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Lumbosacral transitional vertebra: Prevalence in patients with low back pain

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Abstract
Lumbosacral Transitional Vertebrae (LSTV) is the most common congenital anomaly of the lumbosacral spine and may manifest either as a sacral assimilation of the fifth lumbar vertebrae (sascralisation) or separation of the first sacral vertebrae into the lumbar spine (lumbarisation). The prevalence of LSTV is said to vary between 4% and 30% in various studies. Low back pain is quite common problem affecting about 80% of the population in their lifetime. The relationship between LSTV and low back pain has been controversial since its first description by Bertolotti in 1917.
It is a prospective observational study carried out in department of orthopaedics and Radio-Diagnosis in Aiims Patna, bihar from july 2018 to july 2019. Patients presenting to orthopaedic OPD with low back pain for at least 2 weeks and patients presenting with non-orthopaedic problem were included and divided into two groups Group A and Group B respectively.
Out of 340 cases with back pain (200 males and 140 females) and among 300 control group without back pain (180 males and 120 females) were evaluated with mean age 31.1 years in case and 32.53 years in control group. The Incidence of LSTV in Group A (patients with low back pain) and Group B (control) was 18.52% and 12.3% respectively. Incidence of LSTV in patients with low back pain was found to be statistically higher than in patients without low back pain (p value<0.05). There were no statistically significant differences between men and women who had LSTV in both study group (p value for both the group was >0.05). Incidence of sacralisation in Group A and Group B was 73.01% and 78.37% and that of lumbarisation was 26.98% and 21.62% respectively. Incidence of sacralisation and lumbarisation was not statistically significant in both sexes (p value for both the Group was >0.05). Incidence of lumbarisation was statistically higher in women in Group B (p value <0.05). LSTV Type II was most common type of LSTV.
Prevalence of LSTV was found to be higher in patients with low back pain than in patients without back pain. This shows significant correlation between LSTV and low back pain.

Keywords: lumbosacral transistional vertebrae, low back pain, lumbarisation, sacralisation, etc

Introduction
Lumbosacral transitional vertebrae (LSTV) are common congenital anomalies of the lumbosacral spine [1]. Most frequently, the fifth lumbar vertebra shows signs of assimilation to the sacrum, a condition often referred to as sacralisation. In case of lumbarisation, the first sacral vertebra shows signs of transition to a lumbar configuration. Complete transition results in numerical abnormalities of the lumbar and sacral segments [2]. The lumbosacral junction is renamed according to the transition type, resulting in L4-S1 (sacralisation) and L6-S1 (lumbarisation). In most cases, however, transition is incomplete or unilateral [3]. LSTVs are common in the general population, with a reported prevalence of 4%–30% [4]. The degree of morphologic variation of these segments ranges from L5 vertebrae with broadened elongated transverse processes to complete fusion to the sacrum. Conversely, the S1 vertebral segment can show varying degrees of lumbarisation, such as the formation of an anomalous articulation rather than fusion to the remainder of the sacrum, well-formed lumbar-type facet joints, a more squared appearance in the sagittal plane, as well as a well-formed fully-sized disk, rather than the smaller sized disk typically seen between S1 and S2 [5].
Low back pain (LBP) is a very common disorder that affects the whole population, but it is frequently observed in patients 30 to 50 years of age, and exhibits particular importance as a cause of significant workday loss; however no pathology can be demonstrated in 85% of the patients that present with LBP. "Mechanical low back pain" constitutes more than 97% of common LBP. Bones, intervertebral discs, joints, ligaments that form the spine and degenerative changes of these structures are considered to be responsible. Congenital abnormalities of the spine are responsible for less than 1% of LBP [6, 7].
In 1917, Bertolotti was the first to describe an association between LSTV and low back pain (LBP). However, this has remained a matter of debate in the literature for almost a century now8. Castellvi *et al* devised a system to classify varieties of LSTV by using a set of distinguishing morphologic characteristics. This system categorizes LSTV into one of four groups: type I, dysplastic transverse process; type II, incomplete lumbarisation/sacralisation with a unilateral or bilateral pseudoarthrosis; type III, complete lumbarisation/sacralisation; and type IV, mixed. If the morphology differs between the right and the left side, the transition is designated to the side that has the higher type numerically [4, 7].
Correct identification of LSTV is essential because there are important clinical implications. Inaccurate identification may lead to surgical and procedural errors and poor

correlation with clinical symptoms. The purpose of this study is to find the incidence of LSTV in low back pain patients and compare our findings to, existing information about the incidence in general population.

