# MRI CHARACTERIZATION OF SELLAR & PARASELLAR LESIONS AND THEIR CLINICAL CORRELATION

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## ABSTRACT

**Aims & Objectives:** This study aimed to describe the prevalence of the various lesions and to characterize imaging features of the sellar and parasellar lesions and to correlate between clinical and radiological diagnosis.

**Methodology:** This study was done for the characterization of sellar & parasellar lesions with the help of MRI scan, which were done at the MRI centre, MB Hospital, Udaipur, Rajasthan from January 1, 2017, to December 2017. Medical case papers were reviewed for the primary clinical indication that led to a referral for pituitary MRI and serum prolactin levels were noted to follow up regarding surgical or conservative management was done. After analyzing the data results were expressed as frequency of occurrence and percentages of various lesions which were compared with clinical findings.

**Results:** The study population consisted of 80 patients, of which majority were females. MRI revealed abnormality in 68% cases and it was found that combined sellar and suprasellar involvement was there in most of the patients, followed by pure intrasellar and parasellar involvement.

**Conclusion:** The sellar and parasellar regions can be affected by a wide variety of lesions with almost similar presentation. When symptoms of mass effect, visual field deficits and endocrine abnormalities are not sufficient to distinguish these lesions, the use of MRI can helpful in reaching the proper diagnosis.

**Key-words:** MRI, Sellar, Parasellar Lesions.

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## INTRODUCTION

The sella turcica and adjoining parasellar region is an anatomically small but complex area of the central nervous system. A wide range of neoplastic, inflammatory, infectious, developmental and vascular diseases affect this region.[1] Lesions of the sellar and parasellar region are very common, accounting for 10–15%

of intracranial masses based on surgical experience.[2] Pituitary adenomas account for about 90% of lesions of the sellar and parasellar region, according to different large surgical series. However, in 8-15% of cases, an etiology other than a pituitary adenoma is encountered.

Plain skull radiographs are poor at delineating soft tissues, and thus have been replaced by cross-sectional imaging techniques such as CT scanning and MRI. CT scan, though less frequently used, is a useful examination depicting soft tissue calcification, bony destruction, and surgically relevant bony anatomy. However, due to radiation exposure and less optimal soft tissue contrast, they are limited in use for evaluating pituitary lesions. Currently, MR imaging is accepted as the "optimal imaging technique" for this location, with high-contrast, spatially detailed images in multiple imaging planes and lack of ionizing radiation. Preoperative differentiation of these lesions is of clinical importance because it determines the use of surgery versus nonsurgical techniques, a trans sphenoidal versus an intracranial surgical approach, and the degree of resection.[2]

## AIMS & OBJECTIVES

This study aimed to describe the prevalence of the various lesions and to characterize imaging features of the sellar and parasellar lesions and to correlate between clinical and radiological diagnosis.

## MATERIAL AND METHODS

This retrospective randomised hospital based observational / correlational study was conducted in the Department of Radiodiagnosis, MB Hospital & RNT Medical College, Udaipur, Rajasthan during the period of one year from 1st January to 31st December 2017. The study was approved by the Institutional Ethical Committee. All cases, which were referred to us for a pituitary MRI scan were selected for the present study irrespective of age and sex. The patients who were not co-operative and morbidly sick or who were not giving consent for scanning were excluded from this study. In all selected cases, pituitary MRI scans were performed with the help of 1.5 Tesla Philips MRI machine at the MRI Centre, MB Hospital, Udaipur. The standard MR protocol, including non enhanced coronal, sagittal and axial T1 weighted images and axial T2 weighted images; contrast enhanced sagittal and coronal T1 weighted images; dynamic contrast were done for the enhanced study. Medical case papers were reviewed for the primary clinical indication that led to a referral for pituitary MRI and serum prolactin levels were also noted and a thorough follow up regarding surgical or conservative management was done. The data were filled in the predesigned proforma and after collection the data were analyzed and observations were made accordingly to conclude the study. Results were expressed as frequency of occurrence and percentages of various lesions which were compared with clinical findings.

