

# A Practice Survey to Compare and Identify the Usefulness of Neuroendoscope and Exoscope in the Current Neurosurgery Practice

## Abstract

**Background:** The present era is of new tools and technique. Handling of new challenges require, better understanding of microscopic anatomy, which requires better magnification and light. Microscope has played significant role in this, use of endoscope and introduction of exoscope have given new dimensions to this field. **Aim:** This study aims to compare and see the advantages, disadvantages of endoscope with exoscope, will analyze the difference in terms of ergonomics, learning curve, opportunities for training, operating time, magnification, and image quality. **Materials and Methods:** This study was conducted in the Department of Neurosurgery, Bantane Hospital Fujita Health University, Japan. Apart from comparing the specifications of available systems, we conducted a worldwide survey of the two systems through sending questionnaire through mail collected responses and analyzed them. **Results:** Learning curve, magnification, image quality, and ergonomics favors exoscope but depth perception and maneuverability, hand eye coordination, tactile sensation, and usage of different angulation tubes favored endoscope to be superior to exoscope. **Conclusion:** There is more scope for modifications and research in both the instruments. These instruments are not replacement of either and should be used according to their indications.

**Keywords:** Endoscope, exoscope, survey

## Introduction

Optics has played a significant role in the evolution of neurosurgery. The use of magnification came in around 800BC.<sup>[1]</sup> We started using operating microscope in 20<sup>th</sup> century. Neurosurgeons throughout the 1960s also began to formally teach and disseminate the techniques of the surgical microscope. Donaghy and Yasargil organized the first microvascular symposium in October 1966.<sup>[2,3]</sup> With passage of time, we started using improved magnification, with better light system, better maneuverability. Simultaneously, we started using endoscopes. First experiences with the use of this new method in different fields of medicine began in the early 20<sup>th</sup> century. The development of neuroendoscopy was related to the treatment of hydrocephalus.<sup>[4]</sup>

A significant advantage of endoscopy includes improvements in surgeon's comfort, lesser fatigue, and less morbidity.<sup>[5,6]</sup> As compared to operating microscopes focal length is much shorter

in endoscopes, thus needs to be placed in close proximity to the intracranial structures which limits the usage of instruments around the scope and frequent obstruction of the lens by blood and tissue obstructed the work flow which limited the neurosurgical application of endoscopy. Latest in the series exoscope, this is a high definition extracorporeal telescope. Exoscope system was developed over the past decade, appears to be an answer to the limitations of microscope and endoscope.<sup>[6,7]</sup>

Video telescopic operating monitor works on the principle of telescopic surgery with familiar microsurgical instrument; thus, it acts as a bridge between microneurosurgery and endoneurosurgery as well as it improves surgeon comfort, minimizes fatigue, and reduces surgical morbidity and patient discomfort. This system was also used successfully in various cranial and spinal microneurosurgery in place of the microscope as well as in another specialty. In comparison to the endoscope,

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### Access this article online

Website: [www.asianjns.org](http://www.asianjns.org)

DOI: 10.4103/ajns.AJNS\_339\_19

### Quick Response Code:



**How to cite this article:** Panchal S, Yamada Y, Nagatani T, Watanabe T, Kishida Y, Sayah A, et al. A practice survey to compare and identify the usefulness of neuroendoscope and exoscope in the current neurosurgery practice. Asian J Neurosurg 2020;15:601-7.

Submitted: 18-Nov-2019

Revised: 25-Dec-2019

Accepted: 26-Mar-2020

Published: 28-Aug-2020

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the exoscope has a broad field of view (600 vs. 25 mm) and greater mean focal distance (200–300 vs. 3–20 mm), allowing the access of neurosurgical instruments without much difficulty. In addition, it is easier to setup exoscope. With the use of exoscope both the surgeon and assistant gets to see the same view. And also allows the rest of operating room (OR) team to follow the procedure with ease. Stereopsis was a matter of concern with initial exoscope. New 3-D 4K-HD exoscope system has significantly solved this issue.

## Materials and Methods

This study was conducted in the Department of Neurosurgery, Bantane Hospital Fujita Health University, Japan. Apart from comparing the specifications of available systems, we conducted a worldwide survey of the two systems through sending questionnaire through mail [Table 1], collected responses and analyzed them.

