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The relationship between anatomical measurements of the sella turcica and foramen magnum and their effect on nuchal fat thickness in patients with empty sella syndrome

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ABSTRACT

Aims: Empty sella (ES) is a radiological finding characterized by flattening of the pituitary gland and filling of the sella turcica with cerebrospinal fluid (CSF). It is often associated with obesity and increased intracranial pressure (ICP). This study aimed to evaluate the relationship between anatomical measurements of the sella turcica and the foramen magnum (FM) in patients with ES and to investigate the potential association of these structures with nuchal subcutaneous fat thickness.

Methods: Thirty-one patients diagnosed with ES by magnetic resonance imaging (MRI) and 26 age- and sex-matched healthy controls were included in the study. Measurements of the sellar fossa included midsagittal narrow and wide diameters, craniocaudal depth, and transverse diameter. Additionally, FM anteroposterior and transverse diameters were measured. Nuchal subcutaneous fat thickness was also assessed at the FM level. Statistical analyses included group comparisons and correlation analyses.

Results: The ES group showed significantly larger narrow and wide diameters, as well as greater depth of the sellar fossa, compared to controls ($p<0.05$). Although the anteroposterior diameter of the FM was similar between groups, the transverse diameter was significantly narrower in ES patients ($p=0.019$). Nuchal subcutaneous fat thickness was significantly increased in the ES group compared to controls ($p=0.028$). A strong positive correlation was observed between the wide diameter and the depth of the sellar fossa.

Conclusion: The significant enlargement of the sella turcica morphology and the narrowing of the FM transverse diameter in ES patients support the role of cranial bone structures and CSF dynamics in the pathogenesis of ES. Increased nuchal fat thickness may serve as a practical radiological indicator of obesity, which is commonly associated with ES.

Keywords: Anatomical measurements, empty sella syndrome, foramen magnum, obesity, sella turcica

INTRODUCTION

Empty sella (ES), also known as empty pituitary fossa, is a radiological finding characterized by a flattened pituitary gland within a sellar cavity filled with cerebrospinal fluid (CSF). It develops due to primary or secondary causes that lead to pituitary gland shrinkage or injury. The pathogenesis of primary ES involves mechanisms such as idiopathic benign intracranial hypertension (IIH), obesity, arterial hypertension, and insufficiency of the sellar diaphragm. Herniation of the arachnoid space into the pituitary fossa through a weak point in the diaphragma sellae results in the filling of the fossa with CSF, which compresses and shrinks the pituitary gland. Chronic CSF pulsations often cause bony enlargement and remodeling of the sella turcica.[1] Secondary ES usually results from damage due to trauma, tumors, surgery, or radiation therapy, with the sella turcica typically appearing normal in size in these cases.[2]

On MRI, ES is characterized by varying degrees of flattening of the superior surface of the pituitary gland and CSF signal intensity within the sellar boundaries. This condition is often accompanied by bony enlargement and remodeling of the sella turcica. ES is observed in approximately 20% of the population, occurring more frequently in middle-aged obese women, with a female-to-male ratio of 5:1. It may be an incidental finding without clinical significance.

One factor contributing to the formation of ES may be a FM diameter that is narrower than normal. The FM is a key landmark of the skull base,[3] and its morphometry has been linked to brain size, skull size, and intracranial volume.[4,5] Physical examinations of ES patients often reveal obesity.[6] In these patients, body-mass index (BMI), subcutaneous fat thickness measured at the arm and abdomen, and nuchal subcutaneous fat thickness have been correlated.[7] Therefore, measuring nuchal fat thickness on MRI can serve as an indicator of obesity, even when the patient's weight is unknown.

FM stenosis may contribute to both IIH and non-IIH ES cases. This stenosis can result in increased intracranial pressure, altered CSF absorption, and expansion of CSF spaces. Our study aims to enhance understanding of ES pathogenesis by examining the relationship between anatomical measurements of the sella turcica and FM in ES patients. Additionally, given the high prevalence of obesity among ES patients, we investigate whether nuchal subcutaneous fat thickness correlates with these anatomical structures.

