Original Article

Lumbosacral Transitional Vertebrae in Patients with Low Back Pain: Radiological Classification and Morphometric Analysis

Priyanka Daniel, Jerry Joseph Joel[1], Parminder Kaur Rana[2]

Departments of Anatomy and [1]Anaesthesia, Christian Medical College, Vellore, Tamil Nadu, [2]Department of Anatomy, Christian Medical College, Ludhiana, Punjab, India

Abstract

Introduction: Lumbosacral transitional vertebrae (LSTV) are a congenital variation found in patients incidentally. The aim of this study was to find the prevalence of LSTV and to study its morphometric parameters radiologically in comparison with patients with no LSTV, in low back pain patients in Punjabi population. **Material and Methods:** The anteroposterior (AP) and lateral lumbosacral spinal radiographs of 100 patients with low back pain were studied. LSTV were identified and classified based on the Castellvi classification. The width of the transverse processes, superior and inferior vertebral end plate, mid-AP diameter and height of the L5 vertebra, and L5–S1 disc height were measured. All parameters were statistically analyzed and compared between normal and LSTV patients. **Results:** LSTV were found in 22% of low back pain patients, all comprising sacralization of L5, most common Castellvi type being IIA (31.9%). There were a statistically significant increase in the width of transverse processes of L5 vertebrae on both the right and left sides ($P < 0.001$ each) and a significant increase in height of L5 body ($P = 0.03$), with a decrease in L5–S1 disc height ($P = 0.05$) in low back pain patients with LSTV in comparison with patients without LSTV. **Discussion and Conclusions:** LSTV is a common congenital anatomical variation found in patients with low back pain. An increased height of L5 vertebra with a decreased L5–S1 disc height is found to be related to LSTV and can be useful for radiologically suspecting LSTV in patients with low back pain.

Keywords: *Low back pain, lumbarization, lumbosacral transitional vertebrae, sacralization*

Introduction

Low back pain has been a cause of concern for many individuals and forms a huge part of pain and orthopedic outpatient load. The lumbosacral region is a critical area in the spinal column subjected to forces greater than elsewhere in the body with an acute change in the direction of transmission of forces at this level.[1] The sacrum may contain six vertebrae by development of an additional sacral element or through incorporation of the fifth lumbar or first coccygeal vertebrae. Inclusion of the fifth lumbar vertebrae is called "sacralization," and reduction of sacral constituents due to separation of the first sacral vertebra is called "lumbarization." Lumbarization and sacralization of the lumbosacral region is termed as lumbosacral transitional vertebrae (LSTV).[2] LSTV has been found incidentally in patients seeking health care for various other conditions, and Bertolotti was the first to have reported it in 1917.[3] Its importance is still uncertain and its prevalence varies from 4.6% to 37% in different regions.[3,4]

Various classifications of LSTV are described in the literature. Castellvi in 1985 classified LSTV into the following four types based on the type of articulation between the transverse processes and the sacrum. Type I includes LSTV with dysplastic transverse process of width >19 mm (Type IA – unilateral and Type IB – bilateral). Incomplete lumbarization or sacralization comprises Type II LSTV anomaly including an enlarged transverse process with pseudoarthrosis of transverse process and adjacent sacral ala (Type IIA – unilateral and Type IIB – bilateral). Type III LSTV includes complete lumbarization or sacralization with complete fusion of transverse process and adjacent sacral ala (Type IIIA – unilateral and Type IIIB – bilateral). Type IV indicates a mixed type of LSTV anomaly, including a Type IIA, on the one side, and a Type IIIA

How to cite this article: Daniel P, Joel JJ, Rana PK. Lumbosacral transitional vertebrae in patients with low back pain: Radiological classification and morphometric analysis. J Anat Soc India 2019;68:123-8.

