

Regional Disc Change in Segmental Hypoplasia of the Lumbosacral Vertebral Bodies: MR Findings¹

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Purpose: To classify types of vertebral hypoplasia and to investigate the prevalence and patterns of associated disc degeneration.

Materials and Methods: Defining vertebral hypoplasia as occurring when the AP diameter of a lower vertebral body is smaller than that of an upper ones, we retrospectively reviewed the MR images obtained in 34 cases of this condition involving young adults. Two major types and two subtypes, a total of four different entities were classified as follows; type I: hypoplasia involving a single vertebral body; type II: hypoplasia involving serial lower segmental vertebral bodies; subtype a: hypoplastic body located anteriorly along the anterior spinal line; subtype b: hypoplastic body located posteriorly along the posterior spinal line. We also investigated each type of vertebral hypoplasia and patterns of associated disc changes.

Results: Three different types were observed. In type IIa(n= 29), posterior disc occurred in 8/29 cases, diffuse degeneration in 21/29 patients, and posterior disc herniation in all. All type Ia cases(3/3) showed diffuse disc degeneration at both upper and lower disc levels, with posterior disc herniation, while both type IIb cases(2/2) showed diffuse disc degeneration, with bidirectional disc herniation.

Conclusion: By identifying the exact patterns of vertebral hypoplasia, we were able to predict which portion of the disc was likely to degenerate.

Index words : Spine, MR

Spine, intervertebral disks

Spine, abnormalities

One would expect the size of vertebral bodies to increase gradually in the lower direction to the level of L5 - S1 (1, 2). But in fact some variation occurs. For example, the lower vertebral bodies may be smaller than the upper ones. In this situation, changes in vertical stress can be a causative factor in disc degeneration (3).

As far as we are aware, however, no previous report has described the different types of vertebral hypoplasia and the relationship between vertebral hypoplasia and regional disc abnormality. In this paper we therefore classify the types of vertebral hypoplasia and investigate the prevalence and the patterns of associated disc degeneration.

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Received January 17, 2000 ; Accepted May 30, 2000
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Materials and Methods

We retrospectively reviewed the sagittal and axial MR imaging findings of the spine in an initial series of 58 pa-

tients with vertebral hypoplasia. Exclusion criteria included 1) previous spinal disc surgery, 2) the existence of spondylolysis or spondylolisthesis, 3) age over 35 years (it is well known that beyond this age, disc changes are most clearly associated with the aging process), 4) incomplete imaging (lost films). The final definite series consisted of 34 patients (M:F = 26:8) aged between 17 and 35 (mean, 27.1) years. Images of the spine were obtained using a 1.5T unit (GE Medical Systems, Milwaukee, Wis., U.S.A.) and a sequence which included sagittal T1-weighted (TR/TE: 600/39), T2-weighted (TR/TE: 2000/80) and proton density-weighted (TR/TE: 2000/30) spin echo imaging of the entire lumbar spine with the following sequence parameters: 256 × 192 matrix, 260 mm field of view, 5 mm section thickness, and 0.5 mm intersectional gap. In addition, axial T1-weighted (TR/TE: 600/39) and T2-weighted (TR/TE: 2000/80) spin echo images of all lumbar intervertebral spaces (three sections per disc level from L1 to S1) were obtained with the following sequence parameters: 256 × 128 matrix, 160 mm field of view, 4 mm section thickness, 0.5 mm intersectional gap. Vertebral hypoplasia was defined as occurring when the AP diameter of a lower vertebral body was less than that of an upper one, with abrupt transition of the anterior or posterior spinal line, as seen on three consecutive middle sliced sagittal MR images. The AP diameters of adjacent end

plates of vertebral bodies as seen on mid sagittal MR images, were measured and the findings were expressed as the ratio (in percentage). On the basis of the radiographic findings, the following four different entities were classified two major types and two subtypes (Figure. 1). Type I: hypoplasia involving a single vertebral body; Type II: hypoplasia involving serial lower segmental vertebral bodies; Subtype a: hypoplastic body located anteriorly along the anterior spinal line, Subtype b: hypoplastic body located posteriorly along the posterior spinal line. We also investigated the prevalence and location of disc degeneration (anterior, posterior or diffuse) and the direction of disc herniation (anterior, posterior, or bilaterally) at the level of hypoplastic variation. Through which axial cuts were taken at the upper and lower levels. Both axial and sagittal cuts were used to assess the location of disc degeneration and direction of disc herniation. The signal intensity observed on T2-weighted images in the central four-fifths of the T11-T12, T12-L1, or L1-L2 disc was considered the normal standard for each given patient. Discs showing a detectable decrease with respect to that standard were considered to have abnormal signal intensity and disc extension beyond the interspace was considered to be disc herniation. All these images were retrospectively analysed by three neuroradiologists who reached a consensus.

