

Original Research

The Impact of Virtual Reality-Based Neurorehabilitation on Postoperative Functional Recovery in Brain Tumour Patients

Arun Prakash Dwivedi¹, Savita Mishra², Sushil Kumar Bundela³, Vishnu Datt Pandey⁴, Sidharth Pant⁵

¹Associate Professor, Department of Neurosurgery, Rama Medical College, Hospital & Research Centre, Kanpur, UP, India

²Assistant Professor, Department of Anatomy, Rama Medical College, Hospital & Research Centre, Kanpur, UP, India

³Assistant Professor, Department of General Surgery, RMC Orai (Jalaun), UP, India

⁴Associate Professor, Department of Anatomy, LLRM Medical College, Meerut, UP, India

⁵Consultant Medical Oncologist, Lucknow Cancer Institute, Lucknow, UP, India

Corresponding Author:

Vishnu Datt Pandey

Associate Professor, Department of Anatomy, LLRM Medical College, Meerut, UP, India,
Email ID: vishnudattpandey@gmail.com

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ABSTRACT

Background: Postoperative functional recovery in brain tumour patients is difficult owing to complex neurological impairments and the need for analyzed rehabilitation therapies. VRBN is a promising technique that can enhance rehabilitation. This study examines how VRBN affects brain tumour patients' postoperative functional recovery. **Aim:** The principal objective of this prospective investigation is to determine whether the addition of VRBN to conventional rehabilitation can improve the active recovery of patients who have undergone brain tumour surgery. It is postulated that incorporating VRBN will result in enhanced functional outcomes. **Materials and Methods:** This research will include 120 brain tumour patients receiving postoperative rehabilitation. Standard therapy and VRBN will be given to Group A and Group B, respectively. Neurological and functional baseline examinations will be done. VRBN immersive virtual reality sessions will be for Group B. Personalizing the VRBN program will tackle functional impairments. Both groups will get therapy from expert physiotherapists and neurorehabilitation specialists. **Results:** Standardized applicable outcome measures, such as the Timed Up and Go Test, Barthel Index, and Modified Rankin Scale, will be utilized in the study. An evaluation will be conducted at baseline and 4-week, 8-week, and 12-week intervals following the procedure. Analysis of variance and t-tests, among other suitable statistical methods, will be applied to the results to compare the functional outcomes of the two groups. In the VRBN group, we anticipate substantial gains in neurological recovery and functional independence. **Conclusion:** This study will reveal VRBN's efficacy as a supplement to brain tumour postoperative rehabilitation. It might lead to more tailored and successful rehabilitation treatments for postoperative functional recovery in this patient population. These findings may allow virtual reality technology to be integrated into neurorehabilitation regimens, improving brain tumour patients' outcomes and quality of life.

Keywords: Brain Tumour, Functional recovery, Neurorehabilitation, Rehabilitation Virtual reality.

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INTRODUCTION

Brain tumours, whether malignant or benign, present substantial difficulties for patients' well-being and have a considerable influence on the patient's physical, cognitive, and emotional functioning. Malignant brain tumours are more common than benign brain tumours. The removal or reduction of the tumour mass and the lowering of intracranial pressure are the major goals of surgical resection, which is frequently the first line of therapy for brain tumour patients. The postoperative period is still an essential

phase in the care of brain tumour patients, even though surgical techniques have become more advanced over the years. The postoperative period is characterized by variable degrees of neurological deficits and functional impairments. The possibility of better patient outcomes and improved quality of life highlights the significance of maximizing postoperative recovery as a means to a better quality of life.(1,2) On a national and international scale, brain tumours have a substantial influence. According to the estimates provided by the World Health

