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The contribution sagittal counting and iliolumbar ligament in numbering of lumbosacral transitional vertebra

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ABSTRACT

Aim: Transitional vertebra are one of the most common variations in the lumbosacral region. This study aims to evaluate whether sagittal counting and determination of iliolumbar ligament (ILL) level can be used in lumbosacral transitional vertebra (LSTV) numbering.

Method: 156 non-contrast lumbar magnetic resonance imaging (MRI) examinations were included in the study. Patients with stage 2 and higher spondylolisthesis, spinal-pelvic trauma, infection, and spinal surgery history were excluded from the study. T1W cervicothoracic sagittal counting and T2W sagittal images were evaluated in terms of transitional vertebra, and axial oblique T1W images directed to the lumbosacral junction were assessed to determine the level of ILL. Student test and chi-square test were used for statistical evaluation.

Results: Normal lumbosacral segmentation was observed in 118 of 156 cases (75.6%), sacralization was observed in 22 cases (14.1%), lumbalization was observed in 16 cases (10.3%), in total 38 cases were observed. The frequency of transitional vertebra was found to be 24.4%. The LSTV rate was found to be 26.2% in women and 20.4% in men.

Conclusion: ILL usually originates from the transverse process of the L5 vertebra in cases without LSTV. However, in more than half of those with LSTV, the ILL is located outside of the L5 localization. Therefore, the ILL position cannot be used to determine lumbar levels in patients with LSTV. To make an accurate assessment and an accurate enumeration, each level of the vertebral column must be thoroughly evaluated with direct radiography or MRI.

Key words: MRI, transitional vertebra, iliolumbar ligament, sacralization, lumbalization.

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Introduction

Lumbosacral transitional vertebra (LSTV) is a term that describes vertebra that show features of both the lumbar and sacral segments. LSTV is a morphological variation with clinical significance. The relationship between LSTV and low back pain and secondary scoliosis was first described by Bertolotti in 1917 [1, 2]. In various studies; Different structural problems such as bulging discs, annular tears, herniation, central and lateral stenosis, facet arthritis, and spondylolysis are mentioned. Herniation develops in the segment just above the LSTV in 30% or more of the cases. Although it is understood that the unilateral forms are more associated with pain, there is no relationship between pain and the transition side. Although disc herniation is reported at the LSTV level, it is not common. Facet arthrosis may occur and rarely cause stenosis. If a false joint occurs between the transitional segment and the transverse-alar elements of the sacrum, inflammation and/or degenerative joint diseases in this area may cause pain with movement or contact. The L4 nerve root passes anterior to this false joint and may be affected. In selected patients, percutaneous local anesthetic injections can be performed for pain in this false joint [2].

Nerve roots arising from the lumbar and upper sacral segments associated with LSTV may be abnormal. In at least 75% of cases, the L5 nerve root arises from the last mobile vertebra superior to the LSTV. Nerve roots can unite at the level of LSTV [3].

LSTV is characterized by enlargement of the transverse processes. AP and lateral radiographs and, as a complement, AP X-ray (Ferguson-Hibb X-ray) angled 30 degrees cranially relative to the lumbosacral joint can be taken. Oblique radiographs may be taken to visualize spondylolysis, which may be superior to the LSTV level. Oblique-tangential imaging is useful in evaluating degenerative changes in the false joint and its relationship with the sacroiliac joint. The L3 transverse process is typically long, while the L4 transverse process is usually short, slender and upward. These differences and counting of the sacral vertebra may be helpful in distinguishing between lumbarization and sacralization.

Scintigraphy is not sufficient to distinguish between symptomatic and asymptomatic false joints. Magnetic resonance imaging can also be used to count vertebra. CT and MRI can be used together to evaluate disc herniation and stenosis. MRI may help demonstrate the relationship of the enlarged transverse process to the nerve root and edema secondary to bone compression in the false joint [2].

Most centers routinely use different lumbar MRI protocols with different prediagnoses. However, these routine MRI protocols for determining the segment of the transitional vertebra require additional sections to be taken or additional imaging such as direct radiography. In cases where there are transitional vertebra at the lumbosacral junction, determining whether the transitional vertebra is L5 (sacralization) or S1 (lumbalization) is important to prevent level problems that may arise in interventional procedures such as surgery and injection and to partially understand the discrepancies between clinical and imaging. In this study, we evaluated the contribution of the iliolumbar ligament to the diagnosis in the numbering of the transitional vertebra by taking cervicothoracic sagittal counting and axial oblique images of the lumbosacral junction.

