Kocatepe Tıp Dergisi
Kocatepe Medical Journal
23:276-282/ Temmuz 2022 Sayısı

ARAŞTIRMA YAZISI / RESEARCH ARTICLE

LUMBOSAKRAL TRANSİZYONEL VERTEBRA: END PLATE DEJENERASYONUNU HIZLANDIRIR MI ?

LUMBOSACRAL TRANSITIONAL VERTEBRA: DOES IT ACCELERATE END PLATE DEGENERATION ?

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ÖZET

AMAÇ: Lumbosakral bileşkenin en sık görülen doğumsal anomalilerinden biri olan lumbosakral transizyonel vertebra (LSTV) genellikle tesadüfen saptanır. LSTV, geçiş segmentinin üzerindeki hareketi artırabilir ve erken dejenerasyonla ilişkili olabilir. Lomber omurganın dejenerasyonu, normal yaşlanmanın yanı sıra, intervertebral osteokondroz adı verilen nükleus pulposus ve vertebral uç plakaları etkileyen patolojik bir sürecin bir sonucu olabilir. Bu çalışmanın amacı, LSTV ile intervertebral osteokondroz arasındaki ilişkiyi değerlendirmektir.

GEREÇ VE YÖNTEM: 492 hastayı çalışmaya dahil ettik ve LSTV varlığına göre iki gruba ayırdık. LSTV olmayan hastalar kontrol grubu olarak sayıldı. LSTV grubundaki hastalar da geçiş omurlarının düzeyine göre sakralize ve lomberize olmak üzere iki gruba ayrıldı. Tüm gruplarda spondilolistezis, osteokondroz, Modic sinyal değişiklikleri, bel ağrısı ve sinir kökü semptomlarının varlığını kaydettik. Transizyonel vertebra düzeyinin bir üst seviyesindeki osteokondroz prevalansı ile transizyonel vertebrası olmayan hastalardaki aynı seviyeyi karşılaştırdık. Semptomların yaş dağılımını ve sıklığını iki grupta karşılaştırdık.

BULGULAR: LSTV grubunda Modic tip 2 sinyal değişikliklerinin ve intervertebral osteokondrozun daha yaygın olduğunu tespit ettik (% 42.7'ye karşı% 28.7 ve % 67.1'e karşı% 38.3, p <0.05). Sakralize hastalarda L4-5'teki, lomberize hastalarda L5-S1'de intervertebral osteokondroz prevelansı hem aynı grupta diğer seviyelere göre (sırasıyla % 52,7 ve % 63) hem de kontrol grubundaki aynı seviyelere göre anlamlı derecede yüksek bulundu (sırasıyla % 21,4 ve % 24,6). Bel ağrısı olan hastalar, LSTV grubunda daha fazlaydı ve daha erken yaşta görülmekteydi (p <0.05).

SONUÇ: Çalışmamızın sonucunda LSTV'nin intervertebral osteokondroz ve Modic tip 2 değişiklikleri ile ilişkili olduğunu bulduk. LSTV'si olan hastalar, vertebral kolondaki anormal yük aktarımı nedeniyle daha erken yaşta bel ağrısı ile başvurma eğilimindedir.

ANAHTAR KELİMELER: Omurga, Lumbosakral vertebra, Transizyonel vertebra, MRG.

ABSTRACT

OBJECTIVE: Lumbosacral transitional vertebra (LSTV) which is one of the most common congenital abnormalities of lumbosacral junction is usually detected incidentally. LSTV may increase the motion above transitional segment and be associated with early degeneration. Degeneration of lumbar spine may be a result of normal aging, as well as a pathological process that affects nucleus pulposus and vertebral end plates, which is called intervertebral osteochondrosis. The aim of this study is to evaluate the association between intervertebral osteochondrosis and lumbosacral transitional vertebra.

MATERIAL AND METHODS: We included 492 patients into the study and divided them into two groups depending on presence of LSTV. Patients without LSTV were counted as the control group. Patients in LSTV group was also classified into two groups as sacralized and lumbarized depending on the level of transitional vertebra. We noted the presence of spondylolisthesis, osteochondrosis, Modic signal changes, low back pain and nerve root symptoms in all groups. We compared osteochondrosis prevalences at one level above from transitional vertebrae to the same levels in patients without transitional vertebrae. We compared age distribution and frequency of sypmtoms in two groups.

