Causes of Radiculopathy in Young Athletes With Spondylolysis

Causes of Radiculopathy in Young Athletes With Spondylolysis

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Background: The main clinical symptom of lumbar spondylolysis is lower back pain. Radiculopathy rarely occurs without vertebral slippage.

Hypothesis: Spondylolysis in young athletes can cause lumbar radiculopathy.

Study Design: Case series; Level of evidence, 4.

Methods: Ten patients (7 males and 3 females) were included in this study. The age of the patients ranged from 12 to 27 years. We employed plain radiography, computed tomography, magnetic resonance imaging, and selective radiculography if needed.

Results: The pathomechanism was classified into nonspondylolytic radiculopathy (3 cases) and spondylolytic radiculopathy (7 cases). In the nonspondylolytic group, 1 patient had a juxta-facet cyst at L4-5 and 2 patients had a herniated nucleus pulposus. In the other group, spondylolytic-related factors caused radiculopathy, and spondylolysis was in the early or progressive stage in all 7 patients. Radiologic findings indicated that radiculopathy was caused by extraosseous hematoma or edema in the vicinity of the fracture site. The radiculopathy disappeared within a month of nonoperative management, and radiologic abnormalities disappeared 3 to 6 months later.

Conclusion: Radiculopathy can occur together with lumbar spondylolysis without slippage in young athletes. We propose extraosseous hematoma or edema at the site of spondylolysis as the unique pathomechanism causing radiculopathy in young athletes. Radiculopathy is rare in athletes with spondylolysis. Magnetic resonance imaging is a useful tool to clarify the pathologic changes that induce the radiculopathy for both spondylolytic and nonspondylolytic factors.

Keywords: spondylolysis; radiculopathy; hematoma; children

Lumbar spondylolysis is stress fracture at the pars interarticularis[16,17,20] that usually occurs at the level of L5 (K Sairyo et al, unpublished data, 2008). The main clinical symptom of lumbar spondylolysis is lower back pain, and radiculopathy rarely occurs when there is no slippage, especially in children and adolescents.[2,3,9]

Radiculopathy sometimes occurs in senior or elderly patients. It has been reported that radiculopathy is induced by impingement of the nerve root by a so-called ragged edge, which is the hooklike osteophyte of the proximal end of the spondylolysis.[4,5,10,15,19] No other pathologic conditions that may cause radiculopathy in patients with lumbar spondylolysis without slippage, especially in the pediatric cases, have been reported as yet. However, we have previously reviewed 30 cases of lumbar spondylolysis without slippage in patients under age 18 years and found that 5 patients (17%) complained of radiculopathy (K Sairyo et al, unpublished data, 2008). None of these patients showed ragged-edge deformity on CT scans. Thus, radiculopathy may not be so rare in the pediatric population as has been previously thought, and can be caused by a pathologic entity other than the ragged edge.

In this study, we reviewed the clinical records of 10 young athletes with lumbar spondylolysis and radiculopathy to analyze the pathogenesis. They were all very active young athletes under age 27 years. On the basis of our results, we classified the pathomechanism into 2 categories. Furthermore, we identified extraosseous hematoma or edema in the vicinity of the stress fracture site as a possible cause of radiculopathy in young patients with spondylolysis.

PATIENTS AND METHODS

Ten young athletes were included in this study (Table 1). Their ages ranged from 12 to 27 years. There were 7 male and 3 female patients. The chief complaints were leg pain (radiculopathy) and back pain. Plain radiographs or CT scans revealed lumbar spondylolysis. According to the CT staging proposed by Fujii et al,[7] 5 patients were in the early stage, 2 were in the progressive stage, and 3 were in the terminal stage of spondylolysis.

