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# SELECTIVE DORSAL RHIZOTOMY IN CEREBRAL PALSY: THE EFFICIENCY AND THE SPECIFIC FEATURES OF REHABILITATION

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## ABSTRACT

*Selective dorsal rhizotomy is one of the methods used for surgical correction of spasticity in the muscles of the lower limbs with high level of evidence among the patients with cerebral palsy. At the same time, the long-term positive results after surgery can be achieved only when combining surgical treatment with rehabilitation activities. The provided literature review contains a historic reference on the development of the technology along with the current data on the efficiency of surgical intervention with the analyzed research results in terms of the methods and the specific features of rehabilitation among the patients with the diagnosis of cerebral palsy after selective dorsal rhizotomy. Just like other treatment methods, selective dorsal rhizotomy does not exclude the probability of developing complications, but the individual approach during the course of combined, long-term and intensive rehabilitation, as well as following the clinical protocols, can minimize these risks. Stable improvement of motor functions, as well as an increase in the quality of life among patients after selective dorsal rhizotomy and combined rehabilitation courses, confirm the efficiency and the perspectivity of this method.*

***Keywords:*** *cerebral palsy; selective dorsal rhizotomy; spasticity; rehabilitation; physical therapy.*

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## INTRODUCTION

In the Republic of Kazakhstan, just like worldwide, cerebral palsy takes one of the leading places among the incapacitating diseases in children and adolescents. As of the year of 2022, the number of disabled children aged 0–17 years in Kazakhstan was 104,260, of which there were 61,047 boys and 43,213 girls. In 29% of the cases, the causes of cerebral palsy were the diseases of the nervous system. Thus, according to data from the Bureau of National Statistics under the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, in 2022, a total of 14,387 children were registered with newly developing disability, of which 8,497 were boys and 5,890 were girls[1, 2]. Worldwide, each 1,000 of newborns has 2 to 3 cases of cerebral palsy [1]. The spasticity in this type of disease is the predominant type of motor activity impairment (85.8%) [2].

The basis of the pathogenetic mechanism of developing spasticity is the loss of inhibitory control (the disinhibition) over the segmental motor mechanisms on the side of the central neurons and spinal reflexes up to the complete disinhibition of the latter. In cases of spastic diplegia, the hypertone in the lower limbs is more pronounced comparing to upper limbs. The research works with the participation of 1,050 children with the diagnosis of cerebral palsy have studied the spasticity of separate muscles in the lower limbs before and after treatment: the evaluation included the tone of the hip adductor muscle, the hip flexor

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# СЕЛЕКТИВНАЯ ДОРСАЛЬНАЯ РИЗОТОМИЯ ПРИ ЦЕРЕБРАЛЬНОМ ПАРАЛИЧЕ: ЭФФЕКТИВНОСТЬ И ОСОБЕННОСТИ РЕАБИЛИТАЦИИ

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**АННОТАЦИЯ**

*Селективная дорсальная ризотомия — один из методов оперативной коррекции спастичности мышц нижних конечностей с высоким уровнем доказательности у пациентов с церебральным параличом. Вместе с тем долгосрочные положительные результаты после операции могут быть достигнуты только при комбинации оперативного лечения с реабилитационными мероприятиями. В представленном обзоре литературы дана историческая справка о создании технологии, приведены современные данные об эффективности оперативного вмешательства, проанализированы результаты исследований касательно методов и особенностей реабилитации пациентов с диагнозом церебрального паралича после селективной дорсальной ризотомии. Как и другие методы лечения, селективная дорсальная ризотомия не исключает вероятности осложнений, но индивидуальный подход при проведении комплексной, продолжительной и интенсивной реабилитации, а также соблюдение клинических протоколов способны минимизировать эти риски. Стойкое улучшение двигательных функций, а также повышение уровня качества жизни пациентов после селективной дорсальной ризотомии и комплексных курсов реабилитации подтверждают эффективность и перспективность данной методики.*

***Ключевые слова:*** *церебральный паралич; селективная дорсальная ризотомия; спастичность; реабилитация; физическая терапия.*

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muscles, the popliteal tendons of hip muscles (the biceps, the semimembranous and the semitendinous muscles of the posterior surface of the hip), the rectus femoris muscle, the knee extensor/flexor muscles, the gastrocnemius and the soleus muscles. It was shown that the spasticity in the lower (560 patients; 53.3%) and upper (490 patients; 46.7%) limbs decreases the quality of life among the patients, which especially affects the possibilities of unsupported movement or walking using special aids [3–6].