METHODS

Ethics

This retrospective study was conducted with the approval of the Non-interventional Clinical Researches Ethics Committee of Van Yüzüncü Yıl University (Date: 04.02.2025, Decision No: 2025/01-31). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

MRI images of 31 patients diagnosed with ES at the Van Yüzüncü Yıl University Medical Center Neurosurgery Department and 26 age-and sex-matched healthy controls were evaluated. All participants were aged 18 years or older. Patients with a history of intracranial or pituitary surgery or intracranial space-occupying lesions were excluded. Controls were healthy individuals without intracranial pathology who had undergone brain MRI. Age and sex data were recorded for all subjects. Retrospective analyses was performed on patients who were hospitalized between January 2023 and December 2024.

Radiological Diagnosis of an Empty Sella Syndrome

Pituitary MRI examinations were conducted using a 1.5 Tesla MRI scanner (Magnetom Amira, Siemens Medical Systems, Forchheim, Germany). Sagittal T1-weighted, coronal T2-weighted, and contrast-enhanced coronal T1-weighted images were obtained for all cases. A 0.5 molar gadolinium-based contrast agent was administered, and dynamic pituitary imaging was performed. All images were evaluated by a single radiologist. Pituitary thickness was measured on sagittal contrast-enhanced T1-weighted images. Patients were divided into two groups as follows: complete/total ES: More than 50% of the sella filled with CSF; pituitary thickness ≤2mm, partial empty sella: Less than 50% of the sella filled with CSF; pituitary thickness ≥3mm.

MRI Image Analysis

On T1 sequences, the widest and narrowest midsagittal diameters (**Figure 1**, red line), craniocaudal depth (**Figure 1**, yellow line), and transverse diameter of the sellar fossa were measured on axial T2 images at the level connecting the tuberculum sellae and dorsum sellae, where CSF signal was present (**Figure 2**, red line). For FM measurements, the basion and opisthion points were connected on midsagittal images; the anteroposterior diameter (**Figure 1**, blue line) and transverse diameter (**Figure 3**, red line) at this level were measured. Nuchal subcutaneous fat thickness was measured along the line drawn at the FM level (**Figure 1**, green line).

Figure 1. Magnetic resonance imaging (MRI) section showing the midsagittal widest diameter of the sellar fossa (red line), craniocaudal depth (yellow line), anteroposterior diameter of the foramen magnum (blue line), and nuchal subcutaneous fat thickness (green line)

Figure 2. Magnetic resonance imaging (MRI) section showing the transverse diameter measurement of the sellar fossa (red line)

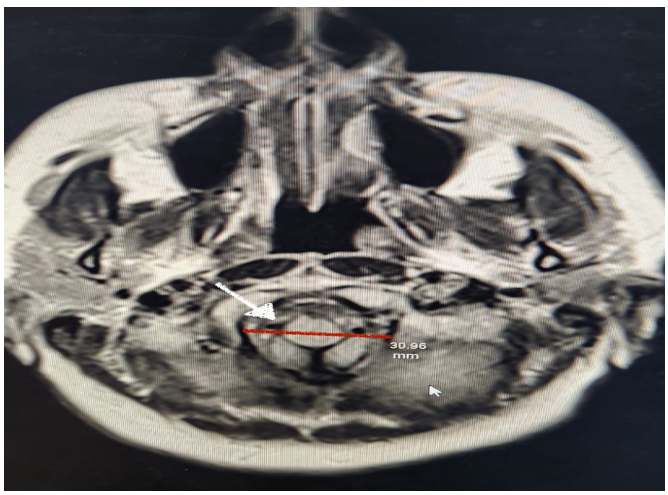

Figure 3. Magnetic resonance imaging (MRI) image showing the transverse diameter measurement of the foramen magnum (red line)

Statistical Analysis

The data analyses were conducted using SPSS software (version 21.0; Chicago, IL). Normality was assessed with the Kolmogorov-Smirnov test. Group comparisons were performed using Student's t-test or the Mann-Whitney U test, as appropriate. Correlation analyses employed Spearman's correlation coefficient. Results are presented as mean±standard deviation (SD), with $p<0.05$ considered statistically significant.