RESULTS: We detected Modic type 2 signal changes and intervertebral osteochondrosis more common in LSTV group (42.7% vs 28.7% and 67.1% vs. 38.3%, p<0.05). Intervertebral osteochondrosis prevelance at L4-5 in sacralized patients (52.7%), and at L5-S1 in lumbarized patients (63%) was found significantly higher than other levels and the same levels in control group (21.4% and 24.6%). Patients with low back pain were more common in the LSTV group and were seen at younger age (p <0.05).

CONCLUSIONS: As a result of our study, we found that LSTV is associated with intervertebral osteochondrosis and Modic type 2 changes. Patients with transitional vertebrae tend to present with lower back pain at an earlier age due to abnormal load transfer in the vertebral column.

KEYWORDS: Spine, Lumbosacral vertebra, Transitional vertebra, MRI.

Geliş Tarihi / Received: 18.04.2021
Kabul Tarihi / Accepted: 27.08.2021
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INTRODUCTION

Lumbosacral transitional vertebra (LSTV) which is one of the most common congenital abnormalities of lumbosacral junction is usually detected with an incidence between 4% and 30% (1).

The load is transmitted to the combined transverse process or abnormal joint instead of lower adjacent disc level because of partial or complete fusion in LSTV, and restricted motion of the disc at lower level . As a result, disc signal at lower level is preserved and incidence of pathology decreases (2 - 6). Nevertheless, increased stabilization between LSTV and sacrum might lead to increase of motion at the levels above transitional segment. Over motion of the intervertebral disc as well as abnormal forces transmitted to the disc accelerate the degeneration on the disc (7 - 11). Although the relationship between LSTV and degenerative changes has been shown, the definition of degeneration was previously broader and any changes due to deterioration in normal anatomy were included in this definition. According to the Lumbar disc nomenclature: version 2.0 degeneration in annular fibrosis and apophyseal osteophytes were accepted as normal changes due to aging and defined as "spondylosis deformans". In contrast, changes in nucleus pulposus and end plates were reported to be a pathological process and defined as intervertebral osteochondrosis (12).

The aim of the present study is to evaluate the association between LSTV and intervertebral osteochondrosis, which is a pathological degenerative process.

MATERIAL AND METHODS

Study Design and Patient Population:

We retrospectively reviewed 564 consecutive lumbar spine magnetic resonance imaging (MRI) studies performed from September 2017 to March 2018 on patients presenting with lower back and leg pain, weakness or numbness of lower limbs. We excluded 72 patients who had lumbar trauma, infection, tumour or surgery or congenital spinal abnormality. We included 492 patients into the study and divided them into two groups depending on presence of LSTV. Patients without LSTV were counted as the control group. Patients in LSTV group were also classified into two groups as sacralized and lumbarized depending on the level of transitional vertebra.

Image Analyses and Definitions:

Lumbar MRI studies were obtained by 1.5 Tesla MRI Device (Siemens Magnetom Symphony, Erlangen, Germany. A spine coil was used to obtain signals. After "localizer", sagittal whole spine localizer (WSL) beginning from C2 to coccyx was acquired **(Figure 1)**.

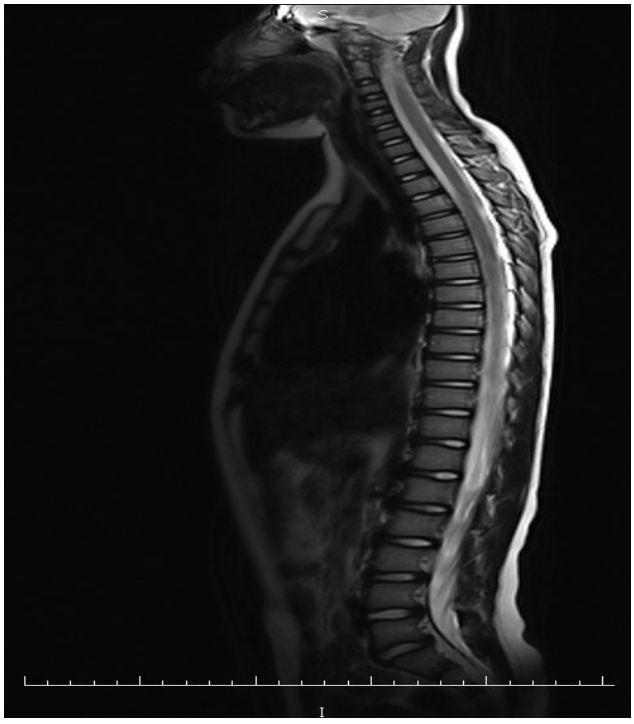

Figure 1: Example of sagittal whole-spine localizer image with T1 turbo spin-echo sequence for numbering lumbar vertebrae.

