# Extent of optico-carotid recess is significantly associated with presence of bony dehiscences and bone thickness in the optico-carotid area*

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## Abstract

**Background**: The objectives of this study were to evaluate the frequency of bony dehiscences in the optico-carotid recess (OCR) area and to measure the thickness of the bony lamellas bordering the OCR, according to our previously proposed OCR classification taking into account the extent of the recess.

**Methodology**: A total of 100 human cadaver heads (n= 200 sphenoid sinuses) were investigated. Samples were divided into groups according to the presence and extent of OCR (no OCR, sub-optical OCR, latero-optical OCR). Bony dehiscences were visually identified and bone thickness was measured by using a high-resolution micrometer.

**Results**: A bony dehiscence in the OCR area was observed in 20%. A significant difference in bony dehiscence occurrence rate between OCR types was found. The wall thickness of the bony carotid artery- and optic nerve canals bordering the OCR were 0.25 ± 0.16 mm and 0.27 ± 0.15 mm, respectively. Significant differences between OCR groups in bony wall thickness of the carotid artery canal and optic nerve canal were found. Samples with a latero-optical OCR had a significant thinner wall of the carotid artery and optic nerve canal than samples with a sub-optical OCR and no OCR.

**Conclusions**: The current results indicate that the presence of an extended OCR, e.g. latero-optical, is highly associated with a greater risk of bony dehiscences and thinner bony lamellas in the OCR region.

**Key words**: optico-carotid recess, sphenoid sinus, anterior skull base, anatomy, endoscopic sinus surgery

## Introduction

The sphenoid sinus has a close relationship to adjacent neurovascular structures, in particular to the optic nerve and internal carotid artery. Numerous key landmarks have been described to minimize the risk of iatrogenic injury of these structures during transnasal-endoscopic anterior skull base surgery. Recent studies reported the optico-carotid recess (OCR) to be the most reliable and safest key landmark in the endoscopic transsphenoidal approach to the optico-carotid region [1-3]. If present, it is located on the lateral wall of the sphenoid sinus between the protrusions of the optic nerve superiorly and the anterior knee of the intracavernous carotid artery inferiorly. Depending on the degree of pneumatization, the OCR can extend far laterally and pneumatize the anterior clinoid process. Based on the course of optic nerve and carotid artery, the OCR has a typically triangular shaped "entrance" (Figure 1). Recently, due to its significant relevance as a surgical landmark in transnasal-endoscopic approaches to the anterior skull base, we have comprehensively investigated the OCR. We have determined an OCR present in 38% of the general population. Furthermore, we have classified the OCR according to its extension and location to the optic nerve into sub-optical and latero-optical OCR. The primary intention of this

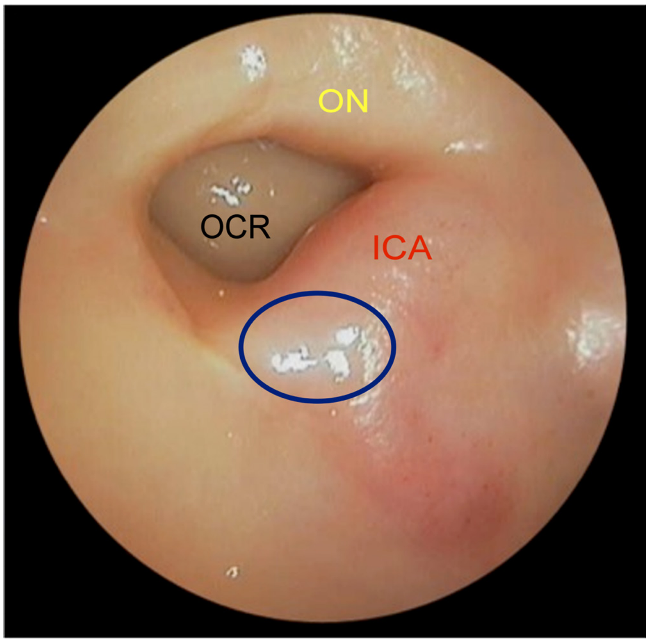


Figure 1. Endoscopic view of optico-carotid recess (OCR) in a right sphenoid sinus. The blue circle encloses the area of dehiscence. ON = optic nerve. ICA = internal carotid artery.

proposed classification was based upon that a more extended OCR appears to be more visible and recognizable during the endoscopic procedure [4]. In the past years during anterior skull base surgery at our Department, we have experienced in some cases significant dehiscences in the bony lamella covering the carotid artery in the OCR region. Post-operative evaluation of the computed tomography (CT) scans revealed that in nearly all of these cases, an extensive latero-optical OCR was present. We hypothesized that the frequency of dehiscences in the OCR area increases with enhanced extension of the OCR. The presence of bony dehiscences and very thin bony lamellas in this area may enhance the risk of iatrogenic injury of carotid artery and optic nerve resulting in fatal consequences include severe hemorrhage and blindness.

