Review article
https://doi.org/10.18019/1028-4427-2024-30-2-282-291

Lumbosacral transitional vertebrae in children and adolescents (literature review, illustrated with clinical observations)

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Abstract

Introduction An analysis of the medical literature devoted to various aspects of transitional lumbosacral vertebrae shows that there are very few publications covering the course of this disease in the pediatric and adolescent population.

Aim To study the issues of epidemiology, diagnosis, treatment and prevention of transitional lumbosacral vertebrae in paediatric and adolescent patients based on the analysis of current medical literature and illustrate the material with our own clinical observations.

Material and methods To analyze the literature on the topic, 75 papers published between 1984 and 2023 were selected. Among them, there were 7 (9.3 %) domestic literary sources, 68 (90.7 %) were foreign. In the process of searching for scientific articles, the resources of the electronic databases of current medical information PubMed and CyberLeninka were used.

Results and discussion The incidence of transitional vertebrae in children and adolescents is 16.8 % of clinical observations, as reported. In the structure of the transitional vertebrae in children, type II of the disease predominates according to the classification Castellvi et al (1984), 43.2 % of cases. The main clinical symptom of the pathology is pain of lumbosacral location, the intensity of which on the visual analog scale in children corresponds to an average of 3.0 points. In adult patients with similar pathology, the average pain intensity measured with the same scale is 7.5 points. The most informative method for diagnosing the disease is computed tomography, which allows obtaining both 3D images and sections at the level of pseudarthrosis between the enlarged transverse process (or processes) of the suprasacral vertebra and the wing of the sacrum. To relieve pain in children with transitional vertebrae, both conservative and surgical methods are used. The most commonly used procedure is pseudarthrectomy. The study of long-term results one year after the intervention allowed us to record the absence of pain in children who underwent surgery. Prevention measures for transitional lumbosacral vertebrae have not been developed.

Conclusion The analysis of the published literature shows that transitional vertebrae are a frequently diagnosed pathology in children and adolescents. Current methods of imaging are able to accurately detect not only the presence of the disease, but also to differentiate its type. The main clinical symptom of transitional vertebrae is pain in the lumbosacral spine which is difficult to relieve with conservative therapy. Pseudarthrectomy is the most frequent surgical method of treatment in children and adolescents that provides stable relief of vertebrogenic pain syndrome. Measures for specific prevention of the disease have not been developed.

Keywords: children, adolescents, lumbosacral transitional vertebrae, pseudoarthrosis, lumbar pain, diagnosis, treatment, pseudoarthrectomy, pain relief, long-term result, literature review

For citation: Skryabin EG, Krivtsov AYu, Kicherova OA, Klokov IN, Zotov PB, Akselrov MA. Lumbosacral transitional vertebrae in children and adolescents (literature review, illustrated with clinical observations). *Genij Ortopedii*. 2024;30(2):282-291. doi: 10.18019/1028-4427-2024-30-2-282-291

INTRODUCTION

Transitional lumbosacral vertebrae in the form of L5 sacralization and S1 lumbarization are classified as a congenital pathology caused by a mutation of the Hox gene at the 4th week of intrauterine development of the fetus [1]. The incidence of the pathology may reach 46 % of clinical observations [2] and depends on what categories of patients are examined, what radiation imaging methods are used and how the results are interpreted [3, 4].

The analysis of current scientific literature devoted to various aspects of the transitional lumbosacral vertebrae shows that there are very few publications covering the course of sacralization and lumbarization in the paediatric and adolescent population [5]. This fact is difficult to explain, given the congenital nature of the disease, and therefore there is high probability of manifestation of clinical symptoms and radiation signs of the pathology in growing patients [6].

Purpose To study the issues of epidemiology, diagnosis, treatment and prevention of transitional lumbosacral vertebrae in paediatric and adolescent patients based on the analysis of current medical literature and illustrate the material with our own clinical observations

MATERIALS AND METHODS

The search for scientific sources was carried out in the PubMed search engine and the CyberLeninka electronic library for the period from 1984 to 2023. The following search words were used in Russian and English: lumbosacral transitional vertebra, children and adolescent population, incidence of pathology, intensity of vertebrogenic pain syndrome (intensity of vertebrogenic pain syndrome), computed tomography, conservative therapy, surgical treatment methods, long-term treatment results, and prevention.

