Original Article | Journal of Orthopaedic Case Reports 2026 October:16(10):Page 550-554

Prevalence and Clinical Impact of Lumbosacral Transitional Vertebrae in Chronic Low Back Pain: A Cross-Sectional Study from Central India

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Learning Point of the Article:

This study highlights that lumbosacral transitional vertebrae (LSTV) are present in nearly one-fourth of patients with chronic low back pain, underscoring their clinical relevance in routine practice. Patients with LSTV experienced significantly higher pain intensity and disability compared to those without transitional anatomy, with high-grade variants (Castellvi Types II-IV) showing the greatest impact.

Abstract

Introduction: Lumbosacral transitional vertebrae (LSTV) are common anatomical variants implicated in chronic low back pain (LBP). Their prevalence and clinical significance remain debated.

Materials and Methods: A hospital-based cross-sectional study was conducted among 350 consecutive adult patients (18–70 years) with chronic non-specific LBP at a tertiary care center in Central India. Demographic and clinical data were recorded, pain intensity assessed using the Visual Analog Scale (VAS), and disability quantified with the Oswestry Disability Index (ODI). Standardized lumbosacral radiographs were obtained and independently reviewed by experienced specialists. LSTV were classified according to Castellvi types. Statistical comparisons were performed between patients with and without LSTV, and across LSTV subtypes.

Results: Of 350 patients, 198 (56.6%) were male; mean age was 42.8 ± 11.6 years. Radiographic LSTVs were identified in 78 patients, yielding a prevalence of 22.3%. Distribution by Castellvi type was: Type I (30.8%), Type II (25.6%), Type III (23.1%), and Type IV (20.5%). Patients with LSTV had significantly higher mean VAS (6.2 ± 1.4 vs. 5.4 ± 1.6; P = 0.002) and ODI scores (34.8 ± 9.7 vs. 29.1 ± 10.2; P = 0.001) compared to those without. High-grade LSTV (Types II-IV) were associated with greater pain and disability than low-grade variants ($P < 0.05$). ANOVA confirmed significant differences in ODI across Castellvi types, with Type III and IV showing the highest disability.

Conclusion: LSTV were present in nearly one-fourth of patients with chronic LBP and were associated with significantly greater pain and disability, particularly in high-grade variants. Recognition of LSTV may aid in clinical evaluation and management of chronic LBP.

Keywords: Lumbosacral transitional vertebrae, Castellvi classification, chronic low back pain, prevalence, Oswestry Disability Index, Visual Analog Scale.

Introduction

Chronic low back pain (LBP) is a prevalent musculoskeletal disorder, contributing to disability, reduced quality of life, and socioeconomic burden. Up to 80% of individuals will experience LBP, with a proportion developing chronic symptoms persisting beyond 3 months [1]. The etiology of chronic LBP is multifactorial, involving degenerative, mechanical, and anatomical factors. Among anatomical variants associated with persistent LBP, lumbosacral transitional vertebrae (LSTV) have garnered attention. LSTV are congenital anomalies at the

Access this article online

Website: www.jocr.co.in

DOI: https://doi.org/10.13107/jocr.2026.v16.i10.8338

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Submitted: 03/07/2026; Review: 10/08/2026; Accepted: September 2026; Published: October 2026

