MR of the pituitary gland postsurgery: serial MR studies following transsphenoidal resection.

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MR of the Pituitary Gland Postsurgery: Serial MR Studies following Transsphenoidal Resection

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PURPOSE: To determine the MR appearance of the pituitary gland in the early and late postoperative periods in order to distinguish operative complications more effectively and to establish a postoperative baseline. **METHODS:** Ten patients were prospectively studied with MR following transsphenoidal resection of a pituitary tumor. Early postoperative studies were obtained at 2 to 8 days following surgery, late studies at 4 to 9 months in all patients and also at 12 to 16 months in five. Major observations were height of the pituitary mass and appearance of the surgical packing. **RESULTS:** Within 8 days following surgery, the height of the pituitary mass was unchanged in two cases, increased in three, and only minimally decreased in five. All decreased in height (average 54%) by 4 to 9 months. Gelfoam packing completely (five) or nearly completely (three) resorbed leaving a normal-size, although deformed, pituitary gland. Fat-packed resection defects persisted (two). **CONCLUSIONS:** In the early postoperative period, the appearance of the pituitary gland is similar in size to its preoperative appearance. Subsequent involution with packing resorption yields a smaller, deformed pituitary gland.

Index terms: Pituitary gland, magnetic resonance; Pituitary gland, neoplasms; Magnetic resonance, postoperative; Sella turcica, magnetic resonance

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Magnetic resonance (MR) has become the procedure of choice for the neuroradiologic diagnosis of pituitary tumors (1, 2). When there is positive correlation with laboratory and clinical findings, MR is usually definitive, obviating the need for further radiologic imaging even in those patients in whom surgical excision is indicated. Currently, the most commonly used surgical approach is the transsphenoidal microsurgical technique (3). Patient follow-up is primarily clinical,with appropriate laboratory (hormonal) and visual field studies. Imaging studies have played a supporting role in the follow-up of functioning adenomas and are the primary tool in following nonfunctioning adenomas (4). Follow-up imaging studies are not ordinarily obtained in the early postoperative period. With successful surgical cure or control of disease, imaging studies are normally obtained 6 to 12 months following surgery. However, an earlier postoperative study may be necessary in instances of possible surgical complications, lack of clinical and/or hormonal response or for radiation therapy treatment planning.

Persistence of an intrasellar mass in the immediate postoperative period has been demonstrated with computed tomography (CT) (4–9), but there has been little reported on the MR appearance in the immediate postoperative period (10). To distinguish effectively perioperative complications, the usual or expected appearance of the pituitary gland in the early postoperative period must be known. Also, in order to establish a new baseline for follow-up or treatment planning, the potential change in appearance over time must be appreciated. The purpose of this study, therefore, is to determine the MR appearance of the pituitary in the early postoperative period following transsphenoidal resection of a pituitary tumor and to compare these findings with the late postoperative appearance.

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Materials and Methods

Ten patients were studied with MR following transsphenoidal resection of a pituitary tumor. There were six women and four men, aged 21 to 66 years. All had clinical and laboratory evidence as well as MR findings indicative of an adenoma. Preoperative MR studies were obtained at various institutions including ours. All underwent nonenhanced studies; eight received gadopentatate dimeglumine (Magnevist; Berlex Imaging, Wayne, NJ). Two unenhanced studies from outside institutions were sufficiently diagnostic of pituitary tumor to be acceptable for this study. Patients entered into the study were referred surgical candidates who underwent standard transsphenoidal removal of an adenoma without complication and who consented to early postoperative and follow-up MR examinations in addition to the standard 1-year follow-up.

