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# Intraoperative MRI for transphenoidal procedures: Short-term outcome for 100 consecutive cases

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ABSTRACT

*Background:* The majority of pituitary lesions are benign and can be cured with complete surgical resection. However, the transsphenoidal technique (the most common approach for pathology in this region) is limited by poor visualization and anatomical constraints. This can lead to incomplete tumor resection and thus increased recurrence rates. The use of iMRI during these procedures offers the advantage of radiographic confirmation during the procedure and may improve extent of resection. We reviewed our experience with this technology in 100 consecutive cases and compared the outcomes to published results.

*Methods:* 100 patients were treated via transnasal transsphenoidal approach using the GE Signa SP 0.5 Tesla (double doughnut design) iMRI system between July 2002 and August 2009 and followed prospectively. Intraoperative findings, imaging results, postoperative MRI and clinical outcome were evaluated to determine the extent of tumor resection, monitor for recurrence and determine outcome.

*Results:* There were 100 patients studied, 81 macroadenomas, 9 microadenomas, and 10 other pathological diagnosis. The average extent of resection was 96% with gross total resection based on iMRI in 76 patients (76%). Four patients (4%) all with macroadenomas greater than 4 cm experienced major perioperative complications (hydrocephalus 2, thalamic infarct 1, major arterial bleeding 1), six patients (6%) developed post-operative CSF leaks, one patient (1%) had post-operative worsening of visual fields, and five patients (5%) had abdominal fat graft infections. Nine patients (9%) including five with known residual tumor required post-operative adjuvant treatment during the follow-up period secondary to either disease progression or failure to achieve endocrinological cure.

*Conclusions:* iMRI-guided transsphenoidal pituitary surgery provides the surgeon with immediate radiographic feedback during the procedure and aides in overcoming the limitations in direct visualization during such procedures. As a result of this it may enable surgeons to perform such procedures with fewer complications and increased rate of gross total resection. However, the impact of this technology on long-term tumor control still needs to be determined with further follow-up.



## 1. Introduction

The vast majority of abnormalities occurring in the sellar/suprasellar region are benign and many can be cured with low long-term recurrence rates when a complete surgical resection is performed [1–3]. However, conventional microsurgical transsphenoidal approaches have been limited secondary to the long, narrow surgical corridor which limits lines of sight and visualization. As a result of this a majority of the intraoperative decisions regarding whether or not optimal resection has been obtained are based on tactile feedback and surgeon experience. The endoscopic approach has gained significant popularity in the past decade because of its improved visualization and ability to overcome certain of the drawbacks of microsurgical approaches. However, even with this technology gross total resection ranges from 59% to 88% and subtotal resection may occur especially in large macroadenomas with either significant supratentorial or lateral extent or in cases where bleeding obscures definitive visualization [2,4–10].

The use of intraoperative MRI for the treatment of these lesions provides surgeons real-time feedback throughout the procedure. It can be used for trajectory planning (anterior–posterior and lateral localization), determining the relationship of tumor to surrounding normal structures (especially for large macroadenomas with significant suprasellar extension or cavernous sinus invasion), and

*Abbreviations:* ACTH, adrenocorticotropic hormone; CSF, cerebrospinal fluid; DDAVP, 1-desamino-8-D-arginine vasopressin (desmopressin); DI, diabetes insipidus; GH, growth hormone; iMRI, intraoperative magnetic resonance imaging; IRB, Institutional Review Board; MRI, magnetic resonance imaging; TPH, transsphenoidal hypophysectomy.

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**Fig. 1.** The GE Signa SP 0.5 T iMRI system at Norton Hospital, Louisville, KY.

for the evaluation of the completeness of surgical resection [11–14]. The goal of this study was to evaluate the results of our prospective series using this technology for transsphenoidal treatment of sellar/suprasellar lesions.

## 2. Materials and methods

All procedures were performed in our 0.5 T "double doughnut" iMRI system (General Electric Signa SP; Milwaukee, Wisconsin) (Fig. 1). Patients requiring transsphenoidal resection for sellar lesions between July 2002 and August 2009 were considered for surgical treatment using iMRI unless there was a contraindication to MRI (5 patients) or emergent surgery was required during times when the system was unavailable (4 patients). Patients with prolactin secreting tumors were only considered candidates for surgical intervention after they failed medical management. Appropriate IRB approval was obtained prior to initiating this study and informed consent was obtained from all patients. Data was collected prospectively and stored in an electronic database, all missing information was obtained whenever possible from hospital and clinic records. Results from the intraoperative MRI scans were compared with the first postoperative MRI (typically performed between 3 and 6 months post-op) to determine whether or not there was evidence of residual disease and to verify the accuracy of iMRI in determining the extent of resection. Subsequent MRI scans were performed on a periodic basis as medically indicated to evaluate for either disease progression or recurrence. The patients overall and endocrinologic outcome was also assessed throughout the hospitalization and during each subsequent office visit.