The methods of correcting the muscle hypertonus in cases of cerebral palsy can be divided into the conservative and the surgical ones. The operative methods include the intrathecal implantation of the Baclofen pump, the selective dorsal rhizotomy (SDR) and orthopedic surgeries [4–9].

The attitude to the SDR worldwide is ambiguous as of today: some countries are actively implementing it into clinical practice, others use it in single cases or do not use at all. This being said, in 2021, the results of a research were published, in which comparison was made for the use of three methods for correcting the spasticity in cases of cerebral palsy — the SDR, the injections of botulinal toxin A and the intrathecal therapy with Baclofen — in various European countries. The highest number of the SDR was performed in Scotland

journal of clinical practice 2025 Vol 16 №1

(59 surgeries) and Sweden (45 surgeries), with Sweden, besides using the SDR, actively using the injections of botulinal toxin A (646 procedures) and the intrathecal therapy with Baclofen (84 procedures). At the same time in Finland and Iceland, there were no registered cases of using the SDR [10]. In Kazakhstan, the SDR method is included into the current clinical protocol of treating cerebral palsy[3], but the research works on the rates of using this surgery were not carried out yet in the republic.

## SELECTIVE DORSAL RHIZOTOMY: THE HISTORY AND THE PRESENT DAYS

The first description of the clinical use of the SDR is dated 1908, when one of the founders of the German and Global Neurosurgery Otfrid Foerster has first carried out four lumbosacral dorsal rhizotomies. Later he has published a report containing the data about 26 patients, 3 of which have deceased, 15 had a stable remission and 8 had a recurrence. In 1978, an Italian Neurosurgeon Victor Fasano has presented a new concept of the surgical methods — the functional dorsal rhizotomy. The principle of the method is the intraoperative evaluation of the abnormal muscle response to electric pulses. The new method has allowed for excising only the bundles, which were responsible for the "abnormal" muscular response. In 1982, the Neurosurgeons Warwick Peacock and Leila Arens modified the SDR for its use at the level of the cauda equina [11]. According to the review [7], W. Peacock in 1986 implemented the SDR in large Pediatric Centers all across the territory of the United States of America. As of today, this method is known worldwide and is used in many Neurosurgery centers as a method for correcting spasticity in cerebral palsy patients, where a sufficient amount of good results was obtained regarding both the short-term and the long-term perspective [6, 8, 12–15].

I. Novak et al. have published a systematic review, in which they have defined the botulinal toxin, the intrathecal Baclofen, the Diazepam and the SDR as the "green light" means in the treatment of cerebral palsy [2], but, of all listed methods, only the SDR provides the patients with a constant decreased muscle tone during the post-surgery period [16, 17]. The positive result remained not only within the timeframes of 3, 6, 12 and 24 months, but also 25 years after surgery [6, 8, 13, 16–19].

In England, a cohort efficiency research was carried out with using the SDR in five neurosurgery centers, where children aged 3–9 years underwent follow-up for 24 months. The main criteria for the SDR outcome were the gait analysis, the results of using the Ashworth spasticity scale and the Gross Motor Function Measure (GMFM-66), the quality of life among the cerebral palsy adolescents as determined by using the CP-QoL questionnaire. Eventually, after 2 years, the GMFM-66 value has increased in almost all the children (137 participants): the total increment was 3.2 units a year; significant improvement was observed in the parameters of the quality of life — practically in all the examined areas [14].

A similar multicenter research was carried out in Germany within the premises of three centers 12 and 24 months after surgery. The criteria for the evaluation of the SDR efficiency included the Ashworth scale, the GFMCS classification of motor functions in cerebral palsy patients and the GMFM-88 gross motor functions measuring scale. Positive changes were reported, with all the parameters measured in 24 months being significantly higher. For example, the Ashworth scale score (when evaluating the right hip adductor muscle) in 12 months has improved in 68% of the participants, in 24 months — in 71%, while the GMFM-88 has increased by 7% and 1 (2%) child had signs of worsening [5].

