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Posterior Epidural Fat on Sagittal MR Images:
Can it Help in Distinguishing Between Isthmic and Degenerative Lumbar Spondylolisthesis?[1]

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Purpose: We tried to assess the value of posterior epidural fat for distinguishing isthmic spondylolisthesis from degenerative lumbar spondylolisthesis on midline sagittal MR images.

Materials and Methods: The midline sagittal MR images of the lumbar spines were retrospectively studied for 50 patients without spondylolisthesis, for 78 patients with isthmic spondylolisthesis and for 43 patients with degenerative spondylolisthesis. The anteroposterior diameter of the posterior epidural fat (ADEF) was measured at each intervertebral disc level by two radiologists and these values were then compared between each group. To normalize for difference of body size, the posterior epidural fat ratio (PEFR) at each level of spondylolisthesis and at L1-2 were also determined for each level of spondylolisthesis, and the PERF was compared between each group. Statistical analysis was performed by the chi-square method.

Results: For the patients with isthmic spondylolisthesis, the ADEFs at the spinal levels with spondylolisthesis were significantly greater than those ADEFs in the control group that were measured at the corresponding disc levels ($p < 0.05$). For the patients with degenerative spondylolisthesis, the ADEFs at the spinal level with spondylolisthesis were significantly less than the ADEFs in the control group that were measured at the corresponding disc levels ($p < 0.05$). The PEFRs obtained at L4-5 were 1.37 ± 0.12 for the control group, 2.61 ± 1.31 for the patients with isthmic spondylolisthesis, and 0.60 ± 0.05 for the patients with degenerative spondylolisthesis. The PEFRs obtained at L5-S1 were 2.25 ± 1.32 for the control group, 3.47 ± 1.69 for the patients with isthmic spondylolisthesis and 1.65 ± 0.18 for the patients with degenerative spondylolisthesis. At both levels, the PEFRs were greatest for the isthmic spondylolisthesis group and smallest for the degenerative spondylolisthesis group, and all the differences were statistically significant.

Conclusion: The posterior epidural fat, which is easily seen structure on the midline sagittal MR image, is significantly increased in isthmic spondylolisthesis, but it is decreased in degenerative spondylolisthesis, and this could be useful in distinguishing isthmic spondylolisthesis from degenerative spondylolisthesis.

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Lower back pain is a common clinical problem and spondylolisthesis is a well-recognized cause of this problem (1 - 3). Spondylolisthesis was first termed by a German obstetrician named Killian in 1854 to describe the forward displacement of one vertebral body on another (4). Although at first this implied the presence of spondylolysis, the classification is now widely used, as pointed out by Wiltse et al (5), for dysplastic, isthmic, degenerative, traumatic and pathological spinal disease (4).

Of these conditions, isthmic spondylolisthesis is the most common type of disease, and this is followed by degenerative spondylolisthesis. Isthmic spondylolisthesis is usually the result of a lysis in the pars interarticularis that is caused by stress or insufficiency fracture, which is probably due to repetitive extension/hyperextension (5) and shear (6). The defect is estimated to occur in approximately 6% of the adult population at some time (4, 7, 8) in their lives,and a greater prevalence of this disease is seen in Eskimos, males, and Caucasians (4). The lumbar spine, especially the L5 vertebra, is most commonly affected. Degenerative spondylolisthesis typically occurs in an older population and the typical site is L4 - 5 (4). The etiology is related to degenerative changes at the facet joints, and it may be due to an abnormal configuration in the facet joints and laminae that predisposes the structures to degenerative changes and subsequent slip, as was demonstrated in a study by Kim and Lee (9). The degree of slippage is usually not as great as that noted in isthmic spondylolisthesis, but even a small degree of slippage can cause significant spinal canal stenosis (4). Therefore, it is important to differentiate between these two types of spondylolisthesis because not only are they different in etiology, but they also have a different prognosis and require different treatment.

