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Original Article

A simple technique for generating 3D endoscopic images

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ABSTRACT

Background: Most neurosurgical photographs are limited to two-dimensional (2D), in this sense, most teaching and learning of neuroanatomical structures occur without an appreciation of depth. The objective of this article is to describe a simple technique for obtaining right and left 2D endoscopic images with manual angulation of the optic.

Methods: The implementation of a three-dimensional (3D) endoscopic image technique is reported. We first describe the background and core principles related to the methods employed. Photographs are taken demonstrating the principles and also during an endoscopic endonasal approach, illustrating the technique. Later, we divide our process into two sections containing explanations, illustrations, and descriptions.

Results: The results of taking a photograph with an endoscope and its assembly to a 3D image has been divided into two parts: Photo acquisition and image processing.

Conclusion: We conclude that the proposed method is successful in producing 3D endoscopic images.

Keywords: Endoscopy, Laboratory, Three-dimensional teaching

INTRODUCTION

The field of neurosurgery has restricted options for active experimentation, and for most neurosurgeons who are visual learners, most photographs are limited to two-dimensional (2D). In this sense, most teaching and learning of neuroanatomical structures occur without an appreciation of depth. However, this trend has recently shifted with display and digital photography advancements.[1,2] This is also observed with the recent trend in virtual reality (VR)/augmented reality (AR) technology, providing a three-dimensional (3D) sense of the related landscape. In this study, we have focused on stereoscopic photography due to its widespread use and accessibility.

Stereopsis, more commonly known as 3D depth perception, is the ability to judge the distance of an objects position in space. Comprehension of the spatial relationship of an object is enhanced with depth perception, allowing engagement and interaction with the world around us. Stereopsis photography aims to present horizontal disparity with visual cues to the human observer, perceiving the impression of depth from discrepancy. According to this principle, depth awareness is formed by slight differences in images of each eye, referred to as binocular disparities. This disparity processed in the visual cortex creates depth perception.[3-5]

The objective of this article is to describe a simple technique for obtaining right and left 2D endoscopic images with manual angulation of the optic. In addition, subsequent processing of these two images for a 3D polarized or stereoscopic projection is described. We offer a modified version for the use of endoscopes, which can be fundamentally practiced in any center without the need for supplemental equipment.

MATERIALS AND METHODS

A cadaveric head fixed with formalin and injected with colored latex and a skull was used to underline the surgical anatomy of an endoscopic endonasal approach. Dissections were performed and pictures were taken with an endoscope utilizing a 0° lens (Karl Storz). Storage and editing of images were performed on a MacBook Pro (Apple, Inc). PowerPoint software (Microsoft, Redmond, WA) was utilized for processing and alignment of photos. The images obtained were viewed wearing passive 3D glasses on a 65 inch 3D TV with 3840 × 2160 resolution (LG, South Korea), connected by an high-definition multimedia interface (HDMI) cable to the MacBook Pro.

RESULTS

The results of taking a photograph with an endoscope and its assembly to a 3D image have been divided into two parts: photo acquisition and image processing.

1st stage: Photo acquisition

We prefer 0° endoscopes for taking photographs. Angulation must be kept at the 6 or 12 o'clock positions when positioned in the cadaveric specimen. Otherwise, from an endoscopic monitor point of view, when taking a photograph of the contralateral side, it will rotate the images clock or counterclockwise resulting in substandard images during postprocessing. The distance from the tip of the endoscope to the site photographed is close, and therefore, the horizontal direction must be extremely precise. Modifying the distance between shots must be avoided due to the possibility of altering the size of near versus far objects, also resulting in poor quality of final 3D images.

It is essential to place a thread passing horizontally and through the midline vertically on the endoscopic screen, dividing the image equally into four squares [Figure 1a]. This will allow us to maintain the horizontal plane. We demonstrate this by first focusing on the area to be photographed. We must verify adequate lighting and balanced saturation of the area. The first picture taken will be the right image [Figure 1b]. Afterward, while maintaining the same vertical, horizontal, and depth position, we aim the endoscope to the left and take the left photo. A bimanual technique is required for maintaining the endoscopic lens in the horizontal plane while rotating right and left. While viewing the guide lines on the monitor screen, the left hand holds the endoscope firmly at the entrance of the nostrils or on the surface of the skull base and the right hand performs lateral movements in the horizontal plane, avoiding left or right rotations.

2nd stage: 3D processing

The dimensions of the PowerPoint slide utilized are 16:9 (widescreen), where we begin by selecting the "insert" tab and then "guides" for the four reference lines to appear for editing.

