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AJNR Am J Neuroradiol 1988, 9 (3) 513-516

<http://www.ajnr.org/content/9/3/513.citation>

This information is current as
of August 25, 2025.

Preoperative Localization of Intracranial Lesions on MR

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Intraoperative identification of small or diffusely infiltrative subcortical lesions may be difficult. The apparent position of an abnormality demonstrated on higher CT sections may be particularly misleading. Lesions seen in the center of the image may be located in the frontal or parietal lobes, depending on the angulation of the plane of the section. Surgical exploration of these lesions is aided considerably by preoperative localization. The procedure is usually performed by using CT in the coronal or axial plane. However, in many cases, coronal planes may be difficult or impossible to obtain on CT. Several localization methods have been described. Most refer the position of the lesion to the skull landmarks or to devices placed externally on the scalp. The proposed method allows for simple and accurate localization of the intracranial process on MR.

Materials and Methods

A grid localizer* (Fig. 1A) can be constructed using flexible plastic tubes. Segments of IV tubing were found to be ideal for this purpose. The grid is assembled over a convex surface—for example, the cranial vault of a dry human skull—to cover a surface of approximately $10 \times 10 \text{ cm}^2$. The individual tube segments, oriented in an x, y direction (nine to 11 segments each), are separated by a distance of approximately 1 cm and cross each other at angles of approximately 90° . The shape of the completed grid attempts to comply with a partial sphere, at the same time maintaining the perpendicular orientation of the two main axes. The system is filled with a solution of copper sulfate and sealed. Caution must be exercised to avoid air bubbles, which could prevent visualization of a segment or even of the entire tube(s).

The principle of localization is explained diagrammatically in Fig. 1B. The position of the object placed under the net of stationary x, y coordinates can be projected onto the grid and expressed in numerical values. During actual localization the grid is placed on the scalp, and MR sections are obtained in two planes, perpendicular to each other (e.g., coronal and sagittal). One image through the center of the lesion in each plane is selected for the localization. The center of the lesion is marked and a line is drawn from that point peripherally to intersect the grid on both images. The position of the lesion is then

related to a corresponding intersection of the x, y tube segments of the grid.

The experimental evaluation of this method using plain tissue and fat capsules showed excellent accuracy of localization of the "lesions" in reference to the external mark.

Preparation

A patient referred for localization usually has had previous CT or MR studies of the head, and a decision to undergo the surgical procedure has already been made. The scalp on the side of the lesion is shaved thoroughly, and the localizer is placed in the general area of the lesion. An attempt is made to align the coordinates of the grid with the intended planes of the MR sections, using the laser beam. The device is then securely taped to the scalp. The patient's head must rest comfortably within the headrest, preferably supported by individual sponges, to avoid any tension on the skin or displacement of the localizer.

Selection of the Planes of the MR Section

Localizing the lesion with reference to the convexity is an important factor in selecting the localizing MR planes. Since the surgical approach is likely to be along the shortest distance through the cranial vault, the MR planes at the level of the lesion should form a right angle with the vault. Generally, parasagittal lesions are localized best in coronal and sagittal sections, while those along the lower convexity are localized best in coronal and axial planes. The MR scan is performed in the supine position, using sequences that best delineate the lesion or the component to be localized.

Marking of the Scalp

Two MR images in perpendicular planes, transecting the center of the lesion or the component to be localized, are selected (Fig. 2). A straight line is drawn from the lesion center, peripherally and perpendicular to the inner table on both images. The lines will transect the grid in specific locations on the x, y axes. Assuming the upper medial corner of the grid represents 0-0, the coordinate values of the lesion for two lines will fall at the crossing point of tube 5 on axial scans

* The device is being developed by Medical Advances, Inc., Milwaukee, WI 53226-0425. Patent pending.

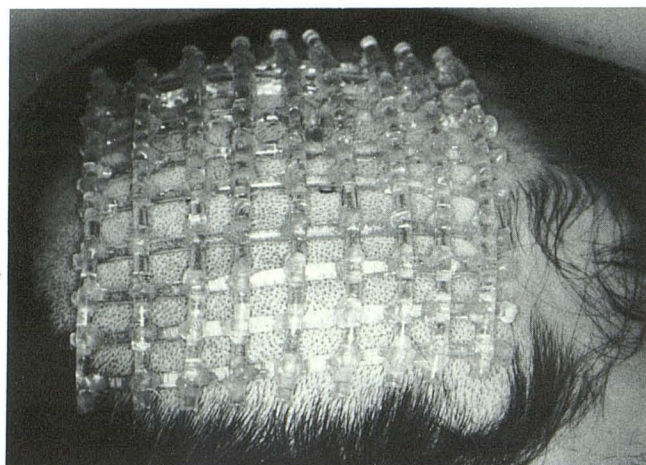
Received July 14, 1987; accepted after revision October 5, 1987.

