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PICTORIAL ESSAY NeuroImaging

Empty Sella on MRI: A Case Series and Pictorial Essay

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ABSTRACT

This is a case series of empty sella cases on MRI scans to explore the causes of empty sella, most affected gender by empty sella, linear measurements of the empty sella (i.e. width, length, and height), the number of partial or complete empty sella of the cases, associated conditions, etc. This case series of ten empty sella cases that were found during brain MRI scans. These cases will be analyzed and measured to give reference values for this condition.

KEY WORDS

Empty Sella; Pituitary Gland; Idopathic Intercranial Hypertension; Hormone Imbalance; Magnetic Resonance Imaging

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Introduction

Empty sella can be caused by increased Intra-Cranial Pressure (ICP), herniation, sheehan syndrome, hormone imbalance, Primary Empty Sella Syndrome (PESS), hyperplasia during pregnancy and lactating period, etc. Empty sella is common more with females than males due to hormonal disorders, menstrual period, pregnancy, menopausal, and other postpartum complications.

This paper will focus on empty sella types, linear measurements, and data of the empty sella cases in order to see is there any relation between the gathered different variables.

Case Series

This is a case series of 10 cases that were collected and the average of measurements were determined among all cases to provide reference values for readers and researchers. As well, the patterns of empty sella were documented and illustrated. Other papers were gathered to compare their results with the results in this case series/pictorial review. The aim of this case series and pictorial essay is to make a reference paper for any following research to build on since there is no available data on this matter presented in the same manner this paper will represent this topic.

Methodology

Measurements were taken on a T1 pulse sequence then determined whether the sella is empty or not was done on a T2 pulse sequence. The history of each case was collected from their medical files after written consents were given. The case series was submitted to the IRB for ethical clearance and it was granted by the ethical committee at King Khalid University in May 2023. The measurements were done on the PAC system. The measurements were analyzed by SPSS and the data were calculated to give an estimation of the weight by using Schloffer formula which is; the weight = the transverse diameter × the anterior posterior diameter × the cranio-caudal diameter × 0.0005. The volume was estimated by using the ellipsoid volume equation which is calculated as the following: the ellipsoid volume = 4/3 π radius of the transverse diameter × radius of the anterior posterior diameter × radius of the cranio-caudal diameter. The whole medical history of each patient was collected to see if some of the symptoms or other conditions have to do with the empty sella. The result is provided below.

Results

All patients are females, 4 out of 10 cases are pathological empty sella, 6 cases were scanned for other indications (i.e. infarction, tinnitus, etc.). The average transverse diameter of the empty sellas is 15.38 mm, the average AP diameter is 14.02 mm, and the average height is 12.07 mm, see (Table 1).

The results show that 5 out of 10 cases are symptomatic, 6 cases out of 10 cases are partially empty sellas, 9 out of 10 cases are primary, and 10 out of 10 are female patients.

Pictorial Essay

The adenohypophyseal tissue normally shrinks in males and females in the fifth decade of age [1]. It must be an average reference value for the volume in women in two categories: pre-menopausal and post- menopausal. Likewise, men will have average measurements, weight, and volume of the pituitary gland before 50 and after 50 years of age.

Partially Empty Sella

The partial empty sella was found in 6 out of 10 cases of this case series and pictorial essay. A selection of figures is provided to give an overview of what types of partially empty sella patterns that were found in the 10 cases (i.e. the sample of this case series) in order to discuss and classify these figures into specific categories later in this paper see (Figs. 1 thru 10).

Fully Empty Sella

The fully empty sella was found in 4 out of 10 cases of this case series. The pituitary tissue appears missing on all imaging sequences. The sella turcia appears bright on T2 and dark on T1 with no contents. No stalk, no flattened pituitary tissue at the base, and no sella contents, only a small bump appears at the end of median eminence which could be the atrophied pituitary gland see (Figs. 11 and 12).

