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Original Article

Radiology Section

Magnetic Resonance Imaging in Evaluation of Pituitary Adenomas

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ABSTRACT

Introduction: Pituitary adenoma often presents with non specific symptoms like headache; Dynamic contrast MRI is important not only in confirming the diagnosis but it also provides information which helps to plan surgical treatment and to evaluate response to medical treatment.

Aim: To evaluate role of MRI in diagnosis of pituitary adenoma.

Materials and Methods: A prospective case series study on 85 patients with pituitary lesions was conducted at the Department of Radio-diagnosis in a tertiary care hospital in Goa (Goa Medical College) over a period of 3 years using 1.5 Tesla unit- Magnetom Avanto, Siemens unit, by using a head matrix coil.

Results: Dynamic contrast enhanced imaging played a crucial role in accurate localization of hormone secreting microadenomas. MRI precisely assessed the invasion of cavernous sinus by macroadenomas on contrast enhanced imaging.

Conclusion: MRI is undoubtedly an indispensible tool to evaluate hypothalamic-pituitary related endocrine disease. In addition to providing a diagnosis, MRI also helps to plan surgical strategies due to its ability to provide multiplanar information about the anatomical relationship of the gland with adjacent structures. MRI is also a modality of choice for follow-up imaging in order to evaluate response to conservative treatment as well as in post operative cases to detect residual lesions / recurrence.

Keywords: Dynamic imaging, Pituitary gland dysfunction, Pituitary macro/microadenoma

INTRODUCTION

Imaging of the pituitary gland has progressed rapidly in recent years. Indirect methods of detecting pituitary gland dysfunction by evaluation of sella turcica on skull films and tomography are being replaced by direct visualisation of the gland with CT and MRI [1,2]. The revolutionary advances that have occurred in imaging modalities of the brain provide extensive details of anatomic relationships and have led to an increased detection rate of pituitary lesions. The introduction of dynamic contrast MR imaging have revolutionised the diagnosis and management of pituitary adenomas. MRI also helps to know nature, extent, operability of tumour and surgical approach. The study was conducted to evaluate the role of MRI in diagnosis of pituitary adenoma.

MATERIALS AND METHODS

A prospective diagnostic case series study on 85 patients with clinical suspicion of pituitary lesions was conducted in the Department of Radio-diagnosis, Goa Medical College, Bambolim, Goa between June 2008 to September 2012. All age group patients ranging from 10-80 years were included in the study. [Table/Fig-1, 2] shows age distribution of pituitary macro and microadenoma. Out of 85 patients 38 were male and 47 were females. The study with a detailed mention of its aim and methodology was presented to the ethical committee at the Goa Medical College for approval. Inclusion criteria were patients with suspected pituitary lesion referred from various departments mainly from the Department of Neurology and Endocrinology on the basis of their clinical presentation. Clinical features of these patients were either due to hypo/

Age (in Years)	Number
10 – 20	02
21 – 30	02
31 – 40	19
41 – 50	11
51 – 60	08
61 – 70	09
71 – 80	02
Total	53

[Table/Fig-1]: Age distribution in macroadenomas.

Age (in Years)	Number
0 – 20	02
21 – 30	08
31 – 40	10
41 – 50	08
51 – 60	02
61 – 70	02
Total	32

[Table/Fig-2]: Age distribution in microadenomas.

hyper functioning of pituitary gland or due to mass effect by pituitary adenoma on adjacent structures leading to visual abnormalities or headache. In all cases the clinical history, a thorough clinical examination and laboratory work up which included Serum Prolactin, Growth hormone levels, Serum IGF-1, Twenty-four hour urine sample for free cortisol levels, Serum ACTH, TSH, T3, T4, FSH and LH; depending on clinical symptoms was performed. Exclusion criteria were patients with Claustrophobia, pacemakers, ferromagnetic prosthetic valve and aneurysm clips. Patient consent for imaging and contrast injection was documented in all cases prior to Imaging. Findings of laboratory investigations mentioned above and the clinical diagnosis were recorded in the study proforma, to be correlated with imaging findings obtained.

The Magnetic Resonance Imaging (MRI) Machine: Plain and post contrast MRI was performed on a 1.5 Tesla unit-Magnetom Avanto, Seimens using a head matrix coil.

