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Age-Related Volume Analysis of the Sella Turcica and Surgical Approach Metrics to the Pituitary Gland from Birth to Adulthood

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Abstract

BACKGROUND/AIMS: The pituitary gland is located in the sella turcica (ST). The volume change of the ST with age affects the pituitary gland. The volume of the ST and the distance from the points of surgical intervention to the pituitary gland should be known prior to surgery. Therefore, the aim of this study was to measure the age-related volumetric development of the ST and to determine the distances of the main surgical landmarks to the pituitary gland.

MATERIALS AND METHODS: Our study analyzed sagittal radiologic images of 794 individuals, aged 1-70 years. ST volumes and the distances for transsphenoidal, transcranial (TC), and frontoparietal (FP) surgical approaches were measured. ST volume was quantified using the Cavalieri principle on sagittal images, while surgical approach distances were determined using a ruler on the same sagittal radiological images.

RESULTS: The mean ST volume in the age range of 1-18 years was 259.32±38.28 mm^3, 262.40±38.74 mm^3 in males and 256±37.67 mm^3 in females. The volume increase in ST was observed at a high rate until adolescence, when bone development was the highest. There was no statistically significant difference in ST volume between genders. The mean lengths of the transsphenoidal, TC, and FP approaches were 81.64±9.62, 80.01±14.85 and 92.56±8.54 mm, respectively.

CONCLUSION: Our study demonstrated that the volume of the ST increases continuously from birth to 18 years of age, with a marked acceleration after 14 years. Additionally, we quantified the distances from various surgical intervention points to the pituitary gland, providing essential data for optimizing surgical approaches.

Keywords: Sella turcica, volume, pituitary, surgery, radiology

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INTRODUCTION

Sella turcica (ST) is the anatomical structure known as the ST in the middle cranial cavity. It contains the pituitary gland. The name "ST" was given due to the anterior and posterior bony processes of the region observed in lateral head images and the resemblance of this depression to a Turkish saddle.[1] ST, which is easily observed on lateral radiographs, is located on the upper surface of the body of the sphenoid bone and consists of the hypophyseal fossa, tuberculum sellae anteriorly, and dorsum sellae posteriorly.

The morphological appearance of ST is established in early embryonic structures. The formation of both the pituitary gland and ST during the prenatal and postnatal periods is a complex process. These two significant structures are located in the boundary region, separating tissues of different origin and development. The pituitary fossa originates directly from the hypophyseal cartilage, which, in turn, is derived from the cranial neural crest cells of the early cartilaginous cranium. During the embryological development of humans, the ST area is the key point for the migration of neural crest cells to the frontonasal and maxillary developmental fields.[2,3]

The development of this anatomically very important region in the prenatal and postnatal period has attracted the attention of scientists for many years due to its possible relationship with various anomalies, malformations and pathologies related to the calvaria and craniofacial region.[4] During childhood and adolescence, the ST undergoes significant growth, corresponding with the overall growth of the skull and the development of the pituitary gland. This period is marked by hormonal surges, particularly during puberty, which necessitate changes in pituitary size and function. ST volume increases to accommodate these changes, and deviations from normal growth patterns can signal endocrine disorders.[5]

Neural, hormonal, vascular, osseous, and meningeal structures form a complex anatomy within the very narrow borders of the ST. The pituitary gland in the center fills 80% of the ST. The remaining area is filled by connective tissue and the perihypophyseal venous plexus.[6-8]

In the literature, changes in ST size and morphology are associated with many pathologies and syndromes.[9-11] Although most of these are chronic disorders that are not life-threatening in the short term, some may be associated with necrosis and/or adenomas of the pituitary gland that require rapid intervention.[12,13] The pituitary gland, located in the pit surrounded by the dura mater, is prone to neoplastic transformation, and as a result, some well-known clinical syndromes occur.[14] Apart from tumors, some diseases such as growth retardation, hypopituitarism, hyperthyroidism, and Williams syndrome are associated with a reduction in ST, whereas pathologies such as Cushing's disease, acromegaly, hypothyroidism, and anorexia nervosa are associated with an increase in ST volume.[6,15]

Today, nearly all surgical interventions in this critical region use the transsphenoidal (TS) approach, except in special cases. The first TS procedure was performed on a cadaver in 1897.[16] This approach has become the preferred method for sellar and parasellar surgeries, especially for pituitary adenomas, due to its ease, absence of scarring, no brain retraction, early patient mobilization, and shorter hospital stays.[17-19] Success requires thorough knowledge of access routes, anatomy, and distances, with the surgical technique and instrument selection guided by preoperative radiologic examinations.[20,21]

