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# Three-dimensional 4K resolution video microscope in an orbitozygomatic approach for skull base tumor

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ABSTRACT

*Background:* The authors propose that the newly developed three-dimensional 4K resolution (3D-4K) video microscope, Orbeye™, can be a user-friendly alternative tool for performing orbitozygomatic craniotomy and tumor removal. It was officially approved in Japan in October 2017.

*Case description:* A 38-year-old, otherwise healthy, woman presented with left impaired visual acuity, motor aphasia, headache, and vomiting. Magnetic resonance imaging (MRI) revealed the presence of a large left sphenoid ridge meningioma with marked perifocal edema and mass effect. Using Orbeye™, en bloc orbitozygomatic craniotomy and skull base tumor removal were safely performed. It enabled us to perform the procedure, and to share the operative image owing to the realistic 3D perception of the operative field, its excellent illumination, and viewing angle. Especially, the lower viewing angle appeared to be extremely difficult to obtain using conventional methods. The patient resumed her daily life, and a postoperative MRI showed total removal of the tumor.

*Conclusions:* Orbeye™ has overcome shortcomings of the operative microscope. It has a user-friendly design, and surgeons' intraoperative fatigue and stress appear to be decreased. It is useful for observers to understand the skull base technical nuances using the 3D-4K image.

## 1. Introduction

Appropriate visualization is indispensable for microsurgery [1]. Operative microscopes were first introduced in 1957 [2], and recently, an exoscope began being used in the field of neurosurgery.

Orbitozygomatic craniotomy is a useful skull base technique for addressing brain neoplasms arising from the anterior and middle cranial fossa [3]. En bloc orbitozygomatic craniotomy was first described by Hakuba et al. Although it is a useful technique for skull base surgery, the manipulation is technically demanding and time-consuming [3]. Furthermore, the operative field is so limited that the visualization of skull base techniques for observers tends to be disturbed [4,5].

In this report, we present an operative case report of orbitozygomatic craniotomy and microsurgical tumor resection using a 3D-4K video-microscope, the Orbeye™ (Sony-Olympus Medical solutions, Tokyo, Japan), which is an alternative user-friendly tool for neurosurgery. The skull base procedure is visualized and facilitated by this 3D-4K video microscope system. An excellent illumination and viewing angle and realistic 3D perception of the operative field are aspects that made this system superior to conventional microscopes. The same 3D-4K image can be shared among the entire operative team.

## 2. Case report

The Orbeye™ (Olympus, Tokyo, Japan) was officially approved in Japan in October 2017, thus the usual written informed consent was obtained. The institutional review board approved this study retrospectively (#18011528). Consensus-based Clinical Case Reporting Guideline Development has been implemented in this study.

A 38-year-old, otherwise healthy, woman was presented with aphasia, headache, and vomiting. No special note was observed in her family history. On admission, a neurological examination showed

*Abbreviations:* Gd-TIWI, gadolinium-enhanced T1 weighted magnetic resonance imaging; MRI, magnetic resonance imaging; 3D, three-dimensional; 4K, 4K resolution.

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incomplete motor aphasia, left impaired visual acuity, and dysesthesia of her left face. Gadolinium-enhanced T1 weighted magnetic resonance imaging (Gd-T1WI) revealed an extra-axial mass lesion (48 × 50 × 40 mm in size) on the right sphenoid ridge (Fig. 1A).

Seven days before the surgery, interventional radiology was performed, and feeders were safely embolized using pushable fibered platinum coils (data not shown).

Total removal of the tumor was performed. Under general anesthesia, the patient was placed in a supine position. Her head was fixed with a Mayfield head clump (4–0-A-1059, Ohwa Tsusho Co., LTD, Tokyo, Japan). A left frontotemporal coronal incision was made. The temporal muscle was interfascially dissected as described by Yasargil [6]. Orbitozygomatic craniotomy was performed as previously described, with minor modification [3].

