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Title: Prevalence of lumbosacral transitional vertebra on lumbar CT and associated degenerative imaging findings in symptomatic patients.

Short title: Lumbosacral transitional vertebra associated degenerative imaging findings.

Abstract

Purpose: This study aimed to assess the prevalence and distribution of lumbosacral transitional vertebra (LSTV) subtypes in patients with low back pain and investigate associated degenerative changes using lumbar CT imaging.

Methods: A retrospective review of 1.035 patients who underwent lumbar CT for low back pain between January 2023 and April 2024 was conducted. 133 with LSTV were identified and classified according to the Castellvi classification. The degenerative changes at the LSTV level, including pseudoarticular degeneration, disc narrowing, facet joint arthropathy, foraminal stenosis, and scoliosis, were evaluated.

Results: LSTV was present in 12.85% of the patient population. Degeneration at the pseudoarticulation was observed in 67.7% of cases, with Types II and IV showing significantly higher rates (98.2% and 100%) compared to Types I (60%) and III (0%). Disc narrowing at the cephalad level was most common in Type III (90%). Facet joint arthropathy was observed in 85.7% of cases, while foraminal stenosis was only found in Type II (9.8%). Scoliosis was more prevalent in Types II (50.9%) and IV (50%) than in Types I (24%) and III (4.5%). Statistically significant differences were observed in pseudoarticular degeneration, disc narrowing, foraminal stenosis, and scoliosis.

Conclusion: LSTV is common in low back pain patients, with Types II and IV showing early degeneration at the pseudoarticulation level that may contribute to symptoms, particularly in young and middle-aged individuals. Nerve root compression due to degenerative hypertrophy is common in Type II and requires careful examination of the LSTV region with imaging methods in symptomatic cases.

Keywords: lumbosacral transitional vertebra, computed tomography, pseudoarticulation, low back pain.

Makale başlığı: Semptomatik hastalarda lomber BT'de lumbosakral transisyonel vertebra prevalansı ve eşlik eden dejeneratif görüntüleme bulguları.

Kısa başlık: Lumbosakral transisyonel vertebra ile ilişkili dejeneratif görüntüleme bulguları.

Öz

Amaç: Bu çalışmanın amacı, bel ağrısı nedeniyle lomber BT çekilen hastalarda lumbosakral transisyonel vertebra (LSTV) yaygınlığını ve alt tiplerinin dağılımını değerlendirmek ve ilişkili dejeneratif değişiklikleri araştırmaktır.

Gereç ve yöntem: Ocak 2023 ile Nisan 2024 arasında bel ağrısı nedeniyle lomber BT çekilen 1.035 hastanın retrospektif incelemesi yapıldı. LSTV'li 133 hasta belirlendi ve Castellvi sınıflandırmasına göre sınıflandırıldı. Psödoartiküler dejenerasyon, disk daralması, faset eklem artropatisi, foraminal stenoz ve skolyoz dahil olmak üzere LSTV seviyesindeki dejeneratif değişiklikler değerlendirildi.

Bulgular: LSTV hasta popülasyonunun %12,85'inde saptandı. Psödoartiküler dejenerasyon vakaların %67,7'sinde gözlendi ve Tip II ve IV'te Tip I (%60) ve III (%0) ile karşılaştırıldığında önemli ölçüde daha yüksek oranlar (%98,2 ve %100) görüldü. Sefalad disk daralması Tip III'te (%90) en yaygındı. Faset eklem artropatisi vakaların %85,7'sinde gözlenirken, foraminal stenoz yalnızca Tip II'de (%9,8) bulundu. Skolyoz Tip II'de (%50,9) ve IV'te (%50) Tip I (%24) ve III'e (%4,5) göre daha yaygındı. Psödoartiküler dejenerasyon, disk daralması, foraminal stenoz ve skolyozda istatistiksel olarak anlamlı farklılıklar gözlendi.

