Case Report

Calvarial Freehand Entry Point Localization using Virtual Orbito-Meatal (OM) Computerized Tomography (CT) Study Plane as Reference: A Case Report

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Background: *Neuronavigation is based on the stereotactic principle which involves applying coordinate values to points in a reference frame. In situations where a navigation system is unaffordable but digital image data in the hospital's data bank are available, a desired entry point location can be calculated by measuring the coordinate values in the image processing software on the computer's intranet. In this report, a virtual orbito-meatal (OM) image study plane was used as the reference for localization of entry point instead of the actual study plane which can vary in angle.*

Objective: *The present study proposes a new technique to localize the desired entry point on the calvarium using a virtual (OM) study plane as reference. Herein, the technique is described, and the results in the operative theatre, which were confirmed by neuronavigation, are presented as a case report.*

Material and Method: *The author reported a case of left fronto-temporal intra-parenchymal brain tumor in a 56-year-old male who presented with headache, nausea, vomiting, disorientation, dysphasia and right side motor weakness. The patient underwent uneventful craniotomy and tumor biopsy, and the pathologic report revealed lymphoma. In the operative room, freehand entry point localization was performed using virtual OM plane as the reference, and outcomes were confirmed by a navigation system before the operation was started.*

Results: *In the present study, the desired entry point location was confirmed by a navigation system with good clinical results. In cases of intra-parenchymal lesions like this one, a navigation system is necessary until the overall operation is finished.*

Conclusion: *A virtual OM study plane can be used as the reference for localizing the desired entry point, but the procedure needs to be conducted on a computer with capable image processing software, which is usually bundled with the computerized tomography (CT) machine. A long-term study entailing neuronavigation supervision should be conducted in the future.*

Keywords: *Entry point, Calvarium, Brain tumor, Orbito-meatal, Image processing, Stereotactic, Neuronavigation*

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In modern neurosurgical operations, neuronavigation systems have a role to play in helping the surgeon to complete pre-operative localization of intracranial lesions, plan entry point and route of approach, and maximize the safety margin of the overall surgical operation[1-4]. The initial purchase price and subsequent maintenance costs of this technology, however, are quite high even when its excellent cost-effective outcomes are taken into account, and this often makes it unaffordable, especially in developing countries which have low budget resources[4]. Consequently, only a few tertiary care hospital centers can afford to have this technology in their operative rooms. Neuronavigation systems use the principle of linking coordinates between digital image data, instruments and patient's anatomy on points in a transformation matrix[3]. In the digital era, radiological image investigations in various modalities are recorded in digital format on the hospital data bank server (*e.g.* the picture archiving and communication system, PACS), and the surgeon can use image viewing software on the computer's intranet, or on CDs containing CT study images from PACS, to do simple editing or measure distances in the image in any view (axial, sagittal or coronal) with accurate scale of proportion on the monitor. In the stereotactic technique, a desired entry point location for convexity brain lesions can be calculated by measuring the coordinate values on three axes (X, Y, Z) in the computer. Previous studies have illustrated localization techniques employing the orbito-meatal (OM) CT study plane as reference[5-9]. Regardless of which CT study plane is used, the present study proposes the freehand technique, using a virtual

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OM plane created on the computer monitor as the reference, in order to localize the desired entry point on the patient's calvarium, after which the outcome should be confirmed by a navigation system. In situations where this technology is unavailable, applying a stereotactic freehand technique is reasonable in terms of scientific means by using digital images for localization to avoid unnecessary extra costs; however, long-term practice in conjunction with a navigation system should be conducted until consistently good outcomes are achieved.

Case Report

A 56-year-old male patient presented with headache, nausea, vomiting, disorientation, dysphasia and right side motor weakness. CT and MRI brain revealed a large lobulated homogenous enhanced intra-parenchymal mass in the left fronto-temporal lobe with surrounding vasogenic brain edema. The patient underwent uneventful craniotomy and tumor biopsy, and pathologic results revealed lymphoma. In the operative room, freehand entry point localization was performed using a virtual OM plane as the reference, and outcomes were confirmed by a navigation system before the operation was commenced.

Surgical technique

A 1x2 window pattern was selected on the computer monitor, and CT images in axial and sagittal view were opened simultaneously in each window. A reference line was enabled, so that when the mouse's pointer was in any view, the other view displayed the corresponding image plane in any level. The monitor surface was covered with a transparent sheet for further drawing purposes. The technique was as follows:

1) The CT image frame that displayed the lens of the orbit was chosen; alternatively, if the lens was not in mid-position, the one that showed the largest diameter of the eyeball was selected (Fig. 1). In sagittal view, the center point of the lens was marked on the transparent sheet.

2) The CT image frame that passed through each external meatus was opened, and the position of the external meatus was marked on the transparent sheet (Fig. 2).

