Clinical Experience with a Coil-Integrated Head Fixation System in the Context of Intraoperative Magnetic Resonance Imaging for Intracranial Lesions

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Introduction

Introduced into clinical practice more than 30 years ago, intraoperative magnetic resonance imaging (ioMRI) has become an indispensable tool, particularly for resection guidance in neurosurgery [1–3]. Nevertheless, the use of ioMRI imposes specific demands on personnel and technical infrastructure, especially with respect to head fixation systems and MRI coils: They determine not only surgical precision, but also image quality, safety, and workflow efficiency.

Head holders provide excellent cranial fixation and precise adjustment of extension and rotation angles according to the operative strategy. Also, they are essential for achieving optimal accuracy when frameless navigation systems are employed [4]. Integrated solutions combining MR-compatible head fixation systems with dedicated coils substantially improve imaging quality and surgical workflow. The limitations regarding head rotation and angulation that were present in early models have since been markedly reduced.

At RKH Klinikum Ludwigsburg, a triple-room ioMRI concept based on the 1.5T MAGNETOM Aera (Siemens Healthineers, Erlangen, Germany) was established in 2017. Until recently, the integrated 8-channel FLEXIBILITY OR Head Holder (NORAS MRI products, Höchberg, Germany) with three to seven fixation points had been used in all cases. In the following, we report on a three-month evaluation of the integrated three-pin LUCY OR Head Holder & 8-Ch Coil (NORAS MRI products, Höchberg, Germany).

Methods

From mid-October 2025 to mid-January 2026, a total of 20 microsurgical procedures were performed using the LUCY OR head fixation system. Workflow requirements, economic efficiency, and technical implementation were systematically evaluated.

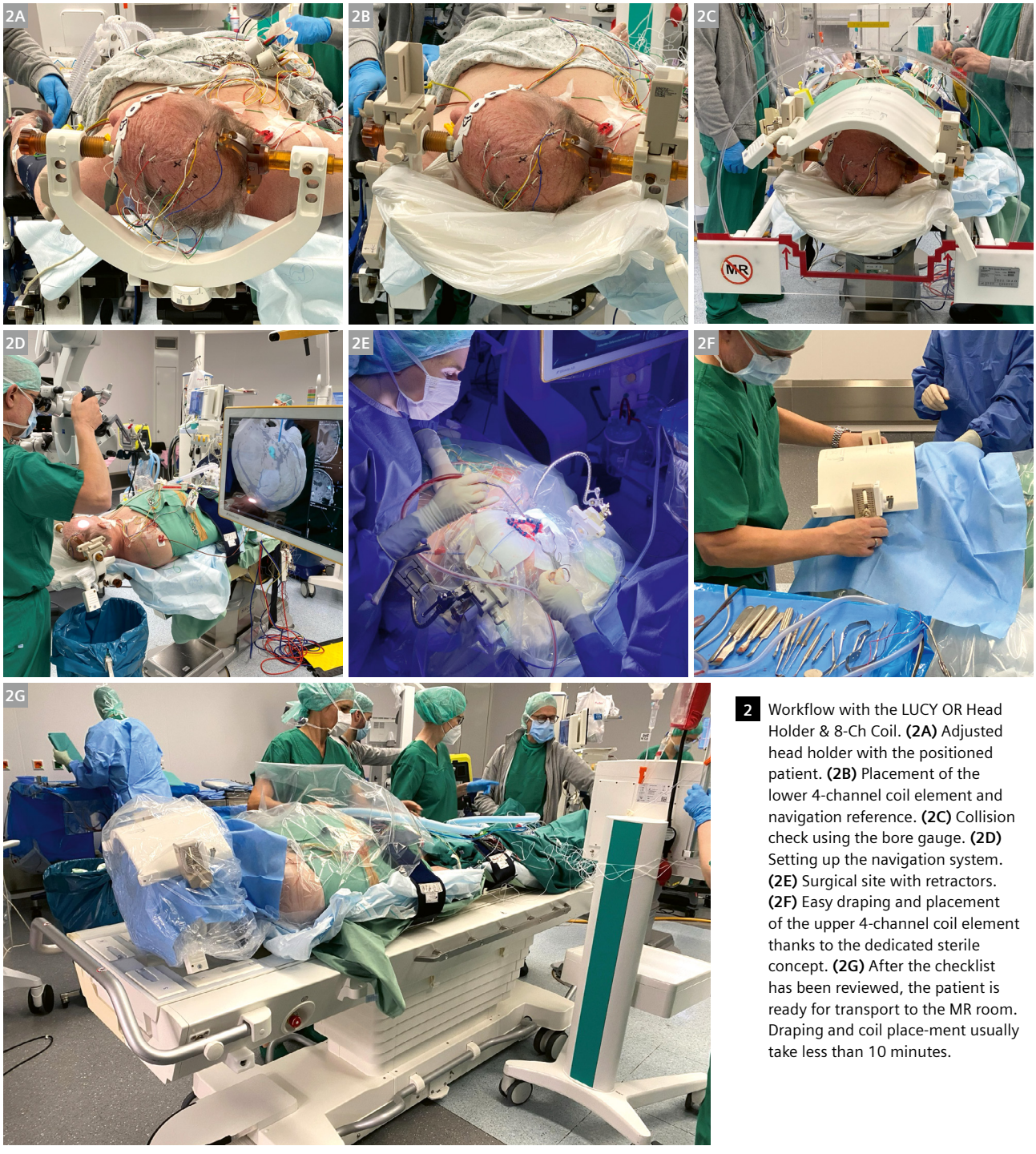
1 Intraoperative MR imaging with the LUCY OR Head Holder & 8-Ch Coil on a 1.5T MAGNETOM Aera.