As for the neurologic examinations, all showed positive results of the straight-leg raising test, indicating

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TABLE 1
Information on All Cases Including Gender, Age, Type of Sport, and CT Stage of the Spondylolysis

Case	Gender	Age, y	Sport	Stage of Lysis on CT
1	Male	27	Professional soccer	Terminal
2	Male	22	College golf	Terminal
3	Male	17	High school basketball	Terminal
4	Female	14	Middle school basketball	Progressive
5	Female	12	Middle school tennis	Progressive
6	Male	13	Middle school soccer	Early
7	Male	16	High school baseball	Early
8	Female	12	Middle school volleyball	Early
9	Male	15	High school soccer	Early
10	Male	13	Middle school baseball	Early

radiculopathy. Only 1 patient (case 1) had any neurologic deficit. This patient had paresthesia, abnormal sensation along the right L5 dermatome including the big toe.

The pathomechanism of the radiculopathy was investigated using plain radiographs, CT scans, and MR images. Selected radiculography was also conducted, when needed.

RESULTS

The pathomechanism was classified into nonspondylolytic radiculopathy and spondylolytic radiculopathy groups. The detail is described in Table 2.

There were 3 patients in the nonspondylolytic group. All of these patients had terminal-stage spondylolysis. The cause of the radiculopathy was identified to be an intraforaminal herniated nucleus pulposus (HNP) for case 1, an intracanal HNP in case 2, and juxta-facet cyst in case 3. Surgical intervention was required to reduce the pain for the patient who was case 3.

Figure 1 refers to case 1. The patient reported burning pain in the right leg and paresthetic sensation along the L5 dermatome. Bilateral terminal-stage L5 spondylolysis was identified on the CT scan; the defects did not have the ragged-edge osteophyte. Magnetic resonance images revealed an intraforaminal HNP at the level of L5-S1. To confirm the source of pain, selected radiculography of the right L5 nerve root was conducted with 1% Xylocaine, and complete pain relief was attained.

Figure 2 refers to case 3. The patient reported right leg pain. On the CT scan, bilateral terminal stage L5 spondylolysis was identified. The defects did not have the ragged-edge osteophyte. On MRI, a juxta-facet cyst at the level of L4-5 was revealed. Pain could not be controlled nonoperatively; thus, surgical removal was required.

There were 7 patients in the nonspondylolytic group. All defects were identified to be in the early or progressive stage on CT scan. Based on the MRI findings, the cause of the radiculopathy was suggested to be an extraosseous hematoma and edema at the site of the fracture. The extraosseous hematoma may irritate or stimulate the nerve root that passes by the fracture site.

TABLE 2
Pathomechanism of the Radiculopathy and CT Stage of the Spondylolysis[a]

	Stage on CT		
Mechanism	Early	Progressive	Terminal
Nonspondylolytic factor group			
HNP (far lateral)	0	0	1
HNP (intracanal)	0	0	1
Juxta-facet cyst	0	0	1
Spondylolytic factor group			
Extraosseous bleeding	5	2	0
Total	5	2	3

[a]HNP, herniated nucleus pulposus.

The clinical course for these 7 patients was very similar. They were all treated nonoperatively; that is, they were asked to stop practicing sports and to wear a brace. Within a month, the leg pain and low back pain disappeared. In all cases, the abnormal signal intensity on the MRI disappeared by around 3 to 6 months after the disappearance of pain.

Figure 3 refers to case 4. This patient was a 14-year-old female basketball player. She visited us with left leg pain and low back pain. The straight-leg raising test was positive at 70° on the left side. As shown in Figure 3A, a CT scan obtained at the initial consultation showed bilateral L4 spondylolysis in the progressive stage. The MRI performed at the first consultation revealed an abnormal signal around the fracture site (Figure 3B). Marrow edema was noted at the pedicle adjacent to the fracture. It was depicted by low signal on T1-weighted scan and by high signal on T2-weighted scan. Around the lamina, especially in the dorsal aspect, that abnormal signal spreads. A large area of very high signal intensity was observed on the T2-weighted MRI. The high signal area on T2-weighted scan was heterogeneously seen with isosignal and low signal on the T1-weighted image. The signal intensity indicated extraosseous hematoma or edema in the vicinity of the stress fracture site. This abnormal signal disappeared after 6 months of nonoperative management. The fracture

