**DOI: 10.26693/jmbs07.06.051**
**UDC 611.018.73**
***Serbin S. I.[1], Dubyna S. O.[1],***
***Bondarenko S. V.[1], Sovgyria S. M.[2],***
***Koptev M. M.[2], Pyrog-Zakaznikova A. V.[2]***

# Morphometric Characteristics of the Glands of the Mucous Membrane of All the Walls of the Human Frontal Sinus in a Norme

**[1]Donetsk National Medical University, Lyman, Ukraine**
**[2]Poltava State Medical University, Poltava, Ukraine**

*The purpose of the work* was to study the microscopic structure of the mucous membrane of all the walls of the frontal sinus of a person in order to obtain morphometric data on its structural components – glands and the submucosal base.

*Materials and methods.* The material for the study was the mucous membrane of the frontal sinus of 110 people who died at the age of 22–86 years from causes not related to the pathology of the paranasal sinuses.

*Results and discussion.* The results of the study showed that the glands in the mucous membranes of all the walls of the frontal sinus are alveolar-tubular in structure. In a morphometric study of such a structural component of the mucous membrane of all the walls of the frontal sinus, as the thickness of the submucosal base, it was shown that the thickest submucosal base is located on the inferior wall (on the left – 423.67 ± 21.33 μm; on the right – 426.45 ± 16.77 μm ($p<0.05$)) and is four times higher than the average values of thickness on the posterior wall and septum.

The outer diameter of the end sections of the glands of septum of the human frontal sinus in a morphometric study averaged 25.42 ± 1.68 μm on the left and 25.89 ± 1.38 μm on the right ($p<0.05$), that is, the smallest compared to other walls.

The values of the average diameter of the end sections of the glands of the mucous membranes of the anterior, inferior, and posterior walls of the frontal sinus probably did not differ between themselves.

*Conclusion.* From the obtained data, it can be clearly seen that the mucous membrane of the inferior wall of the frontal sinus has the greatest functional load, since it has a connection with the nasal cavity in the middle nasal passage.

The information obtained in the course of the study significantly expands knowledge about the structure of the human frontal sinus. Digital morphometric (metric) material with statistical processing confirms and complements the differences in the microstructure of the glands of the mucous membrane of the human frontal sinus in general, and separately on each wall, and in comparison with other paranasal sinuses. This is of great importance for modern otorhinolaryngology, since the glands of the mucous membranes of the paranasal sinuses are links of the mucociliary system, and such a process as mucociliary clearance depends on their quality work.

**Keywords:** human, frontal sinus, mucous membrane, glands, morphometric method.

**Introduction.** The development of the inflammatory process (frontitis) in the frontal sinus (FS) is predetermined primarily by the anatomical structure of the specified sinus [1]. Frontitis and other paranasal sinusitis can also cause complications with spread to nearby organs and tissues (phlegmon of the orbit, brain abscess, meningitis, etc.) [1, 2].

Pathological processes that occur in the FS as a result of its topography and anatomical connections with the surrounding anatomical structures most often lead to complications [3].

But not only the anatomical configuration of this sinus is important for the development of inflammatory changes in the FS, but also the features of the histological structure of its mucous membrane, first of all, of the mucociliary system – the components of which are glands [4].

Therefore, our study is appropriate and relevant today in the context of modern morphology and clinical medicine, primarily otorhinolaryngology.

**The purpose of the study** was to examine the microscopic structure of the mucous membrane of all the walls of the frontal sinus in a norme in order to obtain morphometric data on such indicators as the thickness of the submucosal base and the outer diameter of the end sections of the glands separately on each wall of the studied sinus; to identify the differences in metric data in order to get an idea of the functional load on each wall of the FS separately.

**Materials and methods.** The material for the study was the mucous membrane of the FS of 110 people who died at the age of 22–86 years from causes not related to the pathology of the paranasal sinuses.

The collection of material was carried out in the conditions of the Poltava Regional Pathological and Anatomical Bureau of the Department of Health of the Poltava Regional State Administration (DoH of PRSA) and in the conditions of the Forensic Morgue of the

Bureau of Forensic Examination of the DoH of PRSA in accordance with the cooperation agreements.