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Methodology

This was a prospective observational comparative study carried out in department of orthopedics and Radio-Diagnosis in Aiims Patna bihar from July 2018 to july 2019. It was commenced after taking approval from institutional review board. Patients reporting to orthopaedic OPD with back pain were studied under group A and those patients presenting with non orthopedic problems were included in group B (control).

Sample size: 150 in each group. Though the minimum number of sample size was 150 we included 340 patients as cases and 300 as control group.

Group A (Ortho OPD): Patients (>18 years) presenting to orthopaedics OPD with LBP >2 weeks were included. These patients were assigned to imaging studies: X -ray Lumbosacral spine Antero-posterior and Lateral and presence or absence of LSTV noted.

Group B (Patient with non-orthopedic problem): This group consisted of KUB X ray of patients presenting with non-orthopaedic problem to other department of hospital. This group was considered as control and presumed to be asymptomatic or did not have back pain as major complaints. KUB X-rays of these patients were collected from radiology department for evaluation. Included X ray should show adequate visualization of last thoracic vertebra with attached rib, all lumbar vertebrae including transverse process of first and last lumbar vertebrae, sacrum and iliac crests. In addition to above mentioned exclusion criteria, patients with poor quality radiographs or where there was suboptimal visualisation of all of the above mentioned anatomical landmarks, as well as those with a visible pathological lesion in the lumbar spine and patients with radiological record showing lumbar spinal imaging or OPD record showing a visit to the orthopaedic outpatient department were also excluded. The numbering of lumbar vertebrae was done according to the method described by Bron *et al*. [8] According to this method, vertebrae showing the presence of attached rib, either fully formed or rudimentary, was considered to be the last thoracic vertebrae, and the next caudal vertebrae was named the first lumbar vertebrae. The intercrestal line on anteroposterior radiograph of the lumbar spine was considered to correspond to the L4 – L5 disc space as described by Chakraborty *et al*. An upward and laterally directed transverse process was considered to belong to thoracic vertebrae, whereas a horizontally directed transverse process was considered to belong to lumbar vertebrae. The lumbar vertebrae with the longest transverse process was considered as the third lumbar vertebrae.

We identified transistional vertebra by counting down from the last thoracic vertebrae on the anteroposterior view of LS spine, then if necessary, looked at the lateral x ray for confirmation. If hypoplastic ribs were identified, the vertebrae immediately beneath was designated as L1 vertebrae. Castellvi type II, III and IV were included as transistional states. Type I LSTV were excluded as they lack clinical and surgical significance. Data including age, sex and findings of radiographs including prevalence of LSTV, lumbarisaation, sacralisation were recorded in both study groups.

Exclusion criteria: Patients who were younger than 18 yrs and older than 50 yrs of age. Patients with history of previous lumbosacral spine surgery. Patients with gross degenerative spine changes. Patients with history of recent trauma. Patients with fracture spine. Pregnant female.

Results & Discussion

LSTV are associated with alterations in biomechanics and anatomy of spinal and paraspinal structures [58]. Uncertainty regarding the cause, clinical significance and treatment of LSTV persists. Due to common finding of low back pain and the wide prevalence of LSTV in the general population, it is essential to differentiate between symptoms originating from an anomalous pseudoarticulation from other potential sources of low back pain.

The association of LSTV and low back pain is known as Bertolotti's syndrome. Some authors believe that LSTV could cause symptoms of back pain while others believe that this abnormal vertebra does not affect the incidence of lower back pain. This controversy has been quite intriguing and has been the stimulus for carrying out this present study. The intention was to examine in detail the incidence of this anomaly in patients with low back pain and patients without back pain. Our study aimed to use the incidence of this anomaly in both group of study to establish a relationship between it and low back pain.

