AJNR

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AJNR Am J Neuroradiol 1988, 9 (2) 279-285
http://www.ajnr.org/content/9/2/279

High-Resolution MR Imaging of Juxtasellar Meningiomas with CT and Angiographic Correlation

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The purpose of this study was to compare the relative merits of MR imaging, CT, and angiography in the preoperative evaluation and postoperative follow-up of patients with juxtasellar meningiomas. High-resolution MR studies in nine patients with juxtasellar meningiomas were evaluated and compared with CT and angiography. The techniques were compared for the evaluation of suprasellar, parasellar, and intrasellar extension, as well as for vascular displacement or encasement, postoperative recurrence or residual calcification, and bone changes. MR provided additional information considered significant by the neurosurgeon when compared with CT, and MR was considered superior to CT in the juxtasellar area. Although MR does not obviate angiography, in many cases angiographic findings were predictable by MR.

Before MR imaging, juxtasellar meningiomas were evaluated by high-resolution axial CT images before and after administration of IV contrast material and by angiography [1–4]. Reformatted images in the sagittal and coronal planes or direct coronal images were included in the CT evaluations. Water-soluble contrast cisternography without [5] or with [6] CT has been found useful in assessing juxta- or suprasellar lesions, but this is an invasive procedure. Recent studies assessing MR in the evaluation of meningiomas in various locations have resulted in varying opinions as to its usefulness [7, 8]. Our study concentrates on juxtasellar meningiomas, where MR is more effective owing to the inherent contrast provided by cisternal CSF, meningeal structures such as the diaphragma sellae and lateral wall of the cavernous sinus, and flow-void phenomena in adjacent vessels. Similarly, recent studies concerning the evaluation of juxtasellar abnormalities [9–15] have not concentrated specifically on meningiomas, although some of the studies have included some meningiomas [10, 12, 13, 15].

Materials and Methods

High-resolution MR studies of the juxtasellar region were performed in nine patients (Table 1). On the basis of prior CT evaluations, eight of the nine patients were suspected of having meningiomas, and one was thought to have a pituitary adenoma. In four patients, previous surgery yielded pathologic proof of meningioma before the MR evaluation. MR was performed in these patients for reasons of postoperative follow-up, analysis of recurrent or additional symptoms, or as a baseline MR study to be used for comparison with future follow-up studies. These patients had been evaluated preoperatively by CT and angiography. In four patients preoperative MR was followed by surgical and pathologic proof of meningioma. In three of these CT findings prior to MR were thought to be compatible with meningioma, and in one CT findings initially were thought to represent a pituitary adenoma with suprasellar extension. No presumptive diagnoses of juxtasellar meningioma were based on MR criteria alone unless supported by prior CT. One patient (case 6) evaluated by both MR and CT improved clinically and refused surgery. Since this diagnosis is still in doubt, this is the only case that could possibly be considered false positive.

High-resolution MR images were obtained by using a 1.5-T GE Signa system. Sagittal and

Received March 2, 1987; accepted after revision October 21, 1987.

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AJNR 9:279–285, March/April 1988
0195–6108/88/0902–0279

coronal 3-mm slices were acquired with a 0.6-mm interslice gap, a 16-cm field of view, and an acquisition matrix of 256 × 128. Initial sagittal T1-weighted spin-echo images were obtained with a repetition time (TR) of 800 msec and an echo time (TE) of 20 msec. Coronal spin-echo images were obtained with a multislice variable-echo technique with TR = 2000 msec, TE = 20 and 80 msec, providing spin-density ("balanced") and T2-weighted images, respectively. Axial images were also obtained in some cases.

CT scans were obtained on GE 8800 or 9800 scanners with slice thicknesses of 1.5–10 mm. Direct coronal images and reformatted sagittal and coronal images were obtained in some cases.

TABLE 1: MR, Surgical, CT, and Arteriographic Studies in Juxtasellar Meningioma

Study	No. of Patients
MR:	
Postoperatively only	4
Pre- and postoperatively	3
Preoperatively only	2
Total	9
Surgery:	
Proved meningioma	8
Refused	1
Total	9
Preoperative arteriography	9
CT:	
Preoperatively only	7
Pre- and postoperatively	2
Total	9

Preoperative transfemoral catheter angiography was performed in all cases with selective internal and external carotid injections when possible. Biplane conventional-cut film changers were used.