We tried to determine the value of the posterior epidural fat for distinguishing between the isthmic and degenerative types of spondylolisthesis (Fig. 1).

Materials and Methods

We reviewed the radiology reports of 3485 adults who had undergone MR imaging of the lumbar spine during a one-year period. One hundred thirty-two patients were diagnosed as having spondylolisthesis, and among them 121 underwent conventional radiography and/or CT scanning for the identification of the cause of spondylolisthesis; these 121 patients formed the subjects of this study. Isthmic spondylolisthesis was diagnosed for the patients having bilateral defects in the pars interarticularis, and degenerative spondylolisthesis was diagnosed in those patients that did not have any defect in the pars interarticularis, but they did have degenerative changes at the facet joints. Therefore, 78 patients (61 men, 17 women; age: 18 - 82 years) were diagnosed as having isthmic spondylolisthesis, and 43 patients (18 men, 25 women; age: 36 - 87 years) were diagnosed as having degenerative spondylolisthesis. For the comparison, the MR images of 50 age-matched subjects (18 - 87 years) who had no evidence of spondylolisthesis on conventional radiography and/or CT were also evaluated as a control group.

The MR imagings were performed with surface coils using one of two 1.5T systems (Signa Horizon echo speed type, GE Medical systems, Milwaukee, U.S.A.; Magnetom Vision Plus, Siemens, Erlangen, Germany) or a 1.0T system (Impact Expert, Siemens, Erlangen, Germany). Midline sagittal T1-weighted images were used exclusively for the analysis. The imaging parameters were as follows: repetition time/echo time/excitations, 560/12 or 600/15; section thickness, 4 mm; intersection gap, 1 mm; field-of-view, 30 cm; and the imaging matrix was a 264×512 matrix or a 270×512 matrix.

The anteroposterior diameter of the posterior epidural fat (ADEF) was measured on the midsagittal MR image at each intervertebral disc level as the maximum anteroposterior diameter between the anterior and posterior borders of the posterior epidural fat (Fig. 1). The measurements were obtained three times by one of two radiologists on the PACS (picture archiving and communication system, Marotech, Seoul, Korea) using the vendor-supplied software, and the average values were calculated for each disc level. Statistical analysis was done using the chi-square method to compare the ADEF values among the control group, the isthmic spondylolisthesis group and the degenerative spondylolisthesis group. To normalize the ADEFs according to the

patient 's size, the posterior epidural fat ratio (PEFR) was obtained and it was defined as the ratio of the ADEF at the level of the spondylolisthesis to that at the L1 - 2 level. The ratios were also compared between each group using the chi-square method. P values less than 0.05 were considered statistically significant.

Results

In the control group, the ADEFs were 3.84±1.69 mm (mean±standard deviation) at L1 - 2, 3.10±1.60 mm at L2-3, 3.28±1.78 mm at L3 - 4, 2.26±1.27 mm at L4 - 5, and 2.84±1.10 mm at L5-S1. In patients with isthmic spondylolisthesis (Fig. 2), the ADEFs at the level of the

