

# Intraoperative MRI

*Magnus Kaijser*



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## Efficacy and safety of intraoperative MRI in glioma surgery: a systematic review and meta-analysis of prospective randomized controlled trials

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Agi Güresir, MD,<sup>1,2</sup> Clemens Seidel, MD,<sup>2,3</sup> Andreas Kühnapfel, PhD,<sup>4</sup> and Erdem Güresir, MD<sup>1,2</sup>

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**OBJECTIVE** Maximum extent of resection in glioma yields enhanced survival outcomes. The contemporary literature presents contradictory results regarding the benefit of intraoperative MRI (iMRI). This meta-analysis aimed to investigate the efficacy and safety of iMRI-guided surgery.

**METHODS** The authors searched the PubMed, Embase, and Cochrane Reviews databases for eligible prospective randomized controlled trials through the end of February 2024. Endpoints were extent of resection, progression-free survival (PFS), overall survival, neurological functioning, and surgical complications. Individual patient data regarding PFS were reconstructed using the R package IPDfromKM.

**RESULTS** From 1923 identified results, 3 randomized controlled trials with 384 patients met the inclusion criteria. Extended resections after iMRI were performed in 29.2% of the iMRI cases. Intraoperative MRI-guided glioma surgery (OR 5.40, 95% CI 3.25–8.98;  $p < 0.00001$ ) outperformed conventional navigation-guided surgery in attaining gross-total resection (GTR). In patients in whom a GTR was achieved, the median time to progression was 16.0 months (95% CI 12.3–19.7 months), while the median PFS in patients with a subtotal resection was 9.7 months (95% CI 6.9–12.5 months) ( $p < 0.001$ ). Despite increased GTR rates, postoperative neurological deterioration was equal among the iMRI and control groups (OR 1.0, 95% CI 0.6–1.7;  $p = 0.91$ ,  $I^2 = 0\%$ ). Intraoperative MRI use prolongs surgery by 42 minutes on average (95% CI 3.3–80.7 minutes;  $p = 0.03$ ,  $I^2 = 56\%$ ). The risk of postoperative intracranial hemorrhage (OR 1.9, 95% CI 0.2–16.9;  $p = 0.55$ ,  $I^2 = 0\%$ ) was not increased, while in one study significantly increased infections were observed in the iMRI arm.

**CONCLUSIONS** Intraoperative MRI outperforms conventional surgery in achieving complete glioma resections of all contrast-enhancing tumor portions, enhancing PFS without added risk. Intraoperative MRI is a tool that facilitates these aims without reducing safety in terms of neurological deficits and surgical complications.

<https://thejns.org/doi/abs/10.3171/2024.7.JNS241102>

**KEYWORDS** glioma surgery; gross-total resection; intraoperative MRI; meta-analysis; progression-free survival; randomized trials; tumor

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Commentary

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# Radiology workforce shortage hits Hawaii hospitals with thousands of patient scans in the queue



The president of the Healthcare Association of Hawaii said the shortage in radiologists could delay procedures.

By [Lynn Kawano](#)

Published: Apr. 18, 2025 at 6:59 AM CEST







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# Coroner sounds alarm on impact of radiologist shortage after teen's death

*Hannah Murphy* | April 28, 2025 | Health Imaging | Staffing



A coroner in England is questioning how the availability of radiologists in the region could be impacting patient outcomes.



Commentary

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## Delays for cancer treatment becoming routine

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Jim Reed

Health reporter • @jim\_reed



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Long waits for cancer care are becoming routine across the UK with nearly half of all specialist cancer centres experiencing delays most weeks, the Royal College of Radiologists (RCR) has said.

The college has warned of an "impending crisis" in the cancer workforce, with a "staggering" 30% shortfall in radiologists and 15% shortfall in clinical oncologists.