## OBSERVATIONS AND RESULTS:

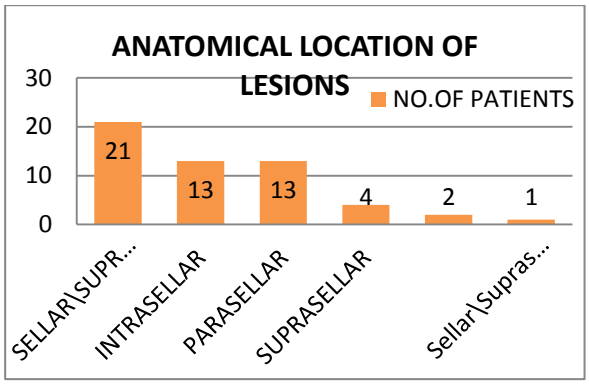
The study population consisted of 80 patients, of which majority were females amounting to 60% (48). Of this, 50% of the study population belonged to 21-40 years age group with the mean age being 38.95±15.91 years. (TABLE 1)

**TABLE-1:** Age wise Distribution of the Cases

| AGE DISTRIBUTION | NO. OF PATIENTS | PERCENTAGE |
|---|---|---|
| 0-20 | 8 | 10% |
| 21-40 | 40 | 50% |
| 41-60 | 27 | 34% |
| 61-80 | 3 | 4% |
| 81-100 | 2 | 3% |
| Total | 80 | 100% |

MRI revealed abnormality in 54 (68%) of total 80 cases, with rest 26 (32%) being normal. MRI revealed combined sellar\suprasellar involvement in most patients i.e. 21(39%), followed by pure intrasellar and parasellar involvement in 13 (24%) cases each.(BAR GRAPH 1)

On MRI, isointense signals were seen in 61% cases on T1WI while T2 sequences showed isointense signals in 43% cases. Isointensity on both T1 and T2 was seen in 17 pituitary adenomas (77%) and 6 meningiomas (100%). T1 hyperintensity was seen in 2 cases of Rathke's cleft cyst, 2 cases of pituitary microadenomas with apoplexy and 1 case of Craniopharyngioma. The CSF intensity signal was seen on both T1 and T2 sequence in 5 cases of empty sella with pituitary flattening. (TABLE 2)




GRE sequence showed susceptibility in 8 (15%) out of 54 abnormal patients, which was due to haemorrhage or calcification in 4 cases of pituitary adenomas, 2 cases of craniopharyngiomas, 1 case of meningioma and 1 of metastasis. DWI showed restriction in 4 (7%) cases of 54 cases. Epidermoid cyst, encephalitis and brain abscess in parasellar regions was responsible for diffusion restriction.

**TABLE-2:** MRI Sequence of the Cases

| MRI SEQUENCE | T1 (n=54) | | | | T2 (n=54) | | | |
|---|---|---|---|---|---|---|---|---|
| INTENSITY | ISO | HYPO | HYPER | CSF | ISO | HYPO | HYPER | CSF |
| NUMBER | 33 | 11 | 5 | 5 | 23 | 6 | 20 | 5 |

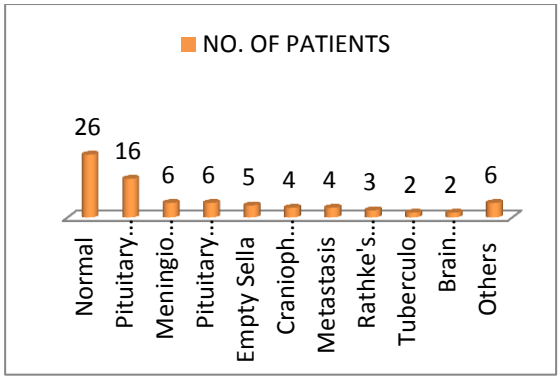
On T1 post contrast study, homogenous enhancement was seen in 17 (31%) cases, followed by no enhancement in 13 (24%) cases and heterogenous enhancement in 8 (15%) cases. Homogeneous enhancement was seen in 10 (63%) of pituitary adenomas, all 6 meningiomas (100%) and 1 case of Tolosa hunt syndrome. Heterogeneous enhancement was seen in 4 cases of pituitary macroadenoma, 3 cases of metastasis and 1 case of craniopharyngioma. Non enhancing lesions were seen in 3 cases of Rathke's