Workflow

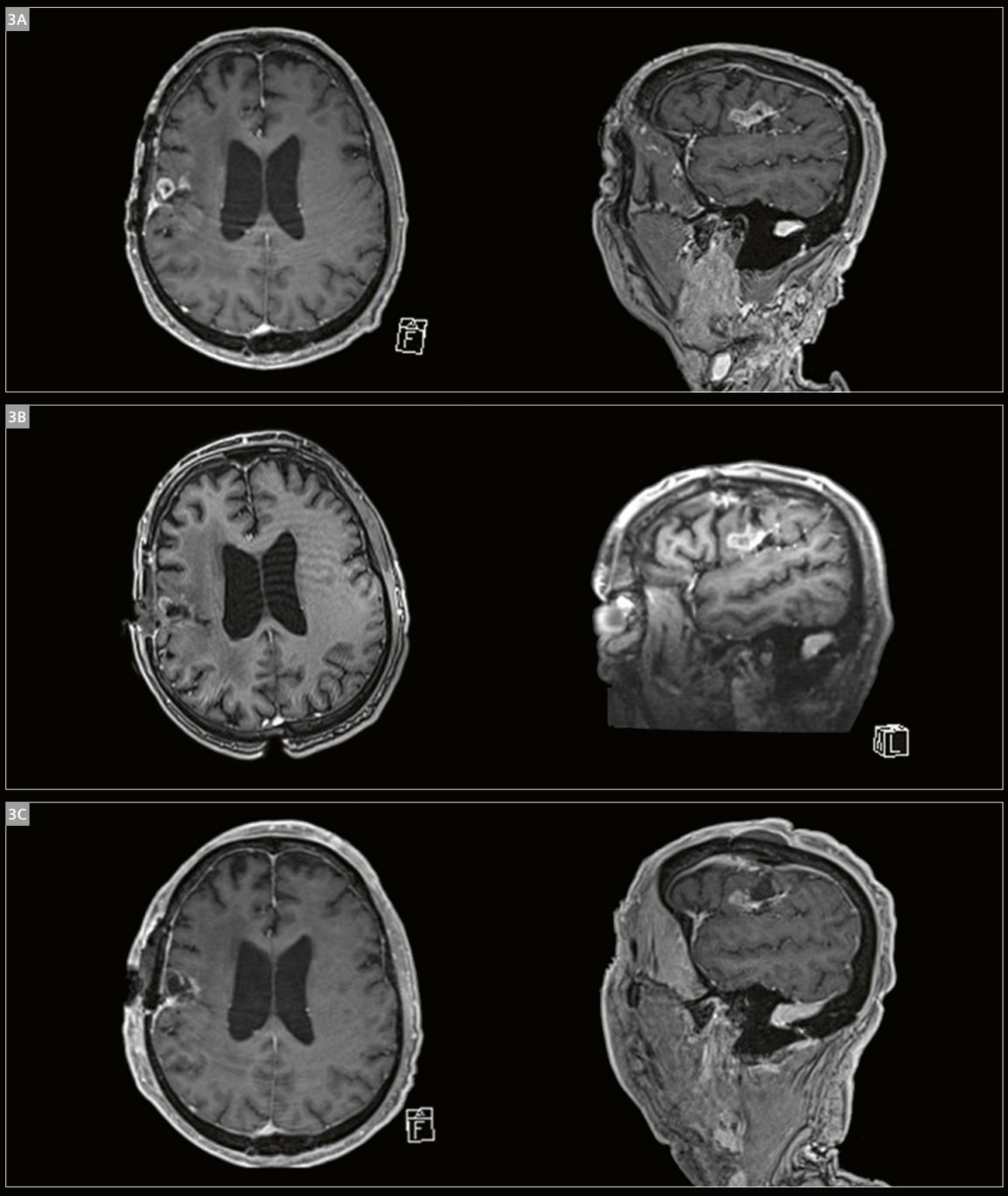
Following patient positioning and anesthesia, the dedicated head holder is mounted and adjusted according to the planned surgical approach. The patient's head is positioned and fixed in the desired orientation, ensuring both mechanical stability and optimal access to the surgical site (Fig. 2A).