Remaining the skull base procedure, the 3D-4K video microscope Orbeye™ (Olympus, Tokyo, Japan) was then introduced (Fig. 1B). While the surgeons should ideally have worn glasses attached to Orbeye™ (Olympus, Tokyo, Japan) to obtain stereognosis, the 3D image was comfortably visualized on the 4K monitoring system with a quality comparable to that of conventional microscopes. The smaller lens barrel of this video microscope enabled the surgeons to obtain the intraoperative image from a low-angled viewing position (Fig. 1C, D). Single-handed manipulation was possible using this videomicroscope's electric holder (Fig. 1E). Macroscopic images were easily obtained (Fig. 1C-E). The 3D-4K image was shared by all members of the operative team.

A pterional keyhole was cut over the frontosphenoidal suture (Fig. 2A and B). The drilling procedure of the orbital roof through the keyhole was visualized and facilitated by this system due to its excellent illumination, the almost horizontal viewing angle (Fig. 1A and B), and realistic 3D perception of the operative field (Fig. 2C). The temporal base side of the bone flap, the lateral side of the sphenoid ridge, and the lateral orbital wall were cut with an electric drill. The bone flap was elevated gradually, and the tiny residual bony connection was safely fractured. Finally, the orbitozygomatic craniotomy was completed (Fig. 2D). The intraoperative video data is attached (Video 1A).

This 3D-4K system's wide depth of field, which could be changed if needed, enabled the operators to perform microsurgery safely (Fig. 2E and F). Total tumor resection was performed using an Orbeye™ (Olympus, Tokyo, Japan) assisted with a microscope (Opmi Pentero 900™, Carl Zeiss Meditec, Tokyo, Japan) and a navigation system (Curve™, BrainLab, Feldkirchen, Germany). In this way, gross total resection of the tumor was completed. The intraoperative video data is also attached (Video 1B).

The hematoxylin-eosin (9130 and 9134, respectively, Sakura Finetek Japan Co., Ltd, Tokyo, Japan) staining revealed transitional meningioma. Although the patient complained of transient disturbance of ocular motility, diplopia, and left face numbness, the postoperative course was uneventful. Her left visual acuity was secured, and her motor aphasia had gradually disappeared during the admission. Post-operative Gd-T1WI revealed total resection of the tumor (Fig. 1B).

## 3. Discussion

The 3D-4K video microscope system Orbeye™ (Olympus, Tokyo, Japan), which is almost equivalent to the 3D-4K exoscope, can easily visualize the difficult and complicated processes of orbitozygomatic craniotomy. Microscopes and endoscopes can be used to obtain similar 3D images, but presenting an equivalent, wide depth of field on a monitor is difficult due to the narrow-angle of the axis of vision with these tools (Fig. 2E). Furthermore, conventional microscopes tend to compel surgeons to keep the uncomfortable posture for a long-time during skull base operations. In contrast, with the Orbeye™ (Olympus, Tokyo, Japan), surgeons can review intraoperative images on a 3D-4K monitor in a relaxed posture [7]. As a result, the video microscope decreases surgeons' intraoperative fatigue and stress (Table 1).

The system also allows the same 3D-4K images to be shared among the surgical team. Although it was presented in figures and anatomical photographs [8,9], the operative nuances of orbitozygomatic

