

Table 3: Intraoperative Imaging (fluoro, MRI, CT)

Author (Year)	Study Description	Classification Process / Evidence Class	Conclusions
Nimsky C, von Keller B, Ganslandt O, Fahlbusch R (2006) ⁵⁹	Prospective case series of 106 NFPA patients received microscopic transsphenoidal resection with endoscopic assistance and intraoperative MRI.	Therapeutic / III	iMRI improved gross total resection from 58% to 82%. Initial iMRI revealed residual adenoma in 57 patients. Among patients who were expected to achieve GTR, 36/85 patients had residual at first iMRI. Further resection led to GTR in 71/85 of this patient subset. The lack of an appropriate control group renders this Class III evidence.
Fahlbusch R, Ganslandt O, Buchfelder M, Schott W, Nimsky C (2001) ⁹	Assessment of extent of resection in 44 patients with pituitary macroadenomas using intraoperative MRI	Therapeutic / III	Intraoperative 0.2T MRI was utilized in 44 patients undergoing transsphenoidal resection of pituitary macroadenomas. In 30% of patients, intraoperative MRI interpretation was felt to be limited by the presence of artifact. Among 33 patients with surgeon-estimated gross total resection, 9 (27%) had residual tumor detected by intraoperative MRI, leading to further resection. Overall, intraoperative MRI increased the rate of complete surgical resection from 43% to 70% as confirmed by delayed MRI. False-positive results for intraoperative residual tumor were observed in 16% of patients. The lack of an appropriate control group renders this Class III evidence.

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Berkmann S, Schlaffer S, Nimsky C, Fahlbusch R, Buchfelder M (2014) ⁶⁰	Retrospective analysis of long-term (median 5.6 years) outcomes following transphenoidal resection of NFPA with use of the intraoperative MRI	Therapeutic / III	Overall observed rate of GTR was 66%, which increased from 44% at time of initial iMRI scan. iMRI had sensitivity and specificity of 100% for detecting residual adenoma compared to use of the endoscope which demonstrated a sensitivity of 21% and specificity of 78%. A 7% recurrence rate among patients with GTR was observed and a 14% progression rate among patients with subtotal resection. 79% of tumor growth occurred within 5 years of resection. The rate of new hypopituitarism was 26%.
Hlavica M, Bellut D, Lemm D, Schmid C, Bernays RL (2013) ⁶²	Retrospective series of 104 NFPA patients utilizing 0.15T ultra-low field intraoperative MRI	Therapeutic / III	iMRI revealed GTR in 56/114 (53.8%) patients via iMRI following initial resection. Among patients (n = 48) with detected residual, 43 (41.3%) had further tumor removal verified by subsequent iMRI. Five patients were deemed to have unresectable residual tumor. Patients received 2.3 ± 1 iMRIs (range 2-8 iMRI). 11 out of 114 total patients had residual tumor at the end of surgery.

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Berkmann S, Schlaffer S, Buchfelder M (2013) ⁶³	Retrospective analysis of residual NFPA tumor volumes comparing intraoperative MRI to delayed MRI findings	Therapeutic / III	Comparison of intraoperative MRI tumor remnant volumes with 3-month delayed MRI volumes demonstrated tumor remnant volume reduction in 50% with complete resolution of the remnant in 64%. No change in tumor volume remnant was observed on MRI performed at 3 months and 1 year postoperatively.
Berkmann S, Fandino J, Muller B, Kothbauer KF, Henzen C, Landolt H (2012) ⁶¹	Retrospective case series 114 NFPA including 79 patients (69%) who had surgery using 0.15T iMRI.	Therapeutic / III	iMRI improved gross total resection (GTR) rates. Initial iMRI determined 45 (57%) with GTR. Among patients with detected residual (n = 34), 31 had additional resection with overall GTR achieved in 65 (82%) patients based on postoperative MRI.
Berkmann S, Schlaffer S, Nimsky C, Fahlbusch R, Buchfelder M (2014) ⁶⁴	Retrospective case series 109 NFPA undergoing surgery using 1.5T iMRI	Therapeutic /III	On the initial iMRI scans, GTR was confirmed in 19 (17%) patients. Additional resection was possible in 62 (67%) patients, resulting in a significant volume reduction and increased GTR rate (49%). After additional resection for 69% of the procedures, the GTR rate on postoperative MRI was 75%.

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Schwartz TH, Stieg PE, Anand VK (2006) ³⁵	Retrospective review of 15 (11 NFPA, 3 acromegaly, 1 resistant PRL) patients who underwent endoscopic transsphenoidal surgery with low-field 0.12T iMRI.	Therapeutic / III	iMRI demonstrated residual tumor in 3 patients with NFPA leading to further endoscopic resection of tumor. In patients with 4 NFPA, iMRI suggested the presence of residual adenoma; however, further endoscopic evaluation revealed these to be normal postoperative changes.
Ebersold MJ, Quast LM, Laws ER Jr, Scheithauer B, Randall RV (1986) ¹⁶	Retrospective analysis of 100 patients with NFPA who underwent surgical resection with median follow-up period of 73 months.	Therapeutic / III	Transsphenoidal surgery was performed in 100 patients with NFPA with use of intraoperative fluoroscopy in all cases. Surgically related mortality was 3%. One postoperative CSF leak required repeat surgery while 2 patients required permanent CSF diversion for acquired hydrocephalus related to subarachnoid hemorrhage. Among the 72 patients who presented with visual impairment, 53 had improvement and 3 had visual worsening related to the surgery. 84% GTR.