Transsphenoidal removal of the adenoma was accomplished through a standard transseptal approach to the sphenoid sinus. The sella floor was opened and a dural window was made through which the tumor was removed. The normal pituitary was spared whenever possible. The tumor resection cavity was packed with Gelfoam (The Upjohn Company, Kalamazoo, MI) in eight patients. In those with a cerebrospinal fluid (CSF) leak (two patients), packing was achieved with a subcutaneous fat graft taken from the lower abdominal wall. One of these two patients also had packing of the cavernous sinus on one side with Gelfoam to control bleeding. The sella floor was reconstructed with an intradural stent of nasal bone (seven patients), nasal cartilage (two patients), or bone and cartilage (one patient). The sphenoid sinus was packed with fat in the cases of CSF leak, also with Avitene in one case to control venous bleeding. In the remaining patients, the sphenoid sinus was not packed. Surgical approach, tumor location, resection, and packing material used within the tumor resection surgical defect were recorded by the surgeon. All of the surgical procedures were performed by the same neurosurgeon.

After appropriate consent, immediate postoperative MR studies were obtained from 2 to 8 days following surgery. All were performed with a 1.5-T imager (Signa; GE Medical Systems, Milwaukee, WI). The initial imaging sequence included sagittal T1-weighted images (4.0-mm thick, no skip, 600/20 (TR/TE)) followed by coronal T1-weighted images (4.0-mm thick, no skip, 600/25, 16-cm field of view), and coronal long repetition time images (5.0-mm thick, 2.5-mm skip, 1800/30–70). After the intravenous administration of 0.1 mmol/kg gadopentetate dimeglumine, coronal T1-weighted images were repeated.

Late postoperative studies were obtained from 4 to 9 months after surgery and, in five patients, also at 12 to 16 months after surgery. Imaging parameters were basically the same for all studies performed at this institution or others.

The following were recorded: height of the pituitary mass, relationship to the optic chiasm, enhancement, visualization of the pituitary gland and stalk, and the appearance of the surgical packing within the sella and sphenoid sinus. Most observations, including measurements, were taken from coronal images. A few measurements were obtained with the distance measurement mode on the image display console; most used the scale printed on the image. Surgical observations noted and recorded included cavernous sinus invasion, intraoperative CSF leak, extent of tumor removal, and method of sella and sinus packing.

Clinical and laboratory follow-up was obtained as clinically appropriate to confirm a favorable response to surgery. The sequential acquisition of laboratory data was not a controlled part of the study protocol. It was not the intent of the study to determine the earliest signs of recurrence, although the presence of either recurrent tumor growth on MR or a change in hormone levels from the postoperative baseline excluded a patient from the study.

Results

Of the 10 patients studied, two had microadenomas and eight macroadenomas. Excess hormone secretion among the macroadenomas was prolactin in four, growth hormone in two, and adrenocorticotropic hormone (ACTH) in one. One patient had a nonfunctioning adenoma. One of the two microadenomas had increased growth hormone production, the other ACTH.

On the preoperative MR scans, the pituitary mass enhanced relatively homogeneously. Hemorrhage was present in three tumors, accounting for a minor portion of the total mass in two and the greater part of the mass in one. The pituitary stalk entered the mass contralateral to the tumor center in three cases, ipsilateral to the mass in one case, and midline in one case. In five cases, the stalk position could not be located because of the large size of the mass.

The pituitary mass was measured as the total height of the adenoma and pituitary gland. Most macroadenomas could not be separated from normal pituitary gland preoperatively. The maximum height was measured from the sella floor or inferiormost extent of the pituitary/tumor mass to its most superior extent. In the immediate postoperative period, two pituitary masses were unchanged and three increased in height as compared with the preoperative scans. The remaining five were decreased in height but only minimally compared with the height of the preoperative mass (5%–33% decrease in height) (Table 1).