Article Info

Received: 29 May 2019
Accepted: 23 August 2019
Available online: 15 October 2019

Address for correspondence:
Dr. Jerry Joseph Joel, Department of Anaesthesia, Christian Medical College, Vellore - 632 002, Tamil Nadu, India.
E-mail: jerryjoseph1812@gmail.com

Access this article online

Website: www.jasi.org.in
DOI: 10.4103/JASI.JASI_61_19
Quick Response Code:

on the other side.[5] Later, this classification was modified by Delport *et al*. into complete and incomplete types. In incomplete (unilateral and bilateral) type, dysplastic transverse process articulates with the sacrum or forms a diarthrodial joint with the sacrum. This includes Type I and II of the Castellvi classification. In complete (unilateral and bilateral) type, bony union occurs between one and both of the transverse processes with the sacrum. This includes Type III and IV of the Castellvi classification.[6]

The correlation of lumbosacral transitional anomalies with low back pain, lumbar disc herniation, and nerve root symptoms has been studied. A strong correlation has been documented between lumbar disc herniation and transitional anomalies.[7] However, the presence or absence of lumbosacral transitional anomalies does not affect nerve root symptoms.[7] The lumbosacral pain associated with LSTV could be due to narrow lumbosacral intervertebral disc or the presence of disc herniation or slippage in spondylolytic spondylolisthesis.[4,7-9] Variant spinal anatomy has been reported to lead to surgical errors in the past too.[10] The aim of the present study was to find the prevalence of LSTV in the population studied, to classify it, and to study the radiological morphometric parameters of LSTV in patients with low back pain in comparison with the morphometric measurements done on normal population in order to facilitate easier detection by pain physicians and orthopedic surgeons on an outpatient basis.

Material and Methods

After ethical clearance from the Institutional Review Board, anteroposterior (AP) and lateral lumbosacral spinal radiographs of 100 patients aged 20–75 years presenting with low back pain to the orthopedic outpatient department in a tertiary hospital in Punjab, India, were studied. LSTV were identified and classified based on the Castellvi classification. Patients with a prior history of significant trauma to the lumbosacral region or any spinal tumors, infections, or metabolic bone disorders or who had undergone any spinal surgeries were excluded from the study.

The following parameters were measured in all patients by a digital caliper within 300 mm operating instruction.

1. On AP view: [Figure 1]
   a. Width of transverse process of L5 vertebra on the right side
   b. Width of transverse process of L5 vertebra on the left side
2. On lateral view: [Figure 2]
   a. AP diameter of the superior vertebral end plate of L5 vertebra
   b. AP diameter of the inferior vertebral end plate of L5 vertebra
   c. Mid-AP diameter of L5 vertebra
   d. Height of vertebral body of L5 vertebra
   e. L5–S1 disc height.

Data were summarized using mean (standard deviation) for continuous variables and frequency along with percentages for non-continuous or discrete variables using SATA statistical Software: 2017. Release 15. College Station, TX: StataCorp LLC.

Results

The study population of 100 patients from a tertiary hospital in Punjab included 47 males and 53 females, with a mean age of 42.15 ± 13.98 years (20–75 years). Of the total number of patients studied, 22 showed LSTV. All cases of transitional vertebrae were of the sacralized variety, and there was no lumbarization seen in our study population. The mean age of all patients with LSTV was 41.5 ± 14.5 years (21–70) with an equal number of males and females.

The patients with LSTV were grouped based on the Castellvi classification [Table 1 and Figures 3], and Figure 4

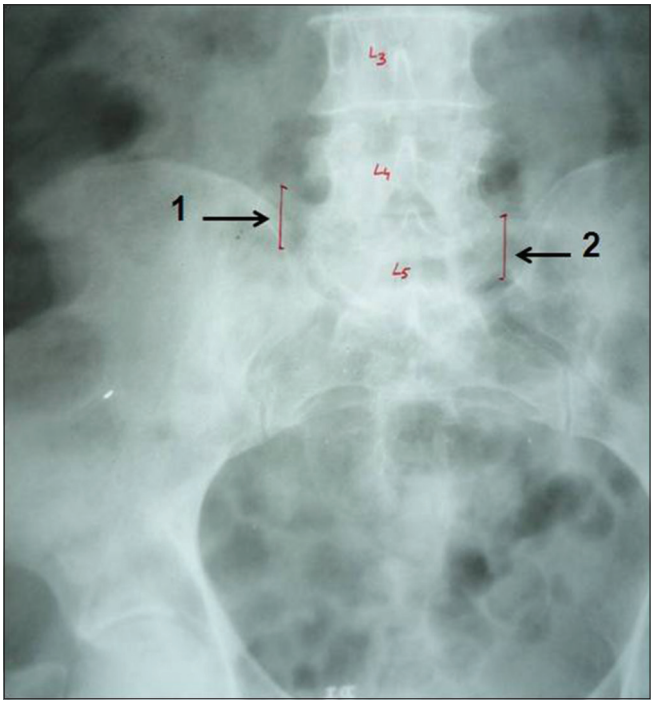

Figure 1: Measurements done on anteroposterior view of lumbosacral spine X-ray. 1: Width of transverse process on the right side, 2: Width of transverse process on the left side

