EVALUATION OF THE STRUCTURE OF THE WALLS OF THE FRONTAL SINUS USING SPIRAL COMPUTED TOMOGRAPHY

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https://doi.org/10.35339/ic.7.2.76–80

Abstract

Introduction. The anatomical structure of the frontal sinus is of key importance for development of its inflammation as well as the complications with the spread to the adjacent organs and tissues (orbital phlegmon, brain abscesses, meningitis). The aim of our study was to compare the density and thickness of the bone tissue of the unchanged frontal sinus in various forms of chronic inflammation. **Materials and methods.** The study involved 121 patients with various forms of chronic frontal sinusitis: 56 with chronic hyperplastic (mucosal hyperplasia (up to 6 mm) and 33 patients with chronic purulent-polypous frontal sinusitis, manifested by a total and subtotal decrease in sinus pneumatization according to spiral computed tomography (SCT). 32 SCT samples were selected to form a comparison group without any abnormalities of the paranasal sinuses. **Results.** The maximum density typical for the lower wall of the frontal sinus under physiological conditions was found to be 107.96 ± 201.64HU, the minimum for the posterior wall in purulent-polypous frontal sinusitis was -103.74 ± 195.37HU.

The bone thickness both in the posterior region and in the region practically did not depend on the degree of the severity of pathological changes in it and was 1.0006 ± 0.538 mm, 0.91 ± 0.26 mm, 0.82 ± 0.169 mm under physiological conditions, with mucosal hyperplasia and with purulent-polypous frontal sinusitis in the posterior wall, respectively. In the region of the lower wall, 4.05 ± 2.04 mm, 2.32 ± 1.16 mm, and 4.002 ± 1.16 mm, respectively.

Conclusion. It can be assumed that the larger the change in PNSs, the lower the bone density. This in turn affects the prediction of possible complications during surgical treatment of chronic frontal sinusitis.

Key words: *frontal sinus, computed tomography, bone thickness, bone density.*

Introduction

The anatomical structure of the frontal sinus is of key importance for development of its inflammation and the complications with the spread to the adjacent organs and tissues (orbital phlegmon, brain abscesses, meningitis) [1]. It is the pathological processes that occur in the frontal sinus due to its topographic and anatomical relationships with nearby structures that most often lead to complications [2]. Their greatest occurrence occurs in chronic frontal sinusitis, because it is associated with bone changes in the sinus walls: bone demineralization, disappearance of trabeculae, cortical destruction, focal sclerosis [3]. These changes are manifested as a decrease in bone density, as shown by Dong et al. [4]. In addition to density, destructive processes often lead to a change in the thickness by the Global Osteitis Scale, in which the degree of destruction is associated with a decrease in the bone thickness [5]. These changes can correlate with severity of the disease, which must be taken into account when planning surgery for the maxillary sinuses and predicting possible complications [6].

2. Purposes, subjects and methods:

2.1. Purpose of our study was to compare the density and thickness of the bone tissue of the unchanged frontal sinus and in various forms of chronic inflammation.

2.2. Subjects & Methods

The study was performed within the framework of the planned complex research work of Kharkiv

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National Medical University "Morphological features of organs and systems of the human body at the stages of ontogenesis", state registration number 0144U004149.

The study involved 121 patients with various forms of chronic frontal sinusitis: 56 with chronic hyperplastic (mucosal hyperplasia (up to 6 mm) and 33 patients with chronic purulent-polypous frontal sinusitis, manifested by a total and subtotal decrease in sinus pneumatization according to the findings of spiral computed tomography (SCT). The patients were selected with the same distribution by gender and age. The age of the subjects was 25 to 60 years. 32 SCT samples were selected to form a comparison group of people aged 25–60 without any abnormalities of the paranasal sinuses (see *Fig. 1*).