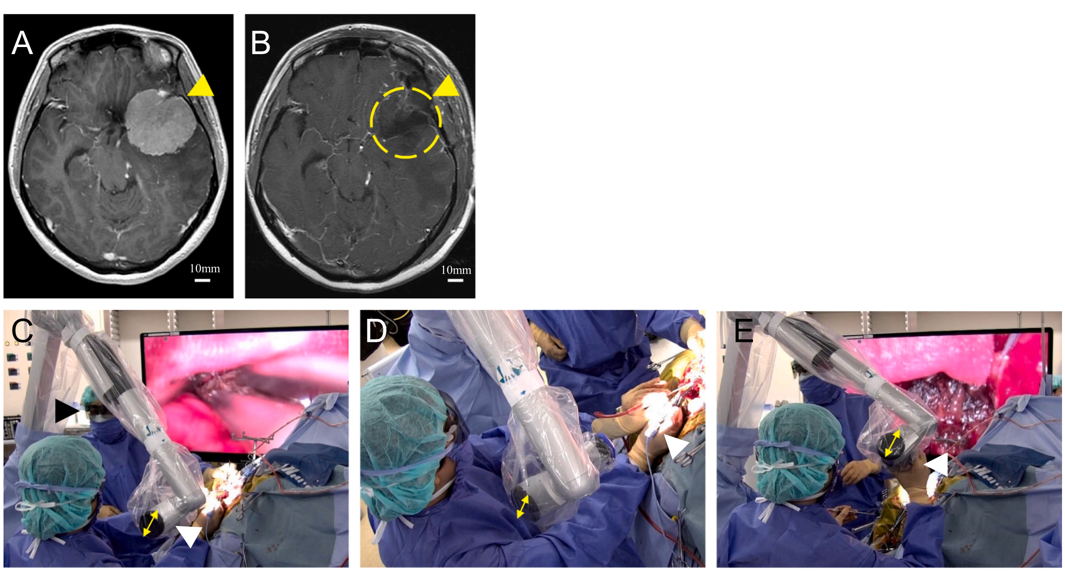


**Fig. 1.** (A) Preoperative axial T1 weighted Gadolinium-enhanced magnetic resonance imaging (Gd-T1WI) revealing the sphenoid ridge meningioma (40 × 50 × 48 mm in size. Yellow arrowhead). The scale bar indicates 10 mm. (B) Postoperative axial Gd-T1WI revealing total resection of the tumor (yellow arrowhead and dashed line). The scale bar indicates 10 mm. (C) Operative positioning of surgical equipment, including the Orbeye™ system. The lens barrel of the video microscope is small and easily set in a low position and almost horizontal angle (white arrowhead). The assistant is watching the monitor placed on the opposite side of the main monitor (black arrowhead). The black circle portion of the microscope is 73.8 mm in diameter (yellow double-arrow). (D) The small lens barrel does not disturb the surgeon's manipulation and increased the latitude of the visual axis, allowing the surgeon to obtain a lower-angled operative image. The 3D-4K monitor visualizes the operative field without forcing the surgeon to maintain an uncomfortable posture (white arrowhead). The black circle portion of the microscope is 73.8 mm in diameter (yellow double-arrow). (E) Single-handed manipulation of the lens barrel is possible due to the electric holder (black arrowhead). The black circle portion of the microscope is 73.8 mm in diameter (yellow double-arrow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

