PEDIATRIC MODIFICATION OF THE JAPANESE ORTHOPEDIC ASSOCIATION SCALE

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Objective. To perform clinical testing of a pediatric modification of the 18-point Japanese Orthopedic Association (mJOA) scale for assessing pathology of the spine and spinal cord in children.

Material and Methods. Functional and neurological status was assessed in 143 pediatric patients with pathology of the spine and spinal cord using the mJOA scale with three age versions (0.5–1.5 years, 1.5–4 years and 4–18 years). The control group included 10 adult patients with a similar pathology profile, who were assessed using the mJOA scale as modified by Benzel.

Results. An initial analysis of mJOA scores across five age groups (0.5–1.5, 1.5–4, 4–8, 8–18, and over 18 years) did not reveal significant differences in final scores. Repeat assessment (mean 3.1 years, range 1–10 years) also showed no significant differences either within or between groups. A secondary analysis was performed in patients with pathology at the cervical, thoracic and lumbar levels of the spinal cord: no significant changes in scale scores were found within the groups over time. At the same time, patients with pathology at the cervical level demonstrated a significantly higher score; they were less likely to have deformity of the lower extremities and dependence on a wheelchair, while sensitivity and movements in the upper extremities were significantly worse than in other groups.

Conclusion. The proposed pediatric mJOA scale demonstrated age consistency and utility. The results of assessing the functional and neurological state of patients using this scale, in addition to being comparable with each other, are comparable with the results of the Benzel mJOA scale in adults.

Key Words: pediatric modification of the Japanese Orthopedic Association scale, pathology of the spine and spinal cord, children.

Please cite this paper as: *Sergeenko OM, Savin DM, Evsyukov AV, Burtsev AV. Pediatric modification of the Japanese Orthopedic Association scale. Russian Journal of Spine Surgery (Khirurgiya Pozvonochnika). 2024;21(2):57–65. In Russian.*

DOI: http://dx.doi.org/10.14531/ss2024.2.57-65.

Sequential assessment of the functional and neurological state of children with spine and spinal cord abnormalities over time, during their growing up, is a challenge for clinicians, as it requires specialized instruments that consider age-related changes. This research provides a new approach that includes the modification of the Japanese Orthopedic Association scale previously modified by Benzel et al. [1] for European adults (mJOA), as well as the modification of the mJOA scale for pediatric patients of different ages with congenital or acquired abnormalities of the spine and spinal cord.

The objective is clinical testing of a pediatric modification of the 18-point Japanese Orthopedic Association (mJOA) scale for assessing spine and spinal cord abnormalities in children.

Material and Methods

There were 143 enrolled patients aged from 6 months to 18 years with spine and spinal cord abnormalities who received treatment at the Ilizarov Center (Kurgan) in 2010–2024. Abnormalities include congenital atlantoaxial dislocation, atlantoaxial rotatory fixation, segmental spinal dysgenesis, as well as open and closed neural tube defects. During the analysis, patients were divided in groups by age and the level of abnormality location.

Assessment was performed using modified versions of the mJOA scale that we adapted for different age groups: mJOA pediatric 0.5–1.5 years (Table 1), 1.5–4.0 years (Table 2), and 4–18 years (Table 3). The control group included 10 subjects over 18 years with similar diseases; they were assessed using the original Benzel's mJOA scale (Table 4). The small size of the control group is associated with the fact that majority of the analyzed abnormalities are typical most particularly for pediatric, not for adult patients.

At the initial visit, each patient was assessed using an age-appropriate scale and subsequently re-assessed after a period of 1 year (minimum) to 10 years (maximum). Clinical and demographic data, including age, diagnosis, and medical history, were registered.

The patients received treatment including surgical procedures on the spine, spinal cord, and lower extremities. Exclusion criteria were severe mental retardation or infantile cerebral paralysis.

Descriptive statistics were used to summarize demographic and clinical data. mJOA scores and other parameters were analyzed using one-way analysis of variance (ANOVA) to identify age-related trends and differences between diagnostic groups. Changes over time were also assessed using the ANOVA test. Analysis of data obtained using the mJOA scale revealed that the distribution of parameters was the normal one. Considering the small number of cases in the sample, statistical parameters were presented as the median with the range of values; it allows more accurate describing the data distribution and minimizing the effect of outliers on the result interpretation.