In our work, we used age periodization according to G. Craig (2000) [5].

After obtaining the mucous membranes of the FS, their fragments were fixed in a 2.5% solution of glutaraldehyde in a phosphate buffer. In the future, sealing was performed in epoxy resin "Epon-812" [6, 7, 8].

To obtain semi-thin sections, an ultramicrotome of Sumy VO "Selmi" UMTP-7 was used. The evaluation of the quality of the obtained sections was carried out using a stereoscopic microscope. For high-quality attachment of sections to the surface of a glass slide, the latter with the sections were kept for a day in a thermostat at a temperature of 45–50°C. Sections were stained using a 0.1% solution of toluidine blue and 1% methylene blue according to J. A. Lynn, or the polychrome method of staining of histological preparations [9, 10, 11].

The study of the obtained preparations was carried out with the help of a light microscope "Konus", equipped with a digital microphotography attachment Sigeta DCM-900 9.0MP with the Viorex 3 program (serial number 5604) adapted for these studies.

A MOV-16 eyepiece-micrometer was used to obtain morphometric indicators [12].

The morphometric method was used to determine the metric indicators of the outer diameters of the end sections of the glands and the thickness of the submucosal base of the mucous membrane of all the walls of the human FS.

Statistical processing of the obtained results was carried out on a personal computer with the help of Statistica 13 and Microsoft Excel 2010 software packages [13].

The work was carried out in accordance with the requirements of the "Instructions on Conducting a Forensic Examination" (order of the Ministry of Health of Ukraine No. 6 dated January 17, 1995), in accordance with the requirements and norms, standard regulation on ethics of the Ministry of Health of Ukraine No. 690 dated September 23, 2009, "The Procedure for Extracting Biological Objects from the Dead, whose Bodies are Subject to Forensic Examination and Pathological-Anatomical Research, for Scientific Purposes" (2018).

**Results and discussion.** In a morphometric study of the mucous membrane of the anterior wall of the FS, it was established that the thickness of its submucosal base did not differ statistically reliably on the left and right and was equal to 299.65 ± 14.63 μm and 302.34 ± 12.98 μm, respectively (**Table 1**).

We examined the identified glands in the submucosal base using the morphometric method – we determined the outer diameters of the end sections. The average values of the outer diameter of the end sections of the glands of the anterior wall of the human FS were 29.85 ± 3.04 μm on the left and 29.84 ± 2.47 μm on the right. No significant differences in the sizes of the end sections were found (**Table 1**).

The indicator of the average thickness of the submucosal base of the inferior wall did not differ statistically reliably on the left and right and was equal to 423.67 ± 21.33 μm and 426.45 ± 16.77 μm, respectively (**Table 1**). Compared to the indicator for the anterior wall, it was 25% higher (**Table 1**).

The average values of the outer diameter of the end sections of the glands of the inferior wall of the human FS were 30.42 ± 2.36 μm on the left and 31.01 ± 1.34 μm on the right (**Table 1**).

**Table 1** – The ratio of the morphometric parameters of the thickness of the submucosal base and the outer diameter of the end sections of the glands of all the walls of the human frontal sinus in a norme, μm

| Indicator | Anterior wall | | Inferior wall | | Poterior wall | | Septum | |
|---|---|---|---|---|---|---|---|---|
| | on the left (n=10) | on the right (n=10) | on the left (n=10) | on the right (n=10) | on the left (n=10) | on the right (n=10) | on the left (n=10) | on the right (n=10) |
| Thickness of the submucosal base | 299.65± ±14.63 | 302.34± ±12.98 | 423.67± ±21.33 * | 426.45± ±16.77 * | 111.17± ±9.77 *, ** | 115.47± ±6.48 *, ** | 127.17± ±8.48 *, ** | 124.93± ±7.89 *, ** |
| Outer diameter of the end sections of the glands | 29.85± ±3.04 | 29.84± ±2.47 | 30.42± ±2.36 | 31.01± ±1.34 | 29.77± ±2.07 | 30.17± ±2.25 | 25.42± ±1.68 *, **, *** | 25.89± ±1.38 *, **, *** |
| ***Note:*** hereinafter – ∞ – $p < 0.05$ compared to the indicators for the opposite side. | | | ***Note:*** * – $p < 0.05$ compared to the values for the anterior wall. | | ***Notes:*** * – $p < 0.05$ compared to the values for the anterior wall; ** – $p < 0.05$ compared to the values for the inferior wall. | | ***Notes:*** * – $p < 0.05$ compared to the values for the anterior wall; ** – $p < 0.05$ compared to the values for the inferior wall; *** – $p < 0.05$ compared to the values for the posterior wall. | |

