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Lumbosacral transitional vertebrae in children and adolescents with a lumbar injury: diagnosis frequency and clinical symptoms

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Abstract

There is a paucity of Russian medical literature reporting lumbosacral transitional vertebrae in children and adolescents. Many important aspects of the condition including two nosologies of sacralization of the L5 vertebrae and lumbalization of the S1 vertebrae have been under-explored. **The objective** was to establish overall frequency and frequency of certain types of lumbosacral transitional vertebrae in children and adolescents who sustained a lumbar injury and to investigate clinical manifestations of the pathology. **Material and methods** A comprehensive examination of 312 children aged 7 to 18 years who suffered a lumbar injury was performed. Lumbosacral transitional vertebrae was radiologically diagnosed in 19 (6.09 %) subjects. Grading system of A.E. Castellvi et al. (1984) was used to classify the pathology. **Results** From 19 patients with lumbosacral transitional vertebrae, sacralization of the L5 vertebrae was detected in 16 (84.21 %) individuals. Lumbalization of the S1 vertebrae was diagnosed in 3 (15.79 %) children. Type II (n = 13) and subtype "b" (n = 10) were most common. No types III and IV of the disease were seen. No clinical symptoms indicating the likelihood of having lumbosacral transitional vertebrae were observed in the patients prior to the lumbar injury. **Conclusion** The frequency of occurrence of lumbosacral transitional vertebrae and its structure were reviewed in children and adolescents. The patients demonstrated no clinical manifestations of the condition before the children sustained lumbar injuries. Various aspects of transitional lumbar vertebrae in children and adolescents require further study.

Keywords: lumbosacral transitional vertebrae, sacralization of L5 vertebrae, lumbalization of S1 vertebrae, children and adolescents

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INTRODUCTION

Pain in the lumbar spine is a common complaint in children and adolescents. A multicenter cohort study published in 2022 reported 21% of adolescents presenting with pain in the lumbosacral spine. This alarmingly high figure was retrieved from a survey of 650,851 adolescents under the age of 18 living in 33 countries [1]. Congenital diseases of the spine including transitional lumbosacral vertebrae can cause vertebrogenic pain syndrome [2]. The incidence of transitional vertebra in the population of all age groups in foreign countries has a reported incidence between 4 [3] to 36% [4]. The incidence of this pathological condition among children and adolescents is unknown [5]. There are publications in the literature mainly reporting clinical cases of diagnosis and treatment of pediatric patients with the condition [6]. The terms "transitional lumbosacral vertebrae" and "Bertolotti syndrome" are rarely used in the Russian medical literature, and there is little awareness of them. Instead, the terms "sacralization of the L5 vertebra" and "lumbarization of the S1 vertebra" are more common without detailing the diagnoses by types of pathology [7]. And even in the cases, scientific publications report only the frequency of diagnosing sacralization and lumbarization along with other nosological forms of lumbosacral anomalies [8].

The objective was to establish overall frequency and frequency of certain types of lumbosacral transitional vertebrae in children and adolescents who sustained a lumbar injury and to investigate clinical manifestations of the pathology.

MATERIAL AND METHODS

The study was defined as “observational, STROBE”, aimed at establishing the frequency of diagnosing types of transitional lumbosacral vertebrae among children and adolescents who have injured the lumbar spine and exploring clinical manifestations of the pathology. The design was an open cohort study.

We have experience in the dynamic monitoring and treatment of 312 children and adolescents aged 7 to 18 years who received uncomplicated fractures of the lumbar vertebral bodies (n = 291) and soft tissue contusions of the lumbar spine (n = 21). Radiological examination of the 312 patients revealed transitional

lumbosacral vertebrae in 19 (6.09 %) individuals. Observations of the 19 cases served as clinical material for achieving the goal set in the study. Radiological examination of the children included conventional radiography of the lumbar spine and sacrum in the anterior-posterior and lateral projections (n = 19), computed tomography (CT, n = 19) and magnetic resonance imaging (MRI, n = 19). The mean age of the patients was 13.4 ± 1.2 years. There were 11 (57.89 %) male and 8 (42.11 %) female patients. The cases of transitional lumbosacral vertebrae diagnosed during the radiological examination were divided into types and subtypes as classified by A.E. Castellvi et al. [9].