The Conservative Party said it would meet current targets for cancer care in England





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Henrik Drott, verksamhetschef röntgenkliniken Västmanland. Foto: Sveriges Radio och Fredrik Sandberg/TT

SJUKVÅRD

## Brist på röntgensjuksköterskor skapar långa köer

1:58 min Dela

Publicerat onsdag 14 april 2021 kl 04.55

- Det är hårt tryck på undersökningar med magnetkamera i Västmanland.
- Trots två kameror på sjukhuset i Västerås, en i Köping och avtal med ett privat röntgenföretag, står 1 300 undersökningar på väntelistan.
- "Orsaken är brist på röntgensköterskor", säger Henrik Drott, verksamhetschef röntgenkliniken Västmanland.

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## **Challenges with intraoperative MRI (ioMRI), from a radiologists viewpoint**

- The scanner is remote from the radiology department
  - The scanner may be of a different brand than other scanners in use
  - There is limited access to the scanner for other patient groups
  - There is no redundancy when the scanner is down
- Difficult to have an efficient and reliable radiological workflow

ORIGINAL ARTICLE

# Intraoperative MRI without an intraoperative MRI suite: a workflow for glial tumor surgery

Henrik Frisk<sup>1</sup>  · Oscar Persson<sup>1,2</sup> · Michael Fagerlund<sup>3</sup> · Margret Jensdottir<sup>1,2</sup> · Victor Gabriel El-Hajj<sup>1</sup> · Gustav Burström<sup>1,2</sup> · Annika Sunesson<sup>3</sup> · Annika Kits<sup>3</sup> · Tomas Majing<sup>4</sup> · Erik Edström<sup>1,5,6</sup> · Magnus Kaijser<sup>3,7</sup> · Adrian Elmi-Terander<sup>1,5,6,8</sup>

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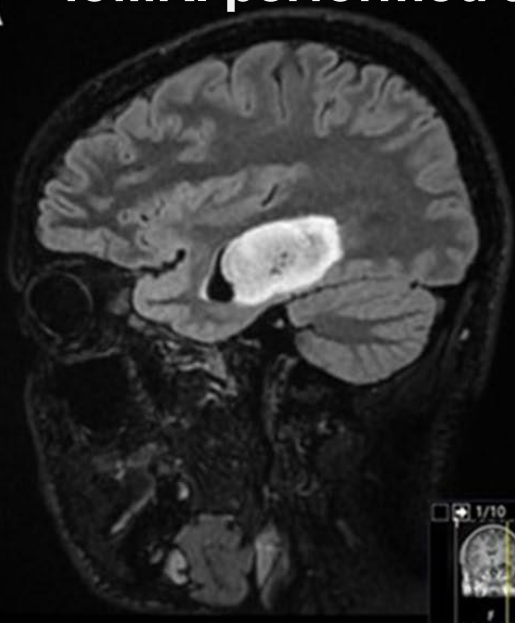
## **ioMRI performed at the radiology department**

- 1) When the attending surgeon decided to perform MRI, the radiology department was informed
- 2) Wound closure was performed (temporary sutures of the dura, craniectomy covering with Spongostan sheets, temporary skin sutures)
- 3) At the dedicated MRI scanner, only short MRI exams were booked allowing for finishing ongoing scans or postponing ones about to begin.
- 4) Transportation to the radiology department and MRI scanning
- 5) MRI reading at the scanner by two senior consultants in neuroradiology together with attending neurosurgeon
- 6) Patient transported to operation room for permanent wound closure or reoperation
- 7) If reoperation, a new neuronavigation plan was created by the attending surgeon at the radiology department with assistance of the two neuroradiologists.