In 2022, the results of a cross-sectional research became available, the one that has studied the motor skills and the life aspects among the patients that had the SDR surgery more than 25 years ago. The comparison group included healthy volunteers of the same age. Upon the examination of the muscles, no significant difference was detected in the muscle tone between the groups. The muscle strength was shown to be lower in patients with the SDR surgery, they also had persisting restriction of the range of motion in the joints of the lower limbs. The psychological health parameters had no differences from the healthy group, but the physical parameters were not approaching the age-corrected reference ranges. This research has shown a positive long-term effect of the SDR.

The SDR surgery is to be proposed for the patients, the scale indexes in which correspond to the GMFCS levels II–III, but some authors recommend arranging the surgery among the children with more expressed impairments (GMFCS levels IV–V). During a multicenter

[3] Clinical Protocols of the Ministry of Health RK-2023 (Kazakhstan) [Internet]. Infantile cerebral palsy: clinical protocol for diagnosis and treatment (Approved by the Joint Commission on the quality of medical services of the Ministry of Health of the Republic of Kazakhstan from 15 December 2023. Protocol No. 199). Available from: https://diseases.medelement.com/disease/детский-церебральный-паралич-кп-рк-2023/17822. Accessed: 15.01.2025. (In Russ.)

research, C.S. Gillespie et al. [8] have studied the efficiency of the SDR among 144 patients with spastic diplegia of GMFCS grade IV–V with dynamic evaluation after one year. Positive dynamic changes were noted in terms of correcting the spasticity, the conclusion was made that the improvement is not as significant as it is in the GMFCS II–III patients (the results obtained when using the GMFM-66 scale has increased by an average of 2.4 units), 30.9% have reported about re-gaining the urinary bladder functions. This has allowed for recommending the use of the SDR in patients with spastic diplegia and with the IV–V class of gross motor functions [8].

It was shown that the SDR effectively decreases the spasticity and improves the mobility of the joints without significant negative effects in terms of the morphology of the muscle tissue and of the locomotor system. Moreover, the use of neuromuscular skeletal modeling during the research has shown an increase of muscle strength when walking (in operated children). According to the opinion from B.A. MacWilliams et al. [19], the SDR, comparing to other treatment methods, shows a clear prolonged effect on the relaxation mechanisms that are required for walking. Long-term monitoring with clinical measurements of local spasticity in patients that have received this surgery, has shown positive dynamic changes with partial or significant regress of motor disorders [4, 19–25]. The discrepancies presented in the literature on the evaluation of the SDR [26] can be explained by small sample size and/or by the absence of objective parameters for the obtained results, by the short follow-up duration after surgery and by medical-social rehabilitation [4, 27].

The end result can also depend on the complications occurring during the course of surgery and at the post-surgery period, which, in turn, can be short-term (lasting less than 1 year after surgery) and remote (occurring after a period of more than 1 year), transient or non-transient, structural or non-structural. The short-term complications, which result in a delay of rehabilitation, may include the CSF leak, the impaired sensitivity, the pulmonary or gastro-intestinal complications (nausea, vomiting, constipations) and the dysfunction of urinary tracts. The remote complications include the deformation of the vertebral column (8.4–20.5%) and spondylosis. The development of remote complications can be related to the early age of the patient (the younger the patient, the higher the risk of deformation in the vertebral column), to the Cobb angle (more than 30 degrees) and to the past history of scoliosis [26, 27].

## REHABILITATION

Rehabilitation is an integral component in the combined treatment of the cerebral palsy patients after the SDR [8, 14, 16, 17]. The ability of children to improve the quality of walking after the SDR combined with physical therapy methods was proven [6]. When assessing the obtained data, 86% of respondents have noted that rehabilitation has fundamental importance for the success of surgery [12].

