

ORIGINAL RESEARCH

The accuracy of using the site of aortic bifurcation in predicting the level of lumbar vertebrae on lumbosacral MRI in an Indian population

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ABSTRACT

When an LSTV is present, the preferred modality is radiograph (Ferguson radiograph) which helps in identification of the individual lumbar vertebral level by the following observations on lumbosacral radiograph: the largest transverse pedicle diameter and the longest inter-pedicular distance is at L5; the longest transverse process is at L3; the neural foramina gradually increase in size from L1 to L5; the iliac wings are located between L4 and L5. Most often lumbar spine imaging is done in cases of non-traumatic low backache and the MRI is the preferred modality in such cases because of its soft tissue resolution. Totally 224 Indian subjects who underwent lumbar spine MRI with whole spine screening in Radiology department were studied. Most of these subjects were referred for evaluation of backache and radiculopathy. After reviewing 21 patients with prior spine surgery, severe alterations in spine curvature, extremely tortuous aorta and spine deformities were excluded. Among the subjects with normal segmentation majority of them had aortic bifurcation at the level of Upper L4 (33.7%), Mid L4 (28.5%). Among the subjects with sacralization majority of them had aortic bifurcation at the level of L3-L4 (27.8%), Mid L3 (22.2%). Among subjects with Lumbarization majority of them had aortic bifurcation at the level of L4 lower (40%).

Key words: Aortic bifurcation, level of lumbar vertebrae, lumbosacral MRI

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INTRODUCTION

Lumbosacral transitional vertebrae (LSTV) is congenital segmentation anomaly of vertebral body characterized by either sacralization of L5 (varying degrees of fusion of last lumbar L5 vertebra to the sacrum with transition to sacral configuration) or lumbarization of S1 (varying degrees of separation of first sacral vertebra S1 with transition to lumbar configuration).¹ Wide range of morphological variation in segmentation, sacralization of L5 varies from broadened elongated transverse process to complete fusion of transverse process with sacrum and the lumbarization S1 varies from formation of anomalous articulation with sacrum, squared appearance on sagittal image, well-formed lumbar type of facet joint and well-formed S1-S2 disc, rather than no/small sized disc.²

Most of the times it's difficult to decide whether it's sacralized L5 or lumbarized S1, so the term LSTV is used in general. LSTV subjects are at risk for surgical

errors such as wrong level spinal surgery or interventional procedures. The prevalence of LSTV is 3-26%, making the differentiation between lumbarization and sacralization important when determining the position of individual lumbar segments on MRI.³

When an LSTV is present, the preferred modality is radiograph (Ferguson radiograph) which helps in identification of the individual lumbar vertebral level by the following observations on lumbosacral radiograph: the largest transverse pedicle diameter and the longest inter-pedicular distance is at L5; the longest transverse process is at L3; the neural foramina gradually increase in size from L1 to L5; the iliac wings are located between L4 and L5.⁴ Most often lumbar spine imaging is done in cases of non-traumatic low backache and the MRI is the preferred modality in such cases because of its soft tissue resolution. The difficulty in identification and numbering of LSTV in MRI is due to many factors

including limited coverage of thoracolumbar junction, inability to identify last rib bearing vertebrae and failed to differentiate between hypoplastic ribs and elongated transverse process. While reading Lumbar Spine MRI without the help of radiographs, other morphological parameters such as vertebral body shape, configuration of S1-S2 disc and the lumbosacral angle are used but are not consistently reliable. To improve the accuracy in numbering lumbar vertebral segments Paraspinal structures can be used as landmarks including the origin of the superior mesenteric artery (SMA), the psoas muscle, pedicles, neural foramina, iliolumbar ligaments, conus medullaris, IVC confluence, renal artery and aortic bifurcation.^{5,6}

METHODOLOGY

The study design and protocol was reviewed and approved by Institutional Review Board.

STUDY DESIGN: Prospective observational study.

STUDY AREA: Lumbosacral spine MRI.

STUDY POPULATION

Totally 224 Indian subjects who underwent lumbar spine MRI with whole spine screening in Radiology department were studied. Most of these subjects were referred for evaluation of backache and radiculopathy. After reviewing 21 patients with prior spine surgery, severe alterations in spine curvature, extremely tortuous aorta and spine deformities were excluded. The 8 subjects with age less than 20 years were also excluded, so final study group includes 195 subjects.

INCLUSION CRITERIA

All Indian subjects referred to Radiology department for MRI Lumbosacral spine.

EXCLUSION CRITERIA

1. Age group <20 years.
2. Subjects who have had metallic devices placed in their body like pacemaker, eye implant, aneurysmal clip and pedicle screws.
3. Subjects refusing consent for the study.