cleft cyst, 5 cases of empty sella, 1 case, each of pituitary microadenoma, epidermoid cyst, low grade glioma and encephalitis. Peripheral enhancement is seen in 3 cases in Craniopharyngioma, 2 cases of brain abscess, 1 case each of pituitary macroadenomas and tuberculoma. Minimal enhancement is seen in 6 cases of pituitary adenoma and 1 case of metastasis.

**TABLE-3:** Contrast MRI Sequence of the Cases

| CONTRAST ENHANCEMENT | NO.OF CASES | PERCENTAGE (%) |
|---|---|---|
| HOMOGENOUS | 17 | 31% |
| HETEROGENOUS | 8 | 15% |
| NON-ENHANCING | 13 | 24% |
| MINIMAL ENHANCEMENT | 7 | 13% |
| PERIPHERAL ENHANCEMENT | 7 | 13% |
| DURAL ENHANCEMENT | 2 | 4% |
| TOTAL | 54 | 100% |

MRI revealed mass effect in 29 (53%) patients, which included optic chiasma\tract invasion in 60%, pituitary compression in 33%, cavernous sinus invasion in 17%, hydrocephalus in 13%, temporal lobe compression in 7% and perilesional edema in 3%.Of the 29 cases which showed mass effect, 11 were pituitary adenoma, 5 were empty sella and meningioma each, 4 were craniopharyngiomas, 2 were Rathke's cleft cyst, 1 was epidermoid cyst and metastasis each.




Of the abnormal cases, pituitary adenoma accounted for 22 (40%) cases, meningioma for 6(11%) cases, empty sella -5(9%) cases, craniopharyngioma and metastasis for 4 (7%) cases each, Rathke's cleft cyst for 3(5%) , brain abscess and tuberculoma for 2(4%). Others (6=11%) included 1 each of neurosarcoid, tolosa hunt syndrome, encephalitis, low grade glioma and lymphocytic hypophysitis. (BAR GRAPH-2)

The most common chief complaint encountered was Headache (34%), followed by visual disturbances (21%), menstrual disturbances (18%), fever (5%), followed by seizures, giddiness\vertigo (4% each), and others (12%) which include infertility, generalized weakness, generalized obesity, abnormal behaviour, difficulty in walking etc. Headache was a common complaint among non-adenomatous lesions while, visual disturbances were present in almost

**TABLE-4:** Distribution of the Cases as per Complaints

| LESION CHIEF COMPLAINT | ADENOMATOUS | NON ADENOMATOUS | TOTAL | P value |
|---|---|---|---|---|
| HEADACHE | 5 | 11 | 16 | 0.35 |
| VISUAL DISTURBANCE | 10 | 7 | 17 | 0.06 |
| MENSTRUAL IRREGULARITY | 3 | 0 | 3 | 0.03 |
| FEVER | 2 | 2 | 4 | 0.69 |
| SEIZURES | 0 | 3 | 3 | 0.13 |
| GIDDINESS, VERTIGO | 0 | 1 | 1 | 0.40 |
| OTHERS | 2 | 8 | 10 | 0.13 |
| TOTAL | 22 | 32 | 54 | 0.06 |

(Correlation of clinical with radiological findings)

equal proportion of adenomatous (10 cases) and non adenomatous lesion (7cases). Only menstrual irregularity was found to have a statistically significant correlation with the occurrence of adenoma ($p<0.05$).(TABLE 4)

Hyperprolactinemia was also found to have significant correlation with pituitary adenoma than with non adenomatous lesion ($p<0.05$). Out of the total 7 patients of hyperprolactinemia, 6 (85%) were diagnosed as Pituitary Adenoma on imaging.(TABLE 5)