RESULTS

The mean age of the ES group was 49.13±10.26 years, while that of the control group was 46.31±8.14 years. Seven patients (22.58%) in the ES group and six patients (23.07%) in the control group were male. The narrow and wide diameters of the sellar fossa were significantly larger in the ES group compared to the control group (p=0.041 and p=0.040, respectively). The transverse diameter of the sellar fossa was similar between groups (p=0.115), whereas the craniocaudal depth was significantly greater in the ES group (p=0.0001) (**Table**).

The anteroposterior diameter of the FM did not differ significantly between groups (p=0.159); however, the transverse diameter was significantly narrower in the ES group compared to controls (p=0.019) (**Table**). Nuchal subcutaneous fat thickness was 9.7±2.5 mm in the ES group and 8.31±2.15 mm in controls, with the ES group showing a significantly greater thickness (p=0.028) (**Table**).

Table. Measurements of the SF, FM and nuchal subcutaneous fat thickness in patients with empty sella and in the control group

Measurement (mm)	Grup	n	Mean±SD	p
SF narrowest diameter	Empty sella	31	12.10±2.23	0.041
	Control	26	11.96±1.47	
SF widest diameter	Empty sella	31	12.85±2.11	0.04
	Control	26	12.18±1.49	
SF tranverse diameter	Empty sella	31	12.96±2.07	0.115
	Control	26	12.20±1.5	
SF depth	Empty sella	31	10.31±1.88	0.0001
	Control	26	7.37±1.87	
FM anteroposterior diameter	Empty sella	31	33.36±2.93	0.159
	Control	26	34.38±2.44	
FM transverse diameter	Empty sella	31	29.88±2.88	0.019
	Control	26	31.61±2.52	
Nuchal subcutaneous fat thickness	Empty sella	31	9.7±2.5	0.028
	Control	26	8.31±2.15	

SF: Sellar fossa, FM: Foramen magnum, mm: Milimetre, SD: Standard deviation

Correlation analysis between sellar fossa and FM measurements revealed a strong positive correlation between the width and depth of the sellar fossa in the ES group (r=0.556, p=0.001). In contrast, a negative correlation was observed between these parameters in the control group (r=-0.443, p=0.023).

DISCUSSION

To our knowledge, no previous studies have directly examined the specific relationship or correlation between the anatomical measurements of the sella turcica and the FM in ES patients. However, both anatomical structures are clinically significant in relation to IIH, which is closely associated with ES. Increased intracranial pressure (ICP) in IIH is believed to affect the morphology of the sella turcica. Chronic CSF pulsations can lead to bony expansion and remodeling of the sella turcica, resulting in compression of the pituitary gland.[8,9]

Consistent with the literature, we observed enlargement of the sellar fossa dimensions in the ES group compared to controls. Quantitative analyses in IIH patients have demonstrated significantly larger sella turcica areas than those in healthy controls. The mean sella area in IIH patients was 200±24 mm^2, compared to 124±25 mm^2 in controls ($p<0.0001$).[10] Additionally, the pituitary gland to sella turcica area ratio (PG/S ratio) was significantly decreased in IIH patients ($p<0.0001$).[11] This reduction is partly attributable to pituitary compression and sella turcica enlargement, particularly in severe or chronic cases, supporting the notion that the ES appearance primarily results from chronic ICP-induced sella expansion.[10,12]

Elevated ICP can also affect adjacent skull base structures; for example, enlargement of the foramen ovale has been observed in IIH.[13] This suggests a generalized remodeling effect of chronic ICP on central skull base anatomy. However, specific effects on FM anatomical measurements, similar to those observed in the sella turcica, have not been reported. In our study, although the anteroposterior diameter of the FM did not differ significantly, the transverse diameter was narrower in patients with ES. This finding suggests that FM stenosis may contribute to increased intracranial pressure, altered CSF absorption, and expansion of CSF spaces closely associated with ES.

