Three-Dimensional Imaging as a Teaching Method in Anterior Circulation Aneurysm Surgery

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Key words
- 3D imaging
- Aneurysm
- Clipping
- Microsurgery
- Surgical anatomy
- Vascular anatomy

Abbreviations and Acronyms
2D: Two-dimensional
3D: Three-dimensional
MCA: Middle cerebral artery

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OBJECTIVE: **Our objective is to present and asses the utility of three-dimensional (3D) intraoperative imaging as a teaching method for anterior circulation aneurysm surgery.**

METHODS: **The senior author's experience in anterior circulation aneurysm surgery during a 28-month period was documented and processed as 3D images and compared with two-dimensional (2D) images. Both 2D and 3D sets of images were created, and, along with a specially designed questionnaire, 30 physicians (15 experienced cerebrovascular surgeons and 15 neurosurgical trainees) were asked to answer the query and state the advantages and disadvantages of both methods.**

RESULTS: **All physicians interviewed agreed that 3D imaging was better than 2D imaging, and that depth perception improved understanding of surgical tactics and anatomical landmarks. The resident/young trainee group seemed to receive more benefit from this than the experienced group. A total of 40% of residents and 20% of the experienced surgeons acknowledged a change in clipping strategy when comparing both sets. 3D imaging improved understanding of the ophthalmic segment in 66.6% of residents and 33.3% of the experienced group.**

CONCLUSION: **Real 3D imaging in anterior circulation aneurysm surgery is an excellent tool to enhance vascular training. Inexperienced trainees seem to benefit greatly from it. This technique might be of use in the future development of new technologies.**

INTRODUCTION

Knowledge of microsurgical anatomy is an essential tool that neurosurgeons use to enhance results and facilitate procedures, making it safer to navigate the brain and its cisterns. There are numerous publications addressing this topic (3, 13, 14, 18). New techniques for didactic use have widened the transmission of such concepts, especially three-dimensional (3D) or stereoscopic imaging (1, 3, 8, 11, 12, 15-17).

A common disadvantage of previous publications is that laboratory anatomy is not the anatomy usually found during surgery in daily practice. It is missing major factors, such as brain turgescence, edema, bleeding, narrowed spaces limited by delicate tissue, and actual pathology (2, 18). It becomes difficult to extrapolate the so-called laboratory anatomy to the operating room, leaving an inexperienced surgeon with only a general anatomic idea of the surroundings of his or her target or the way of access to it, rather than giving the surgeon a full comprehension of the possible obstacles he or she will find. We have completed >2 years of laboratory work in an effort to improve the whole concept of anatomic training and apply 3D techniques to actual patients. In this article, we address the complex and specific microsurgical anatomy of anterior circulation aneurysm surgery.

The 3D viewing of aneurysm surgery adds a sense of depth and improves understanding of complex structural relations, becoming valuable, unpublished, and original didactic material. The aim of this study is to assess the actual benefit of real 3D imaging applied to real microsurgical anatomy as a superior and effective tool in training neurosurgeons. We compare 2D and 3D images and recognize differences and improvements from one method to another.

METHODS

In the past 66 months, one of the authors (P.A.R) has performed 128 anterior circulation aneurysm surgeries (in some patients with multiple aneurysms). In 65% of the cases, 3D images were obtained of the entire procedure—from patient positioning to wound closure. Macroscopic images were obtained by a Nikkon Reflex camera supplemented with a 2.8-mm, 105-mm microlens, with the aid of a Jaspers sliding bar (Jasper Engineering, Medina, Minneapolis, Minnesota, USA) attached to a Manfrotto tripod (Manfrotto, Cassola, Italy). Each shot consisted of a set of paired images with the same target at the

Table 1. Questionnaire Completed by Physicians

Were 3D images easily viewable?	Yes	No
Did it improve the sense of depth compared with the 2D images?	Yes	No
Did any structure appear different between 2D and 3D images?	Yes	No
Was any 2D structure misinterpreted after viewing it in 3D images?	Yes	No
Did clipping strategy change when comparing both methods?	Yes	No
Did the ICA and optic nerve appear in different depths in 3D images?	Yes	No
Were the ophthalmic segment and neighboring structures (optic nerve, anterior clinoid process) better understood in 3D images?	Yes	No
Did the dissection of the lateral aspect of the sylvian fissure become easier to understand compared with 2D images?	Yes	No
When the sylvian fissure was fully opened and dissected, could you recognize >3 depth levels in 3D images?	Yes	No
Did any vascular structure change its orientation compared with 3D images?	Yes	No
Was the orientation of the different segments of the MCA better understood in 3D images?	Yes	No
Was the orientation of the different segments of the ACA better understood in 3D images?	Yes	No