Preparation of Patients: In the case of adult patients, the patients were kept fasting for 6 hours prior to the procedure to avoid complications of contrast administration such as vomiting. It was ensured that renal function test were within normal limits before injecting contrast agent. Intravenous Diazepam was used for apprehensive and uncooperative patients. Before placing the patient in the gantry he/she was explained in vernacular about the procedure and the importance of intraprocedural immobilisation. Pre and post contrast images were obtained in all cases.

METHODOLOGY

MR imaging helps obtain a high-spatial-resolution image with a reasonable signal to noise ratio. Precontrast T1 and T2 weighted spin echo image was first acquired in the axial, coronal and sagittal plane using a high-resolution matrix (256×512), small FOV (20×25 cm), and thin slices (3 mm). T1 fat saturated dynamic and post contrast images were then obtained in all three planes. A three-dimensional Fourier transformation gradient echo was used for the dynamic study. A dose of 0.05-0.1 mmol/kg of gadolinium was injected intravenously. After which, every 10 seconds six consecutive sets of three images were obtained in a coronal plane.

RESULTS

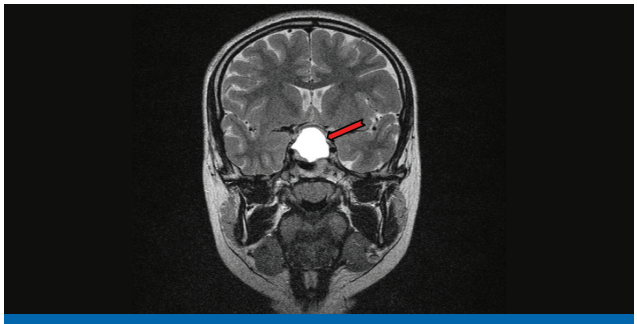
Of the total of 85 cases, 53 (62.3%) cases were pituitary macroadenoma. Of these 30% of the patients presented with headache, 25% with visual disturbances, 33% with headache and visual disturbances, 0.4% with acromegaly, 1.6 % with amenorrhoea, 2% with menstrual irregularity, 2% with galactorrhoea and 6% with menstrual irregularity and galactorrhoea.

In the present study 32 (60.3%) were males and 21 (39.6%) were females.

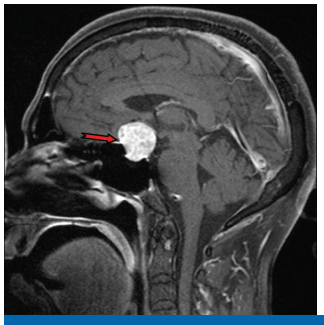
Purely sellar macroadenomas were seen in 11 (20.7%) cases, sellar with suprasellar extension were seen in 23 (43.5%) cases; sellar with sphenoid sinus invasion occurred in 4 (7.5%) cases and sellar macroadenomas with suprasellar as well as sphenoid sinus invasion were seen in 15 (28.3%) cases.

Pituitary macroadenomas ranged in size from 1-3 cm in 22 (41.5%) cases and 31 (58.5%) of them were between 3-5 cm in size. (The greatest dimension was considered). The smallest macroadenoma measures 1.2 cm and the largest 4.9 cm in maximum dimension.

Pituitary macroadenomas showed homogenous signal intensity in 32 (60.4%) cases and the rest 21 (39.6%) cases showed heterogeneous signal intensity. 32 (60.3%) cases



[Table/Fig-3]: Coronal T2WI: shows a macroadenoma appearing hyperintense (like CSF) on non-contrast study, suggesting cystic degeneration.



[Table/Fig-4]: Post Contrast Sagittal T1WI FAT SAT: shows a homogenously enhancing pituitary macroadenoma elevating the optic chiasma.

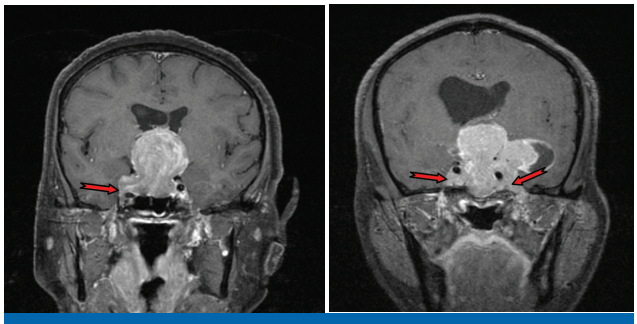
[Table/Fig-5]: Post Contrast Coronal T1WI FAT SAT: shows a homogenous moderately enhancing dumbbell macroadenoma, compressing the optic chiasma (arrow).

of macroadenomas appeared isointense on both T1WI and T2WI. In 14 (26.4%) cases macroadenoma appeared isointense on T1WI and hyperintense on T2WI. In 4 (7.5%) cases macroadenoma appeared hypointense on T1WI and hyperintense on T2WI. Hence, a total of 18 (33.96%) cases were found to have a cystic change [Table/Fig-3]. 3 (5.6%) cases appeared hyperintense on T1WI and T2WI suggesting haemorrhage within.