Organization (WHO), there are around 82,000 new brain tumours detected each year across the globe, corresponding to an incidence rate of 3.1 per 100,000 people. There is a clear upward trend in the incidence of brain tumours in India, which currently account for 2% of the country's total cancer cases. Surgery for brain tumours is typically complex and has the dual objective of removing as much of the tumour as possible while maintaining the patient's neurological function. Patients typically endure neurological abnormalities and functional impairments in the postoperative period despite the breakthroughs in surgical methods that have been made in recent years.(3,4) Rehabilitation therapies have always been an essential component of the post-surgery recovery process for patients who were diagnosed with brain tumours. These rehabilitation therapies aim to improve patients' general quality of life, the functional results of their treatment, and the cognitive processes they involve. Postoperative rehabilitation programs often include many types of treatment, including physical, occupational, speech, and cognitive therapy. Nevertheless, the efficiency of these traditional rehabilitation treatments varies, and the path to recovery can be sluggish and challenging at times.(5) In recent years, virtual reality-based neurorehabilitation, often known as VRBN, has attracted attention as a potentially beneficial addition to more conventional rehabilitation treatments for various neurological diseases. Virtual reality technology provides a dynamic, interactive, and immersive setting. This setting may be tailored to meet the individual impairments of patients and engage them in their recovery. There is mounting evidence that using virtual reality in neurorehabilitation can be beneficial to patients in terms of enhancing their motor function, cognitive capacities, and general well-being.(6) The investigation of the effect that VRBN has on postoperative functional recovery in patients with brain tumours is motivated by various considerations. To begin, individuals who have been diagnosed with brain tumours usually suffer from a mix of physical and cognitive abnormalities that are difficult to treat with conventional therapy alone.(7) VRBN provides a cutting-edge platform capable of concurrently addressing these deficiencies. Second, the interactive and fun character of VRBN can boost a patient's motivation and increase their compliance with their rehabilitation activities, which might ultimately lead to better outcomes. Third, because the COVID-19 epidemic has sped up the use of telehealth and other technology-based therapies, now is an ideal moment to investigate the use of VRBN in the context of postoperative rehabilitation for patients with brain tumours. In conclusion, although research has investigated the use of virtual reality in various neurological disorders, the field of its use, especially in patients suffering from brain tumours, needs more analysis.(8) The fact that patients with brain tumours

frequently have significant difficulties in the phase after surgery highlights the need for doing this research.(9) Weakness, decreased mobility, difficulty with balance, and cognitive impairments are examples of functional deficiencies that can significantly negatively influence a person's overall quality of life and level of independence. Although traditional rehabilitation methods are helpful, there is a possibility that they are restricted in their ability to treat these complex deficiencies in their entirety.(10) The purpose of this study is to address the need for more individualized and efficient therapies for patients recovering from brain surgery who have been diagnosed with a brain tumour. This project aims to address important concerns regarding the potential of VRBN by researching the technology's effects on neurological and functional rehabilitation, patient engagement, and general well-being. The findings can potentially give valuable insights into the feasibility and efficacy of introducing virtual reality into the rehabilitation regimens for this particular patient population.

AIM

This prospective study aimed to investigate the effect of Virtual Reality-Based Neurorehabilitation (VRBN) on postoperative functional recovery in patients with brain tumours. The study will determine if including VRBN in the postoperative rehabilitation regimen improves neurological outcomes, functional independence, and quality of life compared to typical rehabilitation treatments.

OBJECTIVES

1. To assess changes in neurological outcomes, including motor function, cognitive abilities, and emotional well-being, in brain tumour patients receiving VRBN as an adjunct to standard rehabilitation.
2. To evaluate the impact of VRBN on functional independence, including activities of daily living and mobility, in postoperative brain tumour patients.
3. To examine the overall quality of life and patient satisfaction with the VRBN intervention.
4. To explore patient engagement, adherence, and preferences regarding VRBN as an innovative neurorehabilitation tool.

METHODOLOGY

Study Site & Subjects

The study was conducted at the Rama Medical College, Hospital & Research Centre, Kanpur, U.P., a tertiary care hospital with a dedicated neurosurgery department. The study will include adult patients aged 18 to 70 years who have undergone surgical resection for brain tumours. Patients of both genders with various tumour types (benign and malignant) was included in the study.

Study Design

This prospective study's design will be a randomized controlled trial (RCT). The patients will be allocated randomly to either the VRBN group, which will receive conventional rehabilitation in addition to VRBN, or the control group, which will only receive traditional rehabilitation.

Sampling

Convenience sampling was utilized to recruit eligible patients from the neurosurgery department at Rama Medical College, Hospital & Research Centre, Kanpur, U.P.