The indicator of the average thickness of the submucosal base of the posterior wall did not statistically reliably differ on the left and right and was equal to 111.17 ± 9.77 μm and 115.47 ± 6.48 μm, respectively (**Table 1**).

Compared with the indicator for the anterior and inferior walls, the obtained morphometric data were 63% and 74% lower, respectively (**Table 1**).

In a morphometric study of the outer diameter of the end sections of the glands of the posterior wall of the human FS, we found that the average values were 29.77 ± 2.07 μm on the left and 30.17 ± 2.25 μm on the right (**Table 1**). We did not reveal any significant differences with the indicators of the sizes of the end sections of the glands for the anterior and inferior walls of the FS (**Table 1**).

The values of the average thickness of the submucosal base of the septum did not differ statistically reliably on the left and right and were equal to 127.33 ± 8.48 μm and 124.93 ± 7.89 μm, respectively (**Table 1**).

Compared to the indicator for the anterior and inferior walls, the obtained metric data were 58% and 70% lower, respectively (**Table 1**). The parameter did not differ significantly from the values of the thickness of the submucosal base of the posterior wall (**Table 1**).

The outer diameter of the end sections of the glands of the septum of the human FS in a morphometric study averaged 25.42 ± 1.68 μm on the left and 25.89 ± 1.38 μm on the right (**Table 1**).

When comparing the metric data with the above-described walls of the FS, we established negative significant differences with the corresponding indicators (**Table 1**).

In our study, it was shown that the studied glands are complex alveolar-tubular in structure and consist of a system of excretory ducts with end sections (**Fig. 1**).

The information obtained in the course of the study significantly expands knowledge about the structure of the human frontal sinus [4]. From the obtained data, it can be clearly seen that the mucous membrane of the inferior wall of the frontal sinus has the greatest functional load, since it has a connection with the nasal cavity in the middle nasal passage [3].

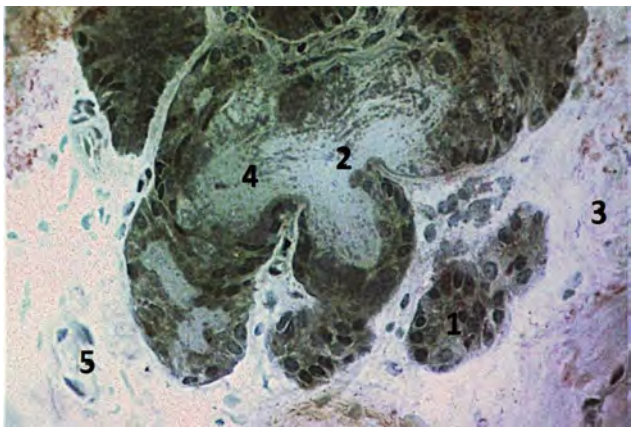


**Fig. 1** – Excretory ducts of the serous glands of the anterior wall of the human frontal sinus. Semi-thin cut. Staining with polychrome dye: Eyepiece $10^x$, Lens $40^x$:

***Notes:*** 1 – end sections; 2 – lumen of the duct; 3 – loose connective tissue of the submucosal base; 4 – secret in the lumen of the duct; 5 – blood vessels

**Conclusion.** Digital morphometric (metric) material with statistical processing confirms and complements the differences in the microstructure of the glands of the mucous membrane of the human frontal sinus in general, and separately on each wall, and in comparison with other paranasal sinuses. This is of great importance for modern otorhinolaryngology, since the glands of the mucous membranes of the paranasal sinuses are links of the mucociliary system, and such a process as mucociliary clearance depends on their quality work.

