2007

Preliminary Experience With 3-Tesla MRI and Cushing's Disease

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TECHNICAL NOTE

Preliminary Experience with 3-Tesla MRI and Cushing's Disease

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ABSTRACT

Because radiographic visualization of a pituitary microadenoma is frequently difficult, we hypothesized that microadenomas associated with Cushing's disease may be better resolved and localized via acquisition with 3-Tesla (3T) compared with standard 1.5-Tesla (1.5T) magnetic resonance imaging (MRI). Five patients (four females, one male; age range, 14 to 50 years old) with endocrine and clinical confirmation of Cushing's disease underwent 1.5T and 3T MRI and corticotropin-releasing hormone stimulation/inferior petrosal sinus sampling (IPSS) as part of their preoperative evaluation. All patients underwent a transnasal trans-sphenoidal pituitary adenomectomy. In two cases, tumor could not be localized on either 1.5T or 3T MRI on the initial radiologist's review. In two other cases, the 1.5T images delineated the tumor location, but it was more clearly defined on 3T MRI. In a fifth case, the 1.5T MRI showed a probable right-sided adenoma. However, on both 3T MRI and at surgical exploration the tumor was localized on the left side. Therefore, in three of five cases, 3T MRI either more clearly defined tumors seen on 1.5T MRI or predicted the location of tumor contrary to the 1.5T images. IPSS identified the correct side of the tumor in two patients, an incorrect location in two patients, and was indeterminate in one patient. In certain cases 3T MRI is a new tool that may ameliorate imaging difficulties associated with adrenocorticotrophic hormone-secreting pituitary adenomas. Its role in the diagnostic evaluation of Cushing's disease will be better defined with further experience.

KEYWORDS: 3-Tesla MRI, Cushing's disease, pituitary gland, imaging

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Skull Base 2007;17:273–278.

Received: May 4, 2007. Accepted: May 15, 2007. Published online: July 18, 2007.
DOI 10.1055/s-2007-985196. ISSN 1531-5010.

Surgical exploration for Cushing's disease in the absence of confirmation by imaging or lateralization by inferior petrosal sinus sampling (IPSS) can lower cure rates.[1–3] Although standard magnetic resonance imaging (MRI) scanners use 1.5T magnets, MRI with stronger magnetic field strength may offer improved image quality and spatial resolution in conditions with subtle differences between normal and abnormal tissue.[4,5] We hypothesized that microadenomas associated with Cushing's disease might be visualized with better resolution and accuracy using high-strength MRI. We present five cases of adrenocorticotrophic hormone (ACTH)-secreting adenomas that showed ambiguous radiographic evidence of tumor on standard MRI. Subsequently, 3T MRI was used to assess the utility of this modality in identifying adenomas associated with Cushing's disease.

MATERIALS AND METHODS

Patients

Five patients (four females, one male; age range, 14 to 50 years old) with endocrine and clinical confirmation of Cushing's disease underwent 1.5T and 3T MRI as part of their preoperative evaluation. Their hospital and office clinic records were reviewed retrospectively. At presentation, their symptoms included hypertension, truncal obesity, headaches, buffalo hump, moon facies, abdominal striae, and hypertension. All patients underwent corticotropin-releasing hormone stimulation and IPSS, which was lateralized in four patients. In the fifth patient, asymmetric venous anatomy precluded left-sided sampling. All patients underwent a transnasal, trans-sphenoidal pituitary adenomectomy.

Magnetic Resonance Imaging Technique

Conventional 1.5 T MRI was performed at outside imaging facilities, and films were reviewed. 3T scans were obtained from a GE (General Electric, Milwaukee, WI) 3T MRI scanner running VH3 level software. Pre- and postcontrast MRIs were obtained using an inversion prepared three-dimensional (3D) spoiled gradient-recalled (MPRAGE) sequences in the coronal plane. The scan parameters were as follows: repetition time = 5.2 milliseconds; inversion preparation time = 300 milliseconds; echo time = 2.1 milliseconds; flip angle = 13 degrees; slice thickness = 1.8 mm; field of view (FOV) = 24 cm; scan matrix = $256 \times 256 \times 63$ at FOV in phase; reconstruction matrix = $512 \times 512 \times 124$; number of excitations (NEX) = 2; and relative bandwidth (rBW) = 63.4 kHz. Imaging findings were based on the radiologists' official report at the time of the study (Table 1).

