THE EXPERIENCE OF SURGICAL TREATMENT OF LUMBAR DISC HERNIATION IN ADOLESCENTS USING ANNULOPLASTY: ANALYSIS OF A SMALL CLINICAL SERIES

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Objective. To assess feasibility, safety and effectiveness of a device for annular defect closure in surgical elimination of radicular compression syndrome in adolescents with degenerative disc disease.

Material and Methods. Five 11—17-year-old patients underwent disc hernia removal and root decompression followed by annuloplasty with a Barricaid implant in 2012—2016. Clinical and radiological (CT, MRI) techniques were used to assess the pain intensity on VAS, the degree of intervertebral disk degeneration according to Pfirrmann, the orientation of the facet joints and the cartilaginous surface, and the severity of sclerosis. The long-term follow-up period averaged 57 months (from 40 to 62 months). Surgical results were evaluated in accordance with the modified MacNub scale at 3 months and 3 years after surgery.

Results. In all cases, surgery had positive clinical effect with complete relief of the pain syndrome, including complete regression of distal paresis of the lower limb. In all patients, the 3-month result of surgery was rated on the MasNub scale as good and 3-year result — as excellent. The position of implants was stable, with no signs of further disc degeneration and decrease in interbody space.

Conclusion. Closure of the annular defect after lumbar microdisectomy provides excellent long-term results in adolescents with radicular compression syndrome associated with herniated discs. However, convincing and reliable assessment of the method requires further studies with a comparative analysis using sufficient clinical material.

Key Words: back pain in children, dorsalgia, degenerative disc disease, disc herniation, annuloplasty, annular defect plasty, Barricaid.

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According to WHO experts, the prevalence of spinal diseases complicated by back pain is considered an epidemic. Epidemiological data indicate that lower back pain is common as in adults, so in children and adolescents [1–6].

Conservative treatment of disc herniation in adolescents is ineffective in 14.4 % of cases [2]. In this case, the cause of radicular compression syndrome in the lumbar spine can be effectively eliminated by surgical intervention that enables return to everyday life, education, and work activities as soon as possible. The standard for surgical treatment of disc herniation is microdiscectomy that can be performed using both open microscopic techniques and endoscopic techniques through various approaches. The rate of excellent and good outcomes for this treatment technique in children and adolescents amounts to 83–100 % [1–3, 6, 7]. However, there may be recurrent disc herniation that occurs in 20% of patients within a few years after surgery [6–9].

Anatomically, the intervertebral disc in children and adolescents is characterized by elastoplastic properties and a high percentage of water in the nucleus pulposus. In our opinion, complete removal of the intervertebral disc in young patients is inacceptable because this may cause secondary pathology in the spinal motion segment and, as a result, the development of pain. However, the presence of several risk factors for recurrent disc herniation in the postoperative period [8–10], such as a large annular fissure (more than 6 mm), flattening of lumbar lordosis, excess body weight of the child, and increased axial loads (exercises), requires creating conditions for prevention of this phenomenon.

One of the ways to prevent recurrent disc herniation is annular repair [9]. In the literature, we have not found examples of the use of annuloplasty in adolescents.

The purpose of this study was to assess feasibility, safety, and efficacy of an annular closure device in surgery for elimination of radicular compression syndrome in adolescents with degenerative disc disease.

Material and Methods

In 2012–2016, 12 adolescent patients with compression radicular syndrome

caused by disc herniation were operated on at the Spinal Surgery Department of the N.N. Priorov National Medical Research Center of Traumatology and Orthopedics. Of these, five patients (Table 1) aged 11–17 years, who had a high risk of recurrent disc herniation, underwent elimination of intervertebral disc protrusion and root decompression, followed by annuloplasty.

At admission, all the patients complained of back pain up to 5–6 points as well as severe radicular pain in the lower extremity (VAS score of 8 to 9). Three patients complained of weakness in the lower extremity (decreased strength of the plantar flexors to 3 or 4 points). All the patients experienced significant functional limitation of daily physical activity due to these symptoms.

In one girl, pain developed because of heavy physical exertion (wrestling). In the other cases, there was no apparent cause of pain. The body mass index of adolescents ranged from 17.9 to 31.0 kg/m^2 (mean, 21.8 kg/m^2).