3) On the points marked in 1 and 2, a line was drawn, representing the OM plane as the virtual study plane (Fig. 3).

4) Perpendicular to the OM plane, a line was drawn to represent the perpendicular auditory meatus (PM) plane[5] (Fig. 4).

Fig. 1 Image frame that passes through the lens (1) of orbit in axial and sagittal view.

Fig. 2 Image frame that passes through the left external meatus (2) in axial and sagittal view.

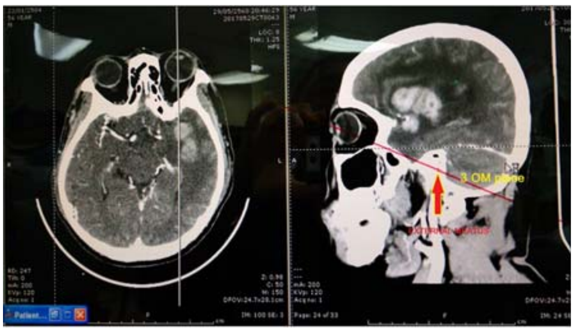

Fig. 3 Orbito-meatal (OM) plane (3) drawn (red line) in sagittal view.

5) The axial image frame in which the desired entry point was identified (Fig. 5 left) was selected. Simultaneously, in sagittal view, a horizontal line appeared representing the actual CT study plane (blue line) at the same level as in the axial view. The mouse wheel was scrolled until the vertical line shown in the axial view passed over the desired entry point, where the actual study plane (blue line) passing the scalp margin at the anterior rim was at the desired entry point in sagittal view (Fig. 5 right).

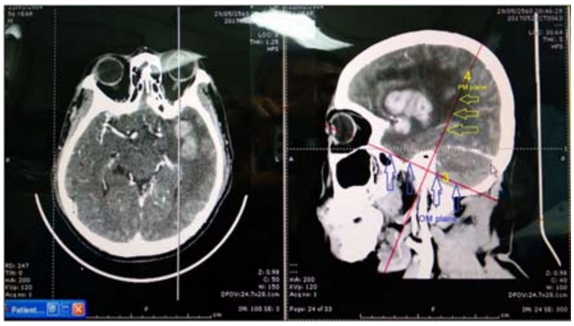

Fig. 4 Perpendicular auditory meatal (PM) plane (4) drawn perpendicular to OM plane (3).

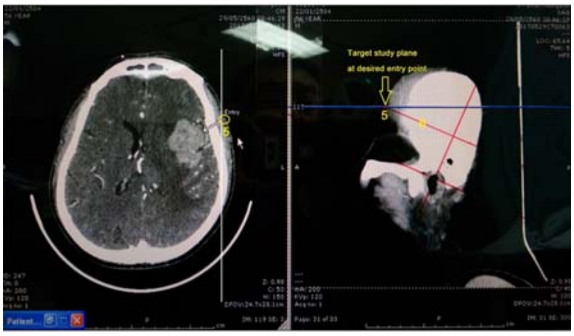

Fig. 5 The desired entry point in axial view (yellow circle, 5) simultaneously shown in sagittal view (arrow, 5). From the desired entry point in sagittal view, a line (6) parallel to the OM plane was drawn across the PM plane (Fig. 5 right).

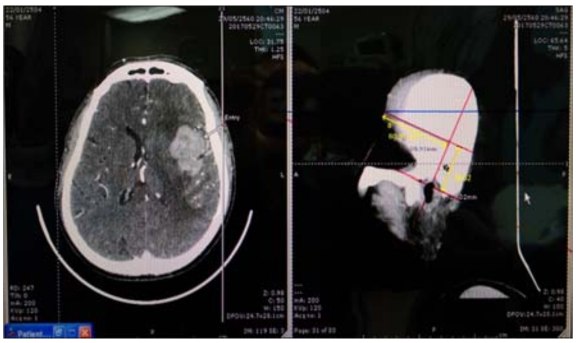

Fig. 6 The desired entry point in sagittal view was calculated using the ruler tool measuring the Z (7) and Y (8) values based on a virtual OM study plane (Fig. 6 right).

6) A line was drawn from the desired entry point in sagittal view parallel to the OM plane across the PM plane (Fig. 5 right). Using the application's ruler tool, the Z and Y values on the virtual OM study were measured as shown (Fig. 6 right).

7) On the scalp skin, the OM plane was marked from the pupil to the external meatus. The PM plane was drawn starting from the external meatus and perpendicular to the OM plane. The last line parallel to the OM plane was marked on the Z and Y values as shown (Fig. 7), unveiling the desired entry point (yellow star).

8) The navigator's reference probe was used to confirm the outcome (Fig. 8, 9).

