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Clinical Article

The Role of Computed Tomography in the Presurgical Diagnosis of Foraminal Entrapment of Lumbosacral Junction

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Objective : On the basis of preoperative computed tomography (CT) scans, we studied the change of the size of anterior primary division (APD) of the L5 spinal root in the presence of foraminal/extraforaminal entrapment of the L5 spinal root.
Methods : Two independent radiologists retrospectively reviewed the preoperative CT scans of 27 patients treated surgically and compared the sizes of the APDs on bilateral L5 spinal roots. If one side APD size was larger than the other side APD size, it was described as left or right "dominancy" and regarded this as "consensus (C)" in case that there was a consensus between the larger APD and the location of sciatica, and regarded as "non-consensus (NC)" in case that there was not a consensus. Oswestry Disability Index (ODI) scores were used for preoperative and postoperative evaluation.
Results : On CT scans, twenty-one (77%) of 27 patients were the consensus group (APD swelling) and 6 (22%) were a non-consensus group (APD no swelling). In 9 patients with acute foraminal disc herniations, asymmetric enlargement of the APD on L5 spinal root was detected in all cases (100%) and detected in 11 (64%) of 17 patients with stenosis. Preoperative ODI score was 75-93 (mean 83) and postoperative ODI scores were improved to 13-36 (mean 21). The mean follow-up period was 6 months (range, 3-11 months).
Conclusion : An asymmetric enlargement of the APD on L5 spinal root on CT scans is meaningfully associated with a foraminal or extraforaminal entrapment of the L5 spinal root on the lumbosacral junction.

KEY WORDS : Computed tomography · Foraminal-extraforaminal entrapment · Lumbosacral junction · Radiculopathy · Surgery.

INTRODUCTION

Foraminal or extraforaminal entrapment of the L5 spinal nerve on the lumbosacral junction is not a rare pathology. These entrapments can result from various causes such as foraminal disc herniation, foraminal stenosis, the formation of osteophytes in the lumbosacral spine[12] or 'far-out syndrome' by L5 transverse process and the sacral ala[16]. Spine surgeons often miss the entrapments, which can cause failed back surgery syndrome[3]. Therefore, foraminal or extraforaminal entrapment of the L5 spinal nerve on the lumbosacral junction is a very important disease entity in patients presenting with L5 radiculopathy[9,14-16].

However, a confirmative diagnosis of these conditions is not easy and the pathology may not be often detected even by conventional magnetic resonance image (MRI)[9].

The purpose of this study was to demonstrate that comparison between symptom-sided anterior primary division (APD) size and opposite-sided APD size of the L5 spinal root along the ventral surface of the sacral ala on conventional computed tomography (CT) scans (Fig. 1) would be very useful in making the diagnosis and surgical decision for foraminal or extraforaminal entrapment of the L5 spinal root at the lumbosacral junction in case of L5 radiculopathy.

MATERIALS AND METHODS

From December 2006 to November 2007, a total of 30

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consecutive patients underwent microsurgical decompression for the L5 spinal root entrapment on the lumbosacral junction by a single surgeon (KHM). Surgical indication was unilateral neurological deficit or radiculopathy refractory to conservative management. Paraspinal approach to L5-S1 for foraminal/extraforminal L5 root entrapment was performed. If the so-called 'double crush of L5' (simultaneous double level entrapment of the L5 spinal root in the intracanalicular area at L4-5 as well as in the lateral zone at L5-S1) was preoperatively suspected, additional decompression at L4-5 was performed. Three of the 30 patients were excluded in this study for the following reasons. One patient was excluded due to no definite entrapment at the L5 root except for venous engorgement on the L5-S1 surgical field, and the other cases preoperatively suspected as 'double crush of L5' were excluded because sciatica might be caused by the L5 root entrapment on the L4-5 level rather than on the lateral zone of L5-S1 in surgical finding. All data were obtained by chart review and insufficient data were completed by phone interview under verbal agreement. The preoperative and postoperative status were evaluated with the Oswestry Disability Index (ODI) scores.

