Aesculap Aeos® Robotic Digital Microscope

Clinical Evidence Summary

ENVISION THE EXTRAORDINARY™

AESCULAP®

Table of Contents

Subjective Workload Measurement of the Transition From a Conventional Operative Microscope to a Robotic Digital Microscope

A Pilot Study

Conclusion

The transition to a proficient exoscope experience where the user reaches a state of high performance, low effort and low frustration could be achieved in approximately 20 procedures. After approximately nine cranial procedures a performance level above 80% is reached whereas spine procedures see an even faster transition.

Reference

Gabrovsky N, Petrov M, Ilkov P, Iordanova I, Velinov N. Brain Spine. 2022 Aug 19;2:100928. doi: 10.1016/j.bas.2022.100928. https://pubmed.ncbi.nlm.nih.gov/36248112/

Study Design

- Forty-one consecutive neurosurgical operations (16 cranial and 25 spinal) using Robotic Digital Microscope (RDM) were analyzed.
- A NASA-TLX Task Load Index questionnaire was adminsitered to assess the subjective workload of a single experienced neurosurgeon to outline the learning curve transitioning from the operative microscope (OPMI) to the RDM.
- The NASA-TLX score was calculated with weight assigned based upon the importance of each criterion with higher importance receiving higher weight: mental demand (1), physical demand (1), temporal demand (2), effort (3), performance (4) and frustration (4).

Results

- The NASA-TLX's major criteria for cranial operations achieved frustration and effort below 20%, and performance above 80% after the ninth operation. Whereas spinal operations achieved frustration and effort below 20%, and performance above 80% after the second operation, and consistently remained there after the eighth operation.
- The use of the RDM resulted in no neck or back strain commonly experienced with the OPMI, which suggests a significant reduction in the work-related musculoskeletal disorders (WMSD) that are becoming widespread in the neurosurgical society.
- The "Lock-on target" function allows the neurosurgeon to "look around corners" in the operative field without leaving their comfortable posture, with a straight back and no neck flexion. This greatly reduces the operator's effort and backpain even in long and difficult cranial cases.

3D Exoscopes are Noninferior to Operating Microscopes in Aneurysm Surgery

Comparative Single-Surgeon Series of 52 Consecutive Cases

Conclusion

Three-dimensional exoscopes are noninferior to operating microscopes regarding surgery duration, patient safety and outcomes in aneurysm clipping procedures. Ongoing exoscope experience enables the surgeon to perform significantly more device adjustments within the same amount of surgical time, allowing optimal surgical field visualization.

Reference

Rossmann T, Veldeman M, Nurminen V, Huhtakangas J, Niemelä M, Lehecka M. World Neurosurg. 2023 Feb;170:e200-e213. doi: 10.1016/j.wneu.2022.10.106. https://pubmed.ncbi.nlm.nih.gov/36334715/

Study Design

- Fifty-two consecutive aneurysm clipping procedures performed by one senior vascular neurosurgeon using either an operating microscope with a mouth switch (25 cases with 27 aneurysms) or a three-dimensional exoscope with a foot switch (27 cases with 34 aneurysms) were analyzed.
- Surgical videos were reviewed to extract the duration of major surgical stages, number of device adjustments, number of clip repositionings and clips implanted.
- Demographic data, imaging characteristics, clinical course and outcomes were extracted from digital patient records and post-operative imaging. A favorable outcome was defined as modified Rankin Scale score 0-2.

Results

- Duration of surgery and different stages was comparable between the devices, except for final site inspection, despite the number of exoscope device adjustments increasing significantly with progressive experience.
- A major benefit of the exoscope allowed adjusting the device while keeping both actively in the surgical field and providing viewing angles that would significantly physically challenging with the operating microscope.
- Favorable patient outcomes (modified Rankin Scale score 0-2) were observed in the microscope (80%) and exoscope (88%) groups, respectively.
- No complications occurred other than two patients experiencing ischemic events in each group.
- Intraoperative conversion from exoscope to microscope was never required.

