http://dx.doi.org/10.35630/2199-885X/2021/11/4.14

THE VARIABILITY AND THE RATIO OF THE PITUITARY GLAND AND PITUITARY FOSSA LINEAR PARAMETERS DEPENDING ON THE SKULL BASE ANGLE

Received 6 July 2021;
Received in revised form 17 August 2021;
Accepted 20 August 2021

Olga Aleshkina[1]✉, Tatyana Bikbaeva[1], Anton Devyatkin[1], Marina Markeeva[2], Tatyana Zagorovskaya[1], Olga Konnova[1], Irina Polkovova[3], Valery Konnov[4]

[1] Human anatomy department, Saratov State Medical University, Saratov;
[2] Department of Otorhinolaryngology, Saratov State Medical University, Saratov;
[3] Department of Mobilization Training of Health and Disaster Medicine, Saratov State Medical University, Saratov;
[4] Department of Orthopedic Dentistry; Saratov State Medical University, Saratov, Russia

✉ *aleshkina_ou@mail.ru*

ABSTRACT — Details of the morpho- & topometric variability of the skull elements and soft tissue formations in the area of the sphenoid bone body, as well as their relationship, serve as the basis for the choice of proper surgical accesses to the respective area. The aim of this study was to identify the typical variability of morphometric parameters and the volume ratio between the pituitary gland and the Turkish saddle pituitary fossa in mature age adults. The method of computer craniometry (involving 100 MRI of people of the first and second periods of their mature age, 22–60) was employed to study the typical variability of the pituitary fossa and pituitary gland linear parameters, regardless of gender. The obtained data revealed that the regularity of morphometric variability and the volume ratio of the pituitary gland and the pituitary fossa depend on the skull base bending angle.

KEYWORDS — pituitary fossa, pituitary gland, craniotype, skull.

INTRODUCTION

The endoscopic research method, if employed in neurosurgery, will enhance significantly the visualization of hard-to-reach areas of the skull inner base, namely the Turkish saddle as well as the nearby bone and brain formations. The choice of surgical access to the respective area is based on the knowledge of the anatomical and topographic position of the skull elements and soft tissue formations and their relationship [7, 11, 28–30]. In case of the endoscopic endonasal transsphenoidal approach to pituitary neoplasm, for instance, the key anatomical points are the bottom of the Turkish saddle, the sphenoid bone platform, the sphenoid bone clivus, the carotid sulci, and the optical foramens [17].

Detailed visualization of the variability in the shape and volume of the pituitary gland, its stalk, the intersection of the optic nerves and other para-sellar structures [22–25] can be obtained through magnetic resonance imaging (MRI), which offers high image resolution.

There are a number of works available, which focus on the description of the chiasmal-sellar area anatomy [9, 10, 13, 20, 26, 27] and which reflect the dimensional features of the Turkish saddle, the shape of the pituitary fossa, along with details of the metric features and the shape of the pituitary gland as well as its topographic position in normal and pathological conditions in people of different ages, gender and race [21, 23, 24]. There have been multidirectional shaping factors identified that determine not only the structural properties of the skull, yet also its relationship with the nearest brain structures [3, 4, 6, 8, 15, 16].

However, few works contain data on the effect that the shape of the skull base has on the variability of morphotopometric parameters of the Turkish saddle and pituitary gland [14, 20], which offer little analysis of the relationship between the Turkish saddle and the pituitary gland, as well as the variability of their linear and volumetric statistical data [12]; besides, there are no comparable typical features of the said structures described. All this means that studying the typical ratio variability of the skull base elements and brain formations is an urgent issue faced by medical craniology currently, which requires detailed research.

Aim of study:

To identify the typical variability of morphometric parameters and the volume ratio of the pituitary gland and the pituitary fossa in mature age adults.

MATERIALS AND METHODS

100 archival magnetic resonance images (patients — people in their first and second periods of

mature age, 22–60) regardless of the gender factor, were studied retrospectively. The sampling included tomograms of patients featuring neither brain surgeries or pathologies, nor issues affecting the skull or brain development.

Brain images were obtained using an Aperto Hitachi magnetic resonance tomograph. Digital craniometry was done with the PACS\RIS software based on the ArchiMed system; the bone and nerve formations were evaluated on T1 and T2 weighted images in three projections.

