Original Article

ANATOLIAN CURRENT MEDICAL

DOI: 10.38053/acmj.1697787
Anatolian Curr Med J. 2025;7(4):420-424

MRI morphometric analysis of anatomical structures affecting transsphenoidal surgery in acromegaly

Gönül Güvenç, Güven Gürsoy
Department of Neurosurgery, Faculty of Medicine, Muğla Sıtkı Koçman University, Muğla, Turkiye

Cite this article as: Güvenç G, Gürsoy G. MRI morphometric analysis of anatomical structures affecting transsphenoidal surgery in acromegaly. *Anatolian Curr Med J.* 2025;7(4):420-424.

Received: 12.05.2025 • **Accepted**: 15.06.2025 • **Published**: 28.07.2025

ABSTRACT

Aims: Functional pituitary adenomas such as acromegaly or Cushing adenoma can cause endocrinopathies and affect tissues. These functional pituitary adenomas can cause anatomical variations by tissue hypertrophy. The aim of this study is to reveal differences of anatomical structures on the surgical route between normal patients and acromegalic pituitary microadenoma patients via magnetic resonance imaging scanning of pituitary gland.

Methods: We investigated magnetic resonance scannings of 20 acromegalic pituitary adenoma patients preoperatively and 20 control patients. Carotid canal width, pyriform apical width, concha widths, frontal skin thicknesses, lip thickness and nasal heights were compared.

Results: Pyriform aperture widths were 22.76±0.94 mm in acromegalic patients and 21.80±0.53 mm in normal patients, concha widths were 9.38±1.22 mm in acromegalic patients and 7.98±0.78 mm in normal patients, frontal skin thicknesses were 6.77±0.38 mm in acromegalic patients and 4.94±1.03 mm in normal patients, lip thicknesses were found as 5.10±0.55 mm in acromegalic patient and 4.18±0.77 mm in normal patients, nasal heights were found as 49.8±0.89 mm in acromegalic patients and 48.88±3.97 mm in normal patients and these differences were statistically significant ($p<0.05$).

Conclusion: Since there are anatomical differences in acromegalic pituitary adenoma patients, variations of these anatomical structures should be defined and approaches should be adapted in transsphenoidal surgeries.

Keywords: Acromegaly, morphometric analysis, transsphenoidal surgery, variation

INTRODUCTION

Acromegaly occurs due to excessive amount of growth hormone (GH) secreted by the anterior pituitary gland, and it has an incidence of 4/1.000.000.[1] Acromegaly has an insidious onset and a slow progression, delaying the diagnosis for several years. Cardiac hypertrophy, hypertension, sleep disorder breathing-associated arrhythmias and daytime sleepiness, reproductive disorders, and cardiovascular diseases are common, whereas congestive heart failure is rare and occurs during prolonged exposure to high GH and insulin-like growth factor (IGF).[2,3]

Microscopic or endoscopic transnasal transsphenoidal approach is widely used by surgeons as a surgical treatment for pituitary tumors. Anatomical variations, such as the deep surgical corridor in the transnasal transsphenoidal approach or reduced intercarotid distance, have been reported in pituitary tumors.[4-7] The knowledge of these anatomical variations by the surgeons and accordingly choosing the appropriate surgical approach decreases the risk of complications. Iatrogenic pseudoaneurysms secondary to internal carotid artery laceration and perforation, caroticocavernous fistula, extensive postoperative hemorrhage and cerebral ischemia can occur during surgery via transsphenoidal approach. The rate of these complications varies between 0.2%–0.4% in the literature.[5,8,9] Normally, the right and left ICAs are 1.4 cm to 2.3 cm apart from each other at the siphon level and 1.2 cm apart from each other on average at the sella level.[5] Nasal and paranasal changes associated with acromegaly can complicate the performance of a transnasal transsphenoidal procedure.[10]

Pyriform aperture width, distance between pyriform aperture and anterior of sphenoid, sphenoid sinus height, angle from nasal floor to sphenoid sinus, lip thickness, concha width and frontal skin thickness in acromegaly patients are different compared to patients with pituitary adenoma other than acromegaly. Paying attention to these anatomical structures and measurements that will come up during the surgical procedure is important in terms of surgical duration and complications.

