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# Stereotaxic Biopsy of the Brain under MR Imaging Control

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Stereotaxic biopsy under computed tomographic (CT) control has become a routine procedure in neurosurgical practice and has a high degree of accuracy with a low morbidity [1–4]. Magnetic resonance (MR) imaging has some advantages over CT in studying the brain and may reveal cerebral lesions where little or no sign is evident with CT [5, 6]. The MR imaging features not seen with CT are usually well localized although in pathologic terms they are often nonspecific. These findings have provided a strong stimulus for the development of stereotaxic biopsy techniques suitable for MR imaging, in part to exploit the new diagnostic information and in part to achieve a better understanding of its significance.

Leksell et al. [7, 8] recently described a stereotaxic system suitable for use with MR imaging as well as the use of conventional MR imaging to confirm the location of bilateral lesions produced in the thalami under CT guidance, but the use of MR imaging–guided stereotaxic biopsy in clinical practice has not been reported previously. We describe a different type of stereotaxic biopsy system suitable for use with MR imaging and illustrate its use in two clinical cases.

## Instrumentation

### *Stereotaxic Frame*

A prototype frame developed by Trent Wells (Southgate, CA) and distributed by Radionics (Burlington, MA) and RDG Electro Medical Equipment (Croydon, Surrey, UK) was used in this study. The frame is similar to that used for CT stereotaxic biopsy [9–11] except that no ferromagnetic material is used; closed metal loops that might conduct eddy currents are avoided; and MR-sensitive material is used in the coordinate indicators. The specific modifications were as follows: (1) The standard aluminum alloy/carbon-fiber base ring was replaced with a nonmetallic paxolin/carbon-fiber structure (fig. 1); (2) The ferromagnetic stainless-steel skull fixation pins were replaced with titanium; (3) The metallic components in the base ring attachment were replaced by paxolin and the carbon-fiber rod coordinate indicators were replaced by carbon-fiber tubes containing a solution of Gd-DTPA with a T1 of about 200 msec, enabling them to be seen on MR scans when appropriately windowed (fig. 2). There were also 12 carbon-fiber tubes rather than the nine rods used with the CT system. The latter configuration required a new computer program to calculate the target position.

### *MR Imaging System*

The imaging system used with the stereotaxic frame has been described previously [12]. A two-turn saddle receiver coil (diameter, 29 cm) was placed around the stereotaxic frame, and the patient was placed in the magnet in the usual way. The transmitter coil was unchanged. Inversion-recovery (IR 1500/500/44) and spin-echo (SE 1500/80) pulse sequences were used.

## Technique

The base ring was attached to the skull under local anesthesia, and sedation was maintained with intravenous mada-

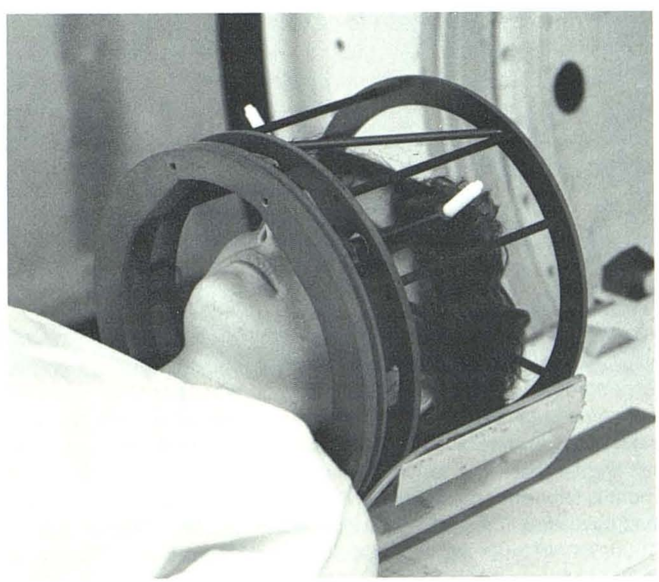

Fig. 1.—Stereotaxic frame with coordinate indicators surrounding patient's head.