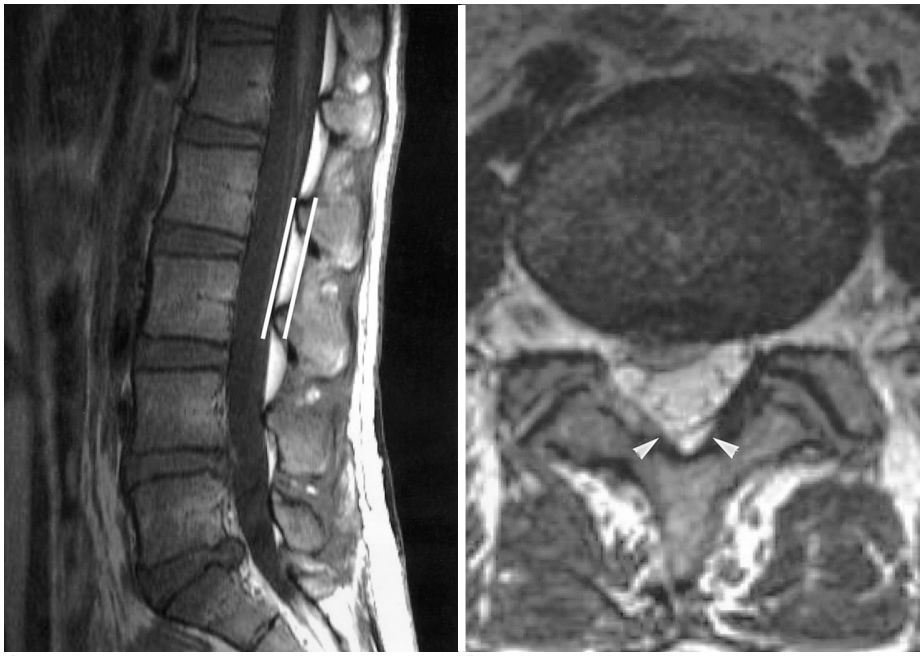

Fig. 1. A 32-year-old female without spondylolisthesis.
A. On the T1-weighted midline sagittal MR image, the posterior epidural fat is seen as high signal intensity posterior to the dural sac, and it is measured as the longest anteroposterior diameter.
B. T2-weighted axial MR image shows the posterior epidural fat at the L4-5 level as a triangular space (arrowheads) with the posterior apex, and it is limited laterally by the ligamenta flava and anteriorly by the dural sac .

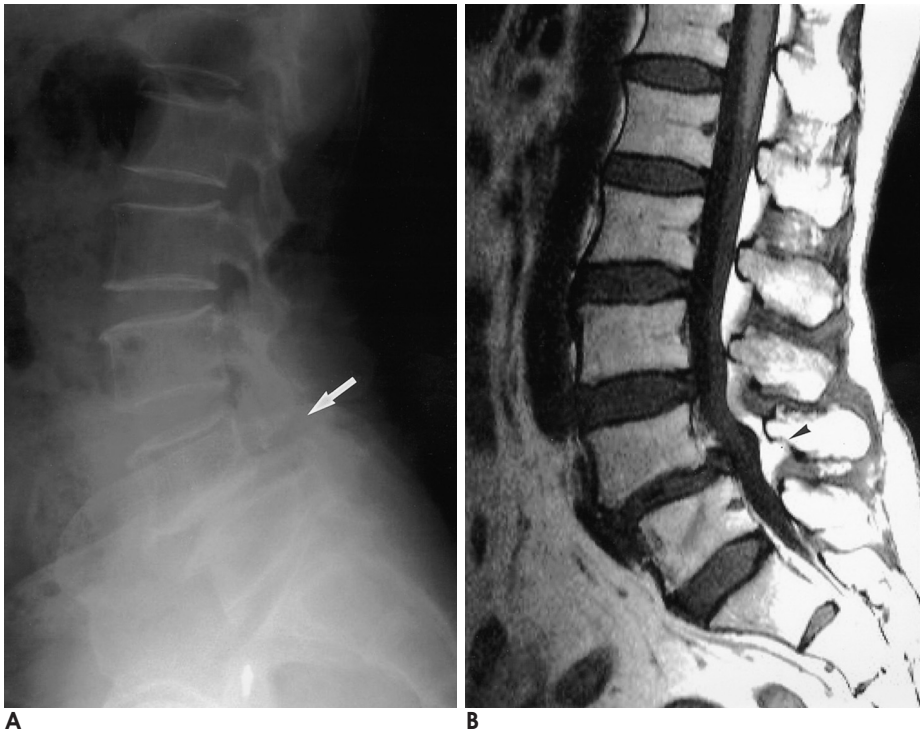

Fig. 2. A 51-year-old female with isthmic spondylolisthesis.
A. The lateral view of the lumbosacral spine shows the defect (arrow) in the pars interarticularis.
B. The T1-weighted sagittal MR image shows an increased anteroposterior diameter of the posterior epidural fat (arrowhead) at L4-5.