The infundibulum was not visualised separately in 44 (83%) cases suggestive of encasement/ involvement, and in the remaining 9 (17%) cases it was visualised separately from the sellar lesion, of which it showed deviation towards the left side in 6 (66.7%) cases, towards the right in 2 (22.2%) cases and was in the midline in 1(11.1%) case.

The optic chiasma was compressed in 31 (58.5%) cases [Table/Fig-4,5], abutted in 7 (13.2%) and was uninvolved in 15 (28.3%) cases.

The third ventricle was compressed by the suprasellar component of the macroadenoma [Table/Fig-6a,6b] with resultant hydrocephalus in 5 (9.4%) cases reviewed [3]. In 23 (43.4%) cases, the macroadenoma was seen to abut the third ventricle without causing hydrocephalus and in 25 (47.2%) cases the third ventricle was uninvolved.

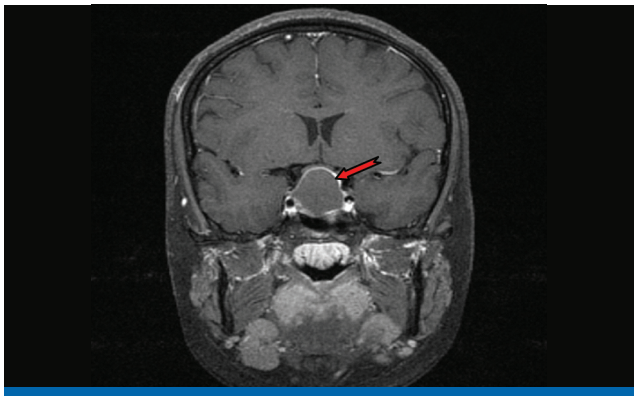


[Table/Fig-6a-b]: (a) Post Contrast Coronal T1WI FAT SAT: shows a large heterogeneously enhancing macroadenoma extending in to right cavernous sinus (arrow) and encasing the right supraclinoid ICA.
(b) Post Contrast Coronal T1WI FAT SAT: shows a large enhancing macroadenoma extending into the cavernous sinuses (arrows) and encasing the supraclinoid ICA (seen as black dot) on both sides. The adenoma is also seen to compress & distort the third ventricle causing hydrocephalus.

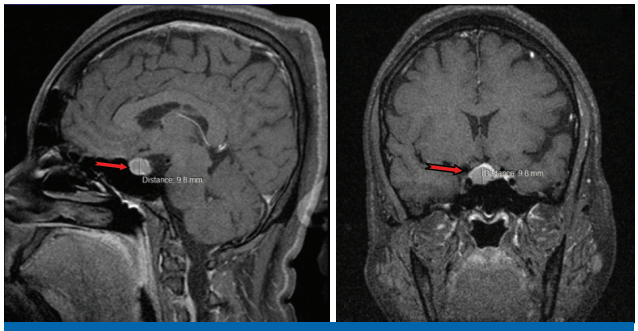
Cavernous Sinus Invasion	Present 36 (68%)		Absent 17 (32%)
	Unilateral	Bilateral	
	30 (83.3%)	6 (16.7%)	

Intracavernous Artery	Encased 19 (52.7%)		Abutted 9 (47.3%)	
	Unilateral	Bilateral	Unilateral	Bilateral
	15 (79%)	4 (21%)	6 (66.6%)	3 (33.3%)

[Table/Fig-7]: Showing % of cavernous sinus invasion and encasement of internal carotid artery by pituitary macroadenoma.



[Table/Fig-8]: Post Contrast Coronal T1WI FAT SAT: shows a macroadenoma with peripheral rim enhancement and a central non-enhancing area suggestive of cystic necrosis within.



