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INNOVATIVE NEUROFEEDBACK THERAPY FOR COGNITIVE IMPAIRMENT IN PATIENTS WITH CEREBROVASCULAR DISEASES

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Abstract

Background: Cerebrovascular diseases remain one of the leading causes of long-term disability and reduced quality of life worldwide. Cognitive impairment following stroke is a common clinical problem that significantly affects patients' functional independence.

Objective: To evaluate the effectiveness of neurofeedback therapy as an adjunct to standard treatment in patients with cerebrovascular diseases.

Methods: A prospective comparative study included 50 patients with cerebrovascular pathology who were treated at the private clinic "Neuromed Service" and the Central Clinical Hospital of JSC "Uzbekistan Railways". Patients were divided into two groups: the control group receiving standard pharmacological therapy (n=25) and the experimental group receiving standard therapy combined with neurofeedback therapy (n=25). Cognitive functions were assessed using the MMSE and MoCA scales before and after a 10-day treatment course. Additional assessments included the Visual Analogue Scale (VAS).

Results: Patients receiving neurofeedback therapy demonstrated significantly greater improvement in cognitive performance and reduction of neurological symptoms compared with those receiving conventional therapy alone ($p < 0.001$). The mean MMSE score increased from 24.7 ± 1.6 to 29.5 ± 1.4 in the neurofeedback group, while MoCA scores improved from 14.6 ± 2.1 to 18.0 ±

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1.7. Patients also showed improvements in attention, emotional stability, and subjective well-being.
Conclusion: Neurofeedback therapy may represent an effective adjunctive approach in the rehabilitation of patients with cerebrovascular diseases and may contribute to improved cognitive recovery and overall clinical outcomes.

Keywords: cerebrovascular disease, neurofeedback, cognitive impairment, stroke rehabilitation, neurorehabilitation

Introduction

Cerebrovascular diseases (CVD) represent one of the most significant challenges in modern neurology due to their high prevalence, disability rates, and long-term consequences. In addition to motor deficits, many patients develop persistent cognitive impairment that significantly limits their daily functioning.

According to the World Health Organization, stroke affects millions of individuals each year and remains a major cause of neurological disability. In many cases, cognitive impairment rather than motor dysfunction becomes the primary factor reducing patient independence.

Clinical observations indicate that memory impairment, attention deficits, mental fatigue, and emotional instability may persist even after completion of standard treatment. These manifestations are often insufficiently addressed within conventional rehabilitation programs.

In Uzbekistan, cerebrovascular diseases remain a major public health concern. Despite progress in pharmacological treatment, cognitive rehabilitation methods are still underutilized in routine clinical practice, highlighting the need for accessible and effective therapeutic approaches.

Neurofeedback therapy is a non-invasive technique based on real-time electroencephalographic (EEG) monitoring that enables patients to learn self-regulation of brain activity. Although international studies have demonstrated

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promising results, clinical experience with this method in patients with cerebrovascular diseases in Uzbekistan remains limited. This study aimed to evaluate the effectiveness of neurofeedback therapy in cognitive rehabilitation.

Materials and Methods

Study Design

A prospective comparative clinical study was conducted involving 50 patients diagnosed with cerebrovascular diseases who received treatment at the Neuromed Service private clinic and the Central Clinical Hospital of JSC "Uzbekistan Railways".

Inclusion criteria

Patients were included in the study if they met the following criteria:

- confirmed diagnosis of cerebrovascular disease
- presence of mild to moderate cognitive impairment
- age between 45 and 75 years
- ability to participate in neuropsychological testing

Exclusion criteria

Patients were excluded if they had:

- severe dementia
- major psychiatric disorders
- traumatic brain injury
- severe systemic diseases affecting cognitive function
- inability to complete neuropsychological testing

Study groups

Patients were divided into two groups:

Control group (n=25)

received conventional pharmacological therapy according to standard neurological treatment protocols.

Neurofeedback group (n=25)

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received conventional therapy combined with neurofeedback training sessions.

Neurofeedback protocol

The neurofeedback course lasted **10 days**. Training sessions were conducted using EEG-based real-time monitoring equipment. During each session, patients received visual and auditory feedback signals aimed at improving cortical self-regulation and functional brain activity.

