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Evaluation of the usability of image projecting augmented reality technique: An experimental study on fresh cadaveric cattle brain

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ABSTRACT

Aims: Detection of the lesion location seated deep in the brain parenchyma and major neuroanatomical sites is an extremely important issue in the practice of neurosurgery. Some type of neurosurgical clinical cranial navigation systems is available in the market. Before using this navigation system in an operation, it needs some preparation period including obtaining of some specific neuro-radiological images and software installation with complex computer programs. In this experimental study, it was evaluated that usage of projecting augmented reality technique simply produced from external image projector in the localization and finding of the frontal horn of the lateral ventricle in the fresh cadaveric uncovered cattle brain.

Methods: Fresh cadaveric cattle brains equally selected in terms of size and weight were used for this experimental study. Eleven brains were axially sliced from a superior to inferior direction to obtain of master JPEG image of each section. The original magnification was kept by using a ruler placed on the right lateral of the images. All images were transferred into the computer. The axially sectioned specimen demo images' including the lateral ventricle section was projected over the integrated specimens over the superior face. A puncturing needle was inserted from surface to the frontal horn of the lateral ventricle of the fresh cadaveric cattle brain according to the guidance of augmented reality images. Coronal sectioning was performed at the level of puncturing needle-inserting site in order to check the correct location of the needle tip.

Results: Twenty-two fresh cadaveric cow brains were used in this experimental study. The brains were grouped into two categories as image generation (n=11) (Group I) and intervention (n=11) (Group II). In two (18. 18%) of the experimental model, the location of the needle was found bad. Average results were achieved in six (54. 54%) of the fresh cadaveric cow brains. In the remaining three (27. 28%) of the cow brains, the location of the needle tip was found in good location. The successful results were obtained in nine (81. 82%) of the experimental materials using image projecting augmented reality technique in fresh cadaveric cow brains.

Conclusion: In conclusion, the augmented reality procedure may enhance the ability of locating lesion and the detection of neuroanatomical sites. There are different types of augmented reality procedures which can be used for neurosurgical procedures. Some of augmented reality procedures are complicated, difficult and time requiring procedure before ready to be uses in the operating room. The usage of simple and fast augmented reality procedure created with projecting of the images over the brain surface was evaluated in this experimental study. The results of this study revealed that the image projecting augmented reality procedure is a safe, fast, and simple procedure. It also shows that the procedure provides the accurate location of the preoperatively selected target seated within the brain parenchyma. This procedure may be used in the brain operations in the location of the lesion after more detailed and further investigations.

Key words: *Brain surgery, neurosurgical location of the lesion, augmented reality, neuro-navigation*

Introduction

Accurate location of the target lesion and its relationship with surrounding neurovascular anatomical structures is extremely important in the neurosurgical intervention of the brain [1-3]. Planning of the skin incision, craniotomy site and the size of the bone opening may be performed in accordance with the data obtained from the preoperative neuro-radiological images [4-6].

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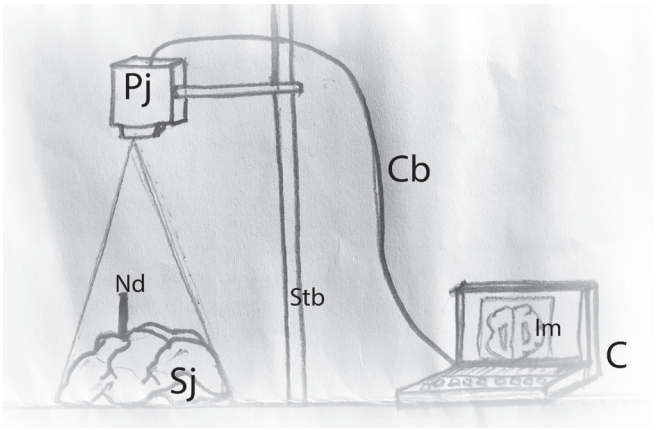

Figure 1. In this figure, the experimental procedure was schematized. The virtual image was projected over the specimen to localize the frontal horn of the lateral ventricle before inserting a needle. (Pj: projector, Nd: needle, Sj: subject, Stb: stabilizer, Cb: cable, Im: image, C: computer).