Table 1 Patient Characteristics, Tumor Imaging Results, and Inferior Petrosal Sinus Sampling Lateralization

Patient	Age/Sex	1.5T MRI	3T MRI	IPSS	Surgical Location of Tumor	Retrospective Reanalysis
1	37/F	Stalk deviation	Hypodensity Rt anterior	Lt side	Rt anterior	Better delineated on 3T
2	14/F	Enlarged, symmetric gland	Enlarged, symmetric gland	Rt side	Anterior midline	Indeterminate on 1.5T or 3T
3	35/F	Slight Lt hypodensity	Clear Lt hypodensity	Lt side	Lt side	Better delineated on 3T
4	50/F	Indeterminate	Indeterminate	Lt side	Lt side	Indeterminate on 1.5T or 3T
5	34/M	Rt-sided tumor	Lt-sided tumor	Equivocal	Lt side	Better delineated on 3T

T, Tesla; IPSS, inferior petrosal sinus sampling; F, female; M, male; Lt, left; Rt, right.

RESULTS

Imaging Outcomes

Based on the 1.5T MRI studies, two patients (cases 1 and 3, Table 1) had correctly lateralized lesions, two patients (cases 2 and 4) had indeterminate lesions, and one patient (case 5) had an incorrectly lateralized lesion. Based on the 3T MRI, two patients (cases 1 and 3, Fig. 1) had adenomas more clearly delineated than on 1.5T MRI, two patients (cases 2 and 4, same as 1.5T MRI) had adenomas in indeterminate locations (Fig. 2), and one patient (case 5) had an adenoma correctly lateralized on the left (Fig. 3). In the latter, 1.5T MRI had incorrectly identified the adenoma as "probable" on the right side. IPSS identified the correct side of the tumor in two patients (cases 3 and 4), an incorrect location in two patients (cases 1 and 2), and an indeterminate location in one patient (case 5) due to venous asymmetry.

A retrospective, side-by-side comparison of 1.5T and 3T MRI was performed by a neuroradiologist (JK). In two cases, evidence of tumor and its location was perceptible and accurate on 1.5T MRI. However, in these same cases, 3T MRI better delineated the lesions. In cases 2 and 4, both 1.5T and 3T MRI failed to identify the presence and location of the tumor. In one of these cases, the intrasellar contents were clearly enlarged and abnormal, but no definite tumor mass could be perceived. In one case (case 5), the tumor was difficult to ascertain on 1.5T MRI but was well delineated as left-sided on 3T MRI. This left-sided abnormality was confirmed at surgery (Table 1).

Clinical Outcomes

In all cases, the location of the adenoma and neoplastic tissue with ACTH-immunoreactivity was confirmed histologically. During a brief follow-up (range, 5 to 12 months), no patient has shown evidence of recurrent or residual disease.

DISCUSSION

Unfortunately, absent radiographic evidence of tumor is often associated with Cushing's disease.[6] In such cases, IPSS remains a useful tool in

