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MR of Craniopharyngiomas: Tumor Delineation and Characterization

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MR imaging and CT (with and without contrast enhancement) were performed in 20 patients with an established or clinically suspected diagnosis of craniopharyngioma. Fifteen had biopsy-proven craniopharyngioma and five had presumed craniopharyngioma based on clinical and CT findings. In two cases MR was superior to contrast-enhanced CT in demonstrating the tumor. A variable appearance on T1-weighted MR images reflected the pathologic appearance of craniopharyngiomas. High intensity on T1-weighted images corresponded to high cholesterol content or presence of methemoglobin. MR was the preferred method in the evaluation of tumor extent, especially in the cavernous sinus and posterior clival region. CT was superior to MR in detecting the presence of calcification, which with the clinical history correctly suggested the diagnosis of craniopharyngioma. Both MR and CT studies are desired initially to establish the diagnosis and to evaluate tumor extent. MR was the preferred method in detecting the presence of recurrent tumor.

Clinical experience with MR has demonstrated its superiority over CT in the evaluation of many brain tumors, and it has been cited by some authors as the examination of choice in screening and delineating tumor extent [1–3] due to its increased sensitivity and direct multiplanar capabilities. The variable histologic appearances of craniopharyngiomas and the difficulty in identifying calcifications with MR has cast doubt on its applicability in suspected craniopharyngioma. Previous reports have included isolated cases in larger studies of brain tumors [4–8]. Because the spectrum of MR appearances of this tumor has not previously been described fully, we correlated the results of MR, CT, and histopathology in 20 patients to characterize the MR appearance and to determine its role in diagnosis.

Subjects and Methods

Twenty-seven MR studies were performed in 20 patients 7–66 years old. Fifteen patients with surgical proof and five with clinical and CT diagnosis of craniopharyngioma are included in the study. MR was performed as part of the preoperative workup in 13 patients. In seven patients it was performed after biopsy or partial surgical resection.

MR and CT studies were performed in all cases. MR studies were performed on one of three imagers. Relative T1-weighted and T2-weighted spin-echo (SE) sequences were obtained in all patients. Sixteen patients were scanned with a 0.35-T scanner (Diasonics). Multislice multiecho images were obtained with a repetition time (TR) of 1000 or 2000 msec and an echo time (TE) of 28 or 56 msec. Three patients were scanned with a 0.3-T imager (Fonar) Multislice single-echo images were obtained with TR = 500/2000 msec, TE = 28/56 msec. Two patients were scanned on a 0.5-T instrument (Picker) Multislice, dual-echo images were obtained with TR = 1000/2000 msec, TE = 40/80 or 60/120 msec. Images were obtained in at least two planes. Surgical pathology reports were reviewed in all cases. Surgical pathologic specimens were reviewed by the authors in six cases. In one case analysis of the hemosiderin content of the specimen was performed by ultraviolet light spectroscopy.

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Results

MR studies demonstrated a wide range of appearances of craniopharyngiomas, especially on T1-weighted images. In nine patients the tumor showed an increase in intensity on T1-weighted images consistent with T1 shortening (Fig. 1). Ten studies demonstrated a tumor of intermediate intensity on T1-weighted images (Fig. 2) with signal intensity greater than CSF and variable homogeneity (Fig. 3). In one case a cystic tumor showed decreased intensity on T1-weighted images (Fig. 4). The craniopharyngiomas were of high signal intensity on T2-weighted images in all but one case, suggesting a long T2 relaxation time (Figs. 1B and 2B).

