

## CLINICAL IMPLICATIONS OF THE NEUROSEGMENTAL LEVEL OF INJURY IN THE TREATMENT OF HIP DISLOCATION AND SUBLUXATION IN CHILDREN WITH SPINA BIFIDA

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**Background.** Hip dislocation and subluxation are common in children with *spina bifida*.

**Aim.** To determine the influence of the neurosegmental level on surgical treatment of hip dislocation and subluxation in children with *spina bifida*.

**Materials and methods.** A total of 114 pediatric patients with *spina bifida* and hip dislocation and subluxation were treated at The Turner Scientific and Research Institute for Children's Orthopedics (Saint Petersburg, Russia) from 2006 to 2015. The patients were divided into two groups according the Sharrard classification of neurosegmental lesions: a study group of 62 patients who underwent hip stabilization surgery and a control group of 52 patients who did not undergo hip stabilization procedures.

**Results.** For patients with a high neurosegmental level (thoracic and L1-L2), surgical treatment for hip dislocation and subluxation, which included most cases (72%), led to motor deterioration (retrospective study). Of 40 patients with a neurosegmental level of L3-L4 and L5-S1, motor level improved in 13 (32.5%) but deteriorated in 10 (36%) of 28 patients in the control group.

**Conclusion.** Determination of the neurosegmental level enables the prediction of motor level and reveals indication for surgical treatment.

**Keywords:** *spina bifida*, neurosegmental level, hip dislocation, hip subluxation.

## НЕЙРОСЕКМЕНТАРНЫЙ УРОВЕНЬ И ЕГО ЗНАЧЕНИЕ ПРИ ЛЕЧЕНИИ ПОДВЫВИХА И ВЫВИХА БЕДРА У ДЕТЕЙ С ПОСЛЕДСТВИЯМИ СПИННОМОЗГОВЫХ ГРЫЖ

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**Актуальность.** Патология тазобедренного сустава у детей с последствиями спинномозговых грыж является частым сопутствующим состоянием и в подавляющем большинстве случаев сопровождается формированием подвывиха и вывиха бедра.

**Цель исследования** — определение влияния нейросекментарного уровня на результаты хирургического лечения подвывиха и вывиха бедра у детей с последствиями спинномозговых грыж.

**Материалы и методы.** В ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России в период с 2006 по 2015 год проведено обследование и лечение 114 пациентов с подвывихом и вывихом бедра с последствиями спинномозговых грыж. Основная группа представлена 62 пациентами, которые получили хирургическое лечение, направленное на стабилизацию тазобедренного сустава. Контрольная группа — 52 ребенка, которые хирургического лечения по поводу подвывиха и вывиха бедра не получили. Внутри каждой группы пациенты распределены на две подгруппы в зависимости от нейросекментарного уровня поражения спинного мозга, используя методику Sharrard.

**Результаты.** У пациентов основной группы с высокими нейросекментарными уровнями (грудной и L<sub>1</sub>-L<sub>2</sub>) хирургическое лечение подвывиха и вывиха бедра в большинстве случаев (16 из 22, то есть 72 %) привело к ухудшению двигательного уровня (архивный материал); у пациентов с нейросекментарными уровнями L<sub>3</sub>-L<sub>4</sub>

и L<sub>5</sub>-S<sub>1</sub> в 13 из 40 случаев (32,5 %) двигательный уровень улучшился, в то время как у пациентов контрольной группы двигательные возможности ухудшились в 10 из 28 (36 %) случаев.

**Заключение.** Определение нейросегментарного уровня позволяет прогнозировать двигательный уровень пациента, тем самым определяя тактику лечения вывиха или подвывиха бедра.

**Ключевые слова:** спинномозговая грыжа, нейросегментарный уровень, вывих и подвывих бедра.

## Introduction

Spina bifida is caused by defective embryonic development of the nervous system and is accompanied by a complex set of clinical manifestations in the spine and spinal cord and in other areas, such as the musculoskeletal and genitourinary systems.

The orthopedic manifestations of spina bifida may be congenital in nature, and these form and progress during postnatal growth and development of the child. Congenital orthopedic manifestations of spina bifida include malformation of the spine, joint contractures, and deformation of the lower extremities caused by intrauterine effects of the neurological deficit on prenatal development. These are detected immediately after birth. Most orthopedic disorders have distinctive dynamics in the postnatal period. The development of the orthopedic effects of spina bifida is characterized by features unusual for the pathogenesis of other paralytic deformities with its main characteristics being muscular imbalance, trophic disturbances, aggravating impact of static and dynamic factors, and the absence of orthopedic prevention of deformities [1–3].