**TABLE-5:** Correlation of S.Prolactin with Pituitary Adenoma

| S.PROLACTIN\ PITUITARY ADENOMA | ADENOMATOUS | NON-ADENOMATOUS | TOTAL |
|---|---|---|---|
| HYPERPROLACTINEMIA | 6 | 1 | 7 |
| NORMAL | 16 | 57 | 73 |

## DISCUSSION

In the present study, the mean age of the study population was 38.95±15.91 years with females being in the majority (60%). This was in concordance with a study conducted by Vikas Batra et al[3] and Banna et al[4]. In their study, they encountered maximum number of patients in the fourth decade, and with female preponderance. Out of 80 patients, MRI revealed abnormality in 54 (68%) of total 80 cases, with rest 26 (32%) being normal. Famini, et al[5] reported normal pituitary gland in 47% of subjects undergoing pituitary MRI for suspected sellar and parasellar lesions. Of the abnormal cases, pituitary adenoma was the most common pathology (40% cases) followed by meningioma (11% cases) being the second most common. Freda[1] et al reported 90% prevalence of pituitary adenomas among the various sellar and parsellar lesions.

The most common chief complaint encountered was Headache (34%), followed by visual disturbances (21%) and menstrual disturbances (18%). The headache was a common complaint among non adenomatous lesions, while, menstrual irregularity showed a significant correlation ($p=0.03$) with pituitary adenoma. Visual disturbances were present in almost equal proportion of adenomatous (10 cases) and non adenomatous lesion (7cases). Famini et al[5] also reported headache (57%) as the most common presenting symptom in patients with nonadenomatous masses. According to G.I. Ogbole et al,[6] visual loss and other neuro-ophthalmic complications are often common presenting complaints in sellar

tumours due to mass effect on optic nerves, chiasm and optic tracts.

## PITUITARY ADENOMA

Of the abnormal 54 cases, pituitary adenoma accounted for the majority of the cases, i.e, 22 (40%) cases with 16 macroadenomas and 6 microadenomas. On T1, pituitary adenomas showed isointensity in 81% cases and hyperintensity in 19%. Hyperintense lesions also showed susceptibility on GRE suggestive of calcification or haemorrhage. 10 cases (62%) out of 16 pituitary macroadenomas showed homogenous enhancement, while 6 cases showed heterogenous enhancement. Our findings were also similar to the results of Johnsen et al,[7] which showed 82% lesions were isointense and 18% of the lesions showing hemorrhage within the adenoma were hyperintense. They also stated that T2-weighted appearance is variable and does not generally provide additional significant diagnostic information.in their study, contrast material was used for examination of 34 of 51 macroadenomas, and 24 lesions (71%) enhanced. Eleven of these (46%) enhanced uniformly, and the remainder enhanced heterogeneously. Of the total 7 cases of hyperprolactinemia, 6 were associated with pituitary adenoma, thus a significant correlation was found between the presence of hyperprolactinemia with pituitary adenoma.

In the present study, the three major chief complaints were headache, visual disturbance and menstrual disturbances, of which visual disturbances (58%) and menstrual irregularities (100%) were more specifically associated with adenoma than headache (31%). According to G.I. Ogbole et al,[6] visual loss and other neuro-ophthalmic complications are often common presenting complaints due to the proximity of sellar tumours to the optic nerves, chiasm and optic tracts and their corresponding mass effect on these structures. The visual symptoms may or may not be accompanied by a history of headache. In our study mass effect in form of indentation of optic chiasma, cavernous sinus invasion and encasement of the carotid artery was present in 68% of pituitary macroadenomas. This was comparable to a study conducted by Johnsen et al[7]. Who showed mass effect in 34 of the 51 patients with macroadenomas (67%), with extension into the suprasellar cistern. Nine out of 16 cases of pituitary macroadenoma were operated and confirmed histopathologically. Rest 7 cases were kept on conservative management either due to patient's refusal of surgery or complicated approach due to carotid artery encasement. Three of the pituitary microadenomas which were symptomatic due to hyperprolactinemia were operated and confirmed as prolactinomas.

