Role of Iliolumbar Ligament in Identification of L5 Vertebra on MRI in Lumbosacral Transitional Anomalies.

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ABSTRACT

Background: Labeling a transitional vertebra (lumbarization or sacralization) as "LSTV" helps in simplifying the reporting process but leads to mis-numbering and must be avoided, as reliable identification of vertebral levels is essential for surgical interventions and image guided interventions. Many parameters have been described to identify the vertebral level; however, there are contradictory results in literature regarding their usefulness. **Objective:** To determine the role of iliolumbar ligament (ILL) on MRI as an identifier of the L5 vertebra in cases of LSTV anomalies. **Methods:** 200 patients with confirmed L5 level (identified on MRI screening of whole spine) were included in the study. These were further divided into group I (159 patients), II (31 patients) and III (10 patients) consisting of normal spine, spine with sacralization and with lumbarization respectively. The level(s) of origin of the ILL was documented in all of them and analysis was done. **Results:** ILL was found bilaterally in all patients. All patients with normal lumbosacral junction had ILL arising from L5 bilaterally. Among sacralization group, 23 patients had ILL arising from L4, 2 patients had ILL arising from L5 and 6 patients had ILL arising from L4 on sacralized side and from L5 contralaterally. Among Lumbarization group 2 patients had ILL arising from S1, 5 patients had ILL arising from L5 and 3 patients had ILL arising from S1 on side of lumbarization and from L5 contralaterally. **Conclusion:** Our study demonstrated that ILL is not a reliable identifier of the L5 vertebra in the setting of LSTV anomalies. It rather identifies the lowest lumbar-type vertebral segment only.

Keywords: Iliolumbar ligament, LSTV, Lumbarization, Sacralization.

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INTRODUCTION

The term "Lumbosacral transitional vertebra (LSTV)" is commonly used for congenital anomalies where the last lumbar vertebra shows sacral vertebrae like morphology (called sacralization) or where first sacral vertebra shows morphology like that of lumbar vertebrae (called lumbarization), simply because it is not always possible to differentiate between these two without imaging of the entire spine.[1]

Labeling a transitional vertebra as "LSTV" in lumbo-sacral spine imaging is helpful in simplifying the reporting process but does not fully address the issue regarding vertebral numbering.[1] This may lead to mis-numbering and must be avoided. Reliable identification of lumbar vertebral levels is essential for surgical interventions, image-guided injections and inter- and intra-disciplinary communications.[2,3]

Many parameters have been described in past to identify the level of the last lumbar vertebral body in

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LSTV. However, there are contradictory results in literature regarding their usefulness. Paraspinal structures such as the iliolumbar ligament [ILL], level of the aortic bifurcation, the origin of psoas muscle, the origin of iliac arteries and the renal arteries have been suggested as means for numbering and determination of the last lumbar vertebra,[4] but found not been useful in many studies. Among these various described parameters, ILL has been reported as the most promising way to identify the L5 vertebra.[5]

The ILL has been described to originate from the transverse processes of the lower lumbar vertebrae, mainly from L5 and occasionally from L4 and inserting into the iliac crests bilaterally.[6-8] It is postulated that the ligament is formed as a result of metaplasia of the quadratus lumborum muscle.[7,9] Embryologically, it has been suggested that formation of ILL starts at 11 weeks of gestation and is well developed by birth.[10] Functionally, the ILL restrains flexion, extension, axial rotation, and lateral bending of L5 on S1.[11]

At present, there is no standardised method to identify LSTV unequivocally and the role of ILL is also somewhat disputed.[12] The aim of this study was to assess the reliability of the ILL to identify the lower lumbar vertebra on MRI in LSTV anomalies.

MATERIALS & METHODS

After approval from the institutional review committee, this prospective cross-sectional study was conducted in Muzaffarnagar Medical College & Hospital from September 2018 to February 2019. Patients of MRI lumbar spine with whole spine MRI screening were included in this study. A total of 200 patients (104 male, 96 female; mean age 44.25 years) were included in the study. Patients were excluded if there were any associated fractures, infection, vertebral metastasis or gross vertebral destruction or previous lumbar spine surgery, disabling the proper evaluation and vertebral counting.