Our study reviewed two groups of patients radiographs i.e., Group A (patients with low back pain presenting to orthopaedics OPD and Group B (patients presenting with non-orthopaedic problem). Total no. of patient in Group A was 340 and total no. of X-ray reviewed in Group B was 300.Age of the patient included in our study was 18-50 years of age. In our study mean age of the patient was 31.20 ± 7.78 in group A and mean age was32.53 ± 7.73 in group B. Minimum age was 18 years and maximum age was 50 years in both groups. Patients below 18 years were excluded because the symptoms of back pain due to LSTV usually starts first time in young age and also this is the age when patient can give consent on their own. Similarly, patients more than 50 years were excluded as there are other causes of back pain common after this age.

The mean age of the patient in our study was in accordance with the study done by Gupta renu *et al*. [10] in 2014 in India in a population of 100 patients, study group age was from 16- 50 years and Masud *et al*. [11] in 2011 studied the incidence of LSTV in Pakistan in 100 patients with age above 18 years. In contrast to our study Ucar *et al*. [12] in a study in 2013, in Turkish population with age group 18-86 years had an average age of 39.5 ± 15.2 years. Secer mehmet *et al*, in 2009, Turkey studied this in age group of 20-30 years with the mean age of the patient of 21.1 ± 0.1 years.

Table 1: Demographic profile according to age in different group

	Group A	Group B
Number of patients	340	300
Mean age (years)	31.1	32.53
Median group (years)	30	33
Range	32	32
Minimum age (years)	18	18
Maximum age (years)	50	50

Table 2: Age wise distribution in both group

	Group A			Group B		
Age(years)	Frequency	Percent	Prevalence of LSTV	Percent	Frequency	Prevalence of LSTV
18-30	171	50.3	28(8.23)	112	32.9	18(6)
31-40	117	34.4	23(6.76)	145	42.6	15(5)
41-50	52	15.3	12(3.52)	43	12.6	4(1.33)

Table 3: Sex distribution according to group of study

Sex	Group A		Group B	
	Number	Percent	Number	Percent
Male	200	58.8	180	60
Female	140	41.2	120	40
Total	340	100	300	100

Table 4: Duration of symptoms in Group A

Character	Group A
Number	340
Mean	23.76
Median	20
Range	148
Minimum	2
Maximum	150

Table 5: Prevalence of LSTV according to group

Parameter	Group A	Group B	P-value (chi-square test)
Total	340	300	
LSTV	63	37	0.031
Percent	18.52	12.3	

Table 6: Prevalence of LSTV according to sex

	Prevalence of LSTV		
	Male	Female	P value
Group A	19%	17.9%	0.790
Group B	12%	10%	0.719

Table 7: Prevalence of sacralisation and lumbarisation

Parameter	Group A	Group B
Sacralisation	13.5	10.3
Lumbarisation	5	2
Total percent	18.5	12.3

Table 8: Prevalence of lumbarisation and sacralisation in Group A

	Male		Female		P value
	Number	Percent	Number	Percent	
Sacralisation	31	15.5	15	10.7	0.204
Lumbarisation	7	3.5	10	7.1	0.129
Total	38	19	25	17.8	

Table 9: Prevalence of lumbarisation and sacralisation in Group B

	Male		Female		P value
	Number	Percent	Number	Percent	
Sacralisation	22	12.2	9	7.5	
Lumbarisation	1	0.6	5	4.2	0.029
Total	23	12.8	14	11.7	

Table 10: Type of LSTV

Types	Group A		Group B	
	Frequency	Incidence	Frequency	Incidence
II	29	8.5	19	6.3
III	23	6.8	12	4
IV	11	3.2	6	2
Total	63	18.5	37	12.3