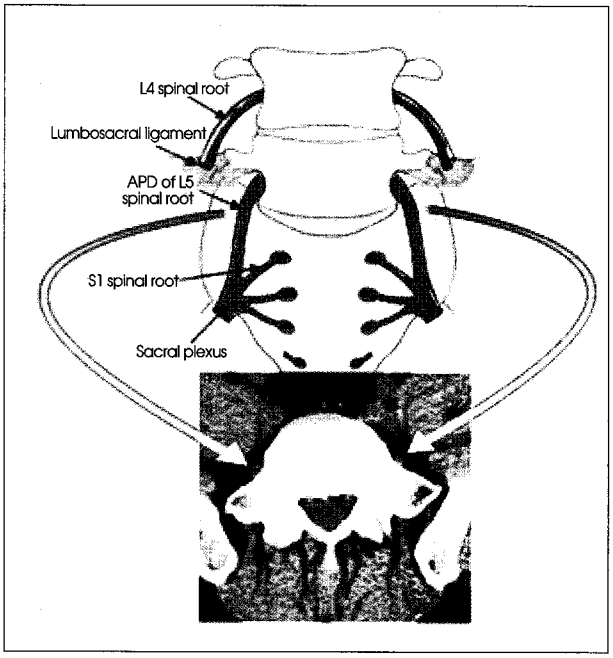

Fig. 1. This illustration demonstrates anterior primary division of L5 spinal root along the ventral surface of the sacral ala.

Two radiologists retrospectively reviewed preoperative CT scans (MX 6000 DUAL, Philips, China) with 2 channels, 2.5 thickness, 5.0 step, TI 1,500msec and KVP 120. They respectively measured the thickness of the APD of the bilateral L5 spinal roots along the ventral surface of the sacral ala without any information about the location of sciatica. APD between the upper endplate of S-1 and upper one thirds of S-1 body was compared on CT axial views (3 images). Under visual inspection, the APD size of the L5 spinal root in one side (right or left) was compared with that in the other side. If one side APD size was larger than the other side APD size, it was described as "Left" or "Right" dominancy and regarded this as "consensus (C)" in case that there was a consensus between the larger APD and the location of sciatica. If there was no difference in size, this was described as "symmetric" and regarded as "non-consensus (NC)." In case that there was a disagreement between two radiologists, they made a meeting point through discussion about it.

Statistical analyses were performed using Statistical Package for the Social Science (SPSS) 14.0K (SPSS Inc, Chicago, IL, USA). Depending on the characteristics of the variables being compared, Fisher's exact test and Two-proportion test were used. A probability value of less than 0.05 was considered to indicate statistical significance.

RESULTS

All patients' data are summarized in Table 1. The mean follow-up period was 6 months (range, 3-11). The mean age of patients in the study was 65 years old (range, 34-77). Twenty-one (77%) of 27 patients were put into the consensus group that had enlargement of the APD of the L5 spinal root on the symptomatic side. Six patients (22%)

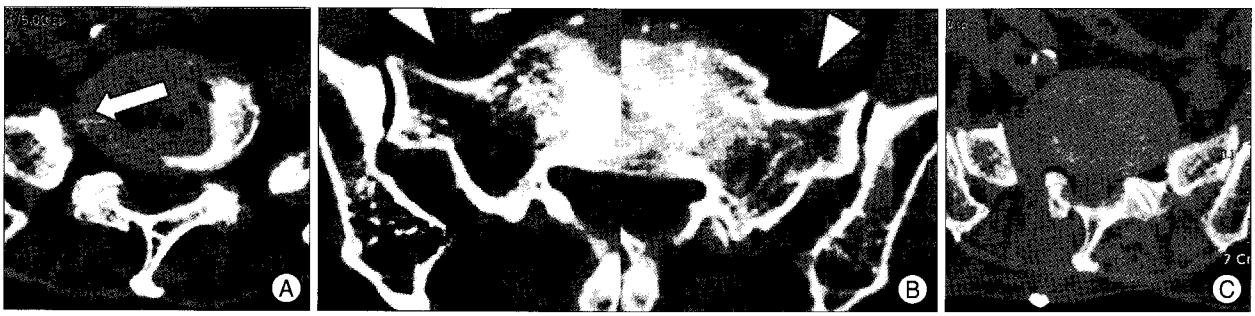

Fig. 2. Preoperative and postoperative computed tomography scans in case 11. A : Extraforaminal entrapment of L5 spinal root (arrow) by sacral ala on L5-S1. B : Asymmetric enlargement of right anterior primary division of L5 spinal root (arrowhead). C : Microscopic decompression of sacral ala.

