The Value of Intraoperative Magnetic Resonance Imaging in Endoscopic and Microsurgical Transsphenoidal Pituitary Adenoma Resection

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■ BACKGROUND: **The routine use of intraoperative magnetic resonance imaging (iMRI) helps to achieve gross total resection in transsphenoidal pituitary surgery. We compared the added value of iMRI for extent of resection in endoscopic versus microsurgical transsphenoidal adenomectomy.**

■ METHODS: **A total of 96 patients with pituitary adenoma were included. Twenty-eight consecutive patients underwent endoscopic transsphenoidal tumor resection. For comparison, we used a historic cohort of 68 consecutive patients treated microsurgically. We evaluated the additional resection after conducting iMRI using intraoperative and late postoperative volumetric tumor analysis 3 months after surgery. Demographic data, clinical symptoms, and complications as well as pituitary function were evaluated.**

■ RESULTS: **We found significantly fewer additional resections after conducting iMRI in the endoscopic group ($P = 0.042$). The difference was even more profound in Knosp grade 0–2 adenomas ($P = 0.029$). There was no significant difference in Knosp grade 3–4 adenomas ($P = 0.520$). The endoscopic approach was associated with smaller intraoperative tumor volume ($P = 0.023$). No significant difference was found between both techniques in postoperative tumor volume ($P = 0.228$). Satisfactory results of pituitary function were significantly more often associated with an endoscopic approach in the multiple regression analysis ($P = 0.007$; odds ratio, 17.614; confidence interval 95%, 2.164–143.396).**

■ CONCLUSIONS: **With the endoscopic approach, significantly more tumor volume reduction was achieved before conducting iMRI, decreasing the need for further resection. This finding was even more pronounced in adenomas graded Knosp 0–2. In the case of extensive and invasive adenomas with infiltration of cavernous sinus and suprasellar or parasellar extension, additional tumor resection and increase in the extent of resection was achieved with iMRI in both groups. The endoscopic approach seems to result in better endocrine outcomes, especially in Knosp grade 0–2 pituitary adenomas.**

INTRODUCTION

Selective microsurgical transsphenoidal adenomectomy was the main operative technique for decades. The endoscopic technique has become a common alternative after its introduction and further development in transnasal transsphenoidal skull base surgery.[1,2] Improved visualization of the sella and less trauma to the nasal mucosa are potential benefits of this approach.[2] Furthermore, the endoscopic approach seems to be superior for invasive pituitary tumors.[3]

Our previously published data show that the routine use of intraoperative magnetic resonance imaging (iMRI) increases the extent of resection (EoR) and decreases the residual volume of pituitary adenomas.[4] Sylvester et al.[5] reported longer progression-free survival (PFS) in patients with gross total resection (GTR) of pituitary adenomas. Furthermore, complementarity and benefit of

Key words
- Endoscopic transsphenoidal surgery
- Intraoperative MRI
- Microsurgical technique
- Pituitary adenoma
- Tumor volume

Abbreviations and Acronyms
ACTH: Adrenocorticotropic hormone
CI: Confidence interval
CSF: Cerebrospinal fluid
EoR: Extent of resection
GH: Growth hormone
GTR: Gross total resection
iMRI: Intraoperative magnetic resonance imaging
MRI: Magnetic resonance imaging
OR: Odds ratio
PFS: Progression-free survival

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a combined approach with iMRI and endoscopy has been reported.[5]

In this study, we evaluated the influence of surgical technique and additional use of iMRI on EoR and residual tumor volume in iMRI and postoperative magnetic resonance imaging (MRI) in transnasal transsphenoidal pituitary surgery. In addition, we have evaluated pituitary function, postoperative tumor volume, and surgical complications.