**Perspectives of further research.** To investigate at the electron microscopic level the relationship between the glands of the mucous membrane of all the walls of the frontal sinus with superficial blood vessels – arteries and veins, and links of the hemomicrocirculatory channel – arterioles, capillaries and venules.

## References

1. Sommer F, Hoffmann TK, Harter L, Döscher J, Kleiner S, Lindemann J, et al. Incidence of anatomical variations according to the International Frontal Sinus Anatomy Classification (IFAC) and their coincidence with radiological sings of opacification. *Eur Arch Otorhinolaryngol*. 2019 Nov;276(11):3139–3146. PMID: 31471655. doi: 10.1007/s00405-019-05612-4
2. Ziegler A, Patadia M, Stankiewicz J. Neurological Complications of Acute and Chronic Sinusitis. *Curr Neurol Neurosci Rep*. 2018 Feb;5;18(2):5. PMID: 29404826. doi: 10.1007/s11910-018-0816-8
3. Alekseeva V. Anatomical predictions of development of rhinosinusitis and its complications. *Inter Collegas*. 2020;7(3):125–30. doi: 10.35339/ic.7.3.125-130
4. Serbin SI, Yeroshenko HA, Svintsyts'ka NL, Sovhyrya SM, Vynnyk NI. *Histo-topohrafichni osoblyvosti lobovoyi pazukhy lyudyny v normi* [Histo-topographic features of the frontal sinus of a normal person]. Monohraf. Poltava; 2019. 118 s. [Ukranian]
5. Malkina-Pykh IG. Growing up in the crisis of adulthood: Handbook of a practical psychologist. 2005.416 s.

6. Belokon' SA, Vitko YuN, Tkachenko PI, Starchenko II, Hryn VH. Optimization of the study of structural elements of biological tissues on histotopographic sections. *Molodyi uchenyi*. 2014;15(74):134–7.
7. *Patent 112472 Ukraine*, MPK A61B 1/00, H01L 33/56 (2010.01). Sposib kompleksnoho morfolohichnoho doslidzhennya chervopodibnykh vidrostkiv lyudyny v epoksydniy smoli «Epon-812» [The method of complex morphological research of human worm-like appendages in epoxy resin "Epon-812] / Hryn VH, Sherstyuk OO, Starchenko II, Pryluts'kyy OK. (UA); zayavnik i vlasnik patentu VDNZU UMSA (UA). № u201512516; zayavl 18.12.15 ; opubl 26.12.16. Byul № 24/2016. [Ukranian]
8. Kostilenko YuP, Boyko IV, Starchenko II. The method of making histological preparations, equivalent to half-thickness sections of a large viewing surface, for multi-purpose morphological studies. *Morfolohiya.* 2007;5:94–6.
9. Lynn J. Rapid toluidine blue staning of Epon-embeded and mounted «adjacent» sections. *Am J Clin Path*. 1965;44:57–58. PMID: 14314220. doi: 10.1093/ajcp/44.1.57
10. *Patent 75669 Ukraine*, MPK G01N 1/30. Sposib zabarvlennya napivtonkykh zriziv [The method of staining semithin sections] / Shepit'ko VI, Yeroshenko HA, Yakushko OS. (UA); zayavnik i vlasnik patentu Shepit'ko VI, Yeroshenko HA, Yakushko OS. (UA). № u201206261; zayavl 24.05.12 ; opubl 10.12.12. Byul № 23/2012. [Ukranian]
11. Yakushko OS, Shepit'ko VI, Yeroshenko HA. Polikhromnyy sposib zabarvlennya histolohichnykh preparative [Polychrome method of staining histological preparations]. *Svit medytsyny ta biolohiyi*. 2013;3(39):61–64. [Ukranian]
12. Avtandilov GG. *Medical morphometry*. 1990. 384 s.
13. Tanavalee C, Luksanapruksa P, Singhatanadgige W. Limitations of Using Microsoft Excel Version 2016 (MS Excel 2016) for Statistical Analysis for Medical Research. *Clin Spine Surg*. 2016;29(5):203–4. PMID: 27135620. doi: 10.1097/BSD.0000000000000382

