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CASE REPORT

Usefulness of Fast Field Echo Resembling a CT Using Restricted Echo-Spacing (FRACTURE) in Pediatric Lumbar Spondylolysis: A Case Report

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Abstract: Multiple computed tomography (CT) scans are required to diagnose lumbar spondylolysis stage and confirm fusion degree. However, multiple CT scans should be avoided because of radiation exposure. There are no case reports of complete diagnosis and treatment of pediatric lumbar spondylolysis without the use of CT. Fast field echo resembling a CT using restricted echo-spacing (FRACTURE) is a magnetic resonance imaging (MRI) sequence used to evaluate bone lesions. Here we report the case of a pediatric patient with lumbar spondylolysis who was able to return to sports after diagnosis, treatment, and bone union confirmation using MRI and FRACTURE.

Keywords: fast field echo resembling a CT using restricted echo-spacing, FRACTURE, lumbar spondylolysis, magnetic resonance imaging

Introduction

Multiple computed tomography (CT) scans have traditionally been required to identify lumbar spondylolysis stage and confirm fusion degree. However, multiple CT scans should be avoided, particularly in children, because of the risk of radiation exposure. Fast field echo resembling a CT using restricted echo-spacing (FRACTURE) is a magnetic resonance imaging (MRI) sequence that is used to evaluate bone lesions.[1] A FRACTURE image was created by adding images captured in similar sequences and subtracting the final image. Here we report the case of a pediatric patient with lumbar spondylolysis who was able to return to sports after diagnosis, treatment, and bone union confirmation using MRI with FRACTURE.

Case Report

A 13-year-old male right-handed soccer player belonging to the Japan Football Association Academy in Fukushima, Japan, was admitted to our hospital. His medical history was unremarkable. At the time of his first visit to our hospital, he presented with a 1-week history of low back pain. A physical examination revealed that his lower back pain was induced by anteroposterior lumbar flexion and performing the left Kemp's test. Lumbar spondylolysis was suspected, and plain radiography and MRI with a FRACTURE sequence were performed.

Plain radiography of the lumbar spine revealed no apparent spondylolysis (Figure 1a). The age of the vertebral body was determined at the apophyseal stage. Lumbar spine MRI revealed no compression of the dura was observed (Figure 1b), changes in both pedicles of the L4 vertebra, with a low signal on T1-weighted images and a high signal on short-tau inversion recovery (STIR) (Figures 1c and 2a). An unclear fracture line on the right side and a partial fracture line on the left side were observed on FRACTURE images (Figures 1d and 2a). Based on the above observations, we diagnosed L4 spondylolysis and determined that the right side was in an advanced stage and the left side was in an early stage.

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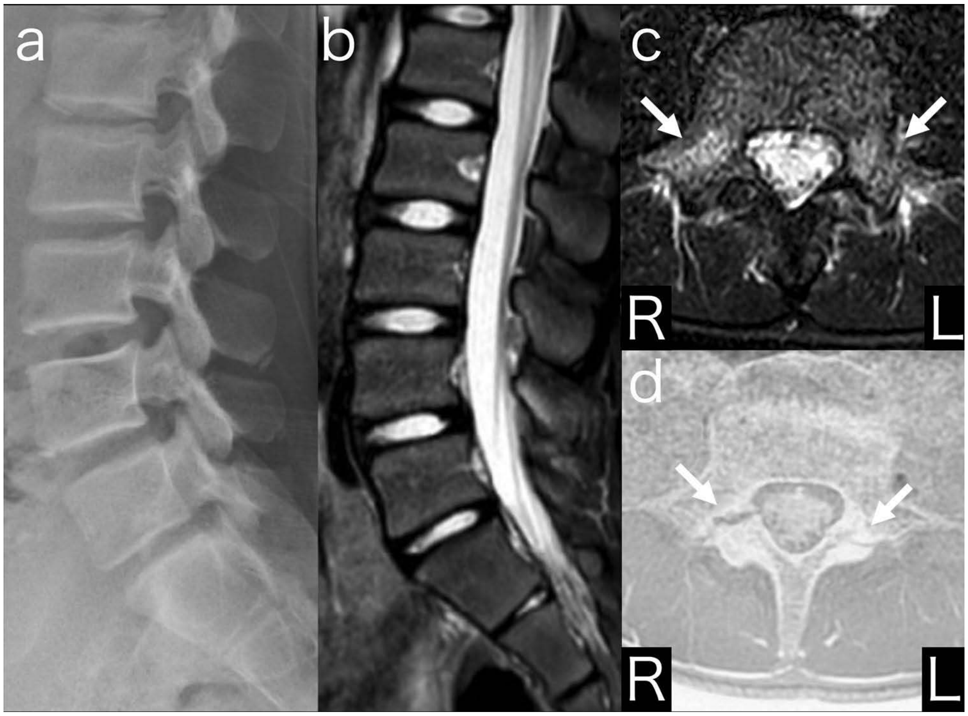