DOI: https://doi.org/10.13107/jocr.2026.v16.i10.8338

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lumbosacral junction, characterized by varying degrees of fusion or articulation between the transverse process of the lowest lumbar vertebra and the sacrum [2]. These anomalies modify spine and pelvis biomechanics, resulting in abnormal load distribution, accelerated degeneration of adjacent discs, and altered nerve root dynamics. LSTV prevalence in the population ranges from 4% to 30%, contingent on diagnostic criteria and study population [3]. Nonetheless, the clinical significance of LSTV remains contentious, with some studies indicating an association with chronic LBP, whereas others regard them as incidental findings. The Castellvi classification offers a standardized framework for categorizing LSTV into four types based on radiographic morphology: Type I (dysplastic transverse process), Type II (pseudoarticulation), Type III (complete fusion), and Type IV (mixed type) (Shaikh et al., 2017)[4]. This classification is utilized clinically and in research, facilitating differentiation between low-grade variants (Type I) and high-grade variants (Types II-IV), which may have a pronounced clinical impact. High-grade LSTVs, particularly those involving pseudoarticulation or fusion, are hypothesized to predispose individuals to pain and disability due to altered spinal mechanics [5]. Mechanisms proposed to link LSTV and LBP include pseudoarticulation acting as a pain generator through abnormal motion and pseudo-joint degeneration; fusionvariants causing compensatory hypermobility and degeneration at adjacent segments, the disc above the transitional vertebra; and altered nerve root orientation and foraminal narrowing contributing to radicular symptoms [6]. These pathophysiological processes highlight the necessity of identifying LSTV in individuals with persistent LBP, particularly when symptoms do not respond to standard treatments.Many patients with chronic low back pain (LBP) are classified as having non-specific LBP despite the lack of adequate radiographic evaluation [7]. This can result in under-recognition of transitional anatomy and incorrect classification of pain causes. In addition, LSTV prevalence and effects may differ among populations due to genetic, environmental, and lifestyle influences. Data from Indian populations are scarce, and few studies have explored LSTV prevalence and its link to pain and disability in chronic LBP. We conducted a hospital-based cross-sectional study at a tertiary teaching hospital in Central India, involving consecutive adults with chronic non-specific LBP. Standardized radiographs were reviewed by specialists, with LSTV categorized according to Castellvi types. Pain severity and disability were measured using the Visual Analog Scale (VAS) and Oswestry Disability Index (ODI). This study aimed to ascertain the prevalence of confirmed LSTV in chronic LBP patients. Secondary goals included analyzing LSTV distribution by Castellvi classification and examining LSTV's relationship to pain and disability severity. Special focus was on comparing low-grade and high-grade variants to clarify their impacts. By examining LSTV prevalence and clinical associations in an Indian cohort, this study adds to evidence on transitional vertebrae in chronic LBP. Results are anticipated to improve awareness, encourage radiographic assessments, and inform personalized management for chronic LBP.

Materials and Methods

Study design and setting

This was a hospital-based cross-sectional observational study conducted in a tertiary care teaching hospital in Central India. The study period extended from August 2023 to July 2024. Written informed consent was obtained from all participants.

Study population

Consecutive adult patients aged 18–70 years presenting to the outpatient clinic with chronic non-specific LBP were assessed for eligibility.

Inclusion criteria

- Age 18–70 years
- Primary complaint of LBP localized between the costal margin and gluteal folds, with or without radiation, of at least 3 months' duration
- Ability to provide informed consent and complete questionnaires.

Exclusion criteria

- History of significant trauma to the lumbosacral spine or pelvis
- Previous spinal surgery
- Known spinal infection, primary or metastatic neoplasm, or inflammatory spondyloarthropathy
- Radiographic evidence of vertebral fracture, spondylolisthesis grade >I, or gross deformity
- Pregnancy
- Inadequate radiographs for confident assessment of lumbosacral anatomy.

Sample size

The sample size was calculated based on an anticipated LSTV prevalence of approximately 20% in patients with LBP, with 5% absolute precision and a 95% confidence level. Using the

Table 1: Clinical and radiographic results of study population (n=350)

Variable	Patients without LSTV (n=272)	Patients with LSTV (n=78)	*P*-value
Mean age (years)	42.5±11.4	43.6±12.1	0.48
Male sex (%)	154 (56.6)	44 (56.4)	0.97
Mean BMI (kg/m^2)	24.6±3.8	24.9±4.1	0.62
Median duration of LBP (months)	13 (IQR 9–22)	15 (IQR 10–25)	0.21
Radicular symptoms (%)	84 (30.9)	28 (35.9)	0.42
Mean VAS score	5.4±1.6	6.2±1.4	0.002*
Mean ODI score	29.1±10.2	34.8±9.7	0.001*

LSTV: Lumbosacral transitional vertebrae, BMI: Body mass index, LBP: Low back pain, IQR: Interquartile range, VAS: Visual Analog Scale, ODI: Oswestry Disability Index, * Statistically signifcant

formula n = Z2pq/d2, the minimum required sample size was estimated at around 250. To increase statistical power and account for non-diagnostic radiographs or incomplete data, we planned to recruit at least 350 patients. Ultimately, 350 patients with complete clinical and radiographic data were included in the final analysis.