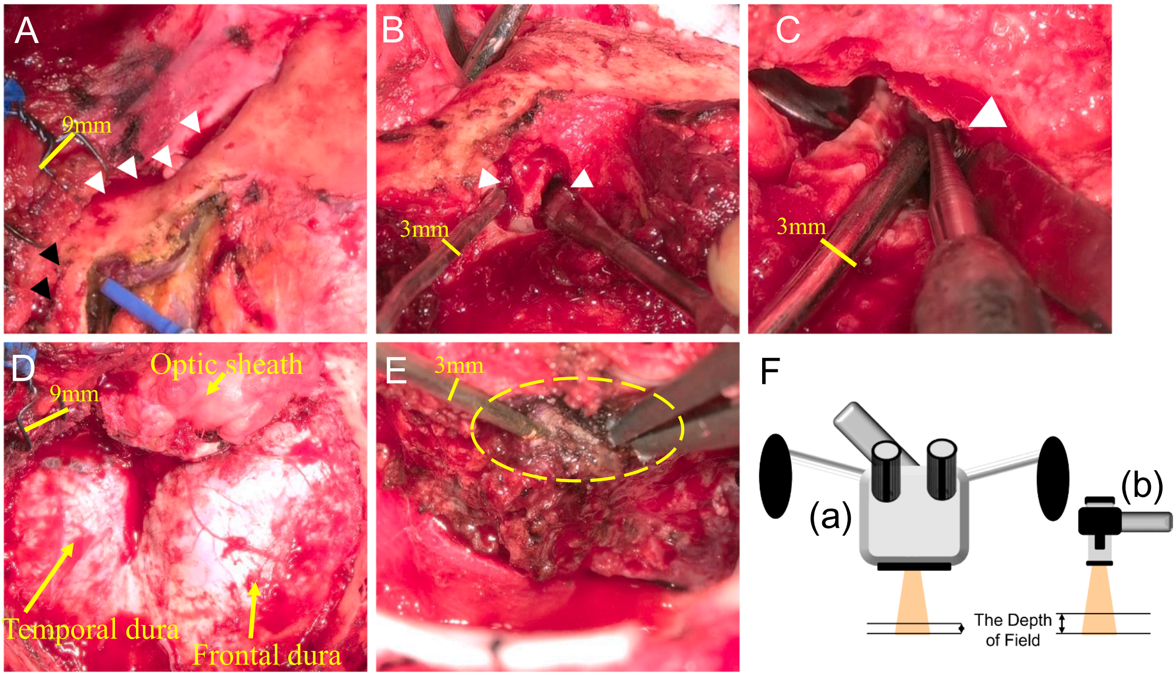


**Fig. 2.** Intraoperative photograph through the Orbeye™ system demonstrating the process of the en bloc left orbitozygomatic craniotomy and microsurgery. The surgical hook indicates 9 mm (yellow line). (A) Exposure of the left zygomatic arch (black arrowheads) and orbital rim (white arrowheads). (B) Through the keyhole, the left orbit (the left white arrowhead), orbital roof, and anterior cranial fossa (the white right arrowhead) are exposed. The suction tube is 3 mm in diameter (yellow line). (C) The drilling process through the keyhole, which has been poorly visualized with conventional devices (white arrowhead). The suction tube is 3 mm in diameter (yellow line). (D) Orbitozygomatic craniotomy has been completed. The left orbital sheath, frontal dura, and temporal dura are exposed (captions and yellow arrows). The surgical hook indicates 9 mm (yellow line). (E) A video microscopic view of the microsurgical tumor resection. A wide range of focused views is obtained, and skull base feeder coagulation is performed (yellow dashed line). The suction tube is 3 mm in diameter (yellow line). (F) A schematic figure explaining the depth of field of the microscope and the exoscope (double arrows). (a) a microscope. (b) an exoscope. The depth of field is defined as the range of distance on the subject side where the microscope or the exoscope appears to be in focus. As shown in this figure, subjectively and maybe objectively, the depth of field of the exoscope is deeper than that of the microscope. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

**Table 1**
Data of the Vitom 3D™ and the Opmi Pentero 900™ are partially quoted from those described by Rossini, et al, and updated (16). * Official data have not been released from the microscope manufacturers. ALA, 5-aminolevulinic acid. HD, high-definition. ICG, indocyanine green. NBI, narrow-band imaging. 3D, three-dimensional. 4K, 4K resolution.$, US dollars.

| | ORBEYE (video microscope/ exoscope) | VITOM 3D (exoscope) | OPMI PENTERO 900 (microscope) | ARveo (microscope) |
|---|---|---|---|---|
| Focal length (cm) | 22–55 cm | 20–50 cm | 20–50 cm (workspace from field lens) | 22.5 – 60 cm |
| Magnification | Optical 1.0–6.0 x Digital 1.0–2.0 x | 8.0–30 x | 1.4–16.2 x | 0.8 – 15.1 x |
| Depth of field (cm) | Not released* | 3.5–10 cm | Not released* | Not released* |
| Field of view (cm) | Not released* | 60 cm | 1.37–17.3 cm | 1.41 – 23 cm |
| Image | 3D-4K | 3D-4K | 3D-HD | 3D-HD |
| Fluorescence | Possible (ICG/ALA/NBI) | Possible (ICG/ALA/NBI) | Possible (ICG/ALA) | Possible (ICG/ALA) |
| Navigation cooperation | Not applicable | Not applicable | Applicable | Applicable |
| Holder of the lens barrel | Electric holder | Pneumatic holder | Electric holder | Electric holder |
| Ergonomics | Good | Good | Not always good | Not always good |
| Cost ($) | ~ $400,000 | ~ $100,000 | ~ $200,000–400,000 | Not released* |

