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## **Supplemental material**

**360° 3D virtual reality operative video for the training of residents in neurosurgery**

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## Supplementary Methods

Detailed explanation of the production of the 360°-3D-VR video

Production of 360°-3D-VR operation videos

We used a 360° camera (Insta360 Pro, Arashi Vision Inc., Shenzhen, China) with an integrated ambisonic microphone for recording the operation in 3D and 6K. Positioning of the 360° camera was challenging since we tried to achieve a close observation and overview at the same time but without interfering with the team's workflow (figure 1). Herefore, we placed the camera close to the center of the OR attached to the anesthesia workstation or to the mount of the surgical lighting system. The 360° camera recorded 6 wide angle videos. Stitching to create one 360° video was performed with Insta360Stitcher. The stereoscopic video of the microscope (Zeiss Kinevo 900) was then integrated into the 360° video onto a virtual screen via Adobe Premiere resulting in a full-length operation video with a 360°-3D view into the OR and the detailed stereoscopic view of the operation microscope (figure 2). It has to be noted that in the aneurysm video operation microscope recording was partly not stereoscopic. After cutting, we used Adobe After Effects to add pictures of neuroimaging, illustrations, overlays, and audio-comments by the chief of the department to provide additional information. The video lengths were 7.5 to 9.5 minutes.

Demonstration of the video

The videos were demonstrated to the participants using HMD during their daily clinical work. For mobility reasons we used a 64GB Oculus-Go-VR headset (Oculus VR, Irvine, California), which does not require an additional laptop or PC. Uploading the 360° videos directly to the headset allowed to watch the videos immediately without requiring internet connection.

Questionnaires

Prior to each video, we used a questionnaire to analyse the resident's experience with VR and their self-assessment of their proficiency of the surgical procedure. To provide an objective evaluation of their surgical experience, we also assessed the number of times the residents had performed or assisted the specific procedure. After watching the videos, the overall quality, different quality items, the feeling of immersion, perceived usefulness and VR-sickness were evaluated using a second questionnaire. The overall quality of the video was rated using German school grades (ranging from 1(very good) to 6(insufficient)). The other quality items were rated with a five-point Likert rating scale (ranging from 1(strong disagreement) to 5(strong agreement); supplementary figure 1 and 2).

Statistics

Descriptive statistics were performed using SPSS Version 24(IBM Corporation, New York, USA), results were presented as mean and range (mean [range]) or median and interquartile range (median [interquartile range]) respectively. We selected three key items to conduct correlation analyses: 1) resolution of the videos as a quality indicator, 2) usefulness assessed by whether this video was suitable preparation for surgery and 3) immersion that the participant evaluated with the feeling of being in the OR. Key items were correlated using the Spearman rank correlation coefficient. The test was 2-sided. The level of statistical significance was defined as  $p < 0.05$ .

**Supplementary Figure 1.** Questionnaire regarding subjective and objective experience with the operation and Virtual Reality (VR) completed by the participants before the 360°-3D-VR video.

<b>Age:</b>
<b>Postgraduate year:</b>
<b>I assisted at this operation ___ times</b> <input type="checkbox"/> < 10 <input type="checkbox"/> 10 - 30 <input type="checkbox"/> >30
<b>I have done this operation partially self-reliant ___ times.</b>
<b>I have done this operation totally self-reliant ___ times.</b>
<b>Please check the number between 1 and 5 that applies best.</b> 1=strong disagreement 5= strong agreement
<b>I feel secure/good prepared for this operation</b> 1      2      3      4      5
<b>I have a lot of experience with this operation</b> 1      2      3      4      5
<b>I have substantial anatomical knowledge in the operation area</b> 1      2      3      4      5
<b>I am satisfied with the technical learning opportunities at my institution</b> 1      2      3      4      5
<b>I am familiar with Virtual Reality (VR)</b> Yes                      No
<b>I used VR before</b> <input type="checkbox"/> never <input type="checkbox"/> <15 min <input type="checkbox"/> <5 h <input type="checkbox"/> >5 h
<b>I can do ___% of the operation self-reliant</b>

**Supplementary Figure 2.** Questionnaire regarding the quality of the 360°-3D-VR video.

<b>Please check the number between 1 and 5 that applies best.</b>					
1=strong disagreement					
5= strong agreement					
<b>This video is a suitable preparation for this operation</b>					
1	2	3	4	5	
<b>I had the feeling to be at the OR</b>					
1	2	3	4	5	
<b>I experienced nausea/dizziness/headaches while watching the video</b>					
1	2	3	4	5	
<b>The video was too short</b>					
1	2	3	4	5	
<b>The video was too long</b>					
1	2	3	4	5	
<b>The important structures were easy to identify</b>					
1	2	3	4	5	
<b>The important steps were described appropriately</b>					
1	2	3	4	5	
<b>The important segments of the operation were included</b>					
1	2	3	4	5	
<b>The resolution was good</b>					
1	2	3	4	5	
<b>The audio was good</b>					
1	2	3	4	5	
<b>I am satisfied with the user interface</b>					
1	2	3	4	5	
<b>I am satisfied with the wearing comfort of the VR headset</b>					
1	2	3	4	5	
<b>The video answered my open questions</b>					
1	2	3	4	5	
<b>Through the video I feel more confident for this particular operation</b>					
1	2	3	4	5	
<b>I think 360° VR operation videos are a good completion of training/teaching</b>					
1	2	3	4	5	
<b>Quality of the video (using German school grades)</b>					
1	2	3	4	5	6