Pathologic specimens were reviewed in an attempt to correlate the varying MR appearances with the wide histologic appearances of craniopharyngiomas. High-intensity signal on T1-weighted images was found to correspond to a high liquid cholesterol content in the tumor, as demonstrated pathologically (Fig. 1), or to the presence of methemoglobin, as demonstrated by ultraviolet visible spectroscopy (Fig. 5). Moderate-intensity signal on T1-weighted images was found in tumors without high cholesterol content (Fig. 2). In each case the tumor demonstrated a high signal intensity on T2-weighted images. In a single case (Fig. 4), the tumor demonstrated low-intensity signal on both T1- and T2-weighted images. This corresponded to a cystic tumor with a high keratin content and delicate bone trabecular network. The presence of extensive ossification throughout the aspirated specimen was a surprising finding. Apparently, the delicate bone trabecular network collapsed with suction and could be aspirated with cyst fluid at surgery. In each case the typical adamantinomatous pattern was present in some of the pathologic sections, confirming the diagnosis. Overall, CT was superior to MR in demonstrating calcifications within the tumors. MR failed to demonstrate areas of calcification in three of 14 cases in which calcification was demonstrated by CT (Figs. 1 and 6). In one case, calcification would have been incorrectly suspected on the basis of MR. The areas of low signal on MR corresponded to low-density regions on CT believed to represent areas of cystic necrosis (Fig. 3).

MR imaging was very sensitive in detecting the presence of pathology. In two cases MR was superior to contrast-infused CT in demonstrating tumor. In one case in which tumor was confined to the suprasellar region the tumor was not appreciated on contrast-infused CT. CT with metrizamide cisternography performed the same day and MR studies

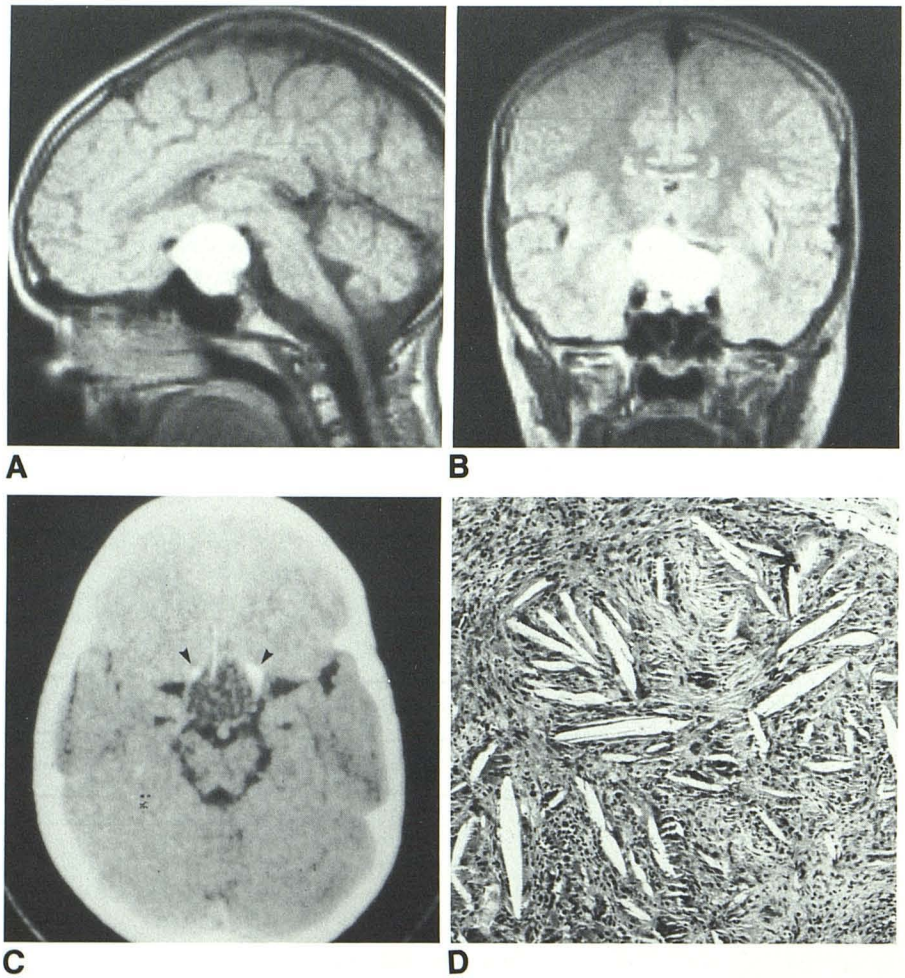


Fig. 1.—8-year-old boy who had multiple surgical resections for recurrent craniopharyngioma. MR was performed as part of periodic monitoring of tumor.