The aim of this study is to determine the changes of anatomical structures that affect surgery in acromegaly patients using preoperative pituitary MR imaging and compare these with the normal patient population without pituitary tumors or sinusitis.

Corresponding Author: Güven Gürsoy, guvengursoy@yahoo.com

This work is licensed under a Creative Commons Attribution 4.0 International License.

METHODS

Ethics

The study was conducted with the permission of İzmir Kâtip Çelebi University Non-interventional Clinical Researches Ethics Committee (Date: 20.12.2017, Decision No: 315). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design

This retrospective clinical study was designed to investigate anatomical changes of the structures which affect the surgical corridor in transsphenoidal surgery of acromegaly patients. Participants were 20 acromegalic patients who were operated between 2010 and 2017, and a control group of 20 healthy people without pituitary tumors or sinusitis.

Study Population

The study included both male and female patients aged 18 years and older with acromegaly, undergoing primary surgery. Patients with surgeries more than once, missing data and/or missing radiological images were excluded. Chronic sinusitis, septal defect or sinus tumor patients were also excluded from control group.

Data Collection

Preoperative radiological images of all patients were obtained by magnetic resonance imaging (MRI) of pituitary gland with a 1-mm slice thickness. The data obtained were examined by the researchers. Age, gender, height, and weight of the patients were recorded.

Morphometric Analysis

Anatomical dimensions were measured in preoperative axial, coronal, and sagittal MRI. Intercarotid distance, carotid canal width (CCW), pyriform aperture width, distance from the pyriform aperture to anterior face of sphenoid, sphenoid sinus height, sphenoid sinus width, sphenoid sinus length, angle from anterior nasal floor to anteroinferior face of sphenoid sinus, concha height, nasal cavity height, and sphenoid sinus pneumatization patterns of these patients were measured at two different time points (**Figure**). The measured dimensions and methods were defined in the figure caption.

Statistical Analysis

All records and data regarding the patients were analyzed with the IBM SPSS 23.00 statistical package program. The study data and median values (SD) of the data were processed and transferred to the statistical program. To determine whether the data follows a normal distribution, the Kolmogorov-Smirnov test was used for small samples (n<50). The Mann–Whitney U test was used to analyze the difference between the acromegaly group and control group. A p value of <0.05 was considered statistically significant.

RESULTS

The mean age of the patients was 45.00±11.05 (27–67) years. Of the 40 patients, 17 (42.5%) were male and 23 (57.5%) were female. Sphenoid pneumatization pattern of acromegaly patients was as follows: 2 (10%) presellar, 6 (30%) sellar, 12 (60%) postsellar. No difference was found between the groups