Understanding changes in the volume of the ST with age is essential for medical professionals, as it can provide insights into normal aging processes, help diagnose pathological conditions, and guide appropriate interventions. The morphology of the ST is important both in the evaluation of treatment outcomes, and late growth changes and in the assessment of cranial morphology.[22] Measurements of the size of the ST as a function of age and information on the normal values of these measurements are insufficient. Changes in the size and morphology of the ST are particularly important for surgical interventions on the pituitary gland, and enlargement of this structure may create difficulties in terms of surgical access to the gland. This is particularly important in endoscopic TS pituitary surgery, where access to the pituitary gland may be impeded by an enlarged ST. Therefore, in our study, we aimed to measure the distances of surgical interventions to the pituitary gland, how these distances change with age, and how ST volume values change with age.

MATERIALS AND METHODS

Individuals

This study was conducted with the permission of Ordu University Scientific Research Evaluation and Ethics Committee (approval number: 2023/242, date: 29.09.2023). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The study was performed retrospectively on sagittal computed tomography (CT) and/or magnetic resonance imaging (MRI) images of a total of 794 individuals aged 1-70 years, admitted to Ordu University Medical Faculty Education and Research Hospital. Retrospective analysis was performed on patients who were hospitalized between January 1st and July 1st, 2024. Individuals with any pituitary gland pathology or cranial deformity were excluded from the study. Therefore, radiological images that should have been excluded were analysed by the emergency medicine physician (Assoc. Prof. A. A., MD, PhD) involved in our study.

Acquisition of Computed Tomography and Magnetic Resonance Imaging Images

Cranial CT and MRI images (Canon Aquilion Lightning, Japan) of all individuals were obtained from Ordu University Training and Research Hospital and the Fonet PACS system. The volume measurements on the image were performed using the Cavalieri principle. The Cavalieri principle is based on counting the points on a dotted ruler placed on the structure to be measured.[23]

Sella Turcica Volume Measurement

In this study, the Cavalieri principle was applied to CT images. The points falling on ST in the image were counted for each slice (Figure 1). Volume calculation was performed with the points obtained in each section as shown in the literature.[24,25]

Transsphenoidal, Transcranial and Frontoparietal measurements

TS distance refers to the distance from the apex of the nose to the anterior wall of the ST. Transcranial (TC) length refers to the distance from the glabella or frons to the anterosuperior part of the ST. Frontoparietal (FP) distance refers to the distance from the bregma point to the upper wall of the ST (Figure 2). TC and FP intervention is a method used especially in cases where transnasal and/or TS interventions cannot be performed, such as during coronavirus disease-2019. Distance measurements were performed on both CT and MRI. TS measurements were performed on 300 sagittal CT and 100 sagittal MRI images, and TC and FP measurements were performed on 200 sagittal CT and 72 sagittal MRI images.

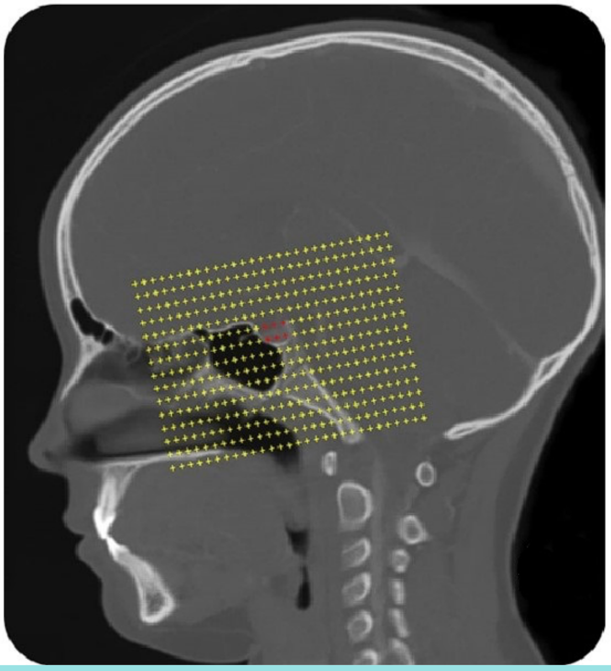

Figure 1. Image of a point ruler applied on the ST according to the Cavalieri principle (red dots represent the points on the ST).

ST: Sella turcica.