The skull base angle relies on the craniometric points n (nasion) — s (cellare) — ba (basion), where the interval is calculated following the three sigmas (3σ) rule. Based on the basilar angle values the following 3 craniotypes were identified: mediabasilar, flexibasilar and platybasilar [2, 5].

The volume of the pituitary gland on brain tomograms was identified by measuring the following parameters in the sagittal projection: length (L) — the distance between the anterior and posterior edges of the gland; height (H) — the distance between the upper and lower edges of the pituitary gland; in the coronary projection: width (W) — the distance between the right and the left edge of the gland. The volume of the pituitary gland was calculated through the Di-Chiro–Nelson formula ($V = ½ \cdot H \cdot W \cdot L$) employed in medical radiology.

The variability of the pituitary fossa linear parameters as well as its volume was calculated through measurements in the sagittal projection: the length of the pituitary fossa (a) — the maximum distance between the anterior and posterior walls of the Turkish saddle, and the height (b) taken as the distance between the bottom of the pituitary fossa and the plane running from the saddle tubercle to its back; in the coronary projection: width (c) — the distance between the medial edges of the carotid sulci (10). The volume of the Turkish saddle was calculated relying on the ellipsoid formula ($V = ¾ \cdot \pi \cdot a \cdot b \cdot c$), where a, b, and c are the lengths of the semi-axes.

The obtained data distribution was checked via the Shapiro–Wilk and Kolmogorov–Smirnov criteria relying on the Lilliefors correction. Since the analyzed distribution did not differ from the normal one, the statistically significant differences between the average values were evaluated based on the Student's criterion, whereas the difference was considered statistically significant at $P<0.05$. The coefficient of variation (Cv%) was estimated following Lakin G. F. (1980), where at the variation coefficient of up to 10%, the variability was interpreted as weak; at 11–25% — average, and in the event the said value exceeded 25% the variability was considered strong.

RESULTS

In case of the flexibasilar craniotype, the pituitary gland length is 3.8 mm shorter (7.7±0.2 mm) than its width (11.5±0.3 mm) while exceeds its height by 2.1 mm (5.6±0.2 mm, $P<0.05$); the volume of the pituitary gland is 254.1±16.1 mm. The length of the Turkish saddle pituitary fossa is 3.1 mm shorter (10.1±0.2 mm) than its width (13.2±0.3 mm) and 1.1 mm longer than its height (9.0±0.2 mm, $P<0.05$), whereas the volume of the pituitary fossa is 630.9±21.1 mm. The length of the pituitary gland is 2.4 mm shorter (7.7±0.2 mm) than the length (10.1±0.2 mm) of the pituitary fossa, while the width of the pituitary gland is 1.7 mm shorter (11.5±0.3 mm) than the width (13.2±0.3 mm) of the pituitary fossa, and the height of the pituitary gland is 3.4 mm shorter (5.6±0.2 mm) than the height (9.0±0.2 mm) of the pituitary fossa ($P<0.05$). The pituitary gland was found to take up 40.2 % of the pituitary fossa volume. All the parameters in question feature an average degree of variability of the characteristic.

As for the mediobasilar craniotype, the length of the pituitary gland is by 4.4 mm shorter (8.6±0.2 mm) than its width (13.0±0.3 mm) while exceeds the height by 2.7 mm (5.9±0.2 mm, $P<0.05$); the volume of the pituitary gland is 334.3±19.8 mm. The length of the pituitary fossa of the Turkish saddle is 3.3 mm shorter (10.2±0.2 mm) than its width (13.5±0.3 mm), and by 2.0 mm exceeds its height (8.2±0.2 mm, $P<0.05$), whereas the volume of the pituitary fossa is 588.9±21.8 mm. The length of the pituitary gland is 1.6 mm shorter (8.6±0.2 mm) than the length (10.2±0.2 mm) of the pituitary fossa, while the width of the pituitary gland is 0.5 mm shorter (13.0±0.3 mm) than the width (13.5±0.3 mm) of the pituitary fossa, and the height of the pituitary gland is 2.3 mm shorter (5.9±0.2 mm) than the height (8.2±0.2 mm) of the pituitary fossa ($P<0.05$). The pituitary gland was observed to occupy 56.6 % of the pituitary fossa volume. All the parameters studied were found to reveal an average degree of the variability of the characteristic.