Results

The findings are recorded in Table 2 and condensed in Table 3, which provides a direct comparison of CT and MR. In each case the extraaxial nature of the mass was indicated about equally by MR and CT. Helpful MR criteria were the broad, dural-based edge; CSF cleft; pial vascular rim; and arcuate bowing and compression of adjacent brain convolutions at the margins of the tumor, as has been described by

TABLE 3: Relative Merits of MR and CT in Assessing Juxtasellar Meningiomas

Finding	No. of Cases (n = 9)		
	CT Superior	CT Equal to MR	MR Superior
Extraaxial nature of mass	0	9	0
Suprasellar involvement	0	0	7
Parasellar involvement	0	3	0
Intrasellar involvement	0	0	7
Calcification	2	1	0
Hyperostosis, blistering, or other bone changes	4	2	0
Postsurgical changes	0	0	4
Vascular displacement or encasement	0	0	4

TABLE 2: Findings in Juxtasellar Meningiomas

	Case No.								
	1	2	3	4	5	6	7	8	9
Location	TS	TS	CS	TS	OG	SOF	PS	PF	TS
Angiography	+[a]	+	+	+	+	+	+	+	+
CT	+[b]	+	+	+	+[a]	+	+[a]	+	+[a]
MR findings:									
Extraaxial nature of mass	+	+	+	+	+	+	+	+	+
Suprasellar involvement	+	+	−	+	+	−	+	+	+
Laterosellar involvement	−	−	+	−	−	+	−	+	−
Intrasellar involvement	+	+	+	+	+	−	+	−	+
Intense on T2-weighting	−	−	−	+	−	+	+	−	−
Calcification:									
CT	+	−	−	+	−	−	−	+	−
MR	−	−	−	−	−	−	−	+	−
Hyperostotis, blistering, or other bony changes:									
CT	+	−	+	+	+	+	−	+	−
MR	−	−	+	±	±	−	−	+	−
Postoperative changes	+	−	−	−	+	−	−	+	+
Vascular encasement	+	−	+	−	−	−	+	−	+

Note.—TS = tuberculum sellae; CS = cavernous sinus; OG = olfactory groove; SOF = superior orbital fissure; PS = planum sphenoidale; PR = petrous ridge; + = study performed or finding present; − = study not performed or finding not present; ± = equivocal finding. Findings not elucidated above include adjacent brainstem infarcts on postoperative MR (case 1), surgical clip artifacts (cases 1 and 5), CT diagnosis of pituitary adenoma (case 2), encasement of cavernous and petrous carotid carotid arteries and third nerve palsy (case 3), allergy to contrast material (case 4), refusal of surgery and diplopia (case 6), elevation of A1 segment of anterior cerebral artery (case 7), clear definition of diaphragma sellae (case 8), and encasement of left supraclinoid internal carotid artery (case 9).

[a] Preoperatively only.

[b] Pre- and postoperatively.

others. In comparison, CT criteria for identification of meningioma included initial increased density; dural attachment; bone changes; calcification; homogeneous, intense contrast enhancement; and surrounding edema.

Although suprasellar extension of the mass could be identified by CT, involvement of the optic nerve(s) and chiasm was identified more accurately by MR in all cases with suprasellar involvement. MR also provided more accurate information than CT on the impact of the mass on the inferior recesses of the third ventricle and hypothalamus. Therefore, MR was considered superior to CT in the evaluation of suprasellar extension.

In each case of intrasellar extension of meningioma, the pituitary tissue could be identified by MR as a separate entity, ruling out pituitary adenoma. The mass in case 2, thought to represent pituitary adenoma with suprasellar extension on the basis of CT findings, was clearly identified by MR to be an extrasellar meningioma with intrasellar extension (Fig. 1). Often the diaphragma sellae and/or a cleft of CSF could be seen to be separating the intrasellar component of meningioma above from the pituitary tissue below. An example of this is shown in Figure 2.