Figure 1 Lumbar spine radiograph and MRI taken at first visit. Lateral-view plain radiography and sagittal STIR-MRI showed no obvious spondylolysis and an apophyseal bone stage (**a** and **b**). Axial STIR-MRI showing high signal intensity (white arrows) in both L4 pedicles (**c**). Axial fast field echo resembling a CT using restricted echo spacing MRI shows fracture lines (white arrows) on both L4 pedicles (**d**).
Abbreviations: MRI, magnetic resonance imaging; STIR, short-tau inversion recovery.

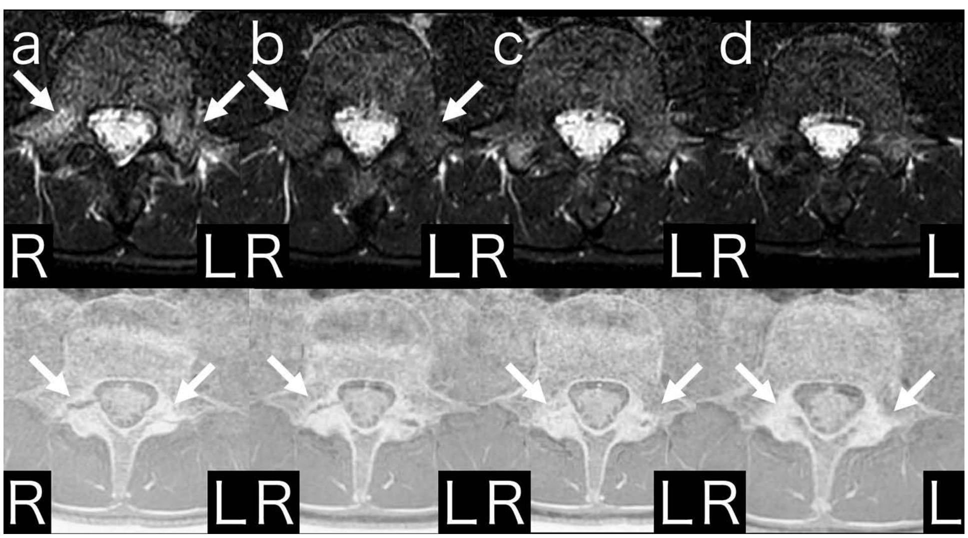

Figure 2 Progression of MRI images (upper row: STIR horizontal view; lower row: FRACTURE horizontal view). STIR-MRI showing hyperintense changes (white arrows) in both pedicles and FRACTURE-MRI showing spondylolysis (white arrows) at the pars at the first visit (**a**). Signal changes in both pedicles disappeared (white arrows), and partial fusion of the right-side fractured segment was observed (white arrow) after 12 weeks (**b**). Bone union of both fractured segments was observed (white arrows) after 5 months (**c**). After 10 months, no recurrence was observed (white arrows) (**d**).
Abbreviations: FRACTURE, fast field echo resembling a CT using restricted echo spacing; MRI, magnetic resonance imaging; STIR, short tau inversion recovery.