Discussion

From the previous figures of partially and fully empty sella, illustrations can be drawn to document the found

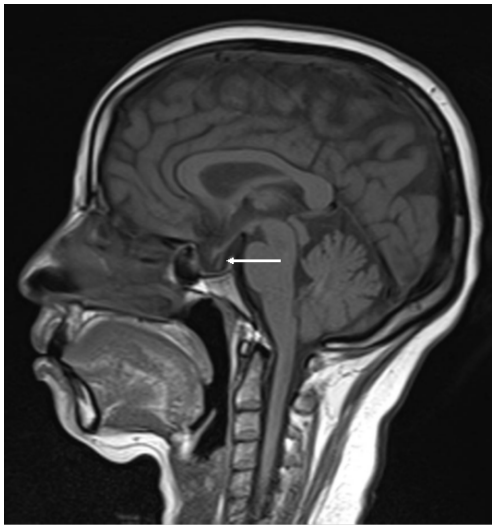

Fig. 1. *An MRI T1 sagittal shows partial empty sella appears as two lobes divided due to the high intracranial pressure.*

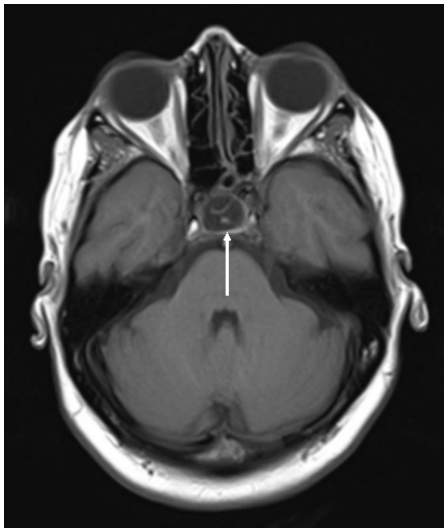

Fig. 2. *An MRI T1 Axial shows partial empty sella and pituitary tissue appear as two lobes.*

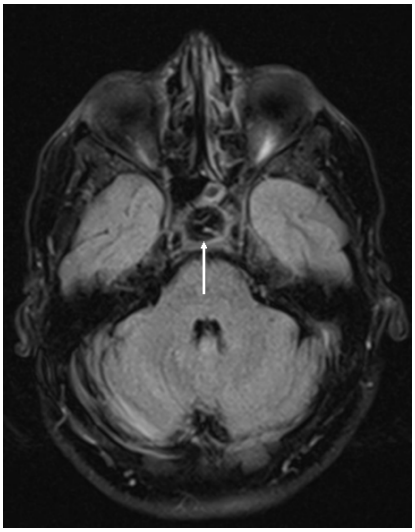

Fig. 3. *An MRI FLAIR axial sequence shows a partial empty sella with two lobes (white arrow).*

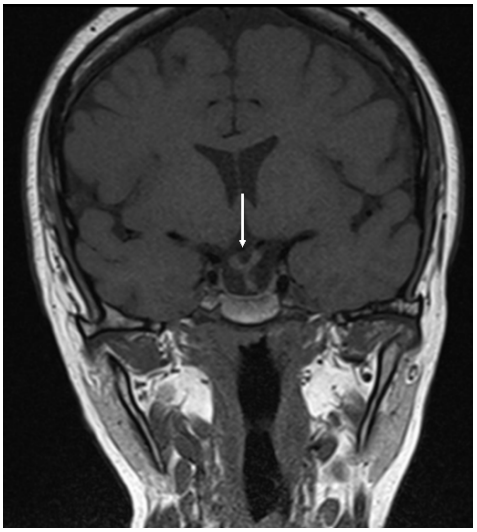

Fig. 4. *An MRI T1 coronal image shows a partial empty sella with two pituitary stalks, divided into two roots, split roots, Y-shaped, or reversed Mercedes sign pituitary infundibulum.*

Fig. 5. *An MRI T1 axial section shows a partial empty sella with a hyper attenuated (pituitary stalk) in the middle (white arrow).*

Fig. 6. *An MRI T2 axial slice shows a partial empty sella with a single root (i.e. the pituitary stalk) in the middle (black arrow).*

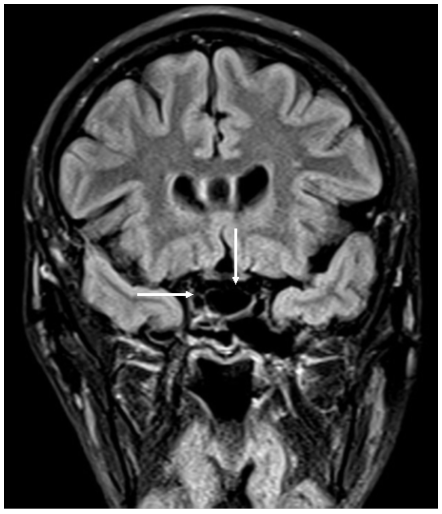

Fig. 7. *An MRI FLAIR coronal sequence shows a partial empty sella with Y-shaped pituitary tissue. Even though, it is pushed to the right side of this picture (white arrows point to the two roots). Notice cavum septum pellucidum above.*