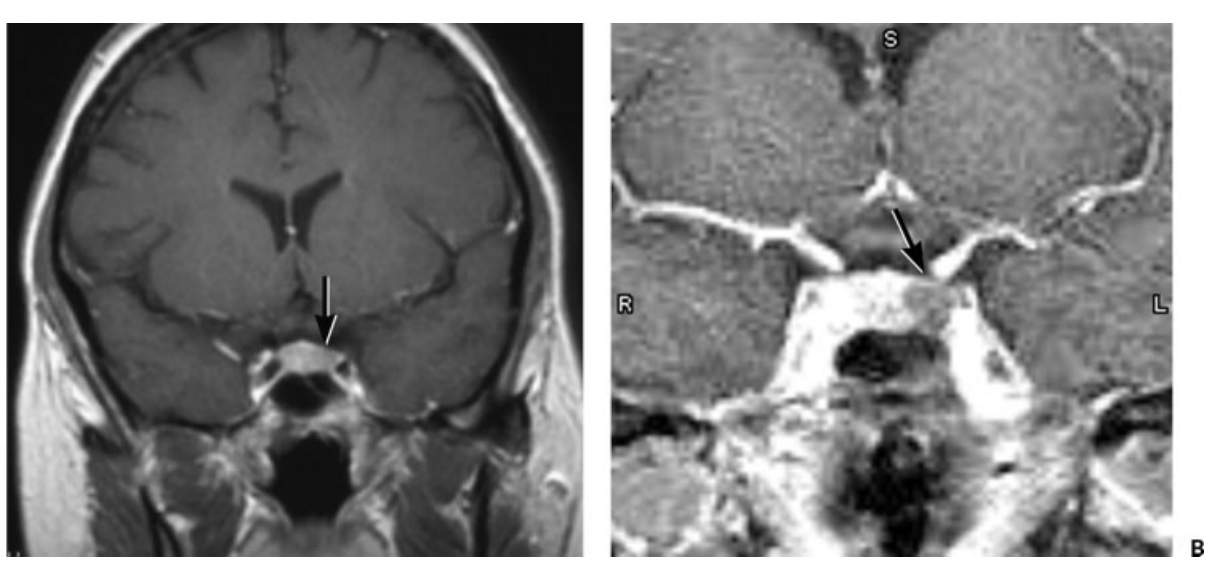

Figure 1 (Case 3) (A) T1-weighted coronal 1.5T MRI with contrast shows slight hypointensity on the left side of the sella (arrow) consistent with a left-sided pituitary mass. (B) T1-weighted 3T coronal MRI with contrast shows marked differentiation of the hypointense tumor (arrow) and surrounding normal gland.

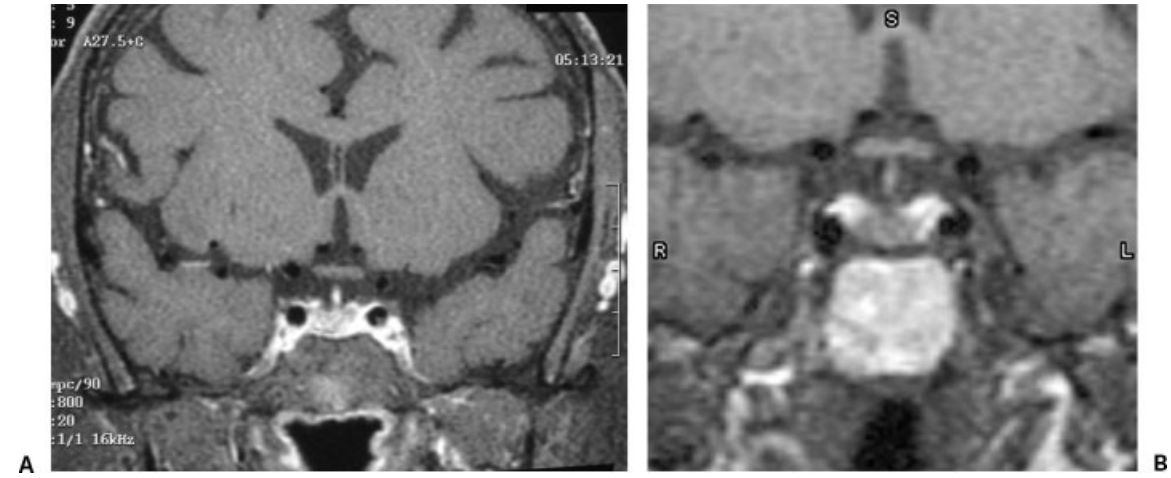

Figure 2 (Case 4) (A) T1-weighted coronal 1.5T MRI and (B) 3T MRI with contrast show enhancement of the intrasellar contents with no clear radiographic definition of the tumor. IPSS indicated a strong left-sided ACTH gradient with a high central-to-peripheral ratio. A left-sided ACTH-secreting adenoma was confirmed at surgery. IPSS, inferior petrosal sinus sampling; ACTH, adrenocorticotropic hormone.

the diagnostic algorithm; however, its potential for inaccuracy is well documented.[7–9] Given these shortcomings, that the improved resolution and image quality afforded by 3T MRI might better differentiate ACTH-secreting microadenomas from normal gland is an attractive hypothesis.