***A*, Sagittal SE image (TE = 28, TR = 1000 msec) with relative T1-weighting. Suprasellar tumor of high signal intensity.**

***B*, Coronal SE image with T2-weighting (TE = 56, TR = 2000 msec). Long T2 of tumor and cavernous sinus extension was important in planning radiation therapy.**

***C*, Axial noninfused CT scan shows peripheral calcification (*arrowheads*) not apparent on MR scans.**

***D*, Pathologic specimen shows large number of cholesterol clefts. High cholesterol tumor content was found to be one cause of high-intensity signal on T1-weighted images.**

Fig. 2.—41-year-old man with headache and visual field deficits.

A, Sagittal image with relative T1-weighting shows moderate signal intensity of suprasellar tumor (TE = 28, TR = 500 msec).

B, Sagittal image with relative T2-weighting shows high signal intensity of tumor (TE = 56, TR = 2000 msec).

C, Coronal MR image shows tumor impinging on right optic nerve (*arrow*), which correlated with symptoms.

D, Metrizamide axial CT scan shows suprasellar tumor. Contrast-enhanced CT before metrizamide study failed to show pathology.

E, Pathologic specimen shows striking lack of cholesterol clefts. Representative section is shown with moderate amounts of keratin (*black arrow*) and typical adamantinomatous cells of craniopharyngioma (*white arrow*). Lack of cholesterol or hemorrhage and presence of keratin may account for longer T1 of this tumor compared with Figure 1.