Fig. 8. *An MRI T1 sagittal shows a flattened pituitary at the level of the skull base (white arrow).*

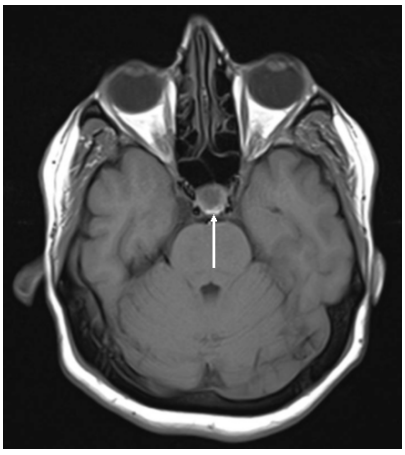

Fig. 9. *An MRI T1 axial shows a flattened pituitary gland at the base of the sella turcia.*

Fig. 10. *An MRI T2 sagittal shows a flattened pituitary gland at the base of the sella turcia.*

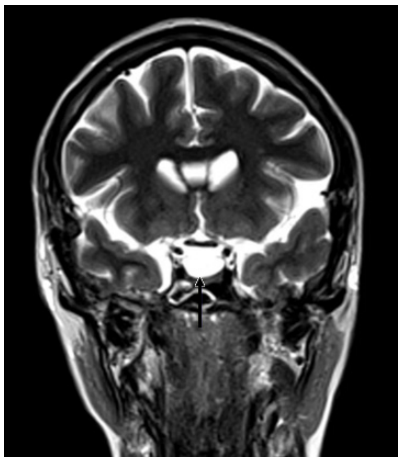

Fig. 11. *An MRI T2 coronal section shows a fully empty sella (black arrow).*

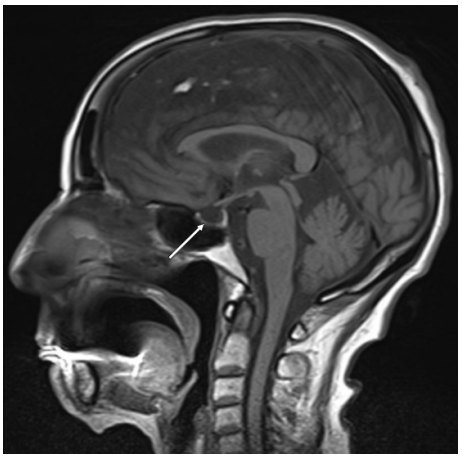

Fig. 12. *An MRI sagittal T1 shows a fully empty sella.*

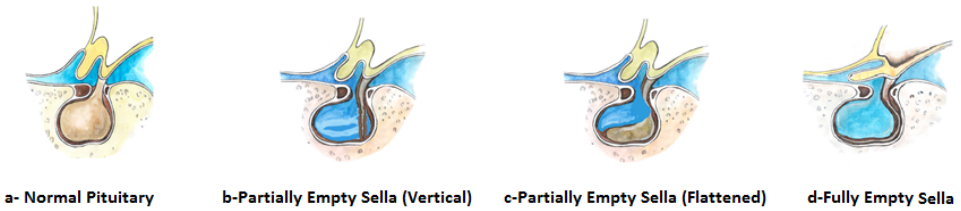

Fig. 13. *Pituitary gland emptiness patterns. In cases of empty sella, the pituitary stalk might have the B pattern where the root might be single or double as seen in the following illustration.*

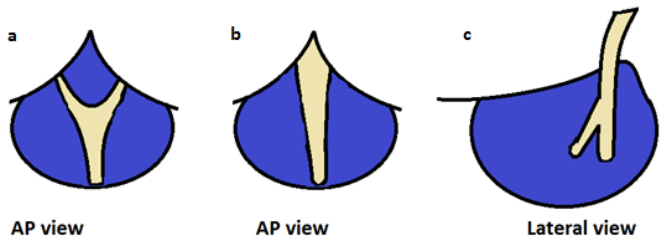

Fig. 14. *Pituitary gland is found in three major patterns in partial empty sella cases. One pattern with a double pituitary stalk, which can be explained by the anatomical explanation that the median eminence is attached to two tuber cinereum which is easy to split with intracranial pressure and the existence of cerebrospinal fluid which resulted in splitting the pituitary stalk into two (i.e. split roots, Y-shaped, or reversed Mercedes sign) as seen in (Fig. 14a), one end (i.e. the anterior and posterior lobes pushed together to appear as a singular tip) with a single pituitary stalk (Fig. 14b), or one root, but two separate lobes (i.e. anterior and posterior). Two cases out of 4 cases were found to be similar to the (Fig. 14b) pattern, one case out of 4 cases looks like pattern (Fig. 14a), and one case looks like (Fig. 14c) pattern.*