Considering these facts, we conducted the present anatomical study in order to evaluate the frequency of bony dehiscences in the optico-carotid region; and to measure the thickness of the bony lamellas bordering the OCR, according to our previously proposed OCR classification. The study hypothesis was that individuals with a latero-optical OCR show the highest prevalence of bony dehiscences and thinnest bony lamellas in the OCR area, followed by individuals with a sub-optical OCR and without an OCR, respectively.

## Materials and methods

A consecutive series of 100 cadaver heads (n= 200 sphenoidal sinus) of unselected human bodies donated to science were included in this anatomical study. The cadavers were donated to the Department of Macroscopic and Clinical Anatomy of the Medical University Graz with approval of the Anatomical Donation Program of the Medical University of Graz and in adherence to Austrian law for such donations. All cadavers were embalmed by Thiel's method [5,6]. This special embalming technique provides a life-like model through the preservation of the original tissue color, consistency, and degree of transparency. Functional endoscopic sinus surgery and sphenoidal sinus disease in the donor's medical history as well as conchal and presellar sinus type [7] rendered as exclusion criteria. Sphenoid sinus pneumatization was classified into sellar, post-sellar, lateral and combined (lateral + post-sellar) [8]. All included samples did not show any signs of prior interventions/manipulations or malformations in the area of interest.

In order to obtain the study's measurements of interest, the cadaver heads were divided in the median-sagittal plane by using a circular saw. The mucosa covering the internal surface of the sphenoidal sinus was then carefully removed. By direct visualization and performance of sphenoidal sinus casting as previously described [4,8], the presence of an OCR was evaluated. An OCR was defined as an intra-sphenoidal sinus recess between a bony protrusion caused of optic nerve superiorly and carotid artery inferiorly with a depth of at least 1 mm. The OCR was categorized according to our previously proposed classification, which takes the extension of the OCR in relation to the position of the optic nerve into account: A latero-optical OCR extends beyond the lateral margin on a virtual vertical line of the optic nerve compared to the sub-optical OCR, which is located solely inferior the optic nerve. Samples were divided into groups according to OCR type (no OCR, sub-optical OCR, latero-optical OCR) [4].

The primary study measurement of interest was the presence of a dehiscence in the bone covering the carotid artery and optic nerve in the OCR area. Dehiscences were determined by direct visualization with magnifying glasses. Secondary study measurements were the thickness of the bony lamellas over the carotid artery and optic nerve bordering the OCR. For that reason, small-sized bony fragments of the respective areas were excised. The excision was performed after the identification of potential bony dehiscences. The thickness of the removed bony fragment was then measured by using a high-resolution micrometer (resolution of 0.001 mm).

SPSS © statistical software, version 26.0 (IBM©, Armonk, NY, USA) was used for statistical analysis. Statistical significance α-level was set at $p<0.05$, two-sided. Categorical variables are presented as absolute numbers and percentages and continuous variables as means ± standard deviations. Chi-squared test with Bonferroni-adjusted post-hoc Z-tests were utilized to compare unpaired categorial data. Cramer's V-coefficient was used to determine the effect size of significant chi-squared tests. Effect size of post-hoc Z-tests was assessed by φ-coefficient. Robust Welch-ANOVA and post-hoc Games-Howell test were utilized for

Table 1. Optico-carotid recess results according to sphenoid sinus pneumatization.

| | Sellar type n=100 | Post-sellar type n=46 | Lateral type n=26 | Combined type n=28 |
|---|---|---|---|---|
| No OCR n=132 | 82 (82) $_a$ | 28 (60.9) $_b$ | 16 (61.5) $_{a,b}$ | 6 (21.4) $_c$ |
| Sub-optical OCR n=38 | 18 (18) $_a$ | 10 (21.7) $_a$ | 6 (23.1) $_a$ | 4 (14.3) $_a$ |
| Latero-optical OCR n=30 | 0 (0) $_a$ | 8 (17.4) $_b$ | 4 (15.4) $_b$ | 18 (64.3) $_c$ |

Categorical variables are presented as absolute numbers and percentages (%). Significant differences in prevalence of optico-carotid recess (OCR) types were found between sinus pneumatization types [$\chi^2(6) = 73.87$; $p < 0.001$; $V = 0.430$]. Each subscript letter (a, b, c) denotes a subset of sinus pneumatization types whose proportions do not differ significantly from each other at the Bonferroni-adjusted significance level.