Materials and Methods

Non-contrast lumbar MRI examination of 156 patients who were sent to Abant İzzet Baysal University İzzet Baysal Medical Faculty, Radiology Department between July 2010 and November 2010 with pre-diagnoses such as low back pain, lumbar discopathy, and radiculopathy were included in the study. Patients with lumbosacral junction stage 2 or higher listesis, pelvic and lower lumbar fracture, spondylodiscitis, history of surgery, and prediagnosis of mass were not included in the study. Of the 156 patients included in the study, 107 were female and 49 were male. The age range of the patients ranged from 15 to 82, and the mean age was calculated as 50.12±1.54. Filming was done with a 1.5 Tesla Siemens Magnetom Symphony (Erlangen, Germany).

Lumbar MRI protocol

T1-weighted (TR/TE, 422/8.8) sagittal count at 4 mm slice thickness from C2 vertebra level to approximately L2 vertebral level, T2-weighted (TR/TE, 3300/126) sagittal 4 mm slice thickness for lumbar vertebra, oblique axial 5 mm slice thickness T1-weighted (T1W) images (TR/TE, 585/15) angled relative to the L4-5 intervertebral disc at the level of approximately L3-S2 vertebral corpuscles were taken. The field of view (FOV) was set to 500 x 500 in sagittal counting slices, 320 x 320 in sagittal T2-weighted (T2W) slices, and 250 x 250 in axial oblique slices.

Radiological evaluation

T1W sagittal counting with a section thickness of 4 mm from the level of C2 to approximately the level of L2, T1W axial oblique images with a section thickness of 4 mm taken towards the lumbosacral junction, and sagittal T2W images with a section thickness of 4 mm in routine lumbar MRI were evaluated from the patients included in the study. In T1W sagittal counting sections, the vertebral body or intervertebral disc level, corresponding to the level of the celiac root and/or superior mesenteric artery originating from the abdominal aorta, was determined. Celiac root and/or superior mesenteric artery levels were determined in sagittal T2W images, and the total number of vertebra in the vertebral column and whether there was lumbalization-sacralization were determined by counting from the vertebral body level to which it corresponds in sagittal counting (Figure 1).

The intervertebral disc between the S1 vertebral body and the rest of the sacrum O'Driscoll et al. evaluated using the classification [4]. According to this;

• Type 1: There is no obvious disc material between the S1 vertebral body and the rest of the sacrum. The resultant appears as a small hypointense signal (Fig. 4A).

• Type 2: A small residual disc is observed between S1 and the other part of the sacrum. The AP diameter of the disc is smaller than the AP diameter of the sacrum (Fig. 4B).

• Type 3: A uniformly shaped disc is observed between S1 and the rest of the sacrum. Disc AP diameter is equal to sacrum AP diameter (Fig. 4C).

•Type 4: There is a uniformly shaped disc between the upper sacral/lower lumbar vertebral bodies and the rest of the sacrum, but the vertebral body in this segment is square. This segment can be L5 or S1 (Fig. 4D).

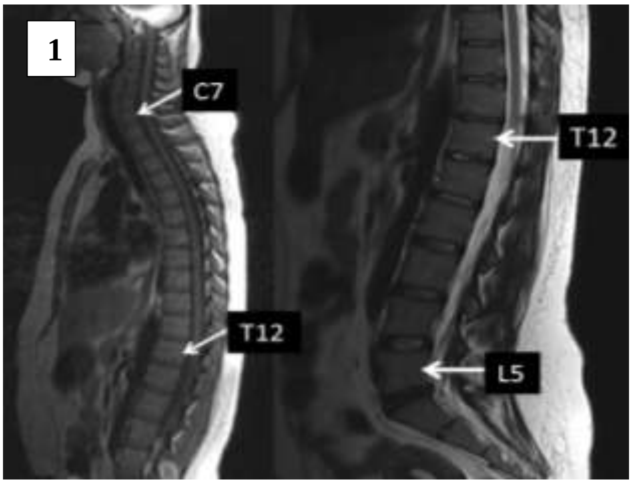
The presence of transitional vertebra at the lumbosacral junction, the total number of vertebra, and the presence of L5 transitional vertebra (sacralization) and S1 transitional vertebra (lumbalization) were evaluated.

