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Symptomatic Lumbosacral Transitional Vertebrae (Bertolotti Syndrome) as a Cause of Low Back Pain: Classification and Imaging Findings

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Abstract: *Objective:* To determine the most common pathologies of lower back pain and the proportion of Bertolotti syndrome (BS) among these pathologies and to reveal possible gender-age differences, and to group the lumbosacral transitional vertebrae (LSTV) according to Castellvi classification and find their prevalence rates. *Method:* The images and reports of 357 patients who underwent magnetic resonance imaging (MRI) of the sacroiliac joint between March 2020 and October 2021, mostly due to low back pain, were evaluated by a radiologist specialized in musculoskeletal radiology. *Results:* The mean ages of patients with and without BS were 43.9 years old and 44 years old, respectively, and there was no correlation between BS and patient age (P = 0.976). The age range of patients with BS was 15–77 years old. Twenty per cent of the patients with BS were younger than 30 years old and 50% were younger than 40 years old. No gender difference was observed among patients with BS (P = 0.572). The prevalence rates if LSTVs according to Castellvi classification, were 10% in Type 1a, 11.4% in Type 1b, 35.7% in Type 2a, 17.1% in Type 2b, 4.3% in Type 3a, 12.9% in Type 3b and 8.6% in Type 4. The main pathologies causing lower lumbar pain were active-chronic sacroiliitis, vertebral and disc degenerations, and facet joint arthrosis, while BS comes after, with 2.8%. In BS, the pain originated from the lumbosacral transitional vertebrae. *Conclusion:* According to our results, BS starts to be seen below the age of 30 years, but there is no significant relationship with age or gender. BS is one of the most common causes of lower lumbar pain after sacroiliitis, vertebral degeneration, and discopathy. There are different hypotheses in the literature about the etiology of BS and there is no common opinion. Therefore, there is a need for multicenter studies with large sample sizes.

Keywords: Bertolotti syndrome; Lumbosacral transitional vertebrae; Sacroiliac joint MRI

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1. Introduction

The lumbosacral transitional vertebra (LSTV) is a congenital vertebral anomaly consisting of the fusion of the transverse process of the last lumbar vertebra with the first sacral vertebral segment [1]. The LSTV encompasses a wide spectrum of morphological variations ranging from partial or complete sacralization of the L5 vertebra to partial or complete lumbarization of the S1 vertebra [2]. Bertolotti associated this anomaly with low back pain in 1917. Bertolotti Syndrome (BS) is a clinical and radiological diagnosis given to patients who experience pain due to LSTV [3]. This syndrome is said to affect 4–8% of the population [4]. Given the social and economic impact of lower back pain on young people, BS should be

included in the differential diagnosis list of low back pain. Magnetic resonance imaging (MRI) of the sacroiliac joint is usually performed for the diagnosis of sacroiliitis, which is one of the causes of low back pain. In addition to sacroiliac joint MRI, facet joint arthrosis, lower lumbar vertebral disc degeneration, osteodegenerative changes in the end plates of the lower lumbar vertebrae, spondylodiscitis, strain/tear/myositis in the erector spinae, scoliosis, metastasis, fracture, and BS can also be evaluated.

The aim of our study is to determine the most common pathologies of lower back pain, to reveal the rate of BS in these pathologies and to investigate the age-gender tendency of BS by compiling the results of sacroiliac joint MRI images and reports.

2. Materials and methods

In this study, the images and reports of 357 patients who underwent MRI of the sacroiliac joint for any indication, mostly low back pain, at the Department of Radiology, Mersin University Faculty of Medicine, between March 2020 and October 2021 were retrospectively evaluated. All reports were reviewed by a radiologist specialized in musculoskeletal radiology with 10 years of experience in radiology. Approval was obtained from the ethics committee of the university (number: 2022/192) before the study was carried out. All sacroiliac joint MRI scans were performed on a 1.5 T Siemens Magneton Area scanner (Erlangen, Germany) using unilateral/bilateral, phased-array abdominal/cardiac or special hip coils. In sacroiliac joint MRI, the axial slice thickness was set as 3.5 mm and coronal slice thickness was set as 4 mm. Images were obtained with T1A, fat-suppressed T1A with and without contrast, followed by fat-suppressed T2A in the axial plane. In the coronal plane, images were obtained with T1A, T1A with and without fat-suppressed contrast, followed by STIR. LSTV evaluation was performed according to the Castellvi classification on coronal T1A images (**Figure 1**).