[Table/Fig-9]: Post Contrast Sagittal T1WI FAT SAT: shows a non-enhancing microadenoma in the anterior pituitary.
[Table/Fig-10]: Post Contrast Coronal T1WI FAT SAT: shows a non-enhancing microadenoma in the lateral aspect of the pituitary gland, extending to the midline.

Percentage of Cavernous sinus invasion by pituitary macroadenoma is shown in [Table/Fig-7].

On post contrast imaging, 32 (60.3%) cases of the macroadenomas showed homogenous enhancement [Table/Fig-4] and 21 (39.7%) cases revealed heterogeneous enhancement with non-enhancing areas within suggestive of necrosis/ haemorrhage/ cystic change [Table/Fig-8] [4].

Prolactin levels were found to be increased in 48 (90.5%) cases of macroadenomas, diagnosed as prolactinomas and raised growth hormone in 2 (3.7%) of cases. Non functional macroadenoams were found in 3 (5.7%) of cases. Histopathologic findings were obtained in 40 (75.5%) of these cases which were managed surgically and were consistent with MRI findings. The remaining 13 (24.5%) patients were treated conservatively.

There are 32 (37.6%) cases of microadenoma in the present study. They were more common in women in the age group of 20-30 years. The patients presented with menstrual irregularities (31%), amenorrhoea (10%), galactorrhoea (24%), infertility (5%) and 30 % with a combination of menstrual irregularity with infertility [5].

In the present study 6 (18.7%) were males and 26 (81.2%) were females.

Of these, 26 (81.2%) showed raised prolactin levels (diagnosed as prolactinomas), and 1 (3%) showed raised levels of growth hormone (diagnosed as somatotrophic adenoma), and in the remaining 5 (15.6%) cases the pituitary microadenomas detected were incidentilomas.

In 14 (43.7%) patients the pituitary gland had a superior convex surface, in 11 (34.3%) a concave surface and in 7 (22%) a flat superior surface was noted.

In the present study, displacement of the infundibulum from midline was observed in 12 of cases.

On plain MRI, 26 (81.2%) of the microadenomas were isointense on T1WI and 6 (18.7%) showed a hyperintense signal on T2WI suggestive of a cystic microadenoma [6].

All the cases which were reviewed on dynamic contrast imaging, differential enhancement of the microadenoma was noted, which appeared as relatively non-enhancing lesions within an intensely enhancing pituitary [Table/Fig-9,10] [7].

The pituitary microadenomas were seen to range between 3-9 mm in size. Of these, 27 (84.3%) were located laterally and 5 (15.6%) in the midline.

These patients were treated conservatively with medical line of treatment with cabergoline or bromocriptine (both dopamine agonists) in case of prolactinomas and octreotide in case of somatotrophic adenoma.

DISCUSSION

Pituitary imaging is important in confirming the diagnosis of pituitary lesions and also in determining the differential diagnosis of other sellar lesions which can produce similar compressive effect as macroadenomas. Historically, before the advent of CT scan or MRI, the pituitary was imaged with lateral skull x-rays to detect remodeling of the pituitary fossa. The radiographic size of sella is however not a sensitive indicator of pituitary gland abnormality, besides radiographs were found to be poor at delineating soft tissues. Thus the plain radiographs were replaced by CT imaging. Although CT was able to detect up to 80-90% of microadenomas between 8-10 mm in size, Radiologists faced a difficulty in identifying smaller nodules [8]. Hence, CT is replaced by Magnetic Resonance Imaging which is now the modality of choice in the imaging of pituitary lesions due to its superior soft tissue contrast, multiplanar imaging capability and lack of ionizing radiation. In addition, MRI also provides useful information about the anatomical relationship of the gland with adjacent structures and helps to plan surgery [9,10]. MRI techniques have witnessed a rapid evolution in diagnosing pituitary lesions, ranging from non-contrast MRI in late 1980s to contrast-enhanced MRI in mid-1990s. Dynamic contrast-enhanced MRI has further increased the sensitivity of diagnosing pituitary microadenomas.

Macroadenomas are easily detected on non-enhanced MRI. Some microadenomas may exhibit a lesion-to-gland contrast on an unenhanced scan, however others are visualised only after injection of contrast. On dynamic imaging the maximum image contrast between the normal pituitary tissue and microadenomas is attained at 30-60 seconds after bolus injection of intravenous contrast, where in most microadenomas appear as relatively non-enhancing lesions within an intensely enhancing pituitary gland. The peak enhancement of the pituitary adenomas is seen to occur at 60-200 seconds, and is seen to persist for a longer duration. Delayed scan (acquired 30-60 minutes after contrast injection) may demonstrate a reversal of the image contrast. This is due to wash out of contrast from the normal pituitary gland which then diffuses into the microadenoma causing it to appear as a hyperintense focus. Such contrast dynamics within the pituitary gland is highly beneficial in detecting microadenomas.