spondylolisthesis were 5.38±1.71 mm at L4 - 5 (n=30) and 3.96±2.29 mm at L5 - S1 (n=48), both of which were significantly greater than those values for the control group that were measured at the corresponding disc levels (p<0.05). In contrast, for the patients with degenerative spondylolisthesis (Fig. 3), the ADEFs at the level of the spondylolisthesis were 0.94±0.18 mm at L4 - 5 (n=33) and 1.19±0.19 mm at L5-S1 (n=10), both of which were significantly less than those values for control group that were measured at the corresponding disk levels (p<0.05).

The PEFRs obtained at L4 - 5 were 1.37±0.12 for the control group, 2.61±1.31 for the patients with isthmic spondylolisthesis, and 0.60±0.05 for the patients with degenerative spondylolisthesis. The PEFRs obtained at L5-S1 were 2.25±1.32 for the control group. 3.47±1.69 for the patients with isthmic spondylolisthesis, and 1.65 ±0.18 for the patients with degenerative spondylolisthesis. At both levels, the PEFRs were greatest in isthmic spondylolisthesis group and they were smallest in degenerative spondylolisthesis group, and these differences were statistically significant.

The 95% confidence interval (CI) of the PEFR for the isthmic spondylolisthesis group at L4-5 was from - 0.01 to 5.23 and that for the degenerative spondylolisthesis group at the corresponding level was from 0.5 to 0.7. The 95% CI of PEFR for the isthmic spondylolisthesis group at L5 - S1 was from 0.09 to 6.85 and that for the degenerative spondylolisthesis group at the corresponding level was from 1.29 to 2.01.

To differentiate degenerative spondylolisthesis from isthmic spondylolisthesis, the upper value of the 95% CI of PEFR for the degenerative spondylolisthesis group was defined as our cutoff value (0.7 at L4 - 5 and 2.01 at L5 - S1), because the 95% CI of PEFR for the isthmic spondylolisthesis group was wide and contained negative value.

With 0.7 as the cutoff value of PEFR for the degenerative spondylolisthesis group at L4 - 5, the sensitivity was 97.5% and the specificity was 92.8%. With 2.01 as the cutoff value of PEFR for the degenerative spondylolisthesis group at L5-S1, the sensitivity was 97.5% and specificity was 80.5%.

Discussion

Spondylolisthesis is a common cause of lower back pain, and this is a common clinical finding in patients (1 - 3). When evaluating lower back pain, plain radiography is still commonly used in spite of a report suggested that plain radiographs of the lumbar spine should not be routinely used for this purpose, except for in the younger population where spondylolysis is highly suspected (10).

Isthmic spondylolisthesis is caused by lysis of the pars interarticularis and it results in the separation of a vertebral body from its posterior elements (1 - 3); the posterior elements either remain normally aligned or they be-

