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Research Paper

The Optimal Time for Postoperative Magnetic Resonance Imaging of the Sella in Patients With Pituitary Adenoma

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ABSTRACT

Introduction: Magnetic resonance imaging (MRI) is the preferred neuroradiologic tool for evaluating the sellar region. Pituitary adenomas account for about 15% of primary intracranial tumors. The optimal time for postoperative MRI of central nervous system neoplasms is 48 hours after surgery. Nevertheless, controversy exists regarding the timing of postoperative MRI in the sellar region. This study analyzed the sellar MRI findings of patients with pituitary adenoma at different times before and after surgery. Finally, we suggest the optimal time for postoperative sellar MRI imaging in patients with pituitary adenoma.

Methods: A total of 28 patients with pituitary adenoma were evaluated. All patients did four sellar MRIs. The first MRI was done before surgery, and three were done 48 hours, two weeks, and three months after the surgery. Finally, the MRI findings at different times were compared to each other.

Results: The pituitary gland and adenoma signals were constant at all time points. The signal of the packing material showed no differences in T1-weighted and T1-weighted with contrast sequences but showed changes in T2-weighted sequences.

Conclusion: Contrary to other intracranial neoplasms, there were no apparent changes in MRI signal intensity during the 3 months after surgery in patients with pituitary adenoma. There was also no superiority of one time point for performing follow-up imaging.

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Highlights

• This is the first study that challenges the need for strict magnetic resonance imaging (MRI) timing in pituitary adenomas.

• The MRI can be delayed for one or two weeks after surgery in patients with pituitary adenomas without diagnostic compromise.

• Flexible timing reduces patient stress and aligns with stable recovery protocols.

Plain Language Summary

Pituitary adenomas are a type of brain tumor located near the base of the brain. After surgery to remove these tumors, doctors often use MRI to check for any leftover tumor or complications. There is a widespread belief that this follow-up MRI should be done within 48 hours after surgery or delayed for two months. It is thought that in the period between these times, the images might be unclear due to blood from the surgery being mistaken for tumor remnants. Our findings challenged this belief. We found that the timing of the MRI did not significantly affect the results in patients with pituitary adenomas. In 48 hours, two weeks, or even three months after surgery, the MRI scans were equally clear for identifying the pituitary gland and checking for any remaining tumor. Therefore, there is no strict need to perform an MRI immediately after surgery. Instead, physicians can wait until the patient's conditions become more stable (1-2 weeks after surgery) before imaging. This finding can help reduce unnecessary stress in patients, and allows more flexibility in scheduling follow-up care. It also ensures better recovery for patients by not rushing the imaging process.

1. Introduction

Pituitary adenomas account for about 15% of primary intracranial tumors (Barbieri et al., 2007; Goya et al., 2004; Isobe et al., 2000; Pennacchietti et al., 2016). Except for prolactinoma, the treatment of choice in pituitary adenoma is surgical excision (Mortini et al., 2005). Postoperative imaging is important in detecting possible surgical complications, tumor residue, and treatment planning (Doerfler & Richter, 2008; Moldovan et al., 2016). Magnetic resonance imaging (MRI) is the preferred neuroradiologic method of evaluating the sellar region (Huang & Mukundan, 2016; Zaidi et al., 2016). The reason for the widespread acceptance of the MRI is the appropriate contrast among the different elements of the soft tissue (Hess & Dillon, 2012). Generally, the optimal time for early postoperative MRI in central nervous system lesions is 48 hours after surgery (Albert et al., 1994; Oser et al., 1997; Saunders et al., 2005). Nevertheless, no guidelines determine the best time for postoperative imaging in patients with pituitary adenomas (Kılıç et al., 2001b).

We analyzed the pituitary gland, adenoma, and packing material signals three months after surgery at three time points and finally proposed the optimal time for postoperative imaging after pituitary adenoma surgery.

2. Materials and Methods

Study patients

A total of 28 patients with pituitary adenoma referred to the Department of Neurosurgery at Firoozgar University Hospital in Tehran City, Iran, from July 2019 to March 2021 were examined.