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Fig. 2.—MR scan showing pattern made by 12 coordinate indicators.

zelam (Hypnovel, Roche). Single-slice contiguous IR 1500/500/44 and SE 1500/80 sections of 8-mm thickness were imaged and the coordinates of the indicators and of the target areas were obtained directly from the MR visual display unit. This information was used to calculate the angles and depths for the target areas. The patient was then transferred to an operating theater separate from the MR suite, fully anesthetized, intubated, and prepared for a burr hole. The arc system was attached and the calculated parameters were used to obtain biopsies from the target areas.

## Case Reports

### *Case 1*

A 68-year-old mildly hypertensive woman had been admitted 3 years earlier with ictal onset of a right-sided hemiparesis; this gradually improved, leaving a slight deficit. Two years later she presented with grand mal seizure and transient worsening of her right hemiparesis. A CT scan showed an illdefined region of low attenuation in the left frontal lobe. The lesion appeared unchanged on a CT scan 7 months later but on a follow-up CT scan 11 months later, the lesion had increased in size (fig. 3A). The lesion was seen also on the IR 1500/500/44 scan (fig. 3B) and displayed a central ring. Biopsy of five target areas within the ring, at the margin of the ring, and outside the ring was performed, and histology revealed an oligodendroglioma from the target area within the central ring and reactive gliosis outside the ring.

### *Case 2*

A 38-year-old man had been admitted 2 years earlier with a history of epilepsy associated with left-sided weakness. The CT scan at that time suggested a diffuse right-sided intracerebral tumor, and he underwent a craniotomy and open biopsy. Although no specific pathologic diagnosis was obtained from the biopsy material, he was treated with radiotherapy. After some improvement over a period of 4 months, he presented again with left-sided weakness, ataxia, and slow mentation. A CT scan at this time displayed calcification in the right thalamus, hypothalamus, and deep temporal region as well as a cavity attributable to his previous surgery. MR imaging was performed before surgery, after the radiotherapy, and before stereotaxic biopsy. The latter two scans showed considerable regression of the initial changes, but the features were nonspecific (fig. 4). Biopsy was performed, and histology showed changes compatible with radiation therapy. No tumor tissue was identified. The precise diagnosis remains uncertain.

## Discussion

The modifications that are necessary to adapt standard CT stereotaxic frames for use in MR imaging are relatively straightforward. Ferromagnetic materials must be avoided, and closed conducting loops must be eliminated to avoid artifact from eddy currents. Any suitable material with a short T1 such as Gd-DTPA or oil can be used as a coordinate indicator. With these modifications the frame can be used for MR imaging in a manner similar to that of CT-guided stereotaxic biopsy. Such a system has advantages in regions (such as the brainstem) where detail may be unsatisfactory with CT, as well as in patients with tumors that display only a mass effect on CT but more specific features with MR imaging.

With MR imaging, many lesions display the relatively nonspecific features of an increased T1 and an increased T2; stereotaxic biopsy may permit a specific diagnosis in such cases. Stereotaxic biopsy may help also to explain the changes seen on MR scans and to assess the accuracy of MR imaging in distinguishing tumor from edema with different pulse sequences. No technique has heretofore been available as a "gold standard" for assessing the accuracy of the various MR imaging approaches to this problem, including the use of intravenous Gd-DTPA as a paramagnetic contrast agent [13].

The current frame is being adapted to allow stereotaxic biopsy in the coronal and sagittal planes, which should represent a further useful development. Stereotaxic biopsy represents an extension of the scope of MR imaging and promises to have valuable clinical and research applications.

