3D Exoscope

- 3D-exoscopic extradural Hakuba-Dolenc approach with manipulation of pneumatized anterior clinoid process for the prevention of cerebrospinal fluid leakage: how I do it
- The 3D-Robotic Exoscope Compared With the Microscope in Cochlear Implant and Translabyrinthine Surgery
- How I do it: Tentorial meningioma resection with combination of 3D exoscope and endoscope via subtemporal approach
- Digital 3D exoscope is an effective tool for the surgery of falx and parasagittal meningiomas
- Microsurgical Resection of Meningiomas Using a 4K Three-Dimensional Exoscope: A Descriptive Observational Study
- Non-cadaveric spine surgery simulator training in neurosurgical residency
- Neurocircle microsurgery model: Description of simulation-based training and exoscope
- Head-up Surgery in Current Neurosurgery with Neuroendoscope and Exoscope

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A 3D exoscope is a type of surgical microscope that provides three-dimensional visualization of the surgical field. Although long-term data are still lacking regarding its future as a replacement of the OM, the 3D exoscope has revealed itself as an intense subject of discussion in neurosurgery regarding its implication for surgical education, especially for residents and junior neurosurgeons [1]. Three-dimensional exoscope systems provide an alternative visualization platform for both standard microsurgery and near-infrared fluorescent guided surgery. However, when tumor fluorescence is weak (i.e., low fluorophore uptake, deep tumors), highly sensitive near-infrared visualization systems may be required [2]

Improvement of visualization tools in neurosurgery such as the exoscope has raised the question of how this technology compares to the conventional microscope for surgeon ergonomics, discomfort, and patient outcomes. Exoscopes have the advantage of greater optical zoom, resolution, and illumination at a lower light intensity. Heads-up display for both the primary surgeon and other assistants permits neutral positioning of the surgeons while placing the camera in more angled positions. In a survey sample, this study assesses the surgeon's experience utilizing a 3D exoscope in general neurosurgery cases.

Data were recorded by 8 surgeons at 5 separate hospitals utilizing a mobile phone application survey. Surgeons recorded information about case type, intraoperative clinical outcomes such as blood loss and extent of resection, whether fluorescence visualization was used, as well as surgeon pain when compared to matched cases using conventional tools.

A total of 155 neurosurgical cases were recorded in this multisite study, including 72% cranial cases and 28% spinal cases. Of the cranial cases, 76% were brain tumor resections (31% of which were brain metastases). Surgeons reported significantly less neck ($P < 0.0001$) and back ($P < 0.0001$) pain in cases when using the robotic exoscope compared with the conventional microscope or surgical loupes. Surgeons did not convert to a microscope in any case.

The exoscope provides excellent delineation of tissue with high resolution. Surgeon pain was markedly reduced with the robotic exoscope when compared with conventional technology, which may reduce work-related injury and fatigue, potentially leading to better patient outcomes [3].

Advantages

Enhanced visualization: The 3D exoscope provides high-resolution, stereoscopic 3D images, which can improve visualization of the surgical field, allowing surgeons to see depth and details that may not be visible with a traditional microscope or endoscope.

Improved accuracy: With better visualization, surgeons can perform procedures with greater precision and accuracy, reducing the risk of complications and improving patient outcomes.

Better ergonomics: The 3D exoscope can be adjusted to provide a comfortable working position for the surgeon, reducing the risk of fatigue or strain during long surgeries [4)]

Improved teaching and training: The 3D exoscope allows for easy recording and playback of surgical procedures, providing a valuable tool for teaching and training purposes.

Reduced surgical time: With improved visualization and accuracy, surgeons may be able to complete procedures more efficiently, reducing surgical time and improving patient outcomes.

Minimally invasive procedures: The 3D exoscope provides a minimally invasive approach for certain procedures and provides enhanced 3D visualization.

The exoscope allows first-time users to better perform basic microsurgical tasks in a simulated clinical scenario compared to the operating microscope [5)].