The inclusion criteria were as follows: A diagnosis of pituitary adenoma, being a candidate for endoscopic transsphenoidal surgery, and no history of previous surgery or other therapies such as irradiation and dopamine agonist therapy.

All patients had preoperative contrast-enhanced MRI of the sellar region to determine the extent of the tumor and involvement of adjacent structures. Preoperative, endocrinologic, and ophthalmologic evaluations were carried out for all patients.

Surgical technique

All patients underwent an endoscopic endonasal approach under general anesthesia. The endoscopic equipment used included a 0˚ and 30˚, 4 mm rigid endoscope (Karl Storz; Germany), a full high definition (HD) camera (Image 1, H3-Z), and a wide view HD screen. Gener-

ally, the approach was through the right nostril, but the left side was used if there was a significant septal deviation to the right. The sellar floor was reconstructed using a fat pad covered by Surgicel and gelfoam. Histopathologic analysis was performed to establish the diagnosis.

Postoperative MRI

The MRI was performed with a 1.5 T system (Siemens Medical Solutions). The imaging protocol included non-enhanced T1- and T2-weighted and post-contrast T1 images with a 5-mm section thickness of the axial, coronal, and sagittal planes. All patients had a sellar MRI before surgery and three sellar MRIs at 48 hours, two weeks, and three months after surgery.

Imaging analysis

All MR images were interpreted concerning the contents of the sella: The pituitary gland, pituitary adenoma, and adipose tissue used to pack the sella. The signal for each compartment was recorded in the T1-weighted, T2-weighted, and T1-weighted with contrast sequences at different times.

Statistical analysis

Statistical analysis, including descriptive data analysis, was performed using SPSS software, version 23; (IBM; USA). The sellar contents signal at the different time points were considered non-parametric and were evaluated using the Friedman and sign tests. Two-sided $P<0.05$ were considered statistically significant.

3. Results

Demographic and clinical aspects

The mean age of the participants was 45.8 years. About 60.7% were female, and 39.3% were male. The most common complaint at presentation was the enlargement of the extremities, which affected 8 patients (28.6%). A visual disturbance occurred in 7 patients (25%), while 6 patients (21.4%) had a headache. Ten patients (35.7%) had nonfunctional pituitary adenoma, 10(35.7%) were diagnosed with acromegaly, 6(21.4%) had prolactinoma, and 2(7.1%) had an ACTH-producing tumor.

Of the 28 patients, 25 had macroadenomas, and 3 had microadenomas. After surgery, a residual tumor (incomplete removal) was confirmed in 4 patients (14.2%). Postoperative cerebrospinal fluid rhinorrhea occurred in only 8 cases that improved after conservative treatment. Seven patients (25%) developed transient postoperative diabetes insipidus during hospitalization. On ophthalmological examination, 16 patients (57.1%) showed visual field deficits. The demographic and clinical characteristics are shown in Table 1.

MRI of the pituitary gland

In 27 patients (96.4%), the pituitary gland in the T1-weighted sequence was isointense, and one (3.6%) was hyperintense. In the T2-weighted sequence, 27 patients (96.4%) were isointense, and one (3.6%) was hyperintense. In the T1-weighted with contrast sequence, the pituitary glands of all patients were hyperintense. The postoperative MR images had similar results at 48 hours, 2 weeks, and 3 months after surgery. An overview of the pituitary gland signal is shown in Table 2 (Figures 1, 2 and 3).

MRI of pituitary adenoma

T1-weighted pituitary adenoma signals were hypointense in 14.3% of patients, isointense in 21.4%, hyperintense in 53.6%, and mixed in 10.7%. The T2-weighted sequence was hypointense in 17.9%, isointense in 46.4%, hyperintense in 32.1%, and mixed in 3.6%. The T1-weighted sequence with contrast was hyperintense in 92.9% of patients and mixed in 7.1%. In postoperative imaging, only 4 patients showed tumor residue; the signal intensity showed no difference at various times (Table 2). An overview of the MRI characteristics of the pituitary adenomas is given in Table 3 (Figures 1, 2 and 3).