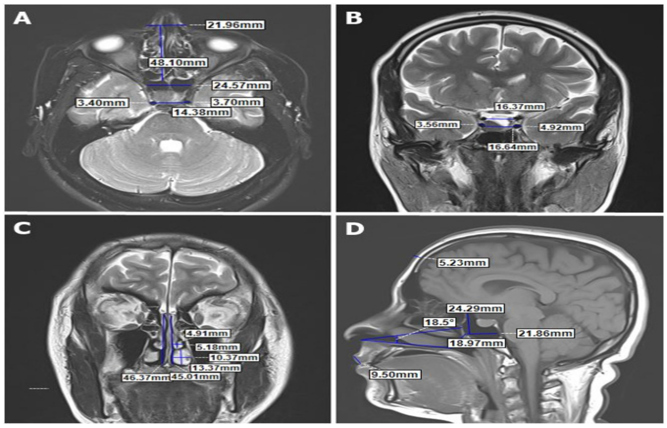

Figure. Anatomical dimensions measured in preoperative axial, coronal, and sagittal MRI. **A:** Axial T2 MRI; Clinoid segment intercarotid distance (14.38 mm), right carotid canal width (3.4 mm), left carotid canal width (3.7 mm), sphenoid sinus width (24.57 mm), pyriform aperture width (21.96 mm), distance from pyriform aperture to anterior face of sphenoid (48.10 mm), **B:** Coronal T2 MRI; Cavernous segment intercarotid distance (16.64), clinoid segment intercarotid distance (16.37), right carotid canal width (3.56 mm), left carotid canal width (4.92 mm), **C:** Coronal T2 MRI; Nasal cavity height right (46.37 mm)-left (45.1 mm), inferior concha width (10.37 mm)-height (13.37 mm), middle concha width (5.18 mm)-height (4.91 mm), and **D:** Sagittal T1 MRI; Sphenoid sinus anterior posterior width (21.86 mm), sphenoid sinus height (24.29 mm), choanal height (18.97 mm), angle from anterior nasal floor to anteroinferior face of sphenoid sinus (18.5), lip thickness (9.5 mm), frontal skin thickness (5.23 mm)

MRI: Magnetic resonance imaging

in terms of intercarotid distance (clinoid segment/cavernous segment). Pyriform aperture width of the acromegalic patient group was significantly higher compared to that in the control group (p<0.05). There was no statistical difference between the groups in terms of sphenoid sinus width and length. However, sphenoid sinus height was significantly higher in acromegalic patients compared to the control group (p<0.05). In acromegalic patients, angle from anterior nasal floor to anteroinferior face of sphenoid sinus (°) was higher compared to the control group (p<0.05). There was no significant difference between the groups in terms of inferior concha width (p>0.05). Although there was no difference in interior concha width, inferior concha width was significantly higher in acromegalic patients (p<0.05). There was no difference in carotid artery width between the groups (**Table**).

DISCUSSION

Intercarotid artery distance (ICD) in our study was found to be lower (15.49±0.99 mm) in acromegalic patients group compared to that in the control group but the difference between the groups was not statistically significant. CCW was also thinner in acromegalic patients than in the normal patients in our study, whereas the difference was not statistically significant.

The endoscopic approach in transsphenoidal surgery is preferred nowadays, due to its ability to provide a dynamic view in the surgical corridor and facilitate deeper advancement. Even though the endoscope facilitates deeper access, it still requires knowledge of the structural abnormalities that form the surgical corridor, as in all surgical cases.[11]

Structural anomalies in acromegalic patients who are to undergo surgery via transphenoidal approach affect anesthesia and surgical outcomes.[7] Anatomically, the surgical corridor

Table. Descriptive statistics of control and acromegalic patients, and comparison of radiological data between the groups

Variable	Control group (n=20)	Acromegaly group (n=20)	p value
Age	47.00±11.84 (28-67)	43.00±10.10 (27-64)	0.273
Sex			
Male	9 (22.5%)	8 (20.0%)	
Female	11 (27.5%)	12 (30.0%)	
Intercarotid distance clinoid segment (coronal) (mm)	15.59±0.99	15.49±0.99	0.771
Intercarotid distance cavernous segment (coronal) (mm)	16.30±1.17	16.27±0.91	0.876
Carotid canal width (coronal, right) (mm)	4.00±0.79	3.92±0.65	0.704
Carotid canal width (coronal, left) (mm)	4.34±0.80	4.10±0.78	0.363
Carotid canal width (axial, right) (mm)	4.51±0.53	4.15±0.70	0.060
Carotid canal width (axial, left) (mm)	4.28±0.78	4.02±0.83	0.276
Pyriform aperture width (mm)	21.80±0.53	22.76±0.94	0.000
Distance from the pyriform aperture to the anterior face of the sphenoid (mm)	41.60±4.88	44.55±3.60	0.039
Sphenoid sinus width (axial) (mm)	16.95±0.18	17.27±0.69	0.051
Sphenoid sinus lenght (mm)	21.00±1.40	21.70±1.57	0.092
Sphenoid sinus height (mm)	20.19±0.73	21.67±1.31	0.000
Angle from anterior nasal floor to anteroinferior face of sphenoid sinus (°)	20.90±0.59	22.92±1.91	0.000
Choanal height (mm)	18.11±1.02	18.63±1.91	0.466
Nasal cavity height (mm)	48.88±3.97	49.80±0.89	0.848
Lip thickness (mm)	4.18±0.77	5.10±0.55	0.000
Concha width, inferior (mm)	15.16±0.66	15.00±1.08	0.486
Concha width, median (mm)	7.98±0.79	9.38±1.22	0.000
Frontal skin thickness (mm)	4.94±1.93	6.77±0.38	0.000