Implementation of a Three-Dimensional (3D) Robotic Digital Microscope (AEOS) in Spinal Procedures

Conclusion

The three-dimensional exoscope provides high quality visualization and depth perception and superior ergonomics, especially in minimally invasive spine approaches.

Reference

Motov S, Bonk MN, Krauss P, Wolfert C, Steininger K, Picht T, Onken J, Shiban E. Sci Rep. 2022 Dec 29;12(1):22553. doi: 10.1038/s41598-022-27082-1. https://pubmed.ncbi.nlm.nih.gov/36581741/

Study Design

- Seventeen spinal procedures performed by three neurosurgeons, with varying degrees of surgical expertise, using a three-dimensional exoscope were analyzed over a four-week period.
- After each procedure, the neurosurgeons completed a questionnaire with 43 items using a five-to-seven-point Likert scale assessing intraoperative satisfaction regarding image quality, ergonomics, usability and fatigue.
- The data was collected 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].
- A variety of spinal pathologies (10 degenerative, four tumor and three infectious cases) with different levels of complexity were included.

Results

- All cases were completely sole with the exoscope and did not require switching to the operative microscope.
- Setup conflicts were observed within the first two lateral cases however an optimized setup based upon patient positioning was quickly established which allowed for improved C-arm positioning. Surgeons agreed (53%) or strongly agreed (47%) that the surgical field was unobstructed during surgeries.
- Surgeons agreed (24%) or strongly agreed (76%) that the 3D image quality perception was satisfactory.
- The exoscope robotic arm provided better control with superior ergonomics and reduced fatigue when compared to the operative microscope.

Three-Dimensional Exoscopic Versus Microscopic Resection of Vestibular Schwannomas

A Comparative Series

Conclusion

The foot switch-operated three-dimensional exoscope is safe and provides comparable clinical and radiological results compared to the operative microscope during resection of vestibular schwannomas.

Reference

Veldeman M, Rossmann T, Huhtakangas J, Nurminen V, Eisenring C, Sinkkonen ST, Niemela M, Lehecka M. Oper Neurosurg (Hagerstown). 2023 May 1;24(5):507-513. doi: 10.1227/ons.0000000000000602.
https://pubmed.ncbi.nlm.nih.gov/36715988/

Study Design

- Thirteen consecutive exoscopic schwannoma surgeries and 26 preceding microsurgical resections with similar surgical complexity via assessment of tumor size (maximum diameter and Koos grade), the presence of meatal extension or cystic components, and preoperative hearing and facial nerve function were analyzed. This study represents a single surgeon's transition from microscope to exclusive exoscopic neurosurgical practice.
- Surgical videos were independently reviewed by three neurosurgeons to count microscope field adjustments (total and per phase) and total length of surgery.
- Extent of resection, decline of facial nerve function at time of discharge, postoperative serviceable hearing, intensive care unit and total length of stay were all captured for statistical analysis.

Results

- Exoscope use was associated with an approximately one hour reduction in total duration of surgery in a multiple regression model.
- Cerebellopontine angle tumor surgery requires viewing simultaneous structures at different depths. This is alleviated by the superior depth of field found in the exoscope.
- The exoscope allows the surgeon to view angles which would be challenging to comfortably work in long periods using a microscope which takes heightened importance when visualizing tumor borders and surrounding anatomical structures.
- Total duration of surgery, hearing preservation and facial nerve function were comparable between the exoscope and microscope groups. Tumor size was identified as the main determinant of surgery duration.

Digital 3D Exoscope is Safe and Effective in Surgery for Intradural Extramedullary Tumors

A Comparative Series

Conclusion

Exoscope-assisted surgery for spinal intradural extramedullary tumors is comparable in safety and effectiveness to traditional microscopic surgery. The exoscope offers advantages including superior video image quality, ergonomics and teaching possibilities. Dedicated practice can overcome the learning without additional risks to the patient.