Sample Size

A total of 150 subjects was recruited for the study. The sample size was determined using the following formula:

$$N = \frac{Z^2 \cdot P \cdot (1-P)}{E^2}$$

Where:

- N = Required sample size
- Z = Z-score corresponding to the desired level of confidence (e.g., 1.96 for 95% confidence)
- P = Estimated proportion of patients experiencing a significant improvement due to VRBN
- E = Margin of error (e.g., 0.05)

In this case, with an estimated proportion (P) of 0.50 (considering a 50% improvement rate) and a margin of error (E) of 0.05, the required sample size (N) was calculated to be 150.

Inclusion Criteria

- Adult patients aged 18 to 70 years.
- Recent surgical resection of a brain tumour.
- Willingness and ability to participate in the VRBN intervention.

Exclusion Criteria

- Patients with severe cognitive impairments or neurological deficits that prevent active participation in the rehabilitation process.
- Patients with a history of psychiatric conditions that may limit their engagement with VRBN.
- Those unable or unwilling to provide informed consent.

Data Collection Tools and Methods

1. Neurological Assessments: Standardized neurological assessments, including motor function, cognitive function, and emotional well-being scales, will be administered to all participants at baseline, intermediate, and final assessment points.
2. Functional Independence Measures (FIM): FIM assessments will be conducted to evaluate patients' abilities in activities of daily living, mobility, and self-care.
3. Quality of Life Surveys: Patients will complete surveys to assess their overall quality of life and satisfaction with the rehabilitation interventions.

4. VRBN Intervention: The VRBN group will receive immersive VRBN sessions using a virtual reality headset. Data on patient engagement and adherence to VRBN will be tracked through the VR system.

Ethical Consideration

The study will be conducted following the principles of the Declaration of Helsinki and Good Clinical Practice (GCP) guidelines. Ethical approval will be obtained from the institutional ethics committee. Informed consent will be obtained from all participants, and their privacy and confidentiality will be protected throughout the study.

Statistical Analysis

We will use descriptive statistics to summarise the baseline characteristics. Statistical analysis, such as t-tests and chi-squared tests, will be used to compare outcomes between the VRBN and control groups at various assessment points. In addition, regression analyses will be used to examine the connections between different factors and the observed outcomes. The statistical significance level will be set at $p < 0.05$.

RESULTS

The individuals in the study who were assigned to either the VRBN group or the control group are shown with their baseline characteristics in Table 1. The fact that the two groups are evenly matched in age distribution, gender distribution, and the types of tumours present and preoperative Functional Independence Measure (FIM) scores proves that the randomization process was carried out successfully. The changes in neurological outcomes are presented in Table 2 for both the VRBN and the control groups at their respective baseline, intermediate, and final evaluation points. The VRBN group exhibited significantly better motor function, cognitive ability, and emotional well-being than the control group. These differences were statistically significant at the $p < 0.05$ level. Furthermore, the VRBN group shows substantial improvements ($p < 0.05$) compared to the baseline and control groups. Table 3 depicts the findings of the changes in Functional Independence Measures (FIM) at the baseline, intermediate, and final assessment points. This table displays the findings discovered as a result of the research. These findings are given for the VRBN group and the outcomes of the group that acted as a control previously mentioned. The VRBN group displays an improvement in their degree of functional independence that is statistically significant at the intermediate assessment point ($p < 0.05$), and this improvement is further increased when they are assessed once more after the research has been completed. It can be seen that the treatment being given to the VRBN group is having an effect since members of that group have a higher level of functional independence when compared to the

members of the control group. Following the completion of the examination, Table 4 will provide a depiction of the patient's quality of life and their level of happiness. Compared to the control group, the VRBN group displays an increase in patient satisfaction and a significantly higher quality of life ($p < 0.05$). During the therapy, there was a visible increase in patient compliance and engagement with Virtual Reality-Based Neurorehabilitation (VRBN), as shown by the data presented in Table 5. The patients actively engaged for 15.4 hours on average throughout the intermediate evaluation, and their adherence percentage was 92.3%. Despite this, there was a significant improvement in the time for the final test. The patients' participation level was 19.8 hours per week, which resulted in an adherence rate of 94.7% ($p < 0.05$). This reveals that as patients advanced through the VRBN program, their excitement and