On the early postoperative studies, enhancement was inhomogeneous with a nonenhancing area that appeared to correspond to the site of tumor resection and surgical packing. In three cases, there was a thin peripheral enhancing rim. Surgical cavities packed with Gelfoam displayed

TABLE 1: Pituitary Mass on Coronal MR

	Adenoma	Preoperative		Early Postoperative				Late Postoperative		
		Height (mm)	Extension to Chiasm	Height (mm)	(Days)	Packing	Extension to Chiasm	Height (mm)	(Months)	Extension to Chiasm
1	PRL	18	0	13	(2 days)	G	0	4	(6.5 mo)	0
2	GH	10	+	14	(3 days)	G	++	11	(5.5 mo)	+
3	GH	18	0	18	(3 days)	F	+	12	(4 mo)	0
4	PRL	15	++	13	(4 days)	F	++	6	(7 mo)	0
5	NFA	33	+++	33	(4 days)	G	+++	14	(4 mo)	0
6	PRL	18	+	16	(3 days)	G	0	5	(4 mo)	0
7	ACTH	5	0	8	(8 days)	G	0	4	(6 mo)	0
8	GH	40	+++	38	(3 days)	G	+++	11	(6.5 mo)	0
9	PRL	40	+++	27	(3 days)	G	0	16	(9 mo)	0
10	ACTH	13	0	13	(3 days)	G	0	6	(8 mo)	0

Note.—Key: Adenoma: PRL = prolactin secreting; GH = growth hormone; ACTH = adrenocorticotropic hormone; NFA = nonfunctioning adenoma. To chiasm: 0 = no involvement; + = extension to chiasm; ++ = minimal impression; +++ = moderate or greater elevation. Packing: G = Gelfoam; F = fat.

variable MR signal intensity. In the majority of cases, signal intensity was isointense to the pituitary gland with an irregular center of decreased signal intensity on T1-weighted images. On T2-weighted images, there was a further decrease in signal intensity over a larger area.

Late postoperative studies were obtained 4 to 9 months following surgery. All cases demonstrated a decrease in height of the pituitary mass on the second postoperative study compared with the first one. This decrease was marked in most cases (21%–75% decrease in height, average 54%). The maximum total height on late studies was 16 mm; five cases were 10 mm or less. When compared with preoperative studies, nine cases showed a late decrease in height of 20%–78%. In one microadenoma, the postresection mass increased slightly from 10 to 11 mm (Table 1).

On the late postoperative studies, enhancement was more homogeneous. In those in which Gelfoam was used, there was either complete resorption (five cases) or a marked decrease in size of the packing defect (three cases). The pituitary gland assumed a normal or near normal appearance in the five patients with complete resorption. In two patients, the pituitary gland was deformed, normal in size but eccentrically positioned, with a defect on the contralateral side extending to the sellar floor. In one patient, the pituitary gland itself appeared normal in size, but combined with the persistent fat packing, the total pituitary mass appeared slightly enlarged. In two patients, there was residual tissue that enhanced less than the adjacent pituitary, suggestive of residual tumor. In one of these two patients, this appearance has remained unchanged 5 to 16 months after surgery and, therefore, may or may not represent residual tumor. In the other patient, tumor likely remained in one cavernous sinus. The blood prolactin level decreased from 800 ng/mL to 60 to 70 ng/mL and remained at this level and the cavernous sinus remained unchanged on MR for at least 19 months following surgery. The pituitary in another patient remained slightly enlarged and homogeneous in signal intensity and enhancement with the exception of a vertical low signal "cleft" likely representing scar.

Fat packing remained visible in the remaining two cases in which fat was used. In one of these two cases, Gelfoam was also used at the site of cavernous sinus bleeding. That presumed to be Gelfoam packing (by virtue of its location adjacent to the cavernous sinus) exhibited a homogeneous decrease in signal intensity that differed from the more centrally placed fat. The material adjacent to the cavernous sinus (presumably Gelfoam) resorbed completely leaving a defect that extended to the sella floor, whereas the fat packing resorbed incompletely. The pituitary stalk was more often visible on late follow-up studies, appearing less compressed and less displaced, but remained off midline in all but three cases.

The optic chiasm returned to or remained in normal position in seven patients. In three patients, there was herniation of the suprasellar visual system into a partially empty sella. This consisted of inferior bowing of the center of the chiasm and a more vertically oriented course of the optic nerves and tracts.