Sonuç: LSTV bel ağrısı hastalarında yaygındır. Tip II ve IV'te psödoartikülasyon seviyesinde erken dejenerasyon görülür ve bu özellikle genç ve orta yaşlı bireylerde semptomlara katkıda bulunabilir. Dejeneratif hipertrofiye bağlı sinir kökü sıkışması Tip II'de yaygındır ve semptomatik vakalarda görüntüleme yöntemleriyle LSTV bölgesinin dikkatli bir şekilde incelenmesini gerektirir.

Anahtar kelimeler: Lumbosakral transisyonel vertebra, bilgisayarlı tomografi, psödoartikülasyon, bel ağrısı.

Introduction

Low back pain is a significant health problem on a global scale, affecting individuals of all age groups, with a lifetime prevalence rate of up to 84% reported [1].

Lumbosacral transition is a relatively common pathology that is frequently overlooked in the diagnostic process of low back pain [2]. Lumbosacral transitional vertebra (LSTV) is defined as the presence of a unilateral or bilateral lumbar transverse process that articulates with the upper surface of the sacrum [3]. The diagnosis of this condition is made when there is varying degrees of fusion between the transverse process of the terminal lumbar vertebra and the sacrum, and this is recognized as a mechanical cause of low back pain [4].

The prevalence of LSTVs in the general population has been documented as ranging from 4% to 35.5% [5]. Patients who present with chronic lower back pain or functional impairment due to congenital deformity caused by LSTV are diagnosed with Bertolotti's Syndrome. The condition was first described by Mario Bertolotti in 1917 [6, 7].

The most widely employed classification system for imaging is the Castellvi classification, which divides the condition into four types based on the relationship of the transverse process with the sacrum [8]. According to Castellvi, Type I includes hyperplastic transverse processes measuring at least 19 mm. Type II exhibits incomplete lumbarization/sacralization with enlarged transverse processes that form a joint with the sacrum. Type III describes lumbarization/sacralization with loss of the joint space formed by the transverse process and complete bony fusion to the sacrum. Type IV is characterized by the presence of Type II LSTV on one side and Type III LSTV on the other [9, 10].

The recommended course of treatment comprises a range of approaches, including the use of oral medication, physical therapy, steroid injections at the site of pain, and surgical resection or fusion [6].

Computed tomography (CT) and magnetic resonance imaging (MRI) can provide more accurate diagnosis and classification than plain radiography. CT provides the highest accuracy in evaluating bony anatomy and is the most useful modality for evaluating LSTVs [11].

The present study aims to determine the prevalence and distribution of LSTV types according to the Castellvi classification in patients with lower back pain and to calculate the rates of vertebral degenerative changes among the subtypes. This study is the first to investigate pseudoarticular degeneration at the level of the LSTV and degenerative changes at other levels with lumbar CT. Previous studies have predominantly been performed with reconstructions from abdominal CT [12, 13].

Materials and methods

Study design and patient population

In this study, the images of 1.132 patients who were admitted to our center with the complaint of "low back pain" between January 2023 and April 2024 and underwent lumbar CT imaging were retrospectively scanned using our hospital's picture archiving and communication system (PACS). We excluded 25 patients who did not provide optimal imaging conditions due to motion and beam-hardening artifacts. 57 patients had a history of surgery. Additionally, 15 patients with spinal involvement classified as either malignant or benign were excluded from the evaluation. Of the remaining 1.035 patients, 133 patients with LSTV were divided into four groups according to the Castellvi classification and evaluated in terms of degenerative and anatomical spinal, vertebral, and disc changes (degenerative findings between the transverse process and the sacral surface, narrowing in the cephalad intervertebral disc, degenerative changes in the facet joints, foraminal stenosis at the transition level, degenerative spondylolisthesis, and scoliosis).

Permission was obtained from the Pamukkale University Non-Interventional Clinical Research Ethics Committee for the study (date: 30.04.2024, approval number: E-60116787-020-353871).