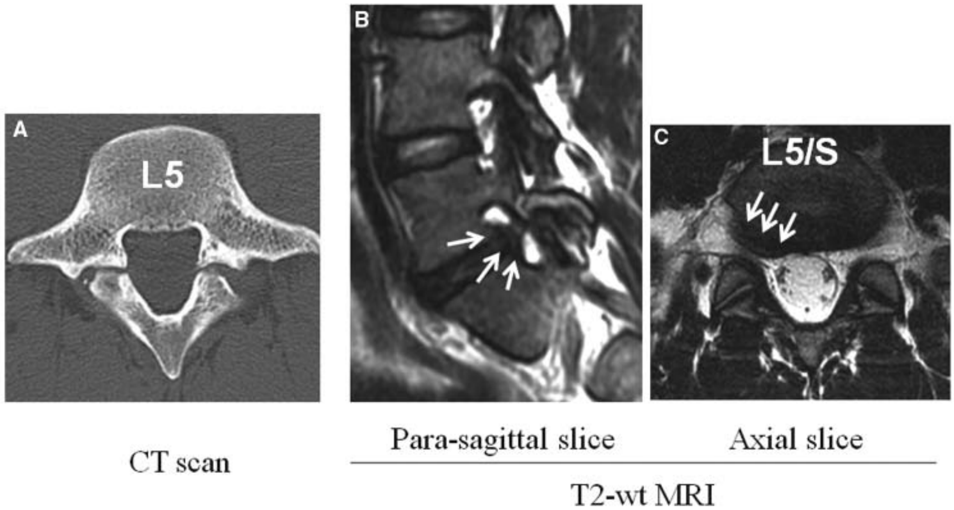

Figure 1. Case 1 is a 27-year-old man who is a professional soccer player. A, on the CT scan, bilateral terminal stage L5 spondylolysis is observed. The defects do not have the ragged-edge osteophyte. B and C, on MRI, an intraforaminal herniated nucleus pulposus at the level of L5-S1 is obvious (arrows).

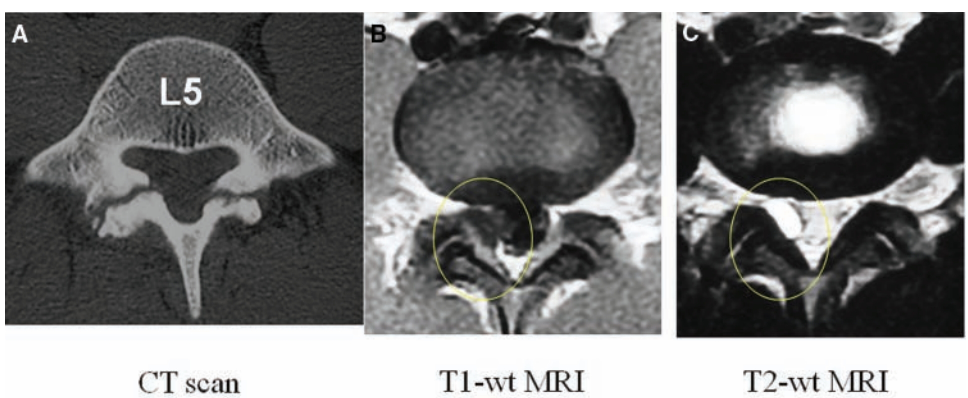

Figure 2. Case 3 is a 17-year-old boy who was a high school basketball player. A, on the CT scan, bilateral terminal stage L5 spondylolysis is identified. The defects do not have the ragged-edge osteophyte. B and C, on MRI, a juxta-facet cyst at the level of L4-5 is obvious (circle).

healed osseously after 7 months of nonoperative management (Figure 3A).