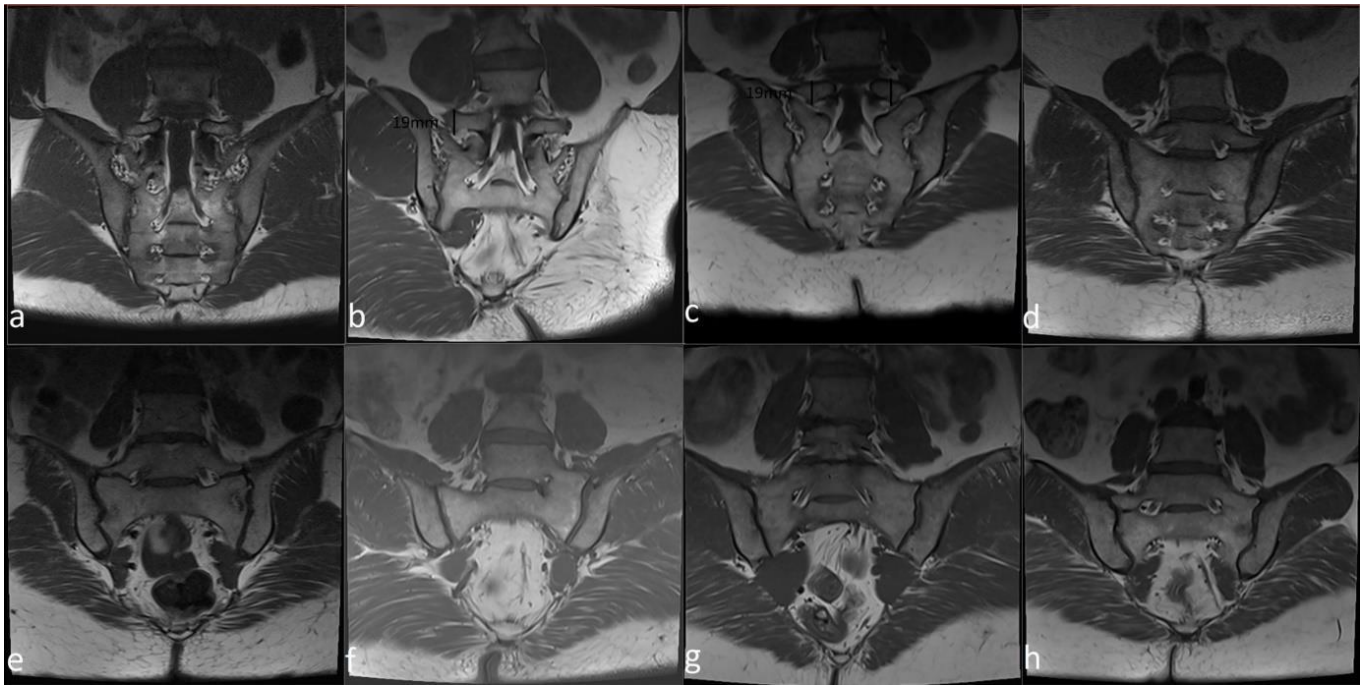

Figure 1. LSTV Types according to Castellvi classification. (a) Normal coronal T1A sacroiliac joint MRI image without lumbosacral transitional vertebrae, (b) triangular dysplastic unilateral transverse process at least 19 mm wide [Type 1a], (c) triangular dysplastic bilateral transverse process at least 19 mm wide [Type 1b], (d) unilateral diarthrodial joint between the transverse process and sacrum [Type 2a], (e) bilateral diarthrodial joint between the transverse process and sacrum [Type 2b], (f) unilateral bone fusion between transverse process and sacrum [Type 3a], (g) bilateral bone fusion between transverse process and sacrum [Type 3b], (h) unilateral diarthrodial joint and unilateral bone fusion [Type 4].