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Use of a high-resolution 3D exoscope allowed the surgeon to simultaneously view the surgical field image and the navigation screen with minimal line-of-sight movement, which improved operative safety. The position memory function of the 3D exoscope allowed easy switching between the exoscope and the microscope and optimal field of view adjustment [7)]

Systems

3D Exoscope Systems.

3D Exoscope for Vascular neurosurgery

3D Exoscope for Vascular neurosurgery.

3D Exoscope for Chiari Malformation

- Treatment of Chiari III Malformation in Infant with 4K 3D ORBEYE Exoscope
- First-in-Man Clinical Experience Using a High-Definition 3-Dimensional Exoscope System for Microneurosurgery

3D Exoscope for Spine Surgery

Three neurosurgeons with different degree of surgical expertise completed a questionnaire with 43 items based on intraoperative handling and feasibility after the procedures. We collected and analyzed data from seventeen patients (35% male/65% female) with a median age of 70 years [CI 47-86] and median BMI of 25.8 kg/m2 [range 21-33]. We included a variety of spinal pathologies (10 degenerative, 4 tumor and 3 infectious cases) with different level of complexity. Regarding setup conflicts we observed issues with adjustment of the monitor position or while using additional equipment (e.g. fluoroscopy in fusion surgery) ($p = 0.007/p = 0.001$). However image resolution and sharpness as well as 3D-depth perception were completely satisfactory for all surgeons in all procedures. The utilization of the exoscopic arm was easy for 76.5% of the surgeons, and all of them declared a significant improvement of the surgical corridor. The 3D-exoscope implementation appears to achieve very satisfactory results in spinal procedures especially with minimally invasive approaches [8].

Posterior Cervical Decompression and Fusion With Exoscope

Posterior Cervical Decompression and Fusion With Exoscope.

Case series

Hines et al. conducted a retrospective analysis of 20 consecutive patients undergoing standard ATL for treatment of medically refractory TLE at our institution. Using pre-operative and post-operative imaging, the coronal plane cuts in which either the head, body, or tail of the hippocampus appeared were counted. The number of cuts in which the hippocampus appeared were multiplied by slice thickness to estimate hippocampal length.

Mean percentage of hippocampal resection was 61.1 (SD 13.1) and 76.5 (SD 6.5) for microscope and exoscope visualization, respectively ($p = 0.0037$).

Use of exoscope for mesial resection during ATL has provided good visualization for those in the operating room and the potential for a safe increase in hippocampal resection in our series. Further investigation of its applications should be evaluated to see if it will improve outcomes [9]

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10 consecutive thoracolumbar (T11-L2) burst fractures associated with spinal cord compression treated with minimally invasive corpectomy and exoscope-assisted spinal decompression. Three main indicators were retrospectively analyzed: surgical time, blood loss, and intraoperative complications.

The data were compared with those obtained from an equal sample of 10 procedures performed by the same surgeon with the same technique, but traditional microscope assisted. User impressions in terms of ergonomics, magnification, and image quality were rated differently.

A small reduction of surgical time and blood loss were observed in the exoscope assisted group. There were no intraoperative complications attributed to visualization mode or conversion to the traditional microscope in any procedure. In our experience the exoscope allowed a better magnification and image definition with better ergonomics and user-friendliness.

In the preliminary experience the exoscope new technology is a safe and effective tool for spinal cord minimally invasive decompression in thoracolumbar burst fractures. The stereoscopic vision provided by 3D images seems to be crucial in hand eye coordination. There are clear advantages in terms of maneuverability, wide field of view, deep focus, and more comfortable posture for the spinal surgeon [10)].

Case reports

A case of a 52-year-old patient in which a meningioma in the upper cervical spine (C1-C2) was removed using a 4K-three-dimensional (3D) exoscope. The advantages of surgical removal of an intradural spinal tumor using an exoscope are illustrated, focusing mainly on vision quality and ergonomics. In addition, some technical details regarding the operating room setup are provided. Based on this experience, a 4K-3D exoscope can be useful for spinal tumor surgery when high magnification of anatomical details is required, allowing the surgeon to operate in a comfortable position throughout the surgical procedure [11)]

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