Inclusion criteria included age of patients under 18; imaging findings with clear radiography and tomograms of the thoracic and all lumbar vertebrae, sacrum, coccyx and iliac wings. Exclusion criteria included the age of patients over 18 years of age, the inability to fully visualize the thoracic, lumbar vertebrae, sacrum, coccyx and iliac wings on radiographs and tomograms of patients. The study was conducted in compliance with the Declaration of Helsinki of the World Medical Association "Ethical principles for conducting scientific medical research involving human subjects" as amended in October 2000 (Edinburgh, Scotland). The data were statistically processed using the Microsoft Excel software package (Microsoft Inc., USA) and Statistica 6.0 (Dell, USA). The data obtained were summarised as p ± m, where *p* was the relative value of the parameters (%), *m* was the representativeness error of the relative value.

RESULTS

Imaging findings of 312 children and adolescents examined for trauma showed transitional lumbosacral vertebrae in 19 (6.09 %) individuals. None of the clinical case was diagnosed with a fracture of the most caudal (transitional) lumbar vertebrae.

The term "lumbosacral transitional vertebrae" (LSTV) includes two conditions: sacralization of the L5 vertebra and lumbarization of the S1 vertebra [10]. Sacralization is understood as unilateral or bilateral, complete or partial fusion of bodies, arches and (or) transverse processes of the last lumbar and first sacral vertebrae [11]. Lumbalization is considered partial or complete separation of the wings (pars lateralis), bodies and arches of the two superior sacral vertebrae [12]. Both conditions are classified as lumbosacral anomalies with Hox gene mutations playing a leading role in the pathogenesis of the pathology [13]. Sacralization of the L5 vertebra was more common (n = 16; 84.21 %) in 19 patients with transitional lumbocruciate vertebrae reported. Lumbarization of the S1 vertebra were diagnosed in 3 (15.79 %) children. Types and subtypes of transitional lumbosacral vertebrae were identified with the generally accepted classification of A.E. Castellvi et al. [9]. The results are presented in Table 1.

Table 1

The frequency of types and subtypes of transitional lumbosacral vertebrae diagnosed in patients of the study group

Types, subtypes of the pathology		Number of cases	
		abs. number	p ± m, %
I	a	4	21.05 ± 9.32
	b	2	10.54 ± 6.85
II	a	3	15.78 ± 8.18
	b	10	52.63 ± 11.44
III	a	–	–
	b	–	–
IV		–	–
Total		19	100.0

Table 1 indicates to the prevalent type II disease (n = 13) with the nature of the anomaly corresponding to the "b" subtype (n = 10). Neither type III nor type IV were observed in the study group. Figure 1 shows the results of multispiral computed tomography of the lower thoracic, lumbar spine and sacrum with reconstruction in a 14-year-old patient T. who sustained an uncomplicated compression fracture of the L1 vertebral body resulting from of a fall from a 2-meter height onto the buttocks.

The girl was diagnosed with a transitional lumbosacral vertebra L5 classified as A.E. Castellvi et al. type II, subtype "b" in addition to a fracture of the vertebral body L1. The discovery of the congenital pathology of the lumbosacral localization was incidental for the patient and her parents. The girl reported no discomfort prior to the fall and the parents had never taken their child to medical institutions because of back pain or posture disorders. None of the 19 patients in the study group had ever complained of pain in the spine before the injury, including the lumbar spine pain that would require seeking medical help. Seven (36.84 %) children reported intermittent discomfort in the interscapular area during or after school hours and referred it to wearing a school bag or backpack on the back. The history of 4 (21.05 %) children showed that they could not fully lean forward and reach the floor with their fingers before the injury. Three (15.78 %) of the children examined at school were recommended to see an orthopaedic surgeon for posture disorders. No skin manifestations such as a birthmark, local hypertrichosis, telangiectasia, etc. that would be indirect symptoms of dysplastic spine [14] could be seen in the projection of the lumbosacral junction in the clinical cases. Thus, the 19 children of the study group demonstrated no clinical symptoms indicating the likelihood of any congenital bone pathology and requiring diagnostic imaging of the lumbar spine and sacrum prior to their injury.