Although parasellar extension was evaluated quantitatively about equally well by CT and MR, CT failed to demonstrate the intrasellar component in the only case in which it was present (Fig. 3). The flow-void phenomenon readily identifies the carotid arteries within the cavernous sinus, and therefore the qualitative effect of vascular encasement there is identified by MR. This may not be possible with CT because both the cavernous sinus and intracavernous carotid arteries enhance after administration of contrast material. Thus, MR demonstrated extension of the meningioma into the carotid canal

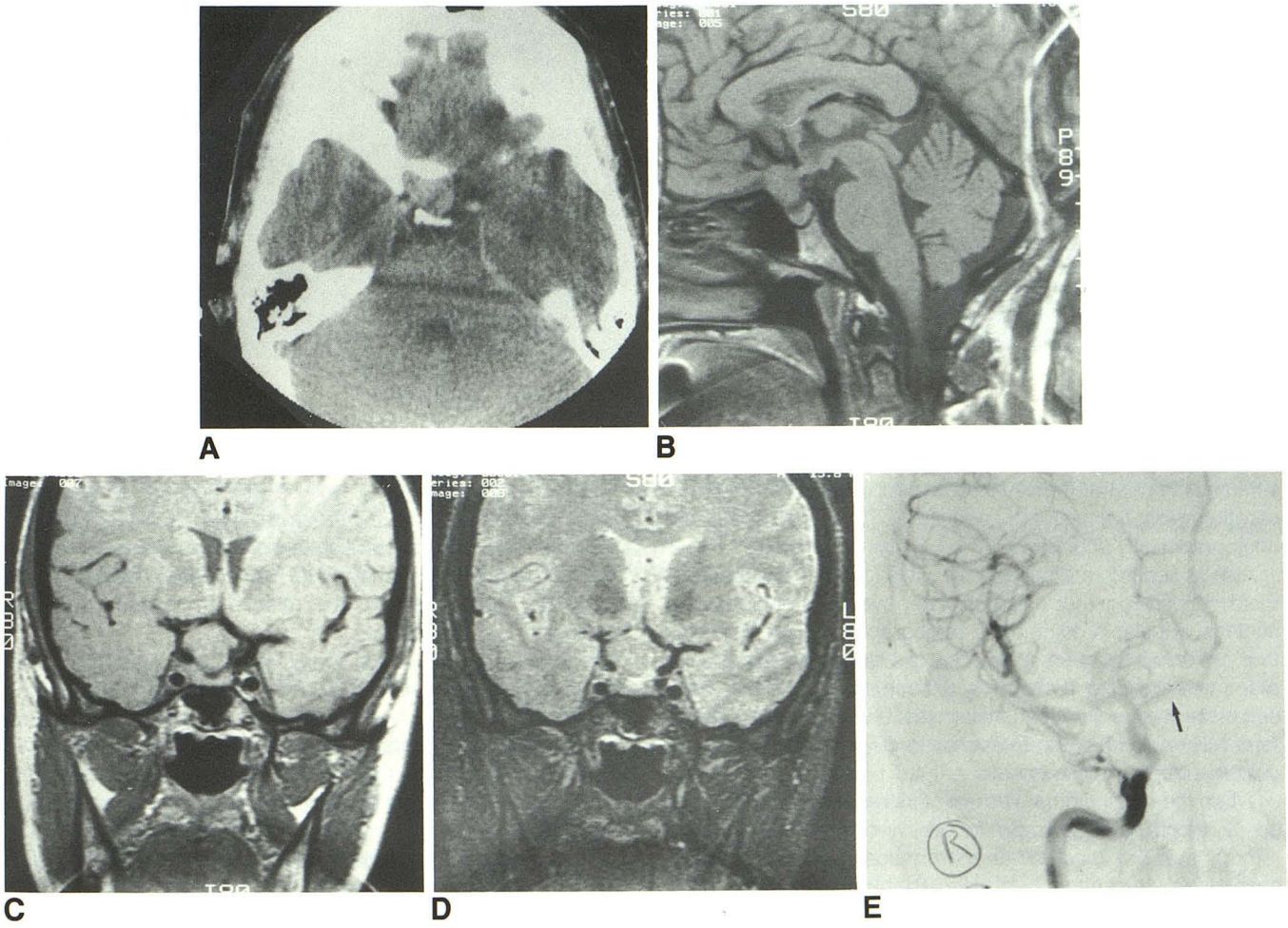

Fig. 1.—Case 2: tuberculum sellae meningioma.