All MR images were acquired using 1.5-T MRI system (Siemens). MRI spine sequences included sagittal T1-weighted (T1w) fast spin echo (FSE) sequence, sagittal T2-weighted (T2w) FSE sequence, sagittal & coronal short-tau inversion recovery (STIR) sequence, axial T2w FSE sequence, axial T1w FSE sequence, coronal T2w FSE sequence and whole spine screening sagittal T2w FSE sequence. Whole spine MRI sagittal T2w images were used to accurately number the vertebrae. The L5 vertebra was identified by counting down from C2 vertebra in pasted sagittal T2w images of whole spine.

The patients were divided into three main groups:-

Group-1: patients with typical normal lumbosacral junction (159 patients)

Group-2: patients with sacralization type lumbosacral junction (31 patients)

Group-3: patients with lumbarization type lumbosacral junction (10 patients).

The patients with sacralization type LSTV (Group-2) were further classified into four types according to Castellvi et al.[13] [Table 1]

The patients with Lumbarization type LSTV (Group-3) were also further divided as partial (incomplete separation of S1–S2 bodies and their neural arches) or complete (complete separation of S1–S2 bodies and their neural arches) according to Mahato NK.[14] Partial lumbarization was further subdivided into unilateral (incomplete separation of S1–S2 bodies and their neural arches on one side and complete separation of S1–S2 bodies and their neural arches on other side) and bilateral (incomplete separation of S1–S2 bodies and their neural arches on both the sides)

Origin of the ILL was documented separately on both right and left sides with respect to the vertebral level.

RESULTS

The 200 patients in the study group were comprised of 104 males and 96 females, with a mean age of 44.25 years (range, 16-85 years). Most common age group in our study was 30-39 years. Out of these,

159 patients (79.5%) had normal lumbosacral segmentation and 41 patients (20.5%) had transitional lumbosacral junctions. Out of 41 patients of transitional lumbosacral junctions, 26 (63%) were males and 15 (37%) were females. Most common age group of patients with transitional vertebrae in our study was 40-59 years.

ILL was found bilaterally in all the patients. All patients from group-1(159 patients) had ILL arising from L5 vertebra bilaterally. In group-2 (31 patients), 23 patients had ILL arising from the L4 vertebra bilaterally, 2 patients had ILL arising from the L5 vertebra bilaterally and 6 patients had ILL arising from the L4 vertebra on one side and from L5 vertebra on the other side. In group-3 (10 patients), 5 patients had ILL arising from the L5 vertebra bilaterally, 2 patients had ILL arising from the S1 vertebra bilaterally and 3 patients had ILL arising from the L5 vertebra on one side and from S1 vertebra on the other side.

Figure 1: MRI images of (a) T2W mid sagittal section of normal spine; (b) T2W axial section of spine shown in (a) at L5 showing ILL arising from L5; and (c) T2W coronal image of same spine again showing ILL arising from L5.
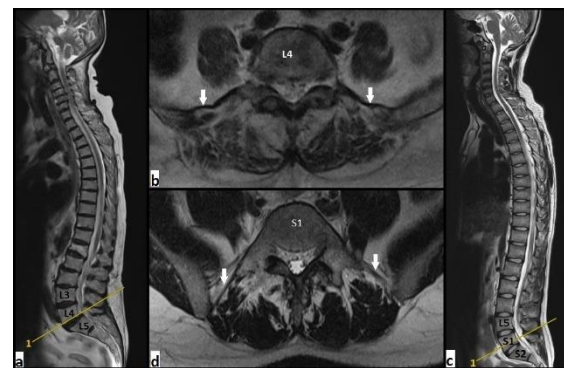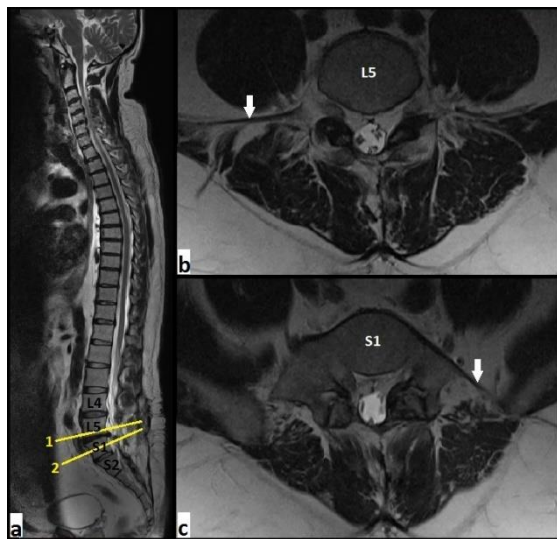