MRI of packing material

The sellar floor was reconstructed with an autografted adipose tissue covered by Surgicel and gelfoam. In the first postoperative MRI of the T1-weighted sequence, the signal of these materials in 7.1% of patients was hypointense, 46.4% was hyperintense, and 46.4% was mixed. The second MRI showed hypointense in 14.3%, hyperintense in 39.3%, and mixed intensity in 46.4%. The third MRI showed hypointense in 10.7%, hyperintense in 46.4%, and mixed intensity in 35.7%. The signal intensities of T1- and T2-weighted images and post-contrast images are indexed in Table 4.

4. Discussion

MRI is currently the preferred neuroradiologic tool for evaluating the sellar region. Postoperative MRI is routinely performed to determine residual or recurrent tumors and possible complications (Doerfler & Richter, 2008; Moldovan et al., 2016). Although the optimal

Table 1. Demographic and clinical characteristics of the study patients

Case No.	Age (y), Sex	Presentation	Size of Tumor	Type of Adenoma	CSF Leak	Residue
1	40, F	Headache	Macroadenoma	Prolactinoma	+	+
2	43, F	Enlargement of extremities	Macroadenoma	GH-secreting		
3	52, M	Obesity	Microadenoma	ACTH-secreting		
4	42, F	Headache	Macroadenoma	GH-secreting		
5	38, M	Infertility	Macroadenoma	Nonfunctional	+	
6	47, F	Enlargement of extremities	Macroadenoma	GH-secreting		
7	49, F	Visual disturbance	Macroadenoma	Nonfunctional		
8	50, F	Infertility	Macroadenoma	Prolactinoma	+	
9	54, M	Enlargement of extremities	Macroadenoma	GH-secreting	+	
10	51, M	Infertility	Macroadenoma	Prolactinoma		
11	55, F	Visual disturbance	Macroadenoma	Nonfunctional		+
12	38, F	Headache	Macroadenoma	Nonfunctional		
13	47, F	Visual disturbance	Macroadenoma	Nonfunctional	+	
14	44, F	Enlargement of extremities	Macroadenoma	GH-secreting		
15	49, F	Enlargement of extremities	Macroadenoma	GH-secreting		
16	48, M	Infertility	Macroadenoma	Nonfunctional		
17	50, F	Visual disturbance	Macroadenoma	Prolactinoma		
18	33, F	Enlargement of extremities	Macroadenoma	GH-secreting		
19	62, M	Headache	Macroadenoma	Nonfunctional		
20	44, M	Enlargement of extremities	Macroadenoma	GH-secreting		
21	51, F	Headache	Macroadenoma	GH-secreting	+	+
22	43, M	Obesity	Microadenoma	ACTH-secreting		
23	39, F	Headache	Macroadenoma	Nonfunctional	+	
24	55, M	Headache	Macroadenoma	Prolactinoma		
25	39, M	Enlargement of extremities	Microadenoma	GH-secreting		
26	42, F	Visual disturbance	Macroadenoma	Nonfunctional	+	
27	40, F	Visual disturbance	Macroadenoma	Prolactinoma		+
28	40, M	Infertility	Macroadenoma	Nonfunctional		

CSF: Cerebrospinal fluid.