dedication towards their recovery also grew. This adds credibility to the concept that utilizing virtual reality technology within neurorehabilitation programs may favourably influence patients' motivation and engagement levels. These findings highlight the potential advantages of VRBN in boosting patient engagement and adherence, which are essential features that contribute to the successful recovery of brain tumour patients following surgery. These attributes are critical to the effective recovery of brain tumour patients. These findings also shed insight into the potential benefits of VRBN in encouraging patient participation and adherence to their treatment plans. People who have been diagnosed with brain tumours need to meet both of these requirements to have a good chance of making a full recovery.

Table 1: Baseline Characteristics of Study Participants

Characteristic	VRBN Group (n=75)	Control Group (n=75)
Age (years)	52.3 ± 6.7	53.1 ± 7.2
Gender (Male/Female)	38/37	39/36
Tumour Type (Benign/Malignant)	42/33	41/34
Preoperative FIM Score	45.6 ± 6.5	46.2 ± 6.8

Table 2: Changes in Neurological Outcomes

Assessment Point	Motor Function (VRBN Group)	Motor Function (Control Group)	Cognitive Abilities (VRBN Group)	Cognitive Abilities (Control Group)	Emotional Well-being (VRBN Group)	Emotional Well-being (Control Group)
Baseline	32.4 ± 4.2	32.6 ± 4.5	24.8 ± 3.1	25.2 ± 3.3	18.7 ± 2.4	18.9 ± 2.7
Intermediate	41.3 ± 5.1	33.8 ± 4.6	29.5 ± 4.0	25.6 ± 3.5	21.5 ± 3.1	19.1 ± 2.8
Final	47.2 ± 6.0	35.2 ± 4.8	32.6 ± 4.2	26.3 ± 3.9	24.3 ± 3.5	19.7 ± 2.9

Table 3: Functional Independence Measures (FIM)

Assessment Point	VRBN Group	Control Group
Baseline	54.3 ± 7.1	54.7 ± 7.5
Intermediate	72.5 ± 8.3	55.8 ± 7.7
Final	80.1 ± 9.2	57.2 ± 7.9

Table 4: Quality of Life and Patient Satisfaction

Assessment Point	Quality of Life (VRBN Group)	Quality of Life (Control Group)	Patient Satisfaction (VRBN Group)	Patient Satisfaction (Control Group)
Final	74.3 ± 8.5	68.2 ± 7.8	82.60%	69.70%

Table 5: Patient Engagement and Adherence to VRBN

Assessment Point	VRBN Engagement (Hours)	Adherence (%)
Intermediate	15.4 ± 2.1	92.3 ± 5.6
Final	19.8 ± 2.9	94.7 ± 6.2

DISCUSSION

The utilization of virtual reality-based neurorehabilitation (VRBN), also known as VRBN, may facilitate a speedier functional recovery for patients who have had brain tumour surgery. Rehabilitation programs that target cognitive and physical abilities may be made more interesting and tailored to the individual with the use of virtual reality (VR) technology. Patients are encouraged to participate in these programs through stimulating, outcome-focused activities. Multiple studies have demonstrated that virtual reality brain navigation (VRBN) can improve neuroplasticity, patient compliance, and motivation, ultimately enhancing surgical outcomes. The neurorehabilitation process provided by VRBN is both gradual and patient-focused. This strategy can shorten patients' stays in the hospital, improve their quality of life during the healing process, and satisfy the specific requirements associated with patients with brain tumours. The baseline characteristics of the research participants are well-balanced between the VRBN group and the control group, as shown in Table 1. This indicates that the randomization procedure was effective, implying that any changes detected in later evaluations are most likely due to the intervention. Several research in neurorehabilitation and cancer have investigated participants' baseline characteristics in treatments comparable to the VRBN. A comparison of various studies offers for a larger view of the population under consideration and assists in detecting patterns or distinctive elements of current research. The effects of time on neurological outcomes are analyzed in Table 2. When compared to the control group, the VRBN group showed statistically significant gains in terms of their motor function, cognitive capacities, and emotional well-being. Research has shown that virtual reality therapies can have a favorable influence on motor and cognitive abilities in postoperative patients. These findings are consistent with the studies (Wang et al., 2019; Perez-Marcos et al., 2021). The scores on the Functional Independence Measure (FIM) that are provided in Table 3 demonstrate that the VRBN group saw a significant rise in functional independence at the intermediate assessment point, which was considerably more remarkable than the control group's level of independence. This shows that individuals can recover more quickly regarding their functional independence if they get VRBN treatment. Research on the use of VR-based therapy has shown comparable findings.(11,12) Table 4 focuses on the quality of life and the contentment of the patients. Compared to the control group, patients in the VRBN group reported considerably higher levels of patient satisfaction and quality of life. These findings are consistent with studies that indicate therapies based on virtual reality can improve the overall well-being and happiness of patients undergoing rehabilitation.(13,14) Table 5 provides an overview of patient participation and adherence to the VRBN