Criteria for inclusion of scientific publications in the study were:

— Full-text scientific articles that report fundamental information about the transitional lumbosacral vertebrae (etiology, classification);

— Full-text scientific publications that provide current information on the course of transitional vertebrae disease (clinical symptoms, issues of radiation diagnostics, conservative and surgical methods of treatment, selected results of therapy) in paediatric patients and adolescents;

— Full-text scientific papers reporting the results of mono-center cohort studies and case-control studies and illustrating clinical cases of children and adolescents that have pain syndrome caused by transitional lumbosacral vertebrae.

Exclusion criteria were abstracts of scientific and practical conferences, scientific articles that do not contain information that the clinical material for the study was children and adolescents with transitional vertebrae of the lumbosacral location.

In total, 75 publications were selected for writing a literature review, of which 7 (9.3 %) were domestic sources and 68 (90.7 %) were foreign ones.

RESULTS AND DISCUSSION

The analysis of the reported information shows that the minimum incidence of the pathology being studied is 6.1 % of clinical cases [7], the maximum is 30.0 % of cases [8], and an average incidence is 16.8 % (Table 1).

General population incidence of diagnosing transitional vertebrae, established on the basis of clinical examination and radiological imaging methods in patients of all ages is in the wide age range, from 4 to 30 % [9], but with the same average incidence of 16 % of cases studied [10].

The main clinical symptom of the disease is pain in the lumbosacral region [11]. The onset of pain regularly starts at the age of 30 years and over [12]. The cause of pain is most frequently degenerative processes in the intervertebral discs and facet joints located above the abnormal spinal motion segment [13–15]. In children and adolescents, due to the anatomical and physiological features of the spine, degeneration of discs and joints is minimally expressed or absent, therefore they do not complain of pain even if the radiation symptoms of the transitional vertebrae are detected [7], or the pain syndrome is mild and rarely exceeds 3 points on the visual analogue scale [16]. In adult patients, the intensity of lumbar pain on a similar scale averages 7.5 points [17].

An important clinical characteristic of pain in adolescents with transitional lumbosacral vertebrae is its site located in the projection of pseudarthrosis or concrescence between the enlarged transverse process of the L5 vertebra and the sacral wing on one or both sides, depending on the type of pathology [7]. The patient, at the request of the physician conducting the clinical diagnosis, can place one of his fingers at the indicated point (1 cm below and medial to the posterior superior iliac spine), localizing the pain and, if it is felt, this fact must be regarded as a positive Fortin finger test [18], inherent in transitional vertebrae [19].

In adolescents, pain in the lumbosacral spine can radiate to the buttock and distally along the lower limb, reaching the level of the foot [20]. The cause of such pain is degenerative damage to the intervertebral disc, up to the stage of sequestration, usually located immediately above the abnormal one [21]. The frequency of diagnosis of transitional vertebrae in pediatric patients with herniated intervertebral discs can reach 30 % of the cases [8].

A number of authors describe cases with pain localized not in the area of pseudarthrosis, but in the projection of the intervertebral joint on the contralateral side, immediately above the abnormal spinal motion segment [22]. A similar clinical situation was reported Brault et al. and showed a possible location of pain on the opposite side in a 17-year-old athlete [23].

Of all the diseases of the paediatric spine, multiplanar scoliotic deformity is the most thoroughly studied (Fig. 1), which occurs and often progresses against the background of transitional vertebrae [24, 25].