Table 1. Prevalence of Each Type of Vertebral Hypoplasia and Patterns of Associated Disc Changes

Type	No.(%)	Location of Disc Degeneration			Direction of Disc Herniation		
		Anterior	Posterior	Diffuse	Anterior	Posterior	Bidirection
Ia	3(8.8)	0	0	*3	0	*3	0
IIa	29(85.3)	0	8	21	0	29	0
IIb	2(5.9)	0	0	2	0	0	2
Total	34(100)		8	*26		*32	2

* Incidence at upper and lower disc level

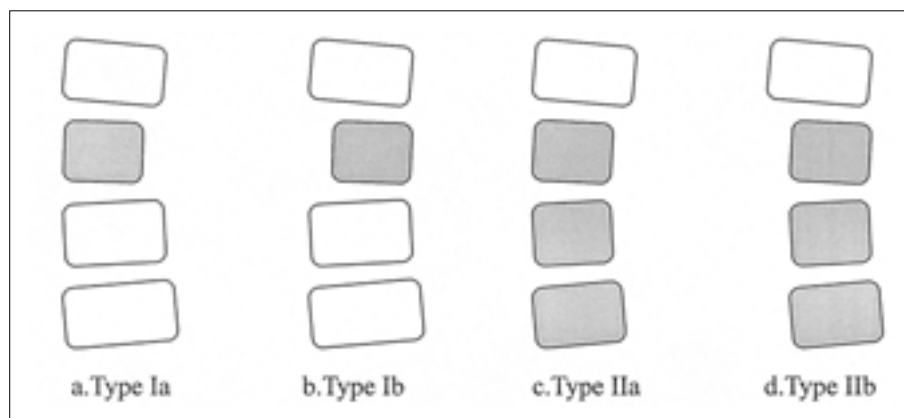


Fig. 1. Diagram illustrates four types of vertebral hypoplasia.

Results

In all 34 patients, hypoplastic lower vertebral bodies had a smaller AP diameter than upper ones, and the ratio of AP diameter between adjacent end plates varied from 83:100 to 93:100(mean 91:100). After reviewing the radiographic imaging findings, four different types of vertebral hypoplasia were classified. Because we had used exclusion criteria in order to reduce bias, only

three different types were included in our study group, However. Type IIa occurred in 85.3% of cases (29/34), type Ia in 8.8% (3/34), and type IIb in 5.9% (2/34). Levels at which segmental hypoplasia was commonly involved were L4-5 (20/34) and L5-S1 (13/34). Among the 29 type IIa patients, anterior disc degeneration was not found, through posterior disc degeneration was noted in 8/29, diffuse disc degeneration in 21/29 and posterior disc herniation in all 29. In all three type Ia patient, diffuse disc degeneration was found at both upper and lower disc

