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THE ROLE OF TRANSCRANIAL MAGNETIC AND ELECTRONEUROMYOGRAPHIC STIMULATION IN CHILDREN AFTER SURGICAL REPAIR OF CONGENITAL SPINAL HERNIA

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Abstract: Congenital spinal hernias (Spina bifida) result in severe organic damage to the central and peripheral nervous systems, leading to considerable motor, sensory, and autonomic impairments. The early postoperative rehabilitation period is often complicated by prolonged pathological processes, muscle atrophy, and disrupted segmental innervation. In recent years, transcranial magnetic stimulation (TMS) and electroneuromyographic stimulation (ENMG-stimulation) have emerged as neuromodulatory therapeutic methods that significantly accelerate neurological recovery.

This study evaluated the clinical significance of TMS and ENMG during early rehabilitation in 30 patients with spina bifida who underwent surgical treatment at the Neurosurgery Department of the Andijan Regional Multidisciplinary Children's Hospital. The results demonstrated that combined neuromodulatory therapy markedly improved muscle strength, sensation, reflexes, psychomotor development, and functional independence. Barthel Index and Denver test outcomes indicated that TMS showed superiority over ENMG across several parameters. Overall, the findings suggest that integrating neuromodulatory technologies into early rehabilitation improves motor development prognosis in children with spina bifida.

Keywords: spina bifida, congenital spinal hernia, transcranial magnetic stimulation (TMS), electroneuromyographic stimulation (ENMG), early rehabilitation, neuromodulation, Barthel Index, Denver screening, motor development, psychomotor recovery.

Introduction

Congenital spinal hernias are neural tube defects characterized by partial membrane-covered protrusion of altered spinal cord structures and cerebrospinal fluid into a herniated sac [1].Among central nervous system malformations, congenital spinal hernias rank second after hydrocephalus, occurring in approximately 1 per 1,000 newborns [9]. The primary clinical concern in affected children is progressive neurological dysfunction manifested by reduced motor and sensory activity, lower limb paresis or paralysis, and loss of nociceptive and tactile sensation. The major etiological factor in congenital spinal hernia is spina bifida—a developmental anomaly caused by failure of the neural tube to close during the fourth week of embryogenesis, resulting in defects of the vertebral column [4].

Both genetic and environmental risk factors contribute to this pathology, including folic acid deficiency, maternal use of anticonvulsants, and hyperglycemic conditions in diabetic pregnancies [6]. Globally, congenital anomalies account for 3–5% of all births and contribute to 25% of infant and early childhood mortality [7].

Anatomically, congenital spinal hernias are most frequently located in the lumbar region (60%), followed by sacral (22.5%), thoracic (10%), and cervical (7.5%) levels [8]. Despite timely surgical repair, many patients remain limited in physical and social functioning due to complications such as pressure ulcers, hydrocephalus, bowel and bladder dysfunction, and

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recurrent infections, which remain among the most significant issues in pediatric neurology [7].
In recent years, **Transcranial Magnetic Stimulation (TMS)** and **Electroneuromyographic Stimulation (ENMG-stimulation)** have been widely used as promising neuromodulatory modalities in early rehabilitation. These technologies enhance communication between the central and peripheral nervous systems by improving synaptic transmission, increasing motor neuron excitability, and accelerating clinical recovery.

Study Objective

This study aimed to evaluate the clinical–neurological significance of TMS and ENMG stimulation during early rehabilitation in 30 children who underwent surgical repair for congenital spinal hernia at the Andijan Regional Multidisciplinary Children's Medical Center (2023–2025). The effects on muscle strength, motor function, sensation, reflexes, psychomotor development, and functional independence were assessed.

Materials and Methods

A total of 30 postoperative patients were included in the rehabilitation program. The patients were assessed in two groups:

Main group: TMS + ENMG stimulation + standard rehabilitation

Control group: Standard rehabilitation only (therapeutic exercise, massage, physiotherapy)

Assessment methods included clinical–neurological evaluation, psychomotor assessment, functional independence measures, and ENMG findings.