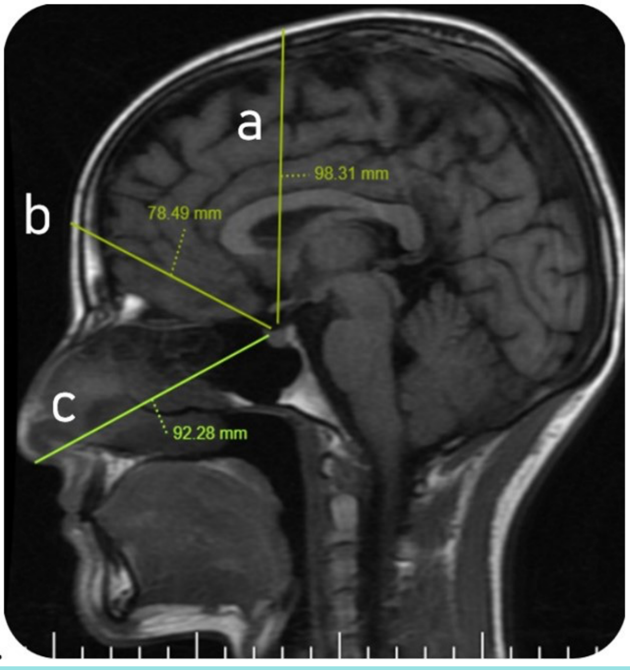

Figure 2. Measurement of frontoparietal (a), transcranial (b) and transsphenoidal (c) distance on the sagittal MRI image of an 18 years-old female.

MRI: Magnetic resonance imaging.

Statistical Analysis

Data were analyzed and distributed using SPSS v28. Normality of distribution was assessed using histogram, Skewness and Kurtosis, standard deviation (SD)/mean, and Kolmogorov-Smirnov test.[26] Normally distributed data are presented as mean ± SD. The comparison of volume and length results between sexes was conducted using Independent samples t-tests. $p<0.05$ was considered statistically significant.

RESULTS

Sella Turcica Volume Findings

ST volume measurements were performed on sagittal CT images of 394 individuals (197 males, 197 females) aged 1-18 years (11 males, 11 females in each age group). The age-related development of ST and its differences gender were determined. The data were plotted using software (GraphPad Prism 8.4.2, trial version).

The mean ST volume was 259.32±38.28 mm^3 in all individuals, 262.40±38.74 mm^3 in male subjects, and 256±37.67 mm^3 in female subjects. ST volume was compared between sexes, and no statistically significant difference was found ($p>0.05$). The minimum (min.) ST volume was 157 mm^3 in female subjects aged 1 year and the maximum (max.) ST volume was 320 mm^3 in 18-year-old male subjects (Figure 3a). Although the volume increase in the ST is observed at a high rate until 10-11 years of age, when the development of bone and pituitary gland is the highest, the increase continues at a reduced rate at later ages (Figure 3b). However, the age-related increase in ST volume may vary from person to person.

Transsphenoidal, Transcranial and Frontoparietal Length Findings

In our study, TS length measurements were performed on 400 individuals (208 males, 192 females) aged between 1 and 70 years (19.70±18.07). TC and FP length measurements were performed on 272 individuals (138 males, 134 females) aged between 1 and 70 years (23.54±20.81). The mean lengths of TS, TC, and FP were 81.64±9.62 (min.-max.: 52.21-102.85), 80.01±14.85 (min.-max.: 43.64-106.48), and 92.56±8.54 mm (min.-max.: 63.55-110.60), respectively (Figure 4). When the distribution of these lengths was analyzed according to gender, TS and FP values were found to be higher in males, and there was a statistically significant difference between genders ($p<0.000$), whereas no difference was found in TC values.

When the changes according to age were examined, a high rate of increase occurred in the period from birth to puberty (1-20 years), when the highest development was observed, and then these increases stabilized in parallel with bone and organ development (Figure 5). According to these values, this rapid increase should be taken into consideration in surgical interventions performed on the pituitary gland in the period from birth to puberty.

As shown in Figure 4, FP length values were commonly found in a narrow range of 90-100 mm, but TC and TS values showed a wide spectrum of variability according to age. The reason for this may be the continuous development of the viscerocranium bones and the variation between individuals due to a combination of genetic, developmental, and environmental factors. Likewise, the growth of the brain and skull bones may occur at different rates in different individuals, leading to variations in TC and TS length.