The mean duration of radicular pain complaints was 14.6 months (9 to 36 months). In this case, all the patients received conservative treatment according to the standard protocol: non-steroidal anti-inflammatory drugs (NSAIDs), centrally acting muscle relaxants, B vitamins, massage, physiotherapy, and exercise therapy. The treatment did not provide pain relief.

On examination, all the patients revealed an antalgic trunk posture and flattening of lumbar lordosis. A characteristic sign was also restricted anterior trunk bending. In all the cases, there was radicular pain. Lasegue's symptom was positive in all the patients. A neurological deficit was detected in three cases (strength of foot plantar flexion was reduced to 3 or 4 points).

All the patients underwent standard radiography of the spine in two projections, functional radiography of the lumbosacral spine, and MRI. In some cases, CT was used to evaluate changes in the bone structures and detect developmental abnormalities of the spine.

In accordance with the recommendations for the nomenclature and classification of the intervertebral disc pathology [11], all disc herniations in the studied series were defined as protrusions. Disc herniations were located at the same level (L5–S1) in 3 patients and at two levels (L4–L5 and L5–S1) in 2 patients; in this case, given the clinical symptoms, surgery was planned only on the L5–S1 disc.

Changes in the MRI signal from vertebral bodies were minimal (Modic 0 or 1).

According to the Pfirrmann classification [12], the severity of intervertebral disc degeneration was grade II in two cases and grade III in three cases.

Changes in the bone-cartilaginous structures of the facet joint were evaluated using MRI, depending on the shape and amount of cartilage covering the joint and were classified in accordance with previously proposed methods [13, 14].

Cartilage condition: grade 1 – uniformly thick cartilage that completely covers both articular surfaces, with a well seen space between them; grade 2 – the cartilage completely covers the articular surface, but there are separate eroded areas; in the posterior parts of the joint, the joint space loses its uniformity; grade 3 – the cartilage does not completely cover the articular surface, there are underlying bone areas contacting the joint cavity; grade 4 – the cartilage is absent, except for traces visible on the articular surface; there are voids characterized by a low intensity of the MR signal.

The severity of articular process sclerosis was classified into four grades: grade 1 – the articular processes have a thin layer of the cortical bone; grade 2 – there are areas of local cortical bone thickening of the articular processes; grade 3 – a thickened cortical bone covers less than half of the articular processes; there are areas of an increased intensity of the MR signal in the joint space; grade 4 – dense cortical bone covers more than half of the facet joint; there are osteophytes.

Articular cartilage degeneration and articular process sclerosis at the level of spinal motion segment including the affected disc were more pronounced on the disc herniation side, grade 2–3 versus grade 1–2 on the opposite side. The facet joint orientation angle was different. Mean values were not calculated, and statistical processing of the obtained data was not performed due to an insufficient sample size.

There was no spondylosis and vertebral body osteophytes in this series.

The indications for surgical treatment of disc herniation in adolescents included persistent radicular pain, paretic syndromes, failed conservative treatment, and topically MRI-confirmed spinal stenosis with compression of the appropriate roots.

All the patients underwent interlaminectomy on the compression side; after disc herniation removal and decompression of the root and dural sac, an annular defect was closed, in order to prevent recurrent disc herniation, with a Barricaid implant fixed to the end plate of the subjacent vertebra (posterior edge of the S1 body).

Results

The follow-up period ranged from 40 to 62 months (mean, 57.4 months). In

Table1
Characterization of operated patients

Patient	Gender	Age, years	Segment	Follow-up duration, months	Severity of disc degeneration based on MRI (Pfirrmann grade)
1st	F	11	L5–S1	62	II
2nd	M	14		61	II
3rd	F	15		40	III
4th	F	16		62	III
5th	M	17		62	III

all the cases, a positive clinical effect with complete pain relief was achieved. In paretic patients, complete regression of neurological symptoms was observed. The severity of back pain was scored (VAS) 2 or 3 at 3 months and 1 or 2 at 3 years. In the long-term period, pain in the lower extremity was scored 0 or 1. According to the modified MacNub scale, the surgery outcome in all the adolescents was good at 3 months and excellent in the long-term period (more than 3 years). All the patients restored the level of physical activity in the nearest 2 to 3 months. There was no recurrent pain within the follow-up period.

In control CT and MRI scans, the position of implants was stable in all the patients. There were no signs of further disc degeneration and a decrease in the interbody height.

Below, we present two clinical examples of the use of annuloplasty in surgical treatment of disc herniation in children.