Results

During a follow-up period of 2 months to 1.5 years after surgery, the outcomes of standard versus complex rehabilitation were compared. Initially, all patients received only standard therapy (neuroprotection, vitamins, physiotherapy, massage, therapeutic exercises) for 2 months.

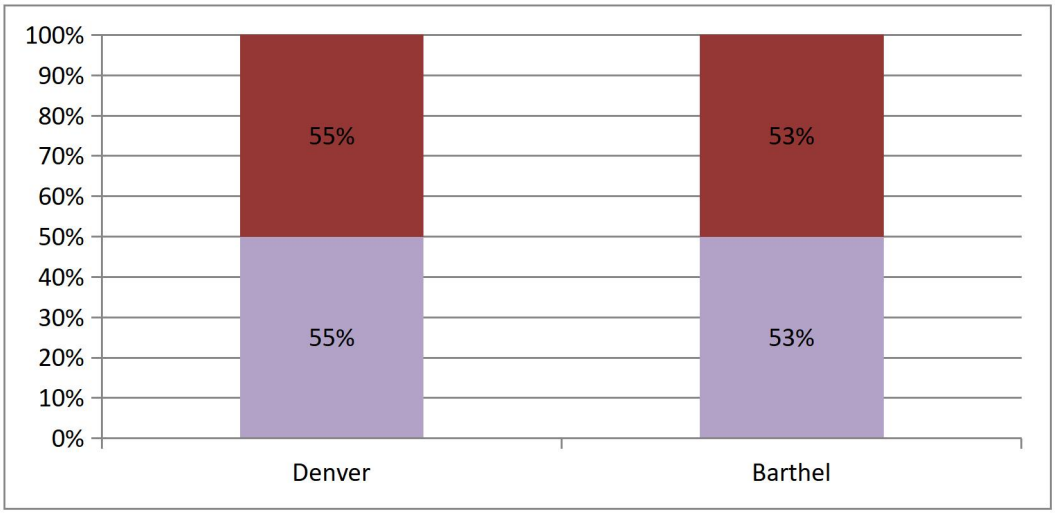

Figure 1. Outcomes after standard treatment

Barthel Index and Denver test scores showed no significant improvement in the control group. This is attributable to the severity of congenital defects, pelvic organ dysfunction, lower

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paraparesis, and deep involvement of spinal structures in the pathological process, indicating the need for long-term rehabilitation.
Consequently, complex rehabilitation—including ENMG and TMS—was introduced and compared. Fifteen patients received ENMG stimulation, and fifteen received TMS.

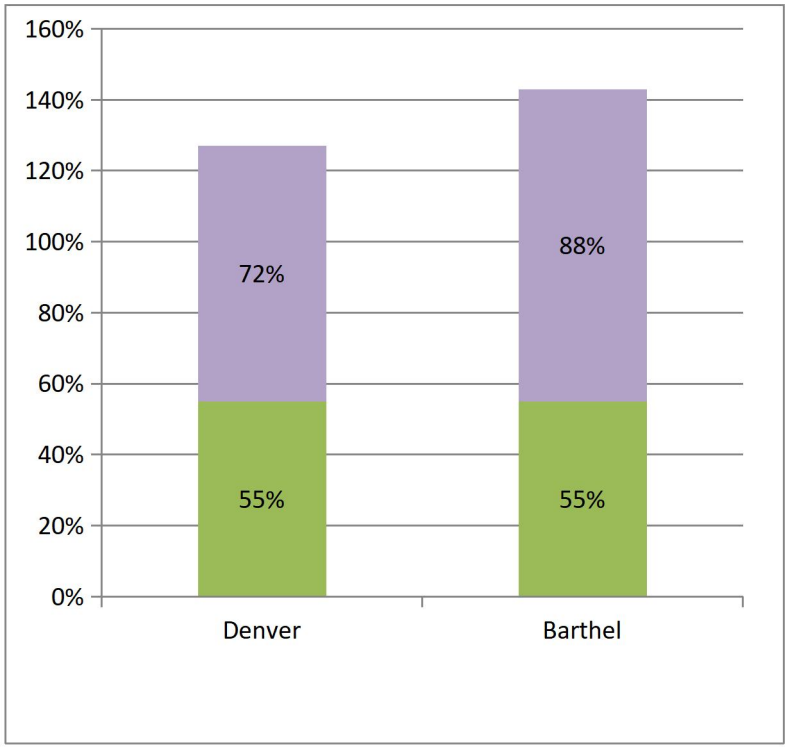

Figure 2. Results after enmg therapy

ENMG stimulation involves delivering targeted electrical impulses to nerves or muscles. Session duration depends on the number of structures treated.
Patients treated with ENMG demonstrated improvements as follows:

Denver scale: from 55% to 72%
Barthel Index: from 55% to 88%

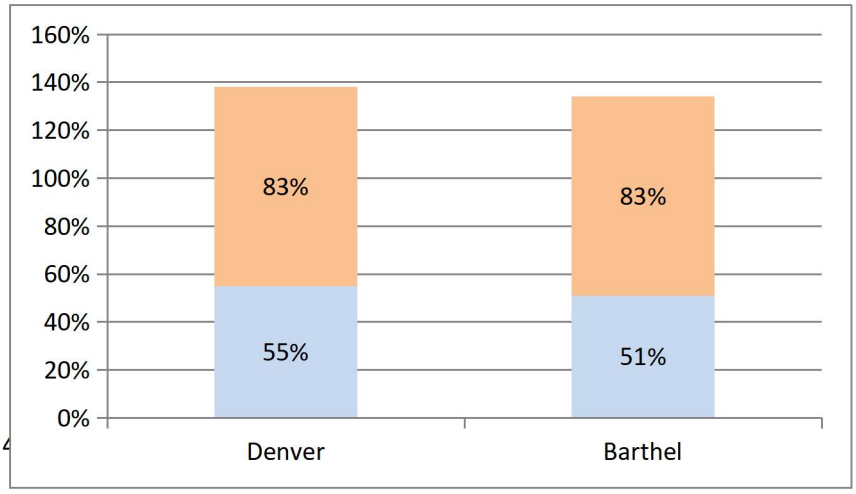

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Figure 3. Results after TMS therapy

TMS stimulates cortical neuronal activity through magnetic fields. Session duration depends on disease severity. Patients treated with TMS demonstrated the following improvements:
Denver scale: from 55% to 83%
Barthel Index: from 51% to 83%
This indicates that TMS was superior to ENMG in several clinical parameters.
Comparative Analysis
Across both treatment groups, approximately **80%** of patients showed positive neurological dynamics following complex therapy. After repeated treatment courses, neurological status improved by up to **95%**.
Treatment parameters included:
ENMG: 10–30 minutes per session, 10–15 sessions, daily or alternate days; repeat after 1–3 months if needed
TMS: 20–40 minutes per session (sometimes 3–10 minutes), 10–30 sessions, daily or alternate days; repeat after 1–3 months
Discussion: this study demonstrates that standard rehabilitation methods alone have limited efficacy in children with congenital spinal hernias. Deep structural abnormalities, demyelination, and reduced motor neuron excitability contribute to slow recovery in early postoperative stages.
International studies support the importance of neuromodulatory techniques. For example, Geerdink et al. (Netherlands) found that while lumbar magnetic stimulation elicited motor evoked potentials in neonates, transcranial responses were inconsistent in newborns due to immature neuronal circuits [5].
Our findings align with these results, suggesting that TMS effectiveness increases with patient age and optimized stimulation protocols.
Pediatric studies have demonstrated that TMS is generally safe when stimulation parameters—intensity, frequency, session duration—adhere to established clinical guidelines [3].
Conclusion: TMS and ENMG stimulation are highly effective neuromodulatory methods for early rehabilitation in children with congenital spinal hernias. Combined application enhances both central and peripheral nervous system activity. Significant improvements were observed in muscle strength, sensation, reflexes, gait, psychomotor development, and functional independence. Increases in Barthel Index, Denver test scores, and ENMG parameters confirm the clinical advantages of TMS and ENMG. Early implementation of these techniques substantially improves motor development outcomes in children with spina bifida.

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