Application of the VITOM 3D exoscope in reconstructive microsurgery

Ho Man Truong Phu, Le Khanh Linh, Nguyen Dang Huy Nhat, Ho Van Nhan, Tran Thanh Dat, Pham Tran Nhat Linh

Hue Central Hospital

Corresponding author:
Ho Man Truong Phu
Hue Central Hospital
16 Le Loi Str, Hue city
Mobile: +84913495833
Email: bsnttrph@yahoo.com

Received date: 01/8/2022
Accepted date: 30/8/2022
Published date: 15/9/2022

Abstract

Introduction: To assess the quality of the Video Telescope Operating Monitor digital 3-Dimension (VITOM 3D) system and the primary results achieved after applying this system for soft tissue defects in reconstructive surgery at Hue Central Hospital (Viet Nam).

Patients and methods: We studied 82 patients (88 free flaps) with ages ranging from 7 to 80 years old undergone the soft tissue and bone defects reconstruction using VITOM 3D exoscope, from March 2019 to August 2022. We used the perspective study and the patients were researched on the properties of injury, on the kinds of flap or procedures, on sizes of flap or vessel, numbers of anastomosis, and on the results of surgery.

Results: In 82 patients with 88 free flaps we used in this study there included 72 Anterolateral Thigh Flaps (ALT) (81.8%), 7 Superficial Circumflex Iliac Perforator Artery Flaps (SCIP) (7.9%), 5 Latissimus Dorsal Flaps (LD) (5.6%) and 4 Fibular free flaps (4.5%). There were 72/88 flaps reaching Good level accounting for 81.2%, 12/88 flaps (15.9%) were at Average, 3/88 flaps (3.4%) were at Bad level due to being partial necrosis and 1 flap being failed with flap necrosis due to infection with MRSA. There were total 93 arterial and 146 vein anastomoses, respectively (on average: 2.7 anastomoses/flap). With the support of VITOM 3D system, we manipulated the arteries and veins having calibers is 2.4 ± 0.5 mm and 1.9 ± 0.4 mm on average, respectively. No anastomosis site complication was and the operative time in average 4.6 hours (ranging from 3 hours to 7 hours)..

Conclusion: We have updated and applied day by day widely, not just in the neurosurgery field, but also in reconstruction microsurgery. The primary results showed the efficiency and practicability of exoscopic 3D technique for soft tissue defect microsurgical treatment. The VITOM 3D system becomes more popular in both treatment for patients and training for students. However, we need to remember that the traditional Operating Microscope (OM) still keeps its valuations so further studies are needed to validate the advantages and disadvantages of VITOM 3D as compared to OM.

Keywords: VITOM 3D, operating microscope (OM), microsurgery.

Introduction

Reconstructive microsurgery is a surgical field where specialized operating microscopes and precision instrumentation are utilized to perform intricate operations on tiny structures. Utilizing magnification up to fifty times that produced by the naked eye and stitches finer than a hair, surgeons are able to repair transected blood vessels and nerves less than 1mm in diameter. The ability to reestablish continuity and blood flow to small, severed nerves and vessels has made a major impact on the potential to restore form and function to individuals impaired by trauma, cancer, and congenital differences. Advances in technology and surgical technique in the early 1960s for the first time allowed surgeons to successfully replant severed digits and limbs. Reconstructive microsurgery has witnessed major advancements in the last decade including the emergence of hand and face transplantation. These techniques are providing a new lease on life for severely injured patients whose problems cannot be solved by more traditional techniques. Advanced computing and robotics continue to foster the expansion of more precise and minimally invasive surgeries while the potential to biologically engineer missing tissues and structures (tissue engineering) offers an exciting gateway to the future. Optical magnification is an essential tool in the practice of vascular surgery as it allows us to accurately identify and define critical anatomic structures, reducing complication rates. Loupes with x 2.5-x 4.5 magnification are most frequently used, although, in some circumstances, the operating microscope may be used. These magnifying instruments are essential to the optimal care of our patients but they often come at the detriment of the operating surgeon in the form of neck or back pain and fatigue. Recent advances in imaging technology have led to the development of a high-definition (HD) compact video microscope to perform open surgery that requires magnification. In 2008, an 'exoscope' system i.e. the video telescope operating monitor (VITOM) was introduced as an alternative to both OM and endoscope [1]. The exoscope VITOM HD 3D system provides images of superb quality, 2-16 times magnification zoom, and good illumination displayed on the large-format 3D-HD flat screen for viewing by the surgeon, assistants, and other operating room personnel[2].