StatPlus for Microsoft Excel was used to perform the analysis.

Results

The patients enrolled included 143 pediatric and 10 adult patients (64 males and 89 females) aged from 0.5 to 34.1 years (mean age 8.4 ± 6.0 years) with homogeneous abnormalities of the spine and spinal cord. According to the level of spine and spinal cord abnormality, patients were divided into 3 groups: cervical (n = 41), thoracic (n = 41), and lumbar (n = 71) spine. Most patients in the cervical spine group had atlantoaxial dislocation (n = 32) or atlantoaxial rotatory fixation (n = 6) with underlying congenital spine abnormality (Klippel-Feil syndrome); each patient received surgical treatment. Most patients of the thoracic and lumbar spine groups had open and closed neural tube defects (n = 43 and n = 63, respectively) with concomitant spine abnormalities and deformities, tethered spinal cord, and deformities of lower extremities; most of these patients also received surgical treatment.

Table 5 provides the study results with regard to the dividing of patients into five age groups: 0.5–1.5 years (n = 3); 1.5–4 years (n = 37); 4–8 years (n = 47); 8–18 years (n = 56), and 18+ years (n = 10).

In addition to the data provided in Table 5, the groups demonstrated similar values for gender (p-value 0.42), levels of myelopathy/myelodysplasia (cervical spine: p-value 0.08, thoracic spine: p-value 0.08, lumbar spine: p-value 0.96), and types of abnormalities (neural tube defects: p-value 0.15; closed neural tube defects: p-value 0.96; atlantoaxial dislocations: p-value 0.32; atlantoaxial rotatory fixation: p-value 0.34; segmental spinal dysgenesis: p-value 0.21).

Comparison of the general mJOA scores and scores by its sections (motor function of the upper extremities, motor function and sensation in the lower extremities, sensation in the upper extremities, and pelvic organs functions) revealed no significant differenc-

Table 1

Modified Japanese Orthopedic Scale: Age of 6 months to 1.5 years

Motor function of the upper extremities	
No motor function in arms	0
Non-functional movements in arms (inability to hold a toy if it is placed in a hand, unable to bring it to a mouth)	1
Motor function in arms is preserved, low functionality (able to hold a toy if it is placed in a hand, but unable to bring it to a mouth)	2
Motor function in arms is preserved, but functionality is limited, constant assistance is required (able to hold a toy if it is placed in a hand, able to bring it to a mouth, does not crawl, does not roll over)	3
Motor function in arms is preserved, functional, but with minor difficulties, assistance is required occasionally (able to hold a toy if it is placed in a hand, able to bring it to a mouth, able to roll over, but does not crawl)	4
No dysfunction (able to hold a toy if placed in a hand, able to bring it to a mouth, rolls over, crawls)	5
Motor function of the lower extremities	
No motor function or sensation in legs	0
There is sensitivity in legs, responses to painful and tactile stimuli, there may be a reflex contraction of leg muscles, but there are no voluntary movements	1
Non-functional movements in legs, no support reflex (unable to stand or crawl on all fours, no support on knees, severe muscle hypotrophy in legs/secondary leg deformity)	2
Motor function in legs is preserved, but functionality is significantly limited, constant assistance is required (stands on all fours, able to crawl on all fours for less than 1 minute, no reflexes in the lower extremities, severe or moderate muscle hypotrophy/ leg deformity)	3
Motor function in legs is preserved, functional, but with significant difficulties, assistance is often required (stands and crawls on all fours for 1 to 5 minutes, weak reflexes in the lower extremities, severe or moderate muscle hypotrophy, leg deformity)	4
Moderate motor function disorders in legs, assistance is required occasionally (stands and crawls on all fours for 5 to 10 minutes, weak reflexes in the lower extremities, moderate deformity of one or both feet)	5
Mild motor function disorders in legs, no assistance is required (stands and crawls on all fours for more than 10 minutes, able to stay on the feet or walk with support, able to sit down independently, weak reflexes in the lower extremities, decreased tone in the leg muscles, mild secondary deformation of one or both feet)	6
Normal motor function in legs (stands and crawls on all fours and/or stands and walks with support, normal reflexes in the lower limbs, no leg extremities, normal muscle tone in legs)	7
Sensory impairment of the upper extremities	
Complete lack of sensitivity (no motor response to pain, tactile stimulation or palpation of an extremity)	0
Severe and moderate sensory impairment (decreased all types of sensitivity, a patient turns the head during sensitivity tests, but there is no motor response or it is extremely weak)	1
Mild sensory impairment. Motor response to one of three types of stimuli is extremely weak (pain, tactile or proprioceptive) with an active response to other stimuli (pulling away/bending an arm, crying)	2
No of sensory impairment (a patient bends the arm during sensitivity tests, a clear response to all types of sensory stimuli)	3
Neurogenic disorders of urination and defecation	
Does not control urination and defecation completely (constant urine leakage or urinary retention requiring catheterization, hydroureteronephrosis and vesicoureteral reflux, frequent urinary infections, lack of anal reflex, dilated anus, fecal smearing or prolonged constipation)	0
Significant problems with urination and defecation (recurrent urinary tract infections, intermittent urinary leakage, intermittent urinary retention requiring catheterization, hydroureteronephrosis and vesicoureteral reflux, weak anal reflex, fecal smearing or prolonged constipation)	1
Mild urinary and defecation impairment (history of single urinary tract infection, vesicoureteral reflux, residual urine after urination, episodes of constipation)	2
No dysfunction (a child urinates every 2-4 hours, without urine leakage, no residual urine after urination, regular defecation and preserved anal reflex)	3

