

Using Magnetic Resonance Imaging to Identify the Lumbosacral Segment in Children

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ABSTRACT

Identification of the lumbosacral (L-S) segment on magnetic resonance (MR) images is important for appropriate treatment of disease in the lumbosacral (L-S) area. In the study, data obtained from plain A-P radiographs of the L-S spine and sagittal MR imaging scans (sagittal T1- and T2-weighted sequences) of the L-S spine and sacrum with the coccygeal bone, are analyzed. Twenty-six children aged 10 to 14 years were examined for back pain. On the standard A-P radiographs of the L-S spine, a L-S transitional vertebra as classified according to the method of Castellvi et al. was found in 17 subjects. The problem arose as to whether this was lumbalisation or sacralisation, and how to determine which vertebra was L5 with S1. On the sagittal MR imaging studies the same question applied. A need emerged for a simple method which would identify the L-S segment on the sagittal MR imaging studies of the L-S spine in children so that in case of a tumor, inflammation, spondilolystesis, or protrusion of a disc, the level in the L-S spine where the problem is localized can be accurately identified. To this objective we selected the method using detection of the S1 vertebra. This involved that, in addition to the sagittal MR imaging scans of the L-S spine, sagittal images of the sacrum and coccygeal bone be also obtained. On the T2-weighted sequence, the sacrum can be clearly distinguished from the coccygeal bone. By counting from the S5 up, the S1 vertebra can be accurately identified. Determination of the S1 vertebra enables detection of the L5 vertebra and, in turn, of all other lumbar vertebrae. In patients in whom a T2-weighted MR studies were done S1 could be precisely determined and so could the L5 vertebra. In this process, whether the patient had a transitional vertebra or whether there was lumbarisation or sacralisation was irrelevant.

Key words: L-S segment, sacrum and coccygeal bone, spine magnetic resonance, transitional vertebra

Introduction

During the verification of the L-S segment on sagittal MR imaging studies, confusion may arise if the L-S segment is displayed alone. This may be caused by the presence of a rudimentary twelfth rib which can be confounded with the transverse processes of the first lumbar vertebra which in turn can cause the Th12 to be confounded with the L1, and vice versa. This, in turn, also results in inaccurate identification of L5 and S1. Confusion may also occur if a L-S transitional vertebra is present (sacralisation or lumbalisation) and L5 may be misinterpreted as S1, and vice versa. In the presence of these congenital anomalies, the accurate determination of the diseased segment (tumor, disc protrusion or inflammation) is rendered difficult, and so is the appropriate treatment. This all require sagittal T1- and T2-weighted MR imaging scans not only of the L-S spine, but also of the

sacrum and of the coccygeal bone to be obtained, enabling simple identification of both the sacral vertebrae and the L-S segment.

Materials and Methods

In this study, readings of the plain A-P radiographs and sagittal MR imaging scans of the L-S spine obtained for determination of the L-S segment in 26 patients ranging in age from 10 to 14 years, were analyzed and presented. All patients complained of back pain. Sagittal T1- and T2-weighted MR imaging of the L-S spine was performed in 6 patients and of the L-S spine and the entire sacrum with the coccygeal bone in 20 patients using a Siemens Magnet Harmony 1.0 T unit, using the 3 mm

TABLE 1
CLASSIFICATION OF LUMBOSACRAL TRANSITIONAL VERTEBRAE ACCORDING TO CASTELLLVI *ET AL.*²

TYPE IA	Unilateral dysplastic transverse process
TYPE IB	Bilateral dysplastic transverse process
TYPE IIA	Enlarged transverse process which forms a unilateral pseudarthrosis with the adjacent sacral ala
TYPE IIB	Enlarged transverse process which forms a bilateral pseudarthrosis with the adjacent sacral ala
TYPE IIIA	Enlarged transverse process which has a unilateral complete fusion with the adjacent sacral ala
TYPE IIIB	Enlarged transverse process which has a bilateral complete fusion with the adjacent sacral ala
TYPE IV	Type IIA on one side and type IIIA on the other

TABLE 2
CLASSIFICATION OF LUMBOSACRAL DISC MORPHOLOGY ACCORDING TO O'DRISCOLL *ET AL.*³

TYPE 1	No disc material present between S1 and the remainder of the sacrum, the junction being identified by a low signal line
TYPE 2	A small residual disc between S1 and the remainder of the sacrum, with the anteroposterior (AP) diameter of the disc being less than the AP diameter of the sacrum
TYPE 3	A well-formed residual disc between S1 and the remainder of the sacrum, the AP diameter of the disc equaling the AP diameter of the sacrum
TYPE 4	A well-formed residual disc between S1 and the remainder of the sacrum but also with an abnormal sagittal outline to the sacrum

thick sagittal spin-echo T1-weighted (TR500:TE15) and T2-weighted (TR4000:TE105) sequences, matrix 256X256, accompanied by plain radiographic studies of the L-S spine in an A-P view. Results were interpreted by two independent radiologists. On plain A-P radiographs of the