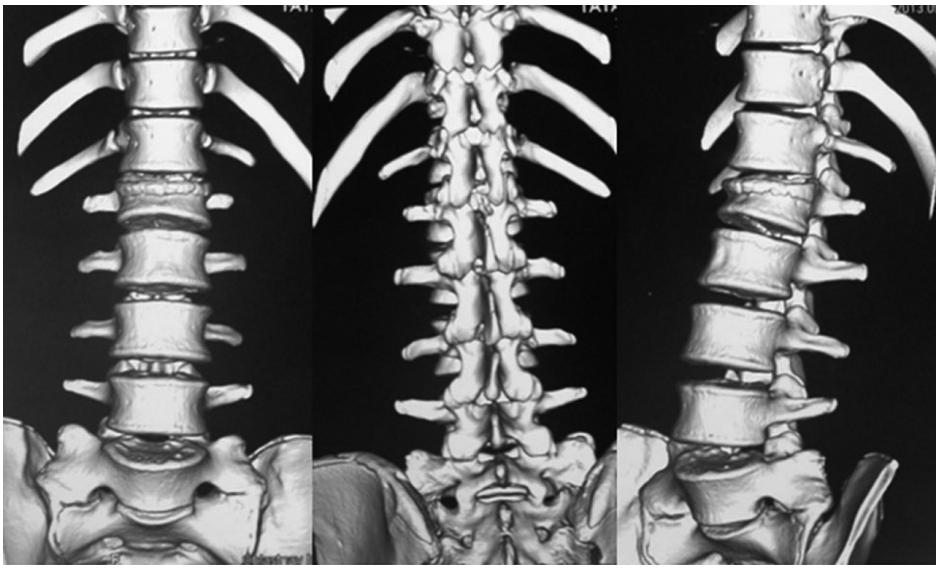

Fig. 1 Radiological findings of the lower thoracic, lumbar spine and sacrum of patient T. indicated transitional lumbosacral vertebra L5, type II, subtype "b", compression fracture of the vertebral body L1 in a 14-year-old

DISCUSSION

The prevalence of diagnosis of transitional lumbosacral vertebrae was examined in 312 children and adolescents with a lumbar injury. The pathology was established in 19 individuals with a relative amount of 6.09 %. Chinese authors B. Zhang et al. examined 92 adolescents without clinical manifestations of vertebrogenic pathology and revealed radiological symptoms of transitional lumbosacral vertebrae in 7.6 % of cases [15]. No other studies on the epidemiological aspects of lumbosacral anomalies in children and adolescents could be found in the literature. Information published in the literature relates only to adult patients. D. Ucar et al. reported radiological findings of 6200 patients aged 18-86 years with the symptoms indicating LSTV found in 18.9 %. The prevalence of LSTV was found as ranging between 4 % and 36 % in a well-represented general population. The article presented data on the racial, ethnic and gender aspects of the disease, the prevalence in patients with vertebrogenic pain syndrome and in individuals with asymptomatic pathology. But the numerous data described in patients and healthy volunteers older than 18 years [16]. Given the fact that there is a paucity of publications on transitional lumbosacral vertebrae in pediatric patients, we consider it important to obtain information on the prevalence of the pathology and on its structure (Table 1).

Castellvi type II was found to be more common and characterized by unilateral (subtype IIa) or bilateral (subtype IIb) pseudoarthrosis between the transverse process(es) of the suprasacral vertebra and the wing(s) of the sacrum or ilium. Overall, type II was diagnosed in 68.41 % of clinical cases with a predominant subtype "b" detected in 76.92 %. A twofold decrease in diagnosis of the condition was seen in type I disease (31.59 %) with predominant subtype "a" detected in 66.66 %.

Type I disease is characterized by an increased size of one (subtype "a") or both (subtype "b") transverse processes of the supra-sacral vertebra and their "contact" with the wing (wings) of the sacrum or ilium. Radiological symptoms characteristic of III and IV types of transitional lumbosacral vertebrae were not diagnosed in 19 cases reported, which was probably due to the relatively small volume of clinical material.

A comparative analysis of the types and subtypes of transitional lumbosacral vertebrae with the data of other researchers could not be performed. We did not find information on the condition in patients under the age of 18. The available publications in the literature reported individual clinical cases of diagnosis of transitional lumbosacral vertebrae in children and adolescents. Overall, we were able to find articles of 6 foreign authors describing clinical scenarios that required surgical treatment in a total of 9 patients aged 13-17 years [2, 5, 6, 17, 18, 19]. Details of the clinical reports are presented in Table 2. Two references presented in the table indicated pain that had not been relieved by conservative methods as indication for surgical treatment. The authors reported the algic syndrome being caused by type IIa transitional lumbosacral vertebrae with concomitant impingement of the L5, S1 roots. The clinical cases are interpreted by modern researchers as "Bertolotti's syndrome" [2, 4-6, 10]. Of the 9 clinical cases described in the articles, seven (77.77 %) underwent surgical resection of the enlarged transverse process of the suprasacral vertebra. The treatment resulted in the relief of algic syndrome for at least a year after surgery in all patients.