***A*, Axial contrast-enhanced CT scan shows enhancing mass within sella.**

***B*, Sagittal T1-weighted MR image reveals that mass is of suprasellar origin with intrasellar extension. Pituitary tissue is separated from mass by CSF cleft.**

***C*, Coronal spin-density MR image confirms suprasellar mass and its impact on optic chiasm lying above pituitary gland. A1 segments of anterior cerebral arteries are elevated by mass.**

***D*, Coronal T2-weighted MR image confirms CSF cleft as high-signal-intensity area between mass and pituitary tissue.**

***E*, Arteriogram confirms elevation of A1 segment of right anterior cerebral artery (*arrow*). Left A1 segment (not illustrated) also was elevated.**

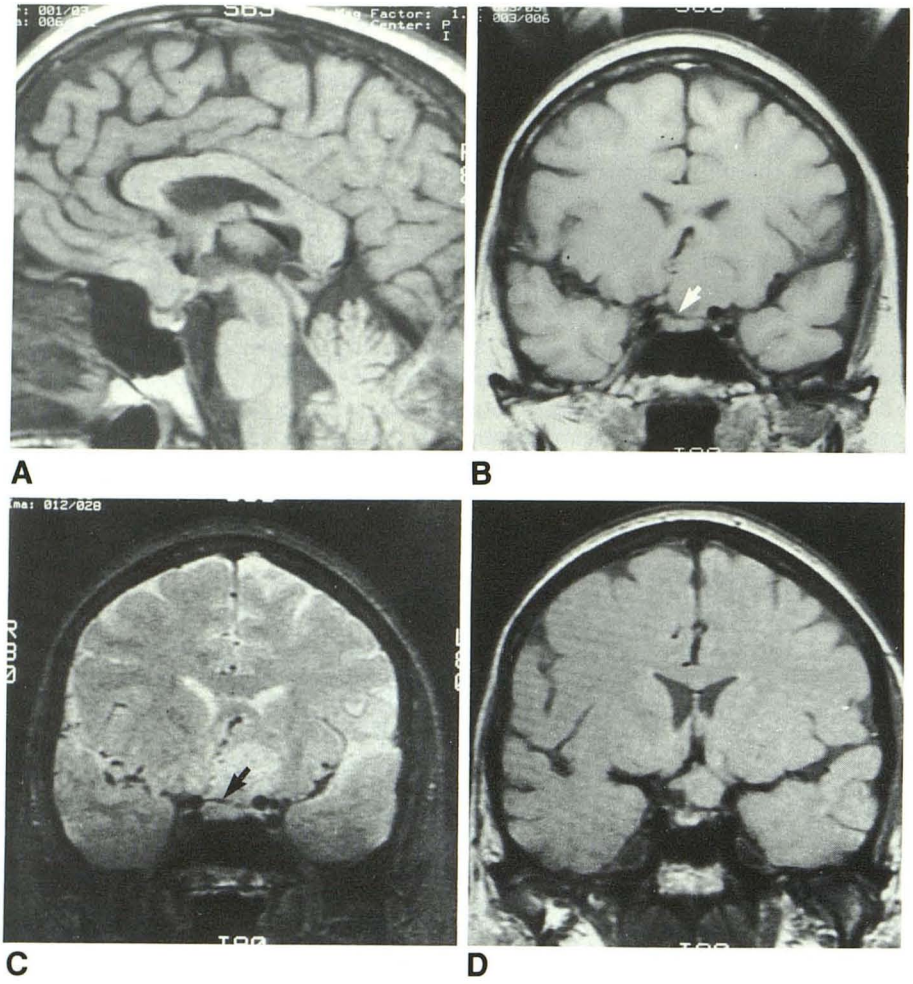

Fig. 2.—Case 7: planum sphenoidale meningioma.

***A*, Sagittal T1-weighted MR image shows suprasellar mass with intrasellar extension lying above intact pituitary gland.**

***B*, Coronal spin-density MR image shows diaphragma sellae between mass and pituitary gland (*arrow*). Extraaxial nature of mass can be appreciated.**

***C*, T2-weighted coronal MR image shows moderate increase in signal intensity within mass. Diaphragma sellae is again identified between tumor and pituitary tissue (*arrow*).**

***D*, Spin-density coronal MR image clearly shows impingement on optic chiasm.**

with encasement of the cavernous and precavernous internal carotid artery; this was not seen with CT, but was confirmed angiographically (Fig. 3).

