DEGENERATIVE SPINE DISORDERS COMPLICATED BY RADICULAR SYNDROME IN CHILDREN: AN EPIDEMIOLOGICAL AND CLINICAL ANALYSIS OF A 17-YEAR REGIONAL COHORT STUDY

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Objective. To analyze epidemiological and clinical features of degenerative disease of the spine complicated by radicular syndrome in children, as well as the effectiveness of its treatment on the example of one of the largest regions of the Russian Federation.
Material and Methods. Design of the study corresponds to a retrospective cohort clinical and epidemiological study for 17 years. The study included 201 patients aged 10–17 years with degenerative changes in the spine complicated by radicular syndrome. An epidemiological analysis included the assessment of the regional incidence of degenerative diseases of the spine in children, and clinical analysis – the effectiveness of conservative and surgical treatment. The age and sex structure of the cohort, the level of pathology, the effectiveness of surgical treatment, and age-related features of early spinal discosis in children as compared with degenerative lesions of the spine in adults were analyzed.
Results. The epidemiological frequency of degenerative diseases accompanied by clinical manifestations and requiring special treatment in the Leningrad Region was assessed as 8.7 per 100 thousand children aged 10–17 years. Conservative treatment was effective in 172 patients, and 29 patients were treated with surgery. Surgical results were followed up for 1 to 16 years after surgery and were evaluated as excellent, good, and satisfactory respectively in 4 (14 %), 20 (69 %), and 5 (17 %) cases. Complications were reported in two cases: migration of the interbody stabilizing implant and positional neuropathy of the peroneal nerve associated with the position on the operating table.
Conclusion. The epidemiological analysis conducted on a regional cohort of the Leningrad Region can be used in assessing the potential need for conservative and surgical treatment of children with degenerative pathology in other regions of Russia. Conservative treatment of this pathology is quite effective, and surgical decompression of nerve roots was required only in 14.4 % of cases.
Key Words: degenerative disorders of the spine in children, radicular syndrome, discosis in children, surgical treatment.
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Acute back pain (dorsalgia) which becomes chronic condition is one of the three most common causes of discomfort in children, along with cephalgia and arthralgia. In pediatric practice, this symptom could be caused not only by functional and physiological features of the developing musculoskeletal system, but also by true degenerative changes that develop due to dysplastic or acquired pathological conditions. It is believed that back pain is rare in infants, but its incidence increases as they grow up. After 30 years of age, almost all people experience persistent back pain in certain periods of their lives. According to the official conclusions of the World Health Organization experts, this medico-social problem has reached the scale of an epidemic, which makes it a disease of 'civilization' [1], and the basis of adult degenerative dorsalgia can be laid in childhood.

The issue under discussion is classified in ICD-10 in the section of "Other dorsopathies" under codes M50.0 (G99.2*), M50.1 (G55.1*), M51.0 (G99.2*), M51.1 (G55.1*). Studies conducted in Scandinavia, which is geographically close to the region of our analysis, estimated the prevalence rates of back pain in healthy children and adolescents in Finland and Sweden as 20–29 % [2, 3]. The data for the Moscow region fit into this range with the frequency of dorsalgia among schoolchildren of 27.7 % [4], whereas in the group of children with musculoskeletal pathology, the rate of degenerative spinal pathology reaches 80.8 % [5]. There are no studies of the epidemiology of early degenerative diseases of the spine, including those accompanied by compression radiculopathy, for this age group, which can be attributed to their rarity in comparison with adults. Therefore, the data at our disposal may be of interest from clinical and epidemiological points of view.

The objective of the study was to analyze epidemiological and clinical features of degenerative disease of the spine complicated by radicular syndrome in children, as well as the effectiveness of its treatment on the example of one of the largest regions of the Russian Federation.

Material and Methods

The system of medical care for children and adolescents in the Leningrad region involves the examination of all patients with neurosurgical pathology under the age of 18 years performed by the staff of the Department of Pediatric Traumatology and Neurosurgery of the Leningrad Regional Children's Clinical Hospital (LRCCH) on an outpatient or an inpatient basis. This study includes information on patients who meet the following criteria:

– age up to 17 years inclusive;

– single place of observation/treatment (Department of Pediatric Traumatology and Neurosurgery, LRCCH);

– the period of initial hospitalization from January 1, 2002 to December 31, 2018;

– residence (registration) of patients in the Leningrad region;

– back/leg pain caused by degenerative disease of the spine with compression of the spinal nerve roots, verified by radiation studies (CT, MRI) and with topically relevant clinical symptoms [6];

– documented course of conservative and rehabilitation therapy, including dehydration, NSAIDs, vascular therapy, orthoses, exercise therapy, physical therapy, as well as minimally invasive manipulations (blockade) with registered clinical and functional effect and planned radiation control of the process.

