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Images

Imaging of Spondylolysis: The Evolving Role of Magnetic Resonance Imaging

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Introduction

The pars interarticularis is a small but important component of the posterior element structures located at the junction of the pedicle, lamina, and inferior and superior articular facet (Figure 1). This structure is subject to a significant amount of force that is transmitted from the vertically oriented lamina to the horizontally oriented pedicle [1-3].

Spondylolysis refers to a defect of the pars interarticularis and reflects a common source of back pain in certain cohorts [4]. Several theories have been postulated to explain the underlying pathophysiology responsible for the pars interarticularis defect [5,6]. The most commonly accepted mechanism is repetitive loading resulting in a fatigue fracture [5]. The injury has been described as a continuum, with stress reactions at one end of the spectrum and chronic nonunion at the other [7].

The incidence of lumbar spondylolysis in adulthood in the general population is approximately 6% and varies depending on ethnicity, gender, and activity [6,8]. The frequency of finding spondylolysis in young athletes with low back pain is much greater, ranging from 11% to 52.6% [5,7,9].

The predominant clinical manifestation of spondylolysis is localized pain. Bilateral spondylolysis can result in spondylolisthesis, easily identified on a lateral lumbar radiograph. However, the diagnosis of acute spondylolysis at the early, stress reaction stage can be challenging. The early detection of spondylolysis is paramount to maximize chances of bony repair and to avoid chronic nonunion and spondylolisthesis [3,10]. Early fractures and stress reactions have a superior prognosis than chronic complete fractures [7]. A high degree of clinical suspicion is required, supported by the use of the most appropriate spinal imaging. This Images column will review the various imaging techniques available for assessing acute lumbar spondylolysis with emphasis on the evolving role of magnetic resonance imaging (MRI).

Imaging

Radiography

Radiographs often serve as the primary imaging modality for the evaluation of low back pain. Although radiographs can readily identify a vertebral slip, pars fractures alone are often difficult to identify [7,10]. In addition, bone marrow edema cannot be assessed on radiography, negating the ability to identify early-stage disease [10], as well as separate an active spondylolysis from an inactive chronic nonunion.

Because evaluation of the pars interarticularis is often suboptimal on routine views of the spine, additional views can be acquired to further characterize, but at the expense of ionizing radiation to a young patient population and with little improvement in sensitivity. These added views include a 45° lateral oblique projection, frontal projection with 30° cranial angulation, and 40° lateral oblique projection with 30° cranial angulation [11-15]. The 45° lateral oblique angle is theoretically transverse to the pars interarticularis, which produces the classic Scottie dog appearance that has been described in the literature, where the pars interarticularis represents the neck of the dog (Figure 2) [15].

Notably, Saifuddin et al [15] compared various radiograph projections with computed tomography (CT) and found that only 32% of the confirmed pars defects were apparent on radiographs that used ancillary lateral oblique views. As such, despite the availability of various projections, radiographic evaluation for suspected spondylolysis remains suboptimal on multiple levels. When the defect is perceptible, the characteristic finding of spondylolysis on radiographs is a linear radiolucency through the pars interarticularis, with or without spondylolisthesis of the involved vertebra (Figure 2).

Nuclear Imaging

Historically, patients without a perceptible pars defect on radiographs, but with persistent clinical

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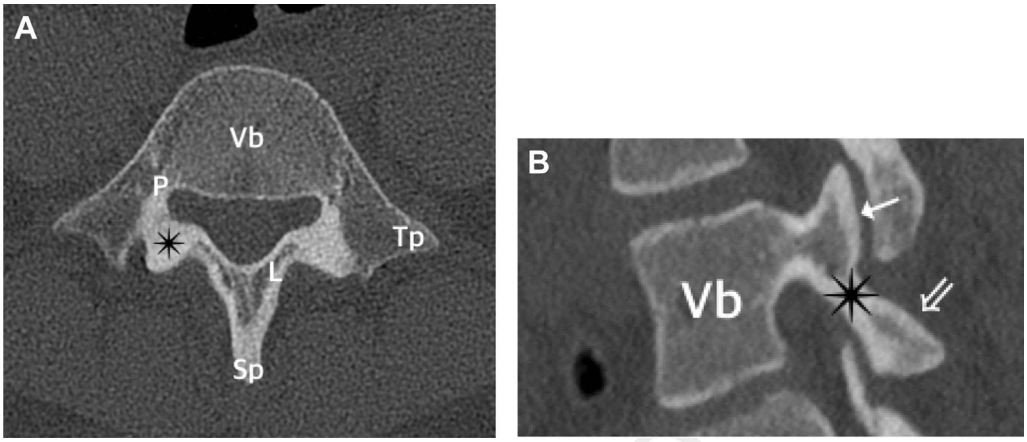

