Vitom-3D for Exoscopic Neurosurgery: Initial Experience in Cranial and Spinal Procedures

Joachim M. Oertel and Benedikt W. Burkhardt

■ BACKGROUND: **The authors describe the application of a new exoscope that offers 3-dimensional (3D) visualization in cranial and spinal neurosurgery in detail.**

■ METHODS: **Five cranial and 11 spinal procedures were performed with a 3D exoscope. Instrument handling, repositioning of the exoscope, handling of the image control unit, the adjustment of magnification and focal length, the depth perception, the image quality, the illumination, and the comfort level of the posture during the procedure were assessed via a questionnaire.**

■ RESULTS: **The following procedures were performed: Microvascular decompression ($n = 1$), craniotomy and tumor resection ($n = 4$), anterior cervical discectomy and fusion with cervical plating ($n = 2$), cervical laminectomy and lateral mass fixation ($n = 1$), shear cervical lateral mass osteosynthesis ($n = 1$), lumbar canal decompression ($n = 1$), transforaminal lumbar interbody fusion ($n = 2$), thoracic intraspinal extradural tumor resection ($n = 1$), and lumbar discectomy ($n = 3$). Instrument handling, the intraoperative repositioning and handling of the VITOM-3D, and the comfort level of the intraoperative posture was rated excellent in 100% of procedures. The image quality was rated equal to the operating microscope in 68.75% of procedures. None of the procedures had to be stopped because of technical problems. No surgical complications were noted that could be related to the use of the exoscope.**

■ CONCLUSIONS: **The 3D-exoscopic system is safe and effective tool to perform spinal procedures and less demanding cranial procedures. The image quality and 3D visualization were comparable with the operating microscope. The technique harbors the unique advantage of excellent comfort for the involved surgical team during the procedure.**

INTRODUCTION

Excellent visualization and illumination of the surgical field are essential to perform any kind of surgery safely and successfully. In the 1970s, the operating microscope was introduced to the neurosurgical community and quickly became one of the most important tools of the neurosurgical armamentarium. Since then, the operating microscope continually has been modified to what is now a high-precision device that offers a 3-dimensional (3D) perception of the surgical field and enables the surgeon to adjust the focal length, the magnification, and the brightness via an electronical drive.

Despite the aforementioned characteristics, the operating microscope is associated with several limitations such as, for example, its large size, which occupies a significant amount of space in the operating theater. Furthermore, the cost of a modern operating microscope for neurosurgical applications varies from $150,000 to $500,000 or more, which makes it a considerable investment. In addition, the binocular lenses of the operating microscope are connected to the head of the microscope and limited in their movability. This limitation often requires the surgeon and the assistant to crick his or her upper body and to bend his or her neck to visualize structures in remote corners. The surgeon and the assistant often have to remain in this uncomfortable posture for hours, which can influence the surgeon's concentration level and the surgical outcome.

Key words
- Cranial
- Exoscope
- Microsurgery
- Telescope
- Three-dimensional
- Spinal
- VITOM 3D

Abbreviations and Acronyms
2D: Two-dimensional
3D: Three-dimensional

Department of Neurosurgery, Saarland University Medical Center and Saarland University Faculty of Medicine, Homburg-Saar, Germany

To whom correspondence should be addressed: Joachim M. Oertel, M.D.
[E-mail: oertelj@freenet.de]

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In the past decades, engineers have developed and refined telescopic systems and cameras to improve the visualization and the illumination of the surgical field. For example, high-definition cameras have been introduced that allow a much better visualization of the surgical field than the former standard-definition cameras.[1] Currently with most systems the surgical field is displayed on a movable wide screen, which is positioned on the opposite side of the surgical table. The surgeon and the assistant can maintain a comfortable posture throughout the entire procedure. Usually the focal distance of these telescopic systems is short (i.e., 2–30 mm) and the field of view is limited (i.e., 25 mm). Therefore, these telescopes are referred to as an endoscope because they need to be introduced into the body cavity. Nowadays, endoscopic procedures are accepted widely in cranial and in spinal neurosurgery.[1-4] It has been demonstrated that endoscopic spinal surgery offers the same clinical outcome as with the microscope with the advantage of reduced blood loss, shorter hospital stay, and less demand for postoperative pain medication.[5-8] Nevertheless, endoscopic procedures frequently are criticized for their lack of 3D-visualization and limitations in instrument handling.