According to the Castellvi classification, Type 1 is characterized by a triangular dysplastic transverse process of at least 19 mm wide. Dysplastic transverse process is classified as 1a if it is unilateral and 1b if it is bilateral. In Type 2, a diarthrodial joint is observed between the transverse process and the sacrum and is considered incomplete lumbarization/sacralization. Type 3 is characterized by a bony fusion between the transverse process and sacrum, considered as complete lumbarization/sacralization. In Type 2 and Type 3, lumbarization/sacralization is classified as "a" if unilateral and "b" if bilateral. If diarthrodial joint is observed on one side and bone fusion is observed on the other side of the same patient, it is considered as Type 4 [5]. Appearances suggestive of acute inflammation and/or chronic degeneration in localizations with diarthrodial joint/bone fusion between the transverse process and sacrum were radiologically evaluated as BS. Areas that were hypointense on T1A images, hyperintense on T2A images, and showed contrast uptake on fat-suppressed postcontrast images were considered as acute inflammation. Areas that were hyperintense on T1A images and suppressed on fat-suppressed sequences were considered as fatty bone marrow infiltration due to hematopoietic red bone marrow ischemia, and areas that were hypointense on T1A and T2A images were considered as increased sclerosis and indicative of chronic degeneration (**Figure 2**). The described pathologies were categorized according to the results of MRI reports.