L-S spine a transitional vertebra was detected in 17 patients, and they were classified according to Castellvi et al.^{1,2} (Table 1). During interpretation of the sagittal T2-weighted MR scans obtained in 6 patients, the L-S segment could not be conclusively identified using the twelfth rib as orientation, that is, it was impossible to clearly demonstrate which vertebra was L5 and which was S1. This initiated L-S spinal, sacral and coccygeal MR imaging in the sagittal plane to be done in the rest of our patients. On these images, the boundary between the sacrum and coccyx was established first, and then the S1 was identified by counting from the S5 up (Figure 1). In this way the sacral section of the spine was determined. By further counting up from there the lumbar vertebrae were also determined and so was the L-S segment. For these interpretations the presence of the transitional vertebra was irrelevant. The lumbosacral disc morphology was evaluated and interpreted according to the classification of O'Driscoll et al.³ (Table 2), and this was performed in the patients with sacral and coccygeal MR imaging done and the L-S segment definitely identified.



Fig. 1. Sagittal MRI of the L-S spine and sacrum. Identification of the S1 vertebral body by means of numbering the sacral segments from S5 up. The borderline between the coccygeal bone and the S5 vertebra is visible.

Results

There was totally 26 patients, 14 (53.8%) girls and 12 (46.2%) boys. On the plane radiographs of the L-S spine, a transitional vertebra was found in 17 (65.4%) patients, and they were classified according to Castellvi et al. (Table 3). T2-weighted sagittal plane images of the L-S spine were obtained from 6 subjects. Orientation by the twelfth rib could not precisely identify which vertebra was L5 and which S1 in these patients due to the presence of a transitional vertebra verified on the plane radiographic studies of the L-S spine in an A-P view. In 20 patients MR imaging of the L-S spine, sacrum and coccygeal bone in the T2-weighted sagittal plane, was performed. Of these, a transitional vertebra was detected in 9 patients, and there was none in 11. In all of them, the S1 vertebra could be accurately identified by counting the sacral vertebrae from S5 to S1. In this manner, the L-S junction could also be identified, and the detection of the L-S seg-

TABLE 3
READING OF PLAIN A-P RADIOGRAPHS OF THE L-S SPINE AND CLASSIFICATION OF THE TRANSITIONAL VERTEBRA BASED ON CASTELI ET AL.²

Transitional vertebra	Number of patients	%
TYPE IA	2	11.8
TYPE IB		
TYPE IIA	2	11.8
TYPE IIB	4	23.5
TYPE IIIA	3	17.6
TYPE IIIB	4	23.5
TYPE IV	2	11.8
TOTAL	17	100.0

TABLE 4
INTERPRETATION OF SAGITTAL MR IMAGES OF THE L-S SPINE AND CLASSIFICATION OF DISC MORPHOLOGY ACCORDING TO O'DRISCOLL ET AL.³

Disc morphology	Number of patients	%
TYPE 1	7	35.0
TYPE 2	7	35.0
TYPE 3	4	20.0
TYPE 4	2	10.0
TOTAL	20	100.0

ment, in turn, enabled identification of the lumbosacral disc. The lumbosacral disc morphology was classified according to O'Driscoll (Table 4). Complete agreement occurred between the readings of both independent examiners.

Discussion

Determination of the L-S segment on sagittal T1- and T2-weighted MR images has got its difficulties. One of these is the rudimentary twelfth rib which can be mistaken for the transverse processes of the first lumbar vertebra, and the other is the L-S transitional vertebra. Hahn et al. tried to avoid this pitfall by imaging the spine from C1 to the lumbosacral transition⁴. Ralston et al. proposed that the right renal artery may be used to identify lumbar levels on sagittal MR imaging because of its position in the plane of L1-L2 disc, however this technique seems to be unreliable due to possible variations in

the anatomy of the right renal artery⁵. Hughes and Saifuddin identify the L5 vertebra through the iliolumbar ligament⁶. Many authors, including Luoma K.^{7,8} and Young JP⁹ studied the problem of the L-S transitional vertebra and its relationship with disc degeneration and back pain. Painful spine and back pain presented a challenge for many authors to investigate¹⁰⁻¹²; however, they did not focus on the identification of the L-S segment. In this study, analysis of the plane A-P radiographs of the L-S spine and their readings confirmed the presence of a transitional vertebra and thus of a pitfall in the identification of the L-S segment on sagittal T1- and T2-weighted MR imaging of the L-S spine. The method for the L-S segment identification according to either Hahn, Ralston, or Hughes appeared to be too complicated to be used in children, and we opted for the method employing determination of the sacral vertebrae. On sagittal T2-weighted MR images of the sacrum and coccygeal bone the border between the coccyx and the sacral vertebrae is clearly visible in children, enabling the counting of the vertebrae. This is the basis of the method we propose for the determination of the L-S segment in this study. The L-S segment was determined by counting from S5 to S1. It needs emphasizing that this method for L-S segment determination is independent of either detection of transitional vertebrae or evaluation of lumbosacral disc morphology. This makes this method simple and fast.