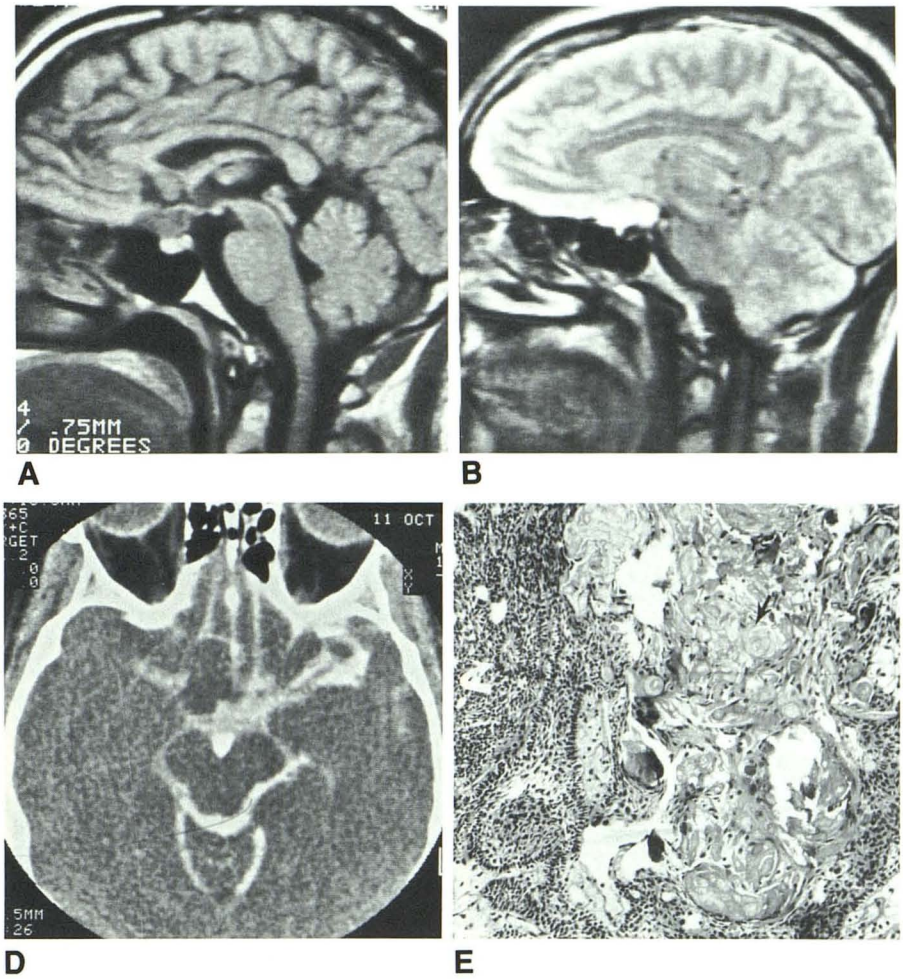
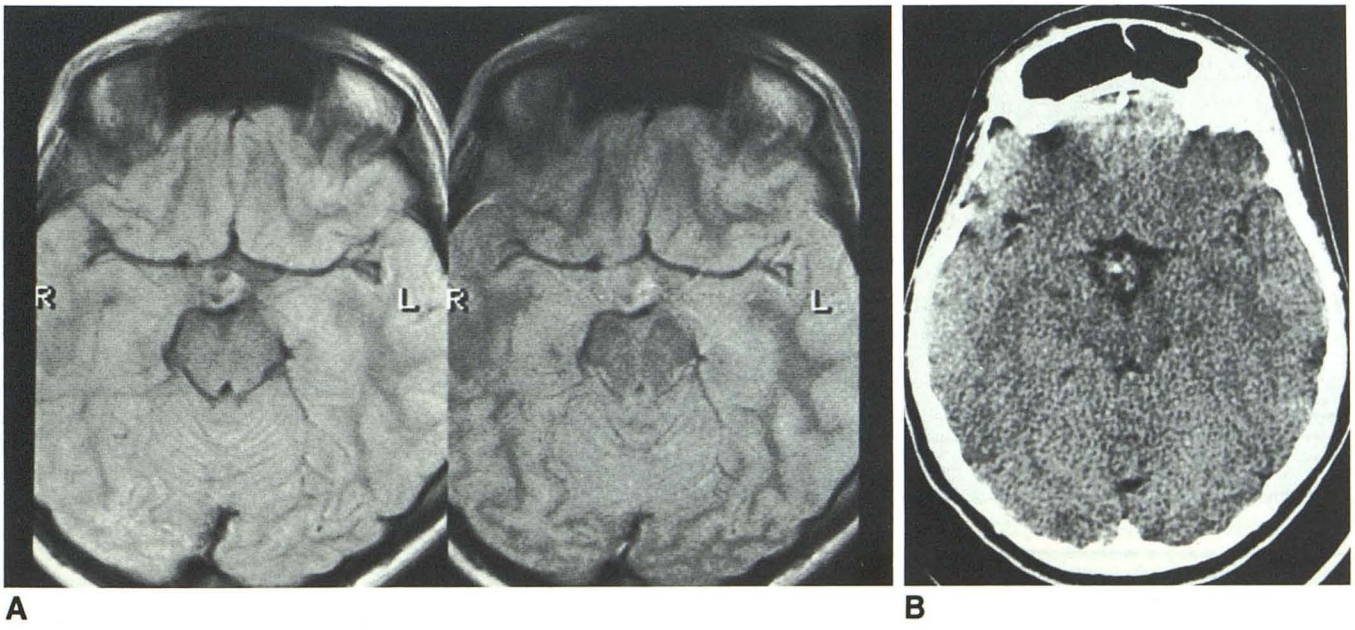


Fig. 3.—19-year-old woman with subsequent surgical resection demonstrating craniopharyngioma.

A, T2-weighted axial MR study shows areas of focal decreased signal intensity also present on T1-weighted images (TE = 30, TR = 2000 msec). Calcification could be suspected on basis of MR study alone.

B, CT scan shows focal areas of decreased density corresponding to areas of decreased signal on MR, believed to represent areas of cystic necrosis.



