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Incidence of pars defects in adolescent idiopathic scoliosis: an MRI study

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Objective: In this study, our aim was to present the incidence rate of pars defect in patients with adolescent idiopathic scoliosis, based on MRI findings.

Methods: Two-hundred twenty adolescent idiopathic scoliosis (AIS) patients with MRI scans, taken either as a preoperative investigation or due to other symptoms between 2006 and 2008, were included in the study. The scans were reviewed for pars defect independently by two experienced musculoskeletal radiology consultants.

Results: Among the 220 patients, 9 patients (4.09%; 8 female, 1 male) were found to have a pars defect. The mean age of the affected patients was 14 (range: 11-20) years. We noted two lumbar/thoracolumbar curves (Lenke 5), four King Type 1, one King Type 2 and two King Type 3 curves. All scoliotic deformities were non-structural. Bilateral pars defect was noted in eight (89%) of these patients. All of the pars defects were at the L5 vertebral level.

Conclusion: Our study revealed a 4.09% incidence rate of pars defect in AIS patients which appeared similar to those previously reported in roentgenographic studies.

Key words: Adolescent idiopathic scoliosis; incidence; MRI; pars defect.

The incidence rate of pars defect associated with idiopathic scoliosis in previous studies has been reported as 6%, based on roentgenographic evaluations.[1] The impact of pars defect in the management of scoliosis has also been described extensively.[2-8] The majority of studies were based on roentgenograms, such as the oblique view at the lumbosacral junction. MRI is reportedly superior in the visualisation and classification of various types of pars defects and morphology.[8-12] Commonly used MRI protocols, such as sagittal T1-W and T2-W fast spin echo (FSE), have been found to be useful in differentiating types of spondylolysis in recent studies.[10]

The reported incidence of spondylolysis is around 5% (range: 1.1-6.4%) in cadaveric specimens.[13,14] Previous radiographic studies have also shown a 7.2% incidence rate of pars defect.[15,16]

Early detection of associated pars defects and differentiation from other associated lesions is crucial. Previous studies have shown that MRI can identify pars defects early in young athletes. However, no previous study on the use of MRI in the identification of spondylolysis in idiopathic scoliosis patients has been published. The aim of the present study was to define the incidence rate of pars defect in idiopathic scoliosis using MRI.

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Patients and methods

We reviewed the MRI scans of 220 patients with adolescent idiopathic scoliosis (AIS) taken either as a preoperative investigation or due to other symptoms between 2006 and 2008. Patients with congenital spinal anomalies were excluded. Only patients twenty years of age or younger were included in the study. Scoliotic and lordotic curves were measured using Cobb's method in patients with a pars defect.

A total of 88.9% (n=8) patients with defects were female and one patient was male. Eighty-eight percent of patients were Caucasian, while one patient was Asian. Sixty-six percent (n=6) of patients were scanned for back symptoms and the remainder (n=3) were scanned preoperatively to rule out any associated cord anomalies. Three patients received corrective spinal surgery with anterior release and instrumentation. None of them had instrumentation across the pars defect. Hence, no problem was experienced during identifying pars defect due to presence of metalwork. Case notes were reviewed to document symptoms and clinical outcomes at the latest follow-up.

Sagittal MRI scans were reviewed by two experienced musculoskeletal radiologists using a high-resolution monitor with a 1.5T magnetic resonance system (Philips Medical Systems, Best, the Netherlands). For proper visualization, a minimum of 3 mm of interslice thickness and sagittal and axial images with STIR/fat-suppressed images were required. The presence of pars defect was determined using the available classification system (Table 1). Routine MRI acquisition protocols included TR (461 ms), TE (24 ms), slice thickness (3 mm), interslice gap (0.625 mm), and a field of view (320 mm).[8] Statistical analysis was made using the independent Student's t-test.

Results

Among the 220 patients, 9 (4.09%; 8 female, 1 male; mean age: 14 years; range: 11-20 years) were found to have a pars defect (Fig. 1). We noted a varying severity of curve patterns; two lumbar/thoraco-lumbar curves (Lenke 5), four King Type 1, one King Type 2 and two King Type 3 curves (Table 2).[17] All scoliotic deformities were non-structural and were at the terminal stages (Hollenberg Grade 4). Bilateral pars defect was noted in eight (89%) of these patients. All pars defects were at the L5 vertebral level. Inter-observer agreement between two consultant musculoskeletal radiologists on the presence of pars defects was statistically significant ($p<0.05$).

Table 1. Classification of pars interarticularis based on MRI apperaence.

Grade	Type	MRI features
0	Normal	Normal marrow signal, intact cortical margin.
1	Stress reaction	Marrow edema, intact cortical margins.
2	Incomplete fracture	Marrow edema, cortical fracture incompletely extending through pars.
3	Complete active fracture	Marrow edema, cortical fracture completely extending through pars.
4	Fracture non-union	No marrow edema, fracture completely extending through pars.