Table 2. Results of bony dehiscences and bony lamella thickness in the optico-carotid recess area.

| | No OCR n=132 | Sub-optical OCR n=38 | Latero-optical OCR n=30 | p-value |
|---|---|---|---|---|
| Bony dehiscences in the OCR area | 8 (6.1) $_a$ | 12 (31.6) $_b$ | 20 (66.7) $_c$ | <0.001* |
| Thickness of bone covering the carotid artery in the OCR area | 0.31 ± 0.17 $_a$ | 0.18 ± 0.09 $_b$ | 0.12 ± 0.06 $_c$ | <0.001* |
| Thickness of bone covering the optic nerve in the OCR area | 0.32 ± 0.16 $_a$ | 0.24 ± 0.14 $_b$ | 0.18 ± 0.07 $_c$ | <0.001* |

Continuous variables are presented as means ± standard deviations in mm. Categorical variables as absolute numbers and percentages (%). * represents statistical significance at the Bonferroni-adjusted α-level. Each subscript letter (a, b, c) denotes a subset of optico-carotid recess (OCR) groups whose proportions do not differ significantly from each other at the adjusted significance level.

comparisons of unpaired continuous variables, as Levene tests for variance homogeneity turned out significant. Eta-squared coefficient ($\eta^2$) was applied to ascertain the effect size of significant variance analyses.

## Results

In total, 200 sphenoidal sinuses of 100 human cadaver (43 men, 57 women; mean age: 81 ± 11,3 years) were investigated. Sellar, post-sellar, lateral and combined sinus pneumatization type occurred in 100 (50%), 46 (23%), 26 (13%) and 28 (14%) sides. 44 of the specimens showed on at least one side an OCR. 20 of them had a unilateral OCR whereas the remaining 24 samples showed a bilateral OCR. In total, an OCR occurred in 68 of 200 (34%) sides. Significant differences in OCR presence were found between sinus pneumatization types [$\chi^2$ (3) = 20.09; $p < 0.001$; $V = 0.317$]: the combined type showed the highest prevalence of OCR presence (14/28, 50%), followed by lateral (6/26, 23%), post-sellar (8/28, 17%) and sellar (12/100, 12%), respectively. Divided according to the extent of pneumatization, a sub-optical and latero-optical OCR were found in 19% and 15% of the sides (38/200 and 30/200), respectively. Detailed results of OCR subtypes according to sphenoid sinus pneumatization are presented in Table 1.

A bony dehiscence in the OCR area could be identified in 40 of 200 sides (20%). In 34 of these cases (85%), the dehiscence was present over the carotid artery. In 2 cases (5%), a dehiscence in the bony wall of the optic nerve canal was found. In the remaining 4 cases (10%), bony dehiscences in the lamellas covering both, carotid artery and optic nerve, were present. A significant difference in the empirical probability of bony dehiscences in the OCR region was found between OCR types [$\chi^2$ (2) = 60.05; $p < 0.001$; $V = 0.548$]. Bonferroni-adjusted post-hoc Z-tests revealed the following significant findings: Samples with a latero-optical OCR had a 35.1% and 60.1% higher relative frequency of bony dehiscences in the OCR area than samples with a sub-optical OCR ($p < 0.001$; $\varphi = 0.349$) and without an OCR ($p < 0.001$; $\varphi = 0.622$), respectively. Moreover, sub-optical OCR samples showed a 25% higher empirical probability of bony dehiscences than OCR-negative samples ($p < 0.001$; $\varphi = 0.329$).
Including all samples, the wall thickness of the bony carotid artery- and optic nerve canals were 0.25 ± 0.16 mm and 0.27 ± 0.15 mm, respectively. Significant differences between OCR groups in bony wall thickness of the carotid artery canal [Welch's F(2, 92.4) = 44.53; $p < 0.001$; $\eta^2 = 0.196$] and optic nerve canal [Welch's F(2, 79.8) = 19.63; $p < 0.001$; $\eta^2 = 0.097$] were found. According to post-hoc Games-Howell test, samples with a latero-

optical OCR had a significant thinner wall of the carotid artery and optic nerve canal than samples with a sub-optical OCR ($p = 0.020$) and without an OCR ($p < 0.001$). Furthermore, samples with a sub-optical OCR showed a thinner bony wall of the carotid artery canal and optic nerve canal than samples without an OCR ($p < 0.001$). Detailed study findings are presented in Table 2.