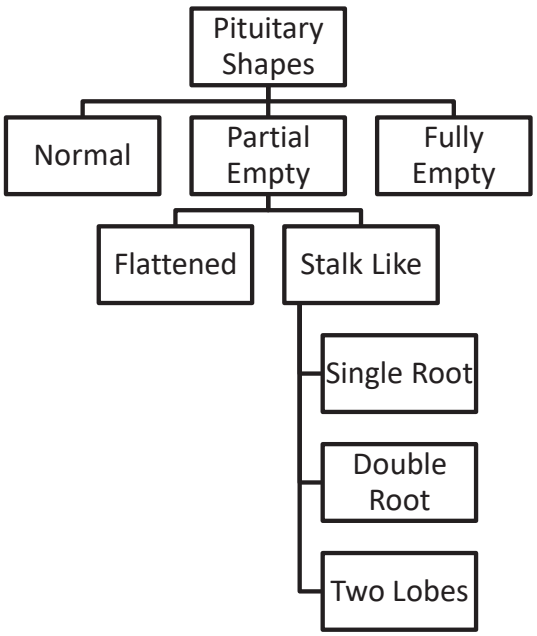

Diagram 1. *It shows the classification of all patterns that were found in this case series about empty sellas. Notice that the single root has one end or one tip. As well, the two lobes has only a single root. That's why everyone in a specific category.*

patterns that were seen in the cases. These patterns can be summarized in the following figures see (Figs 13 and 14).

From the previous figures and illustrations see (Figs. from 1 thru 14), a conclusion can be drawn that a pituitary gland can be in one of three states; 1-normal, 2-partially empty, and 3-fully empty. The partial empty can be divided into two categories; 1-pituitary stalk-like appearance only and 2-flattened pituitary. The pituitary stalk like appearance can be divided into three categories; 1-two roots (i.e. split roots, Y-shaped, or reverse Mercedes-Benz sign), 2-a stalk with a single root, and 3- one root with two separate lobes (i.e. anterior and posterior) see (Diagram 1).

Classification of partially empty sella and fully empty sella in different papers are classified by different criteria, like Auer et al. (2018) [2], who claimed that if the CSF is ≤ 50% of the pituitary gland tissue, then it is a partial empty sella and if the CSF is ≥ 50% of the pituitary tissue then is a complete empty sella. Other authors [3,4], claim the same criteria with the addition of two conditions,

Table 1. Linear measurements and estimation of weight and volume.

Patient Number	Sex	Age	Transverse Diameter (mm)	Anterior Posterior Diameter (mm)	Cranio-Caudal Diameter (mm)	Estimated Weight* (gm)	Estimated Volume** (m^3)
1	F	79	13.54	13.99	10.96	1.03	1,086.30
2	F	42	19.60	16.40	12.83	2.06	2,157.70
3	F	22	17.50	11.43	12.72	1.27	1,331.00
4	F	41	14.54	19.52	16.37	2.32	2,431.00
5	F	60	15.86	14.96	14.45	1.71	1,794.00
6	F	40	15.11	12.22	10.25	0.94	990.30
7	F	70	16.89	12.03	11.22	1.14	1,193.70
8	F	43	12.61	12.61	8.21	0.74	776.20
9	F	43	14.12	14.02	10.7	1.05	1,109.00
10	F	44	14.11	13.04	13.02	1.19	1,253.45
Mean	-	48.4	15.38	14.02	12.07	1.34	1,412.26
Normal [1]	-	-	12	8	9	0.5	449.50

**The Schloffer formula used to calculate the estimated weight which is calculated as the following; weight = the transverse diameter × the anterior posterior diameter × the cranio-caudal diameter × 0.0005. **The estimated volume was measured using the ellipsoid volume equation which is calculated as the following; ellipsoid volume = 4/3 π radius of the transverse diameter × radius of the anterior posterior diameter × radius of the cranio-caudal diameter. Millimeter = mm, Gram = gm, and millimeter3 = mm3.*

the pituitary gland tissue must be ≤ 2 mm to be considered an empty sella on CT/MRI! If the pituitary gland tissue is ≥ 3 mm then it is considered a partial empty sella on CT/MRI. This criteria is wrong simply because if a case scored 2.5 mm which is it? Partially or fully empty sella. Also, the criteria is used on CT as well, which is not perfect to measure the soft tissues and especially the pituitary gland. Another paper claims that the criteria is, if the CSF fills ≥ 60% of the hypophyseal fossa, then it is empty and below 50% is partial [5], which is wrong again and it makes the same mistake as the previous one. But why a criterion is needed when the sella can be seen fully empty or partially (i.e. contains a pituitary tissues)!