As far as the platybasilar craniotype is concerned, the pituitary gland length is 3.7 mm shorter (9.2±0.2 mm) than its width (12.9±0.4 mm) at the same time being 3.1 mm longer than its height (6.1±0.2 mm, $P<0.05$); the pituitary gland volume is 368.1±26.7 mm. The length of the pituitary fossa is 4.2 mm shorter (10.8±0.2 mm) than its width (15.0±0.4 mm) and by 2.9 mm exceeds its height (7.9±0.2 mm, $P<0.05$). The volume of the pituitary fossa is 673.8±32.3 mm. The length of the pituitary gland is 1.6 mm shorter (9.2±0.2 mm) than the length (10.8±0.2 mm) of the pituitary fossa, the width of the pituitary gland is 2.1 mm shorter (12.9±0.4 mm) than the width (15.0±0.4 mm) of the pituitary fossa and the height of the pituitary gland is 1.8 mm shorter (6.1±0.2 mm) than the height (7.9±0.2 mm) of the pituitary fossa ($P<0.05$). The pituitary gland proved to occupy 54.6% of the pituitary fossa volume. The results obtained showed an average degree of the characteristic's variability.

COMPARATIVE ANALYSIS AMONG THE SKULL BASE TYPES

In the flexibasilar craniotype, the length of the pituitary gland is 0.9 mm shorter than in case of the mediobasilar and 1.5 mm shorter compared to the platybasilar type ($P<0.05$). The height of the pituitary gland features no significant differences in craniotypes. The width of the pituitary gland in the platy- and the mediobasilar types shows similar values and exceeds by 1.4 mm ($P<0.05$) the same dimension in the flexibasilar type. The pituitary gland volume was found to be the smallest for the flexibasilar craniotype, if compared to the mediobasilar one, where the volume is larger by 80.2 mm^3, and in case of the platybasilar type – by 114 mm^3.

The length of the pituitary fossa in case of the platybasilar craniotype exceeds that of the flexibasilar type by 0.7 mm, and by 0.6 mm — of the mediobasilar ($P<0.05$), while this parameter does not statistically differ between the flexi- and mediobasilar types. The height of the pituitary fossa features a significant prevalence in the flexibasilar craniotype if compared to the mediobasilar type — by 0.8 mm, and by 1.1 mm — compared to the platybasilar, while this parameter shows no statistically significant difference for the medio- and platybasilar types. The width of the pituitary fossa was the biggest in the platybasilar craniotype, exceeding by 1.8 mm that of the flexibasilar, and 1.5 mm — of the mediobasilar types ($P<0.05$). In the platybasilar type, the volume of the pituitary fossa is 83.4 mm^3 larger than in the mediobasilar type ($P<0.05$), with no statistical difference observed between the volume pertaining to the other types of the skull base.

A comparative analysis of the ratio between the pituitary fossa volume and the volume of the pituitary gland showed that the largest volume of the pituitary fossa is occupied by the pituitary gland in case of the mediobasilar and platybasilar craniotypes (56.6% and 54.6%, respectively), thus exceeding — by 16.3% and 14.3% — similar volume indicators in case of the flexibasilar type (40.3%).

DISCUSSION

The morphology of the sphenoid bone Turkish saddle is of applied value for clinical anatomy, since its shape and size allow making judgments of the pituitary gland status [13]. Our study revealed not only the typical morphometric variability of the pituitary fossa and of the pituitary gland, yet also of their volume ratio. The largest values of the length of both the pituitary fossa and the pituitary gland, for instance, are to be observed in the platybasilar craniotype, the smallest being found in the flexi- and mediobasilar types. Some authors note that the shape and size of the Turkish saddle depend on the height of the skull and its base length [18], while others deny the dependence between the shape, the Turkish saddle and the shape of the skull [9, 10].

The data on the age and sex variability of the pituitary gland linear parameters are scarce and contradictory [21–25], while they do not reflect any relationship with the arch shape and the skull base. The average values of the pituitary gland size obtained through this study fall within the range of the values presented by the said authors without taking into account the craniotype. We also identified the typical variability of the pituitary gland width and length with the predominance of these parameters in the platybasilar craniotype, and did not detect the dependence of its height on the type of skull base. The volume ratio of the studied structures showed that more than 50% of the pituitary fossa volume is occupied by the pituitary gland in the medio- and platybasilar types, and only 40.3% — in case of the flexibasilar type, whereas the results of such a ratio without taking into account the typical variability [12] ranged from 68% to 100%, the average value being 86%. Given the lack of research and publications, it appears important to follow studying the features of the typical morphometric variability of soft-tissue brain and skull structures, employing advanced research methods.