Microsurgery

Microsurgery is very popular and useful in a lot of fields of medicine including neurosurgery, organic transplantation, plastic and reconstructive surgery, transgender medicine, urology...In the limited study, we just provide the role and function of microsurgery in plastic and reconstructive surgery. Reconstructive microsurgery is a general term that is used to describe the surgical treatment of patients with complex injuries involving skin, muscle, tendons, nerve, and bone, where sections of living skin, muscle, and bone are transplanted from one part of the body to another. Microsurgery is a surgical discipline that combines magnification with an advanced microscope, specialized precision tools, and various operating techniques. Thus microsurgery allows the flap to be transferred far from the donor site restoring form and function to areas of the body that have lost skin, fat, muscle movement, and/or skeletal support. Microsurgery has expanded reconstructive surgerys elements and strategies and is still evolving. Along with the multidisciplinary approach and good principle of wound care, the repair and restoration strategies using microsurgery have widened the possibilities for limb salvage from complex chronic wounds.

This technique allows the surgeon to use the injured patients own bone or tissue to cover a wound, rebuild an arm or a leg, or restore lost function. The key to this technically complicated procedure is the careful microscopic reattachment of the tiny blood vessels to the tissues being transplanted so that they continue to live and function in their new location. The advent of reconstructive microsurgery in the early 1960s led to a new phase of possibilities for limb-saving procedures. Although pedicle local fascia-subcutaneous or muscle flaps continue their useful role, microsurgical free tissue transfer is usually necessary for larger defects and also for areas where there are no loco-regional options. Bringing in healthy, well-vascularized tissues overcomes local constraints and also has a proven role in fracture healing. As the use of free tissue transfer has become more established, innovation and technical refinements have resulted in an evolution of flap surgery that has been applied to lower limb surgery, including the use of perforator or free-style free flaps. A similar development occurred in the reconstruction of bone and composite defects with vascularized bone and osteo-subcutaneous flaps [3].

Operating microscopy

In 1673, Anthony van Leeuwenhoek invented the microscope, opening a new era for enlarging a small object through a lens system. It created a revolution in the world of bacteriology and later in the field of histology. The major innovation of the microscope was that it produced a magnified image on the retina providing increased visual detail. With improvements in lens quality, optical methods, and other aspects of instrumentation, Leeuwenhoeks original design was improved and modified during the past 3 centuries, later adding photography to record the object [4]. Since its introduction in neurosurgery in the late 1950s, the operating microscope (OM) is the gold standard visualization tool in neurosurgery because of its illumination, stereoscopy, and magnification. The OM resulted in a dramatic leap forward in capability to perform operations, such as clipping of cerebral aneurysms and tumor removal, with a readily apparent improvement in surgical outcome and reduced morbidity [5].

The 2 key features of the OM are the large object distance, most commonly used at 250 to 300 mm from the optical system, and the large field of view. The focal distance provides ample working room for the introduction and removal of surgical instruments and prevents the lens from being frequently obscured by blood, tissues, or instruments. Further, the large focal distance permits the positioning of the OM in a wide spectrum of angles and positions to permit visualization of deep structures or structures obscured by bone anatomy, without blocking the working area [4].