No direct causal relationship has been established between specific anatomical measurements of the sella turcica or FM and nuchal fat thickness in ES patients. However, nuchal fat thickness is an important indirect marker related to the clinical status of IIH patients, a condition frequently associated with ES. Obesity, a common risk factor for both primary ES and IIH, underlies this association. In patients with IIH and ES, subcutaneous fat thickness measurements have been used to differentiate whether the ES is incidental or related to chronically elevated ICP. Patients diagnosed with IIH (with ES) had significantly higher scalp fat thickness (mean 9.0 mm) and neck soft tissue thickness (mean 19.5 mm) compared to controls with incidental ES ($p<0.0001$).[8] These thickness measurements suggest that obesity may serve as a potential imaging marker in IIH, which is prevalent among obese patients.[14-16] Increased subcutaneous fat thickness in the neck and scalp, combined with clinical symptoms such as age, headache, or visual complaints, strongly suggests that the ES finding is associated with IIH.[8]

Anatomical measurements of the sella turcica, including maximum anteroposterior and craniocaudal dimensions as well as the position of the infundibulum, did not differ significantly between patients with IIH and incidental ES patients without IIH.[8] This suggests that the appearance of the ES and sella turcica measurements alone are not specific

indicators; however, increased nuchal fat thickness and clinical symptoms contribute pathological significance to the ES findings associated with IIH.[8,11] Therefore, rather than a direct effect of sella turcica or FM anatomical measurements on nuchal fat thickness, the latter-serving as a marker of obesity-strongly supports the presence of IIH in conjunction with sella turcica morphology as clinical and radiological indicators.[14-16]

FM measurements have not been directly correlated with nuchal fat thickness in the literature; however, the FM is clinically significant as a passageway for vital craniocervical junction structures in conditions of elevated ICP, such as IIH.[7,17-19]

Limitations

Limitations of this study include the fact that the boundaries of the sellar fossa and FM are bony structures, making computed tomography (CT) more suitable than MRI for precise measurements. Additionally, the retrospective design and reliance on MRI images for measurements represent further limitations. Subgroup analyses comparing partial versus total ES and IIH status could provide more detailed insights into their relationships with sellar fossa and FM measurements; the absence of such subgroup data is another limitation. BMI data were not available in this study; therefore, only nuchal fat thickness was used as a measure of obesity. The lack of BMI data should be considered another limitation of this study. Finally, the relatively small sample sizes of the ES and control groups also limit the study.

CONCLUSION

Consistent with the literature, we observed increased sella turcica depth and anteroposterior diameter in ES patients. The narrower transverse diameter of the FM in ES patients compared to controls may contribute to ES pathogenesis; however, larger prospective studies are necessary to confirm this. Due to their hormonal profiles, ES patients often present with obesity, which is reflected by increased nuchal fat thickness compared to normal controls. Measuring nuchal fat thickness in ES patients can therefore be used as an indicator of obesity.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was conducted with the approval of the Non-interventional Clinical Researches Ethics Committee of Van Yüzüncü Yıl University (Date: 04.02.2025, Decision No: 2025/01-31).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: MB, MEA, ST; Design: MB, ST; Control: MB, MEA, ST; Data Collection and/or Processing: MB, MEA, ST; Analysis and/or Interpretation: MB, MEA; Literature Review: MB, MEA; Article Writing: MB, MEA; Critical Review: All authors.