The hip joint defect in children with spina bifida is a frequent comorbidity and is commonly accompanied by the formation of hip subluxation and dislocation. According to various authors, 30%–50% of children with spina bifida develop subluxation or dislocation of the hip joint during the first 2–3 years of life [4]. Most scientists associate the formation of hip subluxation and dislocation with the nature of the primary lesion in the segmental apparatus of the spinal cord, specifically at the neurosegmental level [5].

Neurosegment refers to a specific portion of the spinal cord in a horizontal plane, giving rise to one pair of spinal nerves [6]. Both in foreign and Russian literature, there are several published reports on the effect of the neurosegmental level of involvement of spina bifida on the indications for treatment of orthopedic disorders [7–9].

The study objective was to determine the effects of the neurosegmental level of spina bifida on the

outcomes of surgical treatment of hip subluxation and dislocation in children with spina bifida.

## Materials and methods

A total of 114 pediatric patients with spina bifida and hip dislocation and subluxation were examined and treated at The Turner Scientific and Research Institute for Children's Orthopedics (Saint Petersburg, Russia) between 2006 and 2015. All patients and/or their parents or guardians signed a voluntary informed consent to participate in the study and for surgery. To assess the hip joints, we used standard and functional X-ray projections. As an indicator determining the degree of gradation of disorders in the hip joint by radiography, we used the most common measurement, which is the migration index for the frontal plane. Hip subluxation was defined as a migration index value of more than 40%. Hip dislocation was characterized as a complete disconnection of the acetabular and femoral articular surfaces.

This study is a comparative analysis of the results of examination and treatment of patients divided into a study group and a control group. The study group consisted of 62 patients, who received surgical treatment to stabilize the hip joint, and the control group comprised 52 patients, who did not undergo surgery for hip subluxation and dislocation.

To eliminate hip subluxation and dislocation, we performed reconstructive surgery, including interventions in the hip and pelvic components of the joint. Femoral bone osteotomy was performed in all cases of joint reconstruction by established procedures considering the initial parameters of the neck-shaft angle and the angle of antetorsion. The correction of changes in the pelvic joint component was performed based on the patient's age, the acetabular index values, and the change in the value of the acetabulum rear edge angle.

During the examination, the neurosegmental level by Sharrard's classification, based on the principle of the force evaluation (in points) of the major muscle groups of the lower extremities innervated by corresponding neurosegments, was determined [10] (Table 1).

Table 1

Classification of motor disorders by Sharrard's neurosegmental level

Level	Muscular force	Neurosegmental level
1	Force of the plantar flexors of foot (4–5 points)	S2
2	Force of the plantar flexors of foot (less than 3 points) Force of the tibia flexor (3 points) Force of the flexors and/or hip abductor muscles (2–3 points)	S1–L5
3	Force of the hip flexors (4–5 points) Force of the tibia flexors (less than 3 points) Force of the extensors and hip abductor muscles (1–2 points)	L4–L3
4	Absence of active extension of the knee joint Force of the hip flexors (adductor muscles) (less than 2 points) Raising the pelvis (3–4 points)	L2–L1
5	Absence of muscle activity of the lower extremities Absence of the ability to raise the pelvis above the support surface in a horizontal position	Thoracic

Two clinical subgroups were formed in the study and control groups of patients considering the involved neurosegmental level.

- Patients with lesions at high neurosegmental levels: thoracic and L1–L2 levels
- Patients with lesions at low neurosegmental levels: L3–L4 and L5–S1 levels

Until 2009, the criterion for inclusion in the study group was the presence of hip subluxation or dislocation, regardless of the neurosegmental level of the lesion, and the criterion for inclusion in the control group was the presence of decompensated somatic pathology or refusal of parents for the surgical treatment (subgroup 1). After 2009, the criteria for inclusion in the study group were expanded to the presence of hip subluxation and

dislocation and the involvement of neurosegmental levels L3–L4 and L5–S1, and the criteria for inclusion in the control group were contraindications for surgical treatment because of the presence of hip subluxation or dislocation and involvement of thoracic level and neurosegmental levels L1–L2, somatic pathology, or refusal of parents for the surgical treatment.