Fig. 1 CT scan of the lumbar spine and sacrum of patient Sh., 15 years old: compensatory left-side lumbar curvature, transitional (lumbarized) lumbosacral vertebra, type IIb (authors' clinical case)

The incidence of comorbidity of these two nosological forms of vertebrogenic pathology ranges from 6.3 [26] to 25.1 % [27]. The gender and age of patients, as well as the type of deformities they have, frequently do not correlate with the known subtypes of transitional vertebrae [28, 29]. However, opposing opinions have also been published. Thus, Can et al. provide data that among 125 children with sacralization of the L5 vertebra, 66 (52.8 %) subjects had scoliotic spinal deformity, while cases of unilateral sacralization, in contrast to bilateral ones, in teenage girls were more often accompanied by spinal curvature [30]. In children with genetic Williams-Beuren syndrome, one of the manifestations of which is scoliosis, the incidence of dtecting transitional vertebrae is 57 % of clinical observations [31], which is several times higher than the known general population comorbidity [27, 32].

Only a few publications in the available medical literature are devoted to the peculiarities of treatment tactics in children with scoliosis associated with transitional vertebrae. Thus, Hu et al. warned the colleagues against performing operations at the wrong level. This is due to incorrect numbering of the vertebrae, which is often found in clinical practice [33]. Lee et al. recommended that the extent of the fusion zone in the distal parts must be limited to the L3 vertebra in patients with scoliosis and transitional vertebrae [28]. Yamauchi et al. analyzed 5-year results of surgical correction of type 5 scoliosis according to the Lenke classification in 15 children with lumbosacral vertebrae and found that at all periods of studying long-term results (after 2 weeks, after 2 years and after 5 years post-surgery), the angle of inclination of the L4 vertebra anteriorly exceeded by three degrees on average the values of patients in the control group who had no anomalies [34].

An equally severe type of vertebrogenic pathology in pediatric patients is spondylolysis of the interarticular part of the arches and spondylolytic spondylolisthesis of the lower lumbar vertebrae [35]. Transitional lumbosacral vertebrae in children and adolescents with these serious diseases are diagnosed in 14.7 % of the cases (Fig. 2).

Such incidence of sacralization and lumbarization was established during complex radiological study of 109 children aged 3–17 years with spondylolytic spondylolisthesis of the L4 and L5 vertebrae of severity grade I–IV and spondyloptosis [36].

Yao et al. are confident that increased stability (the authors' term) between the sacralized L5 vertebra and the sacrum leads to excessive mobility at the level of the spinal motion segment L4-L5, which implies an excessive load on the interarticular part of the arch of the L4 vertebra, and means it is a high risk factor for the development of vertebral spondylolysis. The authors diagnosed radiation symptoms of transitional vertebrae in a group of 102 patients of various ages with L4 spondylolysis in 36 % of clinical cases [37].

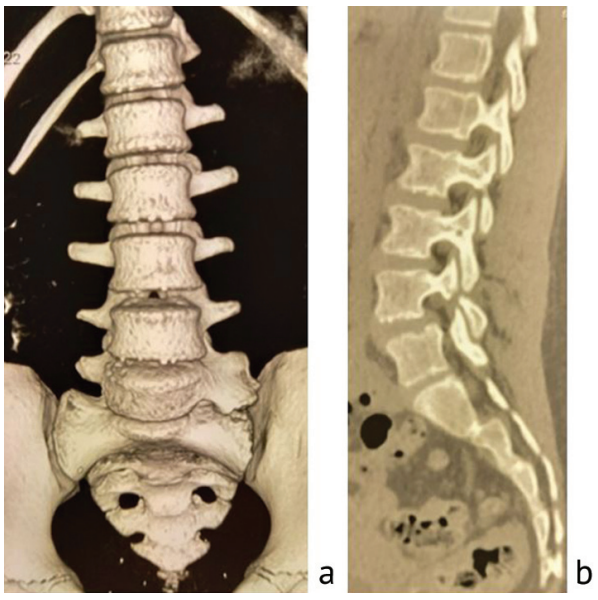

Fig. 2 CT scans of the lumbar spine and sacrum of patient D., 11 years old: transitional (sacralized) lumbosacral vertebra, type IIa; aplasia of the left transverse process of the vertebra T12 and rib 12 on the left (*a*); spondylolysis of the interarticular part of the L4 vertebral arch; spondylolisthesis of the L4 vertebra, grade I (*b*) (authors' clinical case)