## Discussion

The OCR has been reported to be the key landmark for identifying the optico-cartoid region during endoscopic transnasal anterior skull base surgery [1-3]. Van Alyea et al. in 1941 were the first describing this anatomical variation as the "superior lateral recess of the sphenoid sinus" [9]. Fujii et al. subsequently introduced in 1979 the term "optico-carotid recess", which has established in the past decades internationally [10]. However, there was no exact definition of the OCR. For that reason, we have recently conducted a study, in which we provided a precious definition of the OCR, namely an intra-sphenoidal sinus recess between a bony protrusion caused of optic nerve superiorly and carotid artery inferiorly with a depth of at least 1 mm. This definition can be applied readily during pre-operative evaluation of sphenoid sinus imaging, as well as in anatomical studies for research purposes. In that previously large study including 400 sphenoidal sinuses, an OCR could be observed in 29% [4]. By using the same definition in the present study including 200 sphenoidal sinuses, we found a similar OCR prevalence (34%) and therefore we could further validate our proposed definition. Moreover, we have divided the OCR based on its extension and location to the optic nerve into sub-optical and latero-optical OCR. The less extended subtype, sub-optical OCR, is situated solely inferior the optic nerve. A latero-optical OCR extends beyond the lateral margin on a virtual vertical line of the optic nerve and can reach the lateral margin of the anterior clinoid process. The prevalence of the subtypes was distributed equally in the initial study (each 14.5%) [4]. And again, we could observe similar findings in the present study (sub-optical OCR: 19%, latero-optical OCR: 15%). The primary intention of our previously proposed OCR classification was based upon that a more extended OCR appears to be more visible and recognizable during endoscopic anterior skull base surgery (latero-optical > sub-optical). However, in the past years during anterior skull base surgery at our Department, we have experienced in some cases significant dehiscences in the bone covering the carotid artery in the OCR region. Dehiscences in the bony lamellas over the carotid artery and optic nerve can result to direct contact of the artery and nerve with the sphenoid sinus mucosa. This direct contact may forward sphenoid sinus inflammations intracranial and may lead to infectious meningitis, cerebral venous sinus thrombosis or optic neuritis. Moreover, dehiscences may increase the risk for spontaneous cerebrospinal fluid leaks (sCSF). Furthermore, the vulnerability of carotid artery and optic nerve may be enhanced in case of bony wall dehiscences and very thin bony lamellas covering these structures. If the surgeon is not aware of such anatomical variations, iatrogenic injury of these neurovascular structures during surgery may result in fatal consequences, i.e., severe hemorrhage or blindness [11].