In our study, most of the patients in group A were from age group 18-30 years of age followed by age group 31-40 years. This was similar with Gupta renu *et al.* [10] in 2014, in Indian population of 100 patients showed most of the cases were in 21-40 years (86%) of age group. Quinlan *et al.* [13] in a study in Ireland in 2006 found the total Prevalence of LSTV was highest (11.4%) in patients under 30 years of age group. These authors suggested that the transitional vertebrae should be kept in mind when low back pain is apparent in young individuals. Masud *et al.* [11], in 2011 did a study in Pakistan among 100 patients and Prevalence of LSTV below 40 years was 8% and that above 40 years was 19 %. This was in contrast to our study and this may be because they had not defined the upper limit while including the age group. According to Ucar *et al.* [12] in 2013in Turkish population, there were 262 (52.4%) patients older than 35 years of age and 238 (47.6%) younger patients than 35 years of age. No statistically significant difference was found between these two-age group according to the Prevalence of LSTV (p value>0.05). Epstein *et al* in American population found a higher Prevalence of LSTV in teenagers suffering from low back pain.

Since LBP in young individual is infrequently due to disc abnormalities, degenerative changes, and muscular strain, which are the leading diagnosis in adults [14]. We believe from the above observations that finding of LSTV in younger patients with back pain is high. Conversely with advancing age LBP from LSTV tends to be obscured by age related changes.

In our study, among two study groups, in group A, 200 (58.8%) were male and 140 (41.2%) were female and in study group B (control group) 180 (60%) were male and 120 (40%) were female. This was similar with Sharma VA *et al.* [15] in 2011 in a study population of 206 in India, reported 60.2% of male and 39.8% of female. In contrast to our study, in a study by Eyo M.U *et al.* [16] in Nigeria, a higher number and percentage of females (157, 52%) were represented in the sample population than males (143, 48%) similar to the study by Ucar *et al.* [12] in 2013 in Turkey out of 500 patients, 281 women and 219 men were identified as

eligible for study and also study by Masud *et al*. [11] in 2011 in Pakistan out of 100 patients, 48 were male and 52 were females.

Our study had 340 patients with back pain included in group A whose average duration of back pain was 23.76 weeks ± 20.46 with minimum of 2 weeks and maximum of 150 weeks. More than 90 % of non-specific low back pain cases resolved spontaneously within 2 weeks. Prolonged low back pain has a higher tendency for recurrence, thus disturbing the quality of life and leading to workday loss [12]. Patients presenting with back pain for more than 2 weeks needs good evaluation to differentiate between symptoms originating from an anomalous pseudoarticulation from other potential source of low back pain [17].

In our study Prevalence of LSTV in patients with low back pain was 18.52%, similar with the incidence reported by Sharma VA *et al*. [15] in 2011 in Indian population of 206 (18.4%). Santiago *et al*. [16] in 2001 in Spanish population of 138 (18.4%), Steinberg *et al*. [19] in 2003 in Israeli population of 464 (18.3%). Our finding was comparative with the incidence that were reported by Ucar *et al*. [12] in 2013 in Turkey i.e. 500(23.6%) and by Sekharappa V *et al*. [20] in Indian population i.e. 3000(14%).

This high Prevalence in patients with low back pain supports the belief that alteration in mechanics caused by transitional vertebrae may at times contribute to pain generation [11]. The prevalence of lumbosacral transitional vertebrae varies greatly in general population ranging from 4-35% [15]. This wide range may be explained by differences in diagnostic criteria, imaging techniques and confounding factors between the investigated population samples [8].

In contrast to these, some studies showed fairly high Prevalence of LSTV, Masud *et al*. [11] study in Pakistan 100(27%), Delport *et al*. [21] in study in USA 300(30%), Dai *et al*. [22] in a study in 1999 in Chinese population 460(27.4%), Luoma *et al*. [3] in a study in Finland 163(30%), Castellvi *et al*. [4] in USA (30%). Higher Prevalence of LSTV in these studies could be because of inclusion of Type I LSTV in their study which were not included in our study because many of the researchers considered Type I LSTV are of no clinical significance and do not require further evaluation.