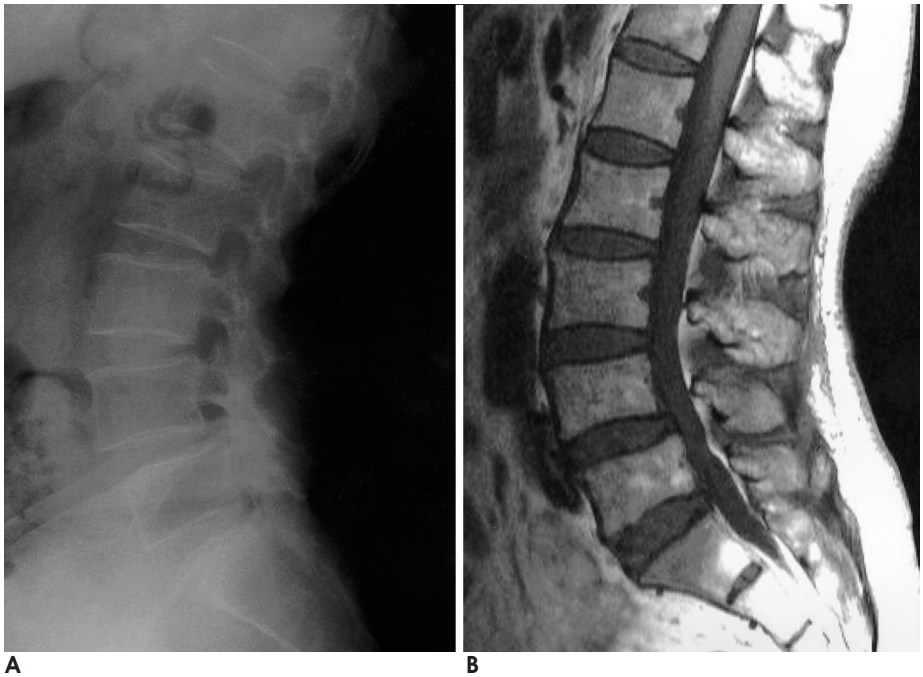

Fig. 3. A 63-year-old female with degenerative spondylolisthesis.
A. The lateral view of the lumbosacral spine shows degenerative change of the facet joints at L4-5 without evidence of spondylolysis.
B. The T1-weighted sagittal MR image shows the markedly decreased anteroposterior diameter of the posterior epidural fat at L4-5.

come posteriorly subluxed. The latter leads to an increase in the sagittal diameter of the spinal canal, and this allows more space for the posterior epidural fat and makes it less likely that the patient will present with radicular symptoms due to canal stenosis. Patients are usually referred for imaging due to symptoms that are caused by other associated abnormalities such as herniated disk, foraminal stenosis, facet hypertrophy or nerve root encroachment that is due to the build-up of fibrocartilage at a pars pseudarthrosis at a later age. Surgical fusion of the involved lumbar segments is usually reserved for the small proportion of patients who have persistent pain despite of conservative therapy, or for those patients with greater than grade II spondylolisthesis (11).

Degenerative spondylolisthesis is characterized by osteoarthritis and degenerative changes in the facet joints, disc degeneration and ligamentous laxity, which can result in anterior slippage of the vertebral body along with an intact posterior arch (1 - 3, 14, 15). This leads to a decrease in the space for the posterior epidural fat. Symptoms of spinal stenosis and nerve root compression frequently accompany this type of spondylolisthesis (11), and this condition requires such surgical treatment as decompression.

Conventional radiography can directly depict the defect for the pars interarticularis and thereby allow differentiation between the isthmic and degenerative types of spondylolisthesis. The anteroposterior and lateral lumbar radiographs can be supplemented by the oblique views in questionable cases (4), but even the oblique views can miss about 13% of spondylolyses, as was noted in a study by Amato et al. (12). Sometimes the differential diagnosis can be made by the " spinous process sign ", where the step between the upper and lower spinous process occurs above the level of the slip for a lytic spondylolisthesis, and at the level of the slip for a degenerative spondylolisthesis; however, this differentation is often difficult to achieve (13). This sign is also observed on MR images, but there are limitations for the generalized usage of this sign due to the following reasons: 1. a large degree of spondylolisthesis is needed to consistently produce the sign and 2. the lower lumbar spinous processes normally have a great variation in their size and alignment (11).