The OM does have several limitations: Firstly, the OM is heavy, and because of the weight and the size of the head stage, the OM requires a large and complex counterbalance system to prevent it from tipping over. This counterbalance takes up a large space of the room, restricts the movement of surgical personnel, and must be draped into the operative field. The hydraulic system used to allow precision movements of the head stage is similarly large and expensive. Modern-day OM typically costs between US $250 000 to $400000, in addition to service contracts, costs for replacement parts, and other equipment. In addition, the OM cannot be moved from site to site with ease. Second, the neurosurgical procedures require the surgeon to look at the anatomy from various angles. Direct binocular vision often requires the surgeon to bend his or her neck and body for extended periods of time. The assistant is often in similar or worse constraints. This position results in surgeon discomfort and fatigue and factors that can result in sub-optimal surgical outcomes. Third, despite this complex and sophisticated optical design of the OM, the depth of field is narrow. Each movement often requires refocusing. More recent OM units simplify this process with electromagnetic control devices, but nonetheless, this is a time-consuming step [4].

VITOM 3D Exoscopic system

In the last years, a new vision system called Video-assisted telescope operating monitor (VITOM) or Exoscopic system has been introduced as an alternative or support to the OM and the endoscope. It consists of a scope located outside the body cavity, over the surgical field, supported by a mobile mechanical arm, projecting to a screen [6]. It produces high-quality video of small surgical fields, with high magnification capacity and a large depth of field, and allows working in a setting that is similar to one of endoscopic surgeries, with possibilities of an application similar to that of the operating microscope. The first prototypes had two major drawbacks however lack of stereopsis and cumbersomeness in the repositioning of the telescope [Figure 1].

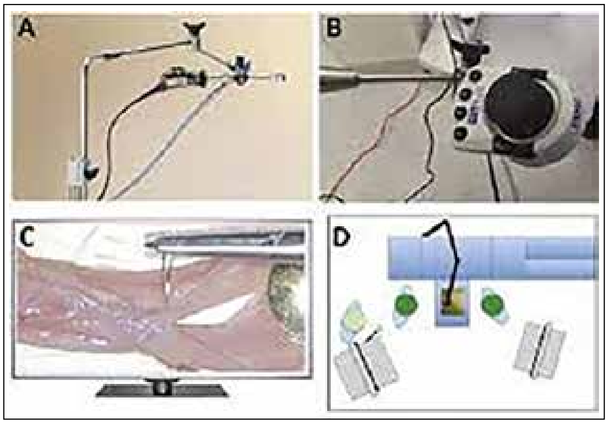

Figure 1: The High-Definition Exoscope System

Figure 2: Image1 pilot

The VITOM 3D system provides many surgical disciplines with a revolutionary solution for the visualization of microsurgical and open surgical interventions [7]. The most important functions are controlled via the Image1 pilot [Figure 2], which is mounted on the operating room table in the direct vicinity of the surgeon. Some advantages of the system are listed below:

Smaller, lighter, and more compact than an operating microscope.

Lower acquisition costs and creates synergistic effects with endoscopy by using the same video tower – thus combining the benefits of endoscopy and microscopy.

Ergonomic work – the user is not confined to the eyepiece.

Improved workflow – the operating room (OR) team can view the procedure in the same image quality as the surgeon.

Patients and methods

A single surgeon (A.G.) performed 82 consecutive cases of microsurgical free flap reconstruction for body soft tissue defects at the Department of Plastic and Hand Surgery Department, Hue Central Hospital, Viet Nam. The patient's ages was ranging from 7 to 82 years old. In this study, we assessed and applied microsurgery by VITOM 3D exoscope (for soft tissue defect reconstructions from March 2019 to August 2022. The defects can be wounds caused by trauma, burn or remaining defects following the tumor removal and scar releases. We used the perspective study in our article and the patients were researched on the properties of injury that required microsurgical reconstruction, on the kinds of flap or procedures we utilized, on sizes of flap or vessels, numbers of anastomosis, and on the results of surgery. In practically, we based on the transfusion flow of flaps (such as vascular thrombosis, arterial spasm), the texture of flaps (partial necrosis or total necrosis), and any complications on the flaps

We debrided radically the soft tissue defects associated with recipient vessel preparation. Then, we raised the flap designed previously and then transferred to cover the defect. Arterial and venous anastomosis was performed under VITOM 3D system (KARL STORZ, Tuttlingen, Germany [Figure 3].

