Magnetic resonance imaging of lumbar vertebral apophyseal ring fractures

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SUMMARY

Posterior lumbar vertebral apophyseal ring fractures are described in three adolescents presenting with severe low back pain, spinal tenderness and lower limb neurological deficit. Magnetic resonance imaging showed severe L4/5 posterior disc protrusion in all three patients. The actual fracture fragment was visualized with difficulty on MRI alone. The diagnosis of apophyseal ring fracture was made by either radiography or CT. Computed tomography delineated the size, shape and site of the fracture fragment. Surgical confirmation was obtained in all cases. Posterior lumbar vertebral apophyseal ring fractures may be difficult to visualize on MR imaging. Careful review of radiographs, supplemented by targeted CT, is necessary for the correct diagnosis and management of this entity.

Key words: avulsion fractures; computed tomography; limbus vertebral fractures; lumbar spine; magnetic resonance imaging.

INTRODUCTION

Fracture of the posterior lumbar vertebral ring apophysis is an uncommon condition that is typically found in adolescents and young adults. These fractures occur at the margins of the superior and inferior vertebral end plates, where fusion between the osteocartilaginous ring apophysis and the adjacent vertebral body is usually incomplete until the age of approximately 20 years. It is important to be able to diagnose this entity and to make a differentiation from simple disc protrusion, because the affected patient would benefit from operative treatment. The imaging features of three adolescents with surgically confirmed posterior lumbar vertebral apophyseal ring fractures are described.

CASE REPORTS

Case 1
A 10-year-old girl presented with a 2-week history of severe low back pain. She did not recall a precipitating event and enjoyed good past health. On examination, she was noted to have pelvic tilting, with truncal shift on forward bending, and left loin firmness. Straight leg raising (SLR) was 60° bilaterally, both lower limb jerks were brisk and muscles of both the L3 myotomes were weak (grade 3/5 power).

Radiographs showed loss of normal lumbar lordosis, with mild scoliosis. Intervertebral disc space heights were preserved with no detectable fracture fragment (Fig. 1a). Magnetic resonance imaging demonstrated severe L4/5 disc protrusion. Although no fracture fragment was apparent, the supero-posterior corner of the L5 vertebral end plate was truncated (Fig. 1b,c). Computed tomography at the L4/5 disc level, using 3-mm-thick contiguous sections with 1 mm overlapping reconstructions, showed a central curvilinear bony fragment arising from the L5 superior end plate. Its relationship to the disc protrusion and L5 corner truncation was particularly well demonstrated on reconstructed sagittal images (Fig. 1d,e). The L4/5 discectomy and fracture fragment removal were performed, with complete resolution of the patient’s pre-operative signs and symptoms.

Case 2
A 14-year-old male gymnast landed heavily on a springboard, resulting in severe low back and bilateral calf pain, aggravated by walking and sitting. On examination, he had marked lower lumbar localized tenderness and paravertebral muscle spasm. Straight leg raising was limited to 40° bilaterally and the
Fig. 1 Case 1. (a) Radiograph shows possible L5 corner truncation but no bony fragment. Sagittal MR (b) spin echo T1 (TR500, TE13) and (c) fast spin echo T2 (TR2500, TE108) images show a large L4/5 disc protrusion (arrowheads). (d) Axial and (e) sagittal reformatted CT images demonstrate the upper L5 apophyseal ring fracture fragment (arrowheads). Supero-posterior L5 corner truncation is seen on the sagittal MR (Fig. 1b,c) and CT (Fig. 1e) images. (5 = L5 vertebral body.)

Fig. 2 Case 2. (a) Radiograph shows a bony fragment (arrowed) posterior to the upper L4/5 disc. (b) The fragment is not apparent on sagittal fast spin echo T2 (TR3500, TE120) images, which show a large L4/5 disc protrusion (arrowheads).
muscles of both L5 myotomes were weak (grade 4/5). Sensation and reflexes were normal.

Radiographs showed a small bony fragment lying in the spinal canal posterior to the L4/5 disc level (Fig. 2a). Magnetic resonance imaging demonstrated mild loss of height and T2 signal of the L4/5 disc, with severe central disc protrusion compressing both L5 nerve roots. The bony fragment was not visible, though the infero-posterior corner of the L4 vertebral body appeared slightly truncated (Fig. 2b). L4 laminectomy, L4/5 discectomy and fracture fragment removal was performed 2 weeks later. Postoperatively, he made a complete recovery.

Case 3
A 19-year-old male presented with severe low back pain, right sciatica, and right foot drop and numbness. His symptoms developed following a weightlifting session 9 months previously and he had undergone conservative management without improvement. On examination, the lower lumbar spine was tender from the L3 to the S1 levels. Straight leg raising was 40° on the right and normal on the left side. Lower limb reflexes were brisk bilaterally. The anterior compartment of the right leg was wasted, with grade 4/5 weakness of the muscles of the right L5 myotome and sensory loss of the right L5 dermatome.