Table 1. Patient data

No.	Age (yr) / Sex	Diagnosis	Dominancy	Consensus	Duration of symptoms	Root block	ODI Pre-op	ODI Post-op (except sex)
1	68/M	Lt. foraminal HNP, L5-S1	Left	C	1M	N	38	12
2	67/F	Rt. foraminal stenosis, L5-S1	Left	C	3W	YI	32	10
3	64/M	Lt. foraminal stenosis, L5-S1	Left	C	1M	YI	29	10
4	44/M	Lt. foraminal HNP, L5-S1	Left	C	3M	YI	35	9
5	50/F	Lt. foraminal HNP, L5-S1	Left	C	1M	YI	37	13
6	75/F	Lt. foraminal stenosis, L5-S1	Left gas	C	10D	YI	32	9
7	70/F	Lt. foraminal HNP, L5-S1	Left	C	1M	YI	41	8
8	60/F	Rt. foraminal stenosis, L5-S1	Symmetric gas	NC	1M	N	35	17
9	72/F	Rt. foraminal HNP, L5-S1	Right	C	10D	YI	38	30
10	34/M	Rt. foraminal HNP, L5-S1	Right	C	1W	N	40	7
11	77/F	Rt. extraforaminal entrapment by sacral ala, L5-S1	Right	C	3M	N	29	8
12	63/F	Rt. extraforaminal HNP, L5-S1	Right	C	1M	N	30	12
13	54/M	R/o Lt. foraminal fibrous adhesion, L5-S1	Left	C	1M	YI	33	10
14	73/F	Rt. extraforaminal entrapment by osteophyte, L5-S1	Right	C	9M	YI	39	32
15	80/F	Rt. foraminal HNP, L5-S1	Right	C	1.5Y	YI	35	8
16	75/F	Rt. foraminal stenosis, L5-S1	Symmetric	NC	1M	YI	29	12
17	63/F	Lt. foraminal stenosis, L5-S1	Left	C	3M	YN	29	10
18	72/F	Lt. foraminal stenosis, L5-S1	Symmetric	NC	2Y	YN	37	13
19	72/M	Lt. foraminal stenosis, L5-S1	Left	C	2.5Y	YI	30	13
20	57/M	Failed back surgery (Rt. foraminal HNP, L5-S1)	Right	C	2W	N	36	35
21	68/F	Lt. HNP, L4-5 & foraminal stenosis, L5-S1 (DC)	Symmetric	NC	15D	N	32	11
22	72/F	Lt. stenosis, L4-5 & foraminal stenosis, L5-S1 (DC)	Symmetric gas	NC	2M	YI	35	8
23	56/F	Lt. stenosis, L4-5 & foraminal stenosis, L5-S1 (DC)	Left	C	20D	N	34	9
24	74/M	Rt. stenosis, L4-5 & foraminal stenosis, L5-S1 (DC)	Right	C	1Y	YN	32	11
25	70/F	Lt. stenosis, L4-5 & foraminal stenosis, L5-S1 (DC)	Symmetric gas	NC	1Y	N	35	9
26	63/M	Lt. HNP, L4-5 & foraminal stenosis, L5-S1 (DC)	Left	C	1Y	YI	33	15
27	64/F	Rt. stenosis, L4-5 & foraminal stenosis, L5-S1 (DC)	Right	C	1Y	YI	31	12

ODI, Oswestry Disability Index; Oswestry Disability Index score consists of 10 multiple-sections (total score 50) that evaluate the patient's activity to function in ten aspects of their use of pain medication and daily lift. Section on sexual life was excluded in our ODI score. So, the total score is 45. C : consensus, D : day, DC : double crush, HNP : herniated nucleus pulposus, gas : epidural gas, M : month, N : not performed root block, NC : non-consensus, W : week, Y : year, YI : performed root block and improved symptom after block, YN : performed root block and no improvement of symptom after block

were put into the non-consensus group that had no difference in the size of bilateral APDs of the L5 spinal root in spite of the presence of L5 root impingement.

The consensus group was composed of foraminal disc herniations (9 cases), foraminal stenosis (9 cases), entrapment by sacral ala (1 case : case 11) (Fig. 2), entrapment by osteophyte on lumbosacral junction (1 case), and R/o fibrous adhesion (1 case). The non-consensus group was composed of foraminal stenosis only.

In all 9 cases of foraminal disc herniations, asymmetric swelling of APD was observed and so, all were consensus. Of 17 patients diagnosed with a foraminal or extraforaminal stenosis (including 2 cases of root entrapment by sacral ala and osteophyte), 11 (64%) were consensus.

In 24 patients, preoperative sciatica improved after microsurgical decompression. Preoperative ODI scores were 75-93 (mean 83) and postoperative ODI scores improved to 13-36 (mean 21). But, in 3 patients, preoperative symptoms were not improved. Persistent sciatica resulted from incomplete decompression (cases 9, 14) and incorrect diagnosis (case 20).

