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TECHNICAL NOTE - NEUROSURGICAL TECHNIQUES

The use of Brainsuite iCT for frame-based stereotactic procedures

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Abstract
Background Frame-based stereotactic procedures are the gold standard because of their superior stereotactic accuracy. The procedure used to be in multiple steps and was especially cumbersome and hazardous in intubated patients. A single-step procedure using intraoperative CT was created to optimize the procedures.
Methods A combined fixation and low profile frame holder was designed for the operating table, allowing positioning for the scanning procedure immediately followed by the surgical biopsy procedure with the same positioning and head fixation. For placement of depth electrodes immediate CT control of positioning was feasible.
Results In the first 8 months the procedure was successfully used 65 times including 8 times in pediatric cases. The procedure duration in awake patients was on average 81 min (range 33 to 202) and in intubated patients (children) on average 89 min (median 89, 78–100).
Discussion This study demonstrates that frame-based stereotactic procedures in all brain locations are a feasible and practical technique with improved workflow and added patient safety and comfort.

Keywords Stereotactic biopsy · Stereotactic placement of depth electrodes · Intraoperative CT · Pediatric · Safety

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Introduction

Frame-based stereotactic procedures are the gold standard because of their superior stereotactic accuracy for both biopsies and placement of depth electrodes [1]. Non-frame-based systems are routinely used when lower precision is acceptable.

Frame-based stereotactic procedures are a multiple-step procedure in standard practice. Previously our practice was to apply the stereotactic head ring in the morning at the ward. The stereotactic CT scan was performed at the Department of Radiology (DR) before noon, and the biopsy was performed after that. In case of intubated patients the head ring was placed in the OR, then the patient was transferred to the DR, scanned and transferred back to the OR. We here present a single-step method for a stereotactic procedure utilizing intraoperative CT (iCT). We describe the practicality and results from our first 8-month usage of this technique.

Method

The patient records including OR registration were retrospectively surveyed and served as quality control; thus, no patient informed consent was needed according to the local ethics committee. Additional informed consent was obtained from all individual participants for whom identifying information was included in this article.

For the procedure a combined fixation and low profile frame holder was designed for the operating table (Figs. 1 and 2).

The procedure for awake patients is as follows:

> In the OR the HRAIM (Radionics® Radiosurgery Head Ring Assembly) base frame is fitted to the patient's head.

Fig. 1 This low profile frame holder is fixed to the operating table. The patient's head is fixed to the frame and the CT scan performed. With the frame attached to the table the vertical position can be obtained compensating for the fixed position of the gantry. The patient position will not be changed until after the biopsy

The patient's head is positioned centrally in the scanner gantry (Toshiba & iCT Brainsuite Brainlab AG, Germany), and intravenous contrast is simultaneously administrated, if necessary. The staff leaves the operating room (OR), and the iCT-scan is performed within 3 min. The iCT moves on rails, and the operating table position is fixed. The images are automatically transferred to iPlannet (Brainlab AG, Germany) and fused with a preoperative MRI including a biopsy trajectory plan if formulated beforehand. On planning the biopsy entry position was carefully chosen to be the top of a gyrus, avoiding cortical vessels as seen on Gd-MRi. The time spent on image transfer, fusion and final confirmation of the plan is generally less than 10 min. The biopsy procedure is performed while the patient stays on the same operating table, with the same head fixation. Since the iCT moves away on rails, the operating procedure (as well as table) is free of physical interference from the scanner (Fig. 2). This allows the patient to maintain a supine position in all cases of biopsy, thus avoiding a brain shift using a 2.7 mm twist drill with no escape of fluid. For the DBS patient the position was changed after scanning to a semi-sitting position so the trajectories were near vertical and the shift of the brain (with a possible brain shift using a 10-mm burr hole) along the course.

If intubation is needed, the above steps are followed after intubation.

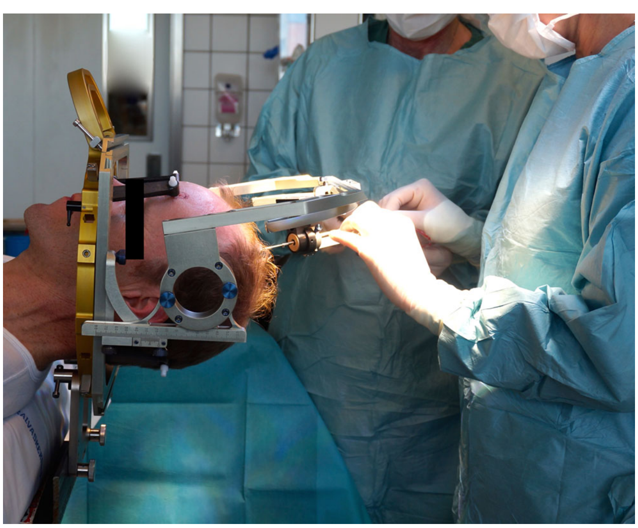

Fig. 2 Low profile frame fitted during biopsy demonstrating multiple locations for access possibilities. In cases of infratentorial biopsies the table is elevated to maximal height, allowing the surgeon to work sitting

Results

During the first 8 months (December 2012–August 2013) this procedure was performed 65 times. Our system has allowed us to perform biopsies from all intracranial locations (Table 1). The duration of the procedure from the patient's arrival in until the departure from the OR for awake patients was on average 81 min [median 76, 33 to the 202 min; for intubated patients (children) on average 89 min (median 89, 78–100 min)]. For the placement of depth electrodes for evaluation of epilepsy or deep brain stimulation

Table 1 Tumor locations

Locations of tumors	Adult	Pediatric
Frontal	19	2
Central core	21	2
Parietal	10	0
Temporal	5	0
Occipital	1	0
Brainstem/posterior fossa	1	4