CONCLUSION

Hence, the regularity of morphometric variability and the volume ratio of the pituitary gland and the pituitary fossa depend on the bending angle of the skull base. All the craniotypes featured the width of the pituitary gland and pituitary fossa prevailing over their length and height. The extreme types reveal variability of the volumetric and linear characteristics of the elements under study: the platybasilar craniotype has the highest values of the linear parameters of the pituitary gland, the length and width of the pituitary fossa, as well as the volume ratio between the gland and the pituitary fossa; the flexibasilar type was found to have the lowest values of the same parameters and the volume ratio of these elements, yet with the height of the pituitary fossa dominating if compared to other types of the skull base. As for the mediobasilar craniotype, the linear parameters fall within the range of values of the extreme types of the skull base, while the volume ratio of the pituitary gland and of the pituitary fossa correspond to the platybasilar type.

REFERENCES

1. **Alekseev V.P., Debets G.F. Craniometry.** Anthropological research methodology. – M .: Science. – 1964 . – 128 p.
2. **Aleshkina O.Yu.** Basic cranial typology of the human skull structure: author. dis. ... doct. honey. sciences. – Volgograd. – 2007 . – 32p.
3. **Aleshkina O.Yu., Aleshkina I.A.** Sexual dimorphism of the combination of the forms of the facial skull and the base of the skull // – Morphology. – 2004. – Vol. 126. – No. 4. – P. 7–8.
4. **Aleshkina O.Yu., Nikolenko V.N., Zaichenko A.A.** Typology of the skull depending on the individual variability of the basilar angle // Morphological sheets. – 2001. – No. 3–4. – P. 14–15. (In Russ.).
5. **Aleshkina O.Yu., Nikolenko V.N.** Basicranial typology of human skull construction – Moscow. – 2014 . – 160 p. (In Russ.).
6. **Aleshkina O.Yu., Polkova I.A., Bikbaeva T.S.** Age and gender variability of dimensional characteristics of the holes of the outer base of the skull // Morphology. – 2018. – Vol. 153. – No. 3. – P. 15–16. (In Russ.).
7. **Gorchakov V.N., Sergeeva I.G., Tulupov A.A.** Neurosurgical anatomy of the brain: textbook. allowance. – Novosibirsk: RITs NSU, 2015 . – 124 p.
8. Variability of the linear parameters of the cranial fossa of the inner base of the skull, depending on the craniotype. Aleshkina O.Yu., Nikolenko V.N., Khurchak Yu.A., Anisimov A.N., Bikbaeva T.S., Polkovova I.A. Morphology. 2018; 153 (3): 16.
9. **Koveshnikov V.G.** On the question of the variability of the shape of the Turkish saddle // Proceedings of the Saratov Medical Institute. –1960. – Vol. 31 (48). P. 92–95.
10. **Maikova-Stroganova B.C., Rokhlin D.G.** X-ray images of bones and joints. Head. – L .: Medgiz. – 1955. – Vol. 3. – 476 p.
11. Operative access to the structures of the skull and brain (classification option). / A.I. Gaivoronsky, D.A. Gulyaev, E.N. Kondakov, D.V. Svistov // Bulletin of the Russian military medical academy. – 2011 – No. 2 (34). – P. 210.
12. The relationship between the pituitary gland and the volume of the Turkish saddle / L.A. Pikulev, S.M. Gerasimov, V.M. Cheremisin, V.M. Shipilov // Archive of Anatomy. – 1970. – No. 9. – P. 98–104.
13. **Speransky V.S.** Fundamentals of medical craniology // M .: Medicine, 1988. – 288 p. (In Russ.).
14. Stereotopometric variability of the Turkish saddle depending on the type of the skull base / O.Yu. Aleshkina, A.A. Devyatkin, T.S. Bikbaeva, I.A. Polkovova, M.V. Markeeva // Operative surgery and clinical anatomy (Pirogov scientific journal). – 2020. – Vol. 4. – No. 4. – P. 4–8.
15. Typical variability of the pterygo-maxillary fissure depending on the shape of the facial skull // I.A. Polkovova, O. Yu. Aleshkina, V.N. Nikolenko, E.V. Chernyshkova, T.S. Bikbaeva // Morphological statements. – 2017. – Vol. 25. – No. 2. – P. 57–59.
16. Typology of the human brain skull from the standpoint of phylo-and ontogenesis / V.N. Nikolenko, O. Yu. Aleshkina, A.A. Zaichenko., E.A. Anisimova // Morphology. – 2002. – Vol. 121. – No. 2–3. – P. 38.
17. **Fomichev D.V.** Endoscopic endonasal removal of pituitary adenomas (anatomical rationale, technique of operations and immediate results): author. dis. ... Cand. honey. sciences. – M. – 2007 . – 25p.
18. **Khokhlov A.P., Protopopov V.V., Khokhlova M.P.** Cranio-saddle ratios in children are normal and determination of the size of the Turkish saddle // Bulletin of roentgenology and radiology. – 1977. – No. 6. – P. 86–88.
19. Combined variability of the anterior cranial fossa with orbital forms in the extreme types of the base of the skull. Aleshkina O.Yu., Anisimova E.A., Zagorovskaya T.M., Khurchak Yu.A., Bikbaeva T.S., Polkovova I.A., Konnova O.V. Morphology. 2018. Vol. 153. No S 3–1. P. 14.
20. Physical features variability of sphenoid bone anatomic structures in adult population. Aleshkina O.Yu., Bikbaeva T.S., Polkovova I.A., Markeeva M.V., Anisimov A.N., Konnova O.V., Fomkina O.A., Konnov V.V. Archiv EuroMedica. 2019. Vol. 9. No 2. P. 49–52. DOI: 10.35630/2199-885X /2020/10/2.8
21. **Denk, C. C. et al.** "Height of normal pituitary gland on MRI: differences between age groups and sexes." Okajimas folia anatomica Japonica 76 2–3 (1999): 81–7.
22. **Ibinaiye PO, Olarinoye-Akorede S, Kajogbola O, Bakari AG.** Magnetic Resonance Imaging Determination of Normal Pituitary Gland Dimensions in Zaria, Northwest Nigerian Population. J Clin Imaging Sci. 2015;5:29. Published 2015 May 29. doi:10.4103/2156-7514.157853
23. **Lamichhane, Tika Ram et al.** "Age and Gender Related Variations of Pituitary Gland Size of Healthy Nepalese People Using Magnetic Resonance Imaging." American Journal of Biomedical Engineering 5 (2015): 130-135. DOI: 10.5923/j.ajbe.20150504.03
24. **Kumar, Kanodia Avinash.** "MRI Measurement of Normal Pituitary Size Using Volumetric Imaging in Scottish Patients." (2017). DOI: 10.19080/CTCMI.2017.01.555563
25. **Rahman, Towhidur et al.** "Three-dimensional pituitary gland volume on MRI – A normative study." KYAMC Journal 9 (2018): 53-55. DOI: 10.3329/kyamcj.v9i2.38147