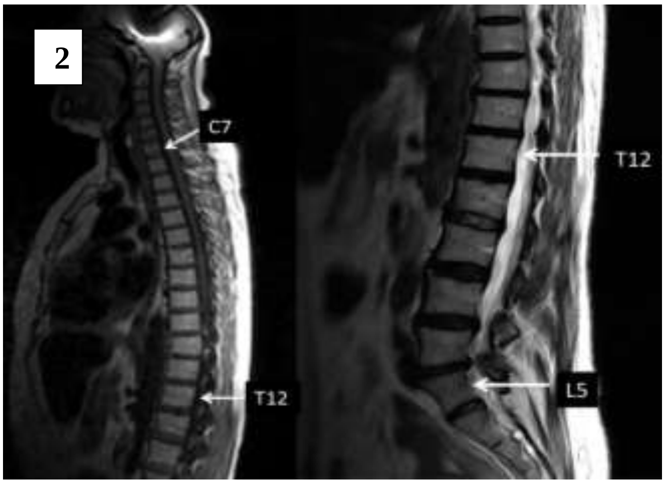
The level of origin of the iliolumbar ligament (ILL) from the transverse process was determined from the axial sections, and the vertebral level was correlated with sagittal T2W images. ILL output from the L5 level was considered normal, ILL output levels L4 and L5, L5 and S1, and only L4 and only S1 levels were considered as a variation.

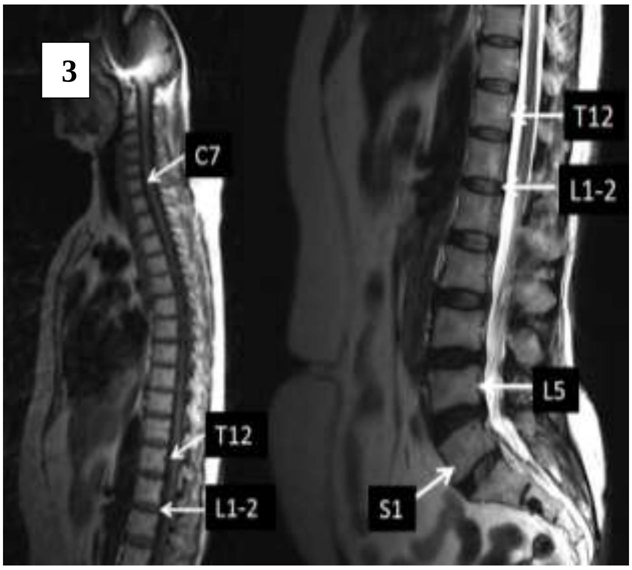
The mean and standard deviation of the patients' ages were calculated. Student's t-test was used to compare the means of numerical values of paired groups in statistical evaluation. Categorical data were evaluated with the Pearson Chi-Square test. Analyzes were performed with the statistical package for social sciences (SPSS, Chicago, IL, USA) version 13.0. Values with a P value of <0.05 were considered statistically significant.