### 2.1. Surgical technique

Patients were taken to the iMRI suite and placed on the table in supine position and then underwent induction of general anesthesia with oral tracheal intubation and packing of the oropharynx with gauze. The nasal mucosa on both sides of the septum was then infiltrated with 1% lidocaine with 1:100,000 epinephrine. The patient was positioned for the transphenoidal procedure in the bore of the magnet with the head gently extended and rotated to the right and the transmit/receive coil was placed around the patients face. Following standard prep the surgical field and magnet were draped. An incision was then made about 5 mm back from the nasal ostium typically on the right side. A submucosal flap was then developed back to the ventral aspect of the sphenoid sinus. Prior to placement of the Hardy retractor T2-weighted imaging was performed in the sagittal plane to confirm appropriate trajectory to the sellar region. During the first half of the study work in the sphenoid sinus and tumor resection was performed using the MRI compatible operating microscope (Zeiss, Oberkochen, Germany). During the later half this was typically performed using an MRI compatible endoscope (Storz, Tuttlingen, Germany).

The sphenoid sinus was opened using osteotomes and Kerrison punches. Imaging was again repeated in the sagittal and axial plane to confirm exact localization prior to removal of the bone over the ventral surface of the sella and opening of the dura. Following dural opening with a diamond knife the sellar contents were inspected and the lesion identified. The lesion was then resected using conventional techniques; for microadenomas the lesion was typically removed en bloc, cystic lesions were drained with removal of the cyst wall whenever possible. Macroadenomas were typically treated with internal debulking especially for large lesions.

Imaging was performed throughout the procedure as was deemed necessary by the surgeon. Typically this consisted of T2 weighted sagittal and coronal sequences. Further tumor resection or operative inspection was then carried out based on the results of this imaging. When it was determined that maximal resection had been obtained imaging was once again repeated this time with sagittal and coronal T1-weighted pre- and post-contrast sequences (Fig. 2). These images were immediately reviewed by the surgeon. If it was felt that a significant potentially resectable lesion persisted than this area was explored for evidence of either residual tumor or blood products, which can simulate residual tumor on intraoperative imaging.

Once resection and imaging were completed then final hemostasis was obtained with Floseal (Baxter Bioscience, Deerfield, IL) when necessary, the field was irrigated. If a fat graft was required this was obtained from harvesting it from the right lower quadrant; otherwise the dural opening was covered with Surgicel (Ethincon, Somerville, NJ) and fibrin glue (Baxter Bioscience, Deerfield, IL). The mucosal flap was reapproximated with the nasal septum being reset to the midline and rhinorockets (Shippert Medical Technologies, Centinnial, CO) were inserted in the bilateral nares and a nasal drip pad placed.

## 3. Results

A total of 100 procedures were performed using this technique during the study period. There were 53 female and 47 male patients ranging from 16 to 81 years (mean 50 years). Pathological diagnosis was pituitary adenoma 90 patients (81 macroadenomas), Rathke's cleft cyst 7 patients, meningioma 2 patients, lymphocytic hypophysitis 1 patient. The average preoperative tumor dimensions were: superior/inferior 2.1 cm (0.4–5.0 cm), lateral 1.8 cm (0.3–3.8 cm).

### 3.1. Initial clinical presentation

Eighty-one patients presented with headache, 56 with visual symptoms and five with pituitary apoplexy. Twenty-four patients had hormonally active pituitary tumors (Prolactin 14, ACTH 7, Growth Hormone 3 patients), and five patients had preoperative diabetes insipidus. Thirteen patients had undergone prior surgical treatment for their lesions and one patient had prior fractionated radiation.

### 3.2. Surgical results

The average surgical time was two hours twenty minutes (0:56–4:27) and the median length of stay was 5 days (2–33 days).

Four patients, all with giant macroadenomas 4–5 cm, suffered major peri-operative complications (4%). The first case involved a