MR imaging is now readily available almost anywhere and it has become the imaging method of choice for examining patients with lower back problems. Spondylolysis can be difficult to appreciate on MR imaging because loss of the marrow signal at the pars on the T1-weighted spin-echo sequence may not necessarily be due to lysis, but this loss may possibly be due to sclerosis of the pars or to a partial voluming effect from the adjacent structures. Jinkins et al. (16) noted the sagittal diameter of the spinal canal increased in patients with spondylolysis. The validity of this observation was proven in a study by Ulmer et al. (11), in which " the wide canal sign "was deemed as highly reliable and effective to differentate between isthmic and degenerative spondylolisthesis. They suggested that when the diameter of the spinal canal at the level of L4 or L5 level exceeds that at L1 by 25% or more, isthmic spondylolisthesis is virtually assured (11).

In our study, we confirmed the value of the posterior epidural fat, which is easily seen on the midline sagittal MR images as a high signal intensity structure posterior to the dural sac and it is limited laterally by the ligamenta flava. The ADEF was noted to be significantly increased in those patients with the isthmic type of spondylolisthesis, whereas it was significantly decreased in those patients with the degenerative type of spondylolisthesis, at each level of spondylolisthesis ($p < 0.05$). This difference in ADEF is due to the structural anatomical differences between the isthmic type and the degenerative type of spondylolisthesis, as was mentioned above. The ratio between the ADEF (PEFR) at L4 - 5 and L1 - 2 was significantly increased for isthmic spondylolisthesis, and the PEFR at L5 - S1 and L1 - 2 was also significantly increased for the isthmic type of spondylolisthesis. Similar to the " wide canal sign " observed by Ulmer et al. (11), the posterior epidural fat could be used as a supplement for the differential diagnosis of spondylolisthesis. The posterior epidural fat is readily seen and can be measured on sagittal T1-weighted MR images even by those physicians who are not experienced with spinal MR imaging, and this could be useful for those cases having sclerosis at the pars that mimick spondylolysis, when the spondylolysis is not directly visualized on plain radiographs and/or on MRI, or when technical factors, such as artifacts, limit the use of axial imaging (11).

References

1. Amundson G, Edwards CC, Garfin SR. *Spondylolisthesis*. In: Rothman RH, Simeone FA, eds. *The spine*, 3rd ed. Philadelaphia: Saunders, 1992: 913-969
2. McPhee B. *Spondylolisthesis and spondylolysis*. In: Youmans JR, ed. *Neurological surgery*, vol.4, 3rd ed. Philadelphia: Saunders,

1990:2749-2784
3. Wood GW. *Other disorders of the spine*. In: Crenshaw AH, ed. *Campbell's operative orthopaedics*, vol.5, 8th ed. St. Louis: Mosby-Year Book, 1992: 3825-3870
4. Hession PR, Butt WP. Imaging of spondylolysis and spondylolisthesis. *Eur Radiol* 1996;6:284-90
5. Wiltse LL, Newman MD, Macnab I. Classification of spondylolisis and spondylolisthesis. *Clin Orthop* 1976;23-29
6. Jackson DW, Wiltse LL. Cirincione RJ. Spondylolysis in the female gymnast. *Clin Orthop* 1976;117:68-73
7. Rothman SL, Glenn WV Jr. CT multiplanar reconstruction in 253 cases of lumbar spondylolysis. *AJNR Am J Neuroradiol* 1984;5:81-90
8. Grenier N, Kressel HY, Schiebler ML, Grossman RI. Isthmic spondylolysis of the lumbar spine: MR imaging at 1.5T. *Radiology* 1989;170:489-493
9. Kim NH, Lee JW. The relationship between isthmic and degenerative spondylolisthesis and the configuration of the lamina and facet joints. *Eur Spine J* 1995;4:139-144
10. Royal College of Radiologists Working Party. Making the best use of a department of clinical radiology, 3rd edn. *The Royal College of Radiologists* 1995:34-35
11. Ulmer JL, Elster AD, Mathews VP, King JC. Distinction between degenerative and isthmic spondylolisthesis on sagittal MR images: importance of increased anteroposterior diameter of the spinal canal (' wide canal sign '). *AJR Am J Roentgenol* 1994;163:411-416
12. Amato M, Totty WG Gilula LA. Spondylolysis of the lumbar spine: demonstration of defects and laminal fragmentation. *Radiology* 1984;153:627-629
13. Bryk D, Rosenkranz W. True spondylolisthesis and pseudospondylolisthesis: the spinous process sign. *J Can Assoc Radiol* 1969;20:53-56
14. Postacchini F, Perugia D. Degenerative lumbar spondylolisthesis. Part I. Etiology, pathogenesis, pathomorphology, and clinical features. *Ital J Orthop Traumatol* 1991;17:165-173
15. Berquist RH, Cabanela ME. *The spine*. In: Berquist TH, ed. *Imaging of orthopedic trauma*, 2nd ed. New York: Raven, 1992:93-206
16. Jinkins JR, Matthes JC, Sener RN, Venkatappan S, Rauch R. Spondylolysis, spondylolisthesis, and associated nerve root entrapment in the lumbosacral spine: MR evaluation. *AJR Am J Roentgenol* 1992;159:799-803