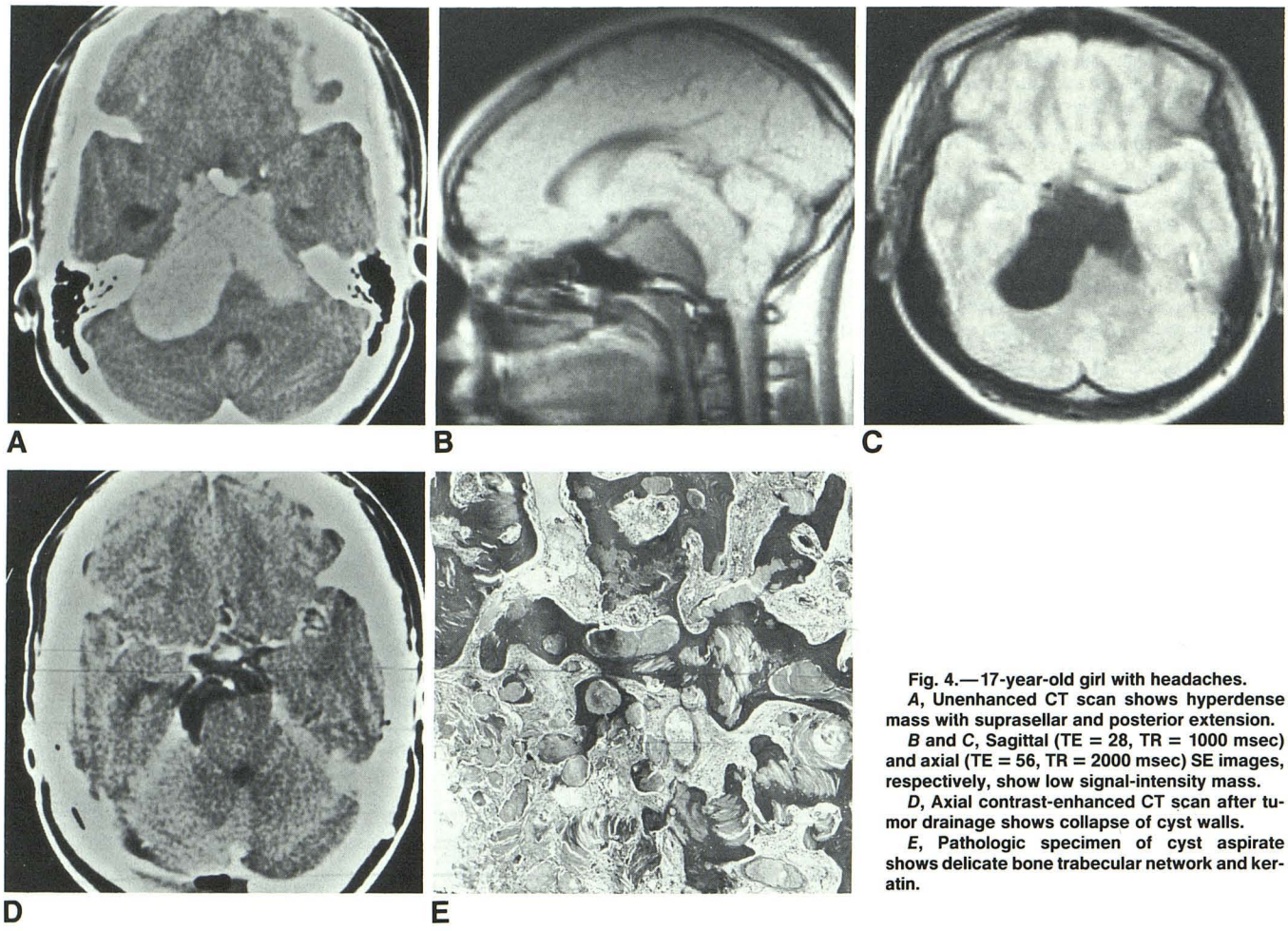


Fig. 4.—17-year-old girl with headaches.

A, Unenhanced CT scan shows hyperdense mass with suprasellar and posterior extension.

B and *C*, Sagittal (TE = 28, TR = 1000 msec) and axial (TE = 56, TR = 2000 msec) SE images, respectively, show low signal-intensity mass.

D, Axial contrast-enhanced CT scan after tumor drainage shows collapse of cyst walls.

E, Pathologic specimen of cyst aspirate shows delicate bone trabecular network and keratin.