METHODS

Patients and Follow-Up Assessment

Patients operated on for pituitary adenoma between 2009 and 2016 were assessed retrospectively. An endoscopic transsphenoidal approach has been performed at our department since 2015 by 2 neurosurgeons without previous experience with the endoscopic technique. Since then, elective patients with pituitary adenoma have been treated with this approach. A historic cohort of 68 consecutive patients treated microsurgically were used for evaluation. The transsphenoidal microsurgical adenomectomy was performed by 3 neurosurgeons experienced in the microsurgical approach. Follow-up assessment including clinical and endocrine status as well as MRI was performed at 3 months after surgery. Preoperative MRI included coronal T2-weighted turbo spin echo as well as coronal, axial, and sagittal T1 sequences with and without gadolinium enhancement. The Knosp classification was used to stratify the invasive growth pattern of adenomas in the cavernous sinus. Endocrine function was evaluated in cooperation with endocrinologists in a multidisciplinary approach before and after surgery. Preservation, worsening, or improvement of pituitary function was reexamined in 4–6 weeks and in 3–6 months after surgery. In addition to standard monitoring of pituitary hormone levels, a hypoglycemic test was mostly used for determination of cortisol and growth hormone (GH) dynamics under stress conditions. For statistical analysis, we defined improvement or stable postoperative pituitary function compared with preoperative examination as a satisfactory result. The worsening of pituitary function was considered an unsatisfactory result. Remission in patients with acromegaly was defined as a normal insulinlike growth factor 1 level and either a suppressed GH level <0.4 ng/mL during an oral glucose tolerance test or a GH level <1.0 ng/mL in random examination. Remission in patients with Cushing disease was defined if cortisol substitution was necessary or if morning cortisol level was in the normal range.

Operating Room Setup and MRI

An intraoperative 1.5-T MRI Espree scanner has been available (Espree [Siemens AG, Erlangen, Germany]) at our department as a 1-room solution since October 2008. The analysis of intraoperative residual tumor was performed on thin-slice (2 mm) high-resolution coronal T2 and contrast-enhanced T1 images using Brainlab iPlan 3.0 (Brainlab AG, Feldkirchen, Germany). Postoperative MRI was performed 3 months after surgery. Preoperative and postoperative MRI was performed either with the intraoperative scanner or with the 1.5-T MRI Symphony system (Siemens AG, Erlangen, Germany).

MRI Volumetric Assessment

Tumor volume was measured after image fusion using iPlan 3.0. Tumor borders were segmented manually on coronal or sagittal T2 and T1 images with gadolinium enhancement. Intraoperative MRI data as well as MRI data 3 months after surgery were used for the analysis.

Surgical Procedure

A binasal transsphenoidal approach was performed in all endoscopic cases. We started using this technique in 2015. Rigid 0°, 30°, and 45° endoscopes with a 4-hands technique and Brainlab iPlan navigation system were used intraoperatively. In the case of invasive adenomas with skull base infiltration, extended endoscopic approaches in cooperation with ear, nose, and throat surgeons were used. Skull base reconstruction was performed with fibrin-coated sponge in the case of small or no intraoperative cerebrospinal fluid (CSF) fistula. Large defects were sealed using a multilayer technique with abdominal subcutaneous fat graft and fibrin-coated sponge or a Hadad flap.[6] The microsurgical procedure was performed with a unilateral transnasal paraseptal and submucosal approach.[1,7]

Surgical Complications

Postoperative meningitis was defined when antibiotic treatment was initiated because of typical clinical signs of meningeal inflammation even if no pathogen was isolated. CSF fistula was considered as a complication if a lumbar drain or revision surgery was necessary. Furthermore, intraoperative and postoperative bleeding, thromboembolic complications, and new transient or permanent neurologic deficits were included.

Data Analysis

The data of 96 patients were evaluated retrospectively. Statistical analysis was performed using SPSS 21.0 (IBM Corp., Armonk, New York, USA). Mann-Whitney U and Fisher exact tests were used for the analysis. Furthermore, univariate and multiple regression models for GTR after iMRI and after surgery as well as for endocrine outcome were built. Influencing variables were preoperative tumor volume, surgical technique, Knosp grade, age, gender, and recurrent surgery. The study was conducted according to the international Declaration of Helsinki. The approval of the local ethics committee was obtained (number 137/16).

RESULTS

Patient Characteristics

A total of 96 patients treated with pituitary adenoma were assessed. A mean age of 54 years (range, 7–78 years) was noted. Males were mostly treated (74%, $n = 71$). The demographic data are summarized in **Table 1**.

Tumor Characteristics and Surgical Procedure

The most common histologic subtype was nonfunctioning adenoma ($n = 65$, 67.7%) followed by GH-secreting ($n = 16$, 16.7%) and adrenocorticotropic hormone (ACTH)-secreting adenoma ($n = 10$, 10.4%; **Table 1**). Forty-nine patients (51%) were graded according to Knosp classification as 0–2 (34 microsurgical, 15 endoscopic) and 47 (49%) as grade 3–4 (34 microsurgical,