Imaging

CT image acquisition of the lumbosacral region was performed using a multidetector CT scanner (Philips Ingenuity 128, Philips Healthcare, Cleveland INC, United States). The following parameters were utilized for the axial lumbosacral CT acquisition: a collimation width of 64 × 0.625 mm, a matrix size of 512 × 512, a slice thickness of 1.5 mm, a tube voltage of 120 kV, and a tube current of 140 mA. The CT images were reconstructed in both the sagittal and coronal planes.

Imaging analysis

Lumbalization and sacralization terms were not used because of the frequent lack of full spinal imaging and the difficulties in precisely identifying the fifth vertebra. The evaluation was conducted by a radiologist with 28 years of experience in the field of radiology, using a structured report form on a PACS (Picture Archiving and Communications System) workstation.

“Degeneration at the LSTV level’’ or pseudoarticulation refers to narrowing the distance between the transverse process and the sacrum, sclerosis of the bony surfaces, and/or osteophyte formation (Figure 1).

“Disc narrowing” was evaluated according to the four-degree scale defined by Videman et al. [14] Except for the L5–S1 disc, cases were considered significant for disc narrowing from grade 1, where the disc height is greater than the cephalad disc.

“Facet joint arthropathy” has been evaluated according to the classification published by Kalichman et al. [15] Changes such as joint space narrowing, osteophyte formation, hypertrophy of the joint protrusion, subarticular sclerosis, subchondral cysts, and the vacuum phenomenon have been considered. Accordingly, images have been considered positive from grade one (mild degenerative disease, characterized by narrowing of the joint space, small osteophyte formation, or mild hypertrophy of the joint) [16].

Nerve root canal stenosis" describes the obliteration of the fat tissue in the intervertebral foramina. It has been considered narrowed when the dimension measured at the level of the nerve canal between the pseudoarticulation and the lateral side of the vertebral body is less than 3 mm. [17] (Figure 2).

Scoliosis is defined as a structural sideways curvature of the spine. A small deviation (<10 degrees) is sometimes called spinal asymmetry, while "true" scoliosis is characterized by a deviation greater than 10 degrees [18].

The term "anterolisthesis" refers to the forward displacement of one vertebral body relative to the vertebral body below it. In the study, anterolisthesis was evaluated according to the Meyerding classification. Vertical lines are drawn along the upper and lower vertebral posterior cortex, and a measurement is taken between them [19]. Sagittal reconstruction images were used to detect anterolisthesis, and its presence or absence was recorded as a binary value.

Statistical analysis

The analysis was conducted using the SPSS 25.0 (IBM SPSS Statistics 25 software (Armonk, NY: IBM Corp.)) package program. Continuous variables are presented as mean ± standard deviation, and median (IQR: 25^{th}-75^{th} percentiles), and categorical variables are presented as counts and percentages. Kruskal-Wallis variance analysis was used to examine differences between groups for numerical data, while the Chi-square test was used for categorical data. The relationships between continuous variables were examined using the Spearman correlation coefficient. A p-value <0.05 was considered statistically significant.

Results

The frequency distributions of CT findings for 133 patients are presented in Table 1. Of the 1035 patients included in the study, 133 (12.85%) (66.2% female, 33.8% male;

age range 15-85 years; mean 58; median 59) were found to have LSTV. The gender disparity was not statistically significant (p=0.257).

The prevalence of degeneration at the LSTV level was 67.7% (90 out of 133) among the patient population. The presence of degeneration was observed in 98.2% of patients in Type II (56 out of 57), in all patients in Type IV (4 out of 4), in 60% of patients in Type I (30 out of 50), and no degeneration was observed in any patient in Type III. Accordingly, these changes were significantly higher in Types II and IV, whereas they were not observed in Type III.

The prevalence of intervertebral disc narrowing at the upper level of the transitional vertebra was 74.4% (99 out of 133) in the study population. This rate exceeded 90% (20 out of 22) in Type III LSTV, although a high prevalence was noted across all LSTV types.

