

Lumbosacral transitional vertebra: Prevalence and its impact on transitional and adjacent lumbar discs

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Abstract: Background: Lumbosacral transitional vertebra (LSTV) is a common congenital anomaly seen in lumbosacral spine. LSTVs include sacralization of the lowest lumbar vertebral body and lumbarization of the uppermost sacral segment. LSTV has been shown to be protective for disc degeneration at the transitional segment, but the adjacent cephalad segment is prone to greater disc degeneration. **Materials and methods:** A retrospective observational study was done to know of prevalence of LSTV; LSTV subjects were categorized into sacralized L5 [n=83] and lumbarized S1 [n=19] groups and to compare the discal changes between these two cases groups with control group [n=186] at transitional and above three cephalad discs. Discal changes were evaluated using Pfirrmann grading system, presence of annular fissure, symmetric bulging disc, asymmetric bulging disc, protrusion, extrusion and effective canal stenosis. **Results:** Prevalence of LSTV was about 16.6%. Sacralization of L5 showed a protective effect at L5-S1 disc level with many parameters showing high levels of significance [p<0.001]. Significantly higher frequency of subjects showed findings associated with degeneration in sacralized L5 cases when compared to control groups, in above three cephalad discs with varying levels of significance [p=0.034 to p<0.001]. Lumbarized S1 subjects also showed significantly higher frequency of degeneration at L5-S1 disc level among various parameters [p=0.048 to p<0.001]. Lumbarization of S1 was protective for higher Pfirrmann grade at L3-4 disc level [p<0.001]. **Conclusion:** Sacralization of L5 protects the disc at the transitional L5-S1 level and predisposes not only the immediate cephalad disc, but also two more adjacent cephalad discs to greater degeneration. Significantly higher frequency of degeneration was also seen at L5-S1 disc level in lumbarized S1 subjects, but these findings along with findings at adjacent two more cephalad segments require further confirmation in a larger study.

Keywords: Lumbosacral transitional vertebra, sacralization of L5, lumbarization of S1

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I. Introduction

Lumbosacral transitional vertebra (LSTV) is a common congenital anomaly seen in lumbosacral spine. LSTVs include sacralization of the lowest lumbar vertebral body and lumbarization of the uppermost sacral segment. Mario Bertolotti first described the morphologic characteristics of LSTV and its association with low back pain in 1917, and this association has been termed Bertolotti syndrome ^[1]. Some studies have suggested that LSTV was not associated with low back pain ^[2,3,4], but the findings of other studies indicated an association of low back pain with LSTV ^[1,5-12]. Studies have demonstrated that LSTV is protective for disc degeneration at the transitional segment, but the adjacent cephalad segment is prone to greater disc degeneration ^[3,13-17]. This MRI based study is taken up to find prevalence of LSTV, evaluate the discal changes at transitional and adjacent three cephalad segments in LSTV subjects and control group. To the author's knowledge no prior study has evaluated discal changes separately at transitional level in sacralized L5 and lumbarized S1 subjects and adjacent three cephalad discs in LSTV subjects.

II. Materials And Methods

A retrospective, observational study was done on subjects who underwent MRI evaluation of lumbar spine for low back pain with or without radiating pain, from January 2018 to June 2019. Out of 1108 subjects who underwent MRI lumbar spine study during this period, 184 subjects had lumbosacral transitional vertebra. Prevalence was calculated based on this data. After calculating the prevalence, subjects were divided into two groups- case group with LSTV and control group (matched for age and gender) without LSTV.

The following exclusion criteria was applied for selection of case and control subjects

- age > 50 yrs (to exclude age related degeneration^[3])
- alignment abnormalities –retrolisthesis/anterolisthesis
- infective spondylodiscitis
- tumors in spine
- history of trauma / compression fractures
- history of prior lumbar spine surgery
- primary bony canal stenosis
- spina bifida

Sample size:

102 subjects with lumbosacral transitional vertebra met the study requirement criteria. Control group consisted of 186 subjects without lumbosacral transitional vertebra.

MRI imaging protocol:

All subjects were imaged in 1.5 T General Electric Signa Explorer MRI machine with same protocol comprising of following sequences.

Whole spine localizer with T2-weighted sagittal fast spin echo (FSE) sequence

Lumbar spine evaluation with -sagittal T1-weighted and T2-weighted FSE sequences

-sagittal and coronal short-tau inversion recovery (STIR) sequences

-axial T1-weighted and T2-weighted FSE sequences.