The study did not include patients with back pain who had signs of juvenile spondylopathy (the so-called juvenile osteochondrosis), which, as a rule, do not include compression radiculopathy, and those who, as a result of a single course of outpatient conservative therapy in municipal hospitals, achieved persistent clinical effect without relapse during the observation period.

Epidemiological analysis included the assessment of the regional incidence of degenerative diseases of the spine in children, and clinical analysis – the effectiveness of conservative and surgical treatment.

Design of the study corresponds to a retrospective cohort clinical and epidemiological study over 17 years.

Results

Considering the focus of the study, the results are divided into two sections: epidemiological and clinical.

Epidemiological features

A total of 201 patients aged 10–17 years met the inclusion/exclusion criteria. The number of children and adolescents registered in the Leningrad Region throughout the study period is shown in Fig. 1 (data from Rosstat).

Recalculation of the indicators suggests that the epidemiological frequency of degenerative diseases of the spine with clinical manifestations that require special treatment was 8.7 per 100 thousand children aged 10–17 years in the Leningrad Region.

In all patients, the onset of the disease was characterized by acute local back pain with subsequent transition to chronic pain and change to radicular one with spread to the limbs (upper/lower) or through the intercostal space. In 27 %, the pain was intermittent in nature, in 19 % there were paresthesias, in 13 %, hypostesia, in 5 %, peripheral paresis, and in 1 %, dysfunction of the pelvic organs.

After clinical, neurological and X-ray examinations, the patients were prescribed a course of conservative treatment, usually including limiting physical activity due to hospitalization and orthotics, short (up to 3 days) courses of dehydration, NSAIDs and vascular therapy. A positive effect was achieved within the first 5–7 days, which made it possible to expand the regimen and switch to rehabilitation treatment: exercise therapy, massage, swimming, etc. [7–10]. In the absence of an effect for two weeks, minimally invasive procedure (blockade with local anesthetic and hormonal drugs) were used.

A decrease in and then the disappearance of a patient's complaints at control points (corresponding to two and four weeks from the start of therapy) were used as the criterion for the effectiveness of treatment. Two groups were formed within the analyzed cohort based on the efficiency of treatment achieved by the time of completion of the study:

I: 172 (85.6 %) patients who achieved persistent positive clinical and neurological effect after conservative therapy and minimally invasive procedures;

II: 29 (14.4 %) patients, which corresponds to 0.3 per 100 thousand of the child population aged 0 to 17 years or 1.26 per 100 thousand children over 10 years old; in these patients several courses of conservative therapy conducted during the year failed to produce a positive effect according to either clinical or X-ray data and surgical treatment was required.

Indications for surgical decompression:

1) progressive or resistant to therapy neurological disorders confirmed by MRI, MSCT, ENMG with topical confirmation of the level of radiculopathy;

2) persistent pain at rest and under mechanical stress, assessed by a patient as severe and very strong (unbearable), which corresponds to 4–7 and 8–10 points on VAS;

3) development of paresis of a functionally significant muscle group, including *m. quadriceps femoris* and dorsal flexors of the foot, creating a pronounced functional defect;

4) acute urinary retention.

The group of operated patients was subjected to more thorough analysis in order to identify factors that could contribute to the development of changes that are refractory to conservative therapy. The incidence rates among operated children of middle and high school age (10–14 and 15–17 years, respectively) are presented in Table 1.

The surgical trends are more clearly illustrated in Fig. 2. Even though during the analyzed period the annual number of surgeries was insignificant (Me = 1.705, min = 0, max = 4), the trend line in the overall group and in children aged 15–17 demonstrate their steady growth, which is most pronounced in adolescents.

Clinical features

Premorbid factors corresponding to the so-called pre-discosis diseases — associated developmental defects (dysplasia) of the skeleton or genetic features — were identified in the majority (n = 172) of the non-operated patients. A typical patient is characterized by a

paratrophy with nutrition unbalanced in volume, composition and quality of ingredients, and in most cases by a sedentary lifestyle. One can identify factors contributing to the development of the pathology even among the patients initially considered healthy, including extreme workloads in professional sports (~3 %), uncontrolled workloads in children from asocial families (~7 %) and genetic predisposition (~40 %), which manifests in the form of clinical signs of undifferentiated connective tissue dysplasia.

Fig. 3 presents the results of the dynamic observation of a patient, illustrating the development of the degenerative process in the spine against the background of one of such conditions: tethered spinal cord syndrome.

The features of the structure of degenerative pathology which served as an indication for surgical intervention are presented in Fig. 4, 5.