Also in regard to angiographic displacement and encasement, MR findings not only correlated well with angiographic findings, but also predicted the angiographic results. This was true not only in the parasellar area, but also in the suprasellar area, where again it may be difficult for CT to separate enhancing tumor from enhancing vasculature (Fig. 4). Therefore, MR was considered superior to CT in defining vascular displacement or encasement.

When the meningioma was not of increased signal intensity on T2-weighted images, postoperative residual or recurrent tumor could be differentiated from postoperative changes such as gliosis or encephalomalacia, which were of increased signal intensity on T2-weighted images. This was helpful in all four of our postoperative evaluations, as illustrated in Figure 4. A single metallic surgical clip in case 5 did not significantly alter the MR interpretation (Fig. 5). Associated brainstem infarcts identified by MR in case 1 were not identified by CT.

Although bone changes such as hyperostosis and blistering may not be seen equally well on MR and CT, in one case (case 3) the sphenoid hyperostosis was seen well on both MR and CT. Tumoral calcifications were not seen as well on MR as on CT unless they were very dense, coalescent, or massive. Table 3 shows the relative occurrence of these findings.

Discussion

Juxtasellar meningioma is a pathologic process frequently amenable to surgical therapy. Defining the optic nerve may be the most important preoperative objective of an imaging study, particularly as to whether there is involvement of the intra- or extracranial portions, which would influence surgical planning. MR appears to be clearly superior to other techniques in defining the extent of impact of juxtasellar masses on the optic nerves, chiasm, hypothalamus, and inferior recesses of the third ventricle [6, 8].

We believe that MR did not obviate preoperative angiography. In particular, we were interested in the source and amount of blood supply and/or vascularity of the tumor. Whether there was any significant contribution by external