Table 2 Time calculated from the patients' arrival in the OR until the procedure was completed, including placing an IPG (implantable pulse generator) in DBS; time in min

Time	Awake	Intubated	DBS/epilepsy
Median	76	89	309
Average	81	89	281
Min	33	78	243
Max	202	100	377

**DBS* deep brain stimulation

(DBS), including IPG (implantable pulse generator) placement, the duration was on average 281 min (median 309, range 243 to 377), including an iCT scan to document the electrode positions. Of the 40 patients for whom a biopsy confirmed a glioma (malignant or low grade), 15 were taken in the frontal lobe, 10 the parietal, 4 the temporal, 1 the occipital lobe and 10 the central core. In the posterior fossa/pons four biopsies were performed, two in the pons respectively confirming a demyelating disease and facilitating aspiration of a cyst in a pons glioma. The other two cases in the posterior fossa were tumor diagnostic in the cerebellar peduncle.

Eight pediatric cases were performed, all using general anesthesia (Table 1). Before implementation of iCT, pediatric cases were cumbersome because of the transportation of intubated and sedated patients between our OR and Department of Radiology two floors below. This was resource intensive and carried a potential risk for the patient (Table 2).

Figure 3 shows the different types of procedures performed and the pathologies diagnosed with the biopsies. The most common indication was diagnostic biopsies of tumors where the diagnosis was confirmed 48 times in adults. In four of five pediatric cases where the stereotactic biopsies demonstrated that the tumor was benign, surgical resection of the tumor was performed at a later date. A definite histological diagnosis could be obtained in all cases of biopsy. The position of the depth electrodes for intracerebral EEG was documented on CT performed immediately after placement and integrated into the preoperative plan. The accuracy of the position of the tip was within a few millimeters.

Besides the enhanced safety, workflow and comfort for the patient, this new setup allows for a mediate control CT scan. This is a great help if hemorrhage is suspected or verification of a biopsy location or electrode placements is needed. In all patients where the procedure was used for placing depth electrodes for epilepsy (2 patients) and for aspiration of a cyst (1 patient), a second CT scan was performed. In none of the cases did it lead to a renewed stereotactic procedure although this would be possible had for example a cyst aspiration been insufficient. Verification of placement of electrodes in epilepsy surgery patients is an integral part of the intracranial EEG investigation.

Discussion

This retrospective study describes a single-stage procedure for stereotactic biopsies using iCT. The many advantages include reduced time for the patient with the head ring mounted, less discomfort with no need to move from one department to another wearing the frame, elimination of the transfer of intubated patients, easy access to the CT for follow-up of cyst aspirations, electrode placement, possible hemorrhage and other complications. With this technique the procedural time may be as short as 33 min, and all locations in the brain are accessible, like when using conventional frame-based stereotaxy.

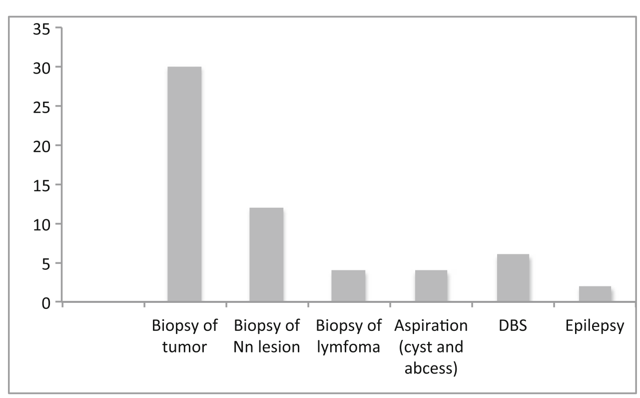

Fig. 3 The number of patients with different indications for a frame-based stereotactic procedure. **Nn* Non-neoplastic, *DBS* deep brain stimulation

Disclosure All authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Conflicts of interest None.

References

1. Smith JS, Quinones-Hinojosa A, Barbaro NM, McDermont MW (2005) Frame-based stereotactic biopsy remains an important diagnostic tool with distinct advantages over frameless stereotactic biopsy. J Neuro Onc 73(2):173–179

Comments

The authors of this interesting article report their preliminary experience with iCT in a variety of surgical procedures.

Intraoperative CT (iCT) is a relatively novel imaging adjuction to operative neurosurgery and has several potential applications ranging from functional neurosurgery, neuro-oncology, vascular and spinal surgery, skull base and hydrocephalus procedures. Procedures such as percutaneous rhizotomy for trigeminal neuralgia can be easly performed with an iCT scan; fusion of a preoperative MRI to localize the ganglion to the intraoperative iCT during the cannulation of the foramen ovale should allow better anatomical targeting and improved results [1]. Biopsy for brain tumors can be performed with iCT together with a frame or frameless platform; again the intraoperative imaging with fusion will allow verification of the target with a relative short time for image acquisition. Placement of depth electrodes for epilepsy and in particular SEEG (stereoEEG) can be performed with the aid of iCT; in this case fusion of 4DCTA/MRI for planning can be coupled with iCT for target verification (a frame-based platform or robotic arm will be necessary in these cases because of the need for accuracy).

iCT has added advantages in terms of cost, time of acquisition of images and logistics compared to iMRI; moreover, patients with DBS leads can be scanned easly with fusion of imaging for target localization. The disadvantage is the anatomical definition, which is less accurate than with MRI, but fusion of the preoperative MRI and iCT will obviate to this problem in several cases.

Other potential applications include skull base (pituitary adenoma in particular) procedures, shunt placement for hydrocephalus and placement of pedicle screws. A robotic arm interlinked with iCT will likely be the next step of development for the iCT, allowing fully automated procedures.

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