Presented at the annual meeting of the American Society of Neuroradiology, New York City, May 1987.

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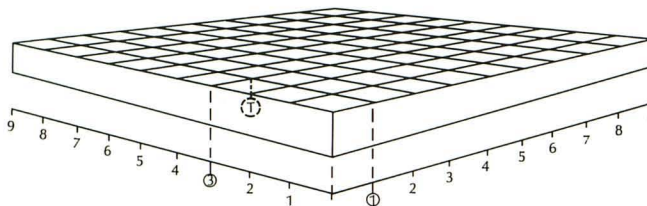
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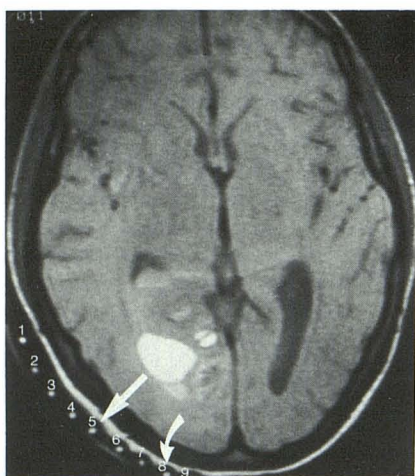
A

Fig. 1.—A, Localizer grid positioned on scalp in preparation for localization of a right posterior frontal lesion. Grid is shaped to fit convexity of cranial vault. The tube segments are arranged in parallel fashion to match orientation of MR sections.

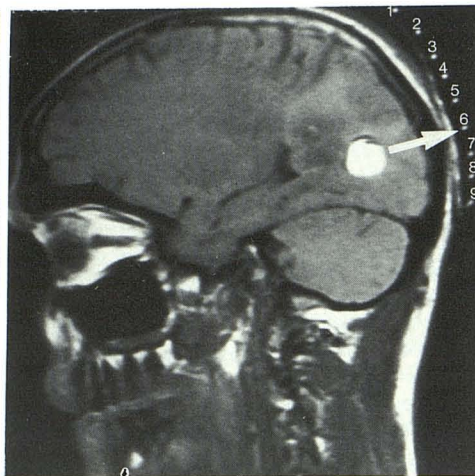


B

B, Schematic showing principle of localization. Position of object (T) located under stationary grid is referred to grid coordinates. The x, y values for the object are 3 and 1, respectively.



A



B

Fig. 2.—MR images of primary parenchymal melanoma, occipital lobe. Localization of hemorrhagic component, not appreciated on CT.

A, Axial plane. Line perpendicular to inner table denotes coordinate 5 (straight white arrow). Localization point can be adjusted according to preferred surgical approach (curved white arrow).

B, Sagittal plane. The coordinate of hemorrhagic component is 6 (arrow).

and tube 6 on sagittal scans, respectively. Therefore, the scalp mark is made at the point of intersection of tubes 5 and 6.

Clinical Material and Results

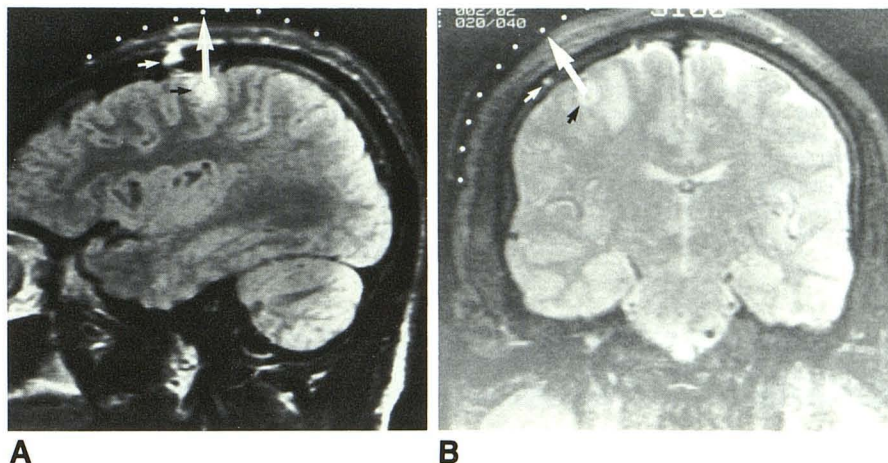
Intracranial mass lesions in 18 patients were localized preoperatively using the method. There were six primary tumors (gliomas), 11 metastases, and one case of cysticercosis (Fig. 3). Six lesions were in the frontal area, five in the parietal, five in the temporal, and two in the occipital lobe. Their longest dimension in axial plane varied from 1.5 cm to 7 cm. Each patient also had a localization CT scan with contrast. There was excellent correlation between MR and CT localization in all patients. All localizations were accurate as confirmed by surgical results.