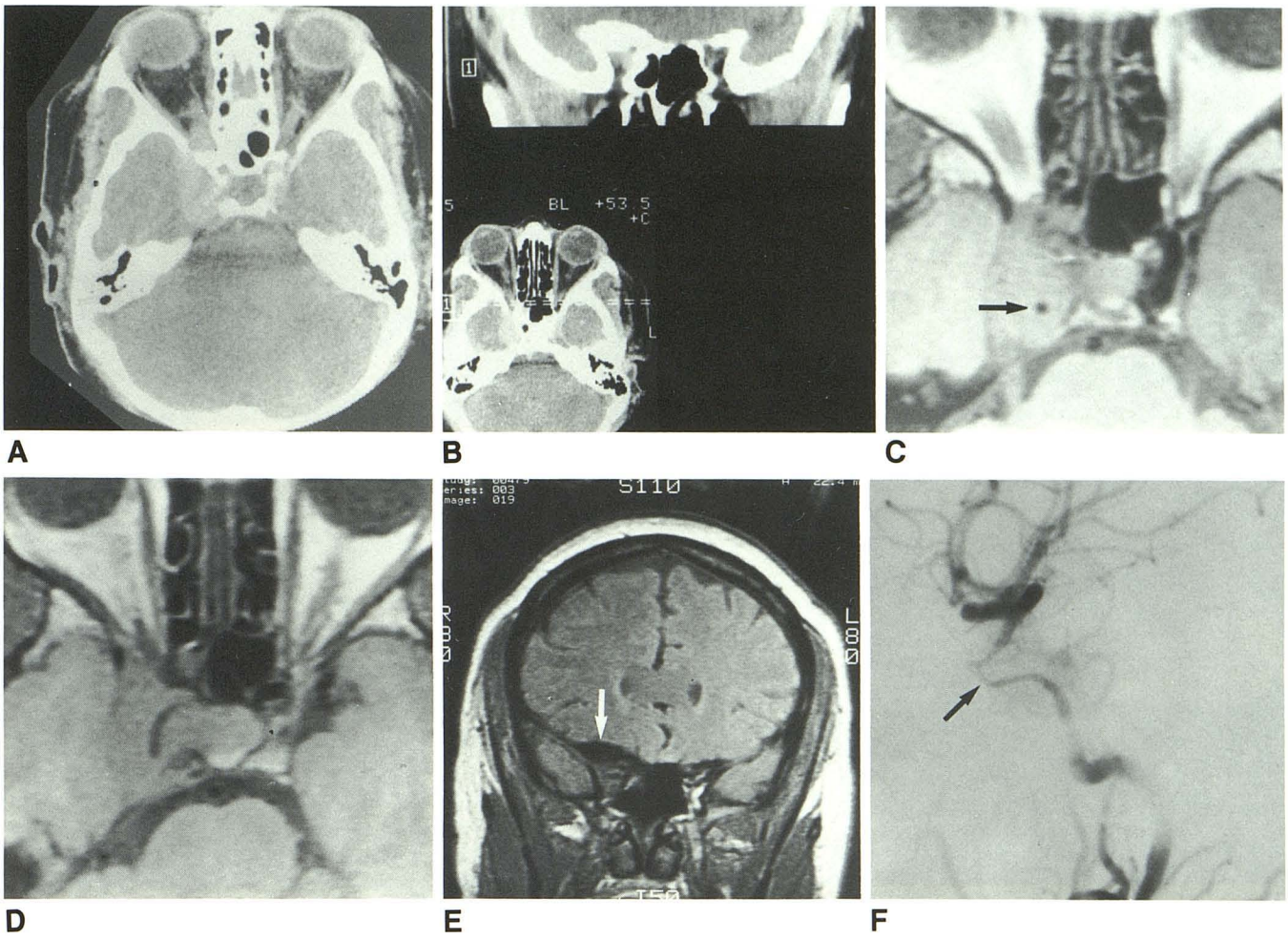

Fig. 3.—Case 3: cavernous sinus meningioma.
***A*, Axial contrast-enhanced CT scan shows enhancing mass expanding right cavernous sinus and extending into right orbital apex.**
***B*, Coronal reformatted contrast-enhanced CT scan shows hyperostosis of right sphenoid bone.**
***C*, Axial spin-density MR image shows tumor mass in right cavernous sinus with encasement of precavernous and cavernous portions of right internal carotid artery (*arrow*). Lateral wall of cavernous sinus separates tumor from temporal lobe.**
***D*, Axial spin-density MR image reveals encasement of cavernous portion of right internal carotid artery, as well as intrasellar and intraorbital extension.**
***E*, Spin-density coronal MR image shows hyperostosis of sphenoid bone (*arrow*) and correlates well with coronal CT scan.**
***F*, Lateral arteriogram confirms encasement of precavernous and cavernous portions of right internal carotid artery (*arrow*).**

carotid sources might be important in terms of potential preoperative embolization. However, external carotid blood supply may be minimal to absent in juxtasellar meningiomas. In addition, we were interested in vascular displacement or encasement, as well as in collateral routes of circulation in case a vessel had to be sacrificed at surgery. In case 1 (Fig. 4) the left A1 segment of the anterior cerebral artery was displaced upward and was small, either from encasement or hypoplasia. However, both left and right anterior cerebral arteries were filled from the right carotid injection. The surgery necessitated sacrifice of the left A1 segment owing to tumor adherence. Follow-up studies revealed a small infarct in the left caudate head owing to interruption of the recurrent artery of Heubner. There was no significant neurologic deficit, however, apparently because of the collateral routes preserving the majority of the left anterior cerebral circulation, as shown angiographically. It is also helpful to be absolutely certain that the lesion in question in this area does not represent aneurysm, although a fairly high level of confidence is possible with MR. It should be emphasized that the angiograms in our series were obtained for the purposes of surgical planning more than for diagnosis.

While bone changes such as hyperostosis, blistering, and calcification may not be seen as well with MR as with CT, this does not appear to detract significantly from the ability of MR to define the nature of the mass in the juxtasellar area. As the CT evaluation of meningioma generally requires IV contrast material, MR would be the obvious choice for pre- and postoperative evaluation of patients who are allergic to contrast material, such as with case 4 in our series. Allergy to contrast material may not necessarily contraindicate angiography, depending on the type of previous reaction, as