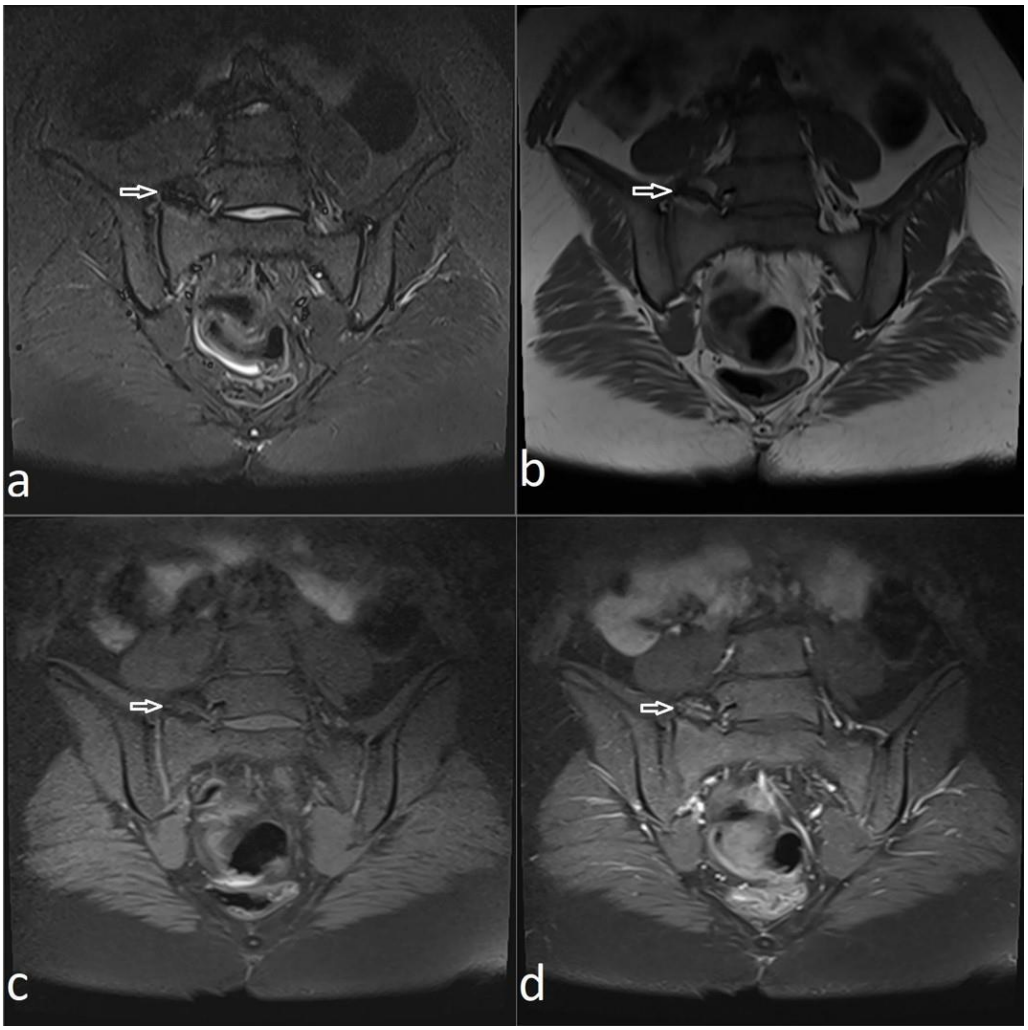

Figure 2. Appearances suggestive of acute inflammation and chronic degeneration in the diarthrodial joint between the LSTV and sacrum, consistent with Bertolotti syndrome. Acute inflammation: Hyperintense areas on STIR images (a) and contrast enhancement on fat-suppressed postcontrast images (d) compared to fat-suppressed non-contrast images (c). Chronic degeneration: Hyperintense areas on T1A images (b) and suppressed areas on fat-suppressed sequences (a, c, d). Fatty bone marrow infiltration due to hematopoietic red bone marrow ischemia.

Shapiro-Wilk test was used to check whether the measurements were normally distributed in the groups. The continuous variables obtained in the study were found to have normal distribution. Mean and standard deviation were used for descriptive statistics and numbers and percentage were used for categorical variables. A student *t*-test was performed to check whether there was a difference between the averages of two groups. Chi-square test was performed to identify the relationships between the categorical variables. $P < 0.05$ was taken as statistical significance.

3. Results

Of the 357 patients who underwent sacroiliac joint MRI, 244 (68.35%) were female and 113 (31.65%) were male. The age range of the women was 13–76 years old, and the mean age was 45.1 ± 12.84 years old. The age range of males was 10–82 years old, and the mean age was 45.1 ± 12.84 years old.

The pathologies that may cause lower lumbar pain in 357 patients who underwent sacroiliac joint MRI were grouped (**Table 1**). The main pathologies causing lower lumbar pain were active-chronic sacroiliiitis, vertebral degeneration, discopathy, and facet joint arthrosis. After these main pathologies, the most common pathology with a prevalence of 2.8% was BS, which was the cause of pain originating from the LSTV.

Table 1. Number and percentages of pathologies that may cause low back pain in patients with sacroiliac joint MRI

	Number	**Percentage**
Sacroileitis (active sacroileitis + chronic sacroileitis + chronically active sacroileitis)	108	30.2
Normal (no radiological pathology)	103	28.9
LSTV	70	19.6
*1a	7	2
*1b	8	2.2
*2a	25	7
*2b	12	3.4
*3a	3	0.8
*3b	9	2.5
*4	6	1.7
Vertebral degeneration and discopathy (vertebral degeneration + facet joint Arthrosis + disc degeneration)	56	15.7
Other causes (degenerative cystic changes + scoliosis + benign cystic bone lesions + erector spinae strain + fracture + metastasis + spondylodiscitis+ iliac wing osteomyelitis + posterior ligamentous injury + piriformis strain)	20	5.7
Total patients	357	100
# Bertolotti syndrome (radiological evidence)	10	2.8

*Subtypes of the LSTV

Bertolotti syndrome is symptomatic LSTV

In our study, the prevalence of LSTVs according to the Castellvi classification was 10% for Type 1a, 11.4% for Type 1b, 35.7% for Type 2a, 17.1% for Type 2b, 4.3% for Type 3a, 12.9% for Type 3b, and 8.6% for Type 4. The ratios of LSTV groups to all patients undergoing sacroiliac joint MRI are also shown (**Table 1**).