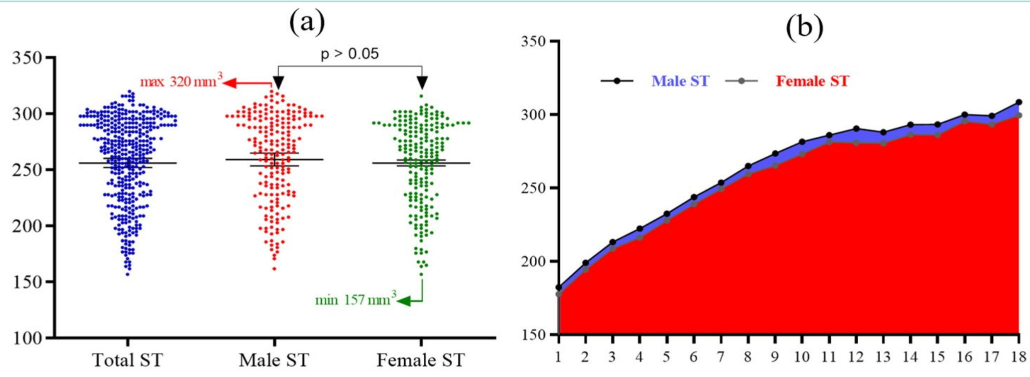

Figure 3. (a) distribution of ST volume in the whole population and by sex (x-axis: ST volume values, mm^3), (b) development of ST volume according to age and sex (x-axis: ST volume values, mm^3; y-axis: ages).

ST: Sella turcica.

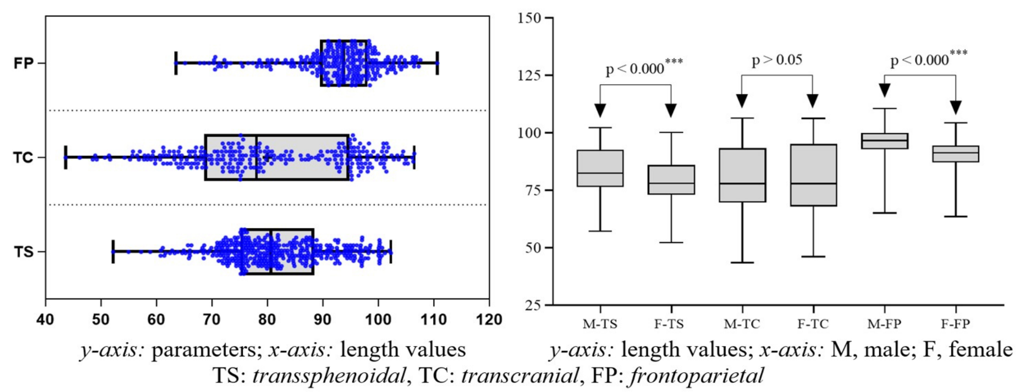

Figure 4. Descriptive statistics of TS, TC and FP lengths and distribution of these lengths according to gender.

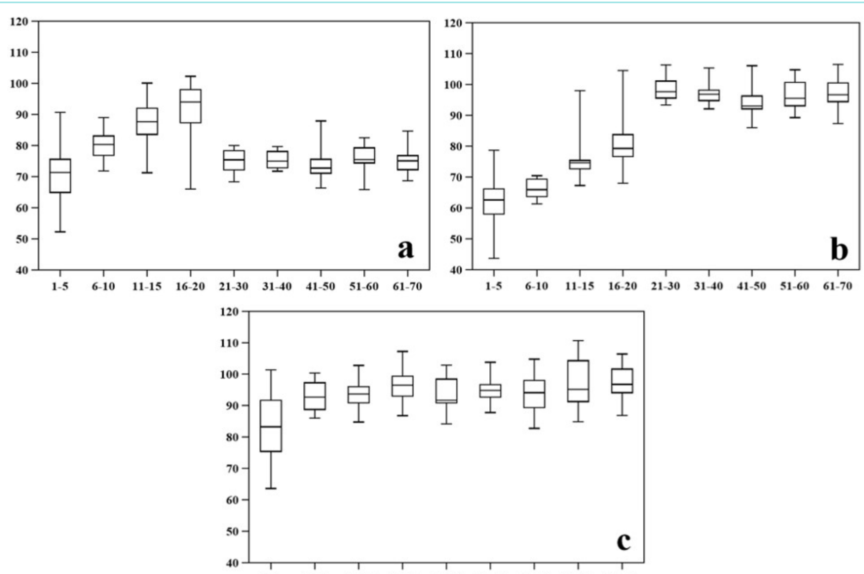

Figure 5. Distribution of TS (a), TC (b) and FP (c) lengths according to age (y-axis: length values; x-axis: age groups).

TS: Transsphenoidal, TC: Transcranial, FP: Frontoparietal.