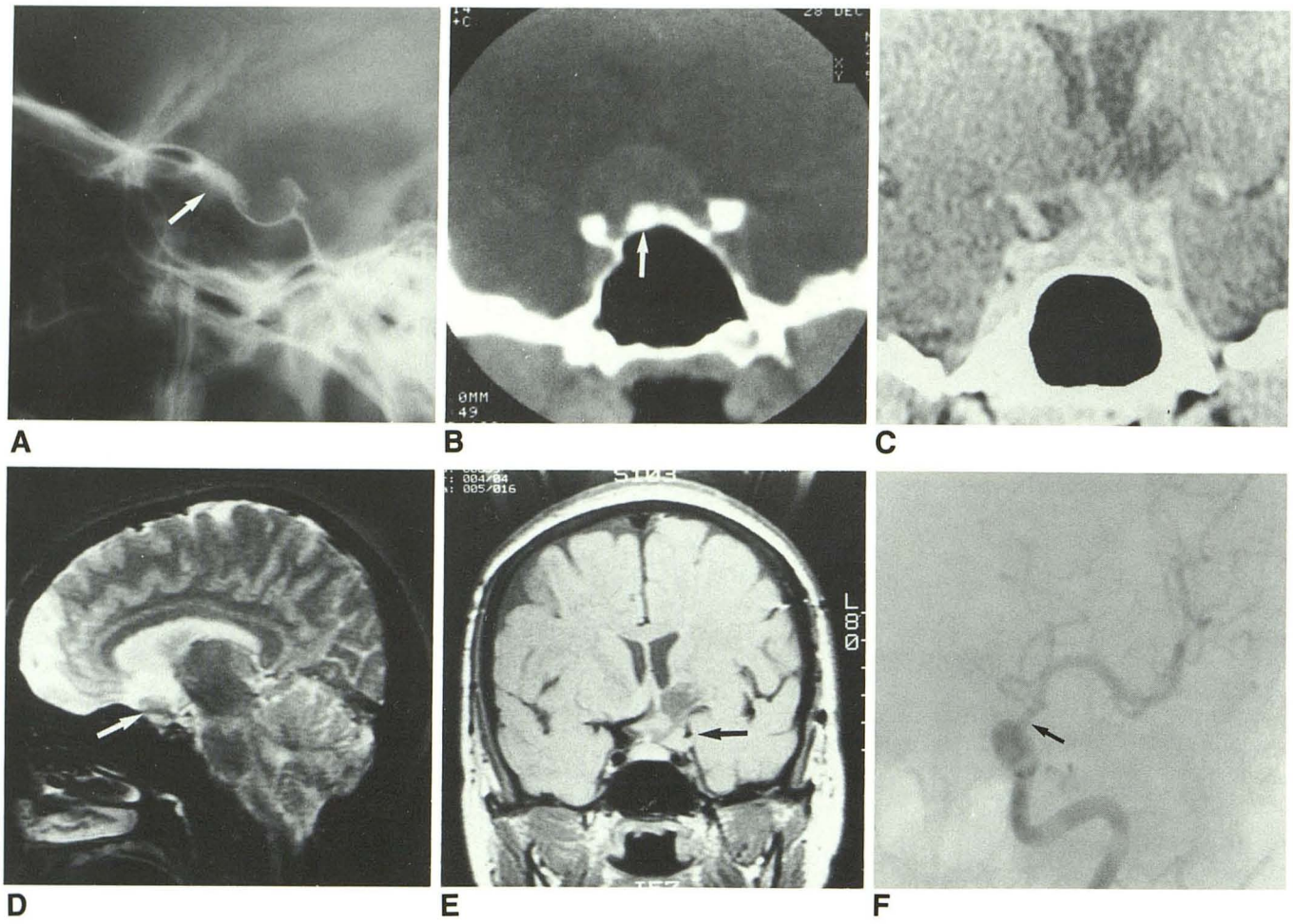

Fig. 4.—Case 1: tuberculum sellae meningioma.

***A*, Preoperative lateral radiograph shows hyperostosis and blistering in area of tuberculum sellae and planum sphenoidale (*arrow*).**

***B*, Preoperative coronal contrast-enhanced CT scan at bone-window settings shows hyperostosis of tuberculum sellae (*arrow*). Enhancing tumor mass can be seen faintly.**

***C*, Postoperative coronal contrast-enhanced CT scan shows residual enhancing mass in suprasellar area. It is unclear whether there is impingement on optic chiasm or vascular encasement.**

***D*, Sagittal T2-weighted postoperative MR image shows high signal intensity in surrounding encephalomalacia, which is easily separated from residual tumor (*arrow*), which does not show increased signal intensity. Hyperostosis cannot be seen.**

***E*, Coronal spin-density MR image clearly shows residual tumor in area of optic chiasm on left, and encasement of left supraclinoid internal carotid artery (*arrow*). However, residual tumor remains above diaphragma sellae.**

***F*, Arteriogram reveals narrowing of supraclinoid internal carotid artery (*arrow*), confirming tumor encasement.**

reactions to contrast material occur less often with arteriographically administered contrast material than without IV administration. Precautions such as premedication with steroids and/or antihistamines and the use of nonionic contrast material might be considered.