### Analyzing instruments

#### EXOSCOPE

(Discussed here are, VITOM, KINEVO, ORBEYE).

#### VITOM

The Storz VITOM (Storz, Tuttlingen, Germany) was the first neurosurgical exoscope, freeing the surgeon from the need to interface directly with the magnifying device.

Initial version:

Length: 14 cm, outer diameter of 10 mm

Light source: 300-W xenonfiber optic light box

Image: 23-inch, high-definition monitor

Working distance: 25–60 cm

Limitation: Steep learning curve,<sup>[8]</sup> fixed pneumatic holder, two-dimensional (2D) view. Now improved to 3D VITOM (Karl Storz, Tuttlingen, Germany).

#### KINEVO

To combine the advantages of both the standard microscope and the 3D exoscope, the KINEVO (Carl Zeiss AG, Oberkochen, Germany) was designed with the idea of creating a robotic, navigational microscope that can be converted into an exoscope.

Advantages: Kinematics/mobility through mouthpiece adjustment, 3D 4 K resolution, indocyanine green video angiography are integrated into the optics to allow the dye runs to be viewed directly through the microscope, rather than looking away to the monitor.<sup>[9]</sup>

Limitations: Heavy footprint/size and impaired workflow.<sup>[9]</sup>

#### ORBEYE

3D 4 K (Olympus, Tokyo, Japan).

**Table 1: Survey questionnaire**

1. Which type of institution you are affiliated with
  - (a) Government hospital
  - (b) Private hospital
  - (c) Visiting consultant
2. How frequently you use exoscope and endoscope
  - (a) Frequently
  - (b) Occasionally
  - (c) Rarely
  - (d) Use only endoscope
  - (e) Use only exoscope
  - (f) Does not use either of these
3. Opportunities for training of endoscope
  - (a) Easily available
  - (b) Available at some places
  - (c) Available at few places only
4. Opportunities for training of exoscope
  - (a) Easily available
  - (b) Available at some places
  - (c) Available at few places only
5. In your opinion which instrument is better for depth perception
  - (a) Endoscope
  - (b) Exoscope
  - (c) Both equally good
  - (d) Both have limitations
  - (e) Microscope is better than both
6. Ease of maneuverability
  - (a) Better with exoscope
  - (b) Better with endoscope
  - (c) Both are equal
  - (d) Both have limitations
7. Learning curve
  - (a) No difference
  - (b) Steep learning curve for both
  - (c) Endoscope is easy in comparison to exoscope
  - (d) Exoscope is easy in comparison to endoscope
8. Image quality
  - (a) No significant difference
  - (b) Exoscope gives better image
  - (c) Endoscope gives better image
9. Which instrument you find magnification is better
  - (a) Endoscope is better
  - (b) Exoscope is having better magnification
  - (c) No significant difference
  - (d) Depends on case to case
10. Duration of surgery
  - (a) Similar in both the instruments with minimal difference
  - (b) Significant difference endoscope takes less time
  - (c) Significant difference exoscope takes less
  - (d) Depends on case to case

Advantages: 3D 4 K ultra-high-definition imaging. The use of 55-inch 4K 3D monitor contributes to a reduction of surgeon fatigue and facilitates team surgery.

Significant reduction in size (95% smaller than the conventional model).

Limitations: One subjective disadvantage has been the visualization of

Bleeding tissue particularly in muscle or white matter. Image quality degrades and is inferior to that of the microscope in these situations.<sup>[9]</sup>

### Neuroendoscopes

A 0-degree angled eyepiece olympus endoscope for endoscope-assisted

Microneurosurgery Figure 1

The use of a microelectro mechanical system has improved light discrimination to view different structures of the brain when obtaining an image.<sup>[10]</sup>

(KARL STORZ GmbH and Co., Tuttlingen, Germany).

Angulation 15–90 degree

Source of light: Light-emitting diode

The most novel is the introduction of the “insect eye” technology,

Developed by Visionsense Corp., (New York, New York, USA), where a 3D

lens system is attached to the endoscope.