26. **Yasa Y.** Morphometric Analysis of Sella Turcica Using Cone Beam Computed Tomography. Yasa Y., Bayrakdar I.S., Duman S.B., Gumussoy I., Ocak A. The Journal of craniofacial surgery. 2016;(12):131–136. https://doi.org/10.1097/SCS.0000000000003223

27. **Yasa Y. A** Cephalometric Analysis on Magnitudes and Shape of Sella Turcica. Rai A.R., Rai R., Tonse M., Vadgaonkar R, et al. Journal of Craniofacial Surgery. 2016;(7):1317–1320.

28. **Dmitrienko S.V.** Analytical approach within cephalometric studies assessment in people with various somatotypes. Archiv EuroMedica. 2019. Vol. 9; 3: 103–111. https://doi.org/10.35630/2199-885X/2019/9/3.29

29. **Domenyuk D.** Structural arrangement of the temporomandibular joint in view of the constitutional anatomy. Archiv EuroMedica. 2020. Vol. 10. № 1. P. 126–136. https://doi.org/10.35630/2199-885X/2020/10/37

30. **Shkarin V.V., Ivanov S.Yu.** Morphological specifics of craniofacial complex in people with various types of facial skeleton growth in case of transversal occlusion anomalie. Archiv EuroMedica. 2019. Vol. 9; 2: 5–16. https://doi.org/10.35630/2199-885X/2019/9/2/5