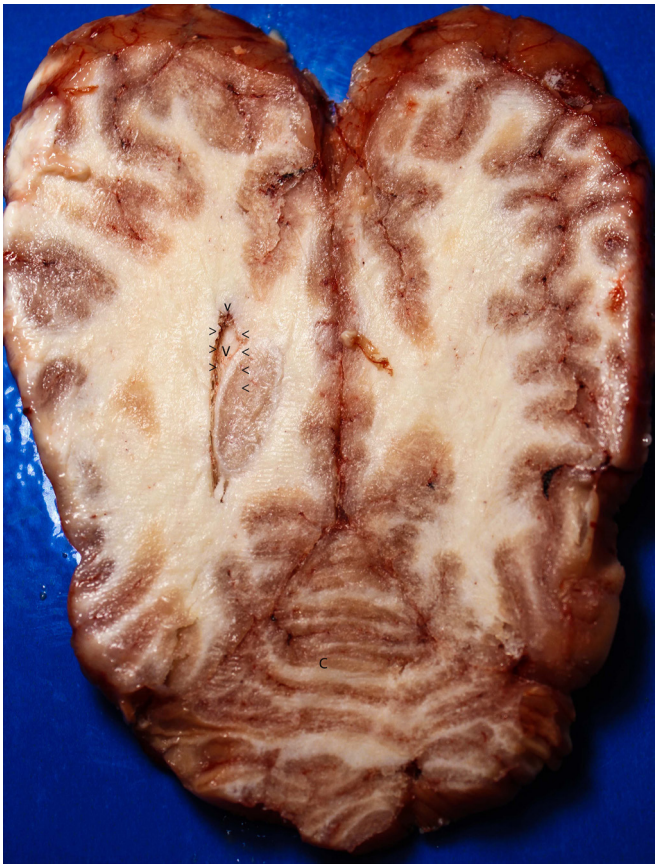

Figure 2. This figure shows axially sectioned brain image. This image was transferred into computer for projection over the experimental subjects during the punctioning process to the frontal horn of the lateral ventricle (V: verntricular horn, arrows shows the border of the frontal horn).

Neuro-radiological images performed from the direction of axial, coronal and sagittal planes may be evaluated in the image processing system of the computer to project the patients' head.

Augmented reality refers to the system that attempts to merge computer graphics and real imagery into a single, coherent perception of an anatomical site [7]. In this system, the graphical images are obtained from the neuro-radiological images (magnetic resonance imaging and computerized tomography of the head) just performed before the operation. Generally these images are obtained axial, coronal and sagittal planes according to Cartesian coordinate system.

The preoperative neuro-radiological images can be transferred into the computer memory to use as the source of augmented reality graphics [4-6]. The graphic images including the target of the pathology can be projected by using a simple, small and suitable projection machine to the patients' head in the hibrite model of the virtual and real imaging in a single place. The real magnification of the imaginary graphics should be arranged according to real anatomic head size of the object. The imaginary graphic planes also should be projected over the head surface depends on the neuro-radiological image obtaining planes.

In this experimental study, the location of the lateral ventricle frontal horn was superficially detected on the brain surface by using projection type augmented reality procedure. For this purpose, it was planned an experimental study in the evaluation of the accuracy of the system by using fresh cadaveric cattle brain. On the other hand, the feasibility of the using of this system in the clinical microsurgical practice was also evaluated. Experimental findings, difficulties, practical methods and suggestions were discussed under the light of the literature.

Materials and Methods

Experimental micro-neurosurgical activities in this study were performed under the operating microscope. Figure 1 shows the technique of image projection. Figure 2 shows the images for projection. Figure 3 shows the experimental procedure. Figure 4 shows the location of the needle. Fresh cadaveric cow brains were used for this experimental study. The fresh cadaveric cow brains were grouped into two categories as image generation (n=11) (Group I) and intervention (n=11) (Group II).

The cadaveric cow brains in Group I were sliced with the equal thickness (5 millimeters) starting from superior to inferior direction for generating of the axial sections. Each side of the axial sections was photographed for converting into the digital JPEG images.