The two-fold predominance of girls in pediatric population is the opposite of what is observed in the adult population. In turn, given the long-term conservative preoperative therapy (see indications for surgery), it can be argued that the onset of the first signs of the disease in children occurs mainly at the middle school age, and the indications for surgery are shifted towards adolescence. Surgery was performed on the cervical spine only in one patient, while 28 out of 29 children were operated on in the lumbar or lumbosacral spine. Remarkably, almost one third of interventions (10 of 29) were performed for a multilevel lesion; for boys the lesion was localized at L4–L5 and L5–S1 levels in all cases, while in girls not only were the lesion levels more diverse, but there was also an obvious increase in the number of lesions in the craniocaudal direction.

The analysis of the medical history of operated patients revealed only three cases of obvious conditions that could lead to the development of radicular compression: back injury, infectious and inflammatory disease and congenital malformation of the spine and spinal cord (Fig. 5). In 26 cases, predisposing factors were detected only with direct examination of the patient and his parents and were associated with hereditary symptoms (most often undifferentiated connective tissue dysplasia), dysplastic changes in the spine (primarily lumbosacral dysplasia: S1 lumbarization and L5 sacralization) or pathology of other organs of musculoskeletal system.

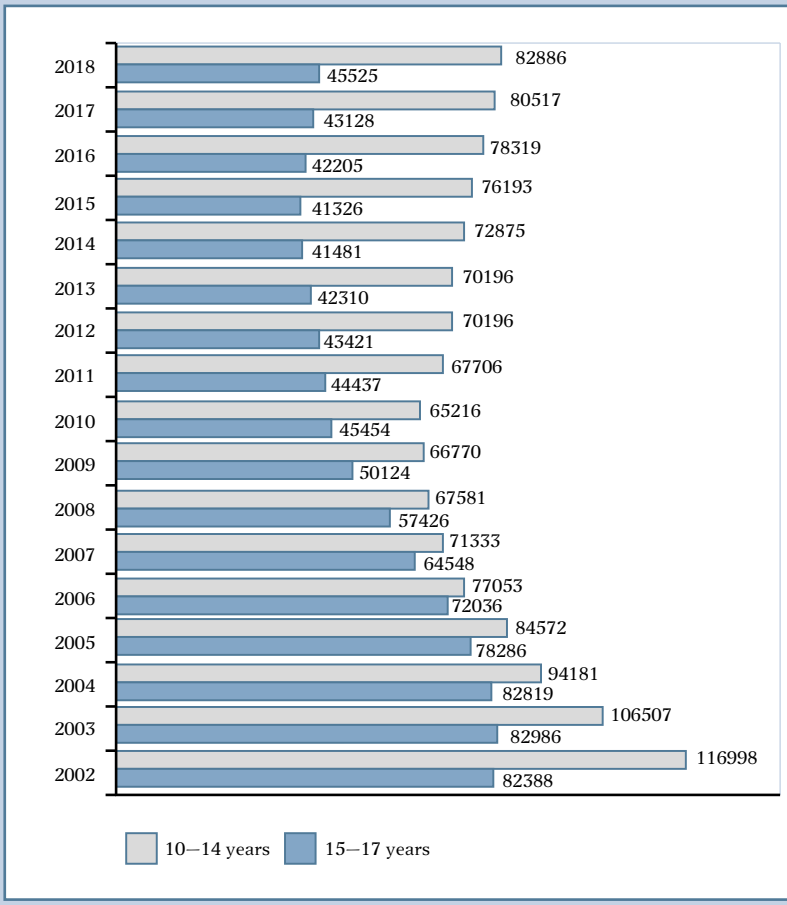

Fig. 1
The number of children and adolescents (10–17 years old), registered in the Leningrad region in 2002–2018 (Rosstat data)

The surgical interventions performed in 29 patients, based on the level of the lesion, are presented in Table 2. Decompression of nerve roots was a mandatory component of all interventions and was performed through posterior approach, except for the lesions of the cervical spine. There were no cases of posterior spinal fusion or spinal instrumentation.

In 96 % of cases, microsurgical discotomy was performed through posterior interlaminar approach using a microscope and special microsurgical instruments, which made it possible to preserve the yellow and posterior longitudinal ligaments as much as possible, and to mobilize the dural sac and neurovascular bundle at the stage of disc removal. In 26 cases, the removal of the changed part of the disc was carried out radically (at least 75 % of its volume), in two cases it was limited to removal of the foraminal component of compression.