DISCUSSION

Volume measurements of organs and structures in our body play a crucial role in diagnosing and monitoring many diseases. Therefore, determining normal organ parameters is essential for accurate evaluation and early diagnosis.[27] In our study, we calculated ST volume, which is associated with various pathologies, especially pituitary adenomas. ST volume can change throughout a person's life due to genetic, hormonal, and environmental factors.[28] We found no statistically significant effect of gender and age on ST volume. Volume values increase rapidly until puberty and then increase more slowly. This may be due to the rapid increase in bone development.

The ST, a saddle-shaped depression in the sphenoid bone, undergoes significant changes in size and morphology during growth. Studies have shown that ST increases in size after birth, with significantly higher volume values in males. The size of the ST changes according to gender and age, especially during adolescence.[29,30]

Similar to our study, Axelsson et al.[31], reported that the rapid increase in ST dimensions gradually slows down in the first years of life, increases again during puberty, and then grows at a low rate in late adolescence. Sathyanarayana et al.[2] found that ST volume was larger in males in their study but did not report a statistically significant gender difference.

During puberty, the pituitary gland usually enlarges, potentially increasing ST size. Clinically, changes in ST volume are important in diagnosing and treating pituitary disorders, craniofacial abnormalities, and some syndromes.[11,32,33]

These changes in ST's size and morphology are particularly relevant for surgical interventions on the pituitary gland. An enlarged ST during growth can pose challenges for surgical access to the gland. As ST size increases, it may encroach upon surrounding structures, complicating surgical interventions. This is especially important in endoscopic TS pituitary surgery, where access to the gland may be hindered by an enlarged ST.

Iskra et al.[33] reported that ST volume was 969.68 mm³ on CT images, 671.33 mm³ on cadavers, and 980.75 mm³ in European studies, in their meta-analysis on ST volume and morphology. Our results were lower than expected, likely due to age differences. Our study only reported ST volume development between 1-18 years. Although adult ST volume has been extensively analyzed, the volume development from birth to puberty is insufficiently studied.[33,34]

The studies are close to each other, and the main reason for the volume differences is the change in the age range. In our study, postnatal development of ST was discussed. Pituitary gland interventions are common due to growth disorders in childhood. Therefore, the initial stage of postnatal development is particularly important. ST development is stabilized after the age of 20 according to studies. In many other studies, adult ST measurements were conducted, and therefore no difference is expected (Table 1).

The base of the ST is separated from the sphenoid sinus by a small bony plate. Therefore, the endoscopic TS approach is the most common and optimal method for surgical treatment of pituitary tumors.[40,41] Although the length of TS has been discussed in many studies, information about its development and variation with age and gender is limited. Since it is the most common method for pituitary gland surgery, knowing the distance relevant to the procedure in all age groups is essential. In a study, the mean length from the columella to the anterior wall of the sphenoid sinus was reported to be 69.71±4.25 mm in individuals

Table 1. ST volume values in the literature

Research	Samples	Genders	Ages	Method	ST volumes
Our study	394 CT	197 males, 197 females	1-18	Cavalieri	259.32±38.28 mm³ (total) 262.40±38.74 mm³ (males) 256.00±37.67 mm³ (females)
Iskra et al.[33]	18,364 radiographs	Not reported	Not reported	Meta-analysis	969.68±53.17 mm³
Yamada et al.[35]	570 CT	Not reported	1-60	De Chiro-Nelson	Age 1=06±19 mm³ Age 25=530±23 mm³ 25+ ages =554±8 mm³
Silveira et al.[36]	95 CBCT	35 males 60 females	16-57	Via software	920.01±163.26 mm³
Chilton et al.[37]	960 radiographs	450 males-510 females	6-16	De Chiro-Nelson	6 years =196 mm³ (males) 255 mm³ (females) 16 years =549 mm³ (males) 462 mm³ (females)
Ortega-Balderas et al.[38]	173 CT	91 females, 82 males	53.2±17.6	De Chiro-Nelson	342.2±88.5 mm³ (females) 378.6±113.9 mm³ (males)
Taner et al.[39]	80 CBCT	40 males, 40 females	26.6±8.6 (females) 27.5±9.0 (males)	De Chiro-Nelson	1102±285.3 mm³ (males) 951.3±278.5 mm³ (females)
Venieratos et al.[49]	20 (dry skulls)	Not reported	Not reported	Via immersion	835 mm³
Sherif et al.[50]	17 CT	All females	41±8	Via software	922±155 mm³
Bakiri et al.[51]	12 CT	All females	38.3±3.6	Via software	796±5.6 mm³

ST: Sella turcica, CT: Computed tomography, CBCT: Cone beam computed tomography.

older than 15 years and 59.32±7.80 mm in individuals younger than 15 years.[42] In our study, we determined the mean length of the TS as 81.64±9.62 mm and the mean length until puberty as 80.86±8.97 mm. These results show that TS length increases rapidly from birth to puberty, then stabilizes.