Facet arthropathy was observed in 85.7% (114 out of 133) of patients, with no significant intergroup difference.

The prevalence of foraminal stenosis was 9.8% (13 out of 133), with all cases occurring in the Type II group.

The prevalence of anterior spondylolisthesis was 19.5% (26 out of 133 patients), and there was no notable difference between groups in the presence of anterior spondylolisthesis.

Scoliosis was identified in 33.1% of patients (44 out of 133), with a higher prevalence observed in Types II and IV. Scoliosis was observed in 50.9% (29 of 57) of patients in Type II, 50% (2 of 4) of patients in Type IV, 24% (12 of 50) of patients in Type I, and 4.5% (1 of 22) of patients in Type III.

Statistically significant differences were observed among LSTV patient intergroups in terms of degeneration of LSTV level (p=0.0012), foraminal stenosis (p=0.0033), narrowing of cephalad disc (p=0.041), and scoliosis (p=0.0013). In contrast, no statistically significant difference was observed between the LSTV patient groups with respect to gender (p=0.276), age (p=0.346), facet arthropathy (p=0.382), and anterior spondylolisthesis (p=0.960).

Discussion

LSTV variation was detected in 12.85% of the total sample of 1035 patients in the present study. Several notable differences were identified between the LSTV patient groups regarding LSTV pseudoarticular degeneration, foraminal stenosis, cephalad disc narrowing, and scoliosis. However, no differences were observed in terms of gender, age, facet arthropathy, and anterior spondylolisthesis. While degenerative changes at the pseudoarticulation level were detected at a higher rate in Type II and Type IV compared

to other types, cephalad disc narrowing was more common in Type III, foraminal stenosis was high only in Type II, and scoliosis was detected at a much lower rate in Type III. These differences between types are important in the differential diagnosis of low back pain.

Previous studies have associated Type II and Type IV LSTV with an increased prevalence of low back and hip pain, as well as lower levels of physical activity [20]. The mechanism behind spinal biomechanical abnormalities caused by LSTV remains unclear [10]. In this study, the detection of pseudoarticular degeneration in almost all Type II and all Type IV patients suggests that LSTV pseudoarticular degeneration begins at an early age (Figure 1). This could explain why LSTV is a common cause of low back pain in younger and middle-aged individuals [11]. The development of degenerative changes at other levels due to the shift of the center of gravity to the upper levels, which is often discussed in the literature, is thought to play a secondary role.

In the present study, more than half of Type I LSTVs (60%) had pseudoarticular degeneration. This suggests that with age, the loss of height in the disc space also reduces the distance between the transverse process and the sacrum, and degeneration develops at this level over time due to friction. L4-5 height loss was found at almost the same rate in Type I LSTVs (64%). This finding shows that Type I LSTV can progress to Type II LSTV over time.

Foraminal and extraforaminal stenosis due to degenerative hypertrophy at the pseudoarticulation level was detected in 13 (9.7%) of the patients, all of whom had Type II LSTVs. Similar rates of 13% have been reported in previous studies [21]. Nerve root compression may result from stenosis at this level [22], so patients with LSTV should undergo a detailed examination for this condition, particularly when clinical signs of L5 nerve root compression are present. Coronal MRI sequences or additional CT imaging can help evaluate the neural foramen.

As demonstrated by numerous studies, the discs situated above the transitional vertebra are more susceptible to early degeneration, while those located between the transitional vertebra and the sacrum exhibit a reduced risk of degeneration [12, 23]. In the present study, it was observed that the loss of height of the intervertebral disc above the transitional vertebra was more prevalent in Type II and Type III. This finding suggests that patients with these types may experience a greater incidence of back pain due to degenerative changes.

Scoliosis was found to be more common in the Type II and Type IV patient groups than in the other types. It was found in about half of the patients in both groups. Scoliosis was found in 24% of the type I group and only 4.5% of the type III group. The presence of

fixed vertebrae at the lumbosacral level due to fusion in Type III may be responsible for a reduced incidence of scoliosis, as observed in Type I. In contrast, the presence of asymmetry, degenerative changes, and instability at the pseudoarthrosis level, as seen in Types II and IV, may contribute to the development of scoliosis. A literature review did not reveal any relevant data on this issue.