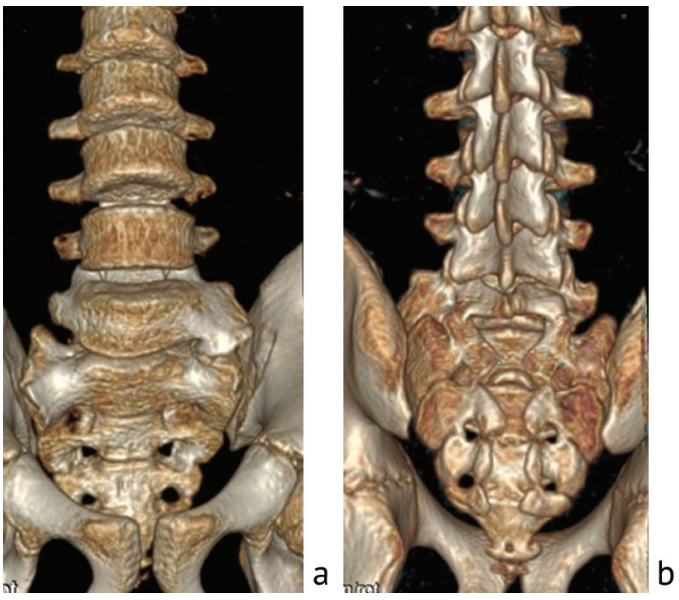

Fig. 3 CT scans of the lumbar spine and sacrum of patient M., 13 years old. Transitional (lumbarized) lumbosacral vertebra, type IIa, front view (*a*). Non-fusion of the posterior part of the arch of the transitional vertebra, non-fusion of the sacral canal (*b*); authors' clinical observations

Nonfusion of the posterior part of the vertebral arches (spina bifida posterior) is one of the most frequently diagnosed developmental anomalies of the lumbosacral location [38]. In children and adolescents with transitional lumbosacral vertebrae, radiation imaging reveals nonfusion of the arches with an incidence of 22.7 (lumbarization) to 27.3 % (sacralization) of cases [39] (Fig. 3).

The main clinical symptom of the comorbid course of these anomalies in children is pain syndrome [40, 41], the severity of which on a visual analog scale usually corresponds to 3 points [16], but in rare cases it can reach an 8-point value [42]. The mutually aggravating impact of the transitional vertebrae and spina bifida posterior is a high risk factor for the formation of degeneration of the intervertebral discs, up to the stage of their sequestration [43]. Thus, Milicic et al. found the presence of disc pathology in 56 (86.1 %) clinical cases in a group of 65 children who had transitional vertebrae and nonfusion of the posterior part of the vertebral arches which was regarded as the cause of lumbar pain. The authors used magnetic resonance imaging for diagnosis [16]. In order to relieve pain in the lumbar region and lower extremity, Kundi et al. administered gabapentin at a dosage of 100 mg three times a day. The result of conservative therapy was pain relief in patients from the initial 8 to the final 4 points on the visual analogue scale [42].

It is known that there are four types of transitional lumbosacral vertebrae, and the first three have subtypes “a” and “b” [44]. In the paediatric and adolescent population, type II predominates while subtypes “a” and “b” occur with almost equal incidence and are characterized by the presence of a zone of pseudo-articulation between the enlarged transverse process of the suprasacral vertebra and the wing of the sacrum from one side (subtype a) or on both sides (subtype b) (Fig. 4).