RESULTS

Table 1A: Association between LSTV and Level of Aortic bifurcation

Aortic bifurcation	Segmentation					
	Normal		Sacralisation		Lumbarization	
	Count	%	Count	%	Count	%
L3	16	9.3%	9	50.0%	0	0.0%
L3 - L4	20	11.6%	5	27.8%	0	0.0%
L4	124	72.1%	4	22.2%	4	80.0%
L4-L5	10	5.8%	0	0.0%	0	0.0%
L5	2	1.2%	0	0.0%	1	20.0%

$$\chi^2 = 46.24, df = 10, p < 0.001^*$$

Among subjects with Normal segmentation majority had aortic bifurcation at the level of L4 (72.1%),

4. Subjects who are not of ethnic Indian origin.
5. Subjects with history of extremely tortuous aorta, aortic aneurysm history of spinal deformities, trauma, infection, tumor and previous spinal surgery.

REFERENCE STANDARD

Whole spine screening and counting of vertebral body levels from C2 downwards.

LIST OF TOOL FOR DATA COLLECTION

1. 1.5 T Siemens Avanto machine.
2. PACS (Picture Archiving and Communication Systems) from MEDIFF technologies (INSTARad and INSTA Pusher) lossless transmission.
3. Workstation with BARCO Coronis 5MP diagnostic gray scale display system for reviewing images.

MRI LUMBAR SPINE PROCEDURE

- Informed written consent is taken from the subject after briefing them about the procedure.
- If contra-indications to MRI exist, the procedure is not done and the subject is excluded from the study.
- Standard Lumbosacral MRI will be performed as given below.

MRI IMAGING PROTOCOL:

All scans were performed on a 1.5 T Siemens Avanto machine.

- **T2W:** Sagittal plane whole spine; 3 mm sections, **TR:** 3400ms, **TE:** 105ms, **FOV:** 300mm
- **T2W:** Axial plane lumbar spine; 4mm sections, **TR:** 4500ms, **TE:** 105ms, **FOV:** 180mm
- T2W-STIR coronal plane dorsolumbar spine; 4mm sections, **TR:** 4000ms, **TE:** 45ms, **FOV:** 300 mm.

IMAGE POST-PROCESSING/ANALYSIS: The raw imaging data obtained from: SIEMENS 1.5T MRI will be sent to PACS (picture archiving and communication system) workstations and viewed on BARCO 5 mega pixel image viewer.

among subjects with sacralization majority had aortic bifurcation at the level of L3 (50%) and majority of

subjects with Lumbarization had aortic bifurcation at the level of L4 (80%) and L5 (20%).

Table 1B: Association between LSTV and Level of Aortic bifurcation

Aortic bifurcation	Segmentation					
	Normal		Sacralization		Lumbarization	
	Count	%	Count	%	Count	%
L3 upper	2	1.2%	3	16.7%	0	0.0%
L3 mid	5	2.9%	4	22.2%	0	0.0%
L3 lower	9	5.2%	2	11.1%	0	0.0%
L3-L4	20	11.6%	5	27.8%	0	0.0%
L4 upper	58	33.7%	1	5.6%	1	20.0%
L4 mid	49	28.5%	3	16.7%	1	20.0%
L4 lower	17	9.9%	0	0.0%	2	40.0%
L4-L5	10	5.8%	0	0.0%	0	0.0%
L5 upper	2	1.2%	0	0.0%	1	20.0%

$$\chi^2 = 64.09, df = 18, p < 0.001^*$$

Among the subjects with normal segmentation majority of them had aortic bifurcation at the level of Upper L4 (33.7%), Mid L4 (28.5%). Among the subjects with sacralization majority of them had aortic bifurcation at the level of L3-L4 (27.8%), Mid L3 (22.2%). Among subjects with Lumbarization majority of them had aortic bifurcation at the level of L4 lower (40%).

DISCUSSION

Following identification of vertebral body level using whole spine localizer (WSL), the level of aortic bifurcation is identified in sagittal and axial MR T2 weighted images.

Aortic bifurcation (AB) is at L4 body level in normal segmentation subjects; shifted cranially or caudally in subjects with sacralization or lumbarization respectively.

NORMAL SEGMENTATION: AB at L4 (72%)-specifically, at upper/mid L4 (63%).

Our study, in normal segmentation subjects AB most frequently found at the level of L4 body (72.1%), followed by L3-L4 disc (11.6%), L3 body (9.3%) levels. When specifying upper/mid/lower vertebral level, we found AB most frequently at upper/ mid L4 body (63%), followed by L3-L4 disc (12%), lower L4 body (9%), L4-L5 disc (6%) and lower L3 body (4%) levels.