Chumnanvej et al.[43] calculated the length from the columella to the sphenoid sinus on six cadavers and found a maximum length of 85.31 mm and a minimum length of 59.05 mm. Similarly, Baig et al.[44] found the mean distance from the nares to the posterior wall of the sphenoid sinus to be 83.82 mm. Although we measured the length from the columella to the anterior wall of the ST, our results are similar to those obtained in previous studies.

The TS approach is primarily preferred for sellar and parasellar tumors due to its low morbidity and mortality rates.[45] In some cases, resection via a TC approach may be required. TC surgery involves accessing the pituitary gland by making an incision in the anterior part of the skull over the frontal bone and retracting part of the brain. This approach is reserved for larger, more complex pituitary tumors that cannot be accessed via the TS route.[46,47]

Less than 10% of pituitary adenomas require craniotomy. TC surgery is necessary in these cases despite its high mortality and morbidity rates. Therefore, knowing the TC distance is crucial for parasellar cavernous sinus and internal carotid artery surgery.[48]

Study Limitations

Since the study is retrospective, the number of images is limited. There are no other limitations.

CONCLUSION

In conclusion, our study revealed differences in ST volume in the studied population and emphasized the importance of individualized surgical planning. Furthermore, precise measurement of the surgical pathways to the pituitary gland provides data necessary for optimizing surgical techniques and minimizing potential risks during procedures. This study paves the way for advances in surgical methodology, especially in the context of pituitary surgery.

MAIN POINTS

- Our study puts forward that the volume of the sella turcica (ST) increases continuously from birth to 18 years of age, with a marked acceleration after 14 years.
- This rapid increase should be taken into consideration in surgical interventions to be performed on the pituitary gland in the period from birth to puberty.
- There was no statistically significant difference in ST volume between the genders.
- Precise measurement of the surgical pathways to the pituitary gland provides data necessary for optimizing surgical techniques and minimizing potential risks during procedures.

ETHICS

Ethics Committee Approval: This study was conducted with the permission of Ordu University Scientific Research Evaluation and Ethics Committee (approval number: 2023/242, date: 29.09.2023)

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.D., A.T., Concept: M.D., İ.U., G.B.U., E.U., Design: M.D., T.E., S.Y., Data Collection and/or Processing: M.D., İ.U., G.B.U., A.A., Analysis and/or Interpretation: M.D., A.T., S.Y., Literature Search: M.D., T.E., Writing: M.D., İ.U., E.U.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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REFERENCES

1. Mutluer S. Sella turcica. Childs Nerv Syst. 2006; 22(4): 333.
2. Sathyanarayana HP, Kailasam V, Chitharanjan AB. Sella turcica-Its importance in orthodontics and craniofacial morphology. Dent Res J (Isfahan). 2013; 10(5): 571-5.
3. Miletich I, Sharpe PT. Neural crest contribution to mammalian tooth formation. Birth Defects Res C Embryo Today. 2004; 72(2): 200-12.
4. Nava de Escalante Y, Abayomi A, Langlois S, Ye X, Erickson A, Ngo H, et al. Validation of case definition algorithms for the ascertainment of congenital anomalies. Birth Defects Res. 2023; 115(3): 302-17.
5. Jankowski T, Jedliński M, Grocholewicz K, Janiszewska-Olszowska J. Sella turcica morphology on cephalometric radiographs and dental abnormalities-is there any association?-systematic review. Int J Environ Res Public Health. 2021; 18(9): 4456.
6. Atherton WW, Kettner NW. The empty sella. J Manipulative Physiol Ther. 1999; 22(7): 478-82.
7. Provenzale JM. Approaches to imaging of the sella: notes on "the volume of the sella turcica". Am J Roentgenol. 2006; 186(4): 931-2.
8. Ananthi KS, Agarwal SK, Kumari MCI. Abnormal small sella-a case report. J Anat Soc India. 2009; 58: 13-5.
9. Tepedino M, Laurenziello M, Guida L, Montaruli G, Troiano G, Chimenti C, et al. Morphometric analysis of sella turcica in growing patients: an observational study on shape and dimensions in different sagittal craniofacial patterns. Sci Rep. 2019; 9(1): 19309.
10. Russell BG, Kjaer I. Postnatal structure of the sella turcica in Down syndrome. Am J Med Genet. 1999; 87(2): 183-8.
11. Axelsson S, Storhaug K, Kjaer I. Post-natal size and morphology of the sella turcica in Williams syndrome. Eur J Orthod. 2004; 26(6): 613-21.
12. Meyer-Marcotty P, Weisschuh N, Dressler P, Hartmann J, Stellzig-Eisenhauer A. Morphology of the sella turcica in Axenfeld-Rieger syndrome with PITX2 mutation. J Oral Pathol Med. 2008; 37(8): 504-10.
13. Andredaki M, Koumantanou A, Dorotheou D, Halazonetis DJ. A cephalometric morphometric study of the sella turcica. Eur J Orthod. 2007; 29(5): 449-56.

