# Real-Time Ultrasound Monitoring During Intracranial Needle Biopsies: Operative Results and Detection of Complications in 100 Cases

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**Key words**
- Biopsy
- Brain neoplasm
- Complications
- Histopathology
- Stereotaxy
- Ultrasonography

**Abbreviations and Acronyms**
CT: Computed tomography
IOUS: Intraoperative ultrasound
MRI: Magnetic resonance imaging
WHO: World Health Organization

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OBJECTIVE: **Intraoperative ultrasound displays dynamic processes intraoperatively. Performing burr-hole biopsies under a real-time visual control is an interesting option for the neurosurgeon. However, the percentage of conclusive diagnoses obtained by this technique and the rate of complications must be evaluated in a larger series.**

METHODS: **One hundred consecutive intracranial biopsies were analyzed. Through a burr hole, the lesion was localized by ultrasonography, and the planned needle trajectory was superimposed onto the image. Intracranial vessels were imaged by Doppler flow signals. Biopsies were taken in a mean depth of 41 mm (maximal 65 mm) from different parts of each tumor.**

RESULTS: **Thirty-six lesions involved the corpus callosum, 16 lesions were located deeply within the white matter, five in the internal capsule, and one in the upper brainstem. There were three cerebellar and 17 temporal lesions. Ten tumors did not exceed a diameter of 15 mm in any plane. The mean time interval from skin incision to the end of suturing was 45 minutes, and the mean time from the surgeons entering the operating theater to leaving the theater was 63 minutes. In 95% of the lesions, a diagnosis could be established. Transient neurologic deficits occurred in five patients, which were permanent in three. In 42 patients without postoperative neurological symptoms, postoperative computed tomography scans were obtained within 24 hours; a visible hemorrhage occurred in eight (19%), six of which were seen intraoperatively.**

CONCLUSION: **When intraoperative ultrasound—navigated biopsies were used they obtained a similar percentage of conclusive diagnoses as stereotactic biopsies. The complication rate is comparable as well. Emerging intracranial complications such as hemorrhages can be observed. However, their incidence cannot be decreased.**

## INTRODUCTION

Despite of the development of advanced brain imaging modalities, most intracranial lesions require a proper histopathological characterization to guide therapy. If a lesion is not reasonably amenable to open surgical approaches, a biopsy remains a viable option. For intra-axial processes, a stereotactical tissue aspiration is generally accepted as the method of choice, providing a high diagnostic yield (12, 21), a very limited invasiveness, and a low complication rate (12, 14). Several technical modifications or alternatives, for instance, frameless stereotactic biopsy (9, 24) or magnetic resonance imaging (MRI)-guided methods (11), have been developed to overcome disadvantages such as limited approaches caused by the stereotactic head frame; however, intraoperative imaging control has not been widely implemented.

Intraoperative ultrasonography (IOUS) is increasingly used by neurosurgeons and, because of the development of special probes, can provide accurate images of intracranial structures through burr holes (18, 22). The axial resolution (i.e., minimal distance between two distinguishable signals) is reported to be about 0.7 mm in transcranial 2-MHz ultrasound (and even better in greater frequencies) (23) and affords more than satisfactory image quality. In contrast to other image-guided biopsy techniques, ultrasonography fulfils the criteria of "real-time" imaging and depicts the changing intraoperative anatomy such as the collapse of cysts (22), the evolution of hemorrhages (1) or the displacement of vulnerable vessels. However, it has not been proven that this technique reduces complications related to surgery.

The goal of this study was to investigate the percentage of conclusive diagnoses and the number of complications in a series of 100 consecutive IOUS-guided burr-hole biopsies of intracranial lesions. We intended to evaluate the advantages as well as the limitations of this real-time method compared with other image-guided biopsy techniques, especially in the detection of emerging complications.

## METHODS

One-hundred operations on 99 patients (53 men/47 women; mean age, 62.6 years)

with intracranial lesions not suitable for microsurgical resection were performed according to our protocol outlined herein. Preoperative MRI of the lesion was available in all but two patients, who carried cardiac pacemakers and underwent contrast-enhanced computed tomography (CT) scanning instead. The maximal axial, coronal, and sagittal diameters of the lesion were measured on the preoperative images.

Only patients with normal coagulation parameters (international normalized ratio, partial thromboplastin time, platelet count) underwent operation. Low-molecular-weight heparin was stopped 1 day before the procedure and platelet inhibitors more than 7 days in advance, if possible. Throughout the operation, normotonia was maintained.