Identification of lumbosacral transitional vertebra

Lumbosacral transitional vertebra was identified by counting vertebrae in caudad direction from C2 vertebra. Hypertrophied transverse process of L5 was identified to categorize subjects as sacralized L5. Castellvi classification^[13] was used to classify sacralized L5 vertebrae into four types. Lumbarized S1 was identified when first sacral vertebra was seen separate from rest of the sacrum.

Discal changes:

Discal changes were observed at transitional level (L5-S1 in case of sacralized L5 and S1-2 in case of lumbarized S1) and above three lumbar discs (L2-3, L3-4, L4-5 in case of sacralized L5 and L3-4, L4-5 and L5-S1). These changes were compared with findings at respective disc levels in control group.

At each level, disc was evaluated under the following:

Disc degeneration was classified using Pfirrmann grading system^[18] into five grades.

Presence of annular fissure, symmetric bulging disc, asymmetric bulging disc, protrusion and extrusion was documented as per the Lumbar spine 2.0 nomenclature classification^[19].

AP dimension of the central spinal canal was measured in sagittal T2 weighted image and subjects with less than 12 mm were included under patients with effective central canal stenosis.

Statistical analysis:

Statistical analysis was performed using the STATA software (version 14). Categorical variables were entered as percentages. A chi-square test was used for statistical comparison between categorical variables of cases and controls. A p value of less than .05 was defined as statistically significant.

III. Results

Prevalence:

Table 1 showing overall prevalence of types of LSTV in men and women [out of 1108 subjects].

	Men Frequency (percentage)	Women Frequency (percentage)	Total Frequency (percentage)
Sacralization of L5	65 (5.86%)	76 (6.86%)	141 (12.72%)
Lumbarization of S1	28 (2.53%)	15 (1.35%)	43 (3.88%)
Total LSTV	93 (8.39%)	91 (8.21%)	184 (16.6%)

Case control study proper:

Out of the 102 subjects in case group, 83 subjects had sacralization of L5 vertebra (39 men and 44 women, mean age 37.26 years) and 19 subjects (12 men and 7 women, mean age of 36.5 years) had lumbarization of S1 vertebra. Control group consisted of 186 subjects (90 men, 96 women; mean age 37.12 years) without lumbosacral transitional vertebra.

Castellvi classification was used to classify the 83 subjects with sacralized L5 into four types as shown in following table 2.

Table 2 showing frequency of Castellvi types of sacralized L5

Type of sacralized L5	Frequency	Percentage
Type I	Unilateral Ia	3
	Bilateral Ib	-
Type II	Unilateral IIa	7
	Bilateral IIb	21
Type III	Unilateral IIIa	2
	Bilateral IIIb	48
Type IV	2	2.41
Total	83	100

Comparison of sacralized L5 subjects with control subjects:

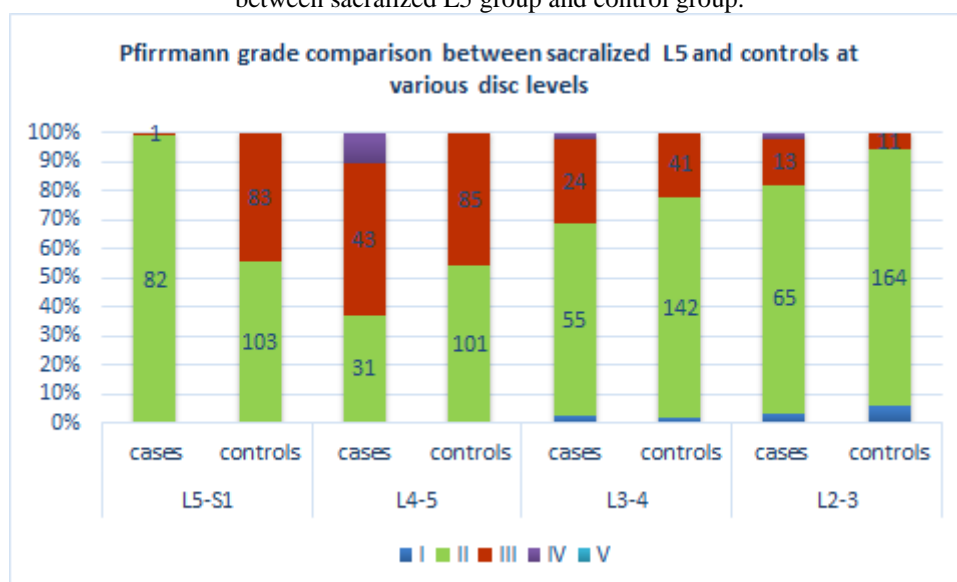
Table 3 showing frequency of Pfirrmann grades for disc degeneration at various disc levels in sacralized L5 cases

Disc level	Frequency of Pfirrmann grading in sacralized L5 cases				
	I	II	III	IV	V
L5-S1	0	82	1	0	0
L4-5	0	31	43	9	0
L3-4	2	55	24	2	0
L2-3	3	65	13	2	0

Table 4 showing frequency of Pfirrmann grades for disc degeneration at various disc levels in controls.