Table 2. MRI characteristics of the pituitary gland signals in 3 different time intervals

Sequence	T1				T2				T1 With Contrast			
Signal Evaluation Time	Postopera-tive	48 h	2nd Week	3rd Month	Postopera-tive	48 h	2nd Week	3rd Month	Postopera-tive	48 h	2nd Week	3rd Month
Hypointense	0	0	0	0	0	0	0	0	0	0	0	0
Isointense	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	0	0	0	0
Hyperintense	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	100	100	100	100
Mixed	0	0	0	0	0	0	0	0	0	0	0	0

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Table 3. MRI characteristics of the pituitary adenoma signals in 3 time intervals

Sequence	T1				T2				T1 With Contrast			
Signal Evaluation Time	Postoperative	48 h	2nd Week	3rd Month	Postoperative	48 h	2nd Week	3rd Month	Postoperative	48 h	2nd Week	3rd Month
Hypointense	14.3	0	0	0	17.9	25	25	25	0	0	0	0
Isointense	21.4	25	25	25	46.4	50	50	50	0	0	0	0
Hyperintense	53.6	75	75	75	32.1	25	25	25	92.9	100	100	100
Mixed	10.7	0	0	0	3.6	0	0	0	7.1	0	0	0

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time for postoperative MRI for a central nervous system neoplasm is 48 hours after surgery, there is controversy about the timing for the pituitary adenoma (Albert et al., 1994; Kılıç et al., 2001a; Oser et al., 1997; Saunders et al., 2005). Several studies recommend that the follow-up MRI should not be done immediately after transsphenoidal surgery because postoperative changes such as swelling, blood products, and packing materials inserted into the sella can lead to misinterpretation of the MRI. These studies recommend waiting for their regression (Rajaraman & Schulder, 1999; Rodriguez et al., 1996).

Steiner et al. (1992) evaluated preoperative and postoperative MR images of 25 patients diagnosed with pituitary adenomas. They recommended that a follow-

Table 4. MRI characteristics of the packing material in 3 time intervals

Sequence	T1			T2			T1 With Contrast		
Signal Evaluation Time	48 h	2nd Week	3rd Month	48 h	2nd Week	3rd Month	48 h	2nd Week	3rd Month
Hypointense	7.1	14.3	10.7	3.4	3.6	35.7	7.1	14.3	10.7
Isointense	46.4	39.3	46.4	10.7	7.1	10.7	46.4	39.3	46.4
Hyperintense	46.4	46.4	35.7	35.7	35.7	17.9	46.4	46.4	35.7
Mixed	100	100	92.9	50	53.6	28.6	100	100	92.9

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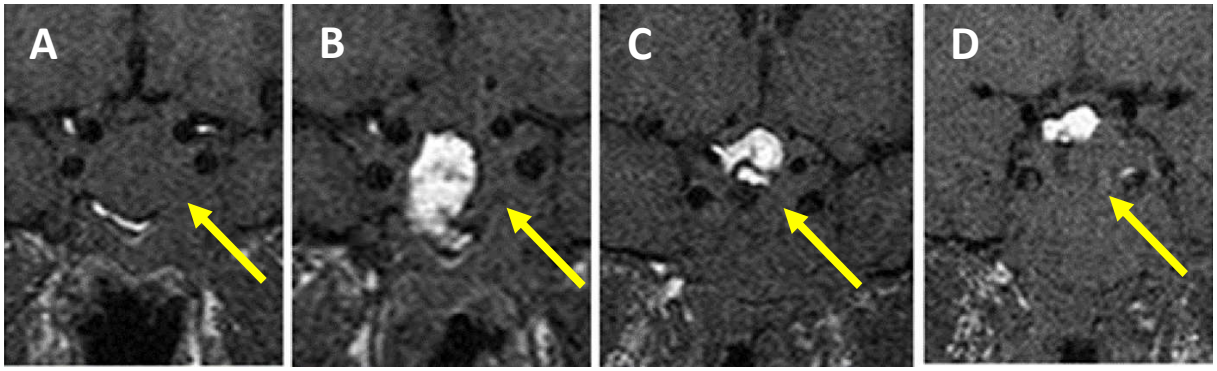

Figure 1. T1-weighted MRI of sella

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Notes: Tl-weighted MRI from sellar region preoperatively (A) and postoperatively in 48 hours (B), 2 weeks (C), and 3 months (D) after surgery. The arrays show the sellar region.

up MRI be done 4-6 months after surgery. On the other hand, some studies have reported that the best time for postoperative MRI was a few days after surgery. Kilic et al. (2001a) assessed 80 patients with pituitary adenomas and found that the best follow-up imaging was 24 hours after transsphenoidal surgery. During this period, inflammation is in the early phase, and the packing material has not degraded and can easily be identified on the MR image. Blood degradation products, such as methemoglobin, have not yet formed and can easily be differentiated from a residual tumor. The current study found no time preference for the performance of postoperative MRI.