Nil Tokgoz *et al.*⁷ studied 1049 cases and in normal segmentation subjects AB was found most frequently at L4 (71.1%) level. Chithrikiet *al.*⁸ studied 221 cases and in normal segmentation subjects AB was found most frequently at L4 body (67%), followed by L3-L4 disc (13.4%), L3 body (9%) and L4-L5 disc (8%) levels.

COMPARISON OF OUR STUDY WITH LITERATURE RESULTS: In normal segmentation subjects AB level in our study correlates well with results reported by other authors.

Overall, AB was most frequently found at L4 body (72%) with most cases are at upper and mid L4 levels (63%).

SACRALIZATION: AB shifted cranially: 84% above mid L4.

Our study, in sacralization subjects AB most frequently found at the level of L3 body (50%), followed by L3-L4 (27.8%), L4 (22.2%). This suggests 78% of cases were above the level of L4. When specifying upper/mid/lower vertebral level, we found AB most frequently at L3-L4 disc (28%), mid L3 (22%), upper L3 (17%), mid L4 (17%), lower L3 (11%) and upper L4 (6%) levels. In 83% of subjects AB was found above the level of mid L4 body.

Nil Tokgoz *et al.*⁷ studied 1049 cases; in sacralization subjects AB was found most frequently at L3 body (51.4%), followed by L3-L4 disc (32.4%) levels. Chithriki *et al.*⁸ studies 221 cases; in sacralization subjects AB was found most frequently at L3 body (59%), followed by L4 body (23%), L3-L4 disc (14%) levels.

COMPARISON OF OUR STUDY WITH LITERATURE RESULTS: In sacralization subjects SMA origin level in our study correlates well with results reported by other authors. When specifying upper/mid/lower vertebral level, we found that 84% were above mid L4. This upper/mid/lower specification has not been addressed by other authors. Overall, 78% subjects with AB are above L4 body level and 84% subjects AB is above the level of mid L4. This suggests the cranial shift of AB in subjects with sacralization.

LUMBARIZATION: AB shifted caudally: 60% below mid L4.

Our study, in lumbarization subjects AB was most frequently found at L4 body (80%), followed by L5 (20%). The most common location is L4 which is similar to the AB level of normal segmentation population. When specifying upper/mid/lower

vertebral level, we found AB most frequently at lower L4 body (40%), upper L5 (20%), mid L4 (20%) and upper L4 (20%) levels. In 60% subjects AB was found below the level of mid L4 levels.

Nil Tokgoz *et al.*⁷ studied 1049 cases; in lumbarization subjects AB was found most frequently at L4 body (42.5%), followed by L4-L5 (32.5%) and L5 body (20%). Chithrikiet *al.*⁸ studied 441 cases; in lumbarization subjects AB was found most frequently at L4 body (47%), followed by L4-L5 disc (33%) & L5 body (13%) levels.

COMPARISON OF OUR STUDY WITH LITERATURE RESULTS:

In our study when we studied AB in relation to whole vertebral body, AB was most frequently found at the same level as in normal segmentation. In fact, other authors with larger series of lumbarization (15 subjects in Chithriki *et al.* study and 80 subjects in Nil *et al.* study) have reported a predominantly caudal shift with 46-53% of subjects showing the AB to be located below L4. When specifying upper/mid/lower vertebral level, we found AB located below the level of mid L4 in 60% of subjects. This infers the caudal shift in AB level in subjects with lumbarization. This correlates well with other studies.

CONCLUSION

Aortic bifurcation (AB):

NORMAL: L4.

SACRALIZATION: Cranial shift.

LUMBARIZATION: Caudal shift.

NORMAL SEGMENTATION: AB at L4 (72%)- specifically, at upper/mid L4 (63%)

In subjects with normal segmentation AB was found at L4 body (72% with upper: 34%, mid: 29%, lower: 9%) followed by L3-L4 disc (12%) levels.

SACRALIZATION: AB shifted cranially: 84% above mid L4

In subjects with sacralization, AB was found at a higher level at the L3 vertebral body (50%) followed by L3-L4 (28%), mid L4 (16%) and upper L4 (6%).

LUMBARIZATION: AB shifted caudally: 60% below mid L4

When viewing the vertebral body as a whole, AB was found most frequently at L4 (80%) followed by L5 (20%). However, when the vertebral level was specified as upper/mid/lower, AB was located below mid L4 in 60%, indicating a caudal shift.

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