

# New innovative use of 3D video exoscope in microsurgical varicocelectomy: A case series

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**Summary** *Introduction: Varicocele affects 10-15% of adult males, and is linked to infertility (35%) and testicular pain (10%). Microsurgical varicocelectomy (MV) is considered the gold standard treatment due to its low complication rates and superior anatomical outcomes. However, conventional MV using a 2D exoscope presents limitations in image depth and surgeon ergonomics. This study presents the use of a 3D video exoscope as a novel tool to enhance visualization and ergonomics during MV.*

*Materials and methods: We report a series of four patients undergoing 3D-assisted microsurgical varicocelectomy using a Zeiss microscope integrated with a 3D video exoscope system. Patients presented with either infertility, testicular pain, or both, with varicocele diagnoses confirmed by physical examination and ultrasound. Procedures were performed subinguinally with artery- and lymphatic-sparing techniques, and the ergonomics and image quality were assessed.*

*Results: All surgeries were successfully completed with the aid of the 3D exoscope. Surgeons reported improved ergonomics, reduced neck and back strain, and enhanced image depth and clarity. The system allowed for up to 10x optical magnification, full-screen UHD 3D visualization, and a wide field of view. No intraoperative complications were noted. Patients tolerated the procedure well, and early outcomes were favorable in terms of symptom relief and semen parameter improvement.*

*Conclusions: The integration of a 3D video exoscope in microsurgical varicocelectomy is a promising innovation. It offers superior image quality, improved surgeon comfort, and may enhance surgical precision. Further studies with larger cohorts and long-term follow-up are warranted to validate these findings.*

**KEY WORDS:** Innovation Exoscope; Microsurgical Varicocelectomy; 3D Video Exoscope.

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## INTRODUCTION

The prevalence of varicocele is approximately 10%-15% in the adult male population; approximately 35% of cases are associated with infertility, and 10% of cases are associated with testicular pain (1). The surgical treatment options for varicocele are numerous, including open ligation (2, 3), laparoscopic high ligation (4, 5), microsurgical varicocelectomy (MV) (6, 7), and embolization of the spermatic vein (8, 9).

MV has become the gold standard surgical procedure for varicocele because it is associated with the lowest risk of complications (varicocele recurrence, hydrocele formation (fluid collection around the testicle) and testicular atrophy) (10-12). Microsurgical varicocelectomy is superior in identifying and preserving arteries and lymphatic vessels by enlarging the spermatic cord through a microscope. MV also helps identify small spermatic veins that will later be ligated. Increased magnification can improve anatomical detail and reduce complications.

Currently, micro-varicocelectomy is performed using a Vitom 2D, but it has limitations. The limitations include a narrow or circular view with magnification up to 7x and 2D images, which can differ in orientation from reality, especially regarding distance and depth. The use of a microscope sometimes causes surgeons to work in a non-ergonomic manner. To overcome these weaknesses, we innovated by using a 3D video exoscope combined with a microscope, which provides greater magnification, better resolution images, and a more accurate orientation.

## CASE PRESENTATIONS

### Case 1

A 15-year-old male with left testicular pain. He is unmarried. Physical examination revealed dilated veins during the Valsalva maneuver in the left scrotum, confirmed by a scrotal ultrasound showing a grade 2 left varicocele. The patient was scheduled for a left 3D MV.

### Case 2

A 31-year-old male with infertility. He reported no ejaculation problems and has been married for 4 years, with no obstetric issues in his wife. A physical examination revealed bilateral varicoceles, which were confirmed by an ultrasound that demonstrated grade 3 right varicocele and grade 2 left varicocele. Semen analysis showed *oligoasthenoteratozoospermia* (OAT). The patient was diagnosed with primary infertility, moderate OAT, and bilateral varicocele. He was scheduled for bilateral 3D MV.

### Case 3

A 32-year-old male with infertility. He reported no ejaculation problems and has been married for 5 years, with no

obstetric issues in his wife. He failed an *in-vitro fertilization* program (IVF) 8 months ago. Physical examination revealed palpable veins during the Valsalva maneuver, confirmed by ultrasound as bilateral varicocele grade 3. Semen analysis showed severe oligoasthenoteratozoospermia. The patient was diagnosed with primary infertility, severe OAT, and bilateral varicocele. He was scheduled for bilateral 3D MV.