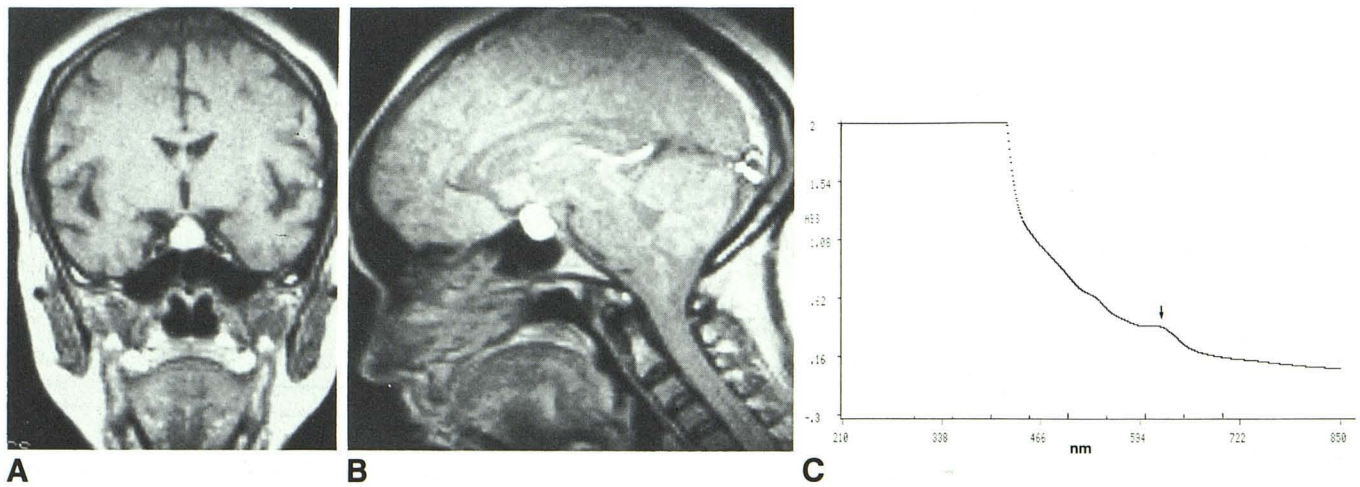


Fig. 5.—38-year-old woman with bitemporal visual field loss.

A, Coronal relative T1-weighted SE image (TE = 28, TR = 500 msec) shows high-intensity-signal suprasellar tumor.

B, Sagittal T2-weighted image shows high-intensity signal of tumor (TE = 56, TR = 1500 msec). Pathologic specimen showed numerous RBCs with few cholesterol clefts.

C, Ultraviolet light spectroscopy of cyst contents shows photopeak at 630 nm indicating presence of methemoglobin (*arrow*). Presence of methemoglobin was found to be one cause of T1 shortening.

