Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

Role of exoscope in intracranial space occupying lesion surgeries: A Prospective study

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Running title- Exoscopes in ICSOL surgeries

Work attributed to: Department of Neurosurgery, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India

Author's contribution :
MJ- Definition of intellectual content, Literature survey, Prepared first draft of manuscript, Implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article, **KVK-** Concept, design , clinical protocol, manuscript preparation, editing and revision, statistical analysis, **SA[3]-** Review manuscript, preparation of tables, **SA[4-]** Manuscript revision **KA-** Coordination and manuscript revision

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Conflicts of interest- nil
Source of funding: There was no financial support concerning this work.
Limitations of the study -

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

Patients with hemorrhagic ICSOL developed spontaneously or due to trauma are not included in the study.

Acknowledgements - The authors are acknowledged to present part of this paper in the form of paper Presentation at MP chapter NSICON 2024.

Abstract

Background - Exoscopes have emerged as a promising and reliable substitute or supplement to the conventional binocular surgical microscope in procedures such as brain tumour and skull base surgery, aneurysm clipping, as well as complex cervical and lumbar spine surgery. They offer a safe and efficient option, potentially paving the way for a groundbreaking era in the realm of innovative tools and techniques within the field of neurosurgery.

AIMS AND OBJECTIVES - The study was conducted to find the practicality, advantages and disadvantages of exoscope assistance rather than use of conventional microscope in ICSOL surgeries.

Material and methods - This Prospective study included patients admitted with intracranial space occupying lesions under department of neurosurgery , GRMC and associated J.A. group of Hospitals from April 2023 to May 2023 who underwent surgery. No randomisation done.

Results : Out of a total of 9 patients, the male population accounted for 57%, while the female population comprised 43%. More than half of the patients, specifically 66.6%, were aged 40 years or older. The prevailing condition among most patients was glioma with a combination of solid and cystic components. During the utilisation of the exoscope, the overall rate of surgical complications was 11.1%. These complications exhibited a similar profile to those observed in patients who underwent the same procedures with the traditional operating microscope. Moreover, there was an overall incidence rate of 11% for switching from the exoscope to the operating microscope during the course of surgery.

CONCLUSION- The utilisation of the exoscope has consistently yielded positive surgical outcomes, surpassing the results achieved with the operating microscope, particularly in surgeries for intracranial space-occupying lesions (ICSOL). The exoscope has emerged as a secure alternative to the traditional operative microscope for common brain procedures, offering several notable advantages. These include user-friendly simplicity, improved 3D visualisation, and enhanced magnification of the surgical field. These advancements have contributed to better surgical results and overall success in ICSOL surgeries.

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

Key words- Intracranial space-occupying lesions (ICSOL), Exoscope, Operating microscope, Neurosurgery

INTRODUCTION:

The traditional microscope has long been relied upon for glioma surgery, the exoscope has emerged as a novel visualisation tool in the field of neurosurgery, specifically for brain tumour resection. With its high-definition heads-up display, the exoscope enables neurosurgeons and their teams to visualise the surgical site with precision. Compared to the conventional microscope, the exoscope offers several notable advantages. It provides approximately twice the optical zoom, allowing for enhanced magnification and visualisation. Additionally, the exoscope utilises light emitting diode (LED) lighting, which reduces tissue glare and minimises the risk of thermal damage. Moreover, the LED lighting may facilitate better delineation of tumour tissue, further enhancing surgical outcomes(1).

The pursuit of highly detailed images and techniques in microsurgery and minimally invasive procedures has yielded significant clinical benefits and patient satisfaction(2). Exoscopes, in particular, have undergone significant technological advancements over the years, with frequent updates to both software and hardware. These devices represent the latest addition to the neurosurgical toolkit, bridging the gap between traditional operating microscopes and endoscopes (3). The development of 3D exoscopes is a testament to the remarkable technological innovations that continue to shape modern surgical practice. From the first 3D High Definition (HD) visualization exoscope to the most recent 3D 4K exoscope, the field of exoscopy continues to evolve and improve year after year.