Table 2

Modified Japanese Orthopedic Scale: Age of 1.5 to 4 years

Motor function of the upper extremities	
No motor function in arms	0
Non-functional movements in arms (inability to hold a toy, a spoon, a pen)	1
Motor function in arms is preserved, low functionality (able to hold a toy, a spoon, a pen, but unable to raise straight arms and bring them to the midline in a prone position)	2
Motor function in arms is preserved, but functionality is limited, constant assistance is required (able to hold and use a toy, a spoon, a pen, able to raise straight arms and bring them to the midline in a prone position, but unable to lift and throw a ball)	3
Motor function in arms is preserved, functional, but with minor difficulties, assistance is required occasionally (able to hold and play with a toy, able to draw with pencil, able to lift and throw a ball, able to eat by hands and by means of a spoon, but unable to hang on a horizontal bar)	4
No dysfunction (able to hold and play with a toy, able to draw with pencil, able to lift and throw a ball, able to eat by hands and by means of a spoon, able to hang on a horizontal bar)	5
Motor function of the lower extremities	
No motor function or sensation in legs	0
There is sensitivity in legs, responses to painful and tactile stimuli, there may be a reflex contraction of leg muscles, but there are no voluntary movements	1
Motor function in legs is preserved, low functionality (able to stand on all fours, but unable to crawl or walk)	2
Motor function in legs is preserved, but functionality is significantly limited, constant assistance is required (able to crawl, stand and walk only with support or special means and only on a flat surface)	3
Motor function in legs is preserved, functional, but with significant difficulties (able to take a few steps without support, but then help or additional verticalization aids are required, unable to go upstairs even with help, does not jump)	4
Moderate gait disturbances, assistance is required occasionally (walks independently, with moderate unsteadiness, able to step over a small obstacle independently or with support, able to go up- and downstairs with assistance or holding onto handrails, unable to jump in place or forward, unable to kick a ball)	5
Mild gait disturbances, no assistance is required (walks independently, able to go up- and downstairs with assistance or holding onto handrails, able to jump on both feet, but unable to jump on one foot, unable to kick a ball)	6
No dysfunction (walks steadily forward and backward, able to go up- and downstairs without support, good jumping strength, able to stand on tiptoes, jump on one foot, kick a ball with right and left foot)	7
Sensory impairment of the upper extremities	
Complete lack of sensitivity (no motor response to pain, tactile stimulation or palpation of an extremity)	0
Severe and moderate sensory impairment (decreased all types of sensitivity, a patient turns the head during sensitivity tests, but there is no motor response or it is extremely weak)	1
Mild sensory impairment. Motor response to one of three types of stimuli is extremely weak (pain, tactile or proprioceptive) with an active response to other stimuli (pulling away/bending an arm, crying)	2
No of sensory impairment (a patient bends the arm during sensitivity tests, a clear response to all types of sensory stimuli)	3
Neurogenic disorders of urination and defecation	
Does not control urination and defecation completely (constant urine leakage or urinary retention requiring catheterization, frequent urinary infections, lack of anal reflex, dilated anus, fecal smearing or prolonged constipation)	0
Significant problems with urination and defecation (urinary retention with occasional leakage, urine leakage during physical activity, need to change diapers or use a catheter more than three times a day, constipation with occasional defecation)	1
Mild urinary and defecation impairment (intermittent leakage of urine, a feeling of incomplete bladder emptying, the need to change diapers or use a catheter less than three times a day, residual urine after urination)	2
No dysfunction (a child urinates every 2–4 hours, without urine leakage, no residual urine after urination, regular defecation and preserved anal reflex)	3