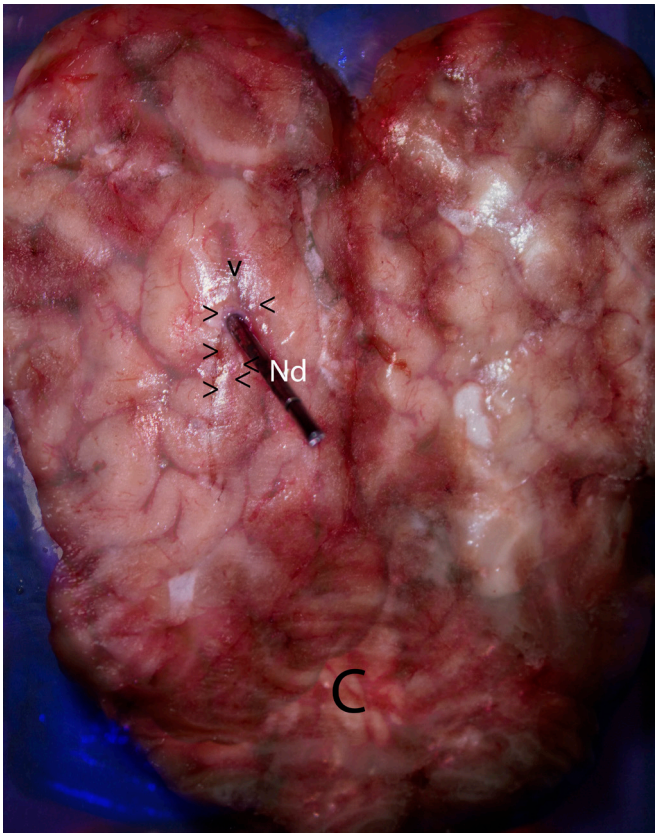

Figure 3. This figure shows the experimental procedure. In this figure the image of the sectioned brain was projected over the brain surface (Nd: needle).

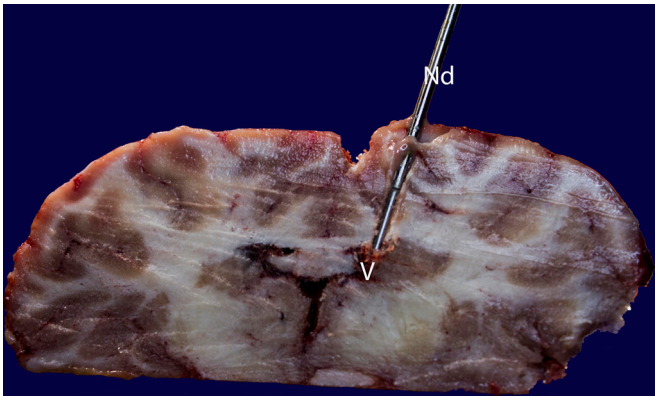

Figure 4. Coronally sectioned brain image along the needle shows the correct location of the needle (Nd: needle, V: ventricle).

All digital images were transferred into the computer. The original magnification was kept by using a ruler placed on the right lateral of the images.

The fresh cadaveric cow brains in Group II were reserved as interventional brains. The target was selected as the frontal horn of the right lateral ventricle. The size of the specimens in Group I were selected based on the size of subjects in Group II. The augmented reality images were selected according to the size of the fresh cadaveric cow brains in Group II. This selected augmented reality image of axially sectioned specimen including the lateral ventricle section was projected overlay the integrated specimens over the superior face using the image projector.

A puncturing needle was inserted from superficial projection to the frontal horn of the lateral ventricle of the fresh cadaveric cattle brain according to guidance of augmented reality images. Coronal sectioning was performed at the level of puncturing needle-inserting site to check the correct location of the needle tip. The success of the experimental process for micro-neurosurgical correct targeting was evaluated within three groups as bad, average, and good.

Results

Twenty-two fresh cadaveric cow brains were used in this experimental study. These specimens were equally divided into two groups as image generation (Group I, n=11) and interventional (Group II, n=11). The weight, height, and length of the photographic images obtained from the specimens in Group I were adjusted based on the same parameters of Group II. The augmented reality images in Group I were used for paired specimens depending on the mentioned parameters. The surgical procedure was performed according to create the virtual target on the brain surface of the fresh cadaveric cow brain using an image projector (LG, PH300-GL, 19 Volt, 2. 1 Ampere, Korea).