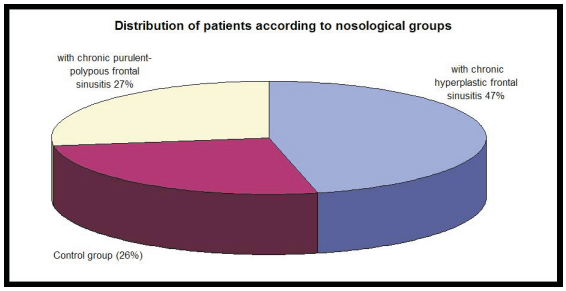


Fig. 1. Distribution of the patients according to nosological groups

This group of subjects underwent SCT examination due to conditions not related to ENT diseases. The article complies with the requirements of the Declaration of Helsinki. All patients were informed of their participation in the study and written informed consent to participate in the study was obtained. The study was approved by the Bioethics Committee of Kharkiv National Medical University.

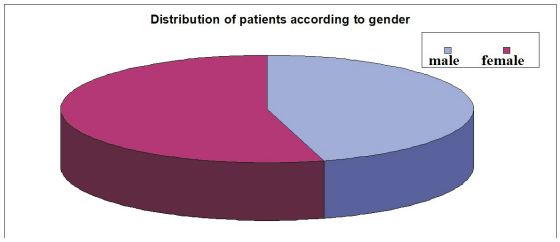


Fig. 2. Distribution of the patients according to gender

All patients underwent a generally accepted clinical examination according to the order of the Ministry of Health No. 181 dated 24.03.2009 "On the approval of medical care protocols in the otolaryngology". The Hounsfield scale [7] was used to evaluate bone density in SCT study, given that according to M. Hofer [8] modern devices are able to cover 4096 shades of gray scale, which represent different density levels in Hounsfield units (HU) (water density is taken as 0 HU, and air as 1000 HU). The calculation of the thickness was carried out in the thinnest section of the wall (see *Fig. 4*).

The obtained digital data were statistically processed using Student-Fisher method, the average value for each variation series (X), standard deviation, and the mean error (m) were determined. Statistical processing was carried out on a personal computer using Microsoft Office Excel 2010 software (USA). The results were considered statistically significant at $p < 0.05$.

Declaration

There is no conflict of interests. We certificate that we do not have any financial or personal relationships that might bias the content of this work.

3. Results & Discussion

The results of determining the thickness and density of bone tissue (HU) in SCT study using the Hounsfield scale are presented in *Tables 1–2*.

In the course of the study, the minimum thickness and density of the posterior of the frontal sinus were determined under physiological conditions and with varying degrees of severity of pathological changes in the sinus. The maximum density typical for the lower wall of the frontal sinus under physiological conditions and was found to be 107.96 ± 201.64HU, the minimum for the posterior wall in purulent-polypous frontal sinusitis was –103.74 ± 195.37HU.

The bone thickness both in the posterior region and in the region practically did not depend on the degree of the severity of pathological changes in it and was 1.0006 ± 0.538mm, 0.91 ± 0.26 mm, 0.82 ± 0.169 mm under physiological conditions, with mucosal hyperplasia and with purulent-polypous frontal sinusitis in the posterior wall, respectively. In the region of the lower wall, it was 4.05 ± 2.04 mm, 2.32 ± 1.16 mm, and 4.002 ± 1.16 mm, respectively.

In all cases the posterior wall was found to be much thinner than the lower, creating the conditions for the spread of purulent-inflammatory processes with the development of intracranial complications. The thickness of the lower wall (4.05 ± 2.04 mm) was shown to be 22.2% higher than the posterior (1.006 ± 0.538 mm) under physiological conditions (see *Fig. 3* A and B). Based on this, it can be assumed that chronic frontal sinusitis creates more favorable conditions

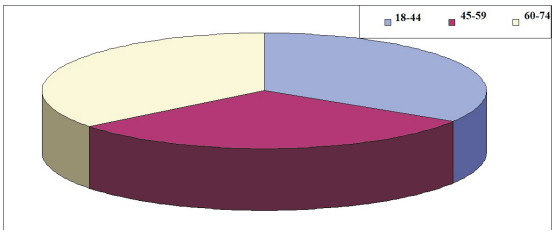


Fig. 3. Distribution of the patients according to the age

of maxillary sinuses, on the contrary, intraorbital complications may prevail over intracranial complications [10].

The study was performed using the findings of spiral computed tomography (SCT), which is a simple, informative, and generally accessible intravital method for determining bone density [11], used to identify the sizes and shape of the frontal sinus, distinguished by large individual and