**Case 4**

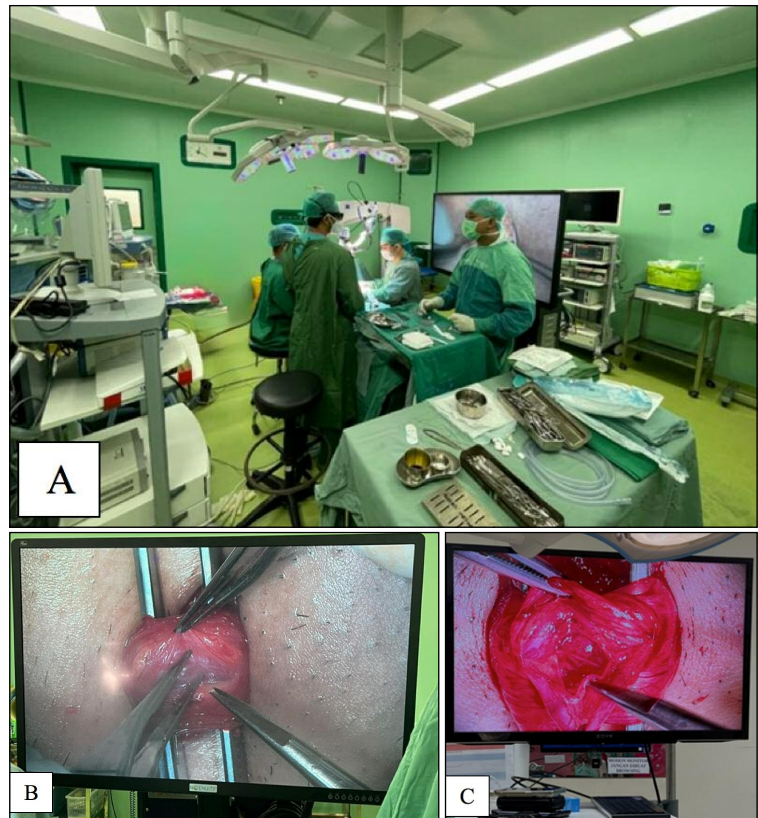
A 35-year-old male with left testicular pain and no children, married for 7 years, with no obstetric issues in his wife. Physical examination revealed palpable veins during the Valsalva maneuver, confirmed by ultrasound as bilateral varicocele (grade 3 for left testicle and grade 4 for right testicle). Semen analysis showed severe oligoasthenoteratozoospermia. The patient was diagnosed with primary infertility, severe OAT, and bilateral varicocele. He was scheduled for bilateral 3D MV.

tomy was performed using a Zeiss microscope and a 3D exoscope (Figure 1). The main binocular was replaced with a 3D exoscope, which acts as a camera receiving images from the microscope. The images are processed by a computer and converted into 3D, displayed on a 3D monitor, and viewed by the operator using 3D glasses. The assistant's monitor, connected via HDMI, shows 2D images of the same quality as the operator's. Both displays achieve UHD quality and can optically zoom up to 10x for clearer and more detailed images. The wide view from the exoscope's video output allows for comprehensive observation, facilitating teaching for residents and shortening the learning curve. (Figure 2).