REFERENCES

1. Saindane AM, Lim PP, Aiken A, Chen Z, Hudgins PA. Factors determining the clinical significance of an "empty" sella turcica. *Am J Roentgenol.* 2013;200(5):1125-1131. doi:10.2214/AJR.12.9013
2. Miljic D, Pekic S, Popovic V. Empty sella. *Endotext*. 2024.
3. Ogolo DE, Ajare EC, Okwuoma O, et al. Morphometric evaluation of the foramen magnum in the West African population: implications for neurosurgical interventions. *Brain Disorders.* 2024;14:100140. doi:0.1016/j.dscb.2024.100140
4. Zdilla MJ, Russell ML, Bliss KN, Mangus KR, Koons AW. The size and shape of the foramen magnum in man. *J Craniovertebr Junction Spine.* 2017;8(3):205-221. doi:10.4103/jcvjs.JCVJS_62_17
5. Cirpan S, Yonguc GN, Mas NG, Aksu F, Orhan Magden A. Morphological and morphometric analysis of foramen magnum: an anatomical aspect. *J Craniofac Surg.* 2016;27(6):1576-1578. doi:10.1097/SCS.0000000000002822
6. Daniels AB, Liu GT, Volpe NJ, et al. Profiles of obesity, weight gain, and quality of life in idiopathic intracranial hypertension (pseudotumor cerebri). *Am J Ophthalmol.* 2007;143(4):635-641. doi:10.1016/j.ajo.2006.12.040
7. Gaillard F, Weerakkody Y, Walizai T, et al. Empty sella. Reference article. *Radiopaedia.org.* 2024.
8. Saindane AM, Lim PP, Aiken A, Chen Z, Hudgins PA. Factors determining the clinical significance of an "empty" sella turcica. *Am J Roentgenology.* 2013;200(5): 1125-1131. doi:10.2214/AJR.12.9013
9. Agid R, Farb RI. Neuroimaging in the diagnosis of idiopathic intracranial hypertension. *Minerva Med.* 2006; 97(6):365-370
10. Ranganathan S, Lee SH, Checkver A, et al. Magnetic resonance imaging finding of empty sella in obesity related idiopathic intracranial hypertension is associated with enlarged sella turcica. *Neuroradiology.* 2013;55(8):955-961. doi:10.1007/s00234-013-1207-0
11. Yuh WT, Zhu M, Taoka T, et al. MR imaging of pituitary morphology in idiopathic intracranial hypertension. *J Magn Reson Imaging.* 2000;12(6);808-813. doi:10.1002/1522-2586(200012)12:6<808::aid-jmri3>3.0.co;2-n
12. Alperin N, Ranganathan S, Bagci AM, et al. MRI evidence of impaired CSF homeostasis in obesity-associated idiopathic intracranial hypertension. *Am J Neuroradiol.* 2013; 34(1):29–34. doi:10.3174/ajnr.A3171
13. Butros SR, Goncalves LF, Thompson D, Agarwal A, Lee HK. Imaging features if idiopathic intracranial hypertension, including a new finding: widening of the foramen ovale. *Acta Radiol.* 2012;53(6):682-688. doi:10.1258/ar.2012.110705
14. Friedman DI, Rausch EA. Headache diagnoses in patients with treated idiopathic intracranial hypertension. *Neurology.* 2002;58(10):1551-1553 doi:10.1212/wnl.58.10.1551
15. Silver RI, Moonis G, Schlosser RJ, Bolger WE, Loevner LA. Radiographic signs of elevated intracranial pressure in idiopathic cerebrospinal fluid leaks: a possible presentation of idiopathic intracranial hypertension. *Am J Rhinol.* 2007; 21(3):257-261. doi:10.2500/ajr.2007.21.3026
16. Bruce BB, Kedar S, Van Stavern GP, Corbett JJ, Newman NJ, Biousse V. Atypical idiopathic intracranial hypertension: normal BMI and older patients. *Neurology.* 2010;74(22):1827-1832. doi:10.1212/WNL.0b013e3181e0f838
17. Wang H, Rosenbaum AE, Reid CS, Zinreich S, Pyeritz R. Pediatric patients with achondroplasia: CT evaluation of the craniocervical junction. *Radiology.* 1987;164(2):515-519. doi:10.1148/radiology.164.2.3602395
18. Bagley CA, Pindrik JA, Bookland MJ, Camara-Quintana JQ, Carson BS. Cervicomedullary decompression for foramen magnum stenosis in achondroplasia. *J. Neurosurg Pediatrics.* 2006;104(3):166-172. doi:10.3171/ped.2006.104.3.166
19. Yasuoka S, Takakura K. Proposal for the definition of" foramen magnum syndrome" foramen magnum tumor and abnormalities. *No To Shinkei.* 1983;35(10):1001-1007.