Case 1. An 11-year-old female patient F. was hospitalized in September 2014 with complaints of low back pain with radiation on the posterior surface of the left thigh. The patient complained of back pain since December 2013 and was followed-up by a neurologist at the place of residence. Since May 2014, the pain intensity increased to a VAS score of 8 to 9; there was pain radiation to the left lower extremity, down into the foot. MRI of the lumbar spine revealed disc herniation at the L5–S1 level with compression of the neural structures. Conservative treatment (a moderately stiff lumbar brace, limited loads, rest, NSAIDs, muscle relaxants, and B vitamins) did not provide a desired effect.

Examination at admission. The skin of the lumbar region was not damaged, of natural color. An antalgic body posture. Bending, flexion, and extension are painful and significantly restricted. On palpation, there was increased tone of the paravertebral muscles in the lumbar region, primarily on the left. The Neri's sign was negative. Dejerine and Amoss signs were positive. Lasegue's symptom was negative on the right and positive on the left when lifting the lower extremity to 45°. Muscle strength in the feet was 5 points. Sensitivity was not affected.

Standard and functional radiography of the lumbar spine in two projections (Fig. 1a) revealed signs of juvenile degenerative disc disease, secondary rotation of the lumbar vertebrae, antalgic kyphosis, lack of physiological lordosis formation upon spine extension, and a decreased interbody height in the L5–S1 segment.

MRI scans (Fig. 1b) revealed degenerative changes in the lumbar spine, paramedian L5–S1 disc herniation (protrusion) on the left on a wide base with a displacement of the entire nucleus pulposus to the posterior longitudinal ligament and thinning of the annulus fibrosus, and bone tissue edema of the L5 inferior articular process on the left.

The patient underwent, under general endotracheal anesthesia, L5–S1 interlaminectomy on the left, microsurgical discectomy, L5–S1 disc herniation removal, decompression of neural structures, and annular defect repair using a Barricaid implant.

The patient was discharged from the hospital on the 4th day. The severity of pain was scored (VAS) 2 at 3 months and 0 at 5 years after surgery. At follow-up examination 62 months after surgery, there were no complaints and activity restrictions. According to the modified MacNub scale, the long-term surgical outcome (after 5 years) was assessed as excellent. In follow-up radiographs and CT scans, the implant was stable (Fig. 2). In MRI scans (Fig. 3), there were no signs of recurrent disc herniation and root stenosis; the nucleus pulposus and the interbody height were preserved; there were no signs of aseptic instability of the L5–S1 segment.

The facet joints had bilateral changes: the cartilaginous surface became more clearly visible in MRI scans; there was no bone tissue edema of the L5 superior articular process on the left; the degree of bone tissue degeneration and sclerosis decreased after 5 years from grade 3 to grade 2 (Fig. 4).

Case 2. We present changes in the disc and articular cartilage based on MRI data in a 16-year-old female patient N. There were no signs indicating cartilage degeneration; the cartilage retained the previous height and nucleus pulposus size. Throughout the follow-up period, changes in the intervertebral disc were classified as grade 3. There were bilateral changes in the facet joints: in MRI scans, the cartilaginous surface was visualized more clearly compared to the baseline condition; the degree of bone tissue degeneration and sclerosis on the left (on the disc herniation side) in the long-term period decreased from grade 3 to grade 2 and remained at the same level on the opposite side (Fig. 5).

The indicators of changes in the disc and facet joints for all the patients are presented in Table 2.

Discussion

The causes of back pain are different: degenerative disc disease, spondylolisthesis, malformations of the lumbosacral junction, spinal deformities, tumors, injuries, systemic skeleton diseases, etc. According to our data, 80.9 % of children with spinal deformities experience back pain of various intensities at different intervals [5]. The prevalence of back pain increases with age, which is associated with intense physical exertion, bearing heavy backpacks, prolonged forced sitting posture, and, accordingly, sedentary lifestyle [3, 5]. According to V.P. Snishchuk and A.Yu. Mushkin [2], the need for special treatment due to clinical manifestations of degenerative diseases in the Leningrad Region is 8.7 per 100,000 patients aged of 10–17 years.