In 4 patients with foraminal stenosis (cases 6, 8, 22 and 25), the CT image demonstrated epidural gas in the foraminal zone of L5-S1 on the symptomatic side and in cases 8 and 25, there was no history of epidural procedure.

The patients in the consensus group with APD enlargement had a wide range of symptom period from three weeks to two-and-a-half year, with its mean period 5.2 months on average. On the other hand, the patients in the non-consensus group without APD enlargement had symptom period from two weeks to two years, with 6.7 months on average.

Table 2 presents analysis of statistical significance on clinical characteristics between consensus and non-consensus group. In acute HNP, stenosis, no existence of epidural gas, and foraminal lesion, swelling of the APD of L5 spinal root was statistically significant (respectively, p = 0.000, 0.037, 0.000, 0.000). However in existence of epidural gas and extraforaminal lesion, swelling of one was not statistically significant (respectively, p = 0.243, 0.050).

Table 2. Comparisons between consensus (n = 21) and non-consensus group (n = 6)

	Consensus (APD swelling) (%)	Non-consensus (APD no swelling) (%)	*p*-value
Diagnosis (no. of paitents)			
HNP	9 (100.0)	0 (0.0)	0.000
Stenosis	11 (64.7)	6 (35.3)	0.037
Epidural gas (no. of paitents)			
Not exist	20 (87.0)	3 (13.0)	0.000
Exist	1 (25.0)	3 (75.0)	0.243
Location (no. of paitents)			
Foraminal	18 (75.0)	6 (25.0)	0.000
Extraforaminal	3 (100.0)	0 (0.0)	0.050

p-value was calculated by Fisher's exact test and Two-proportion test. APD : anterior primary division, HNP : herniated nucleus pulposus.

Case presentation

He (case 20) (Fig. 3) presented with severe right leg pain for 2 weeks. Although he received conservative management, his symptoms gradually worsened. He was experiencing numbness on the posterolateral aspects of his right leg. MRI and CT scans demonstrated central stenosis at L4-5 and right-sided disc herniation at L5-S1 (Fig. 3A). Surgery was performed with right-sided microdiscectomy at L5-S1 and additional decompression was performed at L4-5. However, he continued to complain of persistent sciatica without any improvement after spine surgery. Three days after the operation, the MRI was rechecked and there was not a remarkable lesion. He was discharged on postoperative 7 days with NSAIDs. A radiologist and the author reviewed the preoperative CT scans and MRI and detected an enlargement of the APD of the symptom-sided L5 spinal

Fig. 3. Preoperative magnetic resonance (MR) image and computed tomography (CT) scans in case 20. A : A central stenosis at L4-5 (MR axial view) and right sided disc herniation at L5-S1 (CT scan). B : A suggested foraminal disc herniation (arrow) at L5-S1 and asymmetric enlargement of right PAD of L5 spinal root (arrowhead).

root and mild disc protrusion on the right foraminal zone at L5-S1 (Fig. 3B). Therefore, a selective L5 root block was performed and his symptoms disappeared for 1 week. Although the lateral disc protrusion at L5-S1 was not prominent, we thought that this was the cause of sciatica and we assumed that the asymmetric swelling of the APD of the L5 spinal root was meaningful. We recommended surgery on the lateral zone at L5-S1 but the patient refused.

DISCUSSION

Extraforaminal or foraminal entrapment of the L5 spinal nerve is a pathologic condition that results in L5 radiculopathy. These entrapments can be caused by the osteophytes on the lumbosacral spine[12], L5 transverse process and the sacral ala (the so-called 'far-out syndrome')[16], the lumbosacral tunnel (consisting of L5 vertebral body, the lumbosacral ligament, and the sacral ala)[13], as well as lumbar disc herniation or stenosis. The diagnosis of these pathologic conditions is based on the neurologic symptoms and radiologic findings and can be confirmed by a selective L5 spinal root block[7,10,12].

Radiologic examinations such as CT and MRI effectively reveal a neural entrapment on the central zone. However, MRI does not clearly demonstrate the pathology on the lateral zone. Hashimoto et al.[6] reported that conventional MRI did not identify the root impingement in 9 patients with extraforaminal stenosis in the lumbosacral spine and only MRI using coronal plane imaging demonstrated the root impingement directly in the far lateral zone in all patients. And they reported that in 2 patients, MR axial images showed the enlargement of the L5 spinal root which suggested the presence of root impingement.