Table 1: Distribution of cases of lumbosacral transitional vertebrae grouped according to the Castellvi classification (*n*=22)

Castellvi types	Number of patients (%)
IA	1 (4.5)
IB	4 (18.2)
IIA	7 (31.9)
IIB	3 (13.6)
IIIA	2 (9.1)
IIIB	4 (18.2)
IV	1 (4.5)

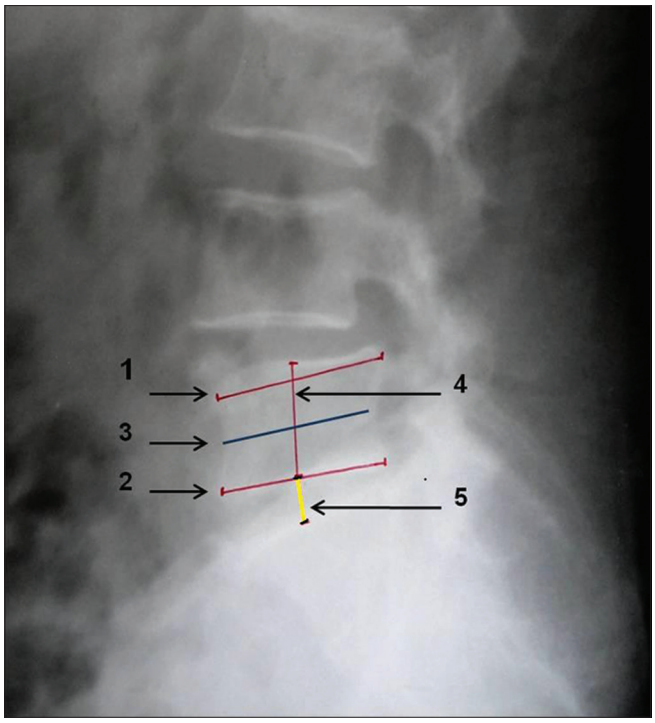

Figure 2: Measurements done on lateral view of lumbosacral spine X-ray. 1: Superior vertebral end plate, 2: Inferior vertebral end plate, 3: Mid-anteroposterior diameter, 4: Height of body of L5, 5: L5–S1 disc height

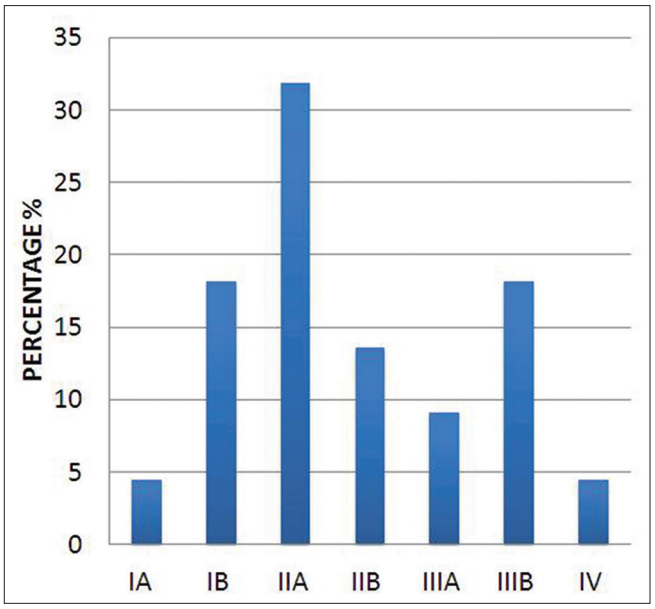

Figure 3: Graph depicting percentage of cases of lumbosacral transitional vertebrae grouped according to the Castellvi classification

Table 2: Distribution of cases of lumbosacral transitional vertebrae grouped according to modified classification (*n*=22)

Type of LSTV	Number of patients (%)
Incomplete unilateral	9 (40.9)
Incomplete bilateral	6 (27.3)
Complete unilateral	3 (13.6)
Complete bilateral	4 (18.2)

LSTV: Lumbosacral transitional vertebrae

Table 3: Means of measurements done on lumbosacral transitional vertebrae and normal patients