WSL has 12 sagittal images of T1 TSE (TR:422, TE:8/1, flip angle:160) and then following images were obtained for each patient, sagittal T1 TSE (TR:594, TE:13/1 slice thickness:4mm), sagittal T2 TSE (TR:3300, TE:26/1, slice thickness: 4mm) images for lumbar vertebra; axial T2 (TR:5280, TE:94, slice thickness: 3 mm) images for disc space. MR images were reviewed by two radiologists who have 4- and 9-year clinical experience by providing a consensus.

LSTV diagnosis was confirmed through WSL, and cranio-caudal numbering was done from C2. Limitation of this method is acceptance of that there are 7 cervical vertebrae and 12 thoracic vertebrae. However, the number may change depending on segmental distribution

variations of thoracolumbar segments and thoracolumbar transitional vertebrae (13). Despite the limitation, WSL is accepted as the most accurate method for vertebra count and LSTV diagnosis (14, 15).

The patients in all groups were evaluated in terms of IOS, Modic signal changes (MC) and spondylolisthesis. IOS identification was performed according to the standards revised by North American Spine Society (NASS), American Society of Spine Radiology (ASSR) and American Society of Neuroradiology (ASNR) in 2014 (12). Modic classification was used for evaluation of MC on end plates of vertebra bodies. According to this classification, MC type 1 indicating the inflammation and bone marrow edema presented a hypointense pattern in T1A sequence and hyperintense pattern at T2A sequences whereas MC type 2 indicating the fat replacement presented a hyperintense pattern at T1A and T2A sequences, and MC type 3 indicating sclerosis presented a hypointense pattern at T1A and T2A sequences (16-17). Spondylolisthesis is sliding of a vertebral body over the lower vertebral body due to degeneration (18).

Spondylolisthesis, IOS and MC in LSTV group were compared to control group at each level. The IOS prevalence at upper level of LSTV in lumbarized (L5-S1) and sacralized (L4-5) patients were compared with other levels in each of the same groups and L4-5 and L5-S1 levels in control group.

We classified the symptoms of the patients as low back pain (LBP) and nerve root symptoms (NRS) (leg pain, motor and sensory deficits in the lower extremities) and noted for each patient.

Statistical Analysis

Parametric data was summarized by mean. Categorical variables were summarized by frequency (percent). The associations between the variables were analysed through Pearson's and Fisher's exact χ^2 test. Any p value less than 0.05 was considered statistically significant. The Statistical Package for Social Sciences for Windows (SPSS Statistics for Windows Version 20.0; SPSS Inc., Chicago, IL, USA) was used for statistical analyses.

Ethical Committee

Ethics committee approval was received for this study from Bolu Abant Izzet Baysal University Clinical Research Ethical Committee on 9 October, 2019 (Decision No: 2019/263).

RESULTS

The evaluation of 492 lumbar MRI revealed that 82 patients had LSTV with a prevalence of 16.6%. Prevalence of lumbarization and sacralization was found 9.3% and 7.3%, respectively. The mean ages were 49.7 (SD 14.8, range 16-77) and 50.3 (SD 15.1, range 15-89) in LSTV and control groups, respectively. There were 35 males (%42.7) and 47 females (%57.3) in LSTV group, 179 males (%43.6) and 231 females (%56.4) in control group.

The number of patients with and without IOS in two groups according to symptoms are shown in **(Figure 2)**.

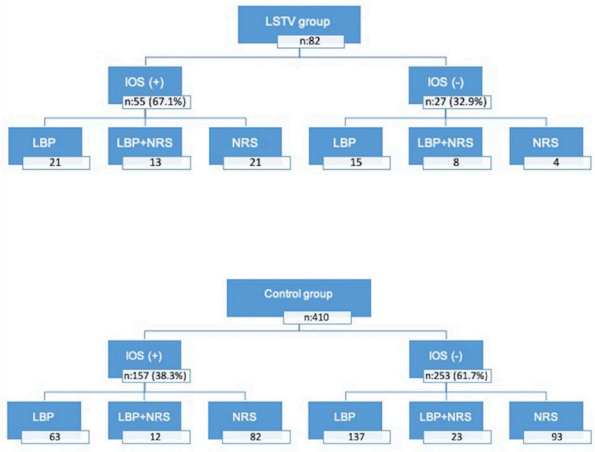

Figure 2: The number of patients with and without IOS in two groups according to symptoms.