According to previously conducted anatomical studies, the prevalence of dehiscences over the bony protrusions of the optic nerve and carotid artery in the OCR area ranged between 3.6% - 12% and 4 - 25%, respectively [12-14]. Contrary, CT-based studies observed carotid artery and optic nerve dehiscences in solely 0.7% and 1.5%, respectively [11]. This discrepancy might be due to the fact that is very difficult/challenging to identify dehiscences in very thin bony lamellas by CT imaging. Hence, the results of the anatomical studies might be more correct. However, in nearly all of the pre-mentioned cases at our Department with significant bony dehiscences in the OCR area, a precise post-operative evaluation of the CT scans revealed the presence of an extensive latero-optical OCR. We hypothesized that 1) the prevalence of dehiscences in the OCR area increases with enhanced extension of the OCR and 2) the thickness of the bony lamellas bordering the OCR decreases with enhanced extension of the OCR. In order to confirm our hypotheses, we evaluated these measurements in the present study according to our previously proposed OCR classification, which takes the extension of the OCR into account. We selected an anatomical study design in order to obtain adequate results. In the total study population, a bony dehiscence in the OCR area was present in 20% (40/200 sides). A carotid artery canal dehiscence was found in 18% (36/200) whereas a dehiscence in the bone covering the optic nerve was overserved in 3% (6/200). The prevalence of bony dehiscences over the carotid artery is higher in comparison to the optic nerve. This might be due to the permanent exposure to pressure caused by the pulsatile nature of the artery. Our findings are in accordance with the results of the previously published anatomical studies [12-14]. However, none of these studies considered additionally the degree of pneumatization in their analyses. We suggested that the extent of OCR pneumatization might be an influencing factor for the presence of such dehiscences, and therefore, we analyzed the frequency of bony dehiscences according to our proposed OCR subtypes: a comparison of the empirical probability of bony dehiscences between OCR types turned out highly significant ($p < 0.001$) with a large effect size ($V = 0.5$). For precise between-groups analyses, we further performed post-hoc tests with Bonferroni adjustment in order to correct for multiplicity. Samples with a latero-optical OCR showed a 35% higher prevalence of bony dehiscences than samples with a sub-optical OCR. On the other hand, individuals with sub-optical OCR showed a 25% higher frequency rate of bony dehiscences than individuals without an OCR. Both differences were highly significant ($p < 0.001$) with a moderate-to-large effect size ($\varphi = 0.3$). In other words, the risk of bony dehiscences in the OCR area rises by approximately one third from no OCR to sub-optical OCR to latero-optical OCR. Therefore, we are able to confirm our primary study hypothesis suggesting that the prevalence of dehiscences in the OCR area increases with enhanced extension of the OCR. Additionally, we further evaluated the thickness of the bone covering the carotid artery and optic nerve bordering the OCR area. Fujii et al. reported a mean thickness of the bone covering the carotid artery and optic nerve in the OCR region of 0.3 mm and 0.4 mm, respectively [(10)]. We could observe similar findings in the present study (0.25 ± 0.16 mm and 0.27 ± 0.15 mm, respectively). As a next step, we analyzed the bone thickness separately for each OCR type. The mean thickness of the bony lamellas bordering the OCR decreased with enhanced extension of the OCR (No OCR > sub-optical OCR > latero-optical OCR, see Table 2). However, if the mean difference of approximately 0.1 mm bone thickness between respective OCR types in ascending order is meaningful in a surgical way, remains debatable. Nevertheless, the bone thickness data supports the surgical significance of the bony dehiscence findings: the extent of the OCR is highly associated with a greater risk of bony dehiscences and thinner bony lamellas in the OCR region. In case of a far extended OCR, e.g., latero-optical, the surgeon should be aware of these anatomical circumstances to minimize the risk of severe intraoperative complications including disastrous hemorrhage and blindness. Besides this intra-surgical significance, our results provide also clinical value in the setting of sCSF and meningoencephaloceles. sCSF can be defined as spontaneous leakage of cerebrospinal fluid through bony dehiscences in the skull base, without any clear identifiable cause. Presence of sCSF and meningoencephaloceles has been associated with obesity and idiopathic intracranial hypertension (IIH). It is proposed that increased dural pulsations caused by the elevated intracranial pressure (ICP) may erode the underlying bone of the skull base over time and ultimately result in a bony dehiscence and dura-sheet thinning. In addition, the increased ICP may protrude brain contents with the overlying meninges through the osseus defects leading to a spontaneous meningoencephalocele. It can be assumed that individuals with pre-existing bony dehiscences and very thin bony lamellas, as in the case of an extended OCR, are at higher risk to develop sCSF and meningoencephaloceles. Patients with anterior skull base sCSF typically present unilateral watery rhinorrhea and may suffer from IIH symptoms like headache, visual defects or pulsatile tinnitus or even may have decreased ICP symptoms (e.g. orthostatic headache, neck stiffness) during active sCSF rhinorrhea. According to a recent international consensus statement, patients with clinically suspected sCSF should undergo high-resolution CT for detection of osseus defects in the skull base. Loco typico of these osseus defects are the roof of the lateral parts of sphenoid sinus and the olfactory cleft/ethmoid roof. Additional high-resolution T2-weigthed magnetic resonance imaging (MRI) with FLAIR or CISS/FIESTA protocols can help to differentiate between sCSF and mucosa inflammation/edema and between meningoencephalocele and skull base neoplasm. Moreover, MRI can identify indirect signs of concurrent IIH, like empty sella, arachnoid pits, tortuous optic nerves or dilated Meckel's cave. The presence of sCSF can further be confirmed by determining beta trace protein and/or beta2 transferrin in the nasal fluid. Nevertheless, identifying bony defects in CT may be very challenging. In cases of confirmed sCSF by beta trace protein and a lack of osseus defects in imaging, the usage of intrathecal fluorescein can be useful to localize the leak during surgery. However, if the pre-op CT reveals a highly extended OCR, e.g. latero-optical OCR, the probability of bony dehiscences in this area is remarkably high according to our anatomical study (up to 2/3). As the lateral parts of the sphenoid sinus are known to be one of the most common location of sCSF, special attention to the OCR area should be given in case of an extended OCR [(15)].