With the patient under general anesthesia, his or her head was fixed in a neurosurgical head frame (Sugita multipurpose head frame; Mizuho, Tokyo, Japan). After a skin incision, an 11-mm-diameter burr-hole was placed at the intended entry point. Neuronavigation was used in two of the patients. The draped ultrasound probe (Hawk 2001 Xl; BK Medical, Herlev, Denmark) was fixed within the biopsy needle guide, which was securely connected to the head holder's self-retaining device. A remote control (19), which can be used to manipulate the scanner functions from within the sterile field, was used during the operation so that no additional person was needed to operate the ultrasound unit.

Before opening of the dura, the lesion was imaged in two planes by IOUS. The probe tip had diameters of 6 × 9 mm and a frequency range from 5.0 to 7.5 MHz. The planned needle trajectory was superimposed onto the ultrasound image (Figures 1-3). The ultrasound duplex mode was activated to localize intracranial vessels by Doppler flow signals and to exclude their presence within the intended biopsy route. Next, the needle (BrainPro titan biopsy cannula 1.8 × 150 mm, lateral opening 10 mm; Pajunk Medical, Geisingen, Germany) was advanced until it reached the skull bone at the rim of the burr hole. Usually, the burr hole was enlarged for 3 $mm^2$ by a rongeur to enable the needle to pass beneath the ultrasound probe, which covers the burr hole. Afterwards, a 3-$mm^2$ dural incision was performed to allow for cerebral needle entry. The maximal insertion depth of the needle was determined by a ring, which was fixed at the needle.

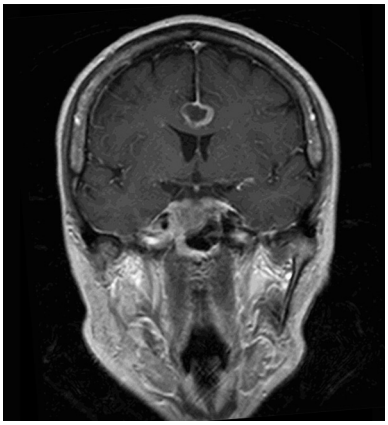

**Figure 1.** T1-weighted, coronal contrast-enhanced magnetic resonance imaging demonstrating a frontal subfalcine lesion in a 60-year-old woman.

Several types of biopsies were taken from varying depths and different parts of the tumor, when appropriate. The entire procedure took place under real-time IOUS monitoring. After final removal of the needle, the ultrasound examination was continued for a minimum of 5 minutes to exclude an emerging hemorrhage.

In 50 patients, a CT scan was performed within 24 hours postoperatively (Figure 4). The retrospective analysis of the data was performed after obtaining approval from the institutional review board.

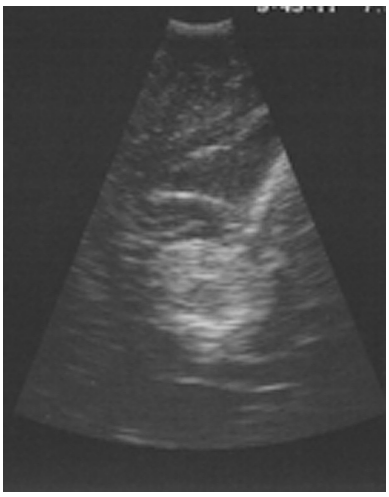

**Figure 2.** Same patient, intraoperative coronal plane ultrasound image of the lesion, through an 11-mm burr hole.

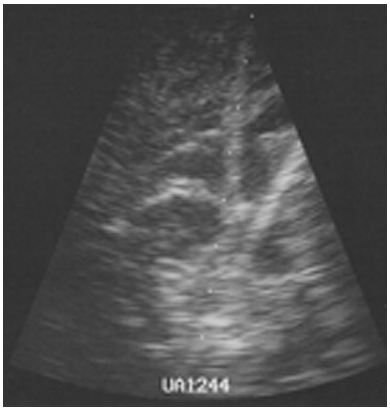


**Figure 3.** Intraoperative image, ultrasound image of the same lesion after biopsy. Note the needle's canal within the lesion.

## RESULTS

### Localization and Technical Aspects

The mean distance between the brain surface and the tumor surface was 41 mm; no lesion was located deeper than 65 mm. The most frequent localization was the corpus callosum (25 cases), and additional 11 lesions did involve this region to a variable extent. Sixteen lesions were located deeply within the white matter, five in the internal capsule and one in the upper brainstem. Three of the patients suffered from suboccipital lesions, and 17 lesions were located in the temporal region. One intraventricular tumor was successfully approached. Ultrasound-guided biopsies in the pineal region or in the infratentorial

**Figure 4.** Postoperative computed tomography of the same patient.