



Original Article

Virtual Reality in Neurosurgery- A Neurostimulator – Based Postgraduate Residency Training: A Novel Step Towards Skillful Young Neurosurgeons

Usman Ahmad Kamboh¹, Sidra Abid¹, Sana Ullah¹, Mehwish Manzoor², Kashif Sultan¹
Mehreen Mehboob¹, Mohammad Ashraf^{1,3}, Sana Jamal¹, Manzoor Ahmad¹

¹Departments of Neurosurgery & ²Oncology, Allama Iqbal Medical College/Jinnah Hospital, Lahore, Pakistan, and ³Wolfson School of Medicine University of Glasgow, Scotland, United Kingdom

ABSTRACT

Introduction/Objective: Virtual Reality (VR) is the need of time in every field of life. Recent biotechnological advances have molded the surgeon-computer relationship. Department of Neurosurgery Jinnah Hospital Lahore has updated the postgraduate training program by adding the virtual reality simulator. We aim to explore the current and future roles and applications of VR and simulation in neurosurgical training that may reduce the learning curve, improve conceptual understanding and enhance visuospatial skills.

Materials & Methods: Eight residents were enrolled in this program. They exercised the basic skills of neurosurgery e.g. suction, use of bipolar cautery, handling of CUSA, use of micro scissors, etc., and the automated software recorded each participant's graph of performance separately. After 1.5 years, they were assessed in real-time on actual patients under the direct supervision of a qualified neurosurgeon. The assessment was done on DOPS (Directly Observed Procedural Skills) Performa.

Results: The results showed that there was a gradual upward learning curve in simulator-based procedures from negative marking to 70% in basic surgical skills and 60% in advanced procedures on average for all the residents whereas the DOPS showed that all residents performed above expectation i.e., 4 or above.

Conclusion: Neurostimulator-based postgraduate training program is opening new horizons for the safe and skillful training of residents. With the advancement of artificial intelligence, its use in training programs will lead to structured and systematic training patterns in the world of neurosurgery.

Keywords: VR (virtual reality), DOPS (Directly Observed Procedural Skills), Simulation-Based Training, Surgeon-Computer Relation.

Corresponding Author: Manzoor Ahmad
Department of Neurosurgery, Allama Iqbal Medical
College/Jinnah Hospital, Lahore, Pakistan
Email: manzoor63@gmail.com

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INTRODUCTION

Neurosurgeons are facing the challenge of performing complex procedures with only a little room for fallacy. Education resources are affected by time and financial constraints. Recent biotechnical progression has influenced surgeon-computer relations.¹ Cadaver and animal laboratories have been of great help in learning but have many practical limitations. For the development of surgical skills in residents, training is important whether in the form of observation or hands-on inside the operation theatre.

Our brain has narrow corridors to operate upon which requires dexterity in a surgeon. So it needs a very facile neurosurgeon that not only knows his tools but also the complex anatomy of the brain.²

In the present study, we used spatial distribution analysis to investigate the effects of hand ergonomics on metrics such as duration of the task, excessive force applied, number of attempts, and the extent of completion of a given task. Department of Neurosurgery Jinnah Hospital Lahore has updated the postgraduate training program by adding the virtual reality simulator. We aim to explore the current and future roles and application of Virtual reality and simulation in neurosurgical training that may reduce the learning curve, improve conceptual understanding and enhance visuospatial skills.

MATERIAL AND METHODS

Study Design & Setting

A prospective study was designed at the Department of Neurosurgery, Jinnah Hospital, Lahore from January 2021 to December 2021.

Participants & Groups

Eight third-year post-graduate neurosurgery residents were divided into two groups (VR Group

& Non-VR Group) by lottery method. Each group had 4 residents. VR Group was trained and assessed on Neuro VR during this time period.

Direct Observation of Procedural Skills (DOPS)

In the first month, each resident had two orientation sessions with a trained VR simulator consultant. In the next two months, each resident practiced basic neurosurgical skills on VR, i.e., use of suction and bipolar cautery for 6 hours per week, and, in the next three months, each resident practiced advanced surgical skills on neuro VR, i.e., Glioma resection, Laminectomy and Endoscopic third ventriculostomy for 6 hours per week. Automated performance metrics (time, force, blood loss, and volume of resection) were calculated by VR after each exercise (Figure 1). In the next six months, the surgical skills of these four residents were assessed on the pre-designed Direct Observation of Procedural Skills (DOPS) proforma of the College of Physicians and Surgeons, Pakistan (CPSP) for the skills they were trained on the simulator, i.e., VR Group.