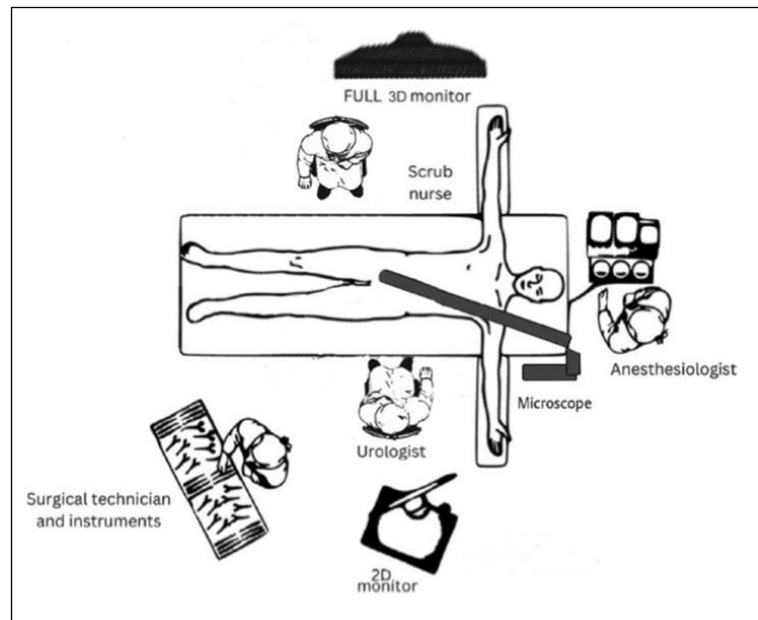
**DISCUSSION**

Varicocele has long been known to affect men's physical and mental health, with surgical techniques evolving over nearly a century. Surgical treatment for infertility or pain caused by varicocele has been widely promoted by clinicians and guidelines worldwide. A more precise and minimally invasive surgical technique called microscopic subinguinal varicocelectomy was first described by Goldstein *et al.* (6) in 1992. The patient experienced fewer difficulties and a better prognosis after all veins were surgically tied off one by one under a microscope while maintaining the lymphatics and arteries. Ito *et al.* (13) (1993) and Marmar and Kim (14) (1994) both used microscopic subinguinal varicocelectomy with lymphatic and artery sparing. They noted fewer problems, a high success rate, and more precise ligation. Consequently, open surgery, microscopic varicocelectomy, laparoscopic varicocelectomy, and varicocele embolization the four fundamental surgical ideas for treating varicocele were estab-

**Figure 1.**  
 A. Overall view of the operative field.  
 B. Operator's monitor using 3D monitor 55".  
 C. Assistant's monitor using 2D monitor 32".



**Figure 2.**  
 Operating theatre 3D microvaricolectomy.



lished. Microvaricolectomy surgery offers a great improvement over open surgery. It is possible to achieve vein ligation and artery and lymphatic vessel protection with the use of a microscope. The surgical approach produces the

best results in terms of safeguarding the testicular blood flow and minimizing postoperative problems, although requiring a longer duration of surgery. Additionally, MV has clear benefits over other treatments, such as a better prognosis and fewer problems, which have led to clinicians all around the world choosing this procedure (15-20).

Previous innovative tools have been used in varicocele surgery like 2D exoscope, but it has some problems like less ergonomic position, low of deep of field and field of view, so, we introduced a new tool for MV by using three-dimensional (3D) exoscope (21), which offers superior optical magnification, image quality, and depth perception (Table 1). These devices replace a standard microscope's optics with a stereo video camera. The final image is displayed on a high-definition monitor so that depth perception can be seen through polarised glasses. In the field of neurosurgery, the 3D exoscope was initially introduced as a substitute for the traditional operating microscope. The authors observed that the exoscope provided excellent comfort for all procedures carried out and that the image quality was comparable to that of a standard operating microscope. Several other studies have demonstrated that the 3D-exoscope may prove superior to the operating microscope in terms of depth of focus, image quality, and ergonomics (22). With the help of two HD-3D monitors positioned on either side of the principal and assistant, the exoscope system provides superior 3D visualization for both observers and surgeons via the use of special 3D glasses, making it an excellent teaching tool for residents and students. Traditional tools and crank stem instruments can be easily transferred from the scrub nurse to the primary surgeon because of the exoscope's larger working area (23). Micro-macro vision switches and long instruments used by the surgeon during spinal instrumented procedures may be the ideal situation (24). Additionally, there is no contamination or image degradation from blood on the lens during surgery because of the camera's greater distance from the surgical site.

Ergonomics is a useful tool for researching the likelihood of musculoskeletal problems and provides strategies for preventing and treating them when they do arise. Surgeons who use an operating microscope may be more susceptible to *musculoskeletal injuries* (MSI) because of their prolonged standing and fixed posture (head and back bending), which puts more mechanical strain on their neck and lower back. One of the unique advantages of the 3D exoscope is that it significantly improves the ergonomics and body mechanics of the participants. When surgeons flexed the neck 30 degrees beyond neutral the weight imparted to the cervical vertebrae increased 4 times (24). Through 4K 3D monitors, surgeons were able to position the exoscope at any necessary angle while maintaining a comfortable, upright, and neutral posture, which may ultimately help reduce surgical errors and times.