Cognitive and psychological assessment

Cognitive and psychological status was evaluated using:

- Mini-Mental State Examination (MMSE)
- Montreal Cognitive Assessment (MoCA)
- Visual Analogue Scale (VAS) for headache intensity

Assessments were performed before treatment and after completion of the therapy course.

Statistical Analysis

Statistical analysis was performed using standard statistical software. Quantitative variables were expressed as **mean ± standard deviation (M ± SD)**. Intergroup comparisons were performed using **Student's t-test**. Differences were considered statistically significant at $\mathbf{p < 0.05}$.

Ethical considerations

The study protocol was approved by the Ethics Committee of Tashkent State Medical University. All participants provided informed consent prior to participation in the study.

Results

Before treatment, patients demonstrated a wide spectrum of subjective and objective neurological complaints. The most frequently reported symptoms included headache (84%), dizziness and balance disturbances (68%), decreased attention and memory (76%), impaired motor coordination (54%), sleep disturbances (38%), and emotional instability with anxiety (42%). In addition,

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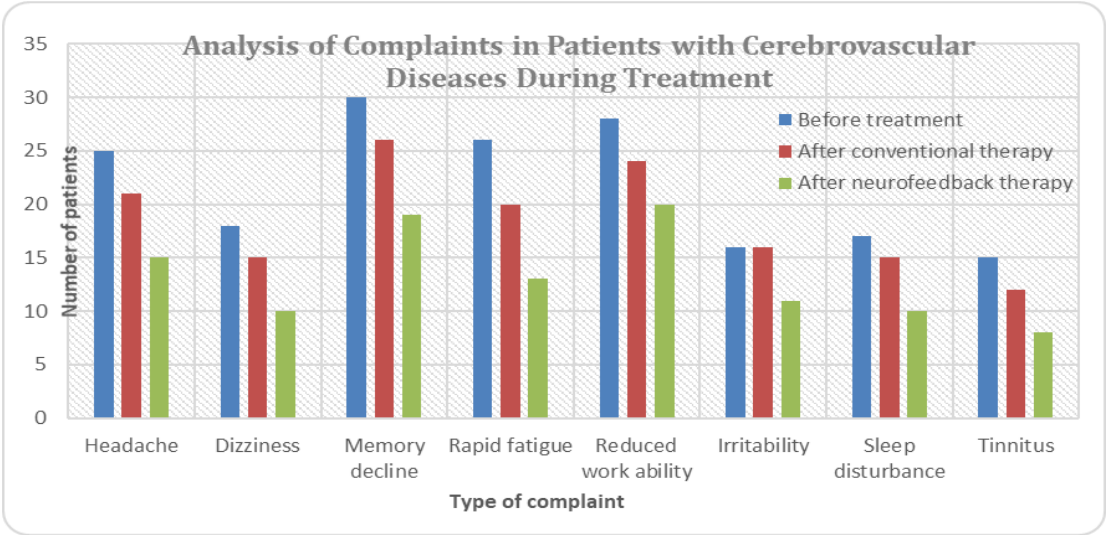
patients presented with objective neurological signs such as facial asymmetry, sensory disturbances (paresthesia, numbness), hypokinesia, and hemiparesis of varying severity.

After completion of therapy, a marked reduction in subjective complaints was observed in both groups; however, the improvement was significantly more pronounced in patients receiving neurofeedback therapy.

Figure 1. Analysis of complaints in patients with cerebrovascular diseases during treatment ($p < 0.01$).



According to VAS assessment, headache intensity decreased:

- from **5.0 to 3.1 points** in the control group
- from **5.0 to 1.9 points** in the neurofeedback group

These differences were statistically significant (**$p < 0.01$**).

Figure 2. VAS headache intensity before and after treatment.