Figure 4 refers to case 5. This patient was a 12-year-old female tennis player. She visited us with left leg pain and low back pain. The straight-leg raising test was positive at 70° on the right side. As shown in Figure 4A, the CT scan at the initial consultation revealed bilateral L4 spondylolysis at the progressive stage. On MRI at the first consultation, an abnormal signal appeared around the fracture site (Figure 4B). Marrow edema is seen at the adjacent pedicle, which is depicted by low signal on the T1-weighted image and high signal on the T2-weighted image. An abnormal signal spreads around the lamina, especially in the dorsal aspect. On T2-weighted MRI, a large area of very high signal is observed. The high signal area on the T2-weighted scan is heterogeneously seen with isosignal and low signal on the T1-weighted scan. The signal intensity indicates extraosseous hematoma or edema that appeared in the vicinity of the stress fracture site. This abnormal signal disappeared after 6 months of nonoperative treatment. The fracture healed osseously at 6 months with nonoperative treatment (Figure 4A).

At present, in addition to T2-weighted MRI, we are obtaining T2-weighted fat saturation MRI, which can suppress the high signal from the fatty tissue. With this technique, extraosseous hematoma or edema is very easy to identify. Examples of CT and T2-weighted fat saturation MRI are presented in Figures 5 and 6.

DISCUSSION

We analyzed the causes of the radiculopathy in young athletes with lumbar spondylolysis. These causes can be

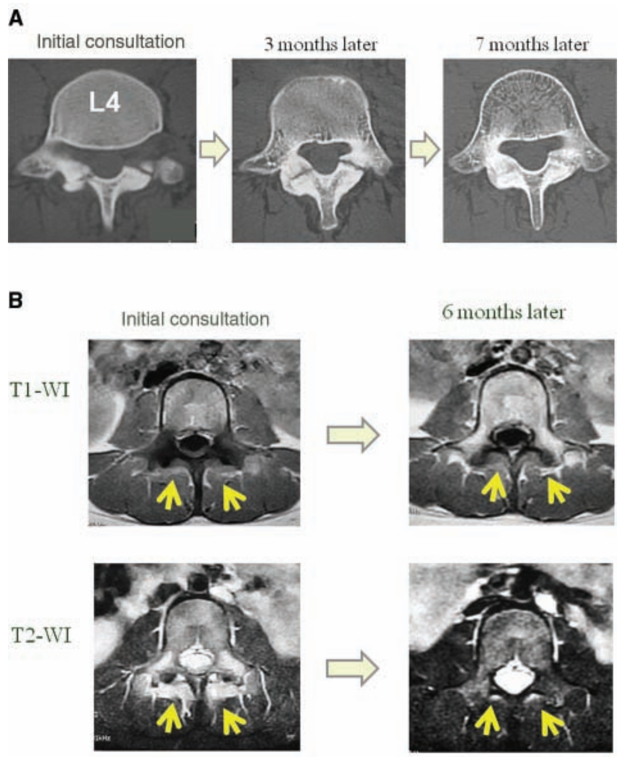

Figure 3. Case 4 is a 14-year-old female basketball player. A, CT obtained at the initial consultation shows bilateral L4 spondylolysis in the progressive stage. The fracture healed osseously after 7 months of conservative management. B, at the first consultation, an abnormal signal appeared around the fracture site on MRI. At the pedicle adjacent to the spondylolysis, marrow edema is seen, which is depicted by a low-signal intensity on T1-weighted and high-signal intensity on T2-weighted image (arrows). Abnormal signal extends around the lamina, especially in the dorsal aspect. On T2-weighted MRI, a large area of very high signal intensity is observed. This high signal intensity area on the T2-weighted scan is heterogeneously seen with isosignal and low signal on T1-weighted MRI. The signal intensity indicates extraosseous hematoma or edema that appeared in the vicinity of the stress fracture site. This abnormal signal disappeared after 6 months of nonoperative management.

divided into 2 major categories, nonspondylolytic and spondylolytic.

