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First-in-man Clinical Experience Using a High-definition 3-dimensional Exoscope System for Vascular Microneurosurgery

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Introduction

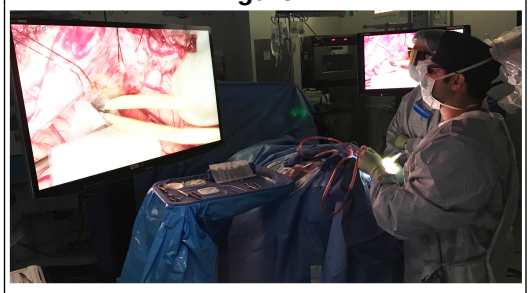
The operative microscope and endoscope have been critical to the evolution of microneurosurgery. However, small operative windows and narrow approach angles limit traditional microscopy, while a short focal length, a small depth of field, and technical constraints imposed by the presence of the endoscope immediately adjacent to the operative field limit neuroendoscopy.

Extracorporeal telescope ("exoscope") systems have recently been designed that combine the benefits of traditional neuro microscopes and endoscopes. These systems possess wide operative fields and focal distances long enough to allow unobstructive positioning, while remaining easily maneuverable to optimize operative angles and surgeon ergonomics. We have previously reported on the development and performance of a novel, three-dimensional (3D), high-definition (4K-HD) exoscope system in the pre-clinical setting [1]. In this work, we assess the operating room workflow, visual haptics, surgeon utilization, and overall functionality of the 3D 4K-HD exoscope for vascular microneurosurgery as part of its first-in-man neurosurgical use.

Methods

The operative workflow, functionality, and visual haptics of the 3D 4K-HD exoscope (3840 × 2160 pixels, fiber optic LED light source; Sony Olympus Medical Solutions, Inc, Tokyo, Japan) were assessed during its first-in-man surgical use to for vascular microneurosurgery.

Figure 1



Intra-operative image demonstrating positioning of the low-profile exoscope camera over the shoulder of the primary surgeon, with in-line visualization of the operative field on a large, 3D HD monitor.

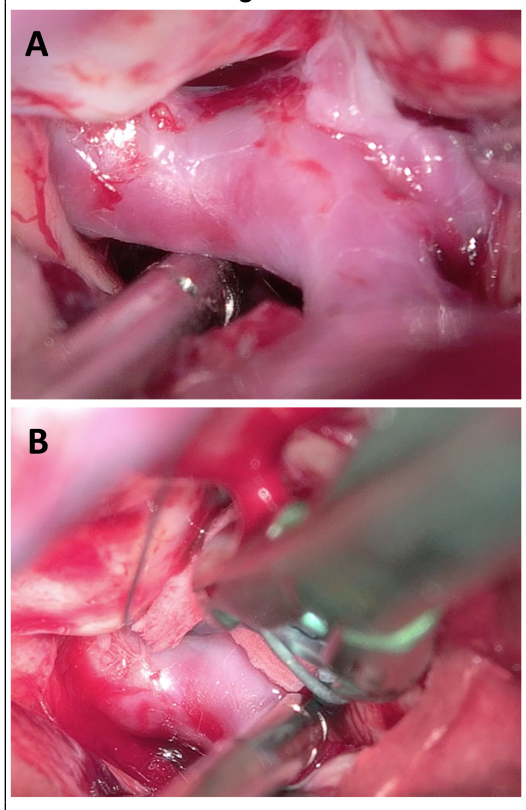
Results

Five microneurosurgical cases (on four patients) were performed exclusively using the 3D 4K-HD exoscope (**Figs. 1-3**). Pathologies treated included two aneurysms, two cavernous malformations, and one arteriovenous malformation. All patients experienced good surgical and clinical outcomes. An intra-operative aneurysm rupture in one case was managed routinely. Similar to pre-clinical assessments, the 3D 4K-HD exoscope provided an immersive three-dimensional surgical experience for the primary surgeon, assistants, and trainees. The small excoscope frame, large depth of field, and hand/foot pedal controls improved exoscope mobility, decreased need to re-focus, and provided unobstructed operative corridors. Flexible positioning of the camera and visual projections kept the surgeon in an ergonomically advantageous position with a horizontal gaze across multiple operative angles.

Conclusions

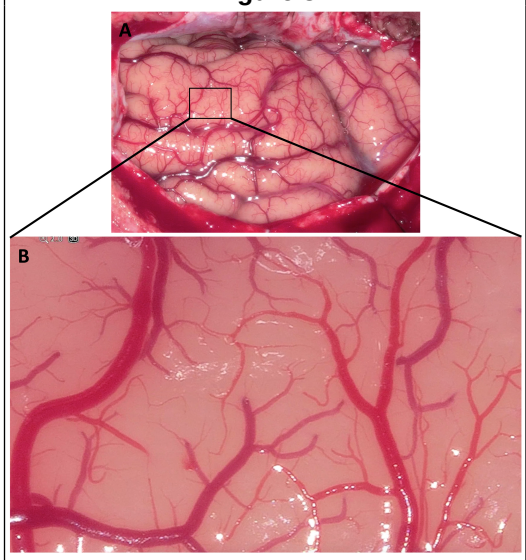
The first-in-man clinical experience with the 3D 4K-HD exoscope confirms its excellent optics and ergonomics for the entire operative team, with high workflow adaptability for vascular microneurosurgical cases. Expanded clinical use of the 3D 4K-HD exoscope is justified.

Figure 2



Intra-operative exoscope images from a right Pcomm aneurysm clipping, demonstrating high-resolution visualization of the MCA during aneurysm dissection (A), and clipping (B).

Figure 3



The exoscope maintains focus throughout its 25.8X range. Intra-operative exoscope images from a pteronial craniotomy demonstrating crisp resolution of cortical vessels at both high (A) and low (B) focus.

Learning Objectives

Learn the clinical potential of the 3D 4K-HD exoscope for vascular microneurosurgery.

References

1) Sack J, Steinberg JA, Rennert RC, Hatefi D, Pannell JS, Levy M, Khalessi AA. Initial Experience Using a High-Definition 3-Dimensional Exoscope System for Microneurosurgery. Oper Neurosurg. 2017 Jun 29. doi: 10.1093/ons/opx145. [Epub ahead of print] PubMed PMID: 29106670.