The sphenoid sinus was usually opacified, presumably with fluid and mucosal thickening, in the early postoperative period. Fat packing imaged as fat. The sphenoid sinus had essentially cleared by the time of the later MR study with

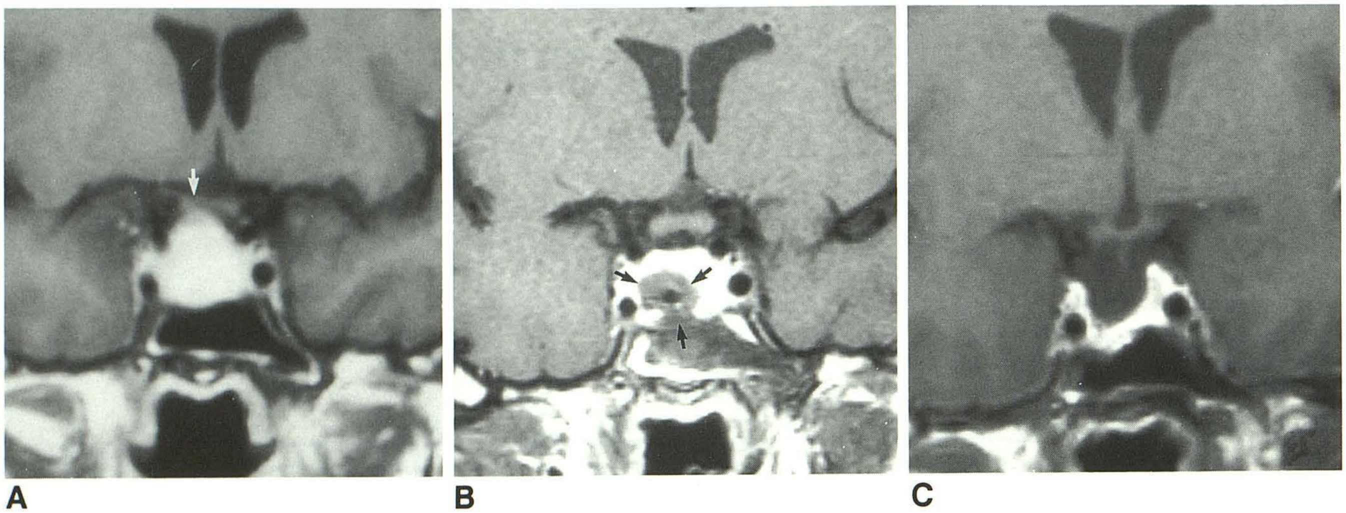


Fig. 1. *A*, Preoperative enhanced coronal T1-weighted image. A macroadenoma slightly elevates the optic chiasm on the right (*arrow*).

B, Enhanced coronal T1-weighted image 3 days postsurgery. The Gelfoam-packed resection defect is visible (*arrows*). There has been minimal decrease in overall size of the pituitary gland.

C, Enhanced coronal T1-weighted image 4 months postsurgery. There is further decrease in pituitary size, the Gelfoam having been resorbed.

the exception of two in which fat packing remained.

On the 1 year (12–16 months) follow-up studies, there was essentially no change in the size or configuration of the remaining pituitary gland/mass. There was a further decrease in the amount of fat packing both in the sella and the sphenoid sinus in one case.