## MENINGIOMA

In the present study, meningiomas comprised 11% of the 54 abnormal cases. They were the second most common lesion to be diagnosed after pituitary adenoma in the sellar\ parasellar region. They arose from a parasellar location in 4 out of 6 (66%) cases and suprasellar location in 2 cases. This was similar to the study of

Benjamin et al[8] and Johnsen et al[7] who both reported rates of occurrence of meningiomas as 20% and 11% respectively. In 15–30% of cases, meningiomas arise from the parasellar region (tuberculum sella, cavernous sinus, planum sphenoidale, diaphragma sellae, clinoid process). Meningiomas are tumors of adults, more commonly occurring in women. Five out of 6 cases in our series occurred in females of 30-60 years age group. Johnsen et al[7] reported a female preponderance in 10 of the 14 meningiomas with an average age of 64 years.

Three out of 6 cases presented with visual disturbances which was possibly due to optic chiasm \optic nerve indentation seen in 4 cases. According to Orakdogeny et al.[9] (2004), visual loss is the most common symptom, even without endocrine dysfunction. The visual loss may begin with monocular blurring and then progresses to bilateral. Imaging features of meningiomas are characteristic and are generally isointense relative to the cortical gray matter on T1- and T2-weighted images, enhancing homogeneously and brightly (all 6 cases showed this feature in our study). Contrast material enhancement of meningioma is usually rapid and striking owing to their highly vascular nature. Enhancement is commonly uniform; in all of cases of meningioma in which contrast material was given, the tumors showed marked, uniform enhancement in the study by Johnsen et al. These lesions can remain stable for a long time and therefore can be safely followed-up only by serial imaging, but in the presence of symptomatic or growing lesions surgery is the treatment of choice. Most of these tumors are approached by a trans-cranial approach; in recent years, however, trans-sphenoidal extended endoscopic approaches have gained momentum.[10] Five out of 6 cases in our study were operated with trans-cranial approach. One patient refused surgery so was kept on follow up imaging.

## CRANIOPHARYNGIOMAS

In the present study, 4 cases of craniopharyngiomas were encountered comprising 7% of the abnormal cases. Two were males and two females with two in <20 years age group and two were around 40 years. Karavitaki et al[11] stated that craniopharyngiomas are uncommon tumors accounting for 2–5% of all primary intracranial neoplasms with no gender difference. Craniopharyngiomas are derived from squamous cell rests in the remnant of Rathke's pouch anywhere along the path of the craniopharyngeal duct. The majority (95%) are located in the sellar/parasellar region with a suprasellar component (purely suprasellar in 20–41%, both supra- and intrasellar in 53–75%), but also entirely intrasellar tumors can occur[11,12] . In our study, 3 out of the 4 cases were in both sellar and suprasellar location, with one being entirely suprasellar.

In the present study, hetergenous signals were seen on T1 and T2 with peripheral enhancement in 3 out of the 4 cases suggesting predominant cystic component . Two of the 4 cases in our study showed susceptibility on GRE which was possibly due to calcification. The MR appearance

of craniopharyngiomas depends on the proportion of the solid and cystic components, the content of the cyst(s), and the amount of calcification.[8] The solid portions of the tumor appear as iso- or hypointense relative to the brain on pre-contrast T1-weighted images, but can also have a mottled appearance owing to calcific regions; they are usually of mixed hypo- or hyperintensity on T2-weighted sequences, and heterogeneously enhance following Gd administration.[13,14] Large calcifications may be visualized as nodular or curvilinear areas of low signal on both T1- and T2[15,16] and are more evident on CT. The cystic components are hyperintense on T1 with a thin peripheral contrast-enhancing rim, and have high or mixed intensity on T2 images.[17] All 4 cases showed mass effect in our study in form of optic chiasm indentation and 3 compressed the adjacent III ventricle with resultant hydrocephalus. All 4 cases were operated and confirmed histopathologically.