Wolfsberger et al[10] used T1-weighted 3D magnetization-prepared rapid-acquisition gradient-echo sequences on 3T MRI to study 42

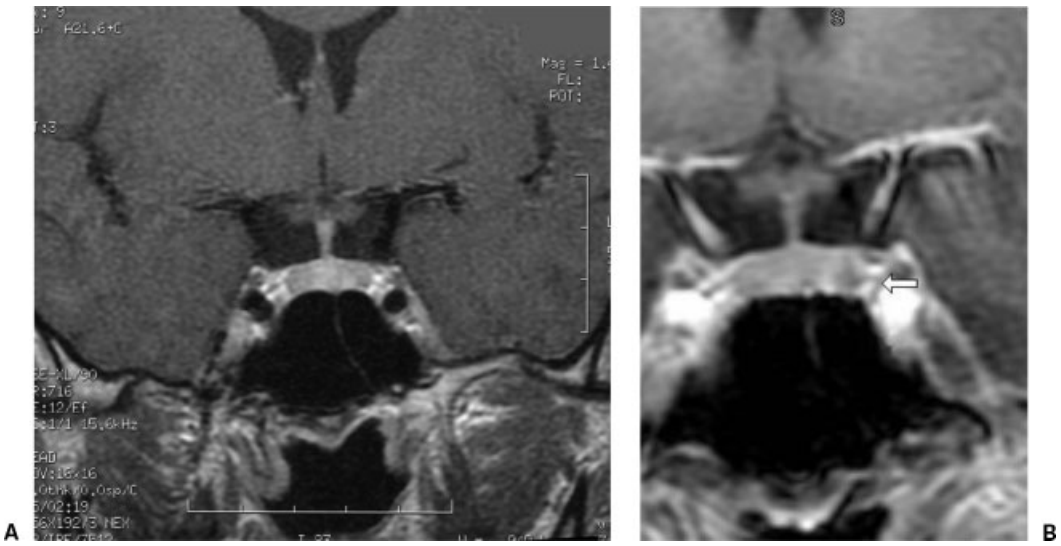

Figure 3 (Case 5) (A) T1-weighted coronal 1.5T MRI with contrast shows no clear tumor margins. The radiologist's interpretation stated ''probable 5.5-mm right-sided pituitary adenoma.'' IPSS could only be obtained on the right side. (B) T1-weighted coronal 3T MRI shows a left-sided hypointensity relative to the surrounding enhancing gland (arrow). This finding is consistent with a pituitary microadenoma, which was confirmed during surgical exploration. IPSS, inferior petrosal sinus sampling.

cavernous sinuses. This modality was used to minimize susceptibility artifacts in the sellar and parasellar region. They concluded that 3T MRI provided superior delineation of an intrasellar tumor involved with the cavernous sinus compared with standard MRI techniques. However, they did not compare standard MRI to 3T MRI with respect to specific tumor types. In fact, the literature lacks any discussion of the potential advantages of 3T MRI compared with 1.5T MRI in identifying ACTH-secreting pituitary adenomas.

Our small and highly selected population precludes strong conclusions. Nonetheless, 3T MRI either further delineated or newly demonstrated a pituitary microadenoma in three of the five cases, even though the findings were equivocal in the remaining two cases. In comparison, 1.5T MRI predicted two cases correctly, two equivocally, and one incorrectly. IPSS predicted two cases correctly and two incorrectly; one was technically infeasible. IPSS correctly lateralized the tumor in case 4 but was inaccurate in case 2. Interestingly, 1.5T MRI (case 5) and IPSS (case 1) incorrectly lateralized the tumor in one case each. Although 3T did not incorrectly lateralize a tumor, it failed to determine the site of tumor in two cases. Both 1.5T and 3T MRI were equivocal in the same two cases (cases 2 and 4).

That 1.5T and 3T MRI were indeterminate in the same two cases indicates that certain ACTH-secreting microadenomas will likely continue to be indistinguishable from adjacent normal gland, irrespective of the magnet strength used in MRI. When, however, a subtle imaging abnormality exists (e.g., cases 1 and 3), the increased magnetic strength of the 3T scanner may be superior to 1.5T in amplifying these radiographic differences. On the basis of case 5, some adenomas appear to be radiographically indeterminate on 1.5T MRI yet determinate on 3T MRI. Undoubtedly, the subtle differences between 1.5T and 3T MRI will be exploited as refinements in head coils and imaging sequences are introduced.

CONCLUSIONS

In certain cases, the new tool of 3T MRI may ameliorate the imaging difficulties associated with ACTH-secreting pituitary adenomas. Although the role of 3T MRI needs to be further defined, the modality may be a useful adjunct in the evaluation algorithm for Cushing's disease and in planning the management of certain cases.

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