Three-Dimensional Imaging in Neurosurgical Research and Education

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OBJECTIVE: **We describe the setup and use of different 3-dimensional (3-D) recording modalities (macroscopic, endoscopic, and microsurgical) in our laboratory and operating room and discuss their implications in neurosurgical research and didactics. We also highlight the utility of 3-D images in providing depth perception and discernment of structures compared with 2-dimensional (2-D) images.**

METHODS: **The technical details for equipment and laboratory setup for obtaining 3-D images were described. The stereoscopic pair of images was obtained using a modified "shoot-shift-shoot" method and later converged to a 3-D image. For microsurgical procedures, 3-D images were obtained using an integrated 3-D video camera coupled to the surgical microscope in both the laboratory and the operating room. Illustrative cases were used to compare 2-D and 3-D images.**

RESULTS: **Side-by-side comparisons of 2-D and 3-D images obtained using all modalities revealed that 3-D imaging was superior to 2-D imaging in providing depth perception and structure identification.**

CONCLUSIONS: **This is the first report in the literature of the methodology for obtaining 3-D endoscopic endonasal images using the 2-D endoscope. The use of 3-D imaging is invaluable in neurosurgical research and education, as it provides immediate depth perception (third dimension), allowing efficient understanding of key spatial relationships. Integration of 3-D imaging in neurosurgical residency programs may increase learning efficiency and shorten learning curves. However, use of 3-D imaging should not replace direct hands-on practice.**

INTRODUCTION

Stereopsis, or depth perception, is the phenomenon whereby 2 slightly different images of an object perceived by each eye are superimposed by the brain to produce a 3-dimensional (3-D) image. Stereoscopic vision is an intrinsic part of our perception of the world and forms the basis for "prehension," which is the ability to reach and grasp objects based on visual guidance.[1] In this article, the terms "stereoscopic" and "3-dimensional" are used interchangeably.

A cornerstone of surgical training is knowledge of the anatomy of the region of interest. Traditionally, anatomy was learned using illustrations depicted in textbooks and observation of procedures in the operating room (OR). Technologic advancement has ushered in a paradigm shift in the world of surgical didactics, with 3-D imaging emerging as a superior tool in neurosurgical education because it enables understanding of key spatial relationships between critical structures.[2-5]

Neurosurgical residency and fellowship training requires learning an increasing number of complex procedures in a short time. There is limited hands-on surgical experience during surgical procedures and via cadaveric workshops. Therefore, 3-D imaging for education and training has become invaluable in fields such as microneurosurgery and endoscopic skull base surgery, where the diminutive size of the structures and their close

Key words
- Education
- Endoscopic endonasal
- Neurosurgery
- Photography
- Stereoscopic
- Three-dimensional (3-D)

Abbreviations and Acronyms
2-D: 2-Dimensional
3-D: 3-Dimensional
CN: Cranial nerve
OR: Operating room
VA: Vertebral artery

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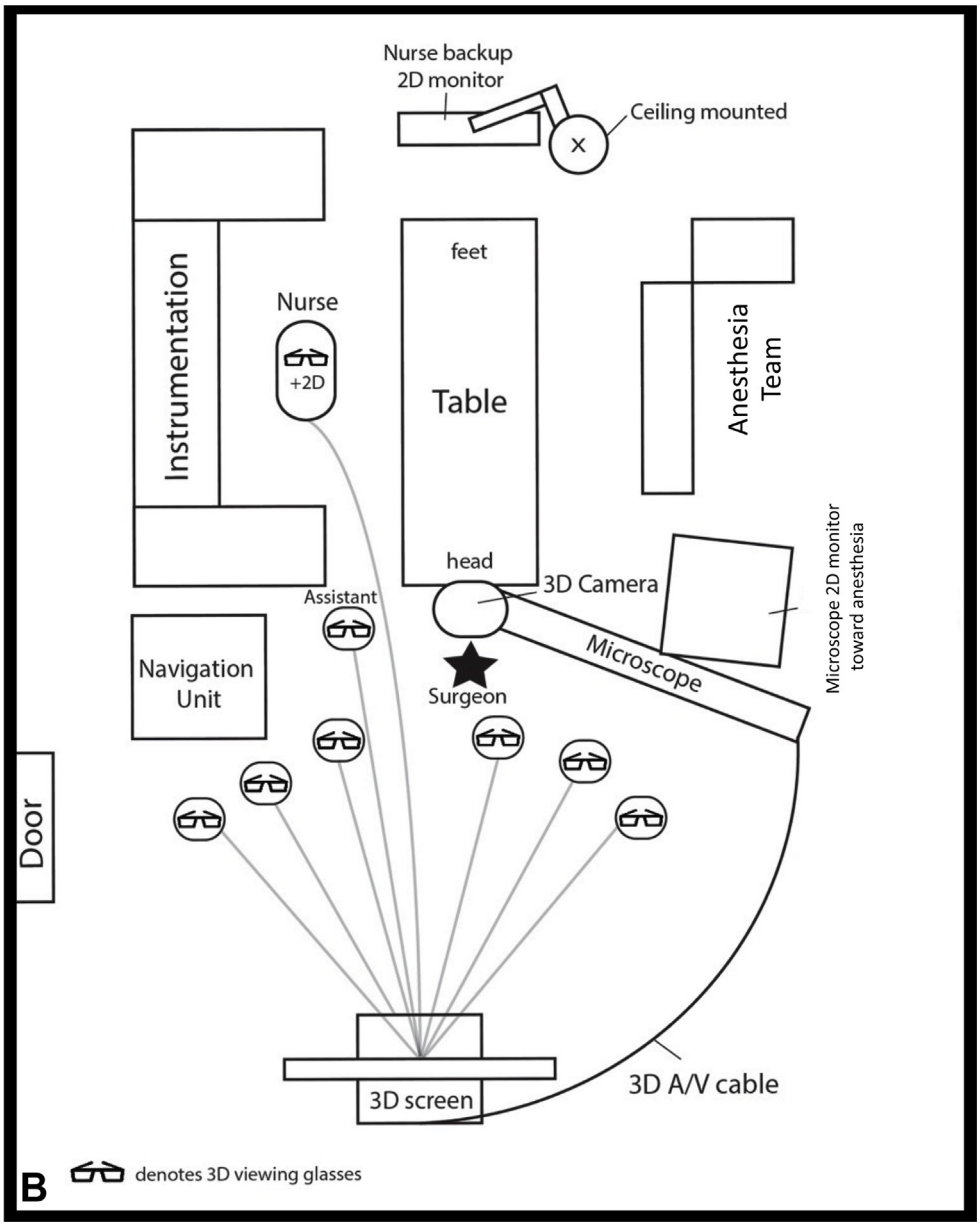
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