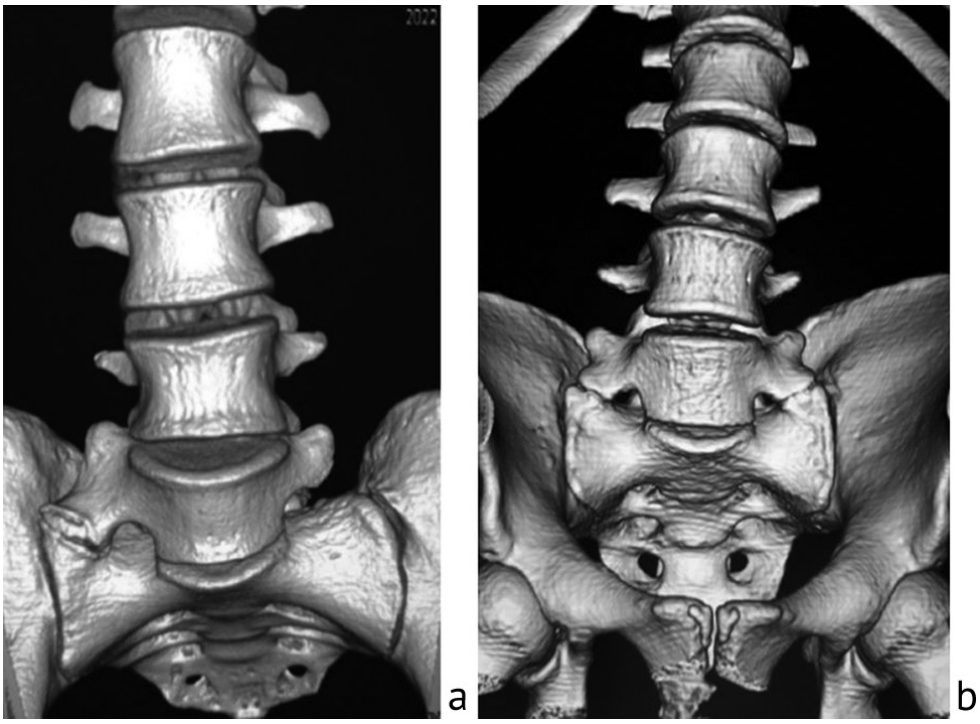

Fig. 4 CT scans of the lumbar spine and sacrum of 17-year-old patients: transitional (sacralized) lumbosacral vertebrae, type IIa (*a*) and type IIb (*b*), authors’ clinical observations

The incidence of detecting transitional lumbosacral vertebrae in paediatric and adolescent patients was reported in 10 scientific articles in the current medical literature, and is based on examination of 3,663 clinical cases (Table 1).

Table 1

Reported information on the incidence diagnosing transitional lumbosacral vertebrae in children and adolescents

Author, country, year, source	Type of study	Number of studied patients	Pathology	Rate of diagnosis, %
Skryabin et al., Russia, 2023 [7]	Monocenter cohort	312	Lumbar spine injury	6.1
Zhang et al., China, 2017 [8]	Case report	80	Intervertebral disc hernia, no complaints	30.0
		92		7.0
Ibrahim et al., USA, 2013 [26]	Monocenter cohort	364	Idiopathic scoliosis	10.4
Chiu et al., Malasia, 2023 [27]	Monocenter cohort	998	Idiopathic scoliosis	25.1
Lee et al., South Korea, 2017 [28]	Monocenter cohort	385	Idiopathic scoliosis	12.2
Garg et al., India, 2021 [29]	Monocenter cohort	198	Idiopathic scoliosis	18.2
Hu et al., China, 2016 [33]	Monocenter cohort	657	Idiopathic scoliosis	10.6
Yamauchiet al., Japan, 2023 [34]	Monocenter cohort	61	Idiopathic scoliosis	24.5
Illeez et al., Turkey, 2022 [43]	Monocenter cohort	400	Low back pain	16.8
Gennari et al., France, 2015 [45]	Case series	116	Low back pain	6.9
Total		3,663		16.78

We analyzed scientific articles written by 17 teams of authors that reported information on the incidence of diagnosing the known types of transitional vertebrae in patients of different ages [4, 10, 37, 43, 46–58]. It turned out that in total of their structure, type II pathology accounts for 43.2 % of clinical observations while types I, III and IV of the disease occur with the incidence of 32.2, 18.0 and 6.6 %, respectively. Detailing the pathology by disease subtypes showed a predominance of type IIa with an incidence of 26.9 %, and type IIb with an incidence of 25.9 % of clinical observations [43, 50, 55].