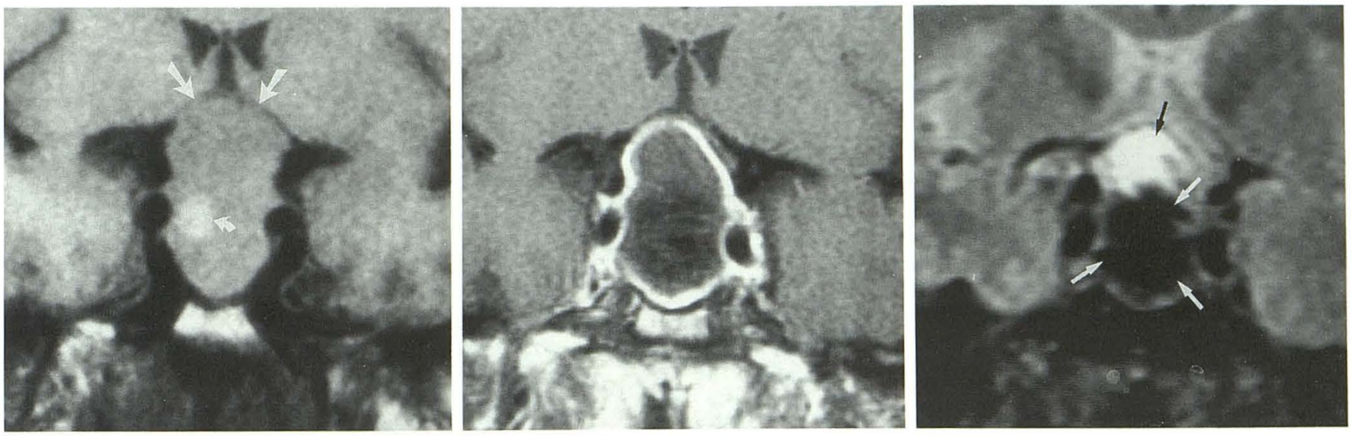
Visual field defects improved to normal in the two patients with field abnormalities and the signs of acromegaly regressed in all three patients so affected. Laboratory confirmation of a return of hormone production to normal was obtained in all cases of functional tumors with the exception of the one case with cavernous sinus residual tumor described above in whom a new baseline was established. There was insufficient laboratory data to correlate involution of the pituitary with change in hormone levels. The length of follow-up in this study is too short to address the diagnosis of tumor recurrence.

Discussion

The transsphenoidal microsurgical technique of pituitary tumor removal involves a surgical approach that traverses the sphenoid sinus and floor of the sella turcica. After removal of the adenoma, the resection cavity in the sella is packed with either Gelfoam or, in the case of a CSF leak, autologous fat. If fat is used, the sphenoid sinus is also packed with fat. In some institutions, fat packing is preferred in most cases; occasionally muscle is used. A nasal bone or cartilage stent is also placed within the sella to reconstruct the defect in the sella floor.

Imaging studies obtained in the early postoperative period demonstrate the sphenoid sinus to be at least partially opacified with thickened mucosa, fluid, and fat. These observations would be anticipated and were confirmed on MR in this study and also reported on CT (5). What came as an unexpected observation on CT studies in the early postoperative period was the alarming lack of change in overall size of the pituitary mass. Follow-up CT studies have shown a decrease in size of the pituitary mass over the 3 or 4 months following surgery (4, 5, 8). Several explanations have been offered to explain this phenomenon, including the packing itself with subsequent resorption, overpacking of the tumor bed, postoperative hemorrhage, persistent tumor or tumor capsule, and adhesions between the diaphragma sellae or tumor and brain tissue (6).

In this series, MR imaging of the postoperative pituitary gland also demonstrated a delay in early involution of the pituitary mass (Figs. 1 and 2). The total height of the mass actually increased slightly in three of 10 patients and decreased to a maximum of only 33% loss of height in five. Delayed studies showed the decrease in total mass to occur primarily at the site of the tumor, also the site of the resection defect and packing (Fig. 1).



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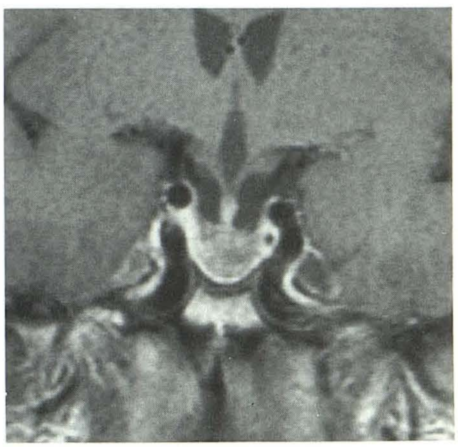

D

Fig. 2. *A*, Preoperative nonenhanced coronal T1-weighted image. A large adenoma contains a small focus of hemorrhage (*curved arrow*) and marked suprasellar extension (*arrows*).