Fig. 1 shows the distribution of patients in the study and control groups.

In all the patients, the motor level was determined by a method proposed by the Medical University of Melbourne for children with consequences of spina bifida, which involves five levels of motor activity (Table 2).

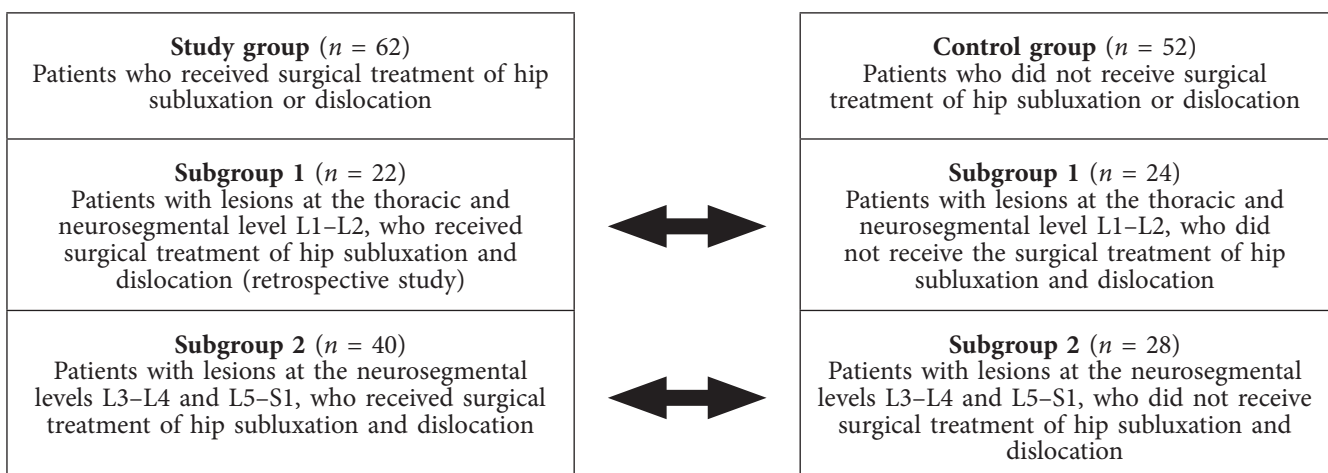


Fig. 1. The distribution of patients in the study and control groups

Table 2

Assessment of motor levels of patients with consequences of spina bifida, proposed by the Medical University of Melbourne

Functional capabilities of the patients	Motor level
Ability to walk no worse than peers	5
Walking with the use of orthoses of the ankle joint without additional support; using a wheelchair for long distance only.	4
Walking within the home using orthoses and additional support; using a wheelchair both outside and inside the home.	3
Walking during treatment at school for a limited time at home; using a wheelchair for moving.	2
Absence of walking	1

Motor level assessment was performed in patients before and after treatment.

## Results and discussion

Based on the results of the examination and treatment, we performed a comparative assessment of the dynamics of the motor levels in patients with lesions at the thoracic level and neurosegmental level L1–L2 (subgroup 1) for the study and control groups. The results are shown in Fig. 2.

As seen from the data in Fig. 2, the motor level did not improve as a result of treatment in any of the pediatric patients in the study group, and in 16 of 22 (73%) patients, the motor level deteriorated. Our analysis of potential causes of this deterioration in the postoperative period showed that 16 of 22 patients had spontaneous fractures of the long bones of the lower extremities due to severe osteoporosis, which often occurs in patients with this condition.

We performed a comparative analysis of the incidence of fractures in patients with lesions at the thoracic level and neurosegmental levels L1–L2 in the study and control groups during the

follow-up period. For patients in the study group, the number of fractures was significantly greater than that in the control group, with 14 of 16 (87%) patients experiencing more than two fractures. The patients with spina bifida are characterized by the appearance of fractures without any obvious trauma.

In the control group, the motor capabilities improved in six of 24 (25%) patients. In four of 24 patients, the motor capabilities deteriorated, and these deteriorations were associated with fractures that occurred during the rehabilitation treatment conducted. In the remaining 14 patients, the motor capabilities did not change. These patients had no contracture in the hip joints, which prevented them from sitting or lying down, and were able to move only by a wheelchair.

