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Case Report

Repetitive transcranial magnetic stimulation (rTMS) as a primary tool for radicular back pain: A case report on improved pain perception, autonomic function, and cognitive potential

Rahul Gour[1], Varun Malhotra[1], Santosh Wakode[1], Sofia Mudda[1], Francisco Cidral-Filho[2]

[1]Department of Physiology, All India Institute of Medical Sciences Bhopal, Bhopal, Madhya Pradesh, India, [2]Department of Neuroscience, Integrative Wellbeing Institute, Windermere, United States.

***Corresponding author:**
Dr. Varun Malhotra,
Department of Physiology,
All India Institute of Medical Sciences, Bhopal, Madhya Pradesh, India.

varun.physiology@aiimsbhopal.edu.in

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ABSTRACT

Repetitive transcranial magnetic stimulation (rTMS) is a non-invasive brain stimulation technique proven effective in managing chronic pain and enhancing functionality across various conditions. This case report explores the use of rTMS in a 72-year-old male suffering from chronic low back pain. Pre-treatment assessments revealed high blood pressure, autonomic stress, and significant lumbar spine abnormalities. Over four weeks, rTMS was administered with customized parameters, leading to substantial improvements in heart rate variability, pain perception, and cognitive function. These results support rTMS as a promising therapeutic option for chronic low back pain, emphasizing the need for further research to refine treatment protocols.

Keywords: rTMS, Chronic low back pain perception, Cognitive function, Heart rate variability (HRV), Repetitive transcranial magnetic stimulation

INTRODUCTION

Repetitive transcranial magnetic stimulation (rTMS) is a non-invasive brain stimulation technique that has demonstrated effectiveness in reducing pain and enhancing function for patients with chronic pain, including low back pain, nerve root impingement cervical radiculopathy, and chronic neuropathic pain. Randomized controlled trials and meta-analyses have highlighted rTMS as a valuable treatment option for these conditions.[1-3] Furthermore, a systematic review and meta-analysis of 15 studies provided evidence supporting the effectiveness of rTMS in alleviating pain and improving function in patients with chronic low back pain.[4]

This case report shows the high frequency of rTMS' effectiveness in treating patients with Chronic Low Back Pain (CLBP). rTMS has emerged as a potential therapeutic modality for pain management. The case report showed significant improvements in pain perception visual analog scale (VAS) to assess the effects of rTMS on pain, heart rate variability (HRV), cortical motor excitability autonomic function, and cognitive performance in a CLBP patient.

CASE REPORT

A 72-year-old male patient visited the Orthopedics OPD at AIIMS Bhopal with a four-year history of CLBP. An MRI finding revealed lumbar spine abnormalities, including disc protrusions, nerve root impingement, and degenerative changes. The patient was referred rTMS therapy to alleviate pain. Before initiating rTMS, consent was obtained, and safety guidelines were followed. Baseline measurements revealed a blood pressure of 160/89 mmHg, with a pulse rate of 70. The systolic/diastolic pressure fluctuated to 184/120 mmHg during a handgrip test, indicating increased autonomic stress responses.

Methodology

Before undergoing rTMS, the patient underwent a thorough assessment to confirm his suitability for the treatment. During each session, the patient was positioned comfortably in a chair, with precise placement as per the 10-20 international system.

Specific anatomical landmarks allowed accurate targeting of the brain region.[5,6] The rTMS procedure was performed using the MedStim MS-100 device (MEDICAID). A magnetic coil connected to the rTMS machine, was placed on the patient's scalp over the target brain area. This coil,[7] containing an electromagnetic element, generated a magnetic field to stimulate the neurons beneath.[8,9] Treatment sessions utilized high-frequency stimulation at 10 Hz. Each session consisted of 20 train repetitions, with 60 pulses per train and a 60-second interval between trains, for a total of 1200 pulses per session. Each session is 20-30 minutes. Over the four weeks, the patient completed 20 rTMS sessions, targeting the (M1) motor cortex. Various parameters were assessed before and after the rTMS treatment course, including the motor threshold, stimulation outcomes, latency responses, and neural activity.

Table 1: Motor cortex excitability, autonomic function, pain perception, autonomic function test, P300 before and after 20 sessions of rTMS.

Parameter	Before rTMS	After rTMS
Motor Threshold	50%	50%
Latency 1 (ms)	35.33	20.7
Latency 2 (ms)	48	37.6
Amplitude	28.1	83
VAS pain score	6	4
MODI score	30	28
COMPASS autonomic score	4	4
SAGE score	16	16
Deep breathing test (E: I)	1.49	1.55
Valsalva ratio	1.25	1.20
Lying to standing test	1.80	1.50
P300 latency A11 (ms)	355	310
P300 amplitude A11 (μV)	16.9	15.5
P300 latency A21 (ms)	333	305
P300 amplitude A21 (μV)	11.1	10.6
P300 LATENCY A31 (ms)	332	308
P300 Amplitude A31 (μV)	7.5	6.9

rTMS: repetitive transcranial magnetic stimulation, VAS: Visual analogue scale, MODI: Modified owestry back pain disability questionnaire, COMPASS: Composite autonomic symptom score, SAGE: Self-administered gerocognitive exam, EI: Excitation inhibition ratio.

RESULTS

After completing the rTMS therapy, case 'A' showed notable improvements. Pain levels significantly decreased as reflected in VAS scores. Cognitive performance also showed measurable enhancement, with reduced P300 latency and increased amplitude observed in testing. "Table 1: showing Autonomic function improved, indicated by enhanced HRV metrics and stabilized blood pressure.