Idiopathic Intracranial Hypertension (IIH) can lead to Empty Sella Syndrome which is characterize by visual disturbance and headache. Diaphragmatic sella deficiency, which allows the herniation of arachnoid space to the sella turcia in 20% of the population [6]. The intracranial hypertension can be a result of transverse sinus stenosis which leads to low absorption of CSF then the CSF spaces get dilated [7].

The causes of empty sella are many, including the following; IIH, pituitary adenoma, post-surgical procedure, post-radiotherapy, pituitary apoplexy, Sheehan Syndrome, hemorrhage, tumors, lymphocytic hypophysitis, trauma, inflammatory diseases (i.e. meningitis, granulomatous sarcoidosis, and tuberculosis), hormonal disorder (i.e. hypothyroidism and hypopituitarism), genetic conditions (i.e. Marfan Syndrome and Ehlers-Danlos Syndrome), medication induced pituitary atrophy (i.e. high dose of corticosteroids and dopamine agonists), and other unknown causes. The differential diagnosis includes the following; rathke cleft cyst, macroadenoma, craniopharangioma, epidermoid cyst, and arachnoid cyst.

Pituitary gland atrophy was associated with psychiat-

Table 2. Empty Sella; partial or full.

Patient	Partial or Full Empty Sella	Type of Partial Empty Sella	Symptomatic	Idiopathic Intracranial Hypertension	Primary/Secondary Empty Sella
1	Full	Not Applicable	Yes	Yes	Primary
2	Partial	Vertical	Yes	No	Secondary
3	Full	Not Applicable	No	No	Primary
4	Full	Not Applicable	No	No	Primary
5	Full	Not Applicable	Ye	No	Primary
6	Partial	Vertical	No	No	Primary
7	Partial	Flattened	No	No	Primary
8	Partial	Flattened	Yes	Yes	Primary
9	Partial	Vertical	Yes	Yes	Primary
10	Partial	Vertical	No	No	Primary
Total	6 partial and 4 full	4 vertical and 2 flattened	5 symptomatic 5 asymptomatic	3 ICH 7 No ICH	9 primary 1 secondary

Intra-Cranial Hypertension =ICH.

Table 3. The table shows the average linear measurements of empty sella in different studies.

Authors	Sample Size	Condition	Length (mm)	Transverse (mm)	Height (mm)	Volume (mm^3)
Krishnan et al. (1991) [8]	19	Depression	10.8 ± 1.2	13.1 ± 2.7	5.4 ± 1.1	577.5 ± 167
Ranganathan et al. (2013) [10]	10	Intercranial Hypertension	-	-	16.27 ± 2.69	197.9 ± 24.4
Sung-eun et al. (2014) [9]	48	Pseudotumor	11.0 ± 1.6	-	8.7 ± 2.2	90 ± 30
Rabia et al. (2022) [11]	114	Empty Sella	13.2 ± 2.43	-	9.11 ± 1.93	-

Millimeter = mm, and Millimeter^3 = mm^3.

ric conditions such as major depression [8],which could be a drug induced atrophy. Another study claimed that pseudotumor cerebri can cause a slight reduction in pituitary size, but the pseudotumor will enlarge the sella turcia (i.e. the bone itself) which will make the sella appears partially empty due to increasing the size of the bony part [9]. A group of studies were collected and compared with the results in this case series see (Table 3).

The table (i.e. Table 3) shows different measurements for the height and volume for three reasons:- 1-the samples have different conditions, 2-the volume might have been measured differently, 3-some studies have been measured many years ago on poor image quality machines which showed poor pictures that were measured which is not accurate, 4-some of these conditions might affect differently the size of sella and pituitary gland tissue, and 5- Some were done on CT scans which is not accurate like MRI in imaging soft tissue and it might have poor imaging at the base of the skull level due to beam hardening artifact in the base of the skull.

Conclusion

This case series and pictorial essay classify the pituitary gland emptiness patterns into specific patterns that can be named to differentiate them. Future studies should focus on which pattern appears in which condition. **R**

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