According to most authors, surgical treatment of degenerative disc disease in adolescents is highly effective and leads to relief of clinical symptoms in 83–100 % of cases. In this case, there are reports of unsatisfactory long-term outcomes of conventional and endoscopic operations [2, 7, 15, 16]. The unsatisfactory outcomes may be, inter alia, associated with loss of the intervertebral disc height in the postoperative period after discectomy, which leads to increased pain, impaired ability to work, and reduced quality of life for patients [17, 18]. The risk of recurrent disc herniation is higher in annular defects of more than 6 mm,

Fig. 1
Standard and functional radiographs in two projections **(a)** and MRI scans of the lumbar spine **(b)** of an 11-year-old female patient F. at admission

and extremely rarely in small fissure-like defects [8, 15, 16, 19, 20].

A relatively new technique for preventing recurrent disc herniation after microdiscectomy is annular defect repair using a Barricaid implant [9, 10].

A potential efficacy of this technique is related to the possibility of preserving the nucleus pulposus with large annular defects and lack of the need for disc curettage. This enables prevention of recurrent disc herniation due to barrier function and slowing down the degenerative cascade of both the intervertebral disc and facet joints of the spinal motion segment. All the data presented enable reducing the severity of back pain in the long-term period [20, 21].

Earlier, there were attempts to use annuloplasty with various implants to reduce the rate of recurrent disc herniation; however, long-term outcomes were not significantly superior to those after standard discectomy, which was probably due to the lack of implant fixation to bone tissue [22–24].

Of particular topicality is the issue of preserving the spinal motion segment function in young patients because complete removal of the disc in adolescents is considered unreasonable. There are reports of disc height loss of more than a quarter of the baseline value after microdiscectomy, which is associated with poor clinical outcomes [15, 16, 20]. In our study, the height of an operated disc in young patients remained at the preoperative level throughout the follow-up period.

Prevention of recurrent disc herniation is a clinically significant factor because repeated discectomy is technically complex and significantly more expensive compared to the primary intervention [25].

Lequin et al. [26] conducted a prospective study of 45 patients who underwent partial discectomy in the lumbar spine using annuloplasty with a Barricaid implant. The authors observed a statistically significant decrease in the pain intensity (VAS) and an improvement in the quality of life (Oswestry index). The intervertebral disc height was preserved in 93 % of cases. Revision surgery was required in three cases due to repeated disc herniation, formation of contralateral disc herniation, and development of gross cicatricial changes in the epidural space.

Sanginov et al. [9] presented the treatment outcomes in 120 patients with a Barricaid implant. Only 2.5 % of the cases required repeated surgical intervention. Recovery of the height of an operated disc and its regeneration occurred in 1.7 % of the patients. The results demonstrated that disc height loss directly correlates with the volume of a removed nucleus pulposus. It is worth noting that the X-ray picture in 25 patients revealed resorption and erosion around the implant bone anchor, which did not affect the clinical symptoms.

In 2018, the data of a multicenter study on comparison of 2-year results of surgical treatment for disc herniations in adults were published [28]. The study included patients with a duration of clinical symptoms of at least 6 weeks and a large intraoperative defect in the annulus fibrosus due to microdiscectomy (6–10 mm). Isolated discectomy was performed in 278 cases, and annuloplasty was used in 276 cases. Repeated surgery due to recurrent disc herniation was required in 5 and 13 % of patients in the annuloplasty group and the standard discectomy group, respectively.

It should be noted that the accumulated positive experience of annuloplasty using Barricaid implants includes only adult patients. However, this experience is not sufficient to evaluate

Fig. 2
Follow-up radiographs and CT scans of the female patient F. 3 months after surgery

Fig. 3
MRI scan of the female patient F. at 5 years after surgery

how reasonable and appropriate the use of this technique in adolescents with a growing spine characterized by specific features. The technique for annular defect closure, which we used in five patients, did not require extension of the surgical approach, demonstrated good results, and was not accompanied by any complications. Of course, more objective assessment of the technique requires a larger group of patients, comparative analysis, and further observation.

Conclusion

Lumbar microdiscectomy with annular defect closure using a Barricaid implant in adolescents demonstrated positive immediate and long-term outcomes in a series of our cases. There is a basis to believe that this technique can be successfully used in young patients with radicular compression syndrome associated with disc herniation. Repair of the annulus fibrosus minimizes the amount of discectomy, which preserves the physiological function of the disc and potentially reduces the risk of degenerative change progression in the disc and facet joints. However, convincing and reliable assessment of the technique requires further research and comparative analysis using sufficient clinical material.