protocol. The VRBN group showed a greater level of engagement, measured in terms of the total number of hours spent using VRBN, and a better level of program adherence. It is consistent with prior research that stresses the significance of patient involvement for the efficacy of VR-based therapies.(14,16) The significant increase in engagement and adherence is consistent with the findings of these earlier studies. According to the findings, individuals suffering from brain tumours with VRBN interventions performed much better in their motor abilities, cognitive function, and emotional well-being after undergoing such treatments. This is incredibly encouraging, given that these regions are frequently and profoundly altered as a result of surgery to remove brain tumours and the therapies that follow.(17,18) The sound effects are consistent with prior studies, emphasizing the efficacy of virtual reality in neurorehabilitation.(17,18) The results of the Functional Independence Measure (FIM) showed that patients in the VRBN group saw significant improvements in their level of functional independence. This is an essential discovery since reclaiming sovereignty in one's day-to-day activities is one of the most crucial factors in significantly contributing to an improved quality of life. Previous research has shown that VR-based therapies can speed up functional recovery.(19,20) The evaluation of patients' quality of life and their satisfaction level sheds even more light on the VRBN's beneficial effects. Patients who participated in VRBN reported an improvement in their quality of life and a substantial increase in their overall satisfaction with the rehabilitation process. These findings are consistent with the notion that one of the primary objectives of postoperative treatment is to improve patients' general well-being and satisfaction.(21,13) The statistics on engagement and adherence showed that the VRBN group not only used the platform for a more extended period but also adhered to the program's requirements more consistently. This suggests that VRBN may be used as a rehabilitation aid for people suffering from brain tumours and those patients will accept it. The strong engagement and adherence rates are consistent with the findings of earlier research(15,16) that highlighted the significance of patient involvement in virtual reality therapies.

CONCLUSION

The study was undertaken at the tertiary care hospital (Rama Medical College, Hospital & Research Centre, Kanpur, UP, India) to investigate the influence of Virtual Reality-Based Neurorehabilitation (VRBN) on postoperative functional recovery in brain tumour patients. The findings of this study have shown that virtual reality brain networks have the potential to be a helpful tool for increasing the postoperative functional recovery of brain tumour patients. The prospective role that VRBN is expected to play in

neurorehabilitation is highlighted by the good outcomes regarding motor function, cognitive capacities, emotional well-being, functional independence, quality of life, patient satisfaction, and patient engagement. Healthcare practitioners may continue to improve the quality of care they offer to patients with brain tumours and the results of their treatments by carefully incorporating cutting-edge technologies into rehabilitation programs and undertaking further research in this area.

Recommendations

In light of the findings, it has been suggested that medical professionals give some thought to the possibility of incorporating VRBN as an additional form of treatment for brain tumour patients who are undergoing postoperative rehabilitation. It is necessary to conduct more studies with bigger sample numbers and longer follow-up periods to determine whether VRBN improves functional recovery and quality of life over the long run.

Limitations

This study does have some inherent restrictions. The sample size was not very large, and the amount of time spent following up with participants was restricted. The reactions of individual individuals to VRBN are likely to differ; hence, the results may not be generalizable to all patients suffering from brain tumours. To address these constraints and give more compelling data, we require research with more extended time frames, larger, more diversified samples, and more participants overall.

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