Figure 3: VITOM 3D system and microsurgical surgeon's team setting

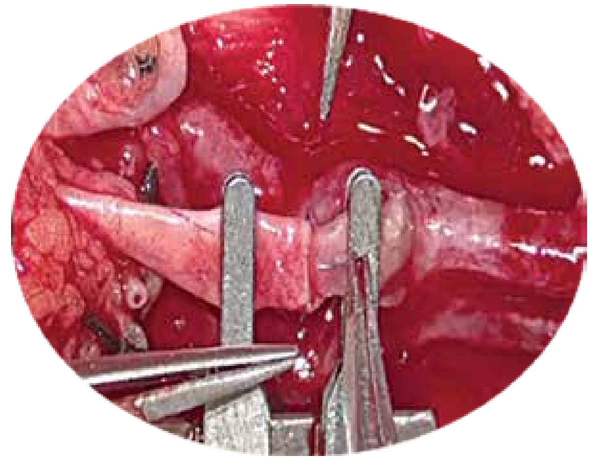

Figure 4: Images of vessels anastomosis under the VITOM 3D

We did surgery simultaneously on two teams including the preparation of the recipient site and harvesting the flap at the donor site. The VITOM 3D just only was applied to all microsurgical anastomoses without flap harvesting. The arterial anastomoses were performed in end-to-end or end-to-side fashions with single stitches on the other hand, the vein anastomoses just only done by end-to-end [Figure. 2]. The number of arterial and vein anastomosis of each patient depended on if there was any vein graft.

Results

From March 2019 to August 2022, we did microsurgery with The Video Telescope Operating Monitor (VITOM) 3D for reconstructive surgery on 82 patients (88 flaps) ranging from 7 to 80 years old (38.10 ± 20.23 years on average). Regarding the location and kinds of injuries, we defined that there were 31 flaps (35.2%) on the upper extremities (Hand, Forearm), 48 flaps (454.5%) on the lower extremities (Foot, Leg, and Popliteal), and the rest of 9 flaps (10.2%) on Head, Neck and Oral cavity. The highest rate of causes leading to the injuries was trauma then followed by burn, tumor removal, and contracture scar release respectively.

The average size of flap was 192.1cm2 (ranging from 35cm2 to 240cm2) in which the biggest length and width were 20cm and 12cm, respectively.

There were total 93 arterial and 146 vein anastomoses, respectively (on average: 2.7 anastomoses/flap). With the support of VITOM 3D system, we manipulated the arteries and veins having caliber is 2.4 ± 0.5 mm and 1.9 ± 0.4 mm on average, respectively.

With our results, there were 72/88 flaps reaching Good level accounting for 81.2%, 12/88 flaps (15.9%) were at Average, 3/88 flaps (3.4%) were at Bad level due to being partial necrosis and 1 flap being failed with flap necrosis due to infection with MRSA. No anastomosis site complication was found (such as vascular wall injury with back-wall or side-wall catches of it). The operative time in average 4.6 hours (ranging from 3 hours to 7 hours).

Discussion

Now a day, belonging to the innovation of electronic technology encouraged the development of optical systems, microscope balance and focus, and microsurgical techniques achieved by surgeons established the OM as a basic part of modern reconstructive and replantation microsurgery. A focusing system with a focal length between 200 mm and 400 mm that permits entry into the surgical field with surgical instruments without colliding the OM or obstructing the surgeon's vision and that can be moved with the use of an electronic drive is ideal [5].

However, the traditional OM still remains some limitations in bulky and heavy mass, difficult movement, reducing the number of participants in surgery... The VITOM 3D will improve those limitations regarding the visual field, magnification, illumination, ergonomics, depth effect, and 3D impression. The possibility to mount the passive holding arm on the rail of the operating table provides a working space up to 750 mm, and the customized distal joint enables the user to position the camera single-handed . The clear and high-resolution 3D impression showed no noticeable difference with the familiar stereoscopy of the OM, so the visualization of target structures and the bimanual microsurgical dissection with familiar micro instruments did not require changes in the surgical techniques. Especially, The application of the VITOM system to surgical procedures has not shown a significant increase in surgical time compared to traditional methods [6], [7].