Parameter measured on L5 vertebra	Normal patients (*n*=78)	LSTV patients (*n*=22)	*P*
Width of transverse process (right)	1.47±0.27 (cm)	1.94±0.49 (cm), *n*=17	<0.001
Width of transverse process (left)	1.50±0.26 (cm)	2.04±0.44 (cm), *n*=18	<0.001
Superior vertebral end plate	4.19±0.39 (cm)	4.23±0.42 (cm)	0.68
Inferior vertebral end plate	4.07±0.35 (cm)	4.16±0.37 (cm)	0.26
Mid-AP diameter	3.86±0.32 (cm)	3.99±0.39 (cm)	0.12
Height of L5 vertebra	3.02±0.33 (cm)	3.18±0.29 (cm)	0.03
L5-S1 disc height	1.07±0.40 (cm)	0.86±0.55 (cm)	0.05

LSTV: Lumbosacral transitional vertebrae

shows the radiographs of the various types of LSTV seen. Maximum LSTV were of the Type IIA (31.9%). LSTV classification based on the type of abnormality (complete/incomplete) and laterality (unilateral/bilateral) was also done [Table 2], and the most common type of LSTV seen was incomplete unilateral (40.9%). Means of the morphometric measurements done on normal and LSTV patients are given in Table 3. The width of transverse processes on both the right and left sides (right $P < 0.001$ and left $P < 0.001$) and the height of the L5 vertebra ($P = 0.03$) were found to be significantly increased in LSTV patients. L5–S1 disc height was found to be significantly lower in LSTV patients ($P = 0.05$).

Discussion

The prevalence of LSTV in the population has been variable region-wise. Incidence as high as 37% and as low as 4.6% has been reported in literature.[3,4] In Indian population, the prevalence of LSTV was found to be 16%.[11] A review study calculated an overall mean prevalence of LSTV as 12.3%.[12] Our study showed an overall prevalence of 22% of LSTV in Punjabi population. This variability in prevalence could be attributed to the probability of involvement of genetic factors in determining the transitional vertebrae.[6,13]

The most common type of LSTV, based on the type of abnormality (complete/incomplete) and laterality (unilateral/bilateral), demonstrated by our study was of the incomplete unilateral type (40.9%). The most common transitional vertebral anomaly has been reported to be of the complete bilateral type, bilateral sacralization being the most prevalent in other studies.[6,14] According to the Castellvi classification, of the total number of cases with LSTV, there were a maximum number of patients with Type II LSTV (45%), Type IIA being the most common type of LSTV seen in our study population (31.9%).