RESULTS

Assessments

Each resident was assessed for one technique per week based on 2 DOPS in the operation theatre. The results of the DOPS proforma of both groups were assessed and compared. The training session of VR groups was assessed by APM (Automated Performance Metrics) for all five procedures. It was inferred from the results that the best cumulative performance was shown by resident A and the technique with the best cumulative performance used was suction (Table 1).

Categorization of DOPS

The cumulative score of DOPS was categorized



Figure 1: Showing Automated Performance Metrics (APMs).

Table 1: VR group APM Score.

Technique	Resident A (%)	Resident B (%)	Resident C (%)	Resident D (%)	Cumulative (%)
Suction	80	65	75	61	70.25
Bipolar	76	65	63	49	63.25
Glioma resection	78	70	62	55	66.25
Laminectomy	60	65	55	53	58.25
ETV	70	60	45	45	55
Cumulative	72.8	65	60	52	

Table 2: Grading used to assess the performance of residents.

Grade	Percentage	Interpretation
1	20%	Poor
2	40%	Good
3	60%	Average
4	80%	Above average
5	100%	Excellent

neurosurgeon on the DOPS proforma twice for each technique. The result of resident A was the best among the all participants with a 76% score and the techniques with the best results were suction and bipolar cautery, i.e., 75%. When it was compared with the non-VR group, it was found that the best performance was 56% on an individual basis and, regarding technique, a 75 % score was achieved in suction (Tables 3 & 4).

based on the score as follows. All the selected techniques were assessed by the same consultant

Table 3: VR group DOPS.

Technique	Resident A (%)	Resident B (%)	Resident C (%)	Resident D (%)	Cumulative (%)
Suction	80	80	80	60	75
Bipolar	80	80	80	60	75
Glioma excision	80	80	80	40	52
Laminectomy	80	60	60	60	65
ETV	60	60	60	20	45
Cumulative	76	72	72	48	

Table 4: Non-VR group DOPS.

Technique	Resident E (%)	Resident F (%)	Resident G (%)	Resident H (%)	Cumulative (%)
Suction	80	60	60	80	70
Bipolar	60	60	60	80	65
Glioma excision	40	60	40	60	50
Laminectomy	40	20	40	40	35
ETV	20	20	20	20	20
Cumulative	48	44	44	56	

DOPS of Analysis & Results in Groups

The analysis of the DOPS of the VR group showed that the majority of the residents secured average scores whereas one resident had a good score which emphasizes the fact that the VR training enhances the real-time performance of the residents and the surgical techniques of suction, bipolar usage, and glioma excision showed above average results by resident A, B & C. In the non-VR group trained residents, DOPS results were good, with the majority of residents showing above-average results in only suction and bipolar usage and poor or good results in the rest of the observed techniques.

DISCUSSION

New gadgets and technologies have changed the work environment for a surgeon in the operation theatre and also for residents, it's easy to learn from visual aids. In this way, it helps surgeons to have the full picture of the pathology in mind. These visualization modalities include digital stereomicroscope, surgical planning, augmented reality (AR), and virtual reality (VR). Planning during surgery and augmented reality are

becoming beneficial tools in the operating room.⁶ For a surgeon to enhance their skills and efficiency, simulators are becoming more common nowadays.

For all levels of trainees, virtual reality is giving more variety of learning experiences due to its improvement in graphics and computations. Virtual reality means that it provides a high level of sensory environment between its user and computer to maintain a human-computer interface that offers the highest level of training. So, surgeons can improve their skills in a short time and transfer these skills in operation theatres more efficiently.

In complex surgical specialties like that ours, manipulating 3D models to learn complex anatomy is very crucial. That is how simulator-based learning is essential in neurosurgery. The earliest VR (Virtual Reality) system was developed in the late 2000s, including a ventriculostomy environment using Immersive Touch and a brain tumor resection environment using NeuroTouch.³⁻⁵ More recent systems have included more surgical scenarios and simulated techniques to advance the training level.¹ These metrics focus on psychomotor skills such as safety, quality,

efficiency, and bimanual dexterity. The ability to move the wrist, hands, and fingers in the restricted field around the tumor plays an important role in surgical performance.