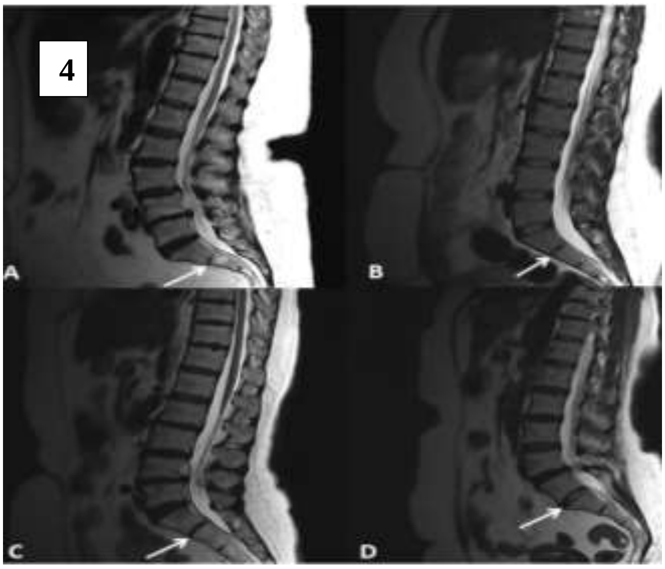
Results

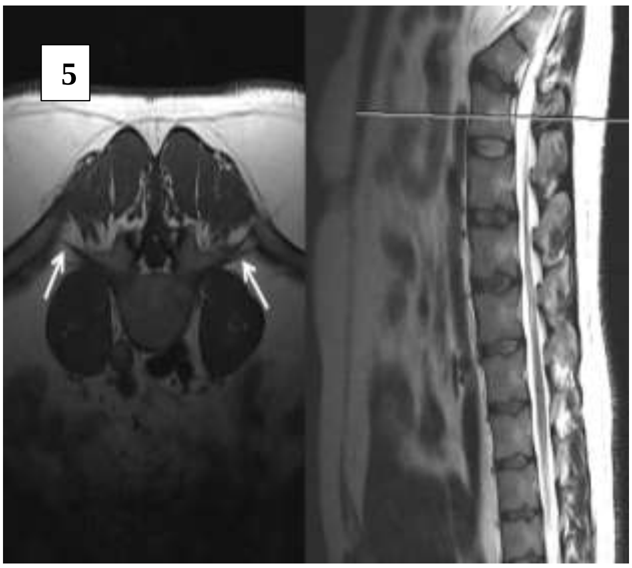
107 women and 49 men were included in the











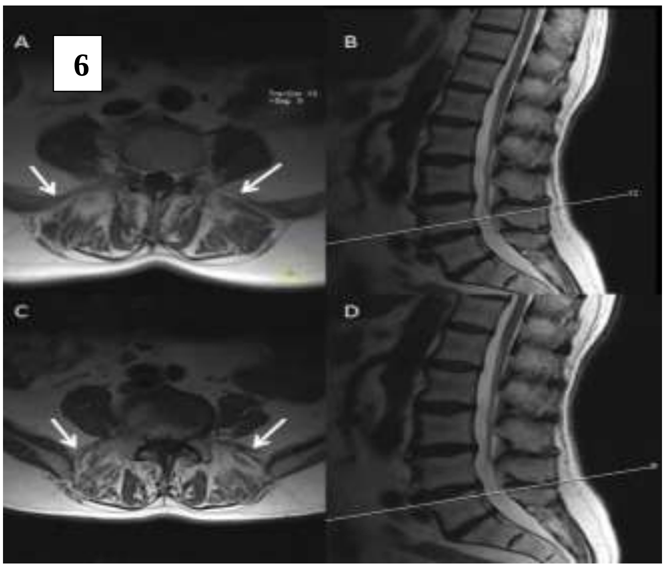
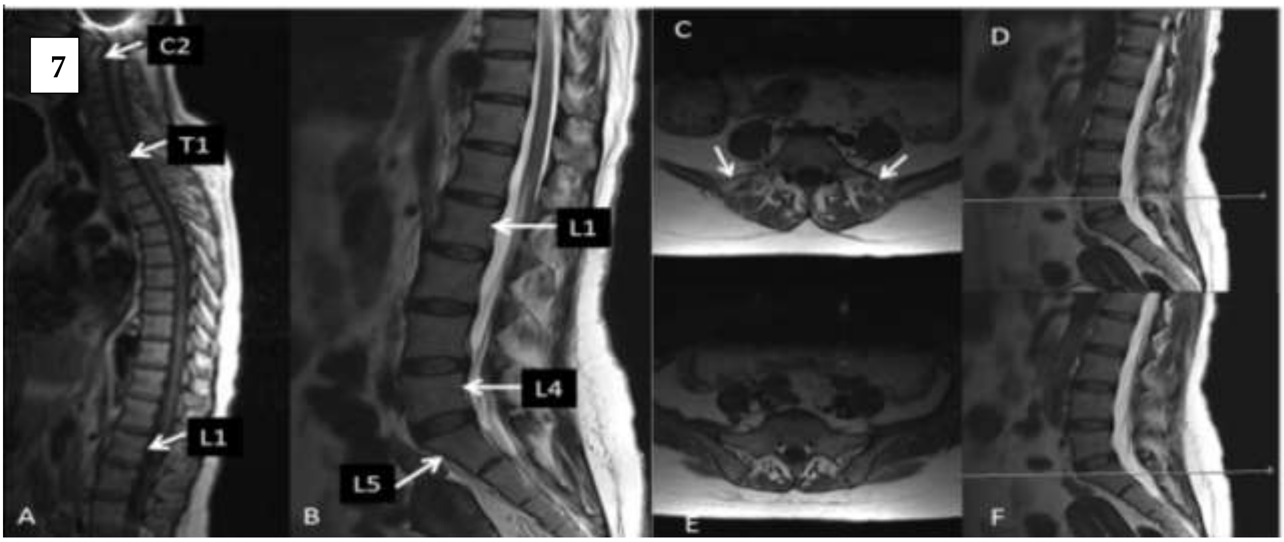