We found that the pituitary gland signals in most patients were isointense in the T1- and T2-weighted and hyperintense in the T1-weighted with contrast. The pituitary gland showed constant signals three months after the surgery and was well-demarcated from the surrounding tissue. Most previous articles reported only good delineation of the pituitary gland after surgery and did not define the signal intensity in each sequence.

Kilic et al. (2001a) concluded that the early postoperative MRI and delayed MRI delineated the pituitary gland. Yoon et al. (2001) did not explain the delineation and signal intensity of the pituitary gland and only reported changes in its configuration after surgery. Kramer et al. (2002) found that the normal gland was not visible in most patients in early postoperative MRI. Steiner et al. (1992) reported that, in 22 of 25 patients, the pituitary gland was well-delineated after surgery but did not compare this result with later follow-up imaging. Dina et al. (1993) reported that in the early postoperative period, the pituitary gland was remarkably similar to its preoperative appearance). Rodriguez et al. (1996) evaluated the size and shape of the pituitary gland after surgery and compared imaging according to these criteria.

Although only 6 patients were found to have a residual tumor, the tumor and packing material were well delineated in all of them. In all patients, the signal for the adenoma in all sequences was constant over time. Despite using the same materials for packing, their signals were different, probably because of the presence of blood that

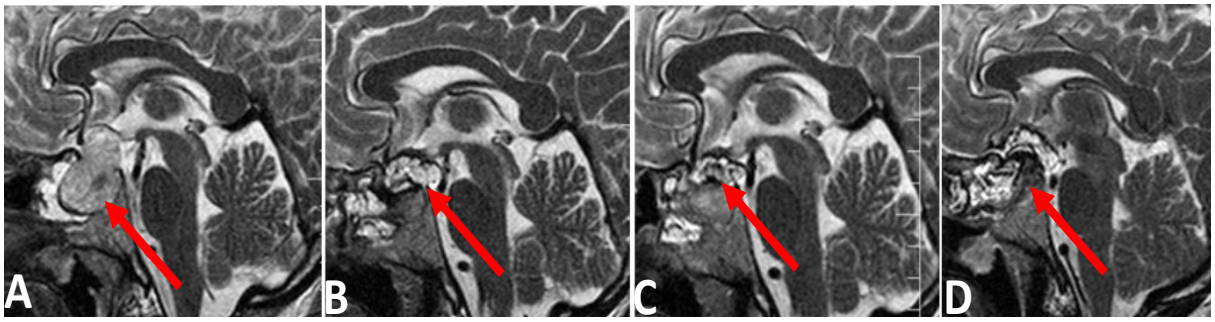

Figure 2. T2-weighted MRI of sella

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Notes: Sagital T2-weighted MRI from sellar region preoperatively (A) and postoperatively in 48 hours (B), 2 weeks (C), and 3 months (D) after surgery. The arrays show the sellar region.

Table 5. Signal differences between time intervals in the patients underwent pituitary adenoma surgery

Groups	Sellar Component					
	Pituitary Adenoma			Packing Material		
	T1	T2	T1 With Contrast	T1	T2	T1 With Contrast
Postoperative and 48 h	P<0.001	P<0.001	P<0.001	-	-	-
Postoperative and the 2nd week	P<0.001	P<0.001	P<0.001	-	-	-
Postoperative and the 3rd month	P<0.001	P<0.001	P<0.001	-	-	-
48 h and the 2nd week	-	-	-	0.625	1	0.5
48 h and the 3rd month	-	-	-	0.375	0.001	1
2nd week and 3rd month	-	-	-	0.25	P<0.001	0.687

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had stained the gelfoam and Surgicel. Packing material MRI signals were compared, and it was concluded that there were meaningful differences in their intensity only in the T2-weighted sequence (Table 5). We observed that the T2 signal intensity of the packing material changed from hyperintense to hypointense. This shift was probably caused by a decrease in the water content and concentration of macromolecules, which have short T2 relaxation times (Mangrum et al., 2018).

