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Clinical Article

The Morphometric Analysis of the Extraforamen in the Lumbosacral Spine : Magnetic Resonance Imaging and Computed Tomography Study

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Objective : The goal of this study is to establish the anatomical criteria of the normal and stenotic lumbosacral extraforaminal tunnel, and also to determine the effect of the pathologic intervertebral disc on the size of extraforaminal tunnel in the lumbosacral spine.
Methods : MRI and CT scans were reviewed and classified into two groups : (1) 40patients with normal discs at L5- S1 (Group 1) and (2) 43 patients that had undergone successful decompression surgery for extraforaminal entrapment at the lumbosacral region(Group 2). In these two groups, the following parameters were compared are compared : the distance between the disc margin and the ala (lumbosacral tunnel) on the axial MRI, and the posterior disc height at L5-S1 on the mid-sagittal MRI.
Results : In the group 1, the mean distance of the lumbosacral tunnel on the axial MRI was 10.1 ± 2.2mm. The mean posterior disc height at L5-S1 was 7.4 ± 1.7mm on the mid-sagittal MRI. In the group 2, the mean distance between the disc margin and the ala (costal process) was 1.6 ± 1.3mm on the axial MRI. The average posterior disc height was 4.4 ± 1.5mm on the mid-sagittal MRI. The posterior disc height and the size of the lumbosacral tunnel between the two groups were statistically different on the paired t-test ($p<0.0001$). However, the posterior disc height was not positively correlated with the size of the extraforaminal tunnel for group 2 ($p=0.909$).
Conclusion : The extraforaminal stenosis was correlated to pathologic disc. However, the posterior disc height was not correlated to the size of the of the extraforaminal tunnel.

KEY WORDS : Morphometric analysis · Extraforamen · Lumbosacral spine · Magnetic resonance imaging · Computed tomography.

Introduction

Although an extraforaminal lesion in the lumbosacral spine may cause lumbar radiculopathy, it is frequently overlooked or misdiagnosed. Unfortunately, this condition can cause the failure of lumbar spine surgery due to the difficulties in making the correct diagnosis before surgery[10,12]. Burton et al[4], have attributed this phenomenon to the lack of recognition of this lesion or because of inadequate treatment of the lateral canal stenosis. In addition, they considered this condition to be the cause of pain in nearly 60% of patients whose symptoms continued despite of surgery. Therefore, the extraforaminal lesion is an important pathologic entity to be identified in those patients with radiculopathy.

In this study, extraforaminal entrapment is defined as the compression of the nerve root at the region known as the intervertebral foramen. Because of the unique anatomical features, such as the ala, the iliolumbar ligamentum and the broad pedicle at the L5-S1 level, the L5 root can frequently be compressed within the extraforaminal zone.

Several studies have reported on the normal foraminal size and the critical dimensions for lumbar foraminal stenosis[3,8,19]. Hasegawa et al[8], have shown in a cadaveric study that significant nerve root compression is commonly associated with the foraminal height of 15mm or less and the posterior disc height of 4mm or less. They concluded that these critical dimensions may be the indicators of the lumbar foraminal stenosis.

However, the anatomical criteria for the normal and pathologic extaforaminal tunnel as well as the relationship between the extraforaminal tunnel and the pathologic intervertebral disc in the lumbosacral spine have not yet been reported on.

The purpose of this study was to establish the normal and pathologic anatomic criteria and to determined the effect of intervertebral disc pathology on the extraforaminal stenosis in the lumbosacral spine by using the standard projections of the MRI and CT scans (the axial and sagittal planes).

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Materials and Methods

MRI and CT scans were reviewed and then classified into two groups : (1) 40patients with normal discs at the L5- S1 level (Group 1) and (2) 43patients with the extraforaminal entrapment in the lumbosacral region that had been successfully decompressed (Group 2).

Group 1 consisted of 18men and 22women. Their average age was 35years and their ages ranged from 21 to 45years. None of the subjects had degenerative disc changes at the lumbosacral level. Group 2 consisted of 10 men and 33women. Their average age was 62years and their ages ranged from 52 to 78years. All of these patients had undergone microsurgical decompression for lumbosacral extraforaminal entrapment. Patients with symptomatic spondylolysis, isthmic or degenerative spondylolisthesis that showed compression of the L5 nerve root were excluded from this study. The patients with multiple levels of compression, including the extraforaminal zone in the lumbosacral spine were also excluded from this study. The patients' diagnoses were established by the combined use of radiological tests, plain and computed tomography, selective nerve root block, and magnetic resonance imaging (MRI). All these patients were treated by utilizing the paramedian tangential approach. Five of these patients had had one previous interlaminar operation, and this had not achieved relief of their pain. For these patients, it was clearly evident that the foraminal or the extraforaminal stenosis had been overlooked in the previous diagnosis.