We have just used the VITOM 3D system in our microsurgical cases regarding to reconstructive microsurgery for 3 years, although we have not got much practical experience, according to the surgical outcome on our research achieved, the feasibility and positive attitude data results were seen in terms of the soft tissue defect coverage goals, especially, we have not any cases to be converted to OM technique. We also have the primary considerations of the advantages of using VITOM 3D system for microsurgical reconstruction by the magnification, illumination, being comfortable for surgeons and assistants, and the outstanding post-op results. All strong points of VITOM 3D facilitate surgeons revascularizing the patency of super small vessels and nerves with larger magnification, clearer light, and higher definition of the image than that of traditional OM. Similarly some of the other authors using the VITOM 3D in microsurgery for neck and head reconstruction also found that harvesting free flaps and performing micro anastomoses with the 3D 4K exoscopic system are feasible and provide optimal stereoscopic view and anatomical details [8][9]. Georgios et al [10] demonstrated the short learning curve in exoscopic microvascular end-to-end anastomosis, and further allows confidence and safety of the use of Exoscope in clinical environment in such a technically demanding surgical task. The limitations on these studies are that we have not yet investigated potential positive features for the operating surgeon and possible physical discomfort during exoscopic microsurgery through a specific questionnaire; the auxiliary screen monitor is required or flap harvesting with the VITOM 3D supports.

Conclusion

Belonging to technological innovations, we have approached and applied day by day widely the VITOM 3D system in reconstructive microsurgery. With optimal achievements and visible benefits, the VITOM 3D system becomes more popular in both treatments for patients and training for students. However, we need to remember that the traditional OM still keeps its valuations, because it is the basic technique to become a microsurgeon and even when we are far from the developmental places, we still can do microsurgery easily. So the research on larger series in the future are needed to validate the indications and advantages of VITOM 3D as compared to OM and its educational value allowing the attendees such as students, residents or fellows to follow and better understand the surgical steps.

References

1. Kenichi Nishiyama, From Exoscope into the Next Generation. J Korean Neurosurg Soc, 2017. 60 (3): p. 289-293.
2. Palumbo, V.D., et al., VITOM(R) 3D system in surgeon microsurgical vascular training: our model and experience. J Vasc Access, 2018. 19(1): p. 108-109.
3. Engel, H., C.-H. Lin, and F.-C. Wei, Role of Microsurgery in Lower Extremity Reconstruction. Plastic and reconstructive surgery, 2011. 127 Suppl 1: p. 228S-238S.
4. Mamelak, A.N., et al., A High-Definition Exoscope

System for Neurosurgery and Other Microsurgical Disciplines: Preliminary Report. Surgical Innovation, 2008. 15(1): p.38-46.

5. Herlan, S., et al., 3D Exoscope System in Neurosurgery-Comparison of a Standard Operating Microscope With a New 3D Exoscope in the Cadaver Lab. Oper Neurosurg (Hagerstown), 2019.
6. Rossini, Z., et al., Video Telescope Operating Monitor (VITOM) 3D: preliminary experience in cranial surgery. Technical Case Report. World Neurosurgery, 2017. 107.
7. Salvatore Ferlito, Ignazio La Mantia, Sebastiano Caruso et all, High Definition Three-Dimensional Exoscope (VITOM 3D); in E.N.T. Surgery: A Systematic Review of Current Experience, J. Clin. Med (2022), 11,p : 36-39
8. Gabriele Molteni., Riccardo Nocini., Michael Ghirelli., et all, Free flap head and neck microsurgery with VITOMR 3D:Surgical outcomes and surgeons perspective Auris Nasus Larynx (2021) 48: p. 464–470
9. Alberto Grammatica., Alberto Schreiber., Alperen Vural., et all, Application of a 3D 4K exoscopic system to head and neck reconstruction: a feasibility study, European Journal of Plastic Surgery (2019) 42: p. 611–614
10. Georgios Pafitanis, Michalis Hadjiandreou, Alexander Alamri, et all, The Exoscope versus operating microscope in microvascular surgery: A simulation non-inferiority trial, Archives of Plastic Surgery (2020) 47(3): p 242-249.