Figure 2: Clockwise- MRI images of; (a) T2W mid sagittal section of LSTV spine with sacralization of L5, (b) T2W axial section of spine shown in (a) at L4 showing bilateral ILL arising from L4; (c) T2W mid sagittal section of LSTV spine with lumbarization of S1; and (d) T2W axial section of spine shown in (c) at S1 showing bilateral ILL arising from S1.

Among the cases of sacralization (31 patients), Castellvi types Ib, IIb, IIIb and IV constituted 25 cases. Of these, 23 patients had ILL arising from the L4 vertebra bilaterally and 2 patients had ILL arising

from the L5 vertebra bilaterally. Castellvi types Ia, IIa and IIIa constituted 6 cases and in all of these cases, patients had ILL arising from the L4 vertebra on sacralized side and from L5 vertebra on the contralateral side.

Among the cases of lumbarization (10 patients), 2 patients had complete lumbarization and had ILL arising from S1 vertebra bilaterally, 5 patients had bilateral partial lumbarization and had ILL arising from L5 vertebra bilaterally and 3 patients had unilateral partial lumbarization and had ILL arising from S1 vertebra on lumbarized side and from L5 vertebra on the contralateral side.

Figure 3: MRI images of (a) T2W mid sagittal section of LSTV spine with partial unilateral Lumbarization; (b) T2W axial section of spine shown in (a) at L5 showing right ILL arising from L5; and (c) T2W axial section of spine shown in (a) at S1 showing left ILL arising from S1.
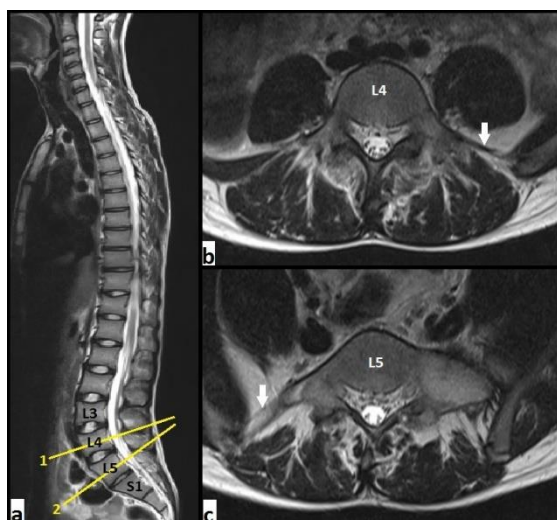
Figure 4: MRI images of (a) T2W mid sagittal section of LSTV spine with sacralization [Castellvi type 2a]; (b) T2W axial section of spine shown in (a) at L4 showing left ILL arising from L4; and (c) T2W axial section of spine shown in (a) at L5 showing right ILL arising from L5.