Surgical outcomes were followed up for 1 to 16 years after the surgery and were evaluated as excellent, good, and satisfactory respectively in 4 (14 %), 20 (69 %), and 5 (17 %) cases. Complications were reported in two cases: in the first case, the migration of an interbody sta-

Table 1
The distribution of patients (n = 29) by age and incidence rates per 100 thousand population

Year	Age of onset			Incidence		
	10–14 years	15–17 years	Total for 10–17 years	10–14 years	15–17 years	Total for 10–17 years
2002	–	1	1	0.00	1.21	0.50
2003	–	1	1	0.00	1.21	0.53
2004	–	–	0	0.00	0.00	0.00
2005	–	–	0	0.00	0.00	0.00
2006	–	–	0	0.00	0.00	0.00
2007	–	–	0	0.00	0.00	0.00
2008	1	–	1	1.48	0.00	0.80
2009	–	3	3	0.00	5.99	2.57
2010	–	2	2	0.00	4.40	1.81
2011	–	4	4	0.00	9.00	3.57
2012	–	2	2	0.00	4.61	1.76
2013	–	1	1	0.00	2.36	0.89
2014	2	1	3	2.74	2.35	2.60
2015	–	4	4	0.00	9.68	3.40
2016	1	2	3	1.28	4.74	2.49
2017	–	0	0	0.00	0.00	0.00
2018	1	3	4	1.21	6.59	3.11
Mean	1.25	2.00	1.71	1.58	3.54	1.26

bilizing implant (T-space peek) required a revision surgery; second case involved positional neuropathy of the peroneal nerve associated with the position on the operating table. In another case, re-intervention was performed in connection with the recurrence of a hernia within 12 months after the first surgery.

The article does not aim to evaluate the effectiveness of different methods of segmental stabilization (4 observations) after decompression operations, especially since their choice was determined by the technical capabilities available at the time of the intervention, which have changed significantly over the last 17 years. Signs of segmental instability were considered to be indications for stabilization.

Discussion

In contrast to adult patients, for whom degenerative lesions of the spine play a leading role in the structure of neurosurgical interventions, indications for surgery are extremely rare in childhood. The main reason for such differences is the anatomical and physiological features of the spinal motion segments in children, especially the elasticity of the intervertebral disc:

1) the nucleus pulposus consists of high-quality macromolecules of the organic matrix, which allows good water retention and makes the disc elastic;

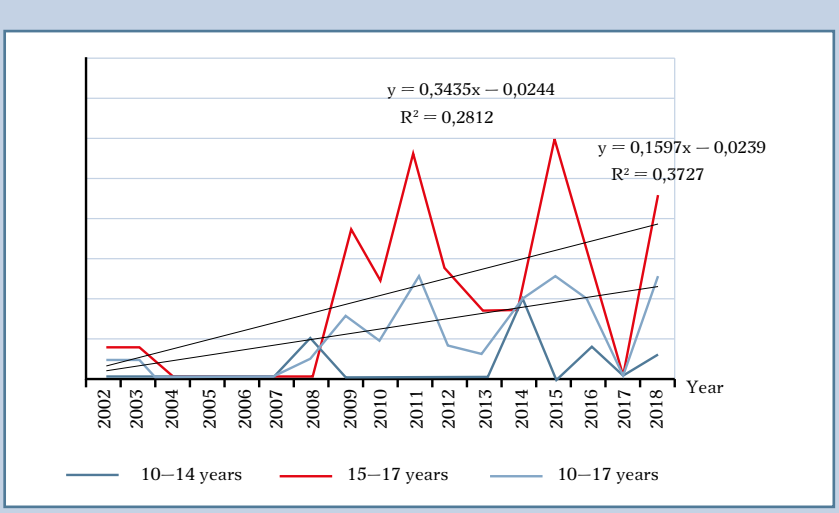

Fig. 2
17-year trend in the surgery rate among children with compression radiculopathy

2) the annulus fibrosus consists of collagen fibers in tonus;

3) cartilaginous endplates consist of hyaline cartilage.

Within the term "degenerative changes in the spine in children," the term "degeneration" reflects the functional-dynamic description of a specific anatomical substrate, while the pain may be caused by several pathological or borderline physiological factors:

– direct mechanical compression of the nerve root by a prolapsed disc;

– irritation of the meningeal branch of the spinal nerve in the posterior longitudinal ligament area by a dislocated disc or at the periosteum of the pedicle in the unstable segment;

– hyperextension of the capsule of the intervertebral joints and entrapment of the synovial folds due to the temporary or permanent segmental hypermobility inherent in the childhood age.

Prolonged exposure to these factors leads to local changes in osmolarity and pH in perineural structures and, ultimately, to a functional morphological change in a compressed nerve root corresponding to aseptic inflammation: nerve bundles become swollen, action potentials are spontaneously excited, and axons demyelinate and atrophy [11]. The faster these changes develop, the rougher the functional disorders are; their severity and duration of pathogenic exposure define the asymptomatic or symptomatic course of the degeneration.