**УДК** 611.018.73

## МОРФОМЕТРИЧНА ХАРАКТЕРИСТИКА ЗАЛОЗ СЛИЗОВОЇ ОБОЛОНКИ УСІХ СТІНОК ЛОБОВОЇ ПАЗУХИ ЛЮДИНИ У НОРМІ

***Сербін С. І., Дубина С. О., Бондаренко С. В., Совгиря С. М., Коптев М. М., Пирог-Заказнікова А. В.***

**Резюме.** *Метою* даного дослідження було отримання метричних даних – середнього діаметру кінцевих відділів залоз та середньої товщини підслизової основи слизової оболонки усіх стінок лобової пазухи людини у нормі.

*Матеріал і методи.* Дослідження було виконано з використанням трупного матеріалу, отриманого при патологоанатомічному розтині 110 людей обох статей, віком від 22 до 86 років, які померли від причин не пов'язаних з патологією приносових пазух, згідно з міжнародними нормами проведення біологічних досліджень.

У даному дослідженні застосовувалися апробовані методики, та використання методу забарвлювання гістологічних препаратів напівтонких зрізів поліхромним барвником.

*Результати* дослідження показали, що вивчаємі залози за будовою являють собою складні альвеолярно-трубчасті залози, та складаються з системи вивідних проток з кінцевими відділами.

За допомогою морфометричного методу було показано, що товщина підслизової основи у складі слизової оболонки лобової пазухи найбільша на нижній стінці (зліва – 423,67±21,33 мкм; справа – 426,45±16,77 мкм ($p<0,05$)), що у чотири рази перевищує аналогічні середні значення товщини на задній стінці і перегородці.

При визначенні середнього діаметру кінцевих відділів залоз було встановлено, що найбільший був на нижній стінці (зліва – 30,42±2,36 мкм; справа 31,01±1,34 мкм ($p<0,05$)), що на 20% більші за аналогічний найменший показник на перегородці.

Середній діаметр кінцевих відділів залоз у складі слизової оболонки передньої, нижньої та задньої стінок лобової пазухи вірогідно не відрізнявся. З точки зору функціонального навантаження – найбільш затребувана слизова оболонка нижньої стінки.

*Висновки.* Цифровий морфометричний (метричний) матеріал зі статистичною обробкою підтверджує і доповнює відмінності у мікроструктурі залоз слизової оболонки лобової пазухи людини як в цілому, так і окремо на кожній стінці, і у порівнянні з іншими приносовими синусами. Отримані метричні показники можливо використовувати для порівняння з показниками патологічно зміненої слизової оболонки лобової пазухи.

**Ключові слова:** людина, лобова пазуха, слизова оболонка, залози, морфометричний метод.

**ORCID and contributionship:**
Serhiy I. Serbin : 0000-0003-4162-9377 A,B,D,F
Serhiy O. Dubyna : 0000-0003-0721-0855 C,E
Stanislav V. Bondarenko : 0000-0002-6554-0724 B,D
Svitlana M. Sovhyrya : 0000-0002-9418-9152 B,C
Mykhaylo M. Koptev : 0000-0002-3726-8911 D,F
Anhelina V. Pyroh-Zakaznikova : 0000-0001-9070-1588 D,E

A – Work concept and design, B – Data collection and analysis,
C – Responsibility for statistical analysis, D – Writing the article,
E – Critical review, F – Final approval of the article

**CORRESPONDING AUTHOR**
**Serhiy I. Serbin**
Donetsk National Medical University,
Department of Human Anatomy
27, Pryvokzalna Str., Lyman 84404, Ukraine
tel: +380508572012, e-mail: tachserg@i.ua

*The authors of this study confirm that the research and publication of the results were not associated with any conflicts regarding commercial or financial relations, relations with organizations and/or individuals who may have been related to the study, and interrelations of coauthors of the article.*

Стаття надійшла 05.10.2022 р.
*Рекомендована до друку на засіданні редакційної колегії після рецензування*