An exoscopic telescope has a longer focal distance and wider field of view. Therefore, an exoscopic telescope can be positioned about 200 mm or even farther above the surgical field. It is not bulky, and the surgeon has an unobstructed working space. In the past decade, several authors of different surgical specialties have demonstrated that a 2-dimensional exoscopic procedure can be performed safely and effectively.[9-11] In the present manuscript, the authors report their initial experience using the 3D exoscopic telescope in cranial and spinal neurosurgery.

MATERIAL AND METHODS

Patient Population

Over a span of 8 days, a total of 16 consecutive procedures, including 5 craniotomies, and 11 spinal procedures, were performed with the VITOM-3D exoscope (Karl Storz GmbH, Tuttlingen, Germany). Each procedure was performed by an experienced consultant neurosurgeon and assisted by a resident of the neurosurgical department. Local ethical committee approval, trial registration, and patient consent were not required as patients were treated with approved diagnostic and therapeutic procedures according to generally accepted standards of care.

After each procedure, the consultant and resident had to answer a standardized questionnaire regarding the instrument handling, the intraoperative handling, and positioning of the VITOM-3D exoscope, the intraoperative handling of the IMAGE1 PILOT control unit (Karl Storz GmbH), the adjustment of magnification, the adjustment of focal length, the depth perception, the image quality, the illumination, and the comfort level of the posture during the procedure.

Each of the aforementioned aspects can be rated as follows; grade 1 is considered to be excellent (superior to the operating microscope), grade 2 is considered to be very good (equal to the operating microscope), grade 3 is considered to be good (almost equal to the operating microscope with minor differences), grade 4 is considered to be satisfactory (considerably inferior to the operating microscope but the surgeon is still able to perform the procedure), and grade 5 is considered to be unsatisfactory (so much inferior to the microscope that the procedures had to be stopped and converted to a microsurgical technique).

Furthermore, the intraoperative wearing of polarization glasses were rated as follows: grade 1 is considered to be not noticeable, grade 2 is considered to be not disrupting, and grade 3 is considered to be disrupting. In addition, comments concerning aspects that were not addressed by the questionnaire could be made. Postoperatively, the video recording was analyzed to measure the percentage of operative time at which the exoscope was used.

The authors are aware that reporting the results of the questionnaire is inherently subjective. However, it is essential to collect different personal opinions about a new product to determine whether it offers any benefits or not in comparison to the operating microscope.

Exoscopic Equipment

The IMAGE1 S CONNECT module (Karl Storz GmbH), the IMAGE1 S D3 link module (Karl Storz GmbH), the power LED light source, and the light cable are the necessary basic equipment for exoscopic visualization. The VITOM-3D exoscope (Figure 1) with a 4K sensor system has a focal distance of 200–500 mm. The zoom is infinitely variable and the magnification ranges approximately from ×8 to ×30.

The VERSACRANE holding arm (Karl Storz GmbH) and mobile stand has an integrated quick release coupling KS-LOCK for use with the VITOM-3D Clamping Jaw (Figure 2). The IMAGE1 PILOT control unit (Figure 3) with a 3D wheel is required for control of camera and other systems. The IMAGE1 PILOT is required for the use of VITOM-3D. The IMAGE1 PILOT is connected to a rotation socket and articulation stand (Figure 3). The intraoperative image is displayed on 32″ 3D monitor (Figure 4).

Intraoperative Setup of the VITOM-3D Exoscope in Spinal and Cranial Procedures

In cranial and in spinal procedures, the patient position on the surgical table and fixation of the patient's head via a Mayfield

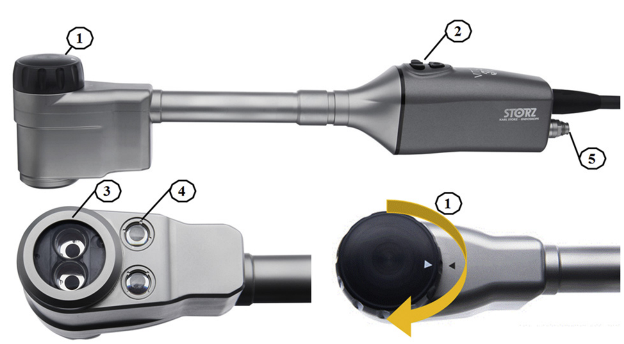

Figure 1. VITOM-3D exoscope. 1, Rotary knob for horizontal image adjustment. 2, Rocker switch to scroll in the menu/functions and control button to open menu/functions. 3, Stereo lens. 4, Light outlet—integrated illumination unit. 5, Connection to fiberoptic light cable.