Exoscopes, like other modern devices, require specific training, although the learning curve is considerably shorter compared to operative microscopes and endoscopes in neurosurgery. As a safe and effective alternative or complement to existing binocular operative microscopes, exoscopes have demonstrated their utility in various procedures such as brain tumour resection, skull base surgery, aneurysm clipping, and vascular microanastomosis.(4) They offer surgeons comfortable and high-resolution visualization while maintaining surgical exposure and patient safety. Integrated features like lock-on-target, waypoints, and foot switches enable efficient camera placement and hands-free return to saved positions. The digital visualization and ergonomic design of exoscopes prove advantageous, even when surgeons need to navigate extreme angles. Several exoscopic systems are currently available for neurosurgical use, including VITOM®, ORBEYE™, Modus VTM, Kinevo 900, BrainPath®, and Aeos®, each with unique technical, software, and hardware characteristics but sharing the same goal (5). Just as operative microscopes revolutionised neurosurgery in the 1960s, exoscopes are poised to usher in a new era of tools and techniques. This review aims to explore the use of exoscopes in preclinical and clinical neurosurgical settings, common procedures performed with

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

exoscopes, their impact on surgical outcomes and workflow, as well as the reported complications, cases switched from exoscopes to microscopes, and a comprehensive evaluation of their advantages and disadvantages compared to microscopes.

Material and methods:

This was a prospective study of patients who were admitted with intracranial space-occupying lesions (ICSOL) under department of neurosurgery, GRMC and associated J.A. group of Hospitals, Gwalior from April 2023 to May 2023 who underwent surgery and analysing the patient's outcome and ease and difficulties of surgery to assess the results.

After the admission of patients, they underwent clinical and radiological examination like non-contrast CT scan of head, plain and contrast MRI Brain before concluding the diagnosis . Pre-operatively all the patients were investigated thoroughly following which after assessment of all the patients they underwent surgical procedure. Intra-operative findings, advantages and disadvantages of exoscopic assisted surgery, operative complications and surgical procedures switched from the exoscope to operative microscope were noted.

Inclusion criteria :

All the patients with radiological diagnosis of intracranial space-occupying lesions and planned for surgery.

Exclusion criteria :

Patients with inoperable and multiple intracranial space-occupying lesions, traumatic and non- traumatic intracranial haemorrhage and those not willing for participation.

RESULTS :

A non-randomised, prospective, single institute study was conducted between April 2023 and May 2023, in GR Medical College and JA group of hospitals (GRMC), Gwalior over a period of two months in the department of Neurosurgery on 9 patients diagnosed with intracranial space-occupying lesions. Based on the data collected and data analyses following observations were made.

Out of this 9 patients (5 male, 4 females) included in this study, 4 patients had glioma , 3 patients had metastasis, 1 patients had meningiomas and 1 patient had pituitary adenoma which was histologically confirmed after exoscopic assisted surgery. During the use of exoscopes, the overall surgical complication rate was 11.1%, which was similar to the complication rate seen in patients treated with operative microscopes. In addition, the quality of the video image, 2D and 3D visualization, and surgical field with exoscopes was rated as superior compared to operative microscopes. The exoscope was found to offer a higher level of comfort for the surgeon's posture during surgery, better educational usefulness, and greater

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

involvement of the operative team. However, the depth perception with exoscopes was rated as similar or inferior to operative microscopes in 2D mode. Workflow and operative time were evaluated as equal or slightly longer than those with operative microscopes.

DISCUSSION:

A study of 9 cases was made of patients with intracranial space-occupying lesions. diagnosis was based on radiological investigations.

Muhammad et al. [6] reported results in cranial surgery comparable to the OM with better visual quality and greater comfort for the surgeon. The combination of surgical magnification and neurosurgery has a long and interesting history. These two fields developed separately until the 1960s, when they were finally combined, leading to a rapid expansion of cerebral surgery[7]. Since then, intraoperative technological advances have continued to improve, with the operative microscope and endoscope allowing for complete resection of glioma and other intraventricular and pituitary tumors, as well as neurovascular and spine diseases, through minimally invasive approaches with excellent lighting and magnification.(8,9).