Also, there are some studies that reported low Prevalence of LSTV. The study done by Elster *et al*. [23] in USA reported 2000 (n=140,7%) and similarly Hsieh *et al*. [24] reported 5.9% of Prevalence of LSTV in American population. They used more stringent criteria to count vertebrae as transitional vertebrae. The prevalence of LSTV in general population ranges from 4-24%. [6] Our study showed the Prevalence of LSTV in patient not presenting with low back pain to be 12.3%. Our study findings were comparative with M Tang *et al*. [25] in a population-based study in China showed 15.8 % as an incidence of LSTV. Ucar *et al*. [23] in 2013 did a retrospective study of prevalence of LSTV in wide and well represented population in Turkey and found Prevalence of LSTV to be 18.9%. French HD *et al*. [7] in 2014 studied LSTV prevalence in Australian population and found the prevalence of LSTV to be 9.9%. This difference can be due to the fact that group B was considered as control group in our study and included KUB X rays of patient not attending orthopaedics OPD for low back pain.

In our study the prevalence of LSTV in Group A was 18.53% and the prevalence of LSTV in Group B was 12.3% and the Prevalence of LSTV in group A was found to be statistically higher than in group B (p value<0.05).However Group B, that consisted of KUB X-rays of patients not attending orthopaedics OPD, may not be representative of general or purely asymptomatic population. But, when this group was considered as a whole, patients were presumed to be less symptomatic with respect to Group A as all patients in Group A were symptomatic and had low back pain with at least 2 weeks duration. Our findings were similar with Sekharappa V *et al*. [20] in 2014 in India which showed the prevalence of LSTV in patients with low back pain to be 14% and patients without low back pain had prevalence of 8.1%. The prevalence of LSTV in patients with low back pain groups were statistically significant (p value < 0.001). Gupta Renu *et al*. [10] in 2014 in a study in Indian population, similar to our study, observed that prevalence of LSTV in patients with low back pain was 26% and in asymptomatic patient the incidence was 15 % and this difference in prevalence was statistically significant.

Otani K *et al*. [26] in a study in 2001 in Japan, found that transitional vertebrae was present in 64 of the 501 patients (13%) of the symptomatic group and 55 of 508 (11%) of the control group. There was no statistically significant difference of prevalence of transitional vertebrae between these two groups. Similar to this, Tini *et al*. [14] in 1997 in a study in Switzerland found an insignificant difference between prevalence of LSTV in patients with low back pain (6.7%, n= 4000) and in the general population (5%, n= 1873). Luoma *et al*. [3] found prevalence of LSTV to be 30% in Finnish population but LSTV symmetric or asymmetric was not associated with any type of low back pain. Several other studies found similar outcomes, concluding no difference in pain, disability level or neurological science between individuals with or without LSTV [17].

In our study, prevalence of sacralisation was higher in both study groups. Prevalence of sacralisation in Group A and Group B was 73.01% and78.37% and that of lumbarisation was 26.98% and 21.62% respectively. Our study was similar with that of study by Masud R *et al*. [11] in a study in 2011 in Pakistan showed prevalence of sacralisation in 81% and lumbarisation in 19% of the population and that by Sekharappa V *et al*. [20] in 2014 in Indian population showed overall prevalence of sacralisation was 11% and lumbarisation was 2%. Ucar D *et al*. [12] in 2013 in a study in Turkey found high prevalence of sacralisation (17.2%) and low prevalence of lumbarisation (1.7%) with total prevalence of LSTV 18.9%. However, Gupta Renu *et al*. [10] in 2014 in indian population found prevalence of sacralisation and lumbarisation to be 5% and 10% respectively. French HD *et al*. [7] in 2014 studied LSTV prevalence in Australian population and found incidence of lumbarisation and saacralisation was 5.3% and 3.8% respectively. When comparing these transitional states individually, sacralisation of the fifth lumbar vertebrae is more common than lumbarization of the first sacral segment [8]. Sacralised L5 has a reported prevalence of 1.7 to 14% whereas lumbarized S1 has a reported prevalence of 3 to 7%. However few studies showed lumbarisation to be more common than sacralisation [17].

In our study there was no statistically significant difference between men and women on incidence of LSTV. Prevalence of LSTV in Group A in male was 19% and in female was 17.9 % and difference was not statistically significant (p value >0.05). Prevalence of LSTV in Group B in male was 12% and in female was 10%, and difference was not

statistically significant (p value >0.05).