At this point, we have two photographs for the construction of a 3D image; it is useful to rename the image files "right" and "left." When placing the guides, a horizontal and vertical line is drawn in the center of the slide, creating two equal halves (right and left). In addition, another vertical line is drawn automatically in the center of each half, which is helpful for centering the images. We import the photos to the slide, dragging each image to its corresponding side from the lateral margins [Figure 2a]. If projected onto a 3D television screen at this point, 3D visualization cannot be achieved since they are not centered [Figure 2b]. To center the images, we must select a point of reference within the center of the dissection. We chose the lateral border of the basilar artery for this purpose [Figure 2c], moving the image left and right as indicated by the red arrows and shown in the supplemental video [Video 1]. Once centering is completed, depth of the dissection and perception of three-dimensionality can be appreciated, although the edges remain uncentered and subsequent modifications are required [Figure 2d]. For this, we create two semicircles from the insert function, clicking "shapes" and selecting a circle with a border. The two semicircles are centered in the middle of each slide and will be pasted over the images to cover the previously uncentered peripheral edges [Figures 2e and f].

Over a 1-month period, endoscopic cadaveric dissections in the sagittal and coronal planes were performed and 3D photographs were taken with the endoscope in accordance to the previously presented procedure. Subsequently, they were aligned with PowerPoint, as described. In all cases, high quality images were obtained for 3D visualization.

Video Link: https://drive.google.com/file/d/1J8El4eCqP8y9xNZX9IcbWCjfJi0XUZXP/view?usp=sharing

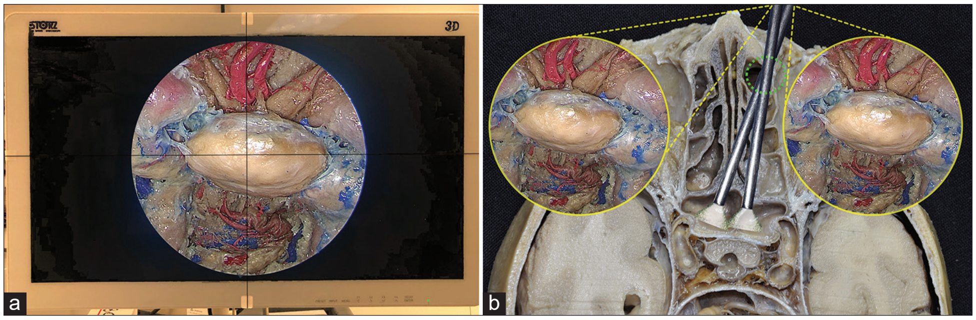


Figure 1: Photo acquisition (a) View of endoscopic monitor with placement of vertical and horizontal threads over the center, dividing the image int o 4 squares. (b) Endoscopic view of the Sellar region displaying left and right photo capturing. In yellow circles the images obtained from the right and left are shown. The green circle shows the point of movement of the endoscope to obtain the two images.

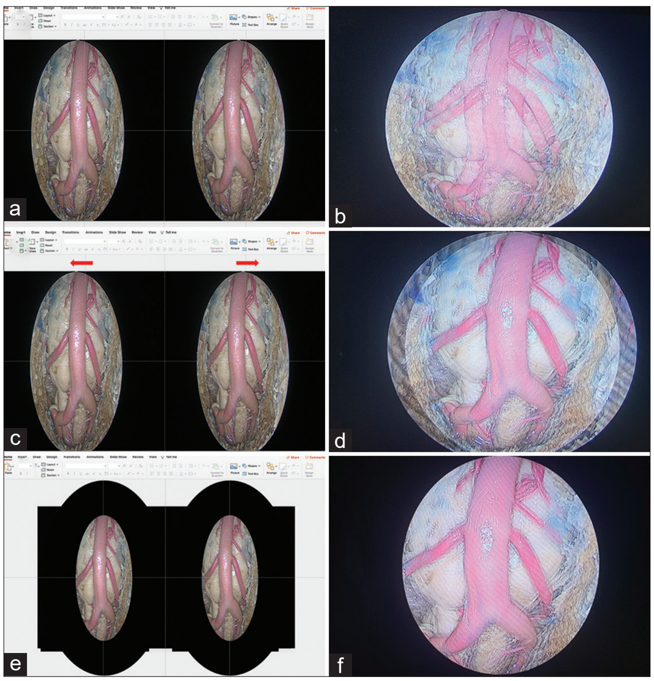
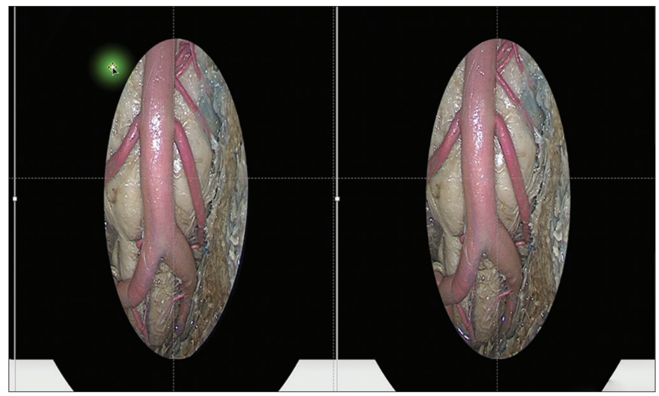