Hopkins’ endoscopic systems and optics have proved to be the most influential in the field of neuroendoscopy and provide the basis of the endoscopes that are used to the present day.

### Results

Specification of endoscope and exoscope, comparison is show in Table 2. Of the 280 surveys that were received at the recipient e-mail addresses, Graphical distribution of the responses are shown in Figures 2-11 and Table 3.

Forty-seven were returned and thus response rate was 16.78%; therefore, the study is based on the analysis of specifications of various available instruments through available literature and opinion of 47 neurosurgeons working in different parts of the world.

### Place of work

Which type of institution you are affiliated with?

Out of 47 responders, majority of people were working in private hospital (83%). 14.9% were working in government hospitals, and 2.1% working as visiting consultant.

### Usage of the two instruments

How frequently you use exoscope and endoscope.

Forty-seven people responded.

53.2% people mentioned frequent usage, 25.5% use only endoscope, 6.4% surgeons used only exoscope, and 4.3% mentioned rarely using either of the instruments.

### Training opportunities

We received 47 responses, majority of the people said training for endoscope is available at some places only and for exoscope it is available at few places only.

### Depth perception

Received 46 responses

Majority of the surgeons (67.4%) felt endoscope is better for depth perception. Only 19.6% felt exoscope is better for depth perception.

### Ease of maneuverability

Forty-six responses

76.1% feel endoscope has got better maneuverability, 19.6% feel its better with exoscope.

**Table 2: Comparing specifications of Endoscope with Exoscope**

Instrument	Endoscope	Exoscope
Working distance	3-20 mm	250-750
Field of view	Small 25 mm	Large 600 mm
Depth perception	Better	Limitation
Image type	2D/3D	2D/3D
Chance of damage to intracranial structures	Possibility	Nil
Blood obscuring the field	Does happen	Never happens
Neck position of surgeon	Neutral	Neutral
Comfort to the assistant	Yes	Yes
Operating time	Varies from case to case	Varies from case to case
Learning curve	Long	Easy
Availability	Commonly available	Few places only
Advantages	Angled view Feasibility in access to small regions	Not possible
Disadvantages	Blind surgical corridor Use limited to some procedures	Difficult to re-position

**Table 3: Survey results**

Questions of the survey	Percent distribution of responses	Graphical representation of the responses
1. Which type of institution you are affiliated with		
Government	14.9	Image 2
Private	83	
Visiting consultant	2.1	
2. How frequently you use exoscope and endoscope		
Frequently	8.5	Image 3
Occasionally	53.2	
Rarely	4.3	
Use only endoscope	25.5	
Use only exoscope	6.4	
Does not use either of these	2.1	
3. Opportunities for training of endoscope		
Easily available	17	Image 4
Available at some places	66	
Available at few places only	17	
4. Opportunities for training of exoscope		
Easily available	6.4	Image 5
Available at some places	21.3	
Available at few places only	70.2	
Do not know	2.1	
5. In your opinion which instrument is better for depth perception (46 response)		
Endoscope	67.4	Image 6
Exoscope	19.6	
Both equally good	4.3	
Both have limitations	2.2	
Microscope is better than both	2.2	
6. Ease of maneuverability (46 response)		
Better with exoscope	19.6	Image 7
Better with endoscope	76.1	
Both are equal	4.3	
Both have limitations	-	
7. Learning curve		
No difference	6.4	Image 8
Steep learning curve for both	6.4	
Endoscope is easy in comparison to exoscope	4.3	
Exoscope is easy in comparison to endoscope	80.9	
Not used exoscope	2.1	
8. Image quality (46 responses)		
No significant difference	8.7	Image 9
Exoscope gives better image	76.1	
Endoscope gives better image	13	
Endoscope is good but not used exoscope	2.2	
9. Which instrument you find magnification is better		
Endoscope is better	10.6	Image 10
Exoscope is better	74.5	
No significant difference	4.3	
Depends upon case to case	10.6	
10. Duration of surgery		
Similar in both the instruments with minimal difference	2.1	Image 11
Significant difference endoscope takes less time	6.4	
Significant difference exoscope takes less	6.4	
Depends on case to case	85.1	