Table 1: Castellvi et al. classification

Types	Characteristics	Subtype (if any)	
Type-I	Dysplastic transverse processes, measuring at least 19 mm in width (craniocaudal dimension)	Ia	Unilateral
		Ib	Bilateral
Type-II	Sacralization with an enlarged transverse process that has a diarthrodial joint between itself and the sacrum	IIa	Unilateral
		IIb	Bilateral
Type III	Sacralization with complete osseous fusion of the transverse process (es) to the sacrum	IIIa	Unilateral
		IIIb	Bilateral
Type IV	A unilateral type II transition with a type III on the contralateral side	-----	

DISCUSSION

LSTV is an anatomical variant which includes both lumbarization of the S1 vertebra and sacralization of the L5 vertebra.[3] Correct identification of an LSTV on imaging studies is essential because of its potential clinical implications. Inaccurate identification may lead to surgical and procedural errors and poor correlation with clinical symptoms.[3] Moreover, there is increased prevalence of disc protrusion or extrusion in the disc above LSTV.[2,15]

We feel that the most reliable way to number the vertebra is by counting down from C2 vertebra. Therefore, our study included only those patients in whom accurate numbering of the last lumbar vertebra or LSTV was possible on whole spine sagittal T2w MRI pasted images. Radiographs of the entire spine may allow the radiologist not only to count from C2 vertebra inferiorly but also to differentiate hypoplastic ribs from lumbar transverse processes; however, there are very few cases nowadays in which plain film of the entire spine of a given patient is available.[16] Moreover, in cases of MRI lumbar spine, whole spine screening is not done routinely at most of the centers. Therefore many parameters have been described in literature like iliolumbar ligament [ILL], level of the aortic bifurcation, the origin of psoas muscle, the origin of iliac arteries and the renal arteries as means for numbering and determination of the last lumbar vertebral body,[4] but have not been found useful in many studies, thereby increasing the chances of mis-numbering of vertebrae.

Among these various parameters described, ILL has been reported as the most promising way to identify the L5 vertebra.[5] Some anatomic and MRI studies have indicated that the iliolumbar ligament (ILL) arises almost exclusively from the L5 transverse process, however all those studies were limited by relatively small numbers of subjects.[5] In our study we have tried to assess whether the vertebra giving rise to ILL can be marked as L5 and can serve as a marker of lumbar levels, which may enable the confident numbering of LSTV.

In our study, ILL emerged bilaterally from the last lumbar vertebra L5 in 83% of the patients. Rest of the patients had origin of ILL from L4 or S1 vertebrae bilaterally or at least on one side.

In this study all patients (100%) with typical normal lumbosacral junction had ILL arising from L5 vertebra bilaterally [Figure 1]. This signifies that ILL is good marker of L5 vertebrae in patients with typical normal lumbosacral junction.

In our study the group of patients with sacralization type LSTV were further classified into four types according to Castellvi et al.[13] The most prevalent Castellvi types were type IIIb and IIb with 15 (48.4%) and 6 (19.4%) patients respectively. Paik et al, after studying over more than 8000 MRI scans, had found that 877 (10.6%) patients had LSTV of Castellvi types II, III, or IV. Of these, 57% had type II (39% type IIa and 18% type IIb) and 34% had type III of Castellvi.[1]

Among the cases of sacralization (31 patients) in our study, Castellvi types Ib, IIb, IIIb and IV of bilateral sacralization constituted 25 cases (81%); out of these, 23 patients (92%) had ILL arising from the L4 vertebra bilaterally [Figure 2a & 2b] i.e. last lumbar like vertebra in these cases and 2 patients (8%) had ILL like ligament arising from the L5 vertebra bilaterally with no recognizable ILL like ligament from L4 vertebra. As L5 vertebrae had sacrum like morphology in these cases, ILL like ligament at L5 level could be considered as sacral ligaments seen normally at S1 level and non-recognition of ILL at L4 level in these patients could be attributed to limitation of non-continuous sections.

Whereas in our study, Castellvi types Ia, IIa and IIIa of unilateral sacralization constituted 6 cases (19%) and in all these cases, patients had ILL arising from the L4 vertebra on the sacralized side and from L5 vertebra on the other side [Figure 3a, 3b & 3c].