Figure 1. Determination of the total number of vertebra in the vertebral column with the help of T1W sagittal counting and sagittal T2W sections.
Figure 2. Sagittal counting and sagittal T2W images show that the L5 vertebral corpus is transitional [sacralized].
Figure 3. In sagittal counting and sagittal T2W sections, it is observed that the S1 vertebral body is transitional [lumbalized].
Figure 4. O'Driscoll et al. lumbosacral junction morphology types on midsagittal T2W images **A]**Type 1, **B]**Type 2, **C]**Type 3, **D]**Type 4.
Figure 5. In the case with normal lumbosacral segmentation, only the iliolumbal ligament [white arrows] is observed at the L5 level.
Figure 6. In the patient with normal lumbosacral segmentation, weaker bilateral ILL is observed at the L4 vertebra level [A and B] and more prominent at the L5 vertebral level [C and D].



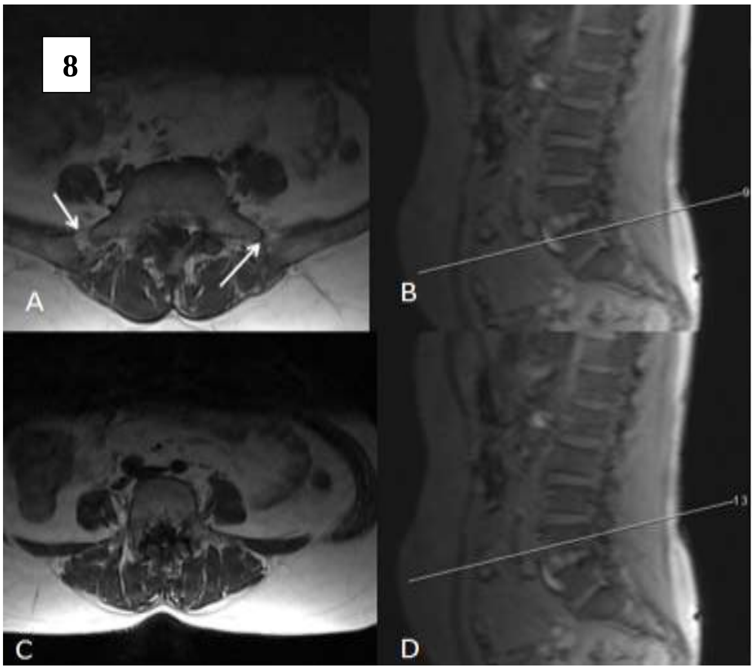


Figure 7. In the case with sacralization [A, B]; only iliolumbal ligament [white arrows] is observed at the level of L4 vertebra [C, D]. At L5 vertebra level, ILL could not be observed [E, F].

Figure 8. In the case with sagittal images in figure 4.3, lumbalization is observed. One weak ILL [white arrows] is observed on each side at the S1 vertebra level [A and B], while ILL is not observed at the L5 level [C and D].

Figure 9. In the case with L5 sacralization, pars interarticularis defect at the level of L4-5 intervertebral disc and secondary L4 stage 1 anterolisthesis.

study; 156 cases with a mean age of 50.12±1.54 were evaluated. Normal lumbosacral segmentation was observed in 118 cases, sacralization in 22 cases (14.1%) (Fig. 2), and lumbalization in 16 cases (10.3%) (Fig. 3) in a total of 38 cases. The frequency of transitional vertebra was found to be 24.4%. The rate of LSTV was found to be 26.2% in women and 20.4% in men, and no statistically significant difference was found according to gender ($p<0.285$). LSTV frequency and distribution rates by gender are given in Table 1.