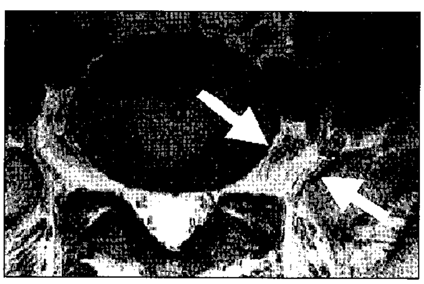

Fig. 1. Distance between disc margin and ala on the axial view of the magnetic resonance image is measured in both groups.

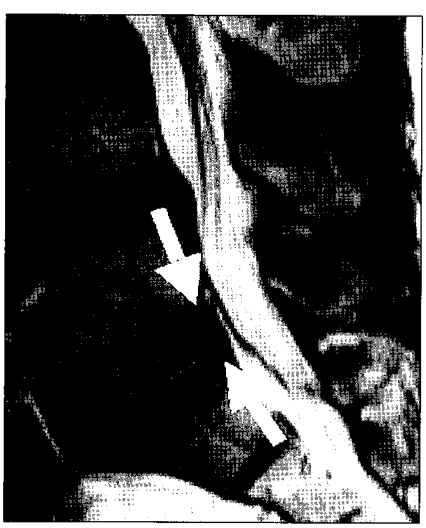

Fig. 2. Posterior disc height at L5–S1 is measured on the mid-sagittal view of magnetic resonance image in both groups.

The distance between the disc margin and the ala was measured on the axial view of the MRI(Fig. 1).

The height of posterior disc at L5-S1 was measured on the mid-sagittal MRI (Fig. 2). The CT scan was used to show the relationship between neural entrapment and the pathologic disc at the extraforaminal zone. The causative factors responsible for narrowing the extraforaminal tunnel were analyzed by MRI and CT scans in the group 2. The circumferential loss of the perineural fat signal at the L5-S1 level on the parasagittal T-1 weighted MRI that was taken for diagnosis of foraminal stenosis was examined in the group 2. Independent sample t-tests were used to analyze the differences between the two groups.

Fig. 3. Parasagittal T–1 weighted magnetic resonance image showing foraminal stenosis and ruptured disc with circumferential loss of perineural fat signal at L5–1 level (black arrow).

Results

For group 1, the mean distance between the disc margin and the ala on the axial view of the MRI was 10.1 ± 2.2mm. The mean height of the posterior disc at L5-S1 was 7.4 ± 7mm on the mid-sagittal MRI.

For group 2, the mean distance between the disc margin and the ala was 1.6 ± 1.3mm on the axial MRI. The mean height of the posterior disc at L5-S1 was 4.4 ± 1.5mm on the mid-sagittal MRI.

The height of the posterior disc and the size of the lumbosacral tunnel between the two groups were statistically different ($p<0.0001$). However, the height of the posterior disc was not related to the size of the extraforaminal tunnel for group 2 ($P= 0.909$). The parasagittal T-1 weighted MRI showed the foraminal stenosis with the circumferential loss of the perineural fat signal at the L5-S1 level in 17 of 43 (40%) patients in the group 2 (Fig. 3).

The data shows that the narrowed extraforaminal tunnels were caused by the annulus bulging in 32patients (74%), the disc protrusion or rupture in 11patients (26%), and the osteophytes of the vertebral body in 27patients (63%) (Fig. 4-6). The major pathognomonic cause of the extraforaminal L 5 nerve entrapment was the bulging annulus fibrosus with osteophytes.

Discussion

Extraforaminal L5 root entrapment is common in patients with the degenerative lumbar disc diseases. When the L5 radiculopathy is due to the multiple entrapments, the foraminal or extraforaminal lesion is frequently overlooked and this result in incomplete decompression, which is one of the common causes of failed back surgery syndrome.

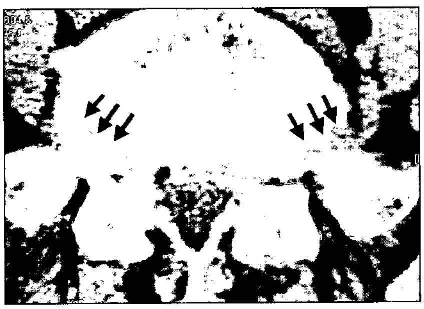

Fig. 4. Computed tomography scan showing narrowing of extraforaminal tunnel result from annulus bulging and ostephytes on both sides (black arrow).