A rigid corset was created to treat the bone union. Exercise therapy was administered according to our hospital's lumbar spondylolysis protocol. This protocol focuses on strength training using an individual's body weight, with jogging initiated after 8 weeks and a return to active sports after 12 weeks. Strength training focused on stabilization, isometric training for the first 6 weeks, and movement training for the latter 6 weeks.

When MRI was performed 12 weeks after the first visit, the signal changes observed earlier in both pedicles disappeared, and the FRACTURE results confirmed partial fusion of the right-sided fractured segment (Figure 2b). Therefore, we extended the protocol until bone union was confirmed. Five months after the initial diagnosis, bilateral bone union was confirmed using FRACTURE imaging (Figure 2c), and the patient returned to soccer after 6 months. Since then, no recurrence has been observed, and 4 months have elapsed since the patient returned to playing soccer (Figure 2d).

Discussion

Previous reports have shown a high degree of agreement between FRACTURE and CT radiographic image analysis for detecting bone fractures.[2] Conventionally, in the diagnosis and monitoring of the progression of lumbar spondylolysis, CT imaging is required to accurately determine spondylolysis stage and bone union degree. At least two CT scans are required: the first to confirm the diagnosis and the second to confirm bone union. Each CT scan carries a radiation exposure of 5–30 mSV.[3] Every time a CT scan is performed to confirm fusion, there is a risk of radiation exposure or organ damage. FRACTURE allows the evaluation of cortical bone without radiation exposure;[4] however, to the best of our knowledge, there are few reports on its use in clinical practice. Based on our experience treating this patient, the application of FRACTURE allowed us to evaluate bone fracture without CT and the concomitant radiation exposure.

Other MRI methods have also been used to confirm bone union. These include black bone imaging,[5] ultrashort-echo time sequence (UTE),[6] and zero-echo time sequence (ZTE).[7] Black bone imaging provides improved soft-tissue/bone contrast by suppressing both fat and water to obtain a uniform soft-tissue background and reduced signal for the cortical bone. By inverting the black-and-white signals of the black bone image, the cortical bone attains a high signal intensity and is used as a CT-like radiograph. The greatest advantage of this method is its versatility, which allows it to be used in any MRI device. The disadvantage of this technique is that the boundary between bone and air becomes unclear. UTE and ZTE collect signals directly from the cortical bone, and their findings correlate best with those of CT scans. However, each requires special hardware such as high-performance coils for rapid switching between the transmitter and receiver coils.[8]

FRACTURE has the advantages of high spatial resolution obtained in a short time while maintaining a high signal-to-noise ratio and almost no restrictions on hardware or software.[8] However, only a limited number of facilities use the Philips FRACTURE sequence. That being said, FRACTURE sequences can be imaged using all MRI scanners from other companies; however, this requires considerable time. The FRACTURE sequence devised by Philips is equipped with artificial intelligence that can save time and capture images quickly.[9] Another drawback of FRACTURE is that bones and calcifications are not the only substances depicted as high signals; if this caveat is not considered while interpreting FRACTURE images, a user may make an incorrect diagnosis.[10] Future studies with more cases are required to validate the usefulness of FRACTURE for evaluating patients with lumbar spondylolysis.

Here we reported the case of a pediatric patient with lumbar spondylolysis who was able to return to sports after receiving a diagnosis, appropriate therapy, and bone union confirmation using MRI with FRACTURE, a specialized MRI sequence used to evaluate bone lesions, diagnose lumbar spondylolysis, and confirm bone fusion.

Ethics Approval and Informed Consent

The patient and his parents were informed that data from the case would be submitted for publication, and the parents gave consent. IRB approval was not required to publish this case report.

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Disclosure

The authors report no conflicts of interests.

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