O'Driscoll et al. when evaluated according to the classification (Figure 4), type 1 in 5 cases, type 2 in 81 cases, type 3 in 37 cases, and type 4 (lumbalized-sacralized) lumbosacral junction was observed in 33 cases. While transitional vertebra was observed in all 33 cases with type 4 lumbosacral junction; except from these cases, type 2 and type 3 lumbosacral junction was observed in 2 patients with sacralization and type 3 lumbosacral junction in one patient with lumbalization [4].

Table 1. Frequency and distribution ratios of transitional vertebra by gender.

LSTV	Female	Male	Total
None (N, %)	79 % 73.8	39 % 79.6	118 %75.6
Sacralized (N, %)	18 % 16.8	4 % 8.2	22 %14.1
Lumbalized (N, %)	10 % 9.4	6 % 12.2	16 %10.3
Total	107	49	156

LSTV: Lumbosacral transitional vertebrae

In 106 cases with normal lumbosacral junction, iliolumbar ligament was observed only at the L5 level (Figure 5); A weak ligament was observed at the L4 level in 9 cases and at the S1 level in 3 cases, in addition to the L5 level (Figure 6). Variation in the iliolumbar ligament level was detected in 12 (10.2%) patients without LSTV. While the iliolumbar ligament was only protruding from the L5 level in only 12 of 38 cases with LSTV, variation was observed in 26 cases (68.4%). A statistically significant difference was observed between these two groups ($p<0.001$), and there is a high probability of variation in the iliolumbar ligament exit level in the presence of transitional vertebra. The relationship between normal and variant forms of ILL and LSTV is given in Table 2.

Table 2. Association of normal and variant forms of iliolumbal ligament with LSTV.

Variables	ILL	
LSTV	**Normal**	**Variant**
None (N, %)	106 % 89.8	12 % 10.2
Visible (N, %)	12 % 31.6	26 % 68.4
Total	118	38

LSTV: Lumbosacral transitional vertebrae; ILL: Iliolumbal ligament.

ILL; In 5 cases with sacralization, it was only at the L4 level (Figure 7), in 6 cases with lumbalization, it was only at the S1 vertebra level (Figure 8), and no ligament could be observed at the L5 vertebra level. Statistically, no statistically significant correlation was found between the presence or absence of ILL at the L5 level and transitional vertebra ($p<0.264$). In the presence of LSTV, the rates of ILL exiting the L5 vertebra transverse process are given in Table 3.

Table 3. ILL rates from L5 vertebra in the presence of LSTV.

Variables	ILL at L5	
LSTV	**None**	**Visible**
Sacralized (N, %)	5 % 22.7	17 % 77.3
Lumbalized (N, %)	6 % 37.5	10 % 62.5
Total	11	27

LSTV: Lumbosacral transitional vertebrae; ILL: Iliolumbal ligament.

In all cases with LSTV, findings such as disc degeneration, bulging disc, annular tear, herniation, facet hypertrophy secondary to the change in biomechanics in an upper segment, and spondylolysis and secondary stage 1 anterolisthesis were observed in one of them (Figure 9).

Unilateral or bilateral hypertrophy was observed in the transverse processes in 26 of the cases with LSTV, Castellvi type 2 in 10, Castellvi type 3 in 10, Castellvi type 1 in one, and Castellvi type 4 transitional vertebra in one of the 22 cases with direct radiographs.

Discussion

The term LSTV includes hypertrophy of the transverse processes of the L5 vertebral body and/or its fusion (sacralization) with the S1 vertebral body to varying degrees; It includes varying degrees of lumbar type vertebral features (lumbalization) of the S1 vertebral body. In cases where lumbalization and sacralization are complete, a change in the number of vertebra in the vertebral column is observed. [5]. The relationship between the presence of LSTV and low back pain has been controversial since it was defined by Bertolotti in 1917. LSTV is found in the general population at rates ranging from 4-30% [6-9], the relationship between the presence of LSTV and low back pain has been controversial since it was defined by Bertolotti in 1917. LSTV is found in the general population at rates ranging from 4-30% [9]. In our study, the frequency of LSTV was found to be 24.4%, and it was found to be similar to the rates in the literature. Sacralization was found in 14.1% of the cases, and lumbalization was found in 10.3%. Although there are studies in the literature mentioning similar sacralization and lumbalization rates [9, 10], sacralization is three times higher [11] or there are also studies stating that lumbalization is more common. No significant difference was found between gender and the frequency of LSTV in our study ($p<0.285$). Lee et al. in one of their studies, they found that sacralization was more common in men [12].