es between pediatric and adult patients (p-value 0.40).

Patients were re-assessed after a mean follow-up of 3.1 years (min 1 year; max 10 years) using age-appropriate scale. There were no significant changes in such results over time.

Table 6 provides the results of a comparison of patients with abnormalities located at the cervical (41 subjects), thoracic (41 subjects), and lumbar (71 subjects) spine. Results of the preliminary analysis (in addition to the data provided in Table 6) demonstrated that the groups were similar in the parameters of gender (p-value 0.16) and age (p-value 0.26).

It should be mentioned that deformity of the lower extremities (p-value 0.0000), psychomotor retardation (p-value 0.001), and wheelchair dependence (p-value 0.03) were less common in the patients of cervical level group indicating milder clinical signs and milder spinal cord injury. When comparing values for sections of the mJOA scale (motor function of the upper extremities, motor function and sensation in the lower extremities, sensation in the upper extremities, and pelvic organs functions), lower scores for motor function and sensation in the upper extremities were revealed in the cervical level group (p-value 0.0000). However, the grade of paresis in the lower extremities and pelvic organs dysfunction was more severe in the thoracic and lumbar spine groups (p-value 0.0000).

The thoracic and lumbar spine groups demonstrated more common deformity of lower extremities and wheelchair dependence (p-value 0.0000 and 0.03). The general mJOA score was various, with a maximum value in patients of the cervical spine group and a minimum value in patients of the thoracic spine group (p-value 0.02). At the end of the follow-up period, patients were re-assessed using age-appropriate scale: the same intergroup differences remained, moreover, values obtained for the score sections and the total score demonstrated no significant changes over time.

Discussion

The classic JOA scale that was originally developed to assess neurological symptoms in adults with spinal abnormalities included four sections for the assessment of motor function in the upper and lower extremities, sensation in the upper extremities, chest, abdomen, and lower extremities. This scale used a total score system ranging from 0 to 17 points [2]. Several modifications of the JOA scale have been proposed over time, with the most popular one performed in 1991 by Benzel et al. [1, 3–5].

The mJOA scale modified by Benzel et al. includes four sections for the assessment of motor function in the upper extremities (0–5 points), sensation and motor function in the lower extremities (0–7 points), sensation in the upper extremities (0–3 points), and bladder function (0–3 points) using a total score system of 0–18 points. Its simple design and scoring system make it easy-to-use for both healthcare professionals and patients. Its adaptability to different languages and cultures contributes to its high use in different regions and different populations. Its flexible use provides consistent and standardized assessments in diverse demographic groups of patients with spine and spinal cord abnormalities.

Originally developed for adult patients with cervical spondylotic myelopathy, this scale has become popular primarily in studies of the effectiveness of treatment in patients with this condition. However, every year there appears a growing number of works with its use for the diseases of the thoracic [6–11] and lumbar [12–15] spine. Currently, this scale is successfully used not only in trials of spinal degenerative diseases and deformities, but also in trials on spinal and spinal cord injuries [16, 17], tuberculous spondylitis [18], spinal cord and spine tumors [19], arachnoid cysts of spinal cord [20–22], Chiari malformation, and syringomyelia [23, 24].