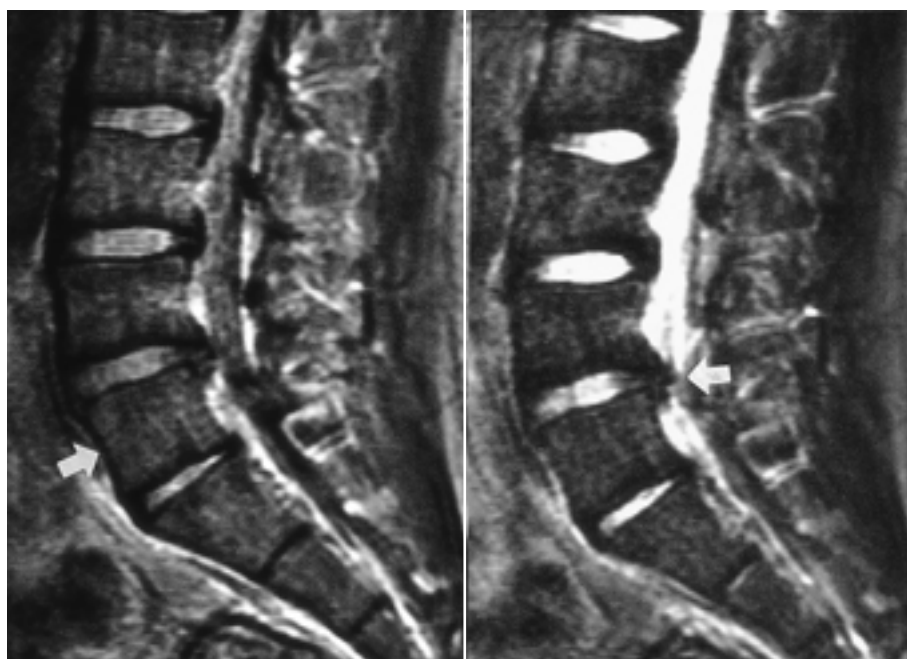


Fig. 2. 23-year-old man of Type IIa vertebral hypoplasia between L4 and L5. (left) Sagittal proton-weighted image shows hypoplasia below L5 vertebral body and hypoplastic bodies located anteriorly along anterior spinal line (right) Sagittal T2-weighted image shows loss of normal signal intensity at the posterior portion of the L4-5 disc with extension of the posterior disc margin beyond the interspace (arrow).

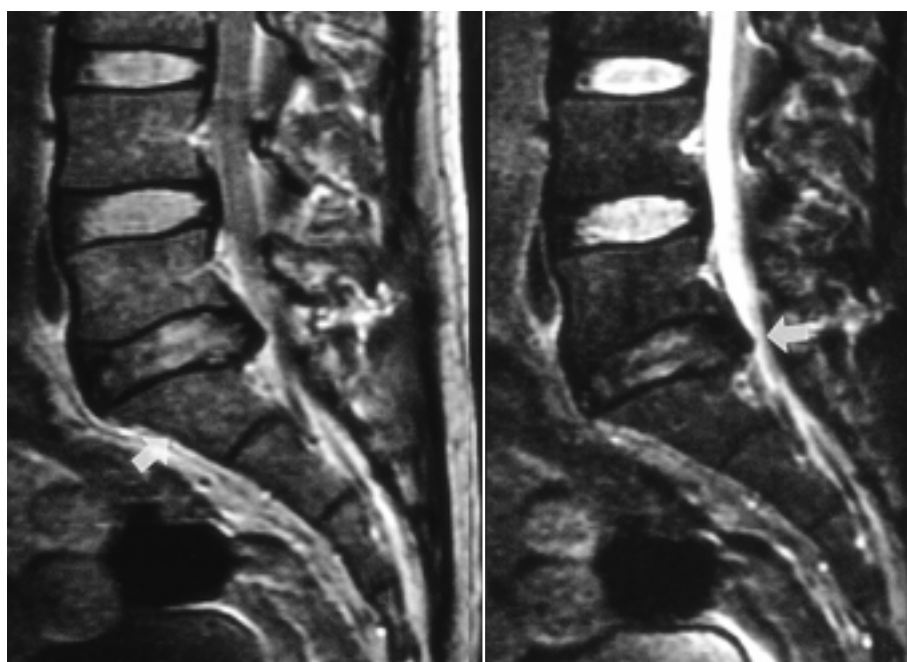


Fig. 3. 34-year-old man of Type IIa vertebral hypoplasia between L5 and S1. (left) Sagittal T1-weighted image shows hypoplasia below S1 vertebral body and hypoplastic bodies located anteriorly along anterior spinal line (right) Sagittal T2-weighted image shows diffuse loss of normal signal intensity of the L5-S1 disc with extension of the posterior disc margin beyond the interspace (arrow).



Fig. 4. 27-year-old man of Type Ia vertebral hypoplasia involving L5 vertebral body. (left) Sagittal T1-weighted image shows hypoplasia involving only L5 vertebral body and hypoplastic body located anteriorly along anterior spinal line (right) Sagittal T2-weighted image shows loss of normal signal intensity of L4-5 and L5-S1 discs with extension of the posterior disc margin beyond the interspace (arrow).