Thus, in patients with lesions at high neurosegmental levels (thoracic and L1–L2), the surgical treatment of hip subluxation and dislocation did not improve the motor level, and in the majority of patients (in our study in 16 of 22, i.e., 72%), their motor level deteriorated. The decrease in motor load in the postoperative period resulted in a decrease in bone density, the

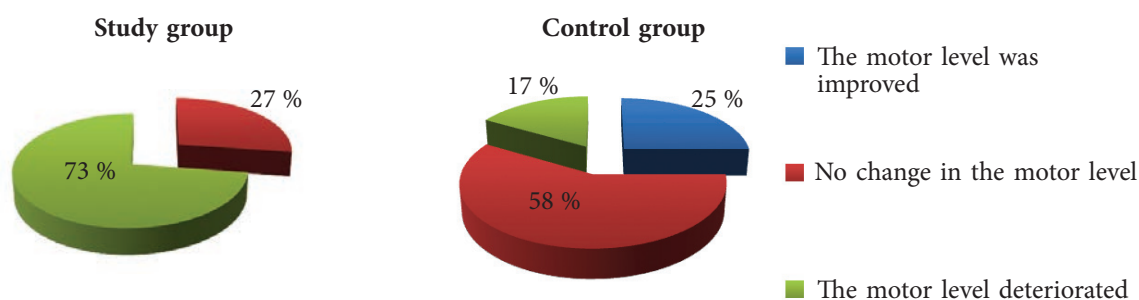


Fig. 2. Dynamics of the motor level in patients with thoracic level and neurosegmental level L1–L2 in the study and control groups

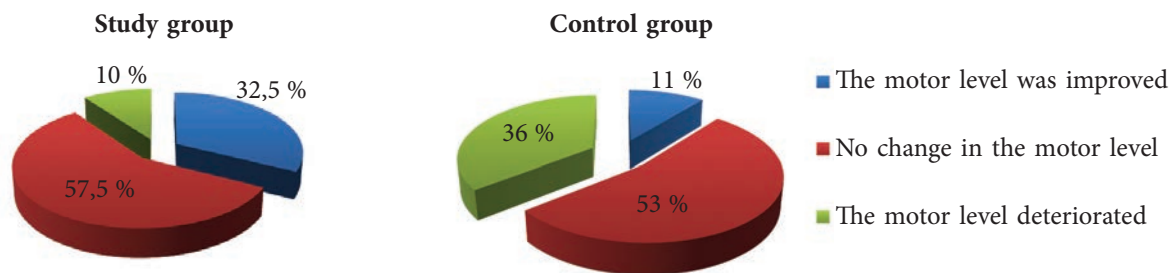


Fig. 3. The dynamics of the motor level in patients with lesions at neurosegmental levels L3–L4 and L5–S1 in the study and control groups

development of osteoporosis, and the formation of a “cascade” of fractures of the long bones, which inevitably led to the deterioration of motor abilities in the patient.

We also performed a comparative assessment of the dynamics of the motor level in patients with lesions at neurosegmental levels L3–L4 and L5–S1 in the study and control groups (subgroup 2). The results are shown in Fig. 3.

As seen in Fig. 3, surgical treatment of hip subluxation and dislocation in the study group improved the motor level in 13 of 40 (32.5%) patients. In 23 of 40 (57.5%) patients, the motor level remained at the preoperative level. At the time of the surgery, all patients had the highest possible motor level, and with timely surgical treatment, the achieved motor capabilities of the patient could be maintained. For the patients in the control group, the motor capabilities deteriorated in 10 of 28 (36%) cases.

Thus, surgical treatment of this patient population with hip subluxation and dislocation resulted in improvement of the motor level in 32.5% cases, whereas the absence of the surgical treatment resulted in motor level deterioration in 36.0% patients.

The results of these studies suggest that neurosegmental level of the lesion determines both the indications for surgical treatment of hip subluxation or dislocation and the motor level of the child.

## Conclusions

1. When planning surgical treatment of pediatric patients with spina bifida with hip subluxation and dislocation, the neurosegmental level of the lesion and the motor level of the child determine the indication of the treatment.

2. The surgical treatment of hip subluxation and dislocation in pediatric patients with lesions

at the thoracic and neurosegmental level L1–L2 is not indicated because it does not lead to an improvement in motor level.

3. The surgical treatment of hip subluxations and dislocations in children with lesions at the neurosegmental levels L3–L4 and L5–S1 demonstrated an improvement of the motor level in 32.5% cases.

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