Fig. 5. T-1 weighted axial magnetic resonance imaging showing disc protrusion in right extraforaminal zone at L5-S1 (white arrow).

Fig. 6. Computed tomography scan showing narrowing of extraforaminal tunnel result from osteophytes in left extraforaminal zone at L5-S1 (black arrow).

Although many clinical studies have reported on the surgical approach for extraforaminal lesion, few studies have focused on the normal or stenotic criteria for the extraforaminal zone in the lumbosacral spine on the MRI and CT findings[1,2,6,13-15,18]. The clinical and radiological characteristics of the extraforaminal disc herniation have been reported on. However, these study did not report the normal and critical stenotic dimensions of the extraforaminal tunnel in the lumbosacral spine[5,7,11].

Hashimoto et al. have shown that the coronal plane MRI can provide the best anatomical declineation of the lumbosacral nerve root complex as related to the adjacent structures[9]. However, the criteria for distinguishing the normal and stenotic extraforaminal zone on MRI imaging and CT scans in the standard axial projections need to be established.

The mean distance between the disc margin and the ala on the axial MRI was about 10mm in normal group. For group 2, on the other hand, the distance was less than 3mm on the axial MRI. Several studies have reported on the extraforaminal entrapment at the lumbosacral spine. The osteophytes on the lower border of the L5 body and the upper border of the sacrum may contribute to the formation of the inferior portion of the tunnel that encases the nerve[14,16]. CT scans are necessary and should be performed to define and demonstrate the extent of bony disease. In this study, the osteophytes of the verterbral body caused the narrowing of extraforaminal tunnel for 27 out of 43patients in group 2.

The diffuse bulging of annulus fibrosus may press the nerve against the sacral ala and L 5 pedicle[2]. The diffuse annulus bulging was the most frequent cause of narrowing of the extraforaminal tunnel in this study. In this study, annulus bulging contributed to the narrowing of the extraforaminal tunnel for thirty-two out of 43patients. Based on the cadaveric studies, many authors have reported that the lumbosacral ligament (LSLs) may compress the L5 spinal nerve and give rise to clinical manifestation[16,17,20]. The buckling or overgrowth of the iliolumbar ligament as well as lumbosacral ligament may result in narrowing of the extraforaminal tunnel. However, the exact role of these the ligaments couldn't be evaluated in this imaging study.

The parasagittal T-1 weighted MRI showed the foraminal stenosis with the circumferential loss of the perineural fat signal at the L5-S1 level in 17 out of 43patients. The loss of the height of the intervertebral disc secondary to the desiccation and degeneration of the disc allows the superior articular process of the inferior vertebra to subluxate anterosuperiorly and this results in the diminished size of the foramen and extraforamen area at the lumbosacral spine. The combination of the disc space narrowing, overgrowth of the iliolumbar ligament, the bulging disc, and bony spur may greatly diminish the foraminal and extraforaminal space to a large extent. In these cases, the L5 nerve root was compressed simultaneously at the two zones, the foraminal and extraforaminal zones. Significant positive correlation was demonstrated between the compression of the nerve root and the height of the posterior disc at the foraminal zone[8]. The changes of the height of the posterior disc may influence the dimensions of the lumbosacral tunnel. However, the height of the posterior disc was not correlated to the size of extraforaminal tunnel in this study. The size of extraforaminal tunnel in this study was mainly affected mainly by the bulged annulus in 32patients (74%), the osteophytes of the vertebral body in 27patients (63%) and the disc protrusion in 11patients (26%).

Conclusion

As measured on the axial MRI, the distance of the extraforaminal tunnel between the disc margin and the ala of the extraforaminal tunnel was about 10mm for the normal morphometric anatomy. The distance of the potential extraforaminal stenosis was noted to be less than 3mm. However, the critical dimension was not always correlated to the clinical findings. Thus, this must always be taken into consideration before arriving at the diagnosis of extraforaminal stenosis.

The extraforaminal stenosis was correlated to the pathologic disc. However, in this study, the height of the posterior disc was not correlated with the size of the extraforaminal tunnel. Our data has shown that the major causes of extraforaminal nerve root entrapment at the lumbosacral spine are bulged annulus fibrosus, the disc protrusion and the osteophytes. In this study, the major pathognomonic cause of the extraforaminal L5 nerve entrapment was the bulged annulus fibrosus along with the osteophytes.

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