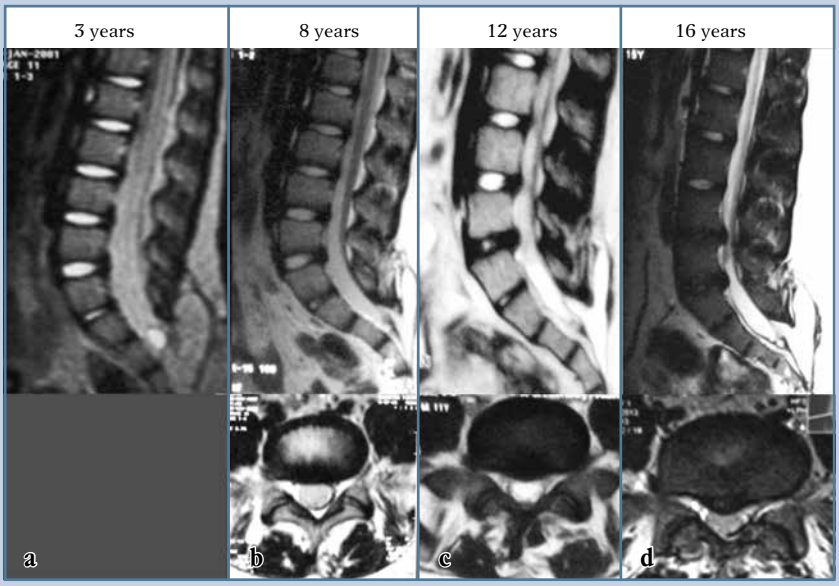

Fig. 3
Age dynamics of degenerative changes in the lumbosacral spine of a patient on T2-weighted MRI images (central sagittal and axial sections at the L5–S1 level):
a – at the age of 3, a well-hydrated matrix of lumbar discs occupying almost the entire disc space, a rudimentary S1–S2 disc (lumbarization), the caudal lipoma, for which the child was operated at the age of 6 months, is visible; **b** – at the age 8, disc hydration decreases, fibrous plates (lamellae) of the L5–S1 disc protrude backwards and to the right, fibrotisation of S1–S2; **c** – at the age of 12, fibrosis and protrusion of L5–S1; d – at the age of 16, progressive degeneration with the formation of hernias of L4–L5, L5–S1 discs with a combined central and radicular stenosis on the right, progressive hypotrophy of the deep extensors of the back with degeneration into the fat and connective tissue mass, straightening of the lumbar lordosis, and arthrosis

Under physiological conditions, when a patient is sitting, intradiscal pressure can vary from 0.27–0.30 MPa (with a slight backward tilt) to 0.46 (strictly upright position) and 0.83 MPa (when tilted forward) [12, 13] which ensures the feeding through the diffusion. The following physiological age-related changes in the intervertebral disc, which Tondury [14] defines as its life cycle, are typical of the early periods:

– mixed feeding of the disc through its own capillary blood flow and diffusion ends by the age of 4, when the disc becomes avascular; the exception is the so-called tracer vessels: small, non-permanent, located on the periphery of the disc, which can undergo a complete reduction over two decades;

– the cartilaginous growth zone of the vertebral body endplate disappears by the age of 18–20 being replaced by bone;

– the ratio of the height of the disc to the height of the vertebral body, which is 1:1 in a newborn, reaches 1:4 or 1:5 in an adult;

– the quantity and quality of water-retaining molecules of mucopolysaccharides in the disc decrease with age, which leads to a decrease in its hydration from 90 to 70 % and the central part of the disc go from elastic state into fibrous-loose one .

The features of disc feeding define the course of a degeneration: age-related or premature, with clinical manifestations or asymptomatic. At an early age, all parts of the disc, the spongy material of the vertebral bodies and the paravertebral tissues (ligaments and joints) are involved in the exchange of fluids and molecules within a single osmotic system, while only the nucleus pulposus is fed by diffusion. From the moment of a child verticalization and active beginning of walking upright, the feeding of the entire disc switches to the diffusion mechanism due to the reduction of its own capillary plexus. The increasing difference between intradiscal and intravascular pressure is accompanied by the formation of a semi-permeable membrane along the lateral boundaries