## Conclusions

The OCR is a key landmark in endoscopic anterior skull base surgery, whose presence can be readily determined pre-operatively by CT. If present, the OCR can be used to reliably identify the carotid artery and optic nerve. In the present study we validated the surgical and clinical significance of our proposed OCR classification which takes the pneumatization extent of the recess into account. The extension of the OCR is highly associated with a greater probability of bony dehiscences and thinner bone thickness in the OCR area. In case of a far extended OCR, e.g., latero-optical, the surgeon should be aware of these anatomical circumstances to minimize the risk of severe intraoperative complications and open the sphenoid sinus with instruments pointing away from these structures is even more important. Therefore, we suggest that determining the OCR type (no OCR, sub-optical OCR, latero-optical OCR) may be included in the pre-op assessment of sphenoid sinus /anterior skull base CT imaging. Moreover, patients with extended OCR may be at higher risk to develop sCSF in the OCR area. If it is very challenging to identify bony dehiscences in the pre-op CT imaging in patients with a clinically suspected sCSF, special attention to the OCR area may be given when an extended OCR is present.

## Authorship contribution

All authors have provided substantial contributions to the conception or design of the work or the interpretation of data for the work. All worked on the draft or revised it critically for important intellectual. The final version was approved for publishing by all authors. The authors agree on accountability for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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## Ethics approval and consent to participate

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## Availability of data and materials

Not applicable.

## Conflict of interest

No conflict of interest exists.

## References

1. Ozcan T, Yilmazlar S, Aker S, Korfali E. Surgical limits in transnasal approach to opticocarotid region and planum sphenoidale: an anatomic cadaveric study. World Neurosurg. 2010; 73(4): 326–333.
2. Li J, Wang J, Jing X, Zhang W, Zhang X, Qui Y. Transsphenoidal optic nerve decompression: An endoscopic anatomic study. J Craniofac Surg. 2008; 19: 1670-1674.
3. Yilmazlar S, Saraydaroglu O, Korfali E. Anatomical aspects in the transsphenoidal-transethmoidal approach to the optic canal: an anatomic-cadaveric study. J Craniomaxillofac Surg. 2012; 40: 198–205.
4. Andrianakis A, Tomazic PV, Wolf A, et al. Optico-carotid recess and anterior clinoid process pneumatization – proposal for a novel classification and unified terminology: an anatomic and radiologic study. Rhinology. 2019; 57(6): 444-450.
5. Thiel W. Die Konservierung ganzer Leichen in natürlichen Farben. Annals of Anatomy. 1992; 174: 185-195.
6. Thiel W. Ergänzung für die Konservierung ganzer Leichen nach W. Thiel. Annals Anatomy. 2002; 184: 267-269.
7. Hammer G, Radberg C. The sphenoidal sinus. An anatomical and roentgenologic study with reference to transsphenoid hypophysectomy. Acta Radiol. 1961; 56: 401–422.
8. Andrianakis A, Kiss P, Wolf A, et al. Volumetric Investigation of Sphenoid Sinus in an Elderly Population. J Craniofac Surg. 2020; 31(8): 2346-2349.
9. Van Alyea OE. Sphenoid sinus anatomic study with consideration of the clinical significance of the structural characteristics of the sphenoid sinus. Arch Otolaryng. 1941; 34: 225-253.
10. Fujii K, Chambers SM, Rhoton AL, Jr. Neurovascular relationships of the sphenoid sinus. A microsurgical study. J Neurosurg. 1979; 50: 31-39.
11. Kazkayasi M, Karadeniz Y, Osman KA. Anatomic variations of the sphenoid sinus on computed tomography. Rhinology. 2005; 43: 109–114.
12. Maniscalco JE, Habal MB. Microanatomy of the optic canal. J Neurosurg. 1978; 48: 402-406.
13. Cumberworth VL, Sudderick RM, Mackay IS. Major complications of functional endoscopic sinus surgery. Clin Otolaryngol. 1994; 19: 248-253.
14. Teatini G, Simonetti G, Salvolini U, et al. Computed tomography of the ethmoid labyrinth and adjacent structures. Ann Otol Rhinol Laryngol. 1987; 96: 239-250.
15. Georgalas C, Oostra A, Ahmed S, et al. International Consensus Statement: Spontaneous Cerebrospinal Fluid Rhinorrhea. Int Forum Allergy Rhinol. 2021; 11(4): 794-803.

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