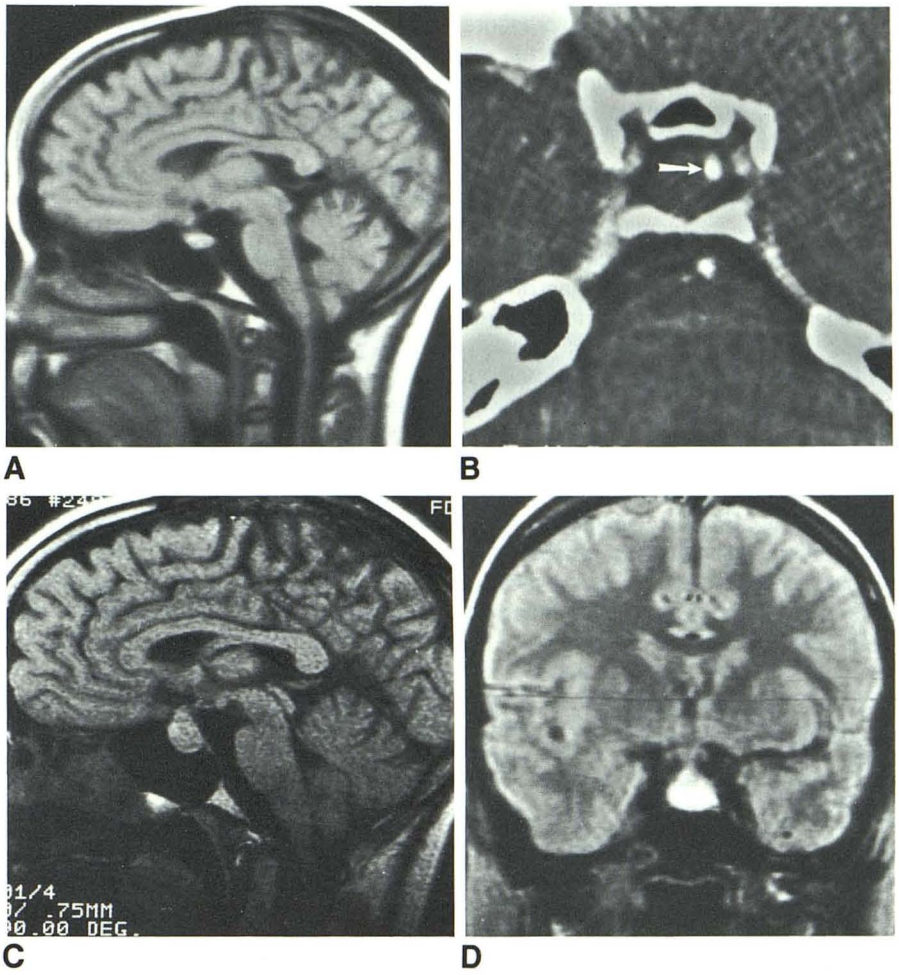


Fig. 6.—19-year-old woman seen for routine follow-up studies after surgical removal of intrasellar craniopharyngioma.

***A*, Recurrence of tumor shows moderate signal intensity on T1-weighted images (TE = 28, TR = 500 msec).**

***B*, Punctate calcification (*arrow*) identified by CT was not seen on MR study.**

***C*, 6 months later. Patient returned with increasing visual field deficits. Enlargement of tumor mass with suprasellar extension is seen on T1-weighted image (TE = 28, TR = 500 msec).**

***D*, Coronal T2-weighted image shows extension of tumor to level of optic chiasm (TE = 56, TR = 2000 msec).**

performed 4 days later clearly demonstrated the abnormality (Fig. 2). In a second patient, pathology was suspected on CT due to the presence of an enlarged sella without demonstration of tumor. MR 2 weeks later showed a 2.5-cm tumor with suprasellar extension. In 10 patients the tumor was located above and within the sella. In nine the tumor was entirely suprasellar. In one the tumor was located only within the sella (Fig. 6). Posterior extension in five cases was well demonstrated on sagittal MR images, which was significant in planning the surgical approach in these cases. In one of these patients the posterior location of the tumor was not appreciated on CT, and the tumor was missed during transnasal biopsy. Subsequent MR revealed the posterior location of the tumor (Fig. 7). Coronal images were especially useful in demonstrating cavernous sinus extension, which was present in one case (Fig. 1) and was important in planning postsurgical radiation therapy.

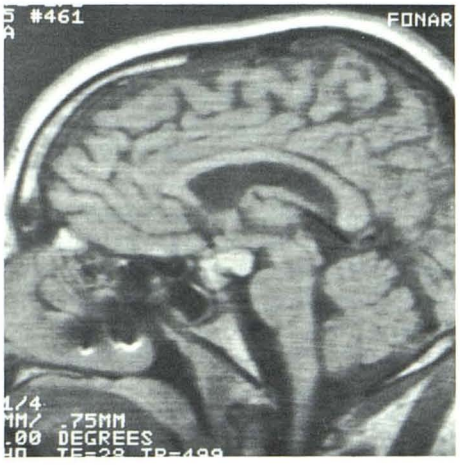


Fig. 7.—27-year-old man with double vision and headaches. Sagittal SE image (TE = 28, TR = 499 msec) shows high-intensity suprasellar tumor extending posteriorly. Biopsy was performed through transnasal approach and normal tissue was obtained. Posterior extension of tumor is important in preoperative surgical planning. Subtemporal exposure may be preferred in cases with significant posterior extension.