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시상 자기공명영상에서의 후경막외지방: 협부 척추골전전위증과 퇴행성 척추골전전위증을 구별하는데 있어서 유용한가?[1]

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목적: 이 연구는 협부 척추골전전위증과 퇴행성 척추골전전위증을 구별하는데 있어 정중시상 자기공명영상에서의 후경막외지방의 가치를 평가하고자 하였다.

대상과 방법: 척추골전전위증이 없는 50명, 협부 척추골전전위증이 있는 78명, 그리고 퇴행성 척추골전전위증이 있는 43명의 환자에서 후향적으로 요추의 정중시상 자기공명영상을 검토하였다. 방사선과 의사 2명이 각 추간판 수준에서 후경막외 지방의 전후지름(Anteroposterior diameter of the posterior epidural fat (ADEF))을 측정하였고 각군을 비교하였다. 신체 크기에 따른 치우침을 보정하기 위해 척추골전전위증이 있는 각 수준에서 척추골전전위증이 있는 수준과 L1 - 2사이의 경막외 지방의 전후 지름의 비율(posterior epidural fat ratio (PEFR))을 계산하였고 각 군을 비교하였다. 통계적 분석는 Chi - square 방법을 이용하였다.

결과: 협부 척추골전전위증이 있는 환자에서 척추골전전위증이 있는 수준에서의 ADEFs는 대조군의 대응하는 추간판 수준에서 측정한 ADEFs보다 의미있게 증가되어 있었다($p<0.05$). 퇴행성 척추골전전위증이 있는 환자에서 척추골전전위증이 있는 수준에서의 ADEFs는 대조군의 대응하는 추간판 수준에서 측정한 ADEFs보다 의미있게 감소되어 있었다 ($p<0.05$). L4 - 5 수준에서 계산된 PEFRs는 대조군에서 1.37±0.12, 협부 척추골전전위증이 있는 환자군에서 2.61±1.31, 그리고 퇴행성 척추골전정위증이 있는 환자군에서 0.60±0.05이었다. L5 - S1수준에서 계산된 PEFRs는 대조군에서 2.25±1.32, 협부 축추골전전위증이 있는 환자군에서 3.47±1.69, 그리고 퇴행성 척추골전전위증이 있는 환자군에서 1.65±0.18이었다. L4 - 5, L5 - S1 두 수준에서 모두 협부 척추골전전위증에서의 PEFRs이 가장 컸고 퇴행성 척추골전전위증에서의 PEFRs가 가장 작았으며 그 차이는 통계적으로 유의하였다.

결론: 정중시상 자기공명영상에서 흔히 보이는 후경막외 지방이 협부 척추골전전위증에서는 의미있게 증가되어 있었고 퇴행성 척추골전전위증에서는 의미있게 감소되어 있었으며 이것이 협부 척추골전전위증과 퇴행성 척추골전전위증을 구별하는데 유용하였다.