Figure 1. Normal vertebral anatomy at the lumbar spine on computed tomography (CT). Axial (A) and sagittal (B) CT images demonstrate normal configuration of the lumbar vertebral arch with an asterisk denoting the intact pars interarticularis flanked by the superior (closed arrow) and inferior (open arrow) articular facets. Vb, vertebral body; P, pedicle; Tp, transverse process; L, lamina; Sp, spinous process.

concern for spondylolysis, have been evaluated with nuclear scintigraphy. Nuclear imaging for spondylolysis uses planar bone scintigraphy with technetium-99m diphosphonate [16].

Radiopharmaceuticals targeting bone are analogs of calcium, hydroxyl groups, or phosphate, which are readily taken up by the bone. Active bone turnover, such as in cases of acute fractures or stress reaction, results in increased radiotracer uptake [16].

Planar imaging can be further enhanced with the use of single-photon emission tomography (SPECT). SPECT uses a gamma camera to acquire multiple 2-dimensional images from multiple angles. A tomographic reconstruction algorithm is then applied to the images, resulting in 3-dimensional data for review. SPECT imaging is more sensitive at identifying a pars defect when compared with planar imaging [5,6,17] (Figure 3). SPECT is useful in the identification of early pars stress reactions and

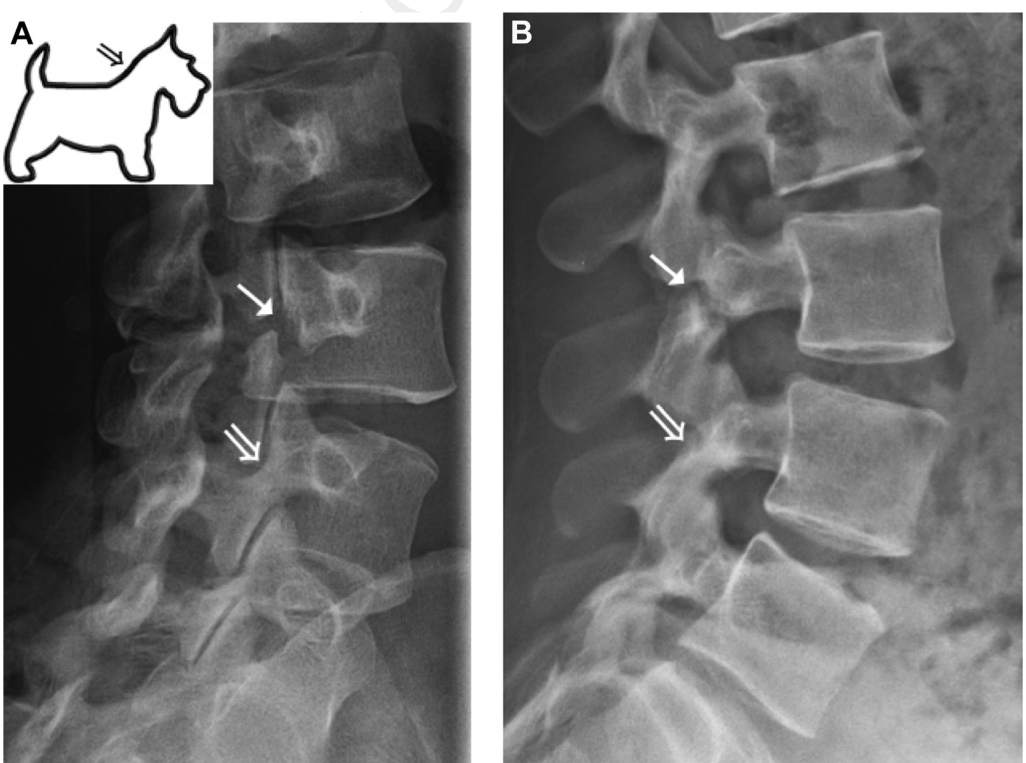

Figure 2. Right-sided pars interarticularis defect at L3 (closed arrow) on oblique (A) and lateral (B) radiographs of the lumbar spine. A normal right L4 pars interarticularis is marked with an open arrow on the radiographs and on a representative artistic rendition of the Scottie dog.