Kilic et al. (2001a) could not differentiate a residual tumor in one-third of patients in the early postoperative MRI because of blood in the tumor bed. Stiner et al. (1992) reported that the adenoma's signal and remnant were constant in all patients except one. They performed postoperative MRI once, compared it with preoperative MRI, and could not differentiate residual tumor from implanted material. In contrast to other studies that assessed the shape of the sellar element, the current study compared post-surgical MRI statistically based on the signal intensity of the sellar contents. The change in signal intensity of the sellar elements is a more objective criterion than their shape.

We concluded that contrary to other intracranial neoplasms, there were no apparent changes in MRI signal intensity in patients with pituitary adenoma over 3 months after the operation. So, there is no advantage to the time of follow-up imaging in patients with pituitary adenoma. Consequently, unlike previous documentation, the Imaging time of the patient with pituitary adenoma was unimportant, and an MRI could be performed any time after surgery.

5. Conclusion

There are no significant differences in MRI findings between 48-hour, two-week, or three-month post-sur-

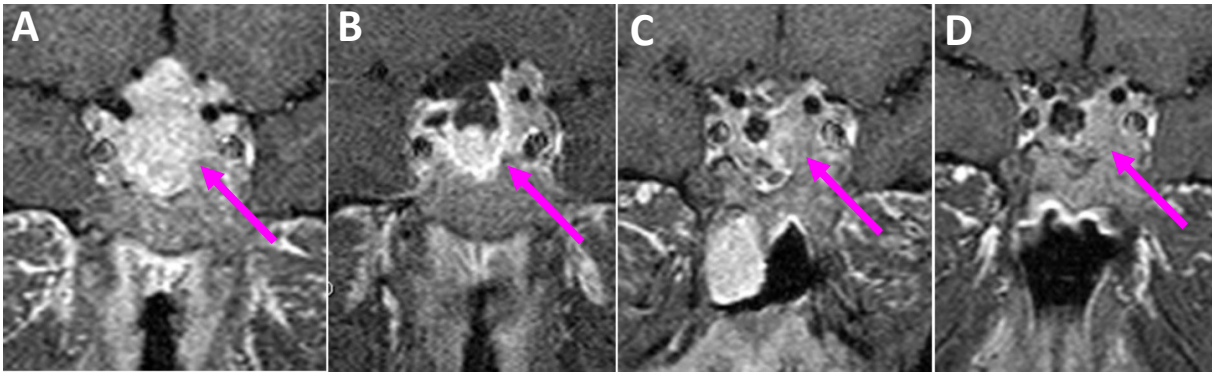

Figure 3. T1-weighted with contrast MRI of sella

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Notes: Coronal contrast-enhanced Tl-weighted MRI from sellar region preoperatively (A) and postoperatively in 48 hours (B), 2 weeks (C), and 3 months (D) after surgery. The arrays show the sellar region.

gery periods in patients with pituitary adenoma. This indicates that the timing of post-operative imaging in pituitary adenomas is not critical for diagnostic accuracy. These findings provide flexibility in the timing of follow-up MRIs, allowing clinicians to prioritize patient stability and recovery before scheduling imaging. By reducing the urgency for immediate MRI, unnecessary stress and logistical challenges for patients and healthcare providers can be minimized. This study is the first of its kind globally, paving the way for updated post-operative care protocols specific to pituitary adenomas.

Ethical Considerations

Compliance with ethical guidelines

The study was conducted with the approval of the Ethics Committee of Iran University of Medical Sciences. The study followed the ethical standards of the 1964 Helsinki Declaration and its later amendments.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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