ICA, internal carotid artery; MCA, middle cerebral artery; ACA, anterior cerebral artery.

same distance with a 15-degree angle incidence. Microscopic images were obtained by applying 2 Nikon Reflex cameras (Nikon, Chiyoda, Tokyo, Japan) each attached to its own image divisor on both sides of the operating microscope. This way, paired images with a 15-degree difference of incidence were obtained. Images were processed with special software, Callipygian 3D (Callipygian freeware, created by Robert A. Swirsky). Data were processed by a 3D program. We created 2 different 3D presentations, one polarized and one using an anaglyphic system. Special 3D glasses are needed to fuse images and obtain the stereoscopic view. 3D images are paired with 2D images to compare both. Although the visual experience contains obvious interpersonal differences, 15 experienced neurosurgeons (with >10 years of experience) and 15 senior residents were given both sets of images and were asked to compare and note advantages and disadvantages. The participants (physicians and senior residents) were selected from 3 different institutions that are validated by the Argentinian Ministry of Health. Interviewed physicians also answered a simple questionnaire (Table 1) to quantify differences. All physicians had access to the entire set of images for each case. However, because of printing and editorial restrictions, only some of the pictures are shown in this article.

Illustrative Cases

The cases presented are illustrative, and it is not the aim of this study to analyze surgical techniques or results. Only 5 representative cases were selected for the participants. Cases are shown so that the reader can appreciate all different steps of aneurysm surgery in 3D images, making this technique a novel tool for learning and communicating with fellow neurosurgery trainees. 2D images are paired to compare both methods.

The senior author uses the pterional approach for most anterior circulation

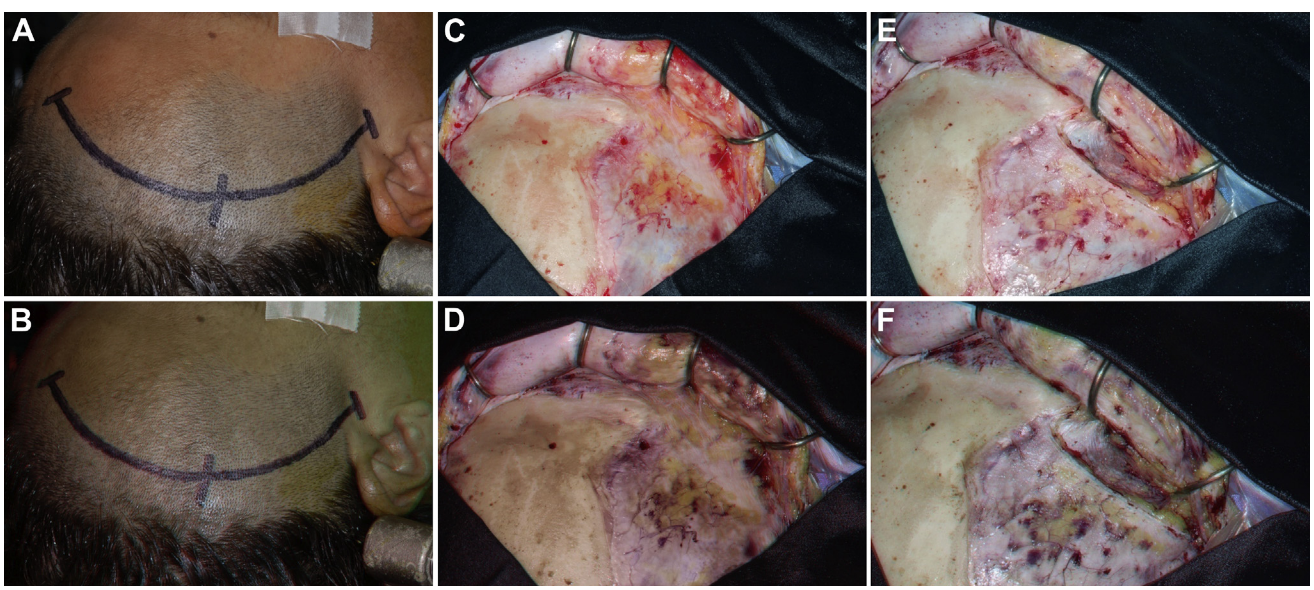

Figure 1. Right pterional approach for anterior communicating aneurysm. (**A**) The position and the incision for the pterional approach can be seen. (**B**) Same picture in 3D. (**C**) The flap includes the skin and the periosteal. The fat tissue between the layers of the temporal fascia can be observed. (**D**) Same picture in 3D. (**E**) Interfascial dissection. The deep layer of the temporal fascia can be seen. (**F**) Same picture in 3D.