There are some limitations to our study. Firstly, it was a retrospective study conducted in a single center, which is prone to selection bias. Another limitation was that the patients included were not asymptomatic, so a control group could not be included in the study. Despite these limitations, the study included a large and homogeneous number of patients. Inter-reader reliability of different degeneration parameters was not performed because it was not the subject of this study.

In conclusion, LSTV has been identified as a prevalent incidental finding, with a prevalence of 12.85% in lumbar CT scans obtained due to low back pain. The present findings indicate that degeneration at the pseudoarticulation level occurs at an early age in Type II and Type IV patient groups, thus providing a rationale for the low back pain observed in young and middle-aged patients with LSTV. Furthermore, the study noted that nerve root compression due to degenerative hypertrophy at the pseudoarticulation level is prevalent, particularly in the Type II patient group. Therefore, care should be taken not to overlook transition areas on MRI or CT scans, especially in symptomatic cases.

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Conflict of interest: No conflict of interest was declared by the authors.

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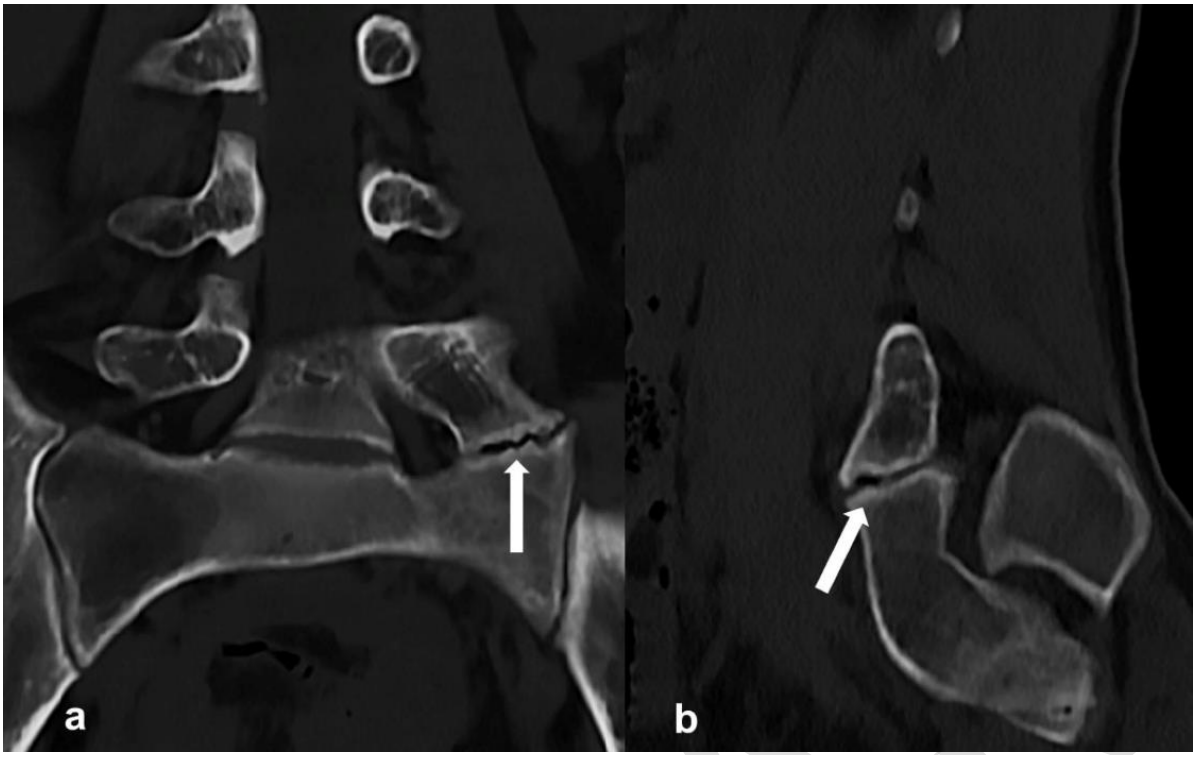