In our study, no gender preference was observed in LSTV ($P = 0.597$). Six of 10 patients with BS in our study were female and four were male. When the gender distribution of patients with and without Bertolotti syndrome was analyzed, no gender preference was observed in BS ($P = 0.572$). In our study, the mean age of patients with LSTV was 47.2 years old and the mean age of patients without LSTV was 43.3 years old. In our study, the mean age of patients with BS was 43.9 years old and the mean age of patients without BS was 44 years old, and no correlation was found between BS and patient age ($P = 0.976$). The age range of patients with BS was 15–77 years. Twenty per cent of the patients with BS were younger than 30 years old and 50% were younger than 40 years old (**Table 2**).

Table 2. Distribution pattern of patients with and without LSTV, BS according to gender and age

	LSTV (+)	**LSTV (-)**	***P***	**BS (+)**	**BS (-)**	***P***
Percentage of female patients	46 (65.7)	198 (69)	0.597	6 (60)	238 (68.6)	0.572
Percentage of male patients	24 (34.3)	89 (31)		4(40)	109 (31.4)	
Average age	47.2	43.3	0.03	43.9	44	0.976

Abbreviations: LSTV, Lumbosacral transitional vertebra; BS, Bertolotti syndrome

4. Discussion

Lower lumbar pain may radiate unilaterally or bilaterally to the hip and lower extremities. Clinicians may request lumbosacral spinal MRI and sacroiliac joint MRI examinations after physical examination and anamnesis to investigate the etiology of lower lumbar pain [6]. Although the main task of radiologists in sacroiliac joint MRI examination is to diagnose possible active or chronic sacroiliitis, they are obliged to convey the pathologies in all areas included in the examination to clinicians by placing them in order of importance. Many pathologies that may or may not be related to each other can be detected by sacroiliac joint MRI examination alone.

In the study by Tini *et al.* 37 (47.4%) of 78 patients with LSTV experienced lower back pain, while 41 (52.6%) did not experience lower back pain. Therefore, they concluded that there was no relationship between LSTV and lower back pain [7]. Since the 1970s, studies have focused on the fact that LSTV does not cause lower back pain in the early period and that BS may be due to degeneration in the LSTV itself or in the structures surrounding the LSTV over time. Therefore, many publications have been made on the etiologies of lower lumbar pain in BS arising from many different localizations. Louma *et al.* stated that disc, spinal canal, and posterior element pathologies above the level of the transitional vertebrae are responsible for the etiology of BS [8]. Mahato *et al.* showed facet joint arthrosis contralateral to the unilateral fusiform or diarthrodial articulating LSTV as the etiology of BS [9]. Ravikanth *et al.* reported extraforaminal stenosis due to the presence of an enlarged transverse process in the etiology of BS [1]. Elster *et al.* found no significant difference in the rate of disc protrusion, stenosis in the neural foramen and spinal canal, spondylolysis, facet joint degeneration, tumor, trauma, and infection between the groups with and without LSTV. However, they found a statistically significant difference in the presence of disc protrusion and neural foraminal stenosis at the level immediately above the LSTV compared to other levels in patients with LSTV ($P < 0.00001$) [10]. Hence, the results of Elster *et al.* contradict the results of Mahato *et al.* and Ravikanth et al., but support the conclusions of Louma *et al.*

Connolly *et al.* reported that degeneration in the abnormal articulation between the LSTV and the sacrum is responsible for the etiology of BS [11]. In our study, appearances suggestive of acute inflammation and/or chronic degeneration in the locations where diarthrodial joint/bone fusion between the LSTV and

the sacrum was observed were evaluated as BS, similar to Connolly *et al*. This syndrome have been reported to affect 4–8% of the population [4]. The prevalence of BS, which we found as 2.8% in our study, is similar to those reported in literature. According to the Castellvi classification, 8 of the 10 cases with BS were Type 2a, one was Type 2b and one was Type 3b. Therefore, it can be said that BS tends to involve the diarthrodial joint rather than the fused joint.