Coronal sectioning of the cow brains was performed through the level of puncturing needle-inserting site to check the destination of the needle tip for the evaluation of the correct location. In two (18. 18%) of the experimental model, the location of the needle was found bad. Average results were achieved in six (54. 54%) of the fresh cadaveric cow brains. In remaining three (27. 28%) of the cow brains, the location of the needle tip was found in good location.

The successful results were obtained in nine (average and good) (81. 82%) of the experimental materials using image projecting augmented reality technique in fresh cadaveric cow brains.

Discussion

This study primarily aimed to evaluate the augmented reality technique in an experimental study. For this purpose, a two-step experimental study model was established in fresh cadaveric cow brains. The first stage of the created experimental model was the image gen-

eration step, which used same size cow brains. The second stage of the experiment was the operation period. In the second stage, the projecting augmented reality source was the images produced in the first stage. The first stage can be accepted as the preoperative neuroradiological period of the clinical situation. The secondary aim of this study was to create an experimental model for the augmented reality procedures.

An appropriate and successful model should have some similarities of the represented model.

On the other hand, another important issue is the easily obtainable and cheap properties with the short and easy preparation period of the model before using the operating microscope, without including any complicated steps such as formalin fixation and silicon filling into the vascular structures. When taking the ethical issues into consideration, live models, in addition to the above mentioned disadvantages, compromise some problematic limitations in experimental practice. There can be some advantages when we evaluate the cow brain under the light of the parameters detailed above.

Since the fresh cadaveric cow brain is not a living model, there is no need for local ethical committee permission. In addition to ethical convenience, the fresh cadaveric cow brains having the intense similarities with the human brain were used in this study. When we think of all these features together, the cow brain can be regarded as a suitable model for this study.

There are a few differences between the human and cow brain. The human brain is larger in size and shape when compared to the cow's brain. Cow brains do not have as many gyrus and sulcus when compared to human brains. The adult human brain weighs about 1200 to 1500 grams and is about 10 to 20 centimeters long. A cow's brain is elongated in shape, whereas a human brain is rounded. The human brain is not only larger, but also heavier than a cow's brain, because it is only 400-600 grams compared to the human brain. There are other differences in human and cow brains but almost all mammals brain are similar.

Except some anatomical differences, the location of the interhemisphaeric sulcus and the ventricles have the same characteristic feature between human and cow brain.

Augmented reality can be described as live direct or indirect view of a physical real-world environment whose elements are augmented by computer generated sensory input such as sound, video, graphics, or GPS data [1,2,4,5]. One's current perception of reality can be enhanced by the functions of this technology. Augmented reality is related to a more general concept called mediated reality, in which a computer modifies a view of reality [4,5]. The term of virtual reality is methodologically different from the term of augmented reality. Virtual reality completely replaces the real world with a simulated one [4-7]. Augmentation is conventionally in real time and in semantic context with environmental elements. With the help of advanced augmented reality procedure the information about the surrounding real world of the user becomes interactive and digitally manipulated. Info about the environment and objects are overlaid on the real world.

Hardware components for augmented reality are mobile modern computing devices and optical projecting systems. Software includes JPEC image reader.

In this experimental study, the master images were obtained regularly sectioned brain slices. Every sequence was photographed regularly. These images were transferred from the memory of camera to the hard disc of the mobile computer. All master JPEG images are converted into the digital images to make suitable for projecting over the cow brains before starting the surgical procedure. The ruler was apparent on the right side of the images for adjusting the magnification.

This experimental study revealed that the success of the image projecting augmented reality technique in the fresh cadaveric cow brains in terms of the fine localization of the predetermined target deep inside the brain was found as 18.18% of the experimental materials. In these materials, 54.54% of them were found as average success. On the other hand, 27.28% of the process was resulted with the good success rates with good location of the needle tip.

Conclusion

The procedure of augmented reality with optical projection of the graphical images of the target may enhance the ability of locating the target and its relationship with surrounding neuroanatomical structure. It is also helpful in the comprehension of the lesion seated deep inside the brain parenchyma. Graphic image projecting system

for augmented reality may be used in the clinical practice. The usability and reliability of the procedure was shown in this experimental study. More detailed and further investigation is necessary to improve the procedure.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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