Results

In the present study, the location of the desired entry point was confirmed using a navigation system, with good clinical results (Fig. 8). The operation was conducted under navigation guidance, the tumor was identified, a biopsy was performed, and the pathological report from the tissue biopsy revealed lymphoma. The operation duration was about 3 hours, and the immediate post-operative period was uneventful. Dexamethasone intravenous injection was given, and post-operative radiation therapy was prepared. Two weeks after the operation, the patient was fully conscious, and motor weakness was considerably reduced. CT scan brain revealed a substantial decrease in the size of the enhanced mass and surrounding brain edema, and the patient was subsequently transferred to the medical department for further treatment.

Discussion

In spite of its high cost, neuronavigation is undoubtedly a great asset in the field of modern neurosurgical operations[10]; however, in developing countries with limited budget resources, few hospitals can afford to make it available in their operative rooms. This preliminary study presents a technique based on scientific means using digital image data with some measuring to localize the desired entry point with the freehand method, rather than simply using anatomical landmarks and mentally-challenging three-dimensional orientation made by an individual. However, a long-term study using a navigation system as reference should be conducted until consistently good outcomes and refinement of the procedures are achieved. The disadvantage of the method used in this study was that it is entirely dependent on a computer with special image software (e.g. PACS viewer) that is capable of manipulating digital image data. This software is usually supplied by the CT manufacturer upon purchase of the machine, but some training is required to learn how to use the software correctly. At Rajavithi hospital, all radiological image investigations are recorded in digital

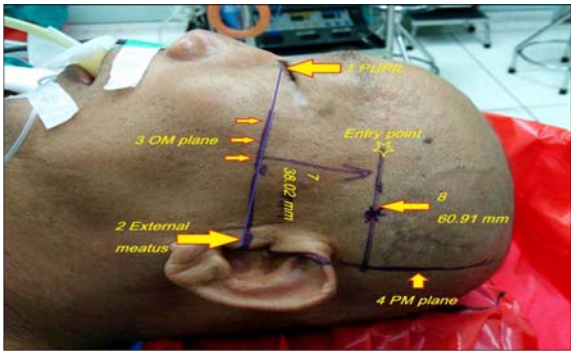

Fig. 7 On the scalp skin, the OM plane (3) was drawn from the pupil (1) to the external meatus. The PM plane (4) was drawn from the external meatus (2) perpendicular to the OM plane. The last line parallel to the OM plane was drawn on the Z (7) and Y (8) values as shown, thus unveiling the desired entry point (yellow star).

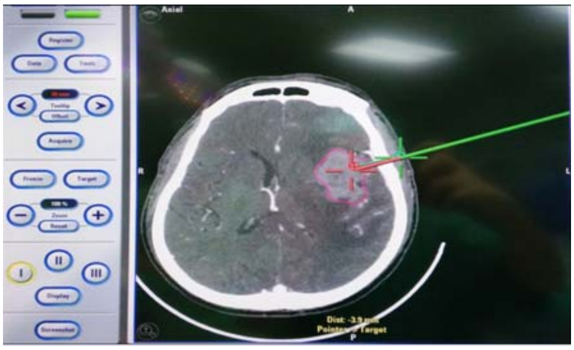

Fig. 8 The desired entry point was confirmed by neuronavigation.

Fig. 9 Tumor was identified in operative field using the navigator's reference probe.

format and stored in the PACS data bank on the hospital's central server, so the computer's intranet can retrieve and manipulate the image study instantaneously even in the operating room. The other limitation of this technique is that it is not suitable for deep-seated intracerebral lesions and cannot substitute for a navigation system at all in these cases. In situations where a navigator system is unaffordable but digital image data is available in the hospital, this freehand technique may be a viable alternative tool for neurosurgeons to employ with greater confidence in localizing the desired entry point for convexity brain lesions.

Conclusion

A virtual OM study plane can be used as a reference for localizing the desired entry point, but the procedure needs to be performed on a computer with capable image processing software which is usually bundled with the purchase of the CT machine. A long-term study supervised using neuronavigation as the reference should be conducted in the future.

What is already known on this topic?

Previous studies of CT localization of convexity brain tumor entry points have used the OM study plane as reference and employed conventional x-ray CT film containing the position of each image frame to calculate the location of the lesion. The advent of navigation systems has resolved this troublesome issue for surgeons, but few hospitals, especially in developing countries, can afford this technology. However, radiological image investigations in hospitals nowadays are almost always stored in digital format including CT scan brain on which navigation systems are based. There has been no previous study of the use of image processing software to imitate the OM CT study plane as reference and calculate the location of the desired entry point on the calvarium using the freehand technique in situations where a navigation system is unavailable.

What does this study adds?

This study proposes a new technique for localizing the desired entry point on the calvarium with a virtual orbito-meatal study plane as the reference.

Potential conflicts of interest

None.

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