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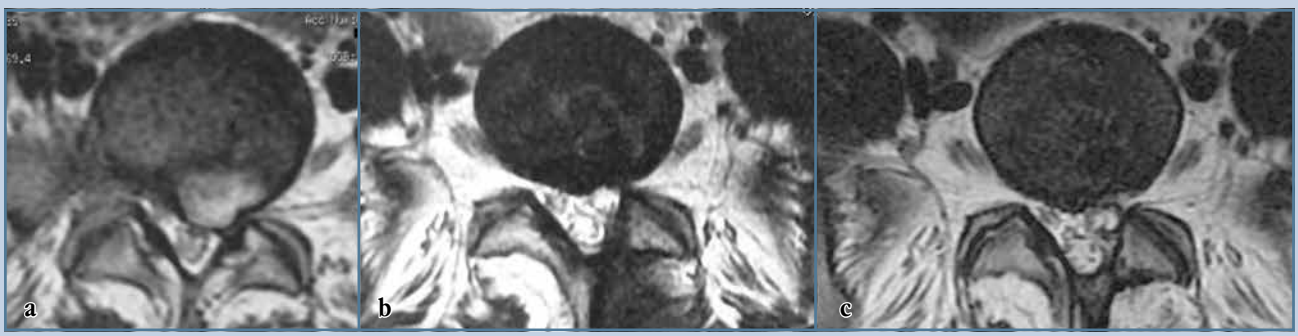

Fig. 4
MRI scans of the L5–S1 intervertebral disc of the female patient F. before surgery **(a)**, 1 year **(b)**, and 5 years **(c)** after surgery

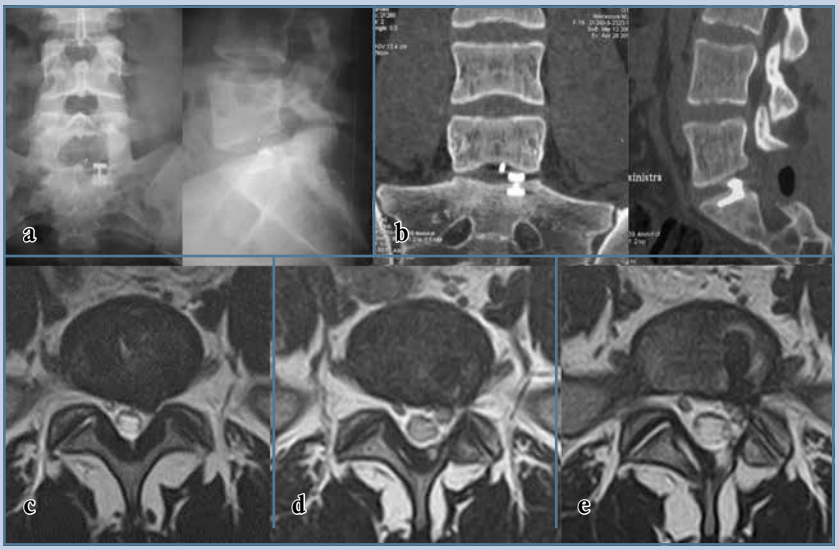

Fig. 5
Data of a 16-year-old female patient N.: radiographs **(a)** and CT scans **(b)** after surgery, MRI scans of the L5–S1 intervertebral disc before surgery **(c)**, 1 year **(d)**, and 3 years **(e)** after surgery

Table 2
Surgical treatment outcomes in adolescents with disc herniation

Patient	Age, years	Follow-up duration, months	L5—S1 disc degeneration based on MRI			Degree of cartilage degeneration				Degree of articular process sclerosis			L5—S1 facet joint angle, deg.
			before surgery	at 3 month	at > 3 years	before surgery		at 3 month	at > 3 years	before surgery	at 3 month	at > 3 years	
1st	11	62	2	2	1	Left*	3	2	2	2	1	1	37°
						Right	2	2	1	1	1	1	36°
2nd	14	61	2	2	2	Left*	3	3	3	2	2	2	34°
						Right	3	3	3	2	2	2	31°
3rd	15	40	3	3	3	Left	2	2	1	1	1	1	35°
						Right*	3	3	2	2	2	2	35°
4th	16	62	3	2	2	Left*	3	2	2	3	2	2	41°
						Right	2	1	1	1	1	1	47°
5th	17	62	3	3	3	Left*	2	2	2	2	2	2	38°
						Right	2	2	2	1	1	1	37°

*surgery side.

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