B, Enhanced coronal T1-weighted image 3 days postsurgery. There is rim enhancement of the pituitary mass with mixed iso- and low-intensity packing.

C, Coronal long TR/TE image. The superior portion of the resection cavity exhibits increased signal intensity (*black arrow*) while there is greater decrease in signal intensity of the Gelfoam-packed area (*white arrows*).

D, Enhanced coronal T1-weighted image 6 months postsurgery. The pituitary is now normal in size.

Gadolinium-enhanced MR demonstrated enhancement of at least some tissue in all cases. The enhancing tissue appeared to be other than packing and presumably represented residual pituitary gland. A thin enhancing rim as seen on CT has been referred to as a persistent tumor capsule (5, 7, 9). Whether this tissue represents residual tumor, tumor capsule, or pituitary gland cannot be determined on a single imaging study. The peripheral enhancing rim in the three largest postoperative masses in this study (average height, 38 mm) assumed a more normal pituitary size and shape within the confines of the sella (average height, 14 mm) 4 to 9 months later (Fig. 2).

The MR signal intensity of the packing was inhomogeneous. Fat retained high signal intensity on T1-weighted images and was readily detected. The fat was mixed with isointense soft tissue or fluid. Gelfoam packing tended to be isointense with pituitary tissue with T1-weighting, although there was an irregular hypointense center. This hypointense signal appeared to be produced by small air bubbles within the Gelfoam in some cases. With T2-weighting, signal intensity was mixed. The periphery of the packing had increased signal intensity while the center was most often moderately hypointense, lower in signal, and larger than on the T1-weighted image or the first echo long TR image (Figs. 2B and 2C). In addressing changes in signal intensity with T2-weighting, one must keep in mind that the slightly thicker, larger field-of-view T2-weighted images have lower spatial resolution than the T1-weighted images. The etiology of the decreased signal with T2-weighting is uncertain. Gelfoam is saturated with saline prior to packing and most certainly retains some trapped air. Few air bubbles could be recognized as such. Blood in the surgical bed or mixed with Gelfoam, having been exposed to air, would likely be in the methemoglobin state, but there was no increase in signal on T1-weighted images to confirm this. Delayed hemorrhage into the surgical site might still be in its deoxyhemoglobin state on day 3 or 4 following surgery. One would then have to assume com-