There have been many studies on the rate of LSTV with different imaging modalities. Elster *et al.* identified LSTV in 140 patients (7%) in a study of 2000 patients with 1500 CT scans and 500 MRI scans [10]. In studies using lumbosacral radiographs, Ravikanth *et al.* [1] identified LSTV in 134 of 500 patients (26.8%), Tini et al. [7] identified LSTV78 of 798 patients (9.7%), Castellvi *et al.* [5] identified LSTV in 60 of 200 patients (30%), and Apazidis *et al.* [12] identified LSTV in 75 of 211 patients (35.6%). LSTV was observed in 70 (19.6%) of 357 patients with sacroiliac joint MRI. There are very few articles that grouped LSTVs according to the Castellvi classification and compared their rates among all subgroups.

The numbers and percentages of LSTV groups of studies done by Castellvi *et al.*[5] and Apazidis *et al*. [12] were compared (**Table 3**). According to the these two studies, the total percentage of Type 1 groups was lower, and the total percentages of Type 2, Type 3 and Type 4 groups were higher. The reason for this difference may be that these two studies were based on lumbosacral radiographs, whereas our study was based on MRI examinations of the sacroiliac joint. According to the Castellvi classification, Type 1 is characterized by a triangular dysplastic transverse process of at least 19 mm wide. Transverse process thickness measurements below 19 mm are considered normal. Differences can be observed in length measurements made on direct radiographs and MRI images. The main reason for the differences in these length measurements may be due to magnification (the image reflected is larger than the size of the object) or distortion (the image reflected is different from the object in terms of shape), which are geometric factors of direct radiography [13].

Table 3. Comparison of the number and percentage of LSTV types according to Castellvi classification

Type of LSTV according to Castellvi classification	Number (percentage) of LSTV patients (Castellvi *et al.*)	Number (percentage) of LSTV patients (Apazidis *et al.*)	Number (percentage) of LSTV patients in our study (percentage)
1a	9 (15)	31 (41.3)	7 (10)
1b	16 (26.6)	18 (24)	8 (11.4)
2a	12 (20)	9 (12)	25 (35.7)
2b	11 (18.3)	8 (10.6)	12 (17,1)
3a	1 (1.6)	4 (5.3)	3 (4.3)
3b	4 (6.6)	3 (4)	9 (12.9)
4	3 (5)	2 (2.6)	6 (8.6)
Number of patients with LSTV	60 (100)	75 (100)	70 (100)
Total number of patients	200	211	357
LSTV/percentage of total patients	30	35.6	19.6

Apazidis *et al.* found that 35 (46.7%) of 75 patients with LSTV were female and 40 (53.3%) were male [12]. Castellvi *et al.* observed 60 patients with LSTV, of whom 28.5% were female and 71.5% were male. Castellvi *et al.* mentioned that LSTV tends to be more common in males [5]. McGrath *et al.* stated in their review that LSTV is more common in males than females [3]. Ravikanth *et al.* did not find a relationship

between LSTV and the gender of the patients [1]. The results of our study were in agreement with Ravikanth *et al.* that no relationship was found between BS and the gender of the patients (**Table 2**).

Ravikanth *et al.* also found no correlation between LSTV and the age of the patients [1]. In our study, patients with LSTV were older than patients without LSTV (P = 0.03) (**Table 2**). Quinlan *et al.* reported that the age of patients with BS was between 15 and 60 years old and the mean age was 32.7 years old [4]. Kapetanakas et al. reported that 18.5% of patients with BS were under 30 years of age [14]. Although the results of our study are consistent with Kapetanakas *et al.*, there was no significant relationship between age and BS.