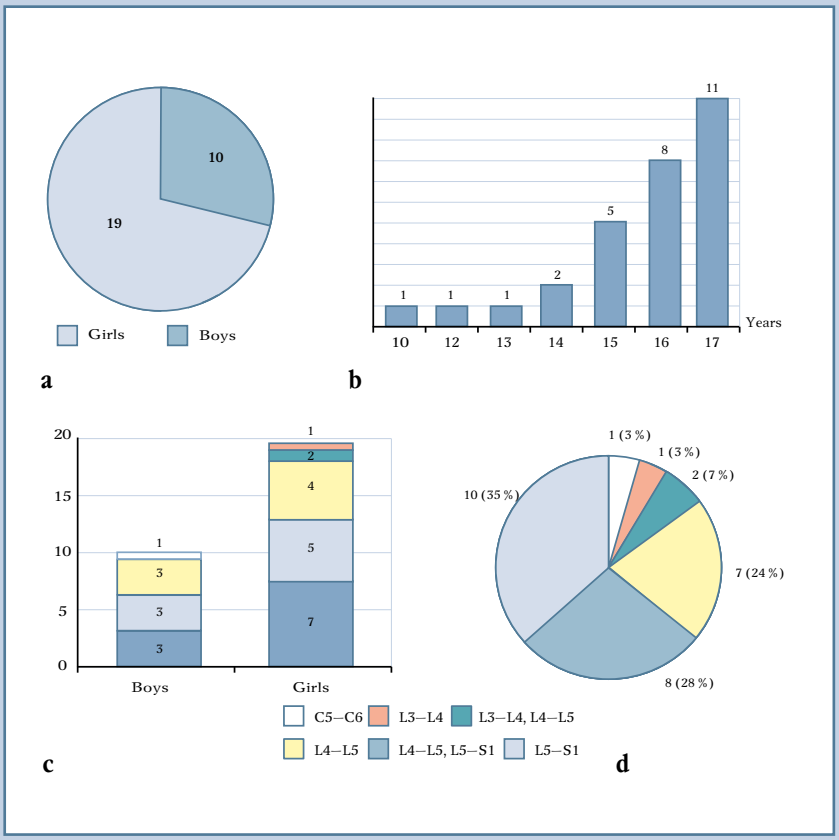

Fig. 4
The structure of degenerative changes in the group of operated children (n = 29): **a** – by gender; **b** – by age; **c** – localization taking into account gender and age; **d** – localization for the group as a whole

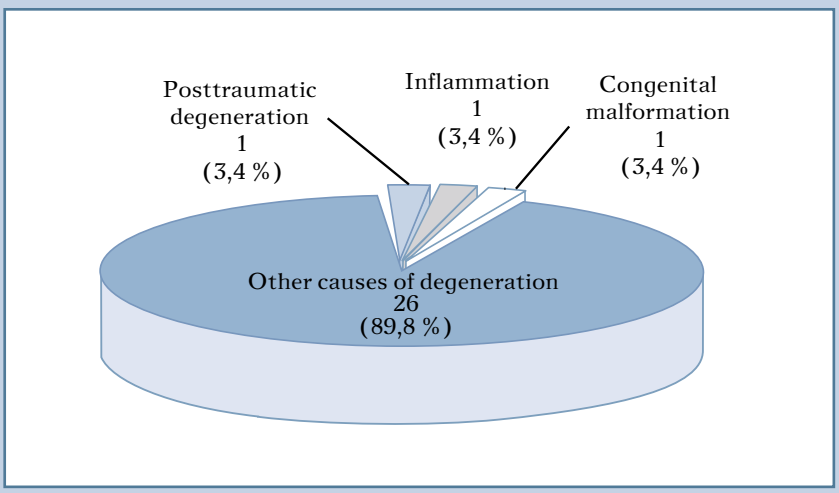

Fig. 5
Factors predisposing to the development of radicular syndromes in the group of operated children (n = 29)

of the annulus fibrosus and endplates of the vertebral bodies, which leads to the gradual formation of two sections different in their mechanical, biological and chemical properties: intradiscal and intraosseous. The difference in hydrostatic (mechanical) pressure and the concentrated solutions that counteract it create an osmotic pressure, which causes the movement of fluid into and out of the disc, including the entry and exit of macro- and micromolecules. In the event of failures in this system, irreversible changes develop.

The processes occurring in discs with a painful or asymptomatic course largely define changes in the spine itself. Early degeneration in children, unlike that in adults, begins in the disc and rarely spreads to other parts of the spinal motion segment. Therefore, it is logical to assume that degenerative lesion in children is early discosis [11], while the actual disc herniations are practically unheard of in children under the age of 10 [15].

The comparison of early discosis and degenerative spinal lesions typical for adults allows us to highlight some differences (Table 3).

Early discosis can develop both in healthy children and those with pre-discosis conditions: congenital and acquired diseases of the brain and spinal cord, spine, extremities, pelvis, which disrupt the physiological biomechanics; with excessive loads as well as post-operative changes in the musculoskeletal system being predisposing factors [16]. Burnei et al. [17] believe that four factors lead to the development of disc hernias in children: heredity, trauma, congenital malformations, and degenerative changes in the spine.