Nonspondylolytic Radiculopathy

In the category of nonspondylolytic radiculopathy, any space-occupying lesion of the neural canal can be included. In the present case series, 3 kinds of pathologic changes were identified: a tumorous condition (juxta-facet cyst), intracanal HNP, and intraforaminal HNP. Once spondylolysis occurs, a biomechanical alteration will follow. In terms of center of rotation during the lumbar motion, it has been reported that the center moves cranially after the occurrence of spondylolysis, compared with the intact spine.[14,18]

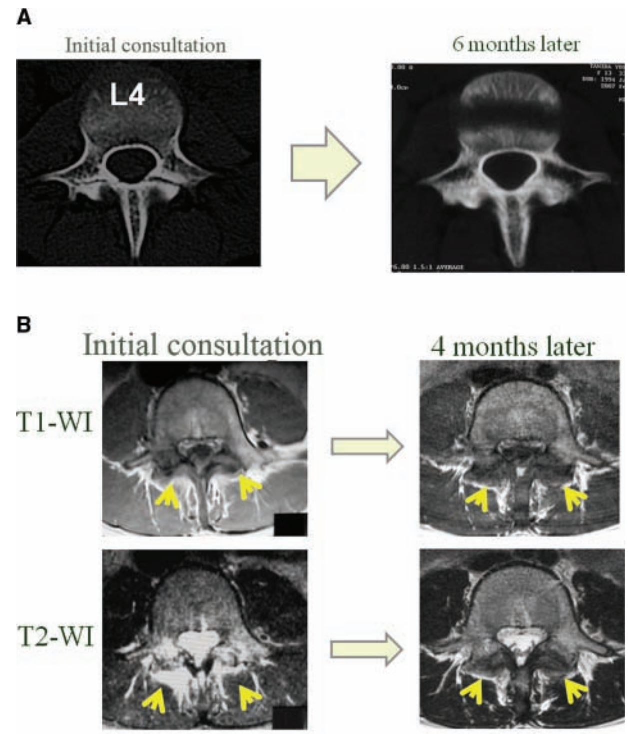

Figure 4. Case 5 is a 12-year-old female tennis player. A, a CT scan at the initial consultation reveals bilateral L4 spondylolysis at the progressive stage. The fracture healed osseously at 6 months with nonoperative treatment. B, on MRI at the first consultation, an abnormal signal appeared around the fracture site (arrows). Marrow edema is seen at the pedicle adjacent to the fracture, which is depicted by low-signal intensity on the T1-weighted image and high-signal intensity on the T2-weighted MRI. An abnormal signal extends around the lamina, especially in the dorsal aspect. On T2-weighted MRI, a large area of very high signal is observed (arrows). The high signal area on the T2-weighted scan is heterogeneously seen with isosignal and low signal on the T1-weighted scan. The signal intensity indicates extraosseous hematoma or edema that appeared in the vicinity of the stress fracture site. This abnormal signal disappeared after 4 months of nonoperative treatment.

Regarding disc stress during lumbar motion, Sairyo et al[13] clarified that biomechanically, stress increases at the cranial adjacent disc as well as at the caudal adjacent disc. They concluded that the increased stress in the disc adjacent to the spondylolysis may facilitate disc degeneration, and finally it may cause HNP. The present clinical results, together with the biomechanical investigation by Sairyo et al,[13] should increase awareness by surgeons of the concomitant occurrence of HNP as a nonspondylolytic factor when a spondylolytic patient displays radiculopathy.

Spondylolytic Radiculopathy

As for the spondylolytic cause of radiculopathy, numerous previous reports have indicated that osteophytes at the site

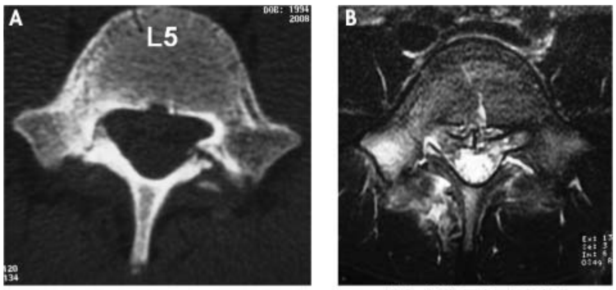

Figure 5. Case 6 is a 13-year-old boy who was a middle school soccer player. A, the CT scan shows L5 bilateral spondylolysis. The stage of the defect is early at the right side and progressive at the left. B, on T2-weighted fat suppression MRI, intraosseous involvement at the pedicle and an extraosseous abnormal image is clearly observed on the right side.

of spondylolysis sometimes compress the traversing nerve root and cause radiculopathy.[4,5,10,15,19] This lesion is the so-called ragged-edge impingement of the nerve root. In the present investigation, we found another type of lesion that can cause radiculopathy in young athletes. All 7 patients showed the following similar radiologic and clinical findings.