There was no significant difference in the prevalence of spondylolisthesis in LSTV group when compared with the control group. MC type 2 and IOS were detected more common in the patients with LSTV (p<0.001) **(Table 1)**.

Table 1: Comparison of degenerative findings between the LTSV and control groups.

	LSTV (n=82)	Control (n=410)	P value
Spondylolisthesis	16 (%19.1)	62 (%15.1)	0.132
MC type 1	8 (%9.7)	39 (%9.5)	0.948
MC type 2	35 (%42.7)	118 (%28.7)	<0.001*
MC type 3	3 (%3.6)	14 (% 3.4)	0.765
IOS	55 (%67.1)	157 (%38.3)	<0.001*

*: p – value of statistical significance. LSTV: Lumbosacral transitional vertebra.

IOS prevalence was similar in lumbarized and sacralized groups. We detected IOS at 61, 39 and 249 lomber disc levels in lumbarized, sacralized and control groups, respectively. IOS prevalence at L4-5 in sacralized patients, and at L5-S1 in lumbarized patients was found significantly higher than other levels in each of same groups. IOS presence in L4-5 level was significantly higher in patients with sacralization than the control group (p=0,001). Similarly, IOS presence in L5-S1 level was significantly higher in patients with lumbarization than the control group (p=0,03) **(Table 2)**.

Table 2: The distribution of IOS in the lumbar levels in lumbarized, sacralized and control groups.

Lumbarization (n=46)		Sacralization (n=36)		Control (n=410)	
Level	IOS (+)	Level	IOS (+)	Level	IOS (+)
L1-2	5 (%10.8)	L1-2	3 (%8.3)	L1-2	19 (%4.6)
L2-3	8 (%17.4)	L2-3	7 (%19.4)	L2-3	38 (%9.2)
L3-4	8 (%17.4)	L3-4	8 (%22.2)	L3-4	48 (%11.7)
L4-5	10 (%21.7)	L4-5	19* (%52.7)	L4-5	88 (%21.4)
L5-S1	29* (%63.0)	L5-S1	2 (%5.5)	L5-S1	101 (%24.6)
All levels	61	All levels	39	All levels	294

*: p-value of statistical significance <0.05 compared to other levels in the same group. IOS: Intervertebral osteochondrosis.

The patient number with low back pain (LBP) in LSTV group was 57 (%69.5), which was significantly higher than 235 patients (%57.3) with LBP, in control group (LBP) (p=0.04). On the other hand, nerve root symptoms (NRS) were seen in 46 (%56) and 210 (%51.2) patients in LSTV and control groups, respectively. There was no significant difference between rates of NRS in two groups (p=0.42). Moreover, the mean ages of patients with LBP were significantly lower, regardless of with or without IOS, in LSTV group **(Table 3 and 4)**.

Table 3: Symptom distribution of the study population.

Group		IOS (+)		IOS (-)	
	Symptoms	LBP	NRS	LBP	NRS
LSTV	Number of patients (%)	34 (61.8%)	34 (61.8%)	23 (85.2%)	12 (44.4%)
Control	Number of patients (%)	75 (47.8%)	94 (59.9%)	160 (63.2%)	116 (45.8%)

IOS: Intervertebral osteochondrosis. LSTV: Lumbosacral transitional vertebra. LBP: Lower Back Pain. NRS: Nerve Root Symptoms.

Table 4: Distribution of the mean ages of patients according to symptoms,

Group		IOS (+)		IOS (-)	
	Symptoms	LBP	NRS	LBP	NRS
LSTV	Mean Age	50.8	57.7	32.9	42.75
Control	Mean Age	57.7	61.4	41.5	46.4
P value		0.013*	0.131	0.005*	0.069

*: p-value of statistical significance <0.05. IOS: Intervertebral osteochondrosis. LSTV: Lumbosacral transitional vertebra. LBP: Lower Back Pain. NRS: Nerve Root Symptoms.