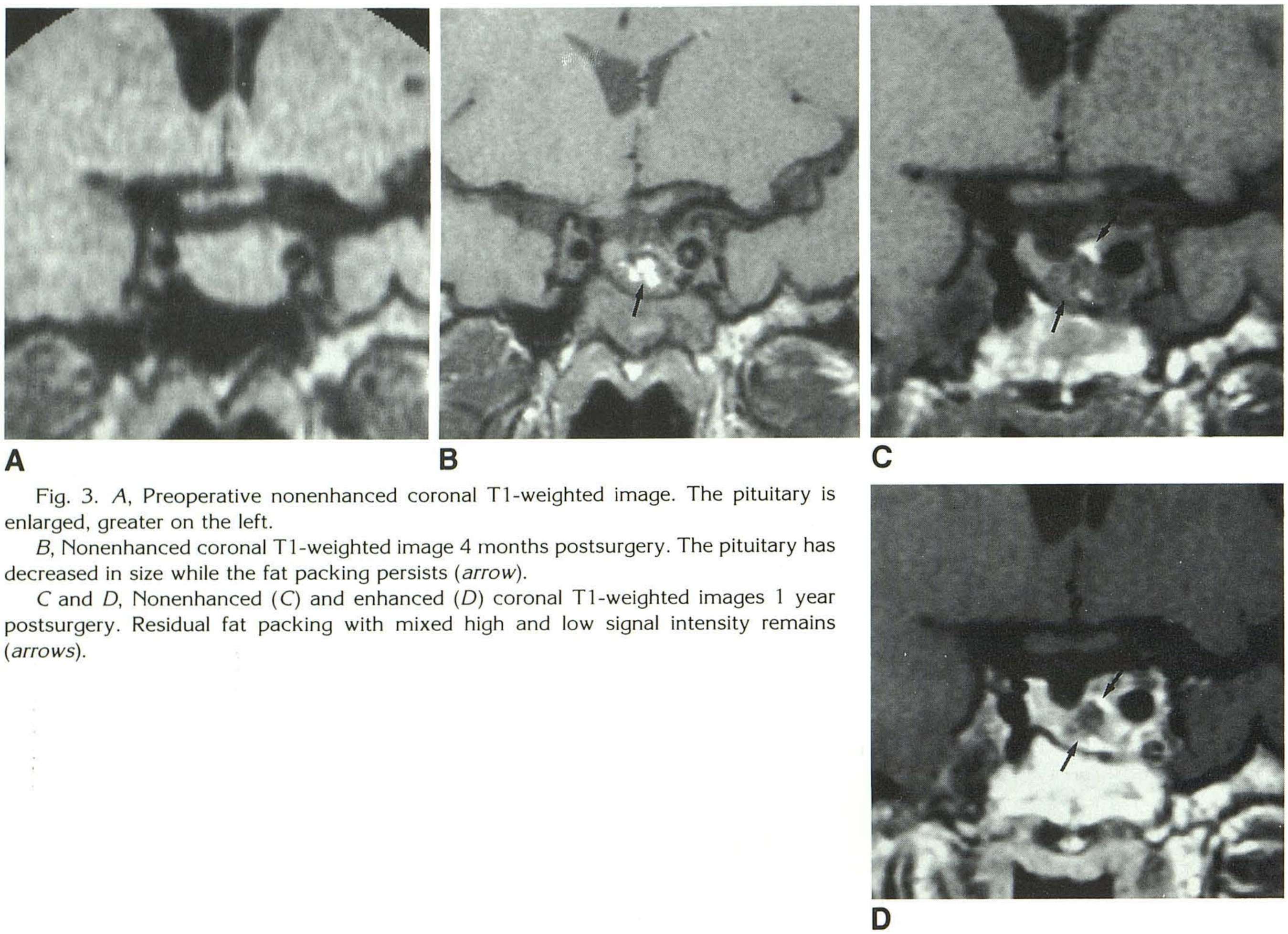

Fig. 3. *A*, Preoperative nonenhanced coronal T1-weighted image. The pituitary is enlarged, greater on the left.

B, Nonenhanced coronal T1-weighted image 4 months postsurgery. The pituitary has decreased in size while the fat packing persists (*arrow*).

C and *D*, Nonenhanced (*C*) and enhanced (*D*) coronal T1-weighted images 1 year postsurgery. Residual fat packing with mixed high and low signal intensity remains (*arrows*).

plete hemorrhage resorption because the increased signal of methemoglobin was not seen on any of the delayed studies. T2 shortening, therefore, is more likely caused by the magnetic susceptibility effects of air trapped within the Gelfoam or by the Gelfoam itself. Fat packing displayed the characteristic decreased signal with T2 weighting. Bone and cartilage stents could not be identified with certainty.

The delayed postoperative studies demonstrated the pituitary gland to have returned to a more normal size, although half were somewhat deformed. In two cases, the pituitary gland occupied only one side of the sella with a defect on the contralateral side extending to the sella floor. In two other cases, the pituitary gland remained deformed by residual fat packing in one and by a vertical low signal cleft that presumably represents scar.

Both persistence as well as disappearance of fat has been observed on CT (5). In this series, intrasellar fat packing was used in only two patients. In both, the sphenoid sinus was also packed with fat. A moderate amount of fat remained in one patient 1 year following surgery. While the amount had decreased, it remained mixed with isointense nonenhancing tissue that likely represents fibrotic scar but could not readily be differentiated from recurrent tumor (Fig. 3). Because Gelfoam packing is resorbed in the first few months following surgery, a new baseline develops with which subsequent examinations can be compared. Fat packing appears to result in a more long-lasting intrasellar effect.