Disc level	Frequency of Pfirrmann grading in controls				
	I	II	III	IV	V
L5-S1	0	103	83	0	0
L4-5	0	101	85	0	0
L3-4	3	142	41	0	0
L2-3	11	164	11	0	0

Graph 1 showing comparison of frequency of Pfirrmann grades for disc degeneration at various disc levels between sacralized L5 group and control group.



L5-S1 disc level:

Qualitative assessment of disc height at L5-S1 was done in sacralized L5 cases by comparing with adjacent discs and all the subjects showed reduced height at this level.

Table 5 showing comparison of discal changes at L5-S1 disc level between sacralized L5 subjects and controls

L5-S1 disc level	Sacralized L5 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirrmann grade III	1	1.2	83	44.62	<0.001	0.151
Annular fissure	0	0	54	29.03	<0.001	-
Symmetric bulging disc	0	0	147	79.03	<0.001	-
Asymmetric bulging disc	-	-	-	-	-	-
Protrusion	2	2.41	58	31.18	<0.001	0.054

L4-5 disc level:

Table 6 showing comparison of discal changes at L4-5 disc level between sacralized L5 subjects and controls

L4-5 disc level	Sacralized L5 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirrmann grade III	43	51.81	85	45.70	NS	-
Pfirrmann grade>II (grade III and IV)	52	62.65	85	45.70	0.010	1.993
Annular fissure	19	22.89	45	24.19	NS	-
Symmetric bulging disc	82	98.80	170	91.40	0.021	8.658
Asymmetric bulging disc	-	-	-	-	-	-
Protrusion	48	57.83	94	50.54	NS	-
Extrusion	3	3.61	5	2.69	NS	-
Effective central spinal canal stenosis	28	33.73	40	21.51	0.033	1.858

NS- not significant

L3-4 disc level:

Table 7 showing comparison of discal changes at L3-4 disc level between sacralized L5 subjects and controls

L3-4 disc level	Sacralized L5 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirrmann grade III	24	28.92	41	22.04	NS	1.438
Pfirrmann grade>II (grade III and IV)	26	31.33	41	22.04	NS	1.613
Annular fissure	11	13.25	0	0.00	<0.001	-
Symmetric bulging disc	72	86.75	57	30.65	<0.001	14.81
Asymmetric bulging disc	3	3.61	6	3.23	NS	-
Protrusion	23	27.71	24	12.90	0.003	2.587
Extrusion	7	8.43	0	0.00	<0.001	-
Effective central spinal canal	2	2.41	0	0	0.034	-

stenosis						
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L2-3 disc level:

Table 8 showing comparison of discal changes at L2-3 disc level between sacralized L5 subjects and controls

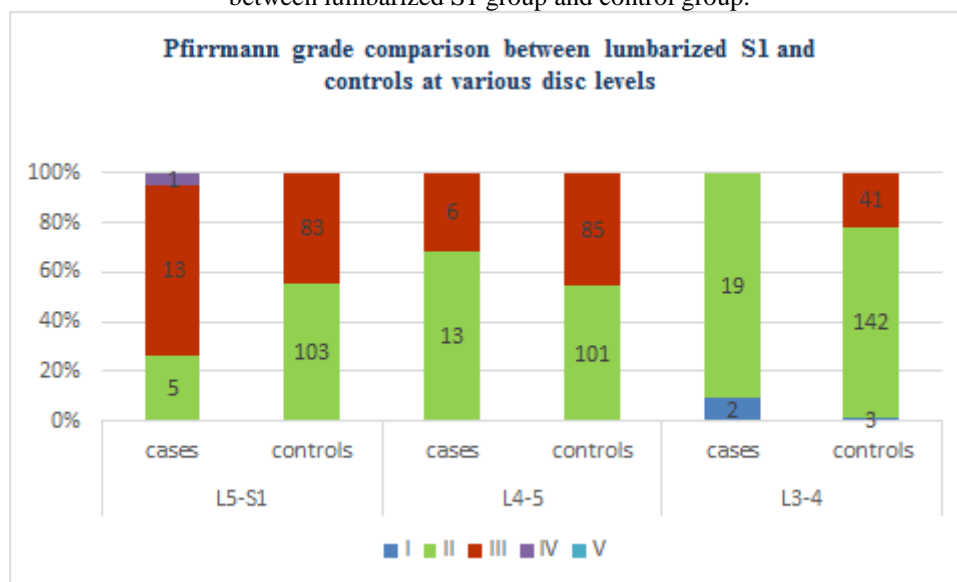
L2-3 disc level	Sacralized L5 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirschmann grade III	13	15.66	11	5.91	0.010	2.954
Pfirschmann grade>II (grade III and IV)	15	18.07	11	5.91	0.002	3.509
Annular fissure	3	3.61	0	0.00	0.009	-
Symmetric bulging disc	30	36.14	14	7.53	<0.001	6.954
Asymmetric bulging disc	2	2.41	3	1.61	NS	-
Protrusion	8	9.64	9	4.84	NS	-
Extrusion	-	-	-	-	-	-
Effective central spinal canal stenosis	-	-	-	-	-	-