Table 2

Literature data on clinical observations of children and adolescents surgically treated for vertebrogenic pain syndrome caused by LSTV

Authors, year of publication, reference number»	Number of patients, gender, age	Type of LSTV	Duration of pain syndrome before surgery	Was there conservative treatment performed before surgery? Was it effective?	Type of surgery performed, its efficacy
Dhanjani S. et al., 2021 [2]	n = 3	IIa	4 years on average	Performed with no effect	Resection of the transverse process. Resection of the transverse process with decompression. Posterior fusion. Pain relief in all patients
Louie C.E. et al., 2019 [5]	n = 2, females, 14 and 16 yo	IIa	9 mo in 14 yo; 2 years 3 mo in 16 yo	Performed with no effect	Resection of the transverse process in both Pain relief
Sumarriva G. et al., 2022 [6]	n = 1, male, 17 yo	IIa	2 years	Performed with no effect	Resection of the transverse process. Pain relief
Cuenca C. et al., 2019 [17]	n = 1, male, 13 yo	IIa	4 years	Performed with no effect	Resection of the transverse process. Pain relief
Babu H. et al., 2017 [18]	n = 1, female, 17 yo	IIa	Not mentioned	Performed with no effect	Resection of the transverse process. Pain relief
Brault J.S. et al., 2001 [19]	n = 1, male, 17 yo	IIa	Not mentioned	Performed with no effect	Resection of the transverse process. Pain relief

In the Russian medical literature, V.P. Snishchuk et al. reported the experience and results of surgical treatment of degenerative diseases of the spine in 29 patients aged 10-17 years, resistant to several courses of conservative therapy. Microsurgical discotomy and removal of at least 75 % of the affected disc was performed using the dorsal interlaminar approach. The authors emphasized that symptoms of undifferentiated connective tissue dysplasia and lumbosacral anomalies, mainly in the form of sacralization of the L5 vertebra and lumbarization of the SI vertebra were predisposing factors for clinical symptoms of vertebrogenic pathology in 26 (89.65 %) of 29 operated patients. Excellent and good outcomes were obtained in 83 % of clinical cases at a long term [20]. It can be concluded that the transitional lumbosacral vertebrae were not the causes of pain in the lumbar spine. It would seem paradoxical, but the 19 clinical cases reviewed reported no pain, and only imaging performed for lumbar injuries allowed detection of sacralization and lumbarization. We believe that this fact should not be considered as an atypical course of transitional lumbosacral vertebrae, because such conditions are characterized by delayed clinical manifestations that manifest as patients grow older and their axial skeleton ossifies [21].

V.S. Yulin et al. emphasize that there are no clinical manifestations of the Bertolotti syndrome in childhood and adolescence with the symptoms developing no earlier than 20-25 years of age in most cases [22]. Vertebral fractures are reported to result in post-traumatic osteochondrosis at the level of compressed bodies and adjacent intervertebral discs [23, 24]. The probability of degeneration after vertebrogenic fractures can be as high as 50 % among injured children and adolescents [25]. The likelihood of an earlier onset and progression of algic syndrome increases in pediatric patients who sustained spinal injuries due to developmental anomalies [26]. Difficulties may arise with establishing the cause of pain: does it result from vertebral fractures or is it the clinical debut of developmental anomalies? The above factors may complicate the choice of rational treatment strategy [27]. Chinese researchers reported interesting statistical data on the relationship between bone anomalies and fractures of the vertebral bodies. C.-M. Ma et al. suggested that patients with congenital anomalies were 11 % more likely to develop vertebrogenic fractures. Their findings supported the principle that healthy bones give the body stabilization and prevent fractures [28].

Considering the fact that the sacralization of the L5 vertebra and the lumbarization of the S1 vertebra result from malformation of the intrauterine development of the fetal spine, it seems unlikely that effective measures can be developed to prevent the diseases at the present stage of health sciences research. Recommendations offered by a group of Russian authors "… to arrange a preventive radiological examination of the lumbosacral spine in childhood and adolescence" in order to diagnose Bertolotti syndrome [22] can be controversial and impracticable for many reasons.

CONCLUSION

The prevalence of transitional lumbosacral vertebrae and the patterns were examined in children and adolescents with injuries. The findings suggested that the condition showed asymptomatic presentation until the children sustained fractures and bruises of the lumbar spine and was established with diagnostic imaging of injured patients. Various aspects of transitional lumbosacral vertebrae are poorly explored in growing patients, and there is a paucity of scientific publications on pediatric patients in the modern medical literature. Solution to the problem requires combined efforts of specialists including orthopaedic and trauma surgeons, radiologists, neurologists, neurosurgeons, physiotherapists and rehabilitation specialists.

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