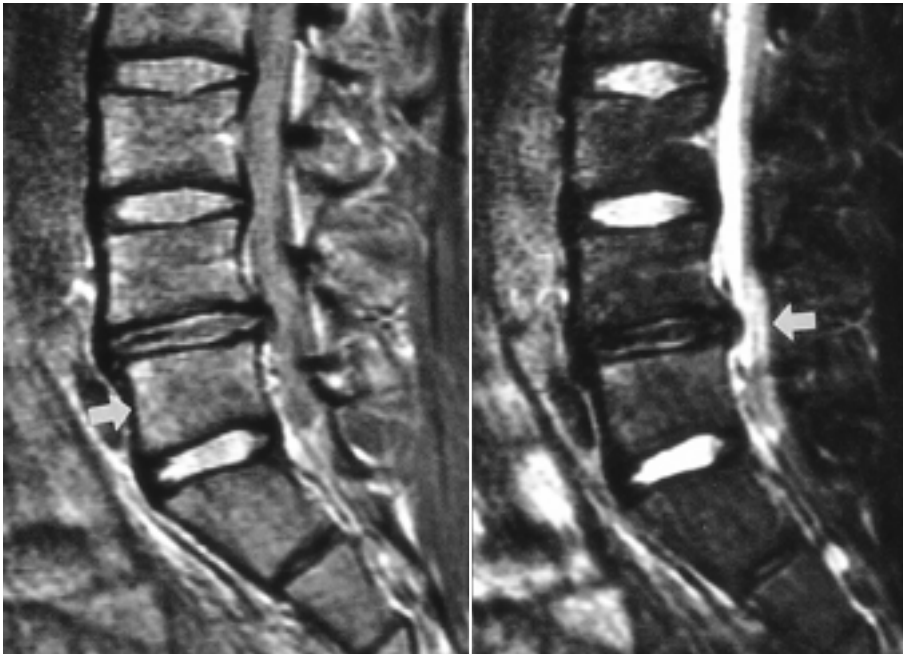


Fig. 5. 20-year-old man of Type IIb vertebral hypoplasia between L4 and L5. (left) Sagittal T1-weighted image shows hypoplasia below L5 vertebral body and hypoplastic bodies located posteriorly along posterior spinal line (right) Sagittal T2-weighted image shows loss of normal signal intensity of the L5-S1 disc with bi-directional disc extension beyond the interspace (arrow).

levels and all three showed posterior disc herniation. In both type IIb patients, diffuse disc degeneration and bidirectional disc herniation were found (Table 1.).

Discussion

The vertebral column supports the weight of the trunk and upper limbs, and also sustains much of the weight of loads supported or carried by these parts of the body (1, 4). The structure of the chain of vertebral bodies and

intervertebral discs and mechanical considerations, indicate that these weights subject the chain mainly to vertical compression forces, the magnitude of which increases from the axis to the lumbo-sacral joints (1, 4, 5). One would therefore expect the size of the vertebral bodies to increase in the same direction, with smooth tapering of anterior and posterior spinal lines, and the lowest lumbar or first sacral vertebra the largest. In general this assumption is supported by serial measurements of the vertebral bodies (1, 2). but some variation occurs, Lower

vertebral bodies, for example, are more hypoplastic than upper ones. In this situation abrupt reduction in size of a lower vertebra leads to the exertion of more compressive force per unit area upon a disc surface than in a case where the lower vertebral body is its usual larger size. It is now generally accepted that in addition to intervertebral disc degeneration, chronic mechanical compressive stress plays an important role in the development of intervertebral disc herniation (6 - 8). It may thus be assumed that hypoplasia of a lower vertebral body can be a causative factor in disc degeneration (including disc herniation). Though many distinct types of vertebral hypoplasia have been proposed, no previous report has examined the relationship between these and regional disc abnormality. The types proposed include hypoplasia involving a single vertebral body, the type involving serial lower segmental vertebral bodies, the type involving a series of vertebral bodies and hypoplasia of an upper segmental vertebral body with abrupt enlargement of a lower body. After a review of the radiographic imaging findings, four different types of vertebral hypoplasia were identified, but because of our exclusion criteria applied in order to reduce bias, only three types were included in our study. Most cases of vertebral hypoplasia occurred at the level of L4-5(20/34) and L5-S1(13/34). The most common form is type IIa, in which all associated disc degenerations was posterior or diffuse and in which posterior directional disc herniation had occurred in all cases. In type Ia hypoplasia, all cases showed diffuse disc degeneration and posterior disc herniation at both upper and lower disc levels. While in type IIb, diffuse disc degeneration and bidirectional disc herniation were found. It appears that for

each type of vertebral hypoplasia, the disc involved has a more vulnerable portion: for each of these types, an understanding of the basic pathogenesis of disc degeneration will require the use of biomechanical models.

In conclusion, vertebral hypoplasia can be a causative factor of early onset degenerative disc disease. By identifying the exact pattern of vertebral hypoplasia, we can therefore, predict which portion of disc is likely to degenerate. The findings we have described may be useful for the clinician who needs to focus on those areas susceptible to disc degeneration.

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