



**BRAIN PLASTICITY AND NEUROREHABILITATION: POST-STROKE RECOVERY
MECHANISMS AND COGNITIVE REHABILITATION METHODS**

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ABSTRACT

This article analyzes brain plasticity mechanisms and neurorehabilitation processes following stroke. Mechanisms of neural plasticity, including synaptic reorganization, formation of new neural pathways, and compensatory mechanisms, play a crucial role in post-stroke recovery. Neuromodulation techniques—such as **transcranial magnetic stimulation (TMS)**, **transcranial direct current stimulation (tDCS)**, and other electro-neurotechnologies—have been shown to accelerate recovery. Cognitive rehabilitation programs aim to restore patients' attention, memory, language, and executive functions, with individualized approaches enhancing effectiveness. The authors review recent research findings and emphasize the efficacy of an integrated approach combining brain plasticity and neurorehabilitation strategies.

Keywords: Brain plasticity, Neurorehabilitation, Stroke, Neuromodulation, Cognitive rehabilitation, Motor functions, Synaptic reorganization, Neurofeedback, Attention and memory, Individualized approach

INTRODUCTION

Stroke is one of the leading causes of disability and death worldwide. According to the **World Health Organization (WHO)**, millions of people suffer from stroke annually, with many experiencing varying degrees of cognitive and physical impairments. Therefore, post-stroke recovery and reintegration into society remain among the most urgent and rapidly evolving fields in medicine.

Brain plasticity, defined as the ability of neurons and neural networks to adapt, is recognized as a key mechanism in post-stroke recovery. Studies show that reorganization of neural pathways, activation of compensatory mechanisms, and formation of new synapses play a crucial role in restoring both cognitive and motor functions.

Neuromodulation methods, including TMS and tDCS, enhance brain plasticity and accelerate recovery. Cognitive rehabilitation programs are designed to restore attention, memory, language, and executive abilities, with individualized approaches further improving effectiveness. Therefore, an integrated approach combining brain plasticity principles, neurorehabilitation, and neuromodulation techniques is of high scientific and clinical importance. This article analyzes mechanisms of brain plasticity, post-stroke recovery processes, neuromodulation, and cognitive rehabilitation methods, providing evidence-based recommendations from recent research.

MATERIALS AND METHODS

Participants: Post-stroke patients aged 45–70 with mild to moderate functional recovery. All personal data were confidential, and written informed consent was obtained.

Neurological assessment tools:

- NIHSS (National Institutes of Health Stroke Scale)
- mRS (modified Rankin Scale)

Cognitive assessment tools:



- MMSE (Mini-Mental State Examination)
- MoCA (Montreal Cognitive Assessment)

Motor function assessment:

- Fugl-Meyer Assessment
- 10-meter walk test

Neuromodulation devices:

- TMS (Transcranial Magnetic Stimulation)
- tDCS (Transcranial Direct Current Stimulation)

Rehabilitation programs:

- Individual and group cognitive exercises
- Neurofeedback
- Motor training exercises

Procedure: Patients underwent **6 weeks of neurorehabilitation**, 5 days per week, 60–90 minutes per session. Exercises were tailored to each patient’s motor and cognitive capabilities. TMS and tDCS sessions targeted affected brain areas **3 times per week, 20 minutes per session**. Cognitive rehabilitation focused on attention, memory, language, and executive functions, delivered individually and in groups.

Data analysis: Statistical analysis was performed using **SPSS 26.0**. Pre- and post-intervention differences were evaluated with **t-tests** and **ANOVA**.

RESULTS

Motor Function Outcomes. Motor function, assessed using the **Fugl-Meyer Assessment (FMA)**, showed a **mean improvement of 18%** in the experimental group (neuromodulation + rehabilitation) after 6 weeks, compared to **7% in the control group** (rehabilitation only).

Table 1. Motor Function Scores (Fugl-Meyer Assessment, points)

Group	Baseline Mean	6-Week Result	Change (%)
Experimental (TMS/tDCS + rehab)	42.5	50.2	18%
Control (rehab only)	43.0	46.0	7%

Cognitive Function Outcomes. Cognitive rehabilitation effectiveness was measured using **MMSE** and **MoCA**. After 6 weeks, the experimental group demonstrated substantial improvements in attention, memory, and language skills.

Table 2. Cognitive Assessment Scores (MMSE and MoCA, points)

Group	Test	Baseline Mean	6-Week Result	Change (%)
Experimental	MMSE	22.4	26.0	16%
	MoCA	19.8	24.1	22%
Control	MMSE	22.7	24.0	6%
	MoCA	20.1	21.5	7%

Summary:

- Neuromodulation-integrated rehabilitation significantly improves motor and cognitive functions.



- Individualized cognitive exercises accelerate recovery of attention, memory, and language.

DISCUSSION

The results confirm the important role of **brain plasticity** and **neurorehabilitation** in post-stroke recovery. FMA and cognitive test improvements indicate that combining **neuromodulation (TMS, tDCS)** with rehabilitation substantially enhances motor and cognitive outcomes.

These findings align with previous studies. For example, Schambra et al. (2020) reported positive effects of neuromodulation on motor recovery, while Toshima et al. (2019) demonstrated the benefits of individualized cognitive rehabilitation. When cognitive exercises and neuromodulation are applied together, brain plasticity mechanisms—**new synapse formation, synaptic reorganization, and compensatory neural pathways**—are activated, accelerating recovery.

Patient factors, including **age, stroke type, and baseline functional status**, significantly affect rehabilitation outcomes. Therefore, tailoring rehabilitation programs to individual neurological profiles increases effectiveness. Integration of neuromodulation and cognitive training in clinical practice improves quality of life and reduces disability. Overall, brain plasticity-based integrated neurorehabilitation is the most effective strategy for post-stroke recovery.

CONCLUSION

Integrated neurorehabilitation approaches that consider **brain plasticity** are highly effective for post-stroke recovery. **Neuromodulation (TMS, tDCS)** combined with individualized cognitive rehabilitation significantly improves motor and cognitive functions. FMA scores showed an **18% improvement**, and cognitive tests (MMSE, MoCA) demonstrated **16–22% improvement** in attention, memory, and language.

These results highlight the superior efficacy of combining neuromodulation with cognitive exercises. Patient age, stroke type, and baseline functional status remain key determinants of rehabilitation success. Individualized and integrated approaches enable faster and more effective recovery. Future research should examine long-term effects of neuromodulation and explore rehabilitation strategies for different stroke subtypes. In summary, integrating brain plasticity and neurorehabilitation is the most relevant and effective approach for post-stroke recovery.

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