Early rehabilitation period begins right after surgery. The opinions of the authors vary regarding the day of initiating physical therapy, with this, the majority of them recommend beginning rehabilitation on day 1–2 after surgery [28]. The authors proposing the rehabilitation activities from day 3–4, justify their opinion by the fact that early verticalization and excessive physical load can become the cause of early postoperative complications, such as CSF leak and an increase of pain syndrome. On day 3, in the absence of contraindications, it is permissible to change the position on the bed — turning and early passive kinesiotherapy. From days 4–7 of the postoperative period, the intensity of physical exercises is being gradually increased, the patient is permitted to sit on the edge of the bed or the chair, to stand on hands and knees, to stand up with aid and support for training the body balance and postural control. Beginning from weeks 2 and 3, it is allowed to start the training sessions on the correct walking pattern, simultaneously perfecting the self-care habits [16]. In the absence of complications, as well as taking into consideration the age and the rehabilitation potential, further activization of the patient is possible 3 days after surgery, performing balancing exercising — in 7 days [6]. The tactics of managing the patients after the SDR is defined by their functional status. Patients of GMFS classes II–III are subject to the transition to the rehabilitation department on days 4–5, where they receive physical therapy for 2 weeks. After discharge, all the patients undergo rehabilitation activities at a rate of up to 4–5 times a week for 6 months, then the periodicity of physical therapy is once in two years [3].

In Kazakhstan, there is an experience of long-term (15 months) clinical follow-up of 4 patients aged 4–8 years with the diagnosis of cerebral palsy after the SDR, of which 2 patients have spastic diplegia (GMFCS III) and 2 patients have tetraparesis (GMFCS IV). Physical therapy was prescribed from days 2–3 and included a set of strength exercises with an accent to the following groups of muscles: hip abductors and foot dorsiflexion muscles. On day 3, the procedures included early positioning of the patients using the spinal assistant


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journal of clinical practice 2025 Vol 16 №1

(sitting posture) for the purpose of eliminating the pelvic retroversion and changing the 90 degrees angle between the body axis and the hip axis. From month 2, positioning was initiated using the sitting posture and the spinal assistant, in case of positive changes, verticalization followed (carried out with the help of special rehabilitation means). The tool for evaluating the efficiency of the SDR combined with rehabilitation was the International Classification of Functioning, Disability and Health. The examinations were carried out in 6 and 15 months after surgery. The authors came to the conclusion that the SDR effectively decreases the spasticity level in the target muscles, promotes to developing new motor skills, such as verticalization and mobility, also shortening the risk of progression for the acquired locomotor system disorders [29].

## CONCLUSION

Selective dorsal rhizotomy is a highly effective method of surgical correction of spasticity in cerebral palsy patients, which is confirmed by multiple research works. The use of the SDR allows for achieving a significant decrease of the muscle tone, for improving the mobility in the joints and for increasing the functional capabilities in the patients, however, for achieving optimal results, it is important to employ the combined treatment program that includes not only the surgery itself, but also the long-term and structurized rehabilitation.

The efficiency of the SDR is due to its ability to selectively affect the nerve roots, which provides a decrease in the spasticity with no significant changes in the structure of the muscle tissue and of the locomotor system. The key factor of success is the postoperative rehabilitation. The optimization of timings and intensity of rehabilitation activities allows for minimizing the risks of complications and promotes to faster restoration of the functional skills. The long-term results of the SDR include the improvement of motor skills, the decrease of mobility restrictions and the increase in the quality of patients' life, which is confirmed by follow-up data with a duration of more than 25 years.

Despite the proven efficiency of the method, its application is accompanied by potential complications, which requires employing an individual approach to selecting patients and thorough following the clinical protocols.

Thus, the integration of the SDR into the combined treatment of the cerebral palsy patients is a promising vector of the modern Medicine, providing an improvement of the quality of life for children and adolescents with this disease.

## ADDITIONAL INFORMATION

**Author contribution.** *D.B. Kurmanova* — concept development, literature search and analysis, data interpretation, data discussion, article writing; *S.T. Turuspekova*, *V.S. Lisnic* — concept development, literature analysis, data interpretation, data discussion, article editing; *G.A. Mukhambetova* — data discussion and interpretation, article editing; *B.K. Demisinova*, *N.K. Mamashayev* — data discussion. The authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

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