Herniation of the suprasellar visual system into the partially empty sella occurred in three patients. The significance of this observation is uncertain. None of the three patients had visual symptoms. The appearance is similar to that reported by Kaufman et al (11), who also noted a lack of correlation between severity of visual symptoms and various degrees of herniation of the suprasellar visual system.

Kaplan et al (4) reported the CT observation of an empty or partially empty sella postoperatively in about half of 108 patients. In that series of 47 patients with functioning adenomas, 22 had hormonal evidence of residual tumor even though most lacked CT tumoral enhancement. They also correlated the degree of displacement of the pituitary stalk with the likelihood of tumor recurrence and, more importantly, a decrease in size of the stalk with cure. No attempt was made to correlate these observations in this study, inasmuch as the stalk was not adequately visualized in most cases and follow-up too short to exclude recurrence.

In conclusion, this MR study has demonstrated that the immediate postoperative pituitary mass may appear remarkably similar to its preoperative appearance. Surgical packing can be identified and tends to occupy a volume similar to that of the resected tumor. Gelfoam is completely resorbed in the first few months following surgery, resulting in residual normal or near-normal appearing tissue that has the imaging properties of the pituitary gland, although it may be deformed or eccentrically positioned. A new baseline image is then established. While the interval between studies varied, the three cases with the earliest follow-up (4 months) also had studies at 12 to 16 months that failed to show further change. Further study would be needed to determine whether this new baseline can be established earlier and if this holds true for all cases. In any event, one must be aware of the potentially deceptive appearance of the pituitary gland in the immediate postoperative period before diagnosing possible complications and also before establishing a baseline for either radiation therapy planning or follow-up studies.

References

1. Kucharczyk W, Davis DO, Kelly WM, Sze G, Norman D, Newton TH. Pituitary adenomas: high-resolution MR imaging at 1.5T. *Radiology* 1986;161:761–765
2. Newton DR, Dillon WP, Norman D, Newton TH, Wilson CB. Gd-DTPA-enhanced MR imaging of pituitary adenomas. *AJNR: Am J Neuroradiol* 1989;10:949–954
3. Kern EB, Laws ER Jr. The rationale and technique of selective transsphenoidal microsurgery for the removal of pituitary tumors. In: Laws ER Jr, Randall RV, Kern EB, Abboud CF, eds. *Management of pituitary adenomas and related lesions with emphasis on transsphenoidal microsurgery*. New York: Appleton-Century-Crofts, 1982: 219–244
4. Kaplan HC, Baker HL, Houser OW, Laws ER Jr, Abboud CF, Scheithauer BW. CT of the sella turcica after transsphenoidal resection of pituitary adenomas. *AJNR: Am J Neuroradiol* 1985;6:723–732
5. Dolinkas CA, Simeone FA. Transsphenoidal hypophysectomy: postsurgical CT findings. *AJNR: Am J Neuroradiol* 1985;6:45–50
6. Teng MMH, Huang C, Chang T. The pituitary mass after transsphenoidal hypophysectomy. *AJNR: Am J Neuroradiol* 1988;9:23–26
7. Allen MB Jr, El Gammal T, Nathan MD. Transsphenoidal surgery on the pituitary. *Am Surg* 1981;47:291–306
8. Ciric I, Mikhael M, Stafford T, Lawson L, Garces R. Transsphenoidal microsurgery of pituitary macroadenomas with long-term follow-up results. *J Neurosurg* 1983;59:395–401
9. Goldman JA, Hedges TR III, Shucart W, Molitch ME. Delayed chiasmal decompression after transsphenoidal operation for a pituitary adenoma. *Neurosurgery* 1985;17:962–964
10. Mikhael MA, Ciric IS. MR imaging of pituitary tumors before and after surgical and/or medical treatment. *J Comput Assist Tomogr* 1988; 12:441–445
11. Kaufman B, Tomsak RL, Kaufman BA, et al. Herniation of the suprasellar visual system and third ventricle into empty sellae: morphologic and clinical considerations. *AJNR: Am J Neuroradiol* 1989; 10:65–76