More immature skeleton and faster course of the disease with pre-discosis predisposition lead to rougher morphological changes in the disc, which, however, may not be directly related to clinical manifestations due to the high reserve capacity of a child. This is why, rather large disc hernias in children, in contrast to those in adults, occur asymptomatically, and degenerative process is only rarely complicated by segmental

Table 2
Stabilization options for operated patients (n = 29)

Level of lesion	Stabilization options	Patients, n	Notes
C5–C6	Disc prosthesis	1	–
L3–L4	No stabilization	1	–
L3–L4, L4–L5	No stabilization	1	–
	Interbody spinal fusion: cage	1	Single-level intervention at L3–L4, causogenic for pain syndrome
L4–L5	No stabilization	5	–
	Interbody spinal fusion: autobone	1	–
	Interbody spinal fusion: cage	1	–
L4–L5, L5–S1	No stabilization	8	Including two-level (4) and one-level (4) interventions; relapse (1)
L5–S1	No stabilization	9	Including that with simultaneous biopsy of the lesion in the vertebral body (1)
	Interbody spinal fusion: autobone	1	–

instability, except for concomitant dysplastic spondylolysis with listhesis.

As for the effectiveness of surgical treatment of degenerative processes in children, our data completely coincide with the opinion of our colleagues who believe that their effectiveness is primarily ensured by the complete decompression of nervous structures, while stabilization is not essential for achieving the clinical effect of the intervention [18–20], which is confirmed by the results of minimally invasive percutaneous interventions [21].

Conclusion

The data obtained within the framework of the 17-year regional cohort study allow us to draw the following conclusions.

1. Epidemiological parameters can be used in the planning and organization of work on the study and treatment of degenerative diseases of the spine in children in other regions of Russia.

2. The creation of regional registers will allow the calculation of the number of pediatric patients with the considered pathology, who potentially require observation and inpatient treatment by orthopedic trauma specialists, neurologists and neurosurgeons for children.

3. The organization of preventive work require identification of the risk group for degenerative lesions of intervertebral discs in children, in which significant weight should be assigned to the so-called pre-discosis conditions including a wide range of congenital diseases of the musculoskeletal system and spinal cord, as well as acquired diseases, including those associated with excessive loads and genetic factors.

4. Degenerative diseases of intervertebral discs in children differ significantly in their genesis from degenerative diseases of the spine in adults: they are more in line with early discosis than osteochondrosis, which should be taken into account when planning treatment and its outcomes.

5. Degenerative diseases of the intervertebral discs in children are rarely accompanied by pronounced clinical manifestations and in most cases successfully respond to conservative treatment.

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Table 3

The main differences between clinically significant discosis in adults and children

Parameter	Age-related discosis	Early discosis
Age of onset	After 30 years of age	Up to 20 years of age
Cause	Changes caused by exo- and/or endogenous factors	Prediscosis factors, genetic predisposition
Manifestations of osteochondrosis	Common	Absent or minimal
Spondyloarthrosis	Typical, including canal stenosis with chronic root irritation syndrome	Not typical, acute root irritation syndrome
Spread of the lesions	More often polysegmental	More often monosegmental
Disruption of the physiological curves of the spine	Common	Rare
Main pathogenetic variant	Disc prolapse	Disc protrusion
Indications for surgery	Common	Rare
Social forecast	Disability	Requirements for career guidance
Gender features	Predominantly male population	Predominantly girls