Reference

Calvanese F, Auricchio AM, Vasankari V, Raj R, Gallè CLC, Niemelä M, Lehecka M. Digital 3D Exoscope is Safe and Effective in Surgery for Intradural Extramedullary Tumors: A Comparative Series. World Neurosurg. 2024 Apr;184:e1-e8. doi: 10.1016/j.wneu.2024.01.136. Epub 2024 Feb 1. PMID: 38307199.
https://pubmed.ncbi.nlm.nih.gov/38307199/

Study Design

- Thirty-five consecutive intradural extramedullary spinal tumors procedures performed by the senior author using either an operating microscope (16 cases) or a three-dimensional exoscope (19 cases) were analyzed.
- Pre- and post-operative clinical findings, imaging studies, intra- and post-operative events, and surgical videos from the procedures were collected and evaluated.
- The surgical videos were analyzed by the authors to evaluate surgical procedure steps, intraoperative adjustments (e.g. zoom, focus and field of view) and image quality.
- The statistic categorical variables were compared between exoscope and microscope groups using Fisher's exact test.

Results

- The exoscope group experienced more consistent gross total resection due to the ability to better visualize structures under the exoscope.
- During situations where the optical head needed to be tilted in either a cranial or caudal orientation the exoscope provided favorable ergonomics by not requiring the unpleasant tilting of the surgeon's whole upper body as typically experienced with the operating microscope.
- The assistant and other observers were able to share the same 3D intraoperative view as the lead surgeon in the exoscope group and therefore offered enhanced teaching opportunities.
- The findings of this study are consist with previously published series of microscope-assisted resection of extramedullary tumors which found gross total resection in 90%-100% of patients.

Comparison of Three-dimensional Digital Exoscope to Standard Operating Microscope in Minimally-invasive Lumbar Decompression

A Cohort Study in a Community Setting

Conclusion

The exoscope is a viable, cost-effective alternative to the surgical microscope for minimally invasive spine surgery (MISS) in a general community-based neurosurgical practice.

Reference

Fulkerson DE, Medich E, Szpisjak DF, Fulkerson DH. „Comparison of three-dimensional digital exoscope to standard operating microscope in minimally-invasive lumbar decompression: A cohort study in a community setting, Interdisciplinary Neurosurgery, Volume 39, 2025, 101993, ISSN 2214-7519, https://doi.org/10.1016/j.inat.2025.101993.

Study Design

- A total of 121 minimally invasive one- and two-level lumbar decompression procedures performed by a single senior surgeon using either an operating microscope (59 cases) or an exoscope (62 cases) were analyzed.
- Four patient cohorts were defined by exoscope versus microscope visualization and one versus two surgical spinal levels.
- Using demographic characteristics of the groups with a similar number of spinal levels, the number of hospital days was compared between groups using the Wilcoxon rank sum test. Surgical time, operating room time and estimated blood loss were compared using Student's t-test. Complications in each group were compared using Fisher's exact test.
- Postoperative data collected included any surgical complications such as cerebrospinal fluid leak, hematoma, need for blood transfusion, new neurologic deficit, medical complications or the need for further surgery due to the same pathology or a related complication within three months.

Results

- The exoscope was comparable to the operating microscope in common surgical metrics.
- Ergonomics was not formally studied, but the lead surgeon reported a clear advantage with the exoscope compared to the operating microscope.
- Exoscope surgical time trended downward in the latter two-thirds of cases when compared to the first third. While not statistically significant, it suggested that as the surgeon progressed through the learning curve there was potential to reduce the time difference between the microscope and exoscope cases.

Through collaborative excellence we will improve the quality of a patient's life and meet the needs of the changing healthcare environment.

Aesculap, Inc. | 3773 Corporate Parkway | Center Valley, PA | 18034
800-282-9000 | aesculapusa.com

Aesculap, Inc. - a member of the B. Braun Group of Companies

DOC1811 06/2025