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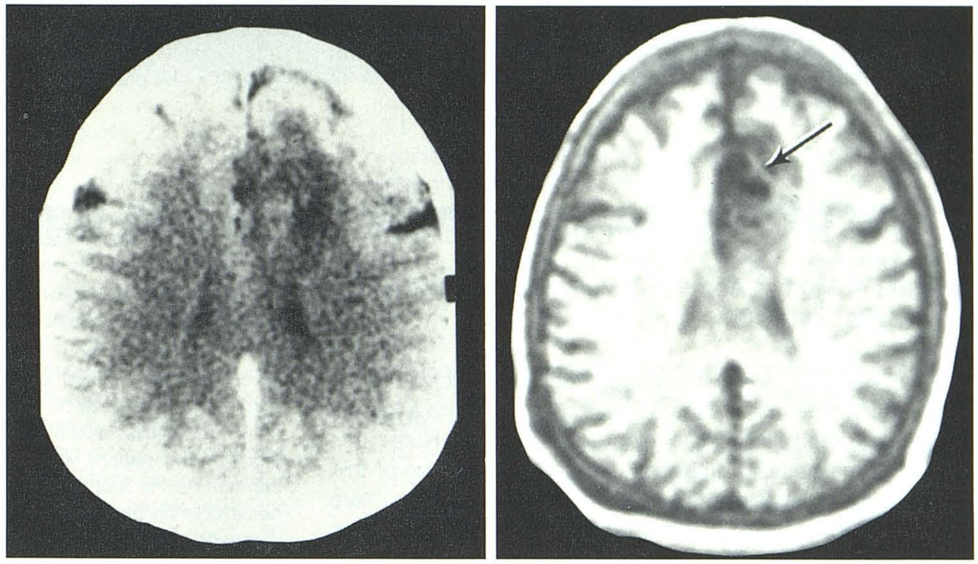
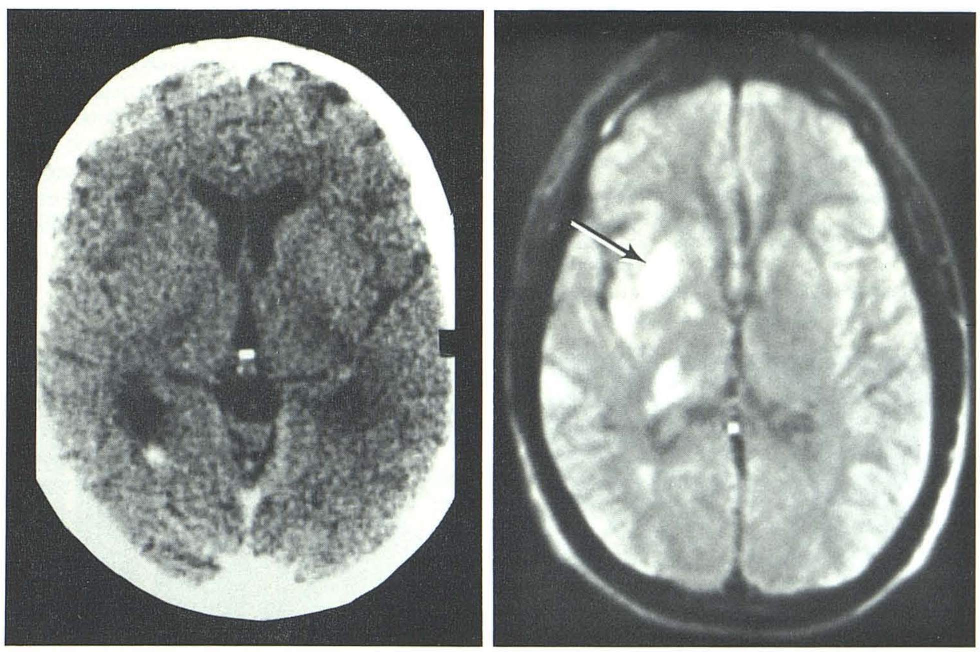


A B

Fig. 3.—Case 1. Contrast-enhanced CT scan (**A**) and IR 1500/500/44 (**B**) scans. Biopsies were obtained in relation to ring within lesions (**B**, *arrow*).



A B

Fig. 4.—Case 2. Contrast-enhanced CT (**A**) and SE 1500/80 (**B**) scans. Abnormal area in **B** (*arrow*) was biopsied.

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