Sagittal images were particularly useful in identifying pars signal changes. One case of a single hypointense line across the pars defect was also included. However, all cases had hypointense signals which suggested that they had reached the terminal stage. Still, no significant change was noted in the adjacent lamina where adaptive changes due to increased weight-bearing were expected. Clearly, such findings were expected in AIS with the pars defect at a stage when they were not scanned with MRI. Over time, early changes in the pars progressed to a stage where healing was no longer possible. Upon further follow-up, two patients required surgical intervention for pars defects. One developed progressive spondylolisthesis requiring fusion. Another patient developed disc degenerative changes and underwent discography.

At the final follow-up, three patients complained of long-term back pain. One of these required thoracic fusion due to persistent thoracic pain. The remainder were satisfied with their activity level.

In most cases, patients with more severe scoliosis had a greater degree of lordosis (Fig. 2). However, a one-tailed Student's t-test was not found to be statistically significant ($p=0.09$).

Discussion

Previous studies have described the incidence rate of pars defect associated with idiopathic scoliosis as

Fig. 1. Arrows pointing towards hypointense pars defects on sagittal images.

approximately 6.2%.[1,13] The association between scoliosis and pars defect necessitates the monitoring of both conditions in the presence of one at the lumbar or thoracolumbar region.[1,3,13,18] However, while classifying AIS, King et al. excluded the lumbar and thoracolumbar curves along with congenital and neuromuscular scoliosis in their series of 405 patients.[19] It has been reported that a pars defect at the L4 region has an increased likelihood of healing than that at the L5-S1 region. Previous studies have concluded that the likely explanation for this is the greater load on axial compression in the L5-S1 region and increase as the lumbar lordosis increases.[7] Movement at the pars, associated degenerative lesions, and reaction to the adjacent area all affect healing of the pars defect following conservative management in a brace.[4] The effect of a pars defect on the postoperative outcome of lumbar fusion surgeries is also well recognised.[20] Thirty-two percent of patients with AIS have pain and 9% of those have underlying pathologies.[21] The presence of a pars defect may cause a progressive compensatory scoliotic deformity in early adulthood, which runs the risk of becoming structural in the future.[7] The index study done by Fisk et al. among 500 patients who needed hospital admission included only adolescents.[1] In previous studies emphasizing early diagnosis of pars defect using MRI, only patients below 19 years of age were included.[22] Operation or conservative management with bracing has also been shown to lead to healing of the pars defect.[4] A recent study suggested that pediatric spondylolisthesis actually occurs through open physis and the early identification of pars defect is therefore important to prevent such deformity.[23]

Table 2. Clinical and radiological details of patients with pars interarticularis defect identified on MRI.

Cases	Sex, age	Curve types King (K), Lenke (L)	Coronal Cobb's angle (°)	Sagittal Cobb's angle (°)	Management	Pars defect grading*	Clinical outcome
Case 1	F12	KI	47	67	Anterior release, instrumentation	4	Satisfactory activity level
Case 2	F12	KII	97	90	Conservative	4	Satisfactory activity level
Case 3	F11	KI	37	75	Anterior release, instrumentation	4	Satisfactory activity level
Case 4	M17	KI	95	93	Anterior release, instrumentation	4	Satisfactory activity level
Case 5	F14	KIII	42	69	Conservative	4	Satisfactory activity level
Case 6	F20	KI	24	58	Conservative	4	Progressive spondylolisthesis
Case 7	F12	KIII	7	65	Conservative	4	Satisfactory activity level
Case 8	F14	L5	30	54	Conservative	4	Satisfactory activity level
Case 9	F14	L5	31	50	Conservative	4	Back pain

*Grading of pars defect according to Hollenberg et al.[10]

Previous studies have classified pars defects as non-lysis, pre-fissure, fissure and pseudarthrosis based on X-ray, CT and MRI evaluation.[22] Further studies have defined early, progressive and terminal stages according to prognosis[4] and investigated radiological healing alongside conservative management with bracing.[24] In another recent study, Sairyo et al. emphasized that the presence or absence of high signal change in the pedicle on T2-weighted MRI was related to bony healing.[12]

Hollenberg et al. classified pars interarticularis defects according to the marrow signal changes in the pars and the adjacent pedicle and articular processes (Table 1).[10] We used this classification in our study (Table 2). A similar classification has been proposed by other investigators who have identified marrow signal changes in the pars and classified the defects as normal (Type 1), sclerotic (Type 2), ill-defined (Type 3) and clearly visible (Type 4).[8,11] However, it has been proposed that the presence of a single or two hypointense lines are necessary to define a pars defect.[8]