The vascular blush of meningioma seen on arteriography may correlate with CT enhancement with IV contrast material. While MR studies without IV paramagnetic contrast agents may not provide this information, recent studies have shown that MR with gadolinium-DTPA yields excellent results in extraaxial masses [16–18]. Recent reports of high-field-strength MR studies [8] have also described rounded and curvilinear hypodense structures within meningiomas thought to represent tumor vessels, as well as a pial vascular rim.

Definition of the lateral wall of the cavernous sinus on MR may be a helpful landmark in parasellar extension, as it defines the boundary between tumor and temporal lobe. The medial wall of the cavernous sinus usually cannot be delineated.

In postoperative patients, differentiation of recurrent or residual tumor mass from ischemic chiasmal syndrome from other causes, such as postoperative adhesive arachnoidopathy, may be possible with MR evaluation. On CT, differentiation of residual or recurrent tumor usually depends on contrast enhancement. This is sometimes difficult, as postoperative changes such as gliosis or granuloma may also enhance. As shown in our study, if a meningioma is not of increased signal intensity on T2-weighted images, postoperative changes that are of increased signal intensity on T2-

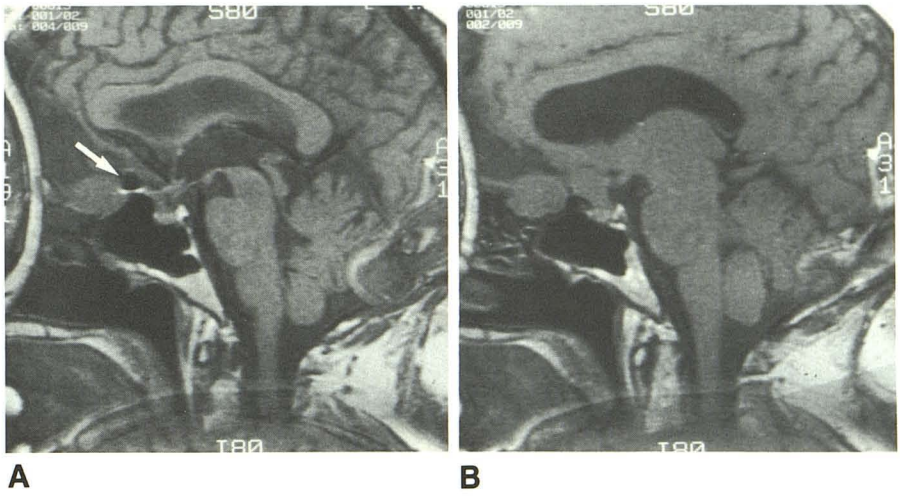

Fig. 5.—Case 5: olfactory groove meningioma, postoperative.

***A*, Midline sagittal T1-weighted MR image shows residual tumor in cribriform plate and optic chiasmal areas. Signal-void artifact (*arrow*) from surgical clip does not affect overall interpretation.**

***B*, Sagittal T1-weighted MR image slightly to the left of midline shows residual tumor involving left optic nerve.**

weighted images, such as gliosis, encephalomalacia, and porencephaly, can be differentiated from tumor. Other studies have shown that only about 40% [7] to 50% [8] of meningiomas are of increased signal intensity on T2-weighted images when compared with cerebral cortex. This compares well with our present series, in which three (33%) of nine tumors were brighter than cortex on T2-weighted images.

In conclusion, when MR and CT are compared directly, MR is the technique of choice in the evaluation of meningioma in the juxtasellar area, both for preoperative planning and postoperative follow-up. MR is effective in the juxtasellar area owing to the inherent contrast provided by cisternal CSF, flow-void phenomena in adjacent vessels, and meningeal structures such as the diaphragma sellae and lateral wall of the cavernous sinus. The MR characteristics of meningiomas on T2-weighted images may be helpful in distinguishing residual or recurrent meningioma from encephalomalacia, gliosis, or porencephaly. MR currently does not obviate preoperative angiography.

ACKNOWLEDGMENTS

We thank Margaret Pirtle for secretarial support and Jay Johnson for photography.

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