Radiographs were normal, with no fracture fragment detected. Magnetic resonance imaging demonstrated moderate central L3/4 and L5/S1 disc protrusions. There was severe right postero-lateral L4/5 disc protrusion, with compression of the right L5 nerve root (Fig. 3a,b). Computed tomography performed through each disc from L3 to S1, using 3-mm-thick contiguous scans with 1.5 mm overlapping reconstructions, showed a small 5 mm curvilinear bony fragment adjacent to the right supero-lateral L5 vertebral end plate (Fig. 3c). This fracture fragment corresponded closely in site to the disc protrusion shown on MR imaging. L3/4, L4/5 and L5/S1 posterior discectomies and fenestrations, together with removal of the fracture fragment, were performed. There was immediate postoperative improvement of right foot numbness, low back pain and sciatica. To date, he continues to have persistent right L5 myotome weakness.

DISCUSSION
Lumbar vertebral apophyseal ring fractures are rare, with approximately 130 cases having been reported to date. Just over a quarter of these cases were adolescents and the rest were adults aged up to 44 years. The osteocartilaginous ring apophysis represents a weak point in the immature vertebra which makes it prone to fracture, while in adults fracture occurrence is explained by delayed fusion of the apophysis to the adjacent vertebral body. Clinical presentations include back pain, muscle spasm and signs of nerve entrapment. Up to half of the reported cases had a history of precipitating trauma, including gymnasts and weightlifters, such as two of our patients. Lumbar apophyseal ring fractures have been classified into four types, with this categorization being found to be helpful in planning surgical excision of the lesions. At surgery, the fracture fragment is often not visible and the lesion may have the appearance of a simple disc protrusion. In patients with vertebral apophyseal ring fractures, the excision of the prolapsed disc needs to include the removal of the associated bony fragment for complete decompression. The association between vertebral apophyseal ring fracture and posterior disc protrusion is due to the relative weakness of the osteocartilaginous junction of the ring apophysis and its firm attachment to the annulus fibrosis by Sharpey’s fibres.

Diagnosis of posterior lumbar vertebral ring fractures cannot be readily made on radiographs. The fracture fragment may be seen as a wedge-shaped bony density, usually located posterior to the vertebral body just cranial to the level of the intervertebral disc. On myelography, an extradural defect or a complete block is frequently present. Computed

Fig. 3 Case 3. (a) Right parasagittal spin echo (SE) T1 (TR500, TE10) image demonstrates severe L4/5 disc protrusion (arrow). Moderate L3/4 disc protrusion is also noted. (b) Axial SE T1 (TR820, TE13) image confirms a right-sided disc protrusion. (c) The curvilinear focal fracture fragment (arrowhead) is clearly demonstrated on the three-dimensional CT image.
tomography is the definitive method for demonstration of ossified apophyseal ring fractures. The site, shape and size of the bony fragment, as well as the presence and extent of the posterior rim vertebral defect, can be clearly defined. Detailed classification of apophyseal fracture subtypes would not be possible without CT. The use of spiral CT to obtain thin-section slices (of 3 mm thickness or less), with overlapping reconstructions and reformatted sagittal or three-dimensional (3-D) images, optimizes lesion visualization. Soft-tissue settings are useful for showing the relationship of the bony fragment to the associated disc protrusion.

The MR appearances of lumbar apophyseal ring fractures were first described by Rothfus et al. in 1990. They suggested that features such as discontinuity and truncation of the postero-inferior vertebral body, displacement of a low-signal avulsed fragment and disc protrusion subjacent to the fragment may be characteristic, hence eliminating the need for other diagnostic studies. However, contrary opinions have since been expressed in two subsequent papers in which MR scans were utilized. From our own experience of three patients, we believe that unless a large fragment containing marrow is present, the avulsed apophyseal fracture may be difficult to detect on MR imaging. Because the fracture fragment is hypointense on all standard MR sequences, it will blend in with the hypointense disc annulus outer fibres and/or the posterior longitudinal ligament and therefore it will appear invisible.

We recommend that if severe lumbar disc protrusion is demonstrated during MRI of an adolescent or young adult with low back pain, a careful search should be made for the signs of apophyseal ring fractures described here, particularly vertebral body posterior corner truncation. Radiographs should be carefully reviewed and, if necessary, supplemented by targeted CT, to confirm the diagnosis. Awareness of this entity and the potential pitfalls of its MR appearances will ensure implementation of the correct surgical management.

REFERENCES
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