Trainees spend less time in operation theatre after it has been established that per week work hours will be 80 hours at maximum. So it has resulted in more time in training a resident and developing skills. So it has become more important to include virtual reality simulators in a training program for patient safety and benefit in addition to other simulation techniques as mentioned above. A large number of doctors who were included in the survey believe that including VR simulators will help the trainers and trainees. The advancement in the VR technique over the last decade has resulted in the enhancement of haptic feedback and the future, it is going to replace cadaver training which is a time-tested technique for the training of residents and young consultants. Hand positioning has been reviewed largely in laparoscopic surgeries where it has been established that there is a link between hand-wrist movement and surgical performance.⁷⁻

⁹ Due to ethical and economical problems in south Asian countries, cadaveric training is difficult.

A significant number of studies are being carried out to assess the neurostimulators and their benefits for surgeons and trainees.¹⁰ It has been seen that senior faculty takes more advantage of virtual reality-based simulators as compared to postgraduate residents who, on the other hand, are more comfortable with cadaveric dissections but it only is the problem at the start of training.¹¹

The Neuro Touch system of the National Research Council of Canada is one of many systems used as a simulator for training in neurosurgery that aids in procedures like brain tumor resection. This system is based on a stereographical rendering technique resulting in microscope-like hand-eye coordination practice which is the basic feature of a binocular

microscope and gives the same feeling of depth as of microscope and also helps trainees to have better three-dimensional anatomy in mind while operating.

Our study showed that there is a significant difference in the DOPS-based assessment of both groups. Neuro VR-trained residents showed average and above-average scores in the third year of their residency and such simulation-based training can lead to an efficient performance in the OR when it is compared to the non-VR group.

Neuro VR-based learning enhances Cognition and procedural reasoning but there is a lack of immersive experience along with a loss of graphic & Haptic feedback to some extent this deficiency on the part of Neuro VR is overshadowed by the training skills it imparts to residents.

Pakistan, being a developing country with limited resources and ethical considerations of cadaver workshops, simulation-based training can be a source of effective training for a highly technically demanding field like Neurosurgery. The Neuro VR is an efficient alternative to the cadaver workshops for the highly sophisticated field. It is recommended by the results of our study that Neuro VR facility should be available at tertiary care hospitals for the teaching of residents.

Satawa et al. predicted in 1993 that all Neurosurgeons will get certification and trained on the simulator in the next 10 years and will practice on specific patients' models before doing the procedure in OR but still we are far away from this prediction. So it is recommended that we should look forward to simulation-based training of all residents and young consultants to enhance the facility of safe neurosurgery in the future for better and promising surgical outcomes.¹² It can also be inferred from this study that simulation-based training can be included in routine training programs as well.

LIMITATIONS OF STUDY

The small sample size and lesser number of sessions of assessment are the limitations of this study. Moreover, we could not get the latest studies for comparison and reference, which may be due to the lesser number of this equipment being available in the institutions.

RECOMMENDATIONS

A larger study with more participants (even from departments of other institutions) and more sessions of assessment. Other departments are recommended to procure such learning aid for better and more confident learning of the trainees.

CONCLUSION

Simulation-based training is now an integral part of every technically demanding field all around the world. Neuro VR is an effective opportunity for residents of a developing country to learn basic and advanced surgical techniques on patients' models and improve their learning curve before performing real-time surgery.

We are optimistic that with further development, systematic assessments through APMs, and rigorous validation, VR simulation-based Neurosurgical training is finally on the horizon.

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Additional Information

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Ethical Review Board Approval: The study was conformed to the ethical review board requirements.

Human Subjects: Consent was obtained by all patients/participants in this study.

Conflicts of Interest:

In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Usman Ahmad	1. Study design and methodology
2.	Mehreen Mehboob	2. Paper writing
3.	Sidra Abid, Sana Ullah, Mehwish Manzoor	3. Data collection and calculations
4.	Usman Ahmad, Muhammad Ashraf	4. Analysis of data and interpretation of results
5.	Kashif Sultan, Sana Jamal, Mehreen Mehboob	5. Literature review and referencing
6.	Manzoor Ahmad	6. Editing and quality insurer