Exoscopes have revolutionised neurosurgery by providing high-resolution 3D imaging of tissue structures, blood vessels, and other features. This advanced technology enables surgeons to perform more precise and accurate procedures while simultaneously allowing the surgical team to view the procedure on a display video. By allowing the surgeon to operate in a comfortable, ergonomic position, exoscopes help reduce fatigue and increase efficiency. These devices combine the benefits of both operative microscopes and endoscopes by providing the form factor of the endoscope with the superior image quality of the microscope, thereby bridging the gap between these two technologies. Overall, exoscopes represent the next generation of operative imaging and have significantly enhanced the field of neurosurgery (10,11).

Certain drawbacks of exoscopic visualization have been reported, particularly in the early stages of 2D exoscopes. These include limited applicability for deep-seated cranial pathologies and challenges in identifying tissues in cases of bleeding. Furthermore, magnification of deep-seated pathologies and the absence of stereopsis were identified as significant limitations. However, these disadvantages have been largely addressed with the introduction of new 3D exoscopes. It is worth noting that, in very few cases, the use of polarised glasses with 3D exoscopes has been associated with mild side effects such as headaches and nausea. Nonetheless, these instances are rare and do not significantly impact the overall benefits and advancements provided by 3D exoscopes in neurosurgery. [12,13,14,].

The ability to view the surgical procedure simultaneously on the same monitor with exoscopes offers several advantages, including improved efficiency and enhanced

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

communication among the surgical team. It allows multiple surgeons to operate together, facilitating collaboration and information sharing. However, there have been instances, as reported by Takahashi and colleagues (15), where assistant surgeons may experience a rotated view of the monitor, causing potential challenges. To overcome this issue, the use of two or more 3D monitors in the operating room can effectively resolve the problem and ensure that all members of the surgical team have an optimal viewing experience.

Exoscopic tools seem to shift from cortical cranial tumour surgery to deep-seated brain tumors, as exoscope technology has progressively improved during the last few years, with results in terms of clinical outcome and surgical complications similar to conventional OM [16] .

Among brain tumors, Gonen and colleagues [17] reported the largest series of glioma resection (56 patients) using the exoscope, accounting for 44 cases of high-grade gliomas and 12 of low-grade gliomas and reporting just one (1.8%) perioperative complication (hemorrhage within the resection bed) in a patient with glioblastoma multiforme.

Similarly, Gassie et al. [18], Piquer et al. [19], Day [20] and Eichberg et al. [21] reported that 30, 25, 22 and 12 patients, respectively, underwent surgical resection for glioma using different exoscopes. Overall postoperative surgical complications with permanent motor deficit range from 0% to 8%.

Rotermund et al. [7] reported the largest series of patients underwent trans-sphenoidal surgery for pituitary adenoma (239 patients), reporting that no serious episodes or minor complications occurred based on the usage of the exoscope, as well as no significant differences regarding the duration of surgery, complications or extent of resection compared to conventional microscopy.

Gonen et al. [17], Khalessi et al. [9], Ahmad et al. [22] had a total of 35 patients with neurovascular pathologies (aneurysms, arteriovenous malformations, cavernomas) who underwent surgery with an exoscope, reporting an overall good outcome and only 2.8% postoperative complications while in this study overall complication rate was found to be 11.1%.

This comprehensive review highlights the extensive body of literature and patient experiences pertaining to brain and spinal surgeries performed with exoscopes. The findings underscore the ease of use, patient safety, improved 3D vision, and enhanced surgical field magnification provided by exoscopes. Additionally, the review emphasises the positive impact of exoscopes on the interaction and collaboration among surgical staff members. These collective findings signify a significant milestone in the field of neurosurgery, paving the way for future advancements and imminent transformations. Moreover, the educational opportunities presented by

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

exoscopes hold great promise for the training and development of young neurosurgeons and medical students.

CONCLUSION :

In summary, exoscopes have gained popularity and are increasingly used in surgical procedures worldwide. They offer numerous advantages over the traditional operative microscope, including better ergonomic posture, improved surgical team involvement, and better quality of 3D imaging. The latest exoscopes offer superior image quality, making them a safe alternative to the operative microscope for most common neurosurgical procedures. However, the lack of depth perception and the need for a short learning curve remain challenges. Nevertheless, the exoscope is considered a useful educational tool in neurosurgery, and its potential to replace the operative microscope in the near future cannot be underestimated. More research is needed to fully understand the pros and cons of using exoscopes in neurosurgery.

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