When radiography or lumbar MRI alone are used to evaluate the presence of LSTV, the numbering may be incorrect due to reasons such as accessory rib, hypoplastic rib, complete lumbalization-sacralization. Therefore, in order to enumerate, paraspinal parameters such as aortic bifurcation, inferior vena cava confluence, proximal right renal artery, celiac trunk, superior mesenteric artery, conus medullaris, end plate ratios have been evaluated in various publications and variations have been found in the levels of these parameters in the presence of transitional vertebra [10, 12-14].

According to the study of O'Driscoll et al., LSTV was observed in all cases with Type 4 lumbosacral junction in our study, but it was determined that the lumbosacral junction may also be of different types in patients with complete lumbalization-sacralization [4].

In our study, we evaluated the contribution of the iliolumbar ligament to the numbering of the transitional vertebra by taking sagittal counting and axial oblique images of the lumbosacral junction. The iliolumbar ligament is a ligament that connects the L5 vertebral transverse process and the iliac wing and is responsible for stabilizing the lumbosacral junction. Hughes and Saifuddin stated in their study that the level of the iliolumbar ligament can also be used to number the lumbar vertebra [13, 15]. However, in our study, we found that there was variation in the ILL output level in patients with LSTV. In all studies on this subject in the literature, ILL has been evaluated from the sections for the disc space, and not all components of the ligament may be visualized. This is among the advantages of our study. in some studies in the literature, it is mentioned that the ILL emerges from the last lumbar vertebra [16, 17]. Although similar findings were observed in our study, the multisegment origin was also observed in some of the cases. Therefore, in routine practice, ILL is not a sufficient parameter in vertebral numbering, and the entire vertebral column should be evaluated with radiography, fluoroscopy, or MRI to make an accurate assessment and numbering [2]. In our study, we evaluated whether there was lumbalization-sacralization by determining the total number of vertebra in the vertebral column by taking sagittal counting. In the literature, there are studies that used vertebral numbering with a similar method [8, 10, 12] . Lee et al.’s study, it was stated that complete lumbalization can be evaluated as normal in cases where sagittal counting is not used [15].

Since not all cases have direct radiographs, Castellvi et al. LSTV typing could not be performed in all cases. This is among the limiting factors of our study. Castellvili et al.[15] and Luoma et al. studies [7] mentioned an increased herniation risk at the level just above the transitional vertebra. Otani et al. found that the risk of a higher level of herniation increases in the presence of transitional vertebra, regardless of its type, and that herniation develops at an earlier age compared to the normal population [6]. In our study, degenerative changes were observed at the upper level of LSTV in all patients.

The presence of transitional vertebra in the cervicothoracal and thoracolumbar regions could not be evaluated by imaging the entire vertebral column, which is the most important limiting factor of our study.

In the presence of LSTV, the entire vertebral column should be evaluated with sagittal counting or radiography to avoid problems caused by incorrect disc leveling before surgery or injections into the false joint due to variations in dermatome-myotomes. In the case of transitional vertebra, each area of the vertebral column should be evaluated completely with radiography or MRI [3].

Conclusion

LSTV is a congenital anatomical variation frequently seen in the general population and patients with chronic low back pain. In 89.8% of cases with normal lumbosacral segmentation, the ILL was protruding from the L5 vertebral level, while this rate was calculated as 31.6% in the presence of LSTV. In the presence of LSTV, variation is also observed at the ILL level, and as a result, it cannot be used for vertebral numbering in routine lumbar MRI examinations. In cases where there is an inconsistency between clinical and imaging, the entire vertebral column should be evaluated with sagittal counting or direct X-ray before surgery or lumbosacral injections. And in the presence of transitional vertebra, each level of the vertebral column should be evaluated completely with direct X-ray or MRI.

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