In our study, group of patients with lumbarization type LSTV (10 patients), 2 patients (20%) with complete lumbarization had ILL arising from the S1 vertebra bilaterally [Figure 2c & 2d] i.e. last lumbar like vertebrae in these patients, 5 patients (50%) with bilateral partial lumbarization had ILL arising from the L5 vertebra bilaterally and 3 patients (30%) with unilateral partial lumbarization had ILL arising from S1 vertebra on lumbarized side and from L5 vertebra on the other side [Figure 4a, 4b & 4c].

We further observed that in the cases of unilateral sacralization and lumbarization, level of origin of ILL was different on right and left side of vertebral column. In all these patients ILL was noted to be arising from last lumbar like transverse process on either side. Hence different level of ILL origin on right and left side should raise suspicion of unilateral LSTV. This observation is limited due to the small sample sizes of the subgroups, but add to the understanding of transitional and segmentation anomalies and emphasizes the need of further studies with larger sample size.

Carrino et al,[17] studied 147 patients with the purpose of verifying the ILL location and evaluating the morphologic features of LSTVs on MRI. They found ILL arising from the L5 vertebra in 122 of the 147 patients. However, in their study, ILL did not always denote the level of L5 but rather simply identified the lowest lumbar-type vertebral segment. Thus, they suggested that ILL could be used to identify the lumbosacral junction rather than L5.

Bressler,[18] also reiterated the same point (that ILL arises from the last lumbar vertebra, which could be L4, L5, or L6 depending on the segmentation of the rest of the spine) in 2007 in response to the study by Hughes and Saifuddin.[5]

Farshad-Amacker et al.[19] studied 770 patients and 71 LSTV cases. They found that ILL correctly identified the L5 vertebra by emerging solely from L5 in 95% of the controls. Conversely, in patients with LSTV, ILL originated solely from L5 in only 25%–38% of the cases. They concluded that the level of the origin of ILL is unreliable for the identification of the L5 vertebra in the setting of an LSTV or other segmentation anomalies, similar to our observation in this study.

The morphology of the ILL that is most often described in the literature is a double band with an anterior and a posterior component,[20,21] although there are reports of a highly variable structure of the ILL.[22,23] The ILL morphology in our study was also variable. The additional or accessory ILL components that were identified were often unilateral and much thinner than the ILL attached to the last lumbar vertebrae. Additional components of the ILL originating from the L4 vertebrae have been reported in previous anatomical studies.[6,10,22] Ignoring smaller additional or accessory components of the ILL and recording only the level of origin of the main ILL increases the reliability of ILL to identify lowest lumbar like vertebrae.

We are of the opinion that identification of an LSTV should prompt additional imaging for verifying numbering, particularly if an intervention is contemplated, to reduce the ambiguity that the presence of an LSTV might introduce.

It is recommended that one should make a specific mention in the lumbar spine MR imaging report regarding how the lumbosacral junction was determined (e.g, "this report assumes that there are five lumbar-type vertebrae, with the lowest lumbar vertebra identified by the ILL"). If an LSTV is present, this should be specified along with its characterization, including the level of lowest well-formed intervertebral disc. This landmark can be identified at fluoroscopy during surgical or percutaneous procedures.[17]

In our study, the axial sections of lumbar spine MRI were non-continuous rather than a batch of sections. This could be a minor limitation of the study.

CONCLUSION

This study has reemphasized the fact that the ILL is not a reliable identifier of the L5 vertebra in the setting of an LSTV, but rather it simply identified

the lowest lumbar-type vertebral segment. The origin of ILL is from L5 vertebra bilaterally in normal patients and from L4 or S1 vertebrae bilaterally in patients with bilateral sacralization or complete lumbarization respectively. In patients with unilateral sacralization or lumbarization, the origin of ILL is different on right and left side corresponding to last lumbar like transverse process. Therefore, labeling of the L5 vertebra solely on the basis of origin of ILL should be avoided to prevent wrong level treatment. Thus we are of the view that in order to number the vertebrae and to identify LSTV, counting should be done from C2 downwards in whole spine imaging, particularly if an intervention is contemplated.

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