After fixation, the lower 4-channel coil element is inserted under the patient's head, and the holders for the upper coil element and the navigation reference are attached and aligned (Fig. 2B).

Before proceeding, a collision check is performed using a bore gauge to confirm safe clearance for intraoperative transfer into the MR bore (Fig. 2C). The navigation system



2 Workflow with the LUCY OR Head Holder & 8-Ch Coil. **(2A)** Adjusted head holder with the positioned patient. **(2B)** Placement of the lower 4-channel coil element and navigation reference. **(2C)** Collision check using the bore gauge. **(2D)** Setting up the navigation system. **(2E)** Surgical site with retractors. **(2F)** Easy draping and placement of the upper 4-channel coil element thanks to the dedicated sterile concept. **(2G)** After the checklist has been reviewed, the patient is ready for transport to the MR room. Draping and coil place-ment usually take less than 10 minutes.



3 Case presentation (1.5T MRI datasets). **(3A)** Preoperative T1 sequences with gadolinium showing the progressive glioblastoma in the lateral perirolandic region. **(3B)** The intraoperative MRI demonstrated residual tumor, predominantly within the precentral gyrus. Resection was continued until a motor-evoked-potential (MEP) stimulation threshold of 2 mA was reached. **(3C)** The early postoperative MRI shows the contrast-enhancing tumor remnants that were intentionally left in place for functional reasons, in keeping with the principle of maximal safe resection.

(Brainlab SE, Munich, Germany) is then initialized to enable accurate registration for reliable intraoperative guidance (Fig. 2D). After sterile preparation and exposure of the surgical field, retractors are positioned (Fig. 2E).

For ioMRI, the surgical site is easily draped according to a dedicated sterile concept. Then the upper 4-channel coil element is placed, completing the 8-channel configuration with optimal proximity to the anatomy for high-quality intraoperative imaging (Fig. 2F).

A structured review of the safety checklist is then carried out. After this, the patient is ready for transport to the MR room (Fig. 2G). Notably, draping and final coil placement usually require less than 10 minutes, demonstrating the efficiency and reproducibility of the setup within a routine intraoperative workflow.

Results

During the three-month evaluation period, 16 glioblastoma resections were performed, including four awake craniotomies. Three procedures were carried out in the prone position, while the others were in supine and lateral. Head rotation ranged from 15° to 60°. In four cases, a transsphenoidal pituitary tumor resection was conducted with a head angulation of up to 30°.

In all cases, the system design enabled an efficient and comfortable workflow while ensuring patient safety throughout the intervention. The head holder provides a robust and stable pinning mechanism that is suitable for different head sizes. The fixation system is height-adjustable and allows rotation, swiveling, tilting, and movement along the z-axis, as well as lateral displacement. Despite being based on a three-pin configuration, fixation remained stable during all procedures and throughout transport into and out of the scanner. Mounting and removing the coils was quick and straightforward and did not interfere with head fixation or life-support equipment, irrespective of patient positioning. The setup includes a dedicated sterile concept, and the head holder allows for easy and efficient cleaning. [5]

Case presentation

In a 70-year-old patient with progressive glioblastoma located in the lateral perirolandic region (primary resection in June 2024, followed by the Stupp protocol), a maximally safe resection was performed under neurophysiological monitoring with ioMRI-guided resection control. Due to the highly eloquent location of tumor components with blood-brain barrier disruption, and the presence of early motor-evoked potentials at a low stimulation threshold (2 mA), complete resection was not feasible from a functional perspective.

The postoperative course was uneventful and without neurological deficits (Karnofsky performance score of 90%). Subsequently, fractionated stereotactic radiotherapy (30 Gy in six fractions) was administered and well tolerated.

This case shows how maximal safe resection was achieved by using ioMRI to increase the extent of cytoreduction, and intraoperative neuromonitoring to preserve neurological function.

Conclusion

Compared with the previous model, the LUCY OR head fixation system with integrated coils demonstrated marked improvements in handling, greater flexibility across all axes while maintaining stability, and consistently high imaging quality. These findings have been confirmed in routine neurosurgical practice. This is particularly relevant for lateral approaches requiring head rotation of more than 30°, such as in insular tumor surgery or during awake craniotomies.

In our experience, the LUCY system offers more straightforward handling in these settings, especially for surgeons accustomed to three point head holders.

References

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