Discussion

Craniopharyngiomas originate from squamous epithelial rests of Rathke's pouch. They are benign, slow-growing tumors. Although primarily tumors of children and young

adults, some may have delayed presentation in middle age or older. They present with headache, visual symptoms, and symptoms caused by dysfunction of the hypothalamus and pituitary gland. Growth failure is often the mode of presentation in a child.

The histologic pattern of craniopharyngiomas [9, 10] is variable and includes a variety of cell types. Diagnosis is made histologically by the identification of nests or cords of stratified squamous or columnar epithelium in loose fibrous stroma reminiscent of the enamel organ of the tooth, and they are considered to have an adamantinomatous pattern. Craniopharyngiomas may be cystic, often with high cholesterol content, or solid, and they contain calcium in 75% of cases.

The wide range of histologic appearances of craniopharyngiomas was reflected in their MR appearances. Although definitive statements concerning calcium and cholesterol content cannot be made without complete sectioning of the entire specimen, qualitative examination of the sections correlated well with the several MR patterns. High intensity on T1-weighted images was noted in cystic lesions with high cholesterol content or containing methemoglobin. Kjos et al. [4] described high-intensity signal on T1-weighted images of hemorrhagic cysts. Bradley and Schmidt [11] showed that methemoglobin formation with T1 shortening at least partially accounts for the increasing MR signal intensity of subarachnoid hemorrhage with time. Moderate intensity on T1-weighted images was noted in tumors lacking significant cholesterol or blood. Both these groups demonstrated high signal intensity on T2-weighted images. In a single case (Fig. 4), low signal intensity was demonstrated on both T1- and T2-weighted images in a cystic lesion high in keratin and having extensive bone trabeculae. In this case CT demonstrated a hyperdense lesion. Braun et al. [12] described hyperdense cystic craniopharyngiomas in four of 63 cases in their series. Their analysis of cyst contents demonstrated a high protein content in these cases. However, the MR appearance of low T1 and T2 signal intensity in our series was explained by the delicate bone trabecular network found at pathologic examination of the cyst aspirate. Despite the presence of ossification, the tumor behaved as a cyst at surgery, and collapse of the cyst walls was seen on postaspiration CT studies.

In the evaluation of craniopharyngioma the presence of calcification is often of diagnostic significance. Holland et al. [8] have shown CT to be superior to MR in the detection of calcification, which was also demonstrated in our study. The failure of MR to demonstrate tumoral calcification is of less importance in the evaluation of tumor recurrence when the tissue diagnosis is known.

MR has proved to be valuable in preoperative and radiation therapy planning due to its multiplanar capabilities. Accurate preoperative knowledge of the tumor extent may lead to a change in the surgical approach [13]. A transnasal approach may be sufficient for an entirely intrasellar tumor. Suprasellar tumor may require a subfrontal approach to allow optimal exposure of the optic chiasm. Cryoprobes may need to be available in this case to peel tumor away from the optic chiasm. Supra- and intrasellar tumor extension may additionally require unroofing of the sphenoid sinus. If the tumor extends posteriorly along the clivus a subtemporal approach may be preferred. A cystic craniopharyngioma may allow a more conservative surgical approach with drainage without removing the walls and with implantation of radioisotopes. MR offers superior information in identifying tumor in the cavernous sinus (Fig. 1B), which would not usually be explored at surgery and would be treated with radiation therapy. Tumor extension into the sphenoid sinus is not as easily identified by MR due to its resemblance to benign conditions such as sinus disease and changes resulting from transnasal biopsy. In cases with supra- and intrasellar tumor, a subfrontal approach with unroofing of the sphenoid sinus would be used, and extension into the sinus would be discovered at surgery.

In summary, MR is more sensitive than CT in identifying the presence and extent of tumor. The wide range of appearances on T1-weighted images reflects the range of histologic appearances of craniopharyngiomas. T1 shortening may reflect the presence of high cholesterol content or methemoglobin. CT is superior to MR in detecting calcifications. Currently, CT is more specific in establishing the diagnosis of craniopharyngioma. MR is preferred in the evaluation of tumor extent for presurgical and radiation planning. MR is valuable in detecting recurrent tumor, particularly in children, to limit radiation exposure.

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