Figure 1. A 20-year-old female patient with Castellvi Type II shows irregularities in the bony surfaces, subchondral sclerosis, and degenerative vacuum phenomena in the joint space at the left pseudoarticulation level (arrows). No signs of degeneration have yet been observed at other levels. Coronal (**a**) and sagittal CT image (**b**)

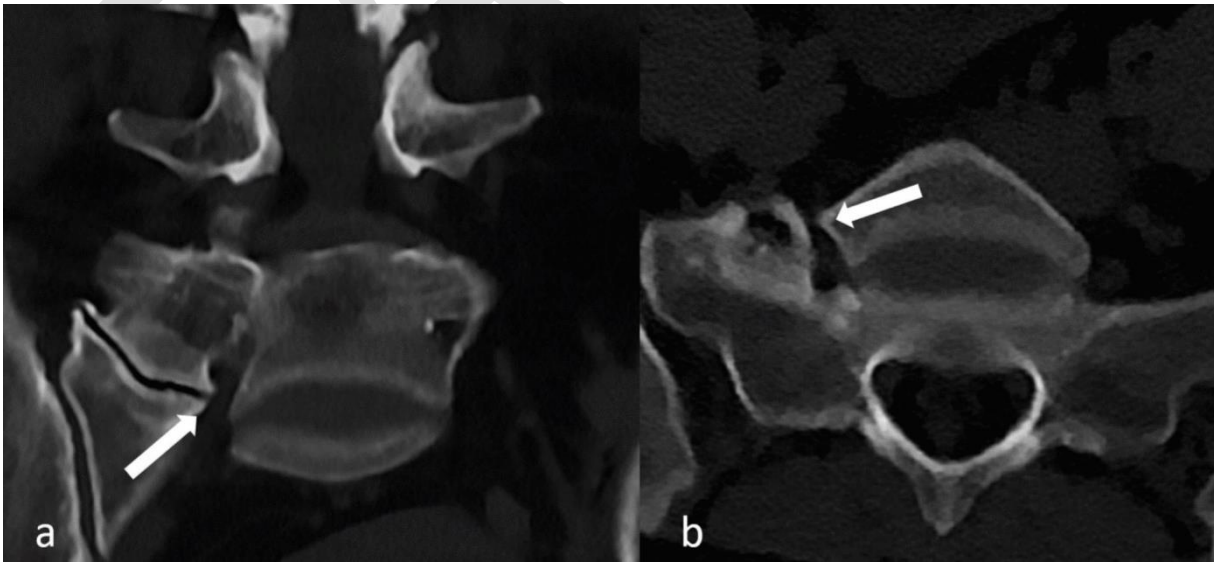

Figure 2. A 58-year-old woman with Castellvi Type II shows narrowing of the neural foramen and compression of the nerve root due to hypertrophy and degenerative changes at the level of the right pseudoarticulation (arrows). Coronal (**a**) and axial CT image (**b**)

Table 1. Distribution of lumbar CT findings

Types	Patients (n:133)	Degeneration of LSTV level	Narrowing of Cephalad Disc	Facet Arthropathy	Foraminal Stenosis	Anterior Spondylolisthesis	Scoliosis
Type 1	50	30	32	41	0	9	12
Type 2	57	56	45	48	13	13	29
Type 3	22	0	20	21	0	4	1
Type 4	4	4	2	4	0	1	2
Total	133	90 (67.6%)	99 (74.4%)	114 (85.7%)	13 (9.7%)	27 (20.3%)	44 (33.0%)
***p* value**		0	0.041	0.252	0	0.96	0

A *p*-value <0.05 was considered statistically significant

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