14. Kovacs GG. Can Creutzfeldt-Jakob disease unravel the mysteries of Alzheimer? Prion. 2016; 10(5): 369-76.

15. Balos Tuncer B, Canigur Bavbek N, Ozkan C, Tuncer C, Eroglu Altinova A, Gungor K, et al. Craniofacial and pharyngeal airway morphology in patients with acromegaly. Acta Odontol Scand. 2015; 73(6): 433-40.

16. Schmidt RF, Choudhry OJ, Takkellapati R, Eloy JA, Couldwell WT, Liu JK. Hermann Schloffer and the origin of transsphenoidal pituitary surgery. Neurosurg Focus. 2012; 33(2): E5.

17. Phogat V, Agarwal M, Sinha VD, Purohit D. Comparative efficacy of transsphenoidal endonasal endoscopic and microscopic pituitary surgery at single center of a developing country. J Neurol Surg B Skull Base. 2021; 82: e88-93.

18. Tan J, Song R, Huan R, Huang N, Chen J. Intraoperative lumbar drainage can prevent cerebrospinal fluid leakage during transsphenoidal surgery for pituitary adenomas: a systematic review and meta-analysis. BMC Neurol. 2020; 20(1): 303.

19. Cappabianca P, de Divitiis E. Endoscopy and transsphenoidal surgery. Neurosurgery. 2004; 45(4): 193-200.

20. Gondim JA, Schops M, de Almeida JP, de Albuquerque LA, Gomes E, Ferraz T, et al. Endoscopic endonasal transsphenoidal surgery: surgical results of 228 pituitary adenomas treated in a pituitary center. Pituitary. 2010; 13(1): 68-77.

21. Jho HD. Endoscopic pituitary surgery. Pituitary. 1999; 2(2): 139-54.

22. Becktor JP, Einersen S, Kjaer I. A sella turcica bridge in subjects with severe craniofacial deviations. Eur J Orthod. 2000; 22(1): 69-74.

23. Lynch TB, Stahl G, Gove JH. Use of stereology in forest inventories-a brief history and prospects for the future. Forests. 2018; 9(5): 251.

24. Değermenci M, Ertekin T, Ülger H, Acer N, Coşkun A. The age-related development of maxillary sinus in children. J Craniofac Surg. 2016; 27(1): e38-44.

25. Ertekin T, Degermenci M, Ucar I, Sagıroglu A, Atay E, Susar H. The intracranial and posterior cranial fossa volumes and volume fractions in children: a stereological study. Int J Morphol. 2014; 35: 1465-72.

26. Yilmaz H, Güler H. Can video-assisted and three-dimensional (3D) anatomy teaching be an alternative to traditional anatomy teaching? Randomized controlled trial on muscular system anatomy. Clin Anat. 2024; 37(2): 227-32.

27. Ezzat S, Asa SL, Couldwell WT, Barr CE, Dodge WE, Vance ML, et al. The Prevalence of pituitary adenomas: a systematic review. Cancer. 2004; 101(3): 613-9.

28. Chiloiro S, Giampietro A, Bianchi A, Tartaglione T, Capobianco A, Anile C, et al. Diagnosis of endocrine disease: Primary empty sella: a comprehensive review. Eur J Endocrinol. 2017; 177(6): R275-85.

29. Taner L, Deniz Uzuner F, Demirel O, Güngor K. Volumetric and three-dimensional examination of sella turcica by cone-beam computed tomography: reference data for guidance to pathologic pituitary morphology. Folia Morphol (Warsz). 2019; 78(3): 517-23.

30. Polat Özandaç S, Kabakcı AG, Öksüzler FY, Öksüzler M, Yücel AH. Determination of sella turcica types in healthy Turkish population. Cukurova Medical Journal. 2020; 45; 738-45.

31. Axelsson S, Storhaug K, Kjaer I. Post-natal size, and morphology of the sella turcica. Longitudinal cephalometric standards for Norwegians between 6 and 21 years of age. Eur J Orthod. 2004; 26(6): 597-604.