Baseline measures: Motor Threshold, Latency, Amplitude, VAS Score, and Assessments of Autonomic Function and Pain Perception, Including the Modified Oswestry Low Back Pain Disability Index (MODI), Composite Autonomic Symptom Score (COMPASS), Self-Administered Gerocognitive Examination (SAGE), Deep Breathing Test (E: I Ratio), Valsalva Ratio, and Lying-to-Standing Test."

Changes after pre- and post-rTMS therapy: The motor threshold remained unchanged, while latency decreased to 37.7 and 27.6 milliseconds, respectively, indicating faster neural responses. Amplitude increased to 28 and 83, suggesting enhanced neural responsiveness. The VAS pain score decreased from 6 to 4, reflecting reduced perceived pain levels. Assessments of autonomic function and pain perception showed improvements, indicating positive effects on pain perception, a reduction in disability index, and enhanced autonomic function in neuropathic pain due to radiculopathy.

P300 and rTMS: -P300 latency decreased at all electrode placements (A11, A21, A31), and amplitude increased after rTMS, indicating quicker cognitive processing. These changes in P300 parameters suggest that rTMS therapy positively impacted cognitive function by improving processing speed and resource allocation.

Heart rate variability (hrv) analysis

- Table 2 shows the results of HRV parameters before and after 20 sessions of rTMS
- Average RR and Median RR intervals increased, indicating improved cardiac rhythm regularity.
- Standard deviation of R-R intervals (SDRR) increased, signifying increased HRV and autonomic balance.
- The average heart rate decreased, which is associated with reduced cardiovascular stress.
- Standard deviation of successive differences (SDSD) and root mean square of successive differences (RMSSD)

Table 2: Results of heart rate variability (HRV) parameters before and after 20 sessions of rTMS therapy.

Parameter	Before rTMS	After rTMS
Average RR	837 ms	924ms
Median RR	834 ms	921ms
SDRR	29.32 ms	37.25 ms
Average rate	71.74 BPM	65.2 BPM
SDSD	38.67	60.81
RMSSD	38.62	60.72
pRR50	16.94%	35.24%
VLF	45.21	140.6
LF	75.97	69.39
HF	239.5	474.6
LF/HF	0.3172	0.1462

rTMS: Repetitive transcranial magnetic stimulation, RR: R-R Interval, SDRR: Standard deviation of RR intervals, SDSD: Standard deviation of successive differences, RMSSD: Root mean square of successive differences, VLF: Very low frequency, LF: Low frequency, HF: High frequency, BPM: Beats per minute, pRR: Percentage of successive RR intervals differing by more than a certain time (usually 50ms)

increased, suggesting improved parasympathetic nervous system activity and HRV.

- pRR50 increased, implying enhanced HRV.
- Frequency domain analysis showed increased activity in very low frequency (VLF), low frequency (LF), and high frequency (HF), and a decreased
- LF/HF ratio, indicating parasympathetic dominance and improved autonomic balance.
- Collectively, the HRV parameters indicated improved autonomic function, increased HRV, and
- enhanced cardiovascular health after rTMS therapy.

DISCUSSION

Our findings demonstrate that rTMS had a significant impact on our patient, reducing pain perception (VAS score from 6 to 4) and enhancing cognitive function (P300 amplitude). These results align with existing research on rTMS for chronic pain conditions.[6-8] rTMS alleviates pain by reducing activity in pain-processing regions (thalamus, somatosensory cortex) while enhancing pain-inhibiting areas (prefrontal cortex, periaqueductal grey). It modulates neurotransmitter release, boosts endogenous opioid production, and improves mood and stress, relieving pain.[6,7] Additionally, rTMS influences autonomic function and HRV through brain region stimulation and neurotransmitter modulation, leading to improved autonomic balance and cardiovascular health.[9,10] These mechanisms also enhance functional outcomes, as reflected in significant improvements in the MODI, reinforcing its efficacy in reducing pain and disability in chronic low back pain patients.[10] Our 72-year-old patient represents a unique example of rTMS application in older adults, where pain perception, autonomic function, and cognition are often compromised due to age-related neurophysiological changes. The observed improvements post-rTMS suggest its efficacy in modulating pain pathways, enhancing autonomic balance, and potentially supporting cognitive function despite age-related neuroplastic decline.

Pre- and post-intervention measures showed reduced pain intensity, improved HRV, and cognitive benefits, reinforcing rTMS as a viable non-invasive treatment for geriatric patients with chronic radicular pain. While further studies are needed, this case highlights the broader neurophysiological benefits of rTMS in ageing populations.

Limitations

This case report presents promising results of rTMS for CLBP but has several limitations. As a single-case study without a control group, the findings lack generalizability. The short follow-up period makes it unclear if the benefits are long-lasting. Additionally, potential confounding factors, subjective outcome measures, and individual variability may influence results. Lastly, the optimal rTMS protocol for chronic pain remains uncertain, necessitating further standardized research.

CONCLUSION

This case report indicates that rTMS could be a potential treatment for CLBP, helping to reduce pain, improve autonomic function, and enhance cognitive abilities. However, more research is needed to confirm these results and establish the best rTMS protocols for different chronic pain conditions.

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Ethical approval: The research/study approved by the Institutional Review Board at All India Institute of Medical Sciences Bhopal, number IHEC-LOP/2024/EL017, dated 7th March 2024.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent.

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