# ioMRI performed at the radiology department

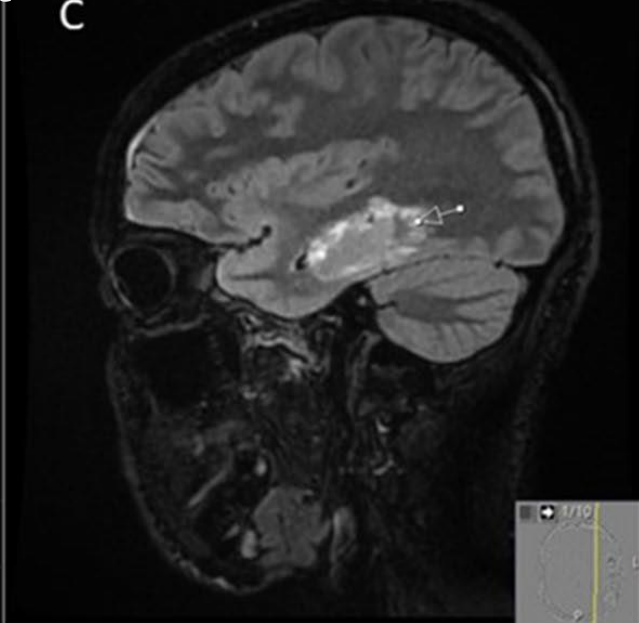
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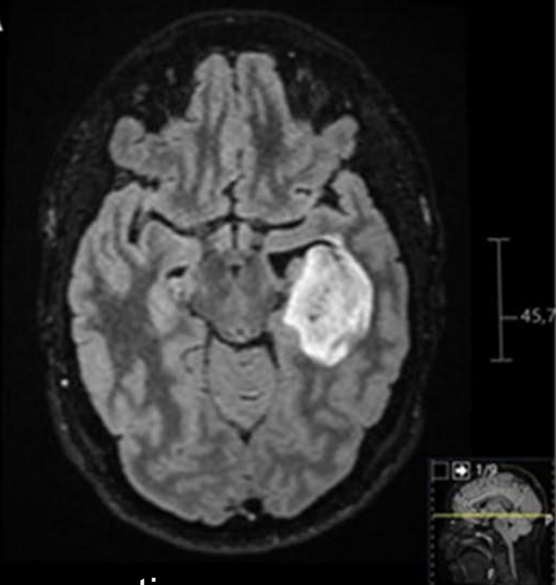
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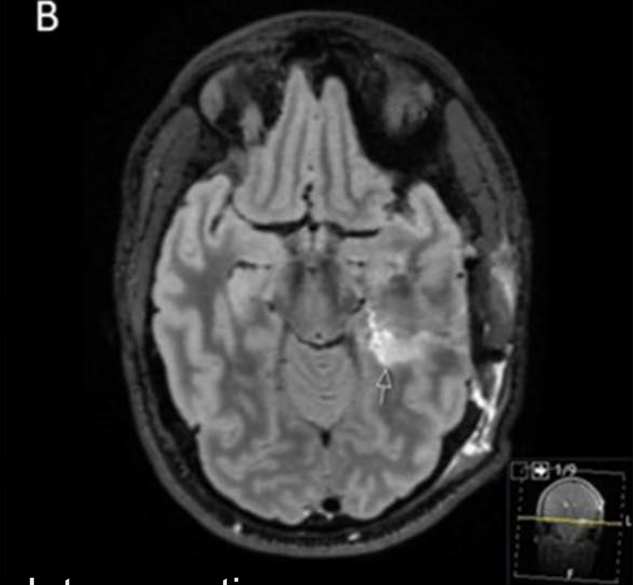


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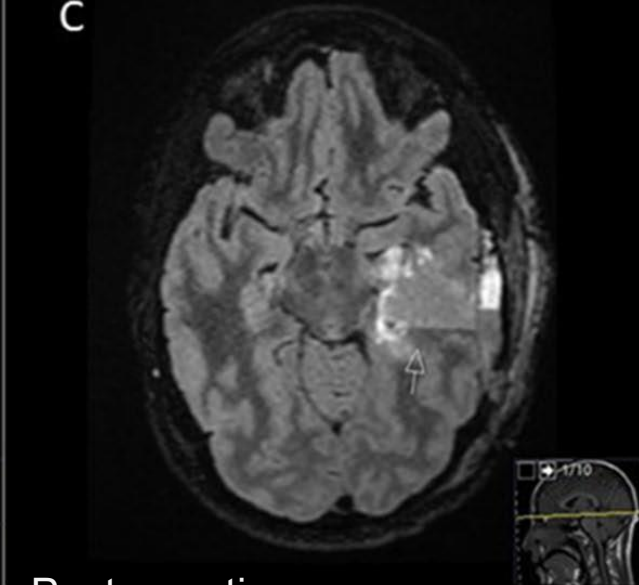
Preoperative

