. We excluded SIFs with purely transverse patterns from this cohort as such fractures would not be expected to result in LSRP. Variations in lumbosacral plexus formation exist that could lead to patients presenting clinically with LSRP at two adjacent levels; the reported prevalence of variations (encompassing conjoined nerve roots or nerve roots coursing through the same neural foramen) ranges from 1.3 to 14% [1, 4, 8, 17]. None of our cases, however, presented with such variant anatomy.

Our lumbar spine MRI protocol includes a sagittal inversion recovery sequence, which, importantly, extends laterally to involve portions of the sacral ala. If the technologist recognizes a bone marrow edema pattern in the sacrum, a supervising radiologist is contacted. At his or her discretion, a dedicated oblique coronal STIR sequence of the sacrum is performed to



**Fig. 1.** Lumbar spine magnetic resonance imaging (MRI) scans of a 53-year-old patient with left-sided radiculoplexopathy. Sagittal inversion recovery (a) and coronal T2-weighted MR images (b) demonstrate stress reaction (a, asterisks) related to a vertically oriented left sacral insufficiency fracture (SIF) (b, arrows). An axial T2-weighted MRI scan (c) demonstrates the SIF (black arrows) and enlargement of the overlying enlarged left lumbosacral trunk (white arrows), as compared with the normal appearance of the right lumbosacral trunk (arrowheads).

evaluate the L5 nerve root or lumbosacral trunk adjacent to the anterior cortex of the sacrum. Although not part of our lumbar spine MRI protocol, fat-suppressed images in the oblique axial plane are also sometimes helpful for evaluating signal characteristics of the involved lumbosacral plexus (Fig. 2). At our institution, lumbar spine MRI also includes a large-field-of-view coronal T2-weighted pulse sequence, allowing for the upper portion of the sacrum to be evaluated in another orthogonal plane.

In addition to providing a diagnosis for a patient's radicular signs and symptoms, we have found that the diagnosis of SIF can be particularly helpful in cases in which the patient has concomitant multilevel lumbar spondylosis and neural foraminal stenosis. Several of

our referring physicians have ordered lumbar spine MRIs in order to determine the appropriate level for epidural cortisone injection. In some cases, the diagnosis of SIF with MRI findings of LSRP has avoided unnecessary intervention.

In conclusion, LSRP caused by SIF is an entity all radiologists should be cognizant of, especially in cases of otherwise unexplained radicular symptoms.

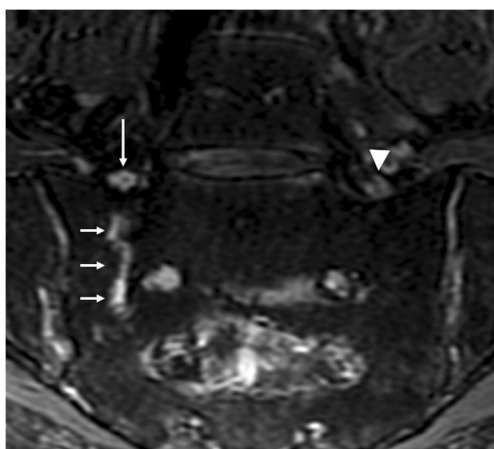
#### Compliance with Ethical Standards

**Conflict of Interest:** The authors declare that they have no conflict of interest.

**Human/Animal Rights:** All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

**Informed Consent:** Informed consent was waived for all patients included in this study.

**Required Author Forms** Disclosure forms provided by the authors are available with the online version of this article.



**Fig. 2.** Oblique coronal T2-weighted fat-saturated MRI of a 57-year-old patient with right-sided radiculopathy demonstrates vertically oriented sacral insufficiency fracture (short white arrows), with hyperintensity of the overlying right lumbosacral trunk (long white arrow), as compared to the normal appearance of the left lumbosacral trunk (arrowhead).

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