DISCUSSION

We detected that IOS and MC type 2 were more common in the LSTV group. The difference in prevalence of spondylolisthesis between LSTV and the control groups, was not significant. There was no significant difference between MC Type 1 and Type 3 in the groups. The findings obtained in the present study suggested that LSTV is associated with the degeneration in the disc as well as end plates of the vertebral body.

Relation of LSTV with spinal instability is controversial. Dar and Peled reported that LSTV and spondylolisthesis were not related (19). In the present study, spondylolisthesis is more common in LSTV group; however, difference between the control group and LSTV group was not significant. However, Aihara et al. conducted a study on 70 cadavers and reported that a thin and weak iliolumbar ligament in the patients with LSTV might be associated with spinal instability and early disc degeneration (8). Furthermore, spinal instability is not a constant process and might be improved with treatment or spontaneously. Toyone et al. (20) indicated the association of MC type 1 with segmental instability and stated that MC type 2 were more common in the patients with stable degenerative disc disease. Braithwaite et al. reported that MC type 1 and type 2 present different stages of same pathological process; Braithwaite et al. (21) and Mitra et al. (22) stated that MC type 1 might transform to MC type 2 in time, after treatment. We found that there is not a significant difference for MC type 1 between LSTV group and the control group; however, we detected MC type 2 is more prevalent in the patients with LSTV. Accordingly, even LSTV might be associated with spinal instability in earlier period, instability might disappear, and spinal degenerative changes might become significant.

The association of LSTV with disc degeneration was demonstrated well. Louma et al. detected that LSTV accelerated the degeneration of the disc at upper level and decelerated the degeneration of the disc at lower level (3). Aihara et al. (8) detected the iliolumbar ligament as the cause of early disc degeneration. Vergauwen et al. (23) reported that disc degeneration increased

significantly at upper level of transitional vertebra. According to the lumbar disc nomenclature published in 2014, disc degeneration is a confusing definition, and causes difficulty to differentiate normal aging and pathological processes. Resnick and Niyagama (24) demonstrated that the condition which was previously identified by Schmorl and Junghanns (25) indicates two distinct conditions of intervertebral disc. Spondylosis deformans affects the annulus fibrosus and adjacent apophysis whereas IOS affects the nucleus pulposus and end plates of the vertebral bodyand might be associated to fissure and atrophy in annulus fibrosus (15). We found that IOS prevalence was 67% which was significantly higher in LSTV group than control group, in which IOS prevalence was 38% **(Figure 3).**

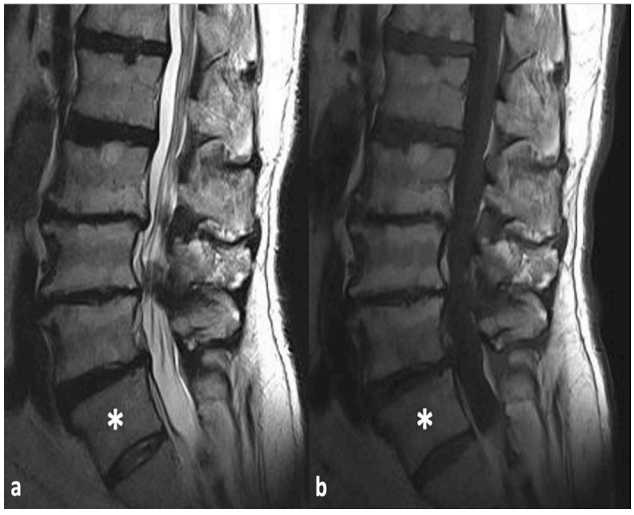

Figure 3: Sagittal T2W(a) and T1W(b) images of lumbar MRI of a 54 years old male patient with transitional L5 vertebra (asterisk). Severe degeneration due to IOS, MC type 2 and bulging discs are observed at 3 levels above L4-5 level. On the other hand, L5-S1 disc has a normal signal and there are not any degenerative changes at this level.

The intervertebral disc was designed to transmit the load. A normal disc acts like a sac filled with liquid and transmits the load to disc surfaces and end plates of vertebral bodies (26). The pathological degeneration occurred in the disc decreases the abnormal motion of the spine, which is called instability, rather than increase the motion (27, 28). Murata et al. reported that angular and translational motions increase in normal or slightly degenerated discs; however, motion decreases in significantly degenerated discs (29). Although a weak iliolumbar ligament in LSTV presents a disposition to segmental spinal instability at upper level, the mobility of the spine decreased by the early degeneration developed in time. There are some opinions suggesting that increased mobility appeared due to LSTV might lead to early degeneration in facet joints (2, 8, 23). The findings obtained in our study indicate that such degeneration is not limited with the disc and affects the end plates where the load is transmitted. Therefore, IOS might be resulted from a process that aimed to compensate the segmental instability, which is associated to LSTV.