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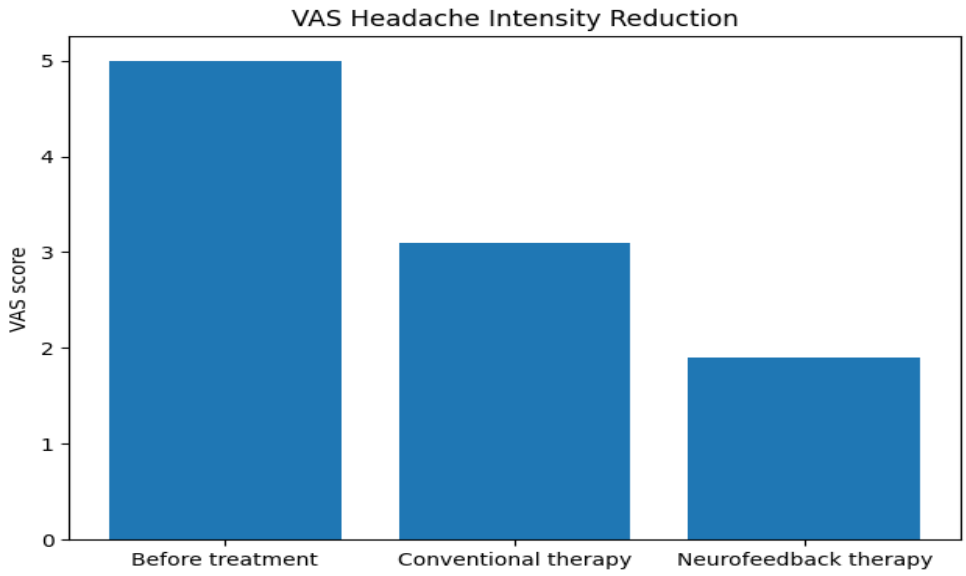

In addition, complaints related to dizziness, fatigue, irritability, reduced work capacity, sleep disturbances, and tinnitus showed a greater reduction in the neurofeedback group compared to conventional treatment.

Objective neurological outcomes

Objective neurological examination revealed positive dynamics predominantly in the neurofeedback group. Improvement in facial asymmetry was observed in **52%** of patients receiving neurofeedback therapy, whereas no significant changes were noted in the conventional therapy group. Sensory disturbances decreased in **60%** of patients in the neurofeedback group. Motor recovery in patients with hypokinesia or hemiparesis was documented in **40%** of patients treated with neurofeedback, compared to **16%** in the conventional therapy group.

Cognitive function assessment

Cognitive function assessment demonstrated statistically significant improvements in the neurofeedback group.

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Table 1. Cognitive assessment results (MMSE and MoCA, M ± SD).

Group	MMSE	MoCA	Statistical significance
Baseline (n=50)	24.7 ± 1.6	14.6 ± 2.1	-
Conventional therapy (n=25)	26.1 ± 1.8	16.3 ± 1.9	$p<0.05$
Neurofeedback therapy (n=25)	29.5 ± 1.4	18.0 ± 1.7	$p<0.001$

Overall, neurofeedback therapy was associated with better cognitive outcomes and improved psycho-emotional state, which was reflected in patients' daily functioning and subjective well-being.

Discussion

The results of this study demonstrate that neurofeedback therapy can significantly enhance cognitive and neurological recovery in patients with cerebrovascular diseases. Patients who received neurofeedback therapy showed greater improvement in cognitive test scores and subjective well-being compared with those receiving conventional treatment alone.

The observed benefits may be explained by mechanisms related to neuroplasticity and improved cortical self-regulation. Neurofeedback training enables patients to modify brain activity patterns through real-time feedback, which may facilitate functional reorganization of neural networks involved in cognitive processes.

Our findings are consistent with previous studies demonstrating the beneficial effects of neurofeedback in neurological rehabilitation and cognitive disorders. Neurofeedback training has been shown to improve attention, memory, and emotional regulation in various clinical populations.

Nevertheless, several limitations of the present study should be acknowledged. The sample size was relatively small, and the duration of observation was limited to the short-term treatment period. Future studies involving larger patient populations and longer follow-up periods are required to further evaluate the long-term clinical benefits of neurofeedback therapy.

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Despite these limitations, the results suggest that neurofeedback therapy may represent a promising and clinically applicable tool for cognitive rehabilitation in patients with cerebrovascular diseases.

Conclusion

Neurofeedback therapy represents a promising adjunctive approach for cognitive rehabilitation in patients with cerebrovascular diseases. When combined with conventional medical treatment, this method may contribute to improved cognitive recovery, emotional stability, and overall quality of life.

Further clinical studies involving larger patient samples are needed to confirm the long-term therapeutic effectiveness of neurofeedback therapy.

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