is deeper and different than in normal patients due to tissue edema, nasal polyp, and bone growth.[6,8] The present study contributes to literature by examining anatomical differences in acromegalic patients.

Ebner et al.[5] found that ICD is lower in acromegalic patients than in the normal patient group. The authors reported that the reduction in the distance of intercarotid artery and the widening of the carotid canals are multifactorial, with changes in vascular anatomy and chronic hypertension possibly being responsible.

Mascarella et al.[12] radiologically screened 212 sellar and parasellar lesions and found that ICD was narrower by 1.59 cm in acromegalic patients compared to that in the control group. In another study, Carrabra et al.[4] found that there was no significant difference between the ICD of acromegalic patients and the control group. Kuan et al.[13] compared 30 acromegalic patients with 15 control patients, and although a lower ICD was detected in acromegalic patients, the difference between acromegalic patients and the control group was not statistically significant. Kuan et al.[13] reported that excessive GH causes thickening of soft tissue, with the tissue layers surrounding the carotid artery in the clival and cavernous segments bringing the carotid arteries closer to the midline.

CCW was found to be thicker in acromegalic patients compared to that in the normal group in the study of Ebner et al.[5] Conversely, Kuan et al.[13] showed that CCW was thinner in acromegalic patients compared to that in the normal group, but the difference was not statistically significant. Gardner et al.[14] state that in the surgical management of acromegaly, reduced ICD should be considered, and although intraoperative carotid artery injury is rare, it can lead to fatal outcomes. They emphasized that mapping the course of the carotid arteries using intraoperative Doppler ultrasonography would be beneficial and that open approach should be considered in cases where the ICD is less than 1 cm. According to the study by Abuzayed et al.[15] on the endoscopic anatomy of the nasal cavity, sphenoid sinus, and sellar region in 30 fresh cadavers, the average minimum distance between the internal carotid arteries (ICA) on both sides ranged from 13 to 22 mm. The authors documented that variations are common in the nasal, sphenoidal, and sellar stages of the transsphenoidal approach. Mascarella et al.[12] compared the distance between ICA using computer tomography (CT) angiography and T2-weighted MRI images and found no statistically significant difference between the two imaging methods. MRI measurements were lower than CT angiography measurements, although the difference between the two measurement methods was not significantly different.

In the study by Ebner et al.[5] it was found that the CCW in acromegaly patients was thicker compared to the normal group. Conversely, Kuan and colleagues[13] have shown that the CCW is thinner in patients with acromegaly compared to the normal group, but the difference is not statistically significant.