Figure 2: 3D Processing with PowerPoint software and projection onto a 3D television screen (a)-Import and proper placement of left and right photos into the slide. (b) Uncentered and misaligned view of images. (c) Alignment of photos with selection of the lateral border of the basilar artery as our point of reference. (d) Depth of dissection and 3D perception is obtained with remaining uncentered edges to be modified. (e) Creation of two semicircles centered in the middle of each slide and pasted over the images correcting the previously uncentered peripheral edges. (f) Finalized view of 3D image.

DISCUSSION

Generation of 3D endoscopic images is a challenging task, with many researchers approaching the problem from different angles. To the best of our knowledge, there is only one publication utilizing stereoscopic principles to obtain 3D endoscopic images.[3] In this study, Martins *et al.* described a similar "shoot and shift" method.[8] However, contrarily to our method, the endoscope was fixated and the head was repositioned continuously. This method can be cumbersome and potentially not feasible for implementation within the operating room. We believe, our approach is conceivably more practical and equal in results. Others have approached this with other methods such as those derived from computational stereo with endoscopic videos.[2,4,6,7] Furthermore, recent advancements in display and camera technology have led to 3D endoscopic cameras. Stereoscopic images can also be obtained with these but can be challenging to operate. However, these systems are not readily available in most neurosurgical centers and long-term use of can lead to headache, fatigue, and eye strain.[5,8,9]



Video 1: Supplemental video.

We recommend organizing images into subfolders so each image pair can have a dedicated folder, preventing a mix of prints. If rotational errors or color differences are encountered, Photoshop software can be used for correction, although we aim for this to be unnecessary. This program can also aid in image padding and cropping to specific aspect ratios, that is, 4:3 16:9, for various display systems. It is prudent to create various aspect ratios so they can be readily available for use in multiple settings.

3D image construction requires the placement of at least two similar images within the same area of focus.

Emphasis should be placed on acquiring pictures based on the stereopsis principle. Stereoscopic photography has been traditionally accomplished by two approaches: the cha-cha/shoot and shift method and the toe-in/hyperstereo technique.[9,10] The first can be carried out by two symmetric camera lenses. Stereo cameras (a camera with two lenses) or two synchronized cameras are utilized to achieve an asymmetric field of view. However, a single camera with one lens (as described in our method) can achieve similar results and is more economical in comparison to those utilizing matched lenses (with identical focal lengths, apertures, magnifications, image planes, and distortions).[10,11] The camera captures a photo and is moved horizontally while maintaining the vertical plane to capture another subsequently. The resulting images are layered together and the nonoverlapping bands are removed [Figure 1a].

An important concept that should be mentioned is the "parallax error," which is the apparent displacement of an object when seen from two different sources.[2] This can be explained with a simple example: An object held near our eyes will shift depending on which eye we utilize to observe the object, resulting in poor depth perception.

The illusion of depth is accomplished by displaying different portions of the images to our eyes, allowing the visual cortex to blend both images back together. Therefore, the main objective is to center the 2 points of interest on both halves of the PowerPoint slide to create a mirror image of one another. Arrangement of the photos will depend on the type of projection system utilized, that is, 3D TV, Matrox, etc. In our case, we project our images on a 3D TV screen. We later place the right photograph on the right half of the slide and the left image on the left half [Figure 2a]. It is essential to clarify that when projecting on a 3D TV, the images must be compressed in half in the horizontal plane.[1,2,11]

The "guides and gridlines" option in the view section of PowerPoint is utilized for dividing the screen into equal parts by creating vertical and horizontal lines. The ruler at the top of the screen can aid in dividing these parts. Posteriorly, we center the two images by dragging the right picture to the right and the left picture to the left, until both images are in the center of the intersection between the vertical and horizontal lines at each half of the slide [Figure 2c]. This is equivalent to the SM demonstrated previously. When projecting the image of the PowerPoint slide to the TV screen, the center of the 3D image is obtained. However, the periphery of the image tends to be misaligned due to the horizontal movement [Figure 2d]. This is corrected by creating two hollow circles to cover the periphery of both images. The color selected should preferably be black [Figure 2e]. During the horizontal movement of the images on PowerPoint, movements made with the arrow keys for the left and right images were equal. Editing is now complete with proper visualization our 3D image [Figure 2f].

CONCLUSION

3D endoscopic anatomical images can be produced through this method, utilizing the inherent capabilities of presentation programs such as PowerPoint. Images created in this manner may aid in a more comprehensive understanding of structure orientation relative to one another and ease the learning curve for the use of endoscopy in neurosurgery.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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