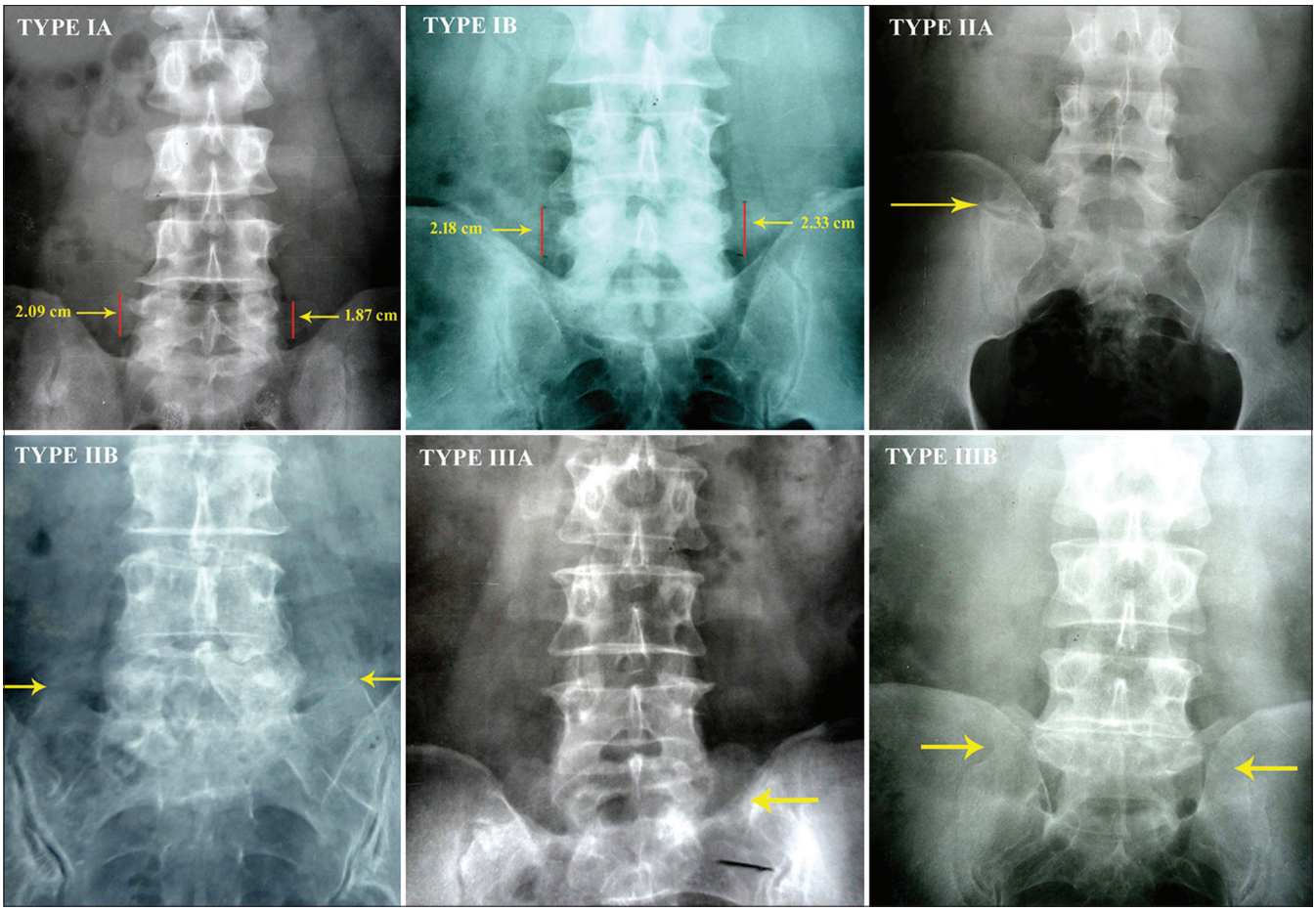

Figure 4: Picture showing various types of lumbosacral transitional vertebrae seen. (Type IA: Right side dysplastic transverse process of width 2.09 cm, Type IB: Bilateral dysplastic transverse process of >19 mm on both sides, Type IIA: Right side pseudoarthrosis between transverse process of L5 and sacral ala, Type IIB: Bilateral pseudoarthrosis between transverse processes of L5 and sacral ala, Type IIIA: Left side complete fusion of sacral ala with L5 transverse process, Type IIIB: Bilateral complete fusion of sacral ala and L5 transverse processes)

A study done by Ahmadinejad *et al*.[15] showed 24.2% Type IIA LSTV, 24.2% Type IIB LSTV, 5.5% Type IIIA LSTV, 28.6% Type IIIB LSTV, and 17.6% Type IV LSTV, with the most common LSTV being Type IIIB. Similar to our findings, Dai *et al*.[16] reported Type II LSTV as the most common type among patients with low back pain. Delport *et al*.[6] reported Type III as the most common type of LSTV observed.

In our study, there has been no reported case of lumbarization. All cases seen were of sacralization, (22%) indicating a much higher prevalence of sacralization in Punjabi population. Eyo *et al*.[4] found an incidence ratio of sacralization to lumbarization as 2:1 with the incidence of sacralization to be 24% and lumbarization to be 13.3% in their study population, indicating that sacralization was more common LSTV. Hughes and Saifuddin[17] found an incidence of 9.2% of sacralization and 4.2% of lumbarization. Hahn *et al*.[18] found sacralization to have an incidence of 7.5% and lumbarization to have an incidence of 4.5%. Leboeuf *et al*.[19] in their study found lumbarization to be 6.0% and sacralization to be 5.5% of study population indicating a higher incidence of lumbarization.

Among the 22 patients with LSTV, there was an equal distribution among males and females, each being 11 in number (50%), with a mean age of 41.50 years ± 14.55 (21–70). Ahmadinejad *et al*.[15] documented that in their study population of 91 patients with LSTV, 36.3% were male and 63.7% were female, with a mean age of 41 ± 15.7 (18–77). This age pattern was similar to that noticed in our study group. Quinlan *et al*.[3] also showed an increased female predilection with 63% of women and 37% of men constituting the Bertolotti group of patients studied. Other studies showed a male predominance in the prevalence of LSTV with Eyo *et al*.[4] documenting a male: female ratio of 3:2 in cases with LSTV.