Most of the literatures showed LSTV to be predominant in males. Eyo *et al.* [16] in a study in Nigerian population reported higher rates in males. In their study despite the higher number of females present in the sample population more males were seen to have LSTV. Our study was in accordance with the study by Ucar *et al.* [12] in 2013 in Turkey whose study found 61 (21.71%) women and 57 (26.03%) men had LSTV. However, there was no statistically significant difference between men and women who had LSTV (p value>0.05). According to study done by Sekharappa V *et al.* [20] in 2014 in India prevalence of LSTV was higher in females by about 1.3 times compared to males.

Study by Nardo L *et al.* [9] in 2012 in American showed prevalence of LSTV was higher in males 28.1% (539 0f 1919) and 11.1% (302 of 2717 of women). Prevalence of LSTV in male was found to be statistically significant.

In our study ratio of male to female with sacralisation was 1.5:1 and the ratio of prevalence of sacralisation to lumbarisation in the male was approximately 5:1. But the ratio of male to female with lumbarisation showed that lumbarisation was common in female in both study groups. Similarly in study Group B ratio of male to female with sacralisation was near 1.5:1 and ratio of prevalence of sacralisation to lumbarisation in male was as high as 10:1. According to Eyo M.U *et al.* [16] in study in Nigeria ratio of male to female with sacralisation was 3:1 and the ratio of prevalence of sacralisation to lumbarisation in the male was approximately 5:1. Similar results were shown by study by Masud R *et al.* [11] in 2011 in Pakistan ratio of male to female with sacralization was 2.5:1 and ratio of prevalence of sacralization to lumbarization was approximately 5:1. Study by Ucar *et al.* [12] in 2013 in Turkey found statistically significant difference between the two sex groups in subjects with sacralisation. According to Mahato N K *et al.* [28] in a study in India sacralisation was more common in males and lumbarisation of S1 were more common in females.

Prevalence of sacralisation and lumbarisation was not statistically significant in both sex (p value for both the Group was >0.05). Prevalence of sacralisation was highly significant if compared among males only in both the Groups. Prevalence of lumbarisation was statistically higher in women in Group B (p value<0.05).

According to our study, LSTV Type II was most common type of LSTV. To minimize the number of categories, we classified the cases independently from the bilateral or unilateral findings into four basic types [14]. We excluded type I from our study because many of the previous study have shown that type I are not significant clinically and donot require further evaluation. Our findings is in accordance with study by Sekharappa V *et al.* [20] in India in 2014, Type IIa was found to be the commonest type followed by Type IIIb. Study done by Ucar *et al.* [12] in 2013 in Turkey found that most common type was Type Ia (6.8%) followed by Type Ib (5.4%), Type IIa (1.6 %), Type IIb (1.8%), Type IIIa (1.4%), Type IIIb (3.4 %) and Type IV (0.8 %). Higher prevalence of Type Ib and Type IIb were found in males, but those results were not statistically significant (p- value>0.05).

In a study of 211 participants, Apazidis *et al.* in 2011 [29] in USA determined Type Ia was most common with a prevalence of 14.7%, however type I a is generally considered to have no clinical significance and does not require further attention in clinical practice 4. In an asymptomatic patient, Nardo L *et al.* [9] in 2012 in USA determined that Type I and Type II were each responsible for more than 40% of total occurrences of LSTV, while Type III and Type IV accounted for 11.5% and 5.25% of occurrences respectively. Same study also pointed out that Type II and Type IV positively correlated with increased prevalence and greater severity of low back pain and buttock pain. Tang *et al* 64 recent study of 928 individuals with LSTV in Chinese population supported this association between Type II and Type IV LSTV with low back pain and gluteal pain.

Conclusion

Our study suggested that there is significant relationship between LSTV and low back pain. Sacralisation is more common problem than lumbarisation in our study and there is no significant difference in incidence of LSTV in male and female. Young patients presenting with back pain needs careful evaluation to differentiate between symptoms originating from anomalous pseudoarticulation from other potential sources of low back pain. Correct identification of this condition can avoid spinal surgery at incorrect levels

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