Discussion

Knowledge of the precise location of an intracranial lesion before craniotomy facilitates surgery and may even modify the surgical approach. This is particularly true when the lesion is small or is located in a vital part of the brain, such as the motor cortex.

Localization is usually performed with CT [1–13]. It is also possible to localize lesions by radionuclear brain scan [14]; and sonography has been used for intraoperative localization of subcortical tumors [15, 16]. Numerous localization methods have been described. In general, these are divided into two groups: those using external radiopaque markers overlying the lesion on the same image [2, 5, 7–9, 11] and those calculating the position of the brain lesion in reference to

Fig. 3.—A and B, MR images show cysticercus abscess in a young Haitian male. An unsuccessful attempt at resection through a small craniotomy was made at another institution. Localization in sagittal and coronal planes, coordinates 5 and 3 (large arrows). The lesion (black arrows) is posterior and inferior to the surgical defect (small white arrows). Grid elements are retouched for clarity.



known landmarks or planes [1, 3, 4, 6, 10, 12, 13]. A method of localization using a reconstruction technique and scout image (topogram) has been described recently by Luft et al. [10]. The final result of localization procedures is placement of an external mark to indicate the position of the lesion. Properly performed localization eliminates the need for exploration during surgery and limits the extent of craniotomy.

Localization procedures using CT are usually carried out in one plane only; this may result in a significant error in estimating the lesion's position with reference to the cranial vault. Such an error is due to the slope of the vault, and occurs most frequently during localization of masses located along the lateral convexity. A similar error may also be made if the angulation of the coronal sections is not adequate (Fig. 4). This error may be minimized by posting the selective sections through the lesion at a right angle to the vault. Localization using MR and the grid has several advantages over localization performed by CT. First, the entire procedure is performed in the supine position, which is usually tolerated better than the prone position required for coronal sections. Second, since marking of the patient's scalp is done after completion of the study, there is no loss of scanning time. The point of localization may be selected after review of the complete MR study in both projections; moreover, additional points can be designated at the same time. Third, the error of parallax is significantly reduced by using two perpendicular planes for localization.

The procedure requires good patient cooperation. Care must be taken to tape the localizer securely to the skin so that the displacement error is eliminated. The success of this method depends mainly on careful regard to its technical aspect.

The procedure of localization with the external grid allows for geometric planning of the approach to and extent of the craniotomy incision. It is reserved mainly for patients undergoing craniotomy for excisional biopsy or resection of a lesion. Sonography can also be used to locate a parenchymal lesion but only intraoperatively, after the bone has been removed. We would anticipate that the use of intraoperative sonography

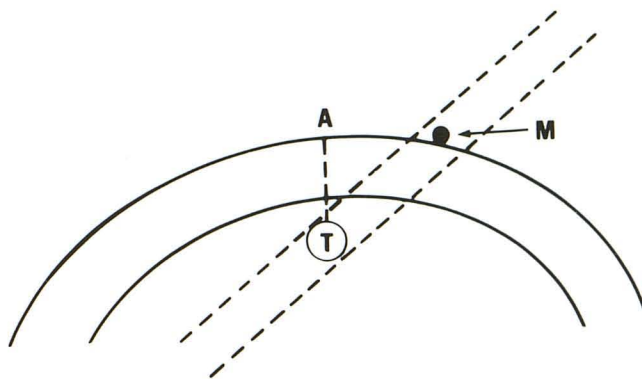


Fig. 4.—Diagram depicting CT localization in coronal plane. Inadequate angulation of the plane of the section. The lesion seen in the image is quite distant from localizing marker. T = lesion, M = scalp marker, A = surgical approach.

in addition to grid localization may be required in small, deeply located lesions.

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