5. Conclusion

According to our study results, Bertolotti syndrome starts manifesting below the age of 30 years, but there is no significant relationship with age or gender. Bertolotti syndrome is one of the most common causes of lower lumbar pain after sacroiliitis, osteodegeneration, and discopathy.

There have been different hypotheses about the etiology of Bertolotti but no consensus has been achieved. Therefore, multicenter studies with a large number of patients are needed.

6. Limitations of the study

The main limitation of the study is that the study was performed retrospectively, and the diagnosis of BS was made radiologically in patients with lower lumbar pain. There is no confirmation of the diagnosis with treatment results after radiological diagnosis.

Disclosure statement

The authors declares no conflict of interest.

Author contributions

Conceptualization: B.T., K.E., and M.N.D.

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Supervision: B.T., K.E., G.T.,

Writing – original draft: B.T., G.T., Y.B.,

Writing- review & editing: B.T., G.T., M.N.D.

References

[1] Ravikanth R, Majumdar P, 2019, Bertolotti's Syndrome in Low-Backache Population: Classification and Imaging Findings. Ci Ji Yi Xue Za Zhi, 31(2): 90–95.

[2] Mahato NK, 2013, Redefining Lumbosacral Transitional Vertebrae (LSTV) Classification: Integrating the Full Spectrum of Morphological Alterations in a Biomechanical Continuum. Med Hypotheses, 81: 76–81.

[3] McGrath K, Schmidt E, Rabah N, et al., 2021, Clinical Assessment and Management of Bertolotti Syndrome: A Review of the Literature. Spine J, 21(8): 1286–1296.

[4] Quinlan JF, Duke D, Eustace S, 2006, Bertolotti's Syndrome. A Cause of Back Pain in Young People. J Bone Joint Surg Br, 88(9): 1183–1186.

[5] Castellvi AE, Goldstein LA, Chan DP, 1984, Lumbosacral Transitional Vertebrae and Their Relationship with Lumbar Extradural Defects. Spine (Phila Pa1976), 9: 493–495.

[6] Bernard SA, Kransdorf MJ, et al., 2017, ACR Appropriateness Criteria Chronic Back Pain Suspected Sacroiliitis-Spondyloarthropathy. J Am Coll Radiol, 14(5S): S62–S70.

[7] Tini PG, Wieser C, Zinn WM, 1977, The Transitional Vertebra of the Lumbosacral Spine: Its Radiological Classification, Incidence, Prevalence, and Clinical Significance. Rheumatol Rehabil, 16(3): 180–185.

[8] Luoma K, Vehmas T, Raininko R, et al., 2004, Lumbosacral Transitional Vertebra: Relation to Disc Degeneration and Low Back Pain. Spine (Phila Pa 1976), 29: 200–205.

[9] Mahato NK, 2011, Facet Dimensions, Orientation, and Symmetry at L5-S1 Junction in Lumbosacral Transitional States. Spine (Phila Pa 1976), 36: E569–E573.

[10] Elster AD, 1989, Bertolotti's Syndrome Revisited: Transitional Vertebrae of the Lumbar Spine. Spine (Phila Pa 1976).14:1373-1377.11.

[11] Connolly LP, d'Hemecourt PA, Connolly SA, et al., 2003, Skeletal Scintigraphy of Young Patients with Low-Back Pain and a Lumbosacral Transitional Vertebra. J Nucl Med, 44(6): 909–914.

[12] Apazidis A, Ricart PA, Diefenbach CM, et al., 2011, The Prevalence of Transitional Vertebrae in the Lumbar Spine. Spine J, 11: 858–862.

[13] Kaya T, 2017, Basic Principles of Radiography and Basic Principles of Radiographic Interpretation. Trd Sem, 5: 1–22.

[14] Kapetanakis S, Chaniotakis C, Paraskevopoulos C, Pavlidis P, 2017, An Unusual Case Report of Bertolotti's Syndrome: Extraforaminal Stenosis and L5 Unilateral Root Compression (Castellvi Type III an LSTV). J Orthopaed Case Rep, 7(3): 9–12.