Conclusion

Patients with pain in the lumbosacral region are often referred for MR imaging in order to improve the accuracy of diagnosis. This pain can result from a range of pathologic conditions from idiopathic causes to inflammation, tumor, spondylolysis, and disc protrusion. Appropriate treatment, particularly surgical, requires that the level in the spine where the pathological condition is localized should be accurately determined. If a transitional vertebra is present in these patients, on sagittal T1- and T2-weighted MR imaging scans of the L-S spine the L5 vertebra can be misinterpreted as S1, and vice versa. Based on the results of our study, not only MR imaging of the L-S spine, but also of the sacrum with the coccygeal bone in the sagittal T1- and T2-weighted plane should be performed for correct identification of L5 and S1, and thus of the L-S segment. This allows the counting of the sacral vertebrae from S5 up, and identification of both the S1 vertebra and the L-S segment. This procedure is fast, easy, and well suited for children and enables accurate localization of a pathological condition in the spine if there exists any.

REFERENCES

- BERTOLOTTI, M., *La Radiologia Medica*, (1917) 113. — 2. CASTELLI, A. E., L. A. GOLDSTEIN, D. P. K. CHAN, *Spine*, 9 (1984) 493. — 3. O'DRISCOLL, C. M., A. IRWIN, A. SAIFUDDIN, *Skeletal Radiol.*, 25 (1996) 225. — 4. HAHN, P. Y., J. J. STROBEL, F. J. HAHN, *Radiology*, 182 (1992) 580. — 5. RALSTON, M. D., T. A. DYKES, B. I. APPLEBAUM, *Radiology*, 183 (1992) 615. — 6. HUGHES, R. J., A. SAIFUDDIN, *Clinical Radiology*, 59 (2004) 984. — 7. LUOMA, K., T. VAHMAS, R. RAININKO, R. LUUKKONEN, H. RIIHIMAKI, *Spine*, 29 (2004) 200. — 8. LUOMA,

K., H. RIIHIMAKI, R. LUUKKONEN, R. RAININKO, E. VIKARI-JUNTURA, A. LAMMINEN, *Spine*, 25 (2000) 487. — 9. YOUNG, J. P., P. H. YOUNG, *Missouri Medicine*, 102 (2005) 70. — 10. CELAN, D., Z. TURK,

Coll. Antropol., 29 (2005) 101. — 11. BENER, A., R. ALWASH, T. GABER, G. LOVASZ, *Coll. Antropol.*, 27 (2003) 95. — 12. FALK, D., *Coll. Antropol.*, 28 Suppl 2 (2004) 59.

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ODREĐIVANJE LUMBOSAKRALNOG SEGMENTA MR-PRETRAGOM KOD DJECE

SAŽETAK

Određivanje lumbo-sakralnog (L-S) segmenta snimanjem magnetnom rezonancijom (MR) važno je za ispravno liječenje bolesti u području lumbo-sakralne (L-S) kralješnice. U ovom su radu obrađeni podaci dobiveni očitavanjem standardnih snimaka L-S kralješnice u A-P projekciji te očitavanjem MR L-S kralješnice i sakruma s kokcigealnom kosti u sagitalnoj ravnini (T1 i T2 sagitalni presjek). Pretrage su učinjene kod 26 djece u dobi od 10 do 14 godina zbog križobolje. Na standardnim snimkama L-S kralješnice u A-P projekciji kod 17 ispitanika nađen je L-S prijelazni kralješak klasificiran po Castellvi i suradnicima. Postavilo se pitanje da li je to lumbalizacija ili sakralizacija i kako odrediti koji je kralješak L5 a koji S1.. Na sagitalnom presjeku MR L-S kralješnice postavilo se isto pitanje. Koji je kralješak L5 a koji S1? Ukazala se potreba pronaći jednostavno određivanje L-S segmenta na sagitalnoj snimci MR L-S kralješnice kod djece, kako bi se u slučaju tumora, upale, spondilolisteze, protruzije diska moglo ispravno odrediti u visini kojeg segmenta L-S kralješnice se nalazi problem. Odlučilo se na određivanje S1 kralješka. Kako? Uz sagitalnu snimku MR L-S kralješnice učinila se i sagitalna snimka sakruma i kokcigealne kosti. Na T2 presjeku jasno se vidi razlika između kokcigelane kosti i sakruma. Brojanjem kralješka od S5 prema gore točno se može odrediti S1 kralješak. Određivanjem S1 kralješka može se odrediti i L5 kralješak a time i svi ostali lumbalni kralješci. Kod ispitanika kojima je učinjen takav presjek na MR moglo se točno odrediti koji je S1 a time i koji je L5 kralješak. Pri tom nije bila važna činjenica da li ispitanik ima prijelazni kralješak i da li se radi o lumbalizaciji ili sakralizaciji.