There were attempts to use this scale in pediatric patients [25–29], however, it is obvious that it requires modifications, especially for the patients under 8 years of age.

Table 3

Modified Japanese Orthopedic Scale: Age of 4 years and over

Motor function of the upper extremities	
No motor function in arms	0
Non-functional movements in arms (able to move a hand, but unable to hold objects, a spoon, a toothbrush, a comb)	1
Motor function in arms is preserved, low functionality (able to hold a spoon and other objects, but unable to use them)	2
Motor function in arms is preserved, but functionality is limited, with significant difficulties, constant assistance is required (able to eat with a spoon, brush teeth, comb hair, put on clothes, use zippers only with constant assistance)	3
Motor function in arms is preserved, functional, but with minor difficulties, assistance is required occasionally (able to eat with a spoon, brush teeth, comb hair, put on clothes, use zippers, fasteners and tie shoelaces, but slowly and clumsily)	4
No dysfunction	5
Motor function of the lower extremities	
No motor function and sensation in legs	0
There is sensitivity in legs, responses to painful and tactile stimuli, there may be a reflex contraction of leg muscles, but there are no voluntary movements	1
Motor function in legs is preserved, low functionality (able to move legs and stand with support/assistance, but unable to walk)	2
Motor function in legs is preserved, but functionality is limited, with significant difficulties, constant assistance is required (able to walk on even floor with support/assistance, but unable to go upstairs)	3
Motor function in legs is preserved, functional, but with significant difficulties, assistance is often required (walks independently but unsteadily, able go up- and downstairs only with help or holding onto handrails)	4
Moderate gait disturbances, assistance is required occasionally (walks with moderate unsteadiness but requires assistance or holds onto handrails when going up- or downstairs)	5
Mild gait disturbances, no assistance is required (walks with slight unsteadiness, but able to go up- and downstairs without assistance or holding onto handrails)	6
No dysfunction	7
Sensory impairment of the upper extremities	
Complete lack of sensitivity (no motor response to stimuli)	0
Severe and moderate sensory impairment (decreased all types of sensitivity)	1
Mild sensory impairment (decrease or absence of superficial sensitivity while maintaining pain and deep sensitivity)	2
No of sensory impairment	3
Neurogenic disorders of urination and defecation	
Does not control urination and defecation (constant urine leakage or urinary retention requiring catheterization 6 times a day, lack of anal reflex, patulous anus, fecal smearing or prolonged constipation)	0
Significant problems with urination and defecation (urinary retention with occasional leakage, frequent urine leakage during physical activity, need to change pads/diapers or use a catheter more than three times a day, constipation, fecal smearing)	1
Mild urinary and defecation impairment (occasional urine leakage, a feeling of incomplete bladder emptying, the need to change pads/diapers or use a catheter less than three times a day, residual urine after urination)	2
No dysfunction (a child urinates every 2-4 hours, without urine leakage, no residual urine after urination, regular defecation and preserved anal reflex)	3

Childhood is characterized by fast changes in functional status over time. For example, a baby holds his/her head up after 2 months of age, crawls after 6 months, sits after 8 months, starts walking on a flat surface after 1 year, walks upstairs independently after 2 years, fastens buttons and ties shoelaces at 5–6 years, etc. [30]. Our modification of the JOA scale was developed for pediatric patients considering all these specific features. It can be used in the trials of spine and spinal cord abnormalities that are typical for pediatric patients, such as cer-

Table 4
Modified Japanese Orthopedic Scale (Benzel)