Takahar et al.[10] investigated nasal and paranasal changes in patients with GH adenomas and other adenomas. In the acromegaly group, they evaluated the relationships between preoperative GH and/or insulin-like growth factor 1 (IGF-1) levels and anatomical features. According to the results of their study, they reported that in the acromegaly group, the distance between the parasellar ICA was significantly shorter and the distance between the nostril and dorsum sellae was significantly longer. They observed nasal mucosa and bone hypertrophy in the acromegaly group and noted a correlation between preoperative GH levels and the width of the piriform aperture. They emphasize that nasal and paranasal changes in acromegaly can complicate surgical intervention and highlight the importance of widening the surgical corridor in front of the sphenoid sinus.[10]

In our study, distance between pyriform aperture and sphenoid in acromegalic patients was found to be higher than normal group. Distance between pyriform aperture and sphenoid was found to be longer in acromegalic patients in a CT study conducted by Carrabra et al.[4] This result showed that the surgical corridor was deeper in acromegalic patients. However, there was no significant difference between the groups in terms of distance between pyriform aperture and dorsum sellae. Saeki et al.[6] found that pyriform aperture-sphenoid distance was higher in acromegalic patients compared to that in patients without acromegaly. Kuan et al.[13] found that pyriform aperture-sphenoid distance was higher in acromegalic patients and those with Cushing's syndrome compared to that in the normal patient group. The direct effect of the long piriform aperture-sphenoid sinus distance is that the surgical field is significantly deeper. This situation emphasizes that reaching the anterior wall of the sphenoid sinus from the nasal cavity can be achieved with longer instruments, but it may reduce maneuverability. Saeki et al.[6] has noted that patients with acromegaly and Cushing's disease tend to have a wider piriform aperture. They state that this condition is a beneficial factor in maneuvering during instrument use.

In our study, 2 (10%) patients had presellar, 6 (30%) patients had sellar, and 12 (60%) patients had postsellar pattern. Carrabra et al.[4] examined the sphenoid sinus pattern of acromegalic patients and found that 26% of the patients had presellar and conchal pattern and 74% had sellar pattern. The rate of presellar, sellar, and postsellar patterns were found to be 10%, 23%, and 67% by Kuan et al.[13] respectively. There are extensive cadaveric studies in the literature, and these studies report that the rate of conchal pattern is 2%, presellar pattern is 15%, sellar pattern is 49%, and postsellar pattern is 34%.[16,17] These studies show that sellar and It shows that the postsellar types constitutes the majority of the cases. This allows access to the sella floor without making a large opening.

There are studies reporting that the anteroposterior length of the sphenoid sinus is shorter, as well as studies indicating no difference compared to controls in acromegaly. Ebner[5,18] reports that technically, a shorter sphenoid sinus length could lead to an involuntary early perforation of the sella during sphenoidotomy. In our study, there was no statistical difference between the groups in terms of sphenoid sinus width and length. However, sphenoid sinus height was significantly higher in acromegalic patients compared to the control group ($p<0.05$).

In acromegalic patients, angle from anterior nasal floor to anteroinferior face of sphenoid sinus (°) was higher compared to the control group in our study ($p<0.05$).

The angle measured in sagittal MRI sections from the anterior nasal floor to the anterior-inferior surface of the sphenoid sinus (NFS angle) indicates the localization of the sphenoid sinus ostium, and this angle is traditionally reported as 30 degrees.[19] Traditional knowledge is based on early anatomical studies, and the generally accepted information is that an angle of 30 degrees is formed from the anterior of the nose to the base to approach the sphenoid sinus ostium. other cadaver studies also confirm this.[19,20] Kuan et al.[13] report that the control group showed a similar NFS angle (24±8 degrees) as mentioned in the literature, while for acromegalics, the angle was much less. Although the likelihood of this condition affecting surgery is low, they emphasize that this variation should be recognized.