Also, dynamic contrast MRI has an equally important role in assessing macroadenomas precisely. Besides assessing the invasion of cavernous sinus by the pituitary macroadenoma, it is also helpful in differentiating residual/ recurrent tumour.

The information provided by MRI in cases of macroadenomas is highly useful to treating physician and surgeon for planning of treatment and operability. In most cases, the tumours remain cytologically benign in spite of their invasive behaviour. Because the intracavernous cranial nerves occupy the lateral position in the sinus, clinical signs of cavernous sinus invasion occur late. It is important to determine whether the invasion of cavernous sinus has occurred because this makes complete surgical removal of the tumour impossible and in these cases radiation therapy is preferred. At MR imaging, the most reliable sign of cavernous sinus invasion is tumour encasing the carotid artery; and the most reliable sign excluding invasion is normal pituitary compressed between the tumour and the cavernous sinus. In the present study 36 (68%) patients showed parasellar invasion. Of these 30 patients underwent transsphenoidal surgery. The preoperative MR imaging were useful in predicting complete removal of parasellar component of adenoma (as assessed by post-operative MRI). Similar results were also obtained by Connor et al., [11]. Inferior extension of pituitary macroadenomas occurs not infrequently and in these cases bone invasion and erosion of the floor of pituitary fossa may occur with possible extension into the sphenoid sinus. In such a case the inferior margin of the mass will be outlined by air in the sphenoid sinus, and there may be associated intracranial air, which is best seen on CT-scan.

Majority of the macroadenomas appear isointense on T1WI and T2WI and show homogenous early enhancement on post contrast study, essentially concurrent with the neurohypophysis, suggesting that the arterial blood supply arises directly from the meningohypophyseal branch. Those showing cystic degeneration / necrosis are seen to have hyperintense signal intensity on T2WI, with a non-enhancing areas within on post contrast images.

Limitation of present study was non performance of delayed scan (30-60 minutes after contrast injection), which was not done primarily due to its time consuming and inconvenience

to the patients. However, one must remember that delayed scan helps to assess enhancement of the microadenoma. Other limitation of the present study was, Diffusion weighted imaging (DWI) was not performed. DWI and apparent diffusion coefficient (ADC) maps can provide information about the consistency (soft/hard) of pituitary macroadenomas and tumour components of pituitary microadenoma. Soft adenoma (easy to operate) appears hyperintense on DWI and shows, low ADC value. Hard adenoma (difficult to operate by Endoscopic Trans-sphenoidal technique) appears hypointense on DWI and shows high ADC values [12]. In addition DWI also helps in early detection of pituitary apoplexy (Haemorrhage/infarction). Thus, DWI should be a part of MRI study for evaluation of pituitary adenoma prior to surgery.

Recent advances in MRI evaluation of pituitary adenoma include Magnetization Transfer (MT) imaging, MR spectroscopy and Intraoperative MRI (IMRI). In MT imaging tissue contrast depends on concentration of macromolecules which is quantified by magnetization transfer ratio (MTR). This helps in differentiating prolactin secreting adenoma (high signal on MT images) from non secreting adenoma (low signal on MT images). This differentiation is important because prolactinomas are treated medically and non secreting adenomas are managed surgically. MT images also help in post-operative assessment of residual tumour (high signal on MT images) when findings are negative on routine MRI sequences [13]. Primary role of MR spectroscopy is to differentiate various types of pituitary lesion. On MR spectroscopy pituitary adenoma may show a choline peak [14]. Use of IMRI during endoscopic pituitary surgery has proven to be very useful in localizing and complete resection of invasive pituitary adenoma [15].

CONCLUSION

MRI is certainly the investigation of choice for evaluating hypothalamic-pituitary-related endocrine diseases. It not only helps in the diagnostic differentiation of these lesions but also provides useful information about the anatomical relationship of the gland with adjacent structures and helps to plan surgical approach. MRI is also an indispensible tool for following up patients treated conservatively, as well as in post-operative cases; to evaluate the response to treatment.

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