Assessment of motor dysfunction of the upper extremities	
No motor function in arms	0
Unable to eat with a spoon, but able to move arms	1
Unable to button a shirt, but able to eat with a spoon	2
Able to button a shirt with significant difficulty	3
Able to button a shirt with mild difficulty and clumsily	4
No dysfunction	5
Assessment of motor dysfunction of the lower extremities	
No motor function and sensation in legs	0
Maintaining sensation without the ability to move legs	1
Able to move legs, but unable to walk	2
Able to walk on even floor with support/assistance (eg, a cane or crutch)	3
Able go up- and/or downstairs holding onto handrails	4
Moderate or mild unsteadiness, but able to go up- or downstairs without holding onto handrails	5
Slight unsteadiness, but able to walk without support and with smooth interaction	6
No dysfunction	7
Sensory impairment of the upper extremities	
Complete lack of sensitivity	0
Severe sensory impairment or pain	1
Mild sensory impairment	2
No of sensory impairment	3
Sphincter dysfunction	
Unable to urinate independently	0
Significant problems with urination	1
Moderate and mild problems with urinary	2
Normal urination	3

vical stenosis associated with atlantoaxial dislocations, systemic diseases (spondyloepiphyseal dysplasia, mucopolysaccharidosis), Chiari malformations, thoracic stenosis associated with segmental spinal dysgenesis, spinal deformity and myelodysplasia associated with open and closed neural tube defects, as well as syringomyelia, spine and spinal cord tumors, tuberculous spondylitis, spine and spinal cord injury. This modified scale provides the continuous assessment of the patient's functional and neurological state throughout his/her childhood and adolescence. The pediatric mJOA scale can be used in patients with this spectrum of diseases until adulthood, followed by the Benzel's mJOA scale that allows monitoring significant functional changes in adulthood [31, 32].

The research demonstrated the age-related consistent use of the developed scale and the possibility of its widespread use in pediatric patients with abnormalities not only of the cervical spine, but also of the thoracic and lumbar spine.

Limitations of the research.

There are several limitations that may be expected to have an effect on the results obtained:

1) small number of patients under 1.5 years, as well as small number of adult patients in the control group;

2) most patients underwent neurosurgical and/or orthopedic surgical treatment; this fact could possibly have an effect on clinical evaluations, however, the results using the scale revealed no significant changes in neurological status during the follow-up period;

3) mild mental retardation in several patients could possibly have an effect on their score.

Conclusion

This research reveals the possibility of the consistent use of the new pediatric mJOA scale for assessing the spine and spinal cord abnormalities both in different age groups, and at different levels of disease location (cervical, thoracic and lumbar spine). The adaptability of the scale to pediatric cases demonstrates its value in monitoring long-term changes, confirms its reasonable use at different periods of childhood in patients with spine and spinal cord abnormalities, as well as its comparability with the Benzel's mJOA scale developed for adult patients.

The study had no sponsors. The authors declare that they have no conflict of interest.
The study was approved by the local ethics committees of the institutions. All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication.

Table 5

Age-stratified analysis of assessment using pediatric mJOA scales during the follow-up period of 1 to 10 years

Parameter		Value				
Age at the time of examination, years		0.5–1.5	1.5–4	4–8	8–18	18+
Number of examined subjects, n		3	37	47	56	10
Gender (n, %)	male	–	16 (43)	18 (38)	27 (48)	3 (30)
	female	3 (100)	21 (57)	29 (62)	29 (52)	7 (70)
Age 1, years, median (range)		1 (0.5–1.3)	2.7 (1.6–3.9)	6.1 (4.0–7.9)	10.6 (8.0–17.4)	23.5 (19.4–34.1)
Time to re-assessment, years, median (range)		4 (3.0–4.5)	2 (1.0–7.0)	3 (1.0–10.0)	3 (1.0–9.0)	2.5 (1.0–6.0)
Age 2, years, median (range)		4.9 (4.3–5.0)	4.8 (2.6–10.0)	8.6 (5.3–16.3)	14.4 (9.2–25.3)	26.6 (20.4–35.1)
Age 1: motor function in arms (assessment, median, range)		5 (3–5)	5 (0–5)	5 (2–5)	5 (1–5)	5 (3–5)
Age 2: motor function in arms (assessment, median, range)		5	5 (1–5)	5 (3–5)	5 (3–5)	5 (3–5)
p-value		0.37	0.91	0.18	0.36	0.77
Age 1: motor function and sensitivity in legs (assessment, median, range)		5 (2–5)	3 (0–7)	3 (0–7)	6 (0–7)	5 (2–7)
Age 2: motor function and sensitivity in legs (assessment, median, range)		7 (4–7)	3 (0–7)	4 (0–7)	6 (0–7)	5 (2–7)
p-value		0.23	0.40	0.72	0.32	0.90
Age 1: sensitivity in arms (assessment, median, range)		3	3 (0–3)	3 (2–3)	3 (0–3)	3 (2–3)
Age 2: sensitivity in arms (assessment, median, range)		3	3 (1–3)	3 (2–3)	3 (1–3)	3 (2–3)
p-value		1.00	1.00	0.14	0.63	1.00
Age 1: pelvic organs function (assessment, median, range)		3 (1–3)	1 (0–3)	2 (0–3)	3 (0–3)	3 (0–3)
Age 2: pelvic organs function (assessment, median, range)		3 (1–3)	2 (0–3)	2 (0–3)	3 (0–3)	3 (0–3)
p-value		1.00	0.79	0.83	0.81	0.84
Age 1: general mJOA (assessment, median, range)		14 (11–16)	12 (0–18)	12 (6–18)	16 (1–18)	16 (10–18)
Age 2: general mJOA (assessment, median, range)		18 (13–18)	13 (3–18)	14 (8–18)	17 (5–18)	15 (10–18)
p-value		0.29	0.56	0.55	0.39	0.94