The association of low back pain and LSTV has been extensively studied and is debated since Bertolotti first described it in 1917 till date.[3,4,6,7,10,20] Bertolotti first described unilateral or bilateral enlargement of the transverse process of the most caudal lumbar vertebra which may articulate or fuse with the sacrum or ilium. He associated these changes with low back pain.[3] Low back pain due to LSTV is thought to be of varied etiology including (i) disc, spinal canal, and posterior element

pathology at the level above the transition;[3,7,20] (ii) degeneration of the anomalous articulation between an LSTV and the sacrum; (iii) facet joint arthrosis contralateral to a unilateral fused or articulating LSTV;[8] and (iv) extraforaminal stenosis secondary to the presence of a broadened transverse process.[7] Stinchfield *et al*.[14] noted that of the 100 patients with LSTV studied, all had low back pain usually of the recurrent lumbosacral type, with radiation into one or both sacroiliac regions and frequently into the buttocks or thigh of one side, made worse by activity and relieved by rest. In a series of 4000 patients, Tini *et al*.[13] reported no correlation between low back pain and transitional vertebrae. In our study population of Punjabi orthopedic patients, a significant number of patients with low back pain had LSTV, although the determination of whether the LSTV contributed to the pain could not be established due to limited sample size. A study done in Turkey found 23.6% of LSTV in the population of low back pain patients studied. The most common anatomical variant was Castellvi Type IA (6.8%).[21] In a case–control study done, comprising 372 cases and 224 controls, the relationship between LSTV and low back pain was analyzed, and the presence of LSTV ($P = 0.039$) was significantly associated with low back pain.[22] Lately, for determining if LSTV contributes to the low back pain, procedures such as steroid or local anesthetic injections into the transverse process pseudoarticulation site are used for diagnostic and also immediate temporary pain relief.[23]

In practice, the accurate assessment of spinal segmentation is crucial in eliminating surgical and procedural errors because most wrong-level spine surgery occurs in patients with variant spine anatomy.[10] LSTV can be identified based on the articulation of the last rib with the T12 vertebra as described by Bron *et al*.[12] The most accurate method of determining LSTV is using AP and lateral lumbosacral radiographs combined with a 30° angled cranially directed AP plain radiograph.[5,12] It has been proposed that the position of the right renal artery adjacent to L1/L2 disc space may be used to identify lumbar levels on sagittal magnetic resonance imaging (MRI) and iliolumbar ligament attachment to transverse process of L5 on axial MRI also to identify the LSTV present.[5] In our study, both AP and lateral radiographs were used for determining the presence of an LSTV by counting down from the last thoracic vertebra identified based on its articulation with the last rib.

The importance of measuring simple morphometric parameters on plain radiographs improves the chances of picking up LSTV on an outpatient basis. The "squared" appearance of transitional vertebrae on lateral radiographs as the ratio of the AP diameter of the superior vertebral end plate to that of the inferior vertebral end plate as ≤1.37 has been reported to be associated with vertebral anomalies.[24] The measurements which had a statistically significant radiological correlation with LSTV were the transverse processes of L5 (significant increase), height of L5 vertebra (significant increase), and L5–S1 disc height (significant decrease). There have not been any studies found that have measured morphometric parameters in LSTV vertebra. These measurements can be used by clinicians on plain radiographs in case of suspicion of LSTV. Further studies are still required on larger samples to support this study.

Conclusion

LSTV was found to be a common congenital anatomical variation in the Punjabi population, the most common LSTV being Castellvi Type IIA (31.9%) according to the Castellvi classification and the incomplete unilateral type (40.9%) according to the type of abnormality and laterality. Measurements found to have a statistically significant radiological correlation with LSTV were the transverse processes of L5 (significant increase), height of L5 vertebra (significant increase), and L5–S1 disc height (significant decrease). Larger studies are yet to be done to determine the morphometric dimensions of LSTV in Indian population.

Financial support and sponsorship

The study was supported and ethically cleared by the institutional review board, Christian Medical College, Ludhiana.

Conflicts of interest

There are no conflicts of interest.