B



Intraoperative

C



Postoperative

## **ioMRI performed at the radiology department**

- 24 patients in the study
- Temporary wound closure 8 min (median)
- Entire MRI procedure: 60 min
  - Departure from operation suite to re-arrival 35 min
  - MRI scanning 20 min

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→ Total time from decision to perform MRI to re-opening of the wound **68** min (range 54-104)

- No adverse events during surgeries, transfers, transportations or MRI exams
- No wound-related complications or infections


# ioMRI performed at the radiology department

Acta Neurochirurgica (2024) 166:80  
<https://doi.org/10.1007/s00701-024-05978-3>

## ORIGINAL ARTICLE



# Two years of neurosurgical intraoperative MRI in Sweden - evaluation of use and costs

Magnus Kaijser<sup>1,2</sup> · Henrik Frisk<sup>3</sup>  · Oscar Persson<sup>3,4</sup> · Gustav Burström<sup>3,4</sup> · Annika Suneson<sup>1</sup> · Victor Gabriel El-Hajj<sup>3</sup> · Michael Fagerlund<sup>1</sup> · Erik Edström<sup>3,5,6</sup> · Adrian Elmi-Terander<sup>3,5,6,7</sup>

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## ioMRI – use and costs

Center	Scanner	Start of follow-up	End of follow-up	Days of follow-up
Uppsala	Siemens Skyra Imris, 3 T	October 26, 2020	August 31, 2022	582
Göteborg	Siemens Skyra Imris, 3 T	January 1, 2021	June 2, 2022	517
Linköping	Siemens Skyra, Stationary, 3 T	March 10, 2020	April 30, 2022	781
Karolinska Solna	GE Signa 1.5 T* and 3 T*	March 17, 2020	May 1, 2022	775

\*Scanners on radiology department, not connected to operation unit



## ioMRI – use and costs

Center	Number of days scanner used	Proportion of days scanner used	Number and type of exams	Hours per intraoperative exam	
				Radiology nurse	Assistant nurse
Uppsala	77	11%	77 intraoperative	8.4	5.3
Göteborg	62	12%	62 - 47 intraoperative - 15 outpatient research	9	-
Linköping	276	35%	760 - 60 intraoperative - 571 neurosurgical and neurointensive inpatients - 129 outpatient research	6	6
Karolinska Solna	1429**	92%	7665 - 64 intraoperative, of which - 34 LITT - 30 other intraoperative - 7601 in- and outpatient exams	2.8	-

\*\*Two scanners

## **ioMRI – use and costs**

Cost assumptions (SEK)\*:

- MRI scanner: 20 million/scanner, 10-year depreciation period
- MRI service: 900,000/year
- Staff costs: Radiology nurse 321/h, Assistant nurse 179/h

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- MRI service: 900,000/year
- Staff costs: Radiology nurse 321/h, Assistant nurse 179/h

Center	Cost MRI scanner/exam	MRI service/exam	Staff costs**	Total cost/exam
Uppsala	47 960	21 580	3 630	73 180
Göteborg	45 690	20 560	2 890	69 150
Linköping	5 630	2 530	3 000	11 160
Karolinska Solna	1 110	500	900	2 520

\* 2023 prices

\*\* Radiologist reading not included

# Conclusions

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- ioMRI performed at the radiology department instead of the operating room may offer a
  - 29-fold reduction in costs and a
  - 70% reduction in time spent by radiology nurses per exam



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  - 70% reduction in time spent by radiology nurses per exam

ioMRI performed at the radiology department may thus strike a balance between satisfying the diagnostic needs of the neurosurgeons without sacrificing the needs of the rest of the hospital