Furthermore, IOS was detected most at L4-5 level in the sacralized group (47%; 29/61), and at L5-S1 level in the lumbarized group (48%; 19/39); IOS was detected most prevalent at upper levels adjacent to LSTV, and it might appear earlier **(Figure 4)**.

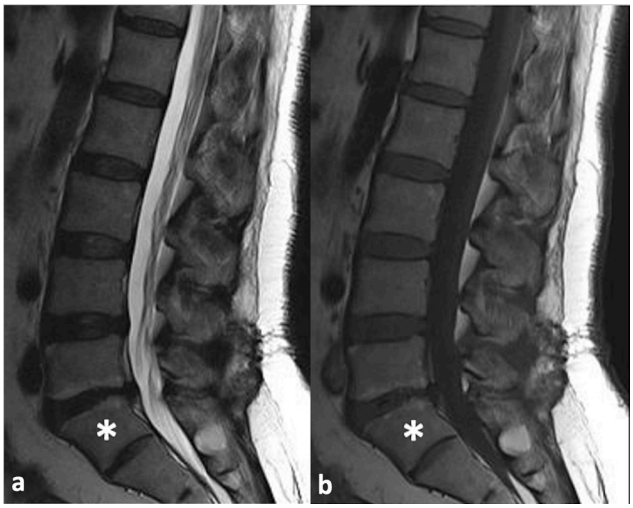

Figure 4: Sagittal T2W(a) and T1W(b) images of lumbar MRI of a 28 years old female patient with transitional S1 vertebra (asterisk). In this patient, whose age is relatively young for lumbar degeneration, in the upper adjacent level to the transitional S1 vertebra, degeneration due to IOS, MC type 2 and bulging disc are observed.

IOS at L4-5 level in the sacralized group, and L5-S1 in the lumbarized group is significantly higher than the control groups at same level and other levels in the same groups.

Although there are contradictory reports on association of LSTV with LBP, the general opinion is that LSTV might be the cause of LBP, under certain conditions. Louma et al. reported that they did not find any association between LSTV and LBP in middle-aged men (3). Tini et al. (30) reported that there is not any correlation between LSTV and LBP in their series consisting of 4,000 patients. However, Konin and Walz (1) reported in their review that despite conflicting reports, LSTV causes LBP in case of abnormal load on the facet joints, disc herniation or nerve root compression. Gopalan and Yerramshetty

(31) investigated the association between LSTV and LBP targeting specific populations in previous studies, and they reported that age, gender, facet arthrosis, segmental instability, traction spurs, osteophytes, stenosis at disc height, degenerative spondylolisthesis and degenerative scoliosis were ignored; and if the factors stated above are regarded, LSTV and LBP are associated. We found that frequency of LBP was higher, and the patients with LBP were significantly younger in LSTV group than control group. We thought this is associated with the report of Mulholland RC, which stated the disc may abnormally transmit the load to the end plates, and this may lead to the pain because of high load focuses appeared (32). Since LSTV is a congenital abnormality that toughens the motion and alters the load transmission in lumbosacral region, abnormal load transmission might be symptomatic earlier in these patients.

There are certain limitations of our study. First, we could not evaluate asymptomatic population because of the retrospective study design. Second, occupation and physical work history of the patient groups were not evaluated. Third, although there are studies suggesting the success of vertebral body count method used to determine LSTV at sagittal plane, there are some limitations. In our study, LSTV was diagnosed by cranio-caudal count method from C2 in WSL; this method has some limitations depending on thoracolumbar segmental distribution variations and thoracolumbar transitional vertebrae.

In conclusion, prevalence of IOS in LSTV increases, particularly at one level above to LSTV. Furthermore, prevalence of MC type 2 increased due to the degeneration on end plates of the vertebral body, in LSTV. The abnormal load transmission resulting from LSTV, might be associated with LBP. Considering the important role of nucleus pulposus and end plates inside the disc on carrying the load of spinal column, such degeneration may appear to compensate the congenital segmental instability due to transitional vertebra.

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