Castle-Kirszbaum et al.[21] have described the skeletal, vascular, and nerve anatomical variations that can be encountered at every stage of surgery, from the nasal, sphenoid, and sellar stages. They have also provided a preoperative checklist. They emphasize that knowledge of anatomy and variations is the key to safe surgery. Acromegaly strongly impacts body composition until biochemical disease remission, characterized by an increase in fat mass. These changes are closely associated with the normalization of IGF-I. There are studies indicating that in acromegaly patients, preoperative body-mass index and elevated IGF-1 levels can constitute prognostic risk factors and should be used in remission follow-up.[22] In the literature, there are publications investigating the relationship between body-mass index and obstructive sleep apnea in patients with acromegaly. in our study, inferior concha width was significantly higher in acromegalic patients ($p<0.05$). However, in our study, the relationship between the body mass indices of acromegalic patients and the morphological changes developing along the surgical corridor has not been investigated.

Limitations

The primary limitation of this study is its retrospective design. The lack of double-blind reading of the morphometric measurements on MR images in the PACS (Picture Archiving and Communication System) can also be considered a limitation. Although the patient group with Cushing's disease not included in our study, other measurement parameters that chould cause soft tissue changes, such as body mass index, could have been included. Another limitation of our study could have been the evaluation of the relationship between preoperative GH and/or IGF-1 levels and anatomical changes in the acromegaly group.