mJOA – modified Japanese Orthopedic Association scale: Benzel modification was used for all individuals over 18 years of age, and the new pediatric modification was used for children under 18 years of age.

Table 6

Pathology level-stratified analysis of assessment using pediatric mJOA scales during the follow-up period of 1 to 10 years

Parameter		Cervical spine pathology	Thoracic spine pathology	Lumbar spine pathology
Number of patients, n		41	41	71
Pathology	ONTD, n (%)	–	22	20
	CNTD, n (%)	1	14	49
	AAD, n (%)	32	–	–
	SSD, n (%)	2	5	2
	AARF, n (%)	6	–	–
Age 1, years, median (range)		9 (0.5–24.0)	4.8 (1.7–34.1)	7.1 (1.0–26.5)
Time to re-assessment, years, median (range)		2.1 (1–8)	3 (1–9)	2 (1–10)
Age 2, years, median (range)		12.2 (4.0–27.2)	8.8 (2.9–35.1)	10.6 (2.6–31.5)
Age 1: motor function in the upper extremities (assessment, median, range)		5 (0–5)	5 (3–5)	5 (3–5)
Age 2: motor function in the upper extremities (assessment, median, range)		5 (1–5)	5	5 (3–5)
p-value		0.18	0.18	1.00
Age 1: motor function and sensitivity in the lower extremities (assessment, median, range)		7 (0–7)	2 (0–7)	5 (0–7)
Age 2: motor function and sensitivity in the lower extremities (assessment, median, range)		7 (1–7)	3 (0–7)	5 (0–7)
p-value		0.34	0.47	0.39
Age 1: sensitivity in the upper extremities (assessment, median, range)		3 (0–3)	3 (2–3)	3 (2–3)
Age 2: sensitivity in the upper extremities (assessment, median, range)		3 (1–3)	3	3 (2–3)
p-value		0.49	0.16	0.73
Age 1: pelvic organs function (assessment, median, range)		3 (0–3)	0 (0–3)	3 (0–3)
Age 2: pelvic organs function (assessment, median, range)		3 (0–3)	0 (0–3)	2 (0–3)
p-value		0.44	0.88	1.00
Age 1: general mJOA (assessment, median, range)		18 (0–18)	10 (6–18)	15 (6–18)
Age 2: general mJOA (assessment, median, range)		18 (3–18)	11 (8–18)	15 (6–18)
p-value		0.31	0.51	0.60

AAD – atlantoaxial dislocation; AARF – atlantoaxial rotatory fixation; CNTD – closed neural tube defect; ONTD – open neural tube defect; SSD – segmental spinal dysgenesis; mJOA – modified Japanese Orthopedic Association scale: the Benzel modification is used for all individuals over 18 years of age, and the new pediatric modification is used for children under 18 years of age.

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Received 28.02.2024
Review completed 10.03.2024
Passed for printing 20.03.2024

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