Naturally, several classifications of types of pars defects have appeared in the literature. Pars defects at their different stages of healing have been classified by several authors.[4,8,10,11,22] The efficacy of routine

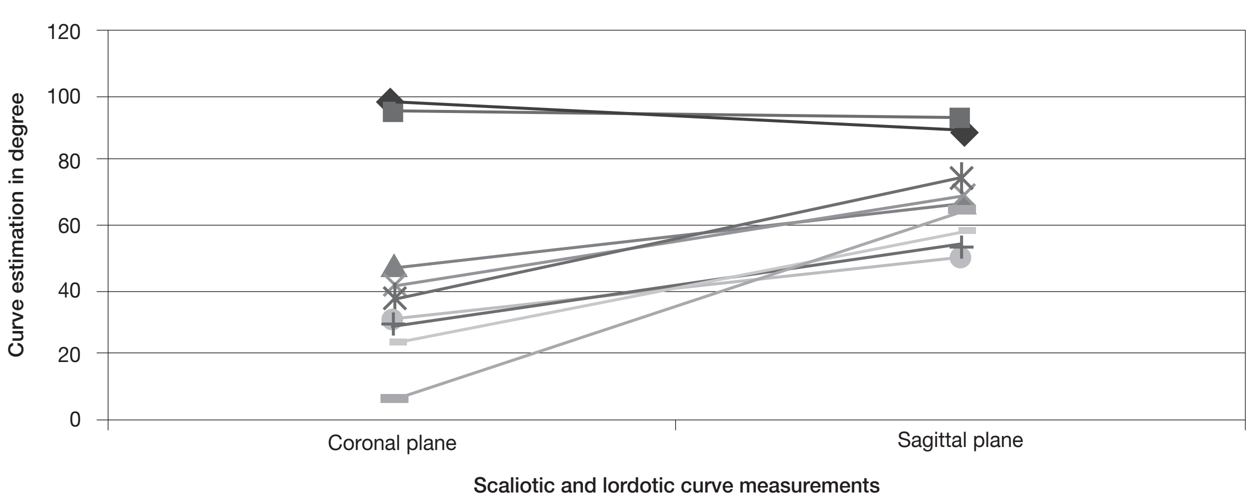

Fig. 2. Correlation between sagittal and coronal plane Cobb's angle.

MRI scans to detect pars defects is not yet well documented.[8] However, MRI may ensure the early detection of pars defect in patients with back pain, as recent studies have shown that high signal intensity can predict healing of early pars defects. Conservative management is recommended in these cases.[24]

The incidence of pars defect in the general population, in both symptomatic and asymptomatic individuals, has also been described in several studies. Management of scoliosis frequently involves MRI evaluation to rule out other abnormalities. Our study has emphasized the need for early detection of associated pars defects and its differentiation from other associated lesions.

The use of MRI in the diagnosis of pars defects based on signal changes in the pedicle has been discussed in recent articles.[7,24] On both T1-W and T2-W images, signal intensity changes enabled the radiologists to identify different stages of pars defect. Spondylolysis occurs as a stress fracture in patients involved in athletic activities and repetitive lumbar extension injuries. Its association with AIS, however, possibly signifies the same stress injury pattern from a different biomechanical environment.[12,20] No significant adaptive change was noted in adjacent lamina in our series, which might represent the terminal nature of pars defects.

Recent studies have compared the CT, MRI, and SPECT evaluation of pars defects and suggested the use of MRI as a first-line investigation tool for juvenile spondylolysis.[9] The ability to identify a pars defect before it becomes evident on plain radiography is crucial. Early pars defects with good healing potential can then be treated with bracing, which results in satisfactory healing. However, to identify similar early lesions, technical alterations, such as the inclusion of thin slice, multiplanar, and fat-suppressed imaging protocols should be included in the routine investigation in AIS. Similar imaging and a high index of suspicion is also invaluable in the investigation of back pain in young patients.

This study was only able to identify pars defects at terminal stages, because our series included scoliosis patients requiring MRI scan either perioperatively or due to back pain. As early MRI scanning of all scoliosis patients is not a current routine practice, it is not therefore possible to identify early MRI signal changes in pars interarticularis. Hence, further large-scale routine MRI studies are necessary to assess the incidence of pars defect in the general population.

In conclusion, our study of the incidence of pars defect in AIS patients, using MRI, has yielded similar results as previous roentgenographic studies. To identify Type 3 or 4 pars defects in routine MRI scans for the evaluation of back pain in adolescents or in preoperative evaluation, additional special axial and oblique acquisitions through the pars should be included in the protocol. The use of MRI as a first-line investigation for juvenile spondylolysis should be considered.

Conflicts of Interest: No conflicts declared.

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