CONCLUSION

The patients with acromegaly have acute soft tissue growth resulting deep surgical corridor. The reduction in distance between the carotid arteries and sphenoid sinus pneumotization are the conditions affecting the surgical path and intervention during transnasal transsphenoidal surgery. Anatomical structures and measurements like pyriform aperture width, the middle concha width, and the angle from anterior nasal floor to anteroinferior face of sphenoid sinus in acromegalic patients differ from the control group. Surgeons should know these anatomical changes for instrument selection and surgery techniques for good outcome.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of İzmir Kâtip Çelebi University Non-interventional Clinical Researches Ethics Committee (Date: 20.12.2017, Decision No: 315).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Netuka D, Majovsky M, Masopust V, et al. Intraoperative magnetic resonance imaging during endoscopic transsphenoidal surgery of growth hormone-secreting pituitary adenomas. *World Neurosurg.* 2016; 91:490-496. doi:10.1016/j.wneu.2016.04.094
2. Colao A, Ferone D, Marzullo P, Lombardi G. Systemic complications of acromegaly: epidemiology, pathogenesis, and management. *Endocr Rev.* 2004;25(1):102-152. doi:10.1210/er.2002-0022
3. Potorac I, Petrossians P, Daly AF, et al. Pituitary MRI characteristics in 297 acromegaly patients based on T2-weighted sequences. *Endocr Relat Cancer.* 2015;22(2):169-177. doi:10.1530/ERC-14-0305
4. Carrabba G, Locatelli M, Mattei L, et al. Transphenoidal surgery in acromegalic patients: anatomical considerations and potential pitfalls. *Acta Neurochir (Wien).* 2013;155(1):125-130. doi:10.1007/s00701-012-1527-6
5. Ebner FH, Kuerschner V, Dietz K, Bueltmann E, Naegele T, Honegger J. Reduced intercarotid artery distance in acromegaly: pathophysiologic considerations and implications for transsphenoidal surgery. *Surg Neurol.* 2009;72(5):456-460. doi:10.1016/j.surneu.2009.07.006
6. Saeki N, Yamaura A, Iuchi T, Sunami K. Bone window CT evaluation on nasal cavity for transsphenoidal reoperations: a sequel to a previous publication. *Br J Neurosurg.* 2000;14(4):379-381.
7. Zada G, Cavallo LM, Esposito F, et al. Transsphenoidal surgery in patients with acromegaly: operative strategies for overcoming technically challenging anatomical variations. *Neurosurg Focus.* 2010; 29(4):E8. doi:10.3171/2010.8.FOCUS10156
8. Laws ER Jr. Vascular complications of transsphenoidal surgery. *Pituitary.* 1999;2(2):163-170. doi:10.1023/a:1009951917649
9. Fukushima T, Maroon JC. Repair of carotid artery perforations during transsphenoidal surgery. *Surg Neurol.* 1998;50(2):174-177. doi:10.1016/s0090-3019(96)00416-8
10. Takahara K, Tamura R, Isomura E, Kitamura Y, Ueda R, Toda M. Variable anatomical features of acromegaly in the nasal cavity and paranasal sinuses: implications for endoscopic endonasal transsphenoidal surgery. *Acta Neurochir (Wien).* 2024;166(1):408. doi:10.1007/s00701-024-06307-4
11. Perondi GE, Isolan GR, de Aguiar PH, Stefani MA, Falcetta EF. Endoscopic anatomy of sellar region. *Pituitary.* 2013;16(2):251-259. doi: 10.1007/s11102-012-0413-9
12. Mascarella MA, Forghani R, Di Maio S, et al. Indicators of a reduced intercarotid artery distance in patients undergoing endoscopic transsphenoidal surgery. *J Neurol Surg B Skull Base.* 2015;76(3):195-201. doi:10.1055/s-0034-1396601
13. Kuan EC, Yoo F, Kim W, et al. Anatomic variations in pituitary endocrinopathies: implications for the surgical corridor. *J Neurol Surg B Skull Base.* 2017;78(2):105-111. doi:10.1055/s-0036-1585588
14. Gardner PA, Tormenti MJ, Pant H, Fernandez-Miranda JC, Snyderman CH, Horowitz MB. Carotid artery injury during endoscopic endonasal skull base surgery: incidence and outcomes. *Neurosurgery.* 2013;73(2 Suppl Operative):ons261-9;discussion ons269-70. doi:10.1227/01.neu.0000430821.71267.f2
15. Abuzayed B, Tanriöver N, Ozlen F, et al. Endoscopic endonasal transsphenoidal approach to the sellar region: results of endoscopic dissection on 30 cadavers. *Turk Neurosurg.* 2009;19(3):237-244.
16. Hamid O, El Fiky L, Hassan O, Kotb A, El Fiky S. Anatomic variations of the sphenoid sinus and their impact on trans-sphenoid pituitary surgery. *Skull Base.* 2008;18(1):9-15. doi:10.1055/s-2007-992764
17. Tomovic S, Esmaeili A, Chan NJ, et al. High-resolution computed tomography analysis of variations of the sphenoid sinus. *J Neurol Surg B Skull Base.* 2013;74(2):82-90. doi:10.1055/s-0033-1333619
18. Ebner FH, Kürschner V, Dietz K, Bültmann E, Nägele T, Honegger J. Craniometric changes in patients with acromegaly from a surgical perspective. *Neurosurg Focus.* 2010;29(4):E3. doi:10.3171/2010.7.FOCUS10152
19. Van Alyea OE. Sphenoid sinus: anatomic study, with consideration of the clinical significance of the structural characteristics of the sphe noid sinus. *Arch Otolaryngol.* 1941;34(2):225-253. doi:10.1001/archotol.1941.00660040251002
20. Kim HU, Kim SS, Kang SS, Chung IH, Lee JG, Yoon JH. Surgical anatomy of the natural ostium of the sphenoid sinus. *Laryngoscope.* 2001;111(9):1599-1602. doi:10.1097/00005537-200109000-00020
21. Castle-Kirszbaum M, Uren B, Goldschlager T. Anatomic variation for the endoscopic endonasal transsphenoidal approach. *World Neurosurg.* 2021;156:111-119. doi:10.1016/j.wneu.2021.09.103
22. Wolf P, Salenave S, Durand E, et al. Treatment of acromegaly has substantial effects on body composition: a long-term follow-up study. *Eur J Endocrinol.* 2021;186(2):173-181. doi:10.1530/EJE-21-0900
23. Amaro AC, Duarte FH, Jallad RS, Bronstein MD, Redline S, Lorenzi-Filho G. The use of nasal dilator strips as a placebo for trials evaluating continuous positive airway pressure. *Clinics (Sao Paulo).* 2012;67(5):469-474. doi:10.6061/clinics/2012(05)11