1. They had early or progressive stage of spondylolysis on CT.
2. Extraosseous hematoma and edema were revealed on MRI in the vicinity of spondylolysis.
3. The MRI abnormality disappeared at around 3 months.
4. Leg pain disappeared within a month of nonoperative management, as did the positive result of the straight-leg raising test.
5. No neurologic deficit was observed.

It has been reported that periosteal edema may appear around a stress fracture of long bones.[1,6,8] The edema usually does not cause additional problems if there is no neural tissue at the site. These previous reports have demonstrated edema in the stress fracture of the long bones, but periosteal edema has yet to be reported in the spine.[1,6,8]

Anatomically, the fracture site at the spondylolysis is close to the nerve root; thus, the ragged-edge osteophyte of the spondylolysis can easily compress the nerve root.[4,5,10,15,19] Similarly, the periosteal edema and hematoma at the fracture site can compress the traversing nerve root and cause radiculopathy. Based on the MRIs from all 7 cases in this study, periosteal edema at the stress fracture (spondylolysis) can be identified as the cause of the radiculopathy.

Magnetic resonance imaging of stress fracture of long bones[1,6,8] has revealed soft tissue abnormalities such as periosteal edema and hematoma around the fracture. Such soft tissue abnormalities could sometimes be misread as tumor or infection when the stress fracture line is not obvious. In the present study all 7 cases had the abnormal high-signal image on T2-weighted MRI that spreads

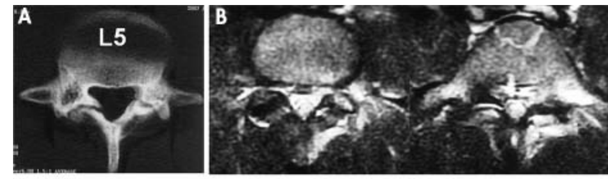

Figure 6. Case 7 is a 16-year-old boy who was a high school baseball player. A, the CT scan shows L5 bilateral spondylolysis. The stage of the defect is progressive at the right side and early at the left. B, on T2-weighted fat suppression MRI, intraosseous involvement at the pedicle and an extraosseous abnormal image is clearly observed at the left side. Note that the hematoma or edema is seen in the foraminal space.

widely to the paravertebral muscles and nerve root foramen, as shown in Figure 6. On T1-weighted MRI, the signal was heterogeneous. Thus, an extraosseous hematoma may exist in addition to the periosteal edema. The 7 patients in the present series were under 18 years of age, and the spondylolysis stage was early or progressive stage, not at the terminal stage (pseudarthrosis). Therefore, the pathologic changes that cause radiculopathy can occur in relatively fresh pediatric spondylolysis.

Clinically, a hematoma with edema is a self-limiting condition that may disappear around 3 to 6 months; thus, nonoperative management can be successful after the appropriate radiologic diagnosis.

In the literature, 2 case reports[11,12] have shown epidural hematoma due to lumbar spondylolysis in 4 young athletes. These patients had a clear mass in the epidural space that compressed the nerve root at the epidural space. Unlike these cases, radiculopathy occurred even though the present 7 patients in this review did not have any space-occupying mass at the epidural space. Thus, the pathologic condition that is proposed based on the current cases series is different from the previous case reports.

In conclusion, although spondylolysis radiculopathy is reported to be rare in young athletes, it actually does occur. The lesion can be divided into 2 categories by MRI analysis: nonspondylolytic and spondylolytic. We propose that extraosseous hematoma and edema can be the cause of the radiculopathy in young athletes with fresh spondylolysis.

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