## EMPTY SELLA

Empty sella (ES) is defined as a herniation of the subarachnoid space into the sella turcica, associated with stretching of the pituitary stalk and flattening of the pituitary gland against the sellar floor (Giustina et al., 2010). In our study, we reported 5 cases of empty sella (9%) of the total 54 abnormal cases with the majority (60%) being females in the third decade and most common presentation being headache. On imaging, CSF intensity was seen in the sella with pituitary compressed against the floor in all cases in the present study (Figure 6). De Marinis et al[18] observed empty sella in up to one third in obese females and associated with different clinical conditions (headache, obesity, hypertension, menstrual disturbances, and endocrine dysfunctions).

## METASTASIS

Metastases are relatively uncommon in this region with reported incidence of less than 1% of cases in surgical series examining patients undergoing transsphenoidal surgery for sellar or parasellar tumors.[19] Metastasis to sellar and parasellar region was seen in 7% (4) cases in our study with no sex predominance, however all belonging to >45 years age group. Three were known case of lung carcinoma and one breast carcinoma. Three were metastasis to parasellar region (clivus, optic chiasm, cavernous sinus and adjacent temporal lobe) while one to posterior pituitary. Clinical presentation was governed by the site of metastasis. Metastasis to optic chiasm presented with visual disturbance, posterior pituitary metastasis presented with polyuria, metastasis to clivus with brainstem involvement presented with difficulty in walking and metastasis to cavernous sinus presented with ocular pain on movements.

On imaging, T1 hypointensity was seen in 75%, T2 hyperintensity in all and heterogenous contrast enhancement in 75%. No susceptibility was seen on GRE or diffusion restriction on DWI. Perilesional edema was seen in one case. All patients were put on chemoradiotherapy. Freda & Post[1] (1999) and Kaltsas et al[20] (2008) evaluated the

imaging features of metastasis on MRI as appearing enhancing isointense or hypointense sellar/suprasellar mass on T1, and usually hyperintense on T2. Komninos J et al[19] described the enhancement after gadolinium administration. Enhancement may be homogeneous or heterogeneous, and rim enhancement can also be seen.

## RATHKE'S CLEFT CYST

Rathke's cleft cysts are comparatively less common and only 3 cases (5%) were seen in the present study who presented with nonspecific symptoms of headache and vertigo. In a similar study by Johnsen et al,[7] two young girls, one presented with chronic headache and other with unrelated seizure disorder were diagnosed to have Rathke's cleft cyst on MRI. All three cases in our study showed hyperintense T1 signals and hypointense T2 signals. None of the three cases showed any enhancement on post contrast study. Freda PU[1] et al stated that Rathke's cysts appear as discrete cystic and non-enhancing lesions on MRI with variable signal intensity on either T1 or T2-weighted images.

## OTHERS

Other less common lesions detected in this region in the present study were 2 cases of brain abscess in the medial temporal lobes, 2 cases of tuberculosis with one presenting as meningeal enhancement along the basal cisterns and other as tuberculoma in the suprasellar cistern. 1 each of neurosarcoid, tolosa hunt syndrome, encephalitis, low grade glioma and lymphocytic hypophysitis were also detected.

## CONCLUSION

The sellar and parasellar regions can be affected by a wide variety of lesions. The presentation of these lesions could be similar. While symptoms of mass effect, visual field deficits and endocrine abnormalities are not sufficient to distinguish these lesions, the use MRI does help in reaching the proper diagnosis. MRI is the modality for characterizing sellar and parasellar lesions, morphology of lesions, nature of contrast material enhancement and extent of lesions.

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**Conflict of Interest:** Nil

## REFERENCE:

1. Freda PU, & Post KD. Differential diagnosis of sellar masses. Endocrinology and Metabolism Clinics of North America, 1999; 28: 81-117.
2. Terada T, Kovacs K, Stefaneanu L, Horvath E.. Incidence, pathology, and recurrence of pituitary adenomas: study of 647 unselected surgical cases. Endocrine Pathology, 1995; 6: 301–310.
3. Vikas Batra , Pankaj Kant Gupta, Ramanand Gehlot, Puneet Awasthi . Radiopathological correlation of sellar and suprasellar masses: our experience. Int J Res Med Sci. 2016 Sep;4(9):3924-3928.
4. Banna M, Baker HL, Houser OW. Pituitary and parapituitary tumours on computed tomography. BJR. 1980;53:1123-43 .