MR myelogram (MRM) can demonstrate more clearly the anatomy of the neural structure around the lumbosacral spine than other radiologic modalities and it can identify nerve root swelling when there is a nerve entrapment[1,2]. Aota et al.[2] reported that use of MRM in the pre-surgical diagnosis of foraminal stenosis is very effective. They demonstrated that; 1) the dorsal root ganglion was significantly larger at the involved site than at the uninvolved site, and 2) in lateral disc herniation, the dorsal root ganglion was significantly larger than in central disc herniation. They[1] also reported again that 3) spinal nerve swelling distal to the impingement site was significantly associated with the corresponding foraminal entrapment. In 17 (68%) of 25 cases, spinal nerve swelling was detected on MRM. This result was similar to our study (11 of 17 cases, 64%).

In general, root impingement results in root swelling owing to the disturbance of blood flow and the inflammatory reaction[2,11]. Dorsal root ganglia (DRG) is particularly sensitive to compression. Pressure on the DRG results in decreased blood flow to sensory nerve cell bodies, which results in neural ischemia, and the neural ischemia is perceived as radicular pain. In addition, histamine-like chemicals and membrane-bound substanced (e.g., phospholipase A2) within the nucleus pulposus of a prolapsed or extruded disc cause inflammation of the DRG, which also results in radicular pain, demyelination of nerve roots, and decreased nerve conduction velocities in the nerves affected by these chemical mediators[5,6].

Heithoff[8] stated that, on the basis of CT scan data, affected nerve roots were enlarged owing to edema distal to the impingement site in lateral stenosis.

In our study, conventional CT scans were used for detection of swelling on the APD at the L5 nerve root in the case of lateral entrapment of the L5 spinal root. The reasons were the following : First, although MRM is a very effective radiologic modality for detecting lateral entrapment, this is not a routine study for all patients with sciatica. Second, CT scans are equipped in most hospitals and the clinical availability is much higher than MRI. Third, in observing the swelling of the APD (located on the ventral surface of the sacral ala) of L5 spinal roots, conventional CT scans were also thought effective. Because the APD of the L5 spinal root passes downward along the ventral surface of the sacral ala (high density on CT scans) and is encased by fat tissue (dark density on CT scans), the APD of the L5 spinal root is well demarcated margin on CT scans and so measurement of thickness is easy.

Case 13 was a very interesting case. He suffered from severe sciatica correlated with the L5 dermatome. However, there was not a definite compressing lesion of the L5 nerve on preoperative CT scans and MRI; yet, there was an asymmetric enlargement of the APD of the symptom-sided L5 spinal root in the images. His sciatica was transiently improved after a selective L5 spinal root block and again aggravated 7 days later. So, exploration of the intracanalicular area on L4-5 and the lateral zone on L5-S1 was decided upon. On the surgical field, there was no definite herniated disc or stenosis, but adhesion and swelling of the L5 spinal root at the lateral zone of L5-S1 were observed. Sciatica improved immediately after exploration. Ido and Urushidani[10] reported similar cases. MRI, myelography, and CT myelography had demonstrated neither disc herniations nor stenosis. But, sciatica was transiently improved by a selective L5 root block. They confirmed, intraoperatively, entrapment of the nerve root by fibrous adhesion and after surgery, sciatica was relieved.

Theresa et al. reported pneumatic nerve root compression

in association with far lateral extruded disc herniation that contained air[4]. In our cases, epidural gas on the lateral zone of L5-S1 was detected in 4 cases (case 6, 8, 22, 25) (in cases 8 and 25, there was no history of epidural procedures). However, it is more plausible to assume that the lateral disc herniation or stenosis was a major lesion rather than to consider that the L5 radiculopathy was caused by pneumatic compression. In consensus group, the mean symptom period was 5.2 months on average, and 6.7 months in non-consensus group. The relationship between the symptom period and the degree of swelling was not considered in our study.

There were several limitations in our study. First, it was difficult to evaluate a statistical significance due to a small number of cases. Second, there was a problem of selection bias. That is, it is highly likely that the surgeons chose the cases with large size of APD appeared in CT before determining the surgery. In case of acute foraminal disc herniation, APD size of surgically treated patients was totally increased, because the surgeons might mainly select the patients with large-sized APD for surgical treatment. Third, CT has a limitation in that it requires 2-3 cuts that provide only a single axial view for comparing bilateral spinal roots, compared to MRM that accommodates comparison of the spinal roots through a long-trace.

CONCLUSION

In our study, it is conformed that a foraminal or extraforaminal entrapment of the L5 spinal root on the lumbosacral junction is significantly related with an asymmetric enlargement of the APD of the L5 spinal root along the ventral surface of the sacral ala on CT scans.

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