Comparison of lumbarized S1 subjects with control subjects:

Table 9 showing frequency of Pfirschmann grades for disc degeneration at various disc levels in lumbarized S1 cases.

Disc level	Frequency of Pfirschmann grading in lumbarized S1 cases				
	I	II	III	IV	V
S1-2	0	15	4	0	0
L5-S1	0	5	13	1	0
L4-5	0	13	6	0	0
L3-4	0	19	0	0	0

Graph 2 showing comparison of frequency of Pfirschmann grades for disc degeneration at various disc levels between lumbarized S1 group and control group.



S1-2 disc level:

Table 10 showing discal changes at S1-2 disc level in lumbarized S1 cases.

S1-2 level	Frequency	Percentage
Pfirschmann grade II	15	78.95
Pfirschmann grade III	4	21.05
Annular fissure	0	0
Symmetric bulging disc	2	10.52
Asymmetric disc bulge	1	5.26
Protrusion	1	5.26
Extrusion	0	0
Effective central spinal canal stenosis	1	5.26

L5-S1 disc level:

Table 11 showing comparison of discal changes at L5-S1 disc level between lumbarized S1 subjects and controls

L5-S1 disc level	Lumbarized S1 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirschmann grade III	13	68.42	83	44.62	0.048	2.688
Annular fissure	4	21.05	54	29.03	NS	-
Symmetric bulging disc	19	100	147	79.03	0.027	-
Asymmetric bulging disc	-	-	-	-	-	-
Protrusion	1	5.26	58	31.18	0.017	0.122
Extrusion	0	0	3	1.61	NS	-
Effective central spinal canal stenosis	8	42.11	18	9.68	<0.001	6.787

L4-5 disc level:

Table 12 showing comparison of discal changes at L4-5 disc level between lumbarized S1 subjects and controls

L4-5 disc level	Lumbarized S1 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirschmann grade III	6	31.58	85	45.70	NS	-
Annular fissure	1	5.26	45	24.19	NS	-
Symmetric bulging disc	16	84.21	170	91.4	NS	-
Asymmetric bulging disc	-	-	-	-	-	-
Protrusion	7	36.84	94	50.54	NS	-
Extrusion	3	15.79	3	1.61	<0.001	11.437
Effective central spinal canal stenosis	2	10.52	40	21.50	NS	-

L3-4 disc level:

Table 13 showing comparison of discal changes at L3-4 disc level between lumbarized S1 subjects and controls

L3-4 disc level	Lumbarized S1 Cases		Controls		p value	Odds ratio
	Frequency	Percentage	Frequency	Percentage		
Pfirschmann grade III	0	0	41	22.04	<0.001	-
Annular fissure	1	5.26	0	0	0.002	-
Symmetric bulging disc	9	47.37	57	30.64	NS	-
Asymmetric bulging disc	0	-	6	3.22	NS	-
Protrusion	7	36.84	24	12.90	0.006	3.93
Extrusion	-	-	-	-	-	-
Effective central spinal canal stenosis	-	-	-	-	-	-

IV. Discussion

Lumbosacral transitional vertebra showed a varied prevalence of 7% to 36% among several studies [3,8,12,14-16,20-22]. Present study showed LSTV prevalence of about 16.6%; prevalence of sacralization of L5 was higher than that of lumbarization of S1 [12.72% vs. 3.88%].

Our study evaluated the relationship between LSTV and disc degeneration at the transitional level and at the adjacent three cephalad discs. In the current study, both the case and control groups showed less percentage of subjects with Pfirschmann grade IV and no subjects with Pfirschmann grade V. This could be probably due to exclusion criteria of age>50 yrs and alignment abnormalities employed in selection of cases and controls.

Comparison of sacralized L5 cases with controls:

Sacralization of L5 showed a protective effect at L5-S1 disc level; only 1 subject had Pfirschmann grade III change [p <0.001]; 2 subjects had disc protrusion [p <0.001] and no subject had annular fissure or symmetric bulging disc [p <0.001]. Our findings of smaller disc heights at the transitional L5-S1 disc level is in concordance with other studies [23-25].

Sacralized L5 subjects showed higher Pfirschmann grade of degeneration at L4-5 disc level [grades III and IV cumulatively] and at L2-3 level [grade III as well as grades III and IV cumulatively]. No significant difference was observed in Pfirschmann grade at L3-4 disc level between cases and controls.

When compared to controls, sacralized L5 subjects showed higher percentage of subjects with symmetric bulging disc [p=0.021] and effective central spinal canal stenosis [p=0.033] at L4-5 disc level without any significant difference in percentage of subjects with annular fissure, protrusion or extrusion.

Significantly higher percentage of subjects in sacralized L5 group had findings of annular fissure [p<0.001], symmetric bulging disc [p<0.001], protrusion [p=0.003], extrusion [p<0.001] and effective canal

stenosis [p=0.034] when compared with that of control group. There was also significantly higher percentage of annular fissure [p=0.009] and symmetric bulging discs [p<0.001] at L2-3 level compared to control group.

According to the above data, there is a protective effect of the sacralized L5 vertebra on the disc at the transitional L5-S1 disc level and a greater prevalence of degeneration in the adjacent discs compared to control group. High levels of significance [p<0.001] was seen for the protective effect at L5-S1 disc level in sacralized L5 patients, probably due to higher percentage of patients with Castellvi type IIIb. The greater the osseous bridging at the transitional level, the more the transitional disc is protected from degeneration^[17]. The mobility and stress of the lumbar spine is then transferred to the adjacent cephalad segment resulting in more degeneration at this level; this finding is similar to previously done studies^[3,13-17]. In addition, current study shows that significant degeneration is also seen in certain parameters in two more cephalad discs and not just the immediate cephalad disc, as discussed above.

Knowledge of the transitional anatomy should be taken into consideration by surgeons when performing fusion surgery, because this could impact the selection of levels as well as the biomechanics of fusion or disc replacement. For example, greater research needs to be done in evaluating the performance and life of a total disc replacement at the high-stress zone of a cephalad adjacent segment to a transitional segment in patients with sacralization of L5^[17].

Comparison of lumbarized S1 cases with controls:

At L5-S1 disc level, lumbarized S1 cases showed higher frequency of subjects with Pfirrmann grade III degeneration [p=0.048], symmetric bulging disc [p=0.027] and effective central spinal canal stenosis [p<0.001] compared to that of controls. But, lumbarized S1 cases showed significantly lesser frequency of subjects with protrusion [p=0.017] compared to that of controls.

At L4-5 disc level, no significant difference was found between cases and controls, except in parameter of extrusion, wherein cases showed significantly higher percentage [p<0.001] than that in controls.

At L3-4 disc level, lumbarized S1 cases showed higher frequency of subjects with annular fissure [p=0.002] and protrusion [p=0.006] compared to that of controls. Lumbarization of S1 was protective for higher Pfirrmann grade at this level [p<0.001].

S1-2 disc level in lumbarized S1 subjects could not be compared with that of control group, as a small rudimentary to absent disc was seen in control subjects. No bulging disc / herniated disc was seen in control group at S1-2 level. Whether S1-2 level in lumbarized S1 group can be compared with L5-S1 level in control group, as these levels are the caudal most mobile segments in these respective groups, needs to be answered.

One limitation of our study is that the degenerative changes were not evaluated under subtypes of sacralized L5, as the sample was small in subjects with Castellvi type I, type IIa, type IIIa and type IV sacralized L5. The interreader reliability of the different parameters was not evaluated as part of this study. In case of Pfirrmann classification, interreader agreement was already shown^[18]. Another limitation of our study is the small sample size [n=19] of subjects with lumbarization of S1. These findings need to be further evaluated in larger sample size of subjects with lumbarization of S1 for confirmation.

V. Conclusion

In conclusion, sacralization of L5 protects the disc at the transitional L5-S1 level and predisposes not only the immediate cephalad disc, but also two more adjacent cephalad discs to greater degeneration. Significantly higher frequency of degeneration was also seen at L5-S1 disc level in lumbarized S1 subjects, but these findings along with findings at adjacent two more cephalad segments require further confirmation in a larger study.

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