The most informative method of radiological visualization of transitional vertebrae in the pediatric population is computed tomography, which allows obtaining both 3D images and sections at the level of pseudarthrosis between the enlarged transverse process (or processes) of the suprasacral vertebra and the wing of the sacrum [59]. Our own clinical observations presented above (Figures 1 to 4) fully illustrate what has been said.

In order to relieve pain in patients with transitional vertebrae, including children, both conservative (medical drugs, physiotherapeutic procedures) and operative (pseudoarthrectomy, radiofrequency ablation, minimally invasive interventions, interbody fusion) methods have been used [6, 60–66].

It is not rare that the positive short-term effect of conservative therapy, especially with medicinal therapeutic blockades, is considered as an indication for surgical intervention [67]. Among surgical techniques in pediatric patients, the most widely used method is pseudoarthrectomy [68]. The essence of the method is to bisect the base of the transverse process of the transitional vertebra with a high-speed drill in order to decompress the mechanical stress in the area of pseudarthrosis [69].

Our study of scientific articles devoted to the use of pseudoarthrectomy in clinical practice found four publications that provide examples of its use in pediatric and adolescent patients (Table 2). In all four publications, the effectiveness of pseudoarthrectomy was pain relief, while conservative therapy had a short-term therapeutic effect.

Table 2

Scientific publications that provide information on the use of the pseudoarthrectomy in the treatment of pain caused by transitional lumbosacral vertebrae in children and adolescents

Author, country, year, source	Type of study	Patients			Duration of pain before surgery	Follow-up duration
		number	sex	age, years		
Sumarriva et al., USA, 2022 [62]	Monoticenter cohort	1	m	17	2 years	4 years
Babu et al., USA, 2017 [70]	Monocenter cohort	1	f	17	4 years	1 years
Cuenca et al., France, 2019 [71]	Monocenter cohort	1	m	13	4 years	1 years
Louie et al., Germany – USA, 2019 [72]	Monocenter cohort	2	f	15	9 months	1 years
					2 years 3 months	

The analysis of the information presented in Table 2 shows that in all cases the authors managed to achieve a positive effect for a long period of time. According to Mikula et al. who compared the results of using pseudoarthrectomy and posterior spinal fusion techniques in a group of patients with lumbar pain caused by transitional vertebrae, the effectiveness of spinal fusion in achieving a positive result exceeds the effectiveness of resection in long term follow-up, more than 1 year, 78 and 28 % of clinical cases, respectively [73]. In pediatric patients that suffer from low-back pain caused by transitional vertebrae, the transpedicular fusion technique was used in one patient with a positive therapeutic effect [61].

A relevant problem in the contemporary paediatrics is prevention of pain associated with congenital spinal diseases [74]. The above fully applies to such pathology in children as transitional vertebrae [75]. Considering the fact that the disease is congenital in nature, and therefore develops in utero, it is not impossible to influence the process of ontogenesis for preventive purposes [76]. The proposals of some authors to conduct a preventive X-ray examination of the spine in children to identify anomalies of its development [12] is not a preventive measure, but is aimed at diagnosing a suspected pathology and is not advisable from some points of view including deontological and anti-radiation ones [36].

CONCLUSION

A small number of scientific articles are devoted to various aspects of transitional lumbosacral vertebrae in paediatric patients. However, the review of the published literature shows that transitional vertebrae are a frequently diagnosed pathology in children and adolescents. Current imaging methods are able to accurately detect not only the presence of the disease, but also to differentiate its type. The main clinical symptom of transitional vertebrae is pain in the lumbosacral spine which is difficult to relieve with conservative methods of therapy. One of the surgical methods most frequently used in children and adolescents is pseudoarthrectomy, which is able to relieve the vertebrogenic pain syndrome. Due to the fact that the disease develops in utero and manifests clinically at different age periods, measures for its specific prevention have not been developed.

Conflict of interests *The authors declare no conflict of interest.*
Funding source *The study was not sponsored.*

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The article was submitted 03.10.2023; approved after reviewing 17.10.2023; accepted for publication 24.02.2024.

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