5. Famini P, Maya MM, & Melmed S. Pituitary Magnetic Resonance Imaging for Sellar and Parasellar Masses: Ten-Year Experience in 2598 Patients. Journal of Clinical Endocrinology & Metabolism, 2011; 96:1633–1641.
6. G.I. Ogbole , O.A. Adeyinka, C.A. Okolo, A.O. Ogun, O.M. Atalabi. Low field MR imaging of sellar and parasellar lesions: Experience in a developing country hospital. European Journal of Radiology, 2012; 81: e139–e146 .
7. Johnsen D.E., W. Woodruf et al. MR Imaging of the Sellar and Juxtasellar Regions. RadioGraphics, 1991;11:727-758.
8. Benjamin Y. Huang, MD, MPH, and Mauricio Castillo, MD, FACR. Nonadenomatous Tumors of the Pituitary and Sella Turcica. Top Magn Reson Imaging, 2005;16:289-299.
9. Orakdogeny M, Karadereler S, Berkman Z, Ersahin M, Ozdogan C, & Aker F. Intrasuprasellar meningioma mimicking pituitary apoplexy. Acta Neurochirurgica (Wien), 2004; 146(5):511-515.
10. Cappabianca P, Cirillo S, Alfieri A, D'Amico A, Maiuri F, Mariniello G, Caranci F, & de Divitiis E. Pituitary macroadenoma and diaphragma sellae meningioma: differential diagnosis on MRI. Neuroradiology, 1999; 41(1):22-26.
11. Karavitaki N, Brufani C, Warner JT, Adams CB, Richards P, Ansorge O,Shine B, Turner HE, & Wass JA. Craniopharyngiomas in children and adults: systematic analysis of 121 cases with long-term follow-up. Clinical Endocrinology (Oxf), 2005;62(4):397-409.
12. Van Effenterre R, & Boch AL. Craniopharyngioma in adults and children: a study of 122 surgical cases. Journal of Neurosurgery, 2002;97:3–11.
13. Choi SH, Kwon BJ, Na DG, Kim JH, Han MH, & Chang KH. Pituitary adenoma, craniopharyngioma, and Rathke cleft cyst involving both intrasellar and suprasellar regions: differentiation using MRI. Clinical Radiology, 2007;62:453–462.
14. Hald JK, Eldevik OP, Brunberg JA, & Chandler WF. Craniopharyngiomas – the utility of contrast medium enhancement for MR imaging at 1.5 T. Acta Radiologica, 1994;35:520–525.
15. Curran JG, & O'Connor E. Imaging of craniopharyngioma. Childs Nervous System, 2005; 21(8-9): 635-639.
16. Smith JK. Parasellar Tumors: Suprasellar and Cavernous Sinuses. Top Magnetic Resonance Imaging, 2005; 16: 307-315.
17. Sartoretti-Schefer S, Wichmann W, Aguzzi A, & Valavanis A. MR differentiation of adamantinous and squamous-papillary craniopharyngiomas. AJNR American Journal of Neuroradiology, 1997; 18: 77–87.
18. De Marinis L, Bonadonna S, Bianchi A, Maira G, Giustina A. Primary empty sella. Journal of Clinical Endocrinology and Metabolism, 2005; 90: 5471-5477.

19. Komninos J, Vlassopoulou V, Protopapa D,Korfias S, Kontogeorgos G, Sakas DE, & Thalassinos NC. Tumors metastatic to the pituitary gland: case report and literature review. Journal of Clinical Endocrinology & Metabolism, 2004; 89: 574–580.

20. Kaltsas GA, Evanson J, Chrisoulidou A, & Grossman AB. The diagnosis and management of parasellar tumours of the pituitary. Endocrine-Related Cancer, 2008; 5: 885–903.

21. Laws ER. Pituitary tumors. therapeutic considerations: surgical. In: Barrow DL, Selman WR, eds. Neumendocrinolog; Concepts in neurosurgem: Baltimore: William & Wilkins, 1992; 5: 395-400.