References

1. Clinical guidelines for diagnosis and treatment of lumbosacral disc herniation. Moscow, 2014. URL: http://ruans.org/Files/Pdf/Guidelines/lumbar_disc_herniation.pdf. In Russian.
2. **Salminen JJ.** The adolescent back. A field survey of 370 Finnish schoolchildren. Acta Paediatr Scand Suppl. 1984;315:1–122. DOI: 10.1097/01241398-198509000-00053.
3. **Brattberg G.** The incidence of back pain and headache among Swedish school children. Qual Life Res. 1994;3 Suppl 1:S27–S31. DOI: 10.1007/BF00433372.
4. **Shostak NA, Pravduk NG, Klimenko AA, Shemetov DA, Arinina EE.** Dorsalgia in young: peculiarities and approaches to treatment. Lechebnoye Delo. 2009;(1):45–50. In Russian.
5. **Vetrile MS, Kuleshov AA, Kokorev AI.** Epidemiology of back pain in children and adolescents aged 9–17 years with musculoskeletal pathology from the Moscow region. In: Actual problems of pediatrics: Proceedings of the 20th Congress of pediatricians of Russia with international participation. Moscow, 2018:425. In Russian.
6. **Baehr M, Frotscher M.** Duus' Topical Diagnosis in Neurology: Anatomy, Physiology, Signs, Symptoms. Transl. from English, ed. by OS Levin. 3rd ed. Moscow: Prakticheskaya Meditsina, 2014. In Russian.
7. **Abuzarova GR, Nevzorova DV, Kumirova EV, Savva NN, Arutyunov GP, Bagnenko SF, Danilov AlB, Danilov AB, Kunyaeva TA, Nikolaeva NM, Molchanov IV, Padalkin VP, Polyakov VG, Pchelintsev MV, Stepanenko SM.** Anesthesia for adults and children in the provision of medical care: Guidelines. Moscow, 2016. In Russian.
8. Federal clinical guidelines for the provision of medical care for children with radicular syndrome. In: Actual problems of pediatrics: proceedings of the XVIII Congress of pediatricians of Russia. Moscow, 2015. URL: www.pediatr-russia.ru/sites/default/files/file/kr_kor.pdf. In Russian.
9. Clinical guidelines for diagnosis and treatment of degenerative spinal stenosis at the lumbosacral level. Moscow, 2015. URL: http://ruans.org/Files/Pdf/Guidelines/spine_stenosis.pdf. In Russian.
10. **Karateev AE, Nasonov EL, Ivashkin VT, Martynov AI, Yakhno NN, Arutyunov GP, Alekseeva LI, Abuzarova GR, Evseev MA, Kukushkin ML, Kopenkin SS, Lila AM, Lapina TL, Novikova DS, Popkova TV, Rebrov AP, Skorobogatykh KV, Chichasova NV.** Rational use of nonsteroidal anti-inflammatory drugs. Clinical guidelines. Nauchno-Prakticheskaya Revmatologiya. 2018;56(Suppl 1):1–29. In Russian. DOI: 10.14412/1995-4484-2018-1-29.
11. **Kraemer J.** Intervertebral Disc Diseases. Transl. from English. Moscow, 2013. In Russian.
12. **Nachemson A.** Back pain: delimiting the problem in the next millennium. Int J Law Psychiatry. 1999;22:473–490. DOI: 10.1016/S0160-2527(99)00022-9.
13. **Ludwig J, Kraemer J.** [Low back pain]. Der Orthopade. 2002;31:337-341. In German.
14. **Tondury G.** [Anatomy and development of the spine with a special reference to the changes of the intervertebral disk with age]. Schweiz Med Wochenschr. 1955;85:825–827. In German.
15. **Salo S, Paajanen H, Alanen A.** Disc degeneration of pediatric patients in lumbar MRI. Pediatr Radiol. 1995;25:186–189.
16. **Schroeder GD, LaBella CR, Mendoza M, Daley EL, Savage JW, Patel AA, Hsu WK.** The role of intense athletic activity on structural lumbar abnormalities in adolescent patients with symptomatic low back pain. Eur Spine J. 2016;25:2842–2848. DOI: 10.1007/s00586-016-4647-5.
17. **Burnei G, Gavriliu S, Vlad C, Georgescu I, Hurmuz L, Hodorogea D.** Discal hernia in children and teenagers: medical, surgical and recovery treatment. Rom J Intern Med. 2006;44:477–481.
18. **Kuleshov AA, Krutko AV, Iskhakov OS, Vetrile MS, Abakirov MD, Peleganchuk AV, Vasilyev AI, Lisyansky IN, Meshcheryakov SV, Kokorev AI.** Surgical treatment of disc herniation in children and adolescents. Hir. Pozvonoc. 2017;14(1):68–77. In Russian. DOI: 10.14531/ss2017.1.68-77.
19. **Khoreva NE, Semenova JB.** Treatment of lumbar disk herniation in adolescents. Pediatric Neurosurgery and Neurology (Neyrokhirurgiya i nevrologiya detskogo vozrasta). 2018;(1):77–84. In Russian.
20. **Dang L, Chen Z, Liu X, Guo Z, Qi Q, Li W, Zeng Y, Jiang L, Wei F, Sun C, Liu Z.** Lumbar disk herniation in children and adolescents: the significance of configurations of the lumbar spine. Neurosurgery. 2015;77:954–959. DOI: 10.1227/NEU.0000000000000983.
21. **Wang X, Zeng J, Nie H, Chen G, Li Z, Jiang H, Kong Q, Song Y, Liu H.** Percutaneous endoscopic interlaminar discectomy for pediatric lumbar disc herniation. Childs Nerv Syst. 2014;30:897–902. DOI: 10.1007/s00381-013-2320-4.

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