Figure 1: Zero degree endoscope

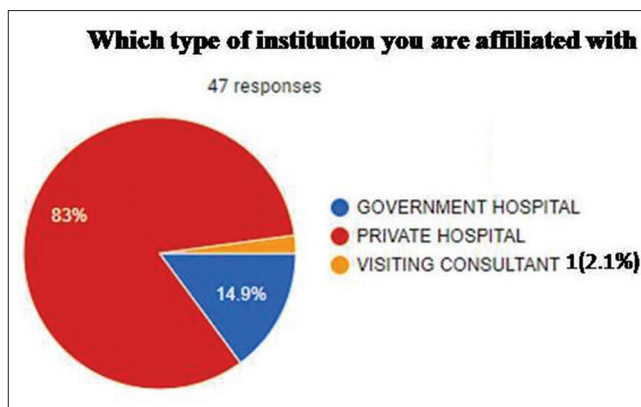


Figure 2: Which type of institution you are affiliated with

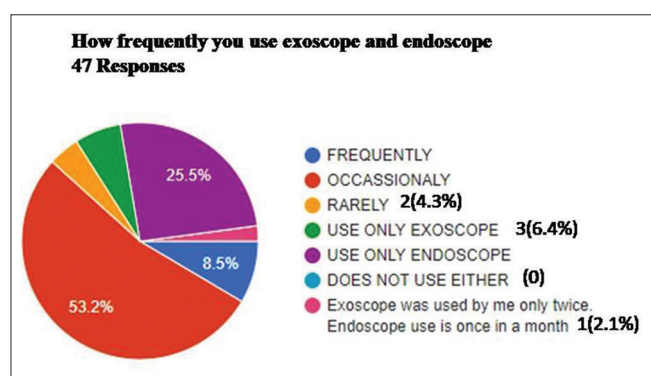


Figure 3: How frequently you use exoscope and endoscope

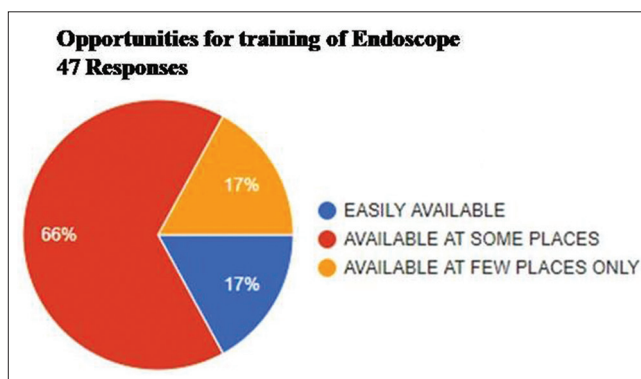


Figure 4: Opportunities for training of Endoscope

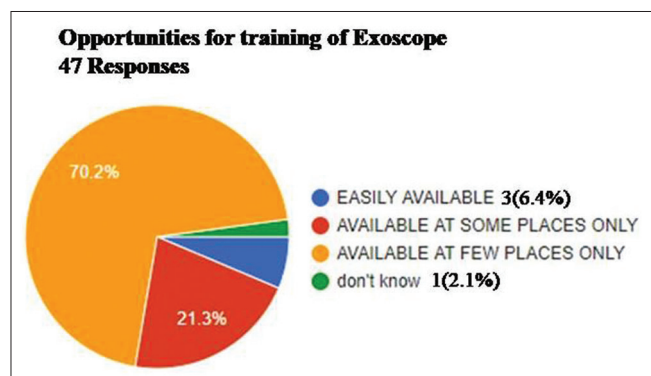


Figure 5: Opportunities for training of Exoscope

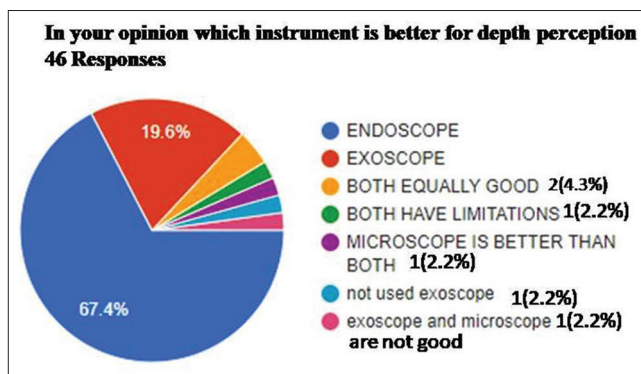


Figure 6: Which instrument is better for depth perception

### Learning curve

Forty-seven responses

Majority of the surgeons, 80.9% said exoscope is easy to learn and work.