References

1. Joel JJ, Dutta D, Das G, Anand Kumar GS, Panchal J, Basak S. Efficacy of transforaminal epidural steroid injection versus intraforaminal or periforaminal ozone for low back pain with radiculopathy. Indian J Pain 2015;29:64-72.
2. Standring S, Ellis H, Healy JC, Johnson D, William A, Collins P, *et al*. Back and Macroscopic Anatomy of Spinal Cord. Gray's Anatomy. 39th ed. Spain: Elsevier Livingstone Churchill; 2005. p. 725-98.
3. Quinlan JF, Duke D, Eustace S. Bertolotti's syndrome. A cause of back pain in young people. J Bone Joint Surg Br 2006;88:1183-6.
4. Eyo MU, Olofin A, Noronha C, Okanlawon A. Incidence of lumbosacral transitional vertebrae in low back pain patients. West Afr J Radiol 2001;8:1-6.
5. Hughes RJ, Saifuddin A. Imaging of lumbosacral transitional vertebrae. Clin Radiol 2004;59:984-91.
6. Delport EG, Cucuzzella TR, Kim N, Marley J, Pruitt C, Delport AG. Lumbosacral transitional vertebrae: Incidence in a consecutive patient series. Pain Physician 2006;9:53-6.
7. Otani K, Konno S, Kikuchi S. Lumbosacral transitional vertebrae and nerve-root symptoms. J Bone Joint Surg Br 2001;83:1137-40.
8. Nicholson AA, Roberts GM, Williams LA. The measured height of the lumbosacral disc in patients with and without transitional vertebrae. Br J Radiol 1988;61:454-5.
9. Kim NH, Suk KS. The role of transitional vertebrae in spondylolysis and spondylolytic spondylolisthesis. Bull Hosp Jt Dis 1997;56:161-6.

10. Konin GP, Walz DM. Lumbosacral transitional vertebrae: Classification, imaging findings, and clinical relevance. AJNR Am J Neuroradiol 2010;31:1778-86.
11. Bustami F. The anatomical features and functional significance of lumbar transitional vertebra. Jordan Med J 1989;23:49-59.
12. Bron JL, van Royen BJ, Wuisman PI. The clinical significance of lumbosacral transitional anomalies. Acta Orthop Belg 2007;73:687-95.
13. Tini PG, Wieser C, Zinn WM. The transitional vertebra of the lumbosacral spine: Its radiological classification, incidence, prevalence, and clinical significance. Rheumatol Rehabil 1977;16:180-5.
14. Stinchfield FE, Sinton WA. Clinical significance of the transitional lumbosacral vertebra; relationship to back pain, disk disease, and sciatica. J Am Med Assoc 1955;157:1107-9.
15. Ahmadinejad N, Ghanaati H, Firouznia K, Khaghani A, Salavati A, Shakiba M. Pathological findings of spinal MRI in patients with lumbosacral transitional vertebra. Res J Biol Sci 2009;4:166-70.
16. Dai L. Lumbosacral transitional vertebrae and low back pain. Bull Hosp Jt Dis 1999;58:191-3.
17. Hughes RJ, Saifuddin A. Numbering of lumbosacral transitional vertebrae on MRI: Role of the iliolumbar ligaments. AJR Am J Roentgenol 2006;187:W59-65.
18. Hahn PY, Strobel JJ, Hahn FJ. Verification of lumbosacral segments on MR images: Identification of transitional vertebrae. Radiology 1992;182:580-1.
19. Leboeuf C, Kimber D, White K. Prevalence of spondylolisthesis, transitional anomalies and low intercrestal line in a chiropractic patient population. J Manipulative Physiol Ther 1989;12:200-4.
20. Luoma K, Vehmas T, Raininko R, Luukkonen R, Riihimäki H. Lumbosacral transitional vertebra: Relation to disc degeneration and low back pain. Spine (Phila Pa 1976) 2004;29:200-5.
21. Uçar BY, Uçar DE, Bulut M, Azboy I, Demirtas A. Lumbosacral transitional vertebrae in low back pain population. J Spine 2012;2:125.
22. Gopalan B, Yerramshetty JS. Lumbosacral transitional vertebra-related low back pain: Resolving the controversy. Asian Spine J 2018;12:407-15.
23. Li Y, Lubelski D, Abdullah KG, Mroz TE, Steinmetz MP. Minimally invasive tubular resection of the anomalous transverse process in patients with bertolotti's syndrome: Presented at the 2013 joint spine section meeting: Clinical article. J Neurosurg Spine 2014;20:283-90.
24. Wigh RE, Anthony HF Jr. Transitional lumbosacral discs. Probability of herniation. Spine (Phila Pa 1976) 1981;6:168-71.