32. Ortega-Balderas JA, Acosta-Flores AB, Barrera FJ, Lugo-Guillen RA, Sada-Treviño MA, Pinales-Razo RA, et al. Volumetric assessment of the sella turcica: a re-evaluation. Folia Morphol. 2022; 81(4): 1014-21.

33. Iskra T, Stachera B, Możdżeń K, Murawska A, Ostrowski P, Bonczar M, et al. Morphology of the Sella Turcica: A Meta-Analysis Based on the Results of 18,364 Patients. Brain Sciences. 2023; 13(8): 1208.

34. Diri H, Tanriverdi F, Karaca Z, Senol S, Unluhizarci K, Candan Durak A, et al. Extensive investigation of 114 patients with Sheehan's syndrome: a continuing disorder. Eur J Endocrinol. 2014; 171(3): 311-8.

35. Yamada T, Tsukui T, Ikejiri K, Yukimura Y, Kotani M. Volume of sella turcica in normal subjects and in patients with primary hypothyroidism and hyperthyroidism. J Clin Endocrinol Metab. 1976; 42(5): 817-22.

36. Silveira BT, Fernandes KS, Trivino T, Dos Santos LYF, de Freitas CF. Assessment of the relationship between size, shape and volume of the sella turcica in class II and III patients prior to orthognathic surgery. Surg Radiol Anat. 2020; 42(5): 577-82.

37. Chilton LA, Dorst JP, Garn SM. The volume of the sella turcica in children: new standards. AJR Am J Roentgenol. 1983; 140(4): 797-801.

38. Ortega-Balderas JA, Acosta-Flores AB, Barrera FJ, Lugo-Guillen RA, Sada-Treviño MA, Pinales-Razo RA, et al. Volumetric assessment of the sella turcica: a re-evaluation. Folia Morphol (Warsz). 2022; 81(4): 1014-21.

39. Taner L, Deniz Uzuner F, Demirel O, Güngor K. Volumetric and three-dimensional examination of sella turcica by cone-beam computed tomography: reference data for guidance to pathologic pituitary morphology. Folia Morphol (Warsz). 2019; 78(3): 517-23.

40. Campero A, Socolovsky M, Torino R, Martins C, Yasuda A, Rhoton Jr AL. Anatomical landmarks for positioning the head in preparation for the transsphenoidal approach: The spheno-sellar point. Br J Neurosurg. 2009; 23(3): 282-6.

41. Cavallo LM, Messina A, Cappabianca P, Esposito F, de Divitiis E, Gardner P, et al. Endoscopic endonasal surgery of the midline skull base: anatomical study and clinical considerations. Neurosurg Focus. 2005; 19: E2.

42. Kim YH, Kim JE, Kim MJ, Cho JH. New Landmark for the Endoscopic Endonasal Transsphenoidal Approach of Pituitary Surgery. J Korean Neurosurg Soc. 2013; 53(4): 218-22.

43. Chumnanvej S, Pillai BM, Chalongwongse S, Suthakorn J. Endonasal endoscopic transsphenoidal approach robot prototype: A cadaveric trial. Asian J Surg. 2021; 44(1): 345-51.

44. Baig S, Asma NK, Patil N. Anatomical variation between columella and sphenoidal sinuses: a study conducted on adult cadavers. Pakistan J Med and Dentistry. 2017; 6: 2.

45. Couldwell WT. Transsphenoidal and transcranial surgery for pituitary adenomas. J Neurooncol. 2004; 69(1-3): 237-56.

46. Maartens NF, Kaye AH. Role of transcranial approaches in the treatment of sellar and suprasellar lesions. Front Horm Res. 2006; 34: 1-28.

47. Buchfelder M, Kreutzer J. Transcranial surgery for pituitary adenomas. Pituitary. 2008; 11(4): 375-84.

48. Mortini P, Giovanelli M. Transcranial approaches to pituitary tumors. Operative Techniques in Neurosurgery. 2002;5:239-251.

49. Venieratos D, Anagnostopoulou S, Garidou A. A new morphometric method for the sella turcica and the hypophyseal fossa and its clinical relevance Folia Morphol. 2005; 64(4): 240-7.

50. Sherif IH, Vanderley CM, Beshyah S, Bosairi S. Sella size and contents in Sheehan's syndrome. Clin Endocrinol (Oxf). 1989; 30(6): 613-8.

51. Bakiri F, Bendib SE, Maoui R, Bendib A, Benmiloud M. The sella turcica in Sheehan's syndrome: computerized tomographic study in 54 patients. J Endocrinol Invest. 1991; 14(3): 193-6.