Data of the VITOM 3D™ and the OPMI PENTERO 900™ are partially quoted from those described by Rossini, et al (14). * Official data have not been released from the microscope manufacturers. ALA, 5-aminolevulinic acid. HD, high-definition. ICG, indocyanine green. NBI, narrow-band imaging. 3D, three-dimensional. 4K, 4K resolution. $, US dollars.

craniotomy processes through the keyhole had been poorly visualized with conventional devices due to its narrow operative corridor, and rarely shared by professional health care providers. These refinements are easily illustrated on the 3D-4K monitor because, as described by Iwata et al, the approximately horizontal visual axis of the Orbeye™ (Olympus, Tokyo, Japan) is available (Figs. 1A, B, 2A-C, and Video 1A) [4,5,10–12]. Good maneuverability in skull base surgery is also one of the advantages of this method (Fig. 1C). The exoscope advantages in resident training have been also reported [4,5,13–15].

As described in Table 1, Fig. 2F, and Video 1B, even assuming that other functional differences between the exoscopes and the microscopes are not significant, subjectively the field of depth in this 3D-4K system is wider than that of conventional microscopes. Thus, the frequencies of repositioning and refocusing were decreased with this system [4]. The 3D-4K video microscope has the potential of replacing conventional microscopic systems in the future.

The 3D-4K images of this video microscope are expected to be superior to those of other conventional exoscope systems. The Vitom™ 3D (Karl-Storz Endoskope, Tokyo, Japan) system also has 4K resolution and may be used with our method [13,16], but the Orbeye™ (Olympus, Tokyo, Japan) system still has some advantages. For example, the Orbeye™ (Olympus, Tokyo, Japan) system has an electric holder that easily fixes the position of the lens barrel. Because both the optical and digital magnification approaches in this system strive to preserve the image quality as much as possible, the magnification potential is expected to be superior to that of other systems (Table 1). Some fluorescent modes of Orbeye™ (Olympus, Tokyo, Japan) are also available (Table 1) [17–19]. A more comprehensive and updated comparison of the exoscopes and microscopes was summarized in Supplementary Table 1, which does not affect our discussion and conclusion.

There are several limitations to the application of the Orbeye™ (Olympus, Tokyo, Japan) system that should be addressed. First, during skull base manipulation, the lens barrel of the video microscope disturbed part of the operator's axis of the direct sighting, causing some stress on the operator. Second, when the surgeon would like to change the operative field drastically, it is difficult sometimes to find the appropriate operative site immediately. This is a disadvantage shared with other exoscopes [16]. Surgeons may want to utilize video microscopes and conventional microscopes until the operator gets used to the system. Third, we avoided the objective comparison of data, especially the data of the depth of field, in this study because the microscope manufacturers have not fully released their official data (Table 1). Fourth, the recording mode of this system can easily be switched; however, the 4K image data can be quite large, depending on its quality. Manipulator should therefore consider how to record the operative images. Fifth, the Orbeye™ (Olympus, Tokyo, Japan) and other 3D-4K exoscope systems should be directly synchronized with some neuronavigation systems shortly, except for Modus V™ and Kinevo™ (Suppl. Table 1). Sixth, when the assistant uses a sub monitor, as it cannot be rotated, it may take some time for the assistant to get used to assisting [4]. Finally, while the cost performance of the Orbeye™ (Olympus, Tokyo, Japan) system is comparable to that of conventional operative microscopes, it may be inferior to that of the Vitom™ 3D (Karl-Storz, Tokyo, Japan) system.

## 4. Conclusion

Orbeye™ (Olympus, Tokyo, Japan) 3D-4K video microscope can illustrate the detailed procedure of skull base surgery including the orbitozygomatic approach. Orbitozygomatic craniotomy and microsurgery can be safely performed using Orbeye™ (Olympus, Tokyo, Japan), and it can prove useful for all members of the operative team.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inat.2021.101315.

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