### Quality of the image

Forty-six responses

Majority of the surgeons said that 76.1% said exoscope gives better image while only 13% found endoscope to give better image quality in comparison to exoscope.

### Magnification

Forty-seven responses

Majority of the surgeons, 74.5% feel exoscope gives better magnification in comparison to the endoscope; only 10.6% said that endoscope is better.

### Duration of surgery

Forty-seven responses

85.1% said that it depends on case to case, 2.1% said it is similar in both the instruments with minimal difference.

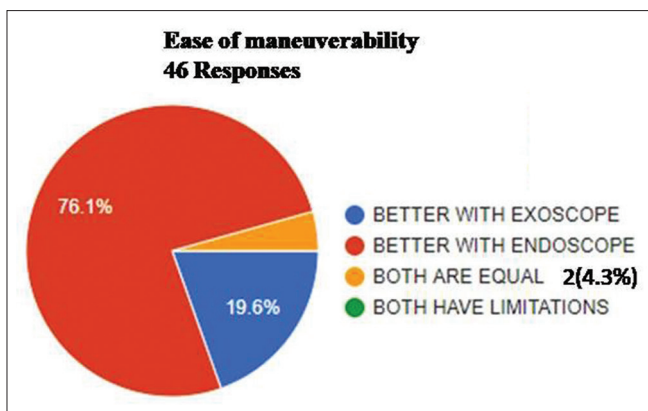


Figure 7: Ease of maneuverability

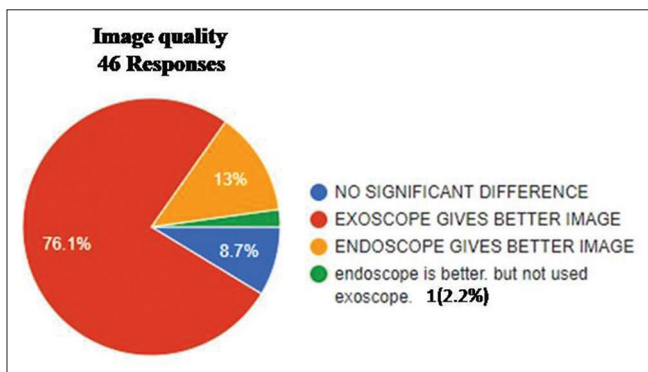


Figure 9: Image quality

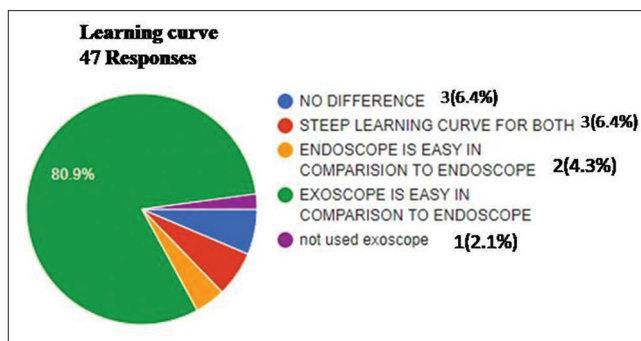


Figure 8: Learning curve

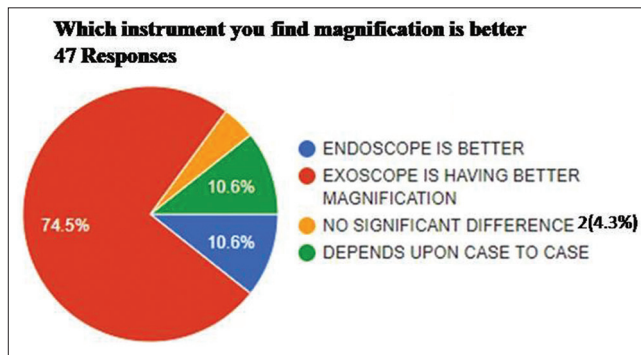


Figure 10: Which instrument you find magnification is better

## Discussion

This study has compared the two operative scope endoscope and exoscope which is actually extension of the preexisting microscope. The use of particular instrument depends on the requirement of case, and capabilities of the instrument. In this study, we have analyzed the specific details of the available endoscope and exoscope system, through survey we gathered the opinion of neurosurgeons working in different parts of the world. Both the endoscope and exoscopes have their advantages and limitations. Exoscope is a newly emerging technique

for neurosurgery allowing visualization of the intracranial structures from outside of the body rather than inside, the way the endoscope does.<sup>[7,11-13]</sup>

Neuroendoscopes utilize long, narrow-diameter rod lenses with short focal lengths and “direct in-line” visual trajectories, resulting in a relatively fixed, narrow field of view that is easily obscured with the introduction of surgical instruments or with moderate to brisk bleeding.<sup>[14]</sup>

Due to the limitation of 2D images, endoscopes generally used for limited procedures such as transsphenoidal, endonasal skull base, or intraventricular procedures.<sup>[13]</sup>

With the development of image guided systems which improves the surgical precision and gives better outcome.<sup>[13,15]</sup>

Exoscope has a wide and larger working distance as compared to neuroendoscopes, thus permits efficient usage of surgical instruments. Being familiar to the traditional operating microscopes learning curve is much smaller. In addition, there are no issues of lens fogging or cleaning, problems frequently encountered with the endoscopy.<sup>[16,17]</sup>

## Neuroendoscopes

### Advantages

- Good maneuverability
- Depth perception
- Minimal brain retraction
- Minimal access
- Access to blind areas using adequate angulation
- Availability
- Good opportunities for training.

### Disadvantages

- Steep learning curve
- Use limited to certain procedures only
- Chance of damage to intracranial structures
- Blood frequently obstructs the vision.

## Exoscope

### Advantages

- Latest exoscope system gives following advantages
- 4K 3D visualization
- Precise images for seeing more
- Anatomical details and tissue structure

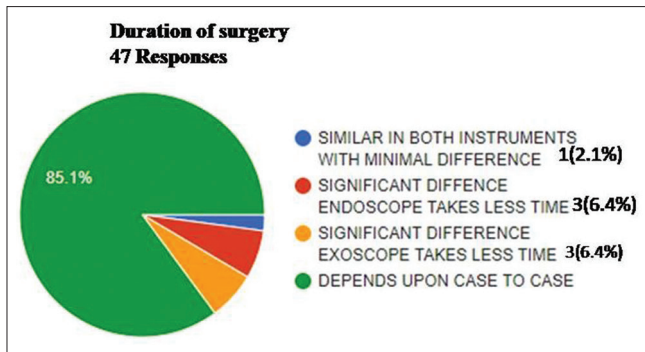


Figure 11: Duration of surgery

- 4K 3D visualization
- No image latency
- Super high  $\times 26$
- More comfortable and natural working posture
- Comfortable heads-up posture
- Freedom from ocular lenses
- Positioning flexibility
- Ample operative space
- Larger working distance
- Wider field of view
- Familiarity with conventional microscopes
- Same picture for surgeon, assistant side-by-side, and other staff.
- No obscuration of surgical field with blood.

#### Disadvantages

- Light does not focus in deeper parts
- Not good for minimally invasive procedures
- Lack of easy availability.

#### Conclusion

The 3-D 4K-HD is a novel exoscope system aimed at improving visualization and overall operative experience of the entire team. Learning curve, magnification, image quality, and ergonomics favor exoscope but depth perception and maneuverability favors endoscope. Hand eye coordination, tactile sensation, and usage of different angulation tubes favored endoscope to be superior to exoscope. As there is more scope for modifications and research in both the instruments, these instruments are not replacement of either and should be used according to the indications.

#### Financial support and sponsorship

Nil.

#### Conflicts of interest

There are no conflicts of interest.

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