The previous preliminary study by using VITOM® 3D also showed comfort and

**Table 1.**

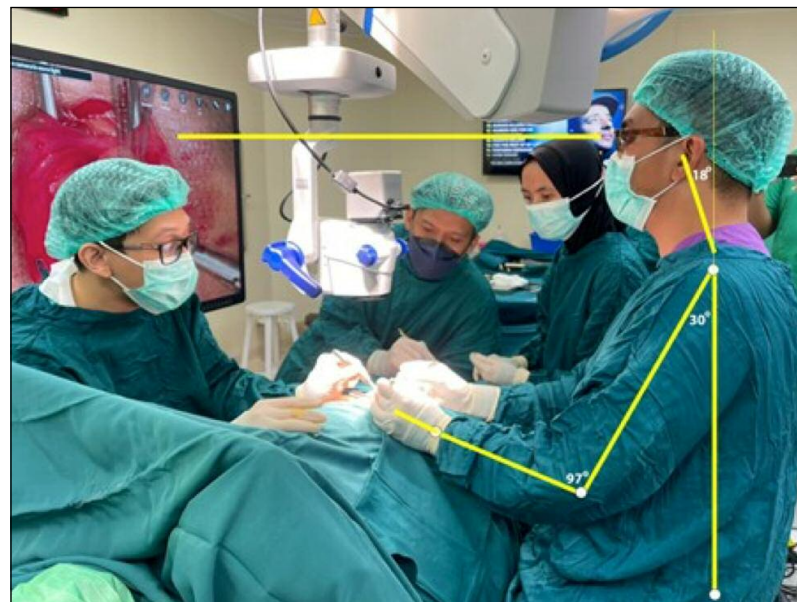
*Resolution and position OM + 3D Exoscope vs VITOM 2D.*

System	VITOM 2D (KARL STORZ, Germany)	OPMI Sensera (ZEISS, Germany) and 3D Exoscope
Illumination	Xenon	Xenon
Magnification (optical zoom)	x 7	x 10
Image quality	HD or 4K UHD	3D 4K UHD
Field of view (mm)	50-150	170
Field of view monitor	Circle	Full Screen
Operator position	Standing	Sitting
Portability	Portable base - manual setup	Suspension system - floor stand/ceiling mount
Depth of field (mm)	35-100	200-415

Source: Duarsa, GWK et al, 2023.

ergonomics position for the operators (25). Despite several guidelines for improving ergonomics in health care, there are still large gaps in the knowledge and practice of ergonomic principles in surgical settings (26, 27). Few articles have assessed the objective ergonomics in 3D exoscope-based procedures. We aimed to narrow this knowledge gap and showed that REBA rated the exoscope to be superior to the OM in MIS-TLIF (5.00 1.26 vs 6.05 1.39,  $p = 0.017$ ). The lack of awareness and training is the primary driver of poor ergonomics. Herein lies the opportunity to prevent MSI. Some articles provide suggestions for protecting MSI by correcting education in OR ergonomics and monitoring specific self-therapy exercises for individual musculoskeletal assets (28, 29). Additionally, in some literature, it is advised to reduce MSI, including the use of ergonomic equipment such as an exoscope and proper ergonomic positioning for the medical service provider, not just taking analgesics to relieve MSI symptoms (30, 31) (Figure 3).

**Figure 3.**  
*Surgical ergonomic 3D varicolectomy.*



## CONCLUSIONS

Innovative tools used in varicocele surgery include the 3D exoscope. The exoscope provided excellent comfort for all procedures carried out, and the image quality is two HD-3D. 3D exoscope significantly improves the ergonomics and body mechanics.

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## DECLARATIONS

**Ethical approval and consent for participate:** Written informed consent was obtained from all patients for the treatment and use of anonymized clinical data for academic purposes.

**Consent for publication:** Written informed consent was obtained from all individual participants included in the case series for the publication of anonymized clinical information and related images.

**Availability of data and material:** All data generated or analyzed during this study are included in this published article.

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