Clinical assessment

Demographic and clinical data were recorded using a structured proforma, including age, sex, occupation, body mass index (BMI), duration of LBP, presence of radicular symptoms, and prior treatment. Pain intensity over the preceding week was assessed using a 10 cm VAS, where 0 indicates no pain, and 10 indicates the worst imaginable pain. Disability related to LBP was quantified using the ODI version 2.0, which yields a percentage score categorized as minimal, moderate, severe, crippled, or bed-bound.

Neurological examination was performed to document motor, sensory, and reflex changes in the lower limbs. Straight leg raise test and other provocative maneuvers were recorded but were not used for inclusion/exclusion decisions unless they indicated alternative pathology requiring urgent intervention.

Radiographic technique

All participants underwent standardized lumbosacral radiographs in the standing position, including:

- Anteroposterior (AP) view centered at the L4-L5 level, ensuring visualization of the lower thoracic vertebrae to the upper sacrum, iliac crests, and transverse processes of L5
- Lateral view of the lumbosacral region.

Radiographs were acquired using the same digital radiography system with standardized exposure parameters. When necessary, an additional Ferguson (30° cephalad-angled AP) view was obtained to better delineate the lumbosacral junction and transverse processes.

Radiographic evaluation and classification

LSTV were identified and classified according to the Castellvi classification:

- Type I: Dysplastic enlarged transverse process (≥19 mm).
- Type II: Incomplete lumbarization/sacralization with pseudoarticulation between enlarged transverse process and sacrum (unilateral IIa, bilateral IIb).
- Type III: Complete osseous fusion of transverse process to sacrum (IIIa unilateral and IIIb bilateral).
- Type IV: Mixed type with Type II on one side and Type III on the other.

For analysis, subtypes were grouped as Types I-IV, irrespective of laterality, and further binary grouping (non-transitional vs. transitional; low-grade [Type I] vs. high-grade [Types II-IV]) was explored. In case of disagreement, a consensus reading was performed.

Outcome measures

The primary outcome was the prevalence of radiographically confirmed LSTV among patients with chronic LBP. Secondary outcomes included:

- Distribution of LSTV according to Castellvi types
- Association between LSTV presence and mean VAS and ODI scores
- Association between high-grade LSTV (Types II-IV) and pain/disability.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using Jamovi. Continuous variables were summarized as mean ±

Table 2: Distribution of Lumbosacral transitional vertebrae according to Castellvi classification (n=78)

Castellvi type	Number of cases	Percentage
Type I (low-grade)	24	30.8
Type II	20	25.6
Type III	18	23.1
Type IV	16	20.5
Total high-grade (II–IV)	54	69.2

standard deviation or median (interquartile range [IQR]) as appropriate; categorical variables as frequencies and percentages. Appropriate statistical tests were used, and P < 0.05 was considered statistically significant.

Results

The study included 350 consecutive patients diagnosed with chronic non-specific LBP for the final analysis. The participants had a mean age of 42.8 ± 11.6 years, ranging from 18 to 70 years, with 198 males (56.6%) and 152 females (43.4%). The mean BMI was recorded at 24.7 ± 3.9 kg/m2, as shown in Table 1. The median duration of LBP was 14 months, with an IQR of 9 to 24 months. Radicular symptoms were observed in 112 patients, accounting for 32% of the cohort.

Prevalence of LSTV

Radiographic assessment identified LSTV in 78 out of 350 patients, resulting in a prevalence rate of 22.3%.

Distribution of LSTV types

The distribution of lumbosacral transitional vertebrae (LSTV), classified according to the Castellvi classification, showed that Type I was the most common variant, accounting for 24 cases (30.8%), followed by Type II with 20 cases (25.6%). Type III was identified in 18 cases (23.1%), while Type IV was the least common, observed in 16 cases (20.5%) as shown in Table 1 . Overall, all four Castellvi types were represented relatively evenly within the study population, with a slight predominance of Type I LSTV.For analytical purposes, 24 cases (30.8%) were classified as low-grade (Type I), whereas 54 cases (69.2%) were categorized as high-grade (Types II-IV).

Pain and disability scores

The mean VAS score for patients with LSTV was 6.2 ± 1.4, compared to 5.4 ± 1.6 for those without LSTV (P = 0.002). Similarly, the mean ODI score was significantly higher in patients with LSTV (34.8 ± 9.7) than in those without LSTV (29.1 ± 10.2; P = 0.001).

Association with LSTV grade

Patients with high-grade LSTV (Types II–IV) exhibited higher mean VAS (6.5 ± 1.3) and ODI (36.2 ± 9.1) scores compared to those with low-grade LSTV (VAS 5.7 ± 1.5; ODI 30.6 ± 8.9; P < 0.05 for both comparisons).

Comparison across Castellvi types

A one-way analysis of variance indicated significant differences in ODI scores across Castellvi types (P = 0.01). Post hoc analysis revealed that patients with Type III and Type IV LSTV had significantly higher disability scores compared to those with Type I.

Discussion

In this hospital-based cross-sectional study, it was found that 22.3% of patients with chronic non-specific LBP had LSTV, a figure consistent with the previously reported range of 15–30% in similar groups [8]. Analysis of Castellvi types revealed that high-grade variants (Types II-IV) were more prevalent than the low-grade Type I. Notably, individuals with LSTV experienced significantly higher levels of pain and disability than those without such transitional anatomy, supporting the idea that LSTV may exacerbate symptom severity [9]. The link between high-grade LSTV and elevated ODI scores implies that pseudoarticulation or bone fusion at the lumbosacral junction might disrupt biomechanics, resulting in abnormal load distribution and accelerated degenerative changes [10]. This observation aligns with existing literature suggesting that LSTV can lead to disc degeneration, facet joint issues, and nerve root compression. Recognizing these variants is clinically important, as they may account for persistent pain in patients otherwise diagnosed with "non-specific" LBP [11]. Our findings highlight the necessity of standardized radiographic evaluation in chronic LBP cases, especially when symptoms seem disproportionate to clinical findings. Identifying LSTV can help clinicians develop tailored management plans, including physiotherapy aimed at core stabilization, avoiding unnecessary procedures, and considering targeted injections or surgical options for certain patients. Clinical message LSTV are frequently found in patients with chronic LBP and are linked to significantly higher pain and disability, particularly in high-grade variants. Routine radiographic assessment of the lumbosacral junction is crucial for accurate diagnosis and appropriate management. LSTV were detected in nearly one-fourth of patients with chronic LBP, confirming their common presence in this group. Patients with LSTV, especially those with high-grade variants, experienced notably greater pain and disability than those without transitional anatomy. Therefore, routine radiographic evaluation and recognition of LSTV are vital for accurate diagnosis and personalized management of chronic LBP.

Limitations

This study was hospital-based and cross-sectional, which may limit generalizability to the wider community. Radiographic evaluation relied on plain X-rays, and subtle anatomical variations detectable by computed tomography or magnetic

resonance imaging could not be assessed. The Castellvi classification, though widely used, may oversimplify the spectrum of LSTV. Pain and disability scores were self-reported, introducing potential recall and perception bias. Finally, the design precludes establishing causality between LSTV and chronic LBP, requiring longitudinal studies for confirmation.

Conclusion

LSTV were detected in nearly one-fourth of patients with chronic LBP, confirming their common presence in this group. Patients with LSTV, especially those with high-grade variants, experienced notably greater pain and disability than those without transitional anatomy. Therefore, routine radiographic evaluation and recognition of LSTV are vital for accurate diagnosis and personalized management of chronic LBP.

Clinical Message

Lumbosacral transitional vertebrae are found in patients with chronic LBP and are linked to significantly higher pain and disability, particularly in high-grade variants. Routine radiographic assessment of the lumbosacral junction is crucial for accurate diagnosis and appropriate management.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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Conflict of Interest: Nil
Source of Support: Nil

Consent: The authors confirm that informed consent was obtained from the patient for publication of this article

How to Cite this Article

Mishra VK, Gawande J, Mishra S. Prevalence and Clinical Impact of Lumbosacral Transitional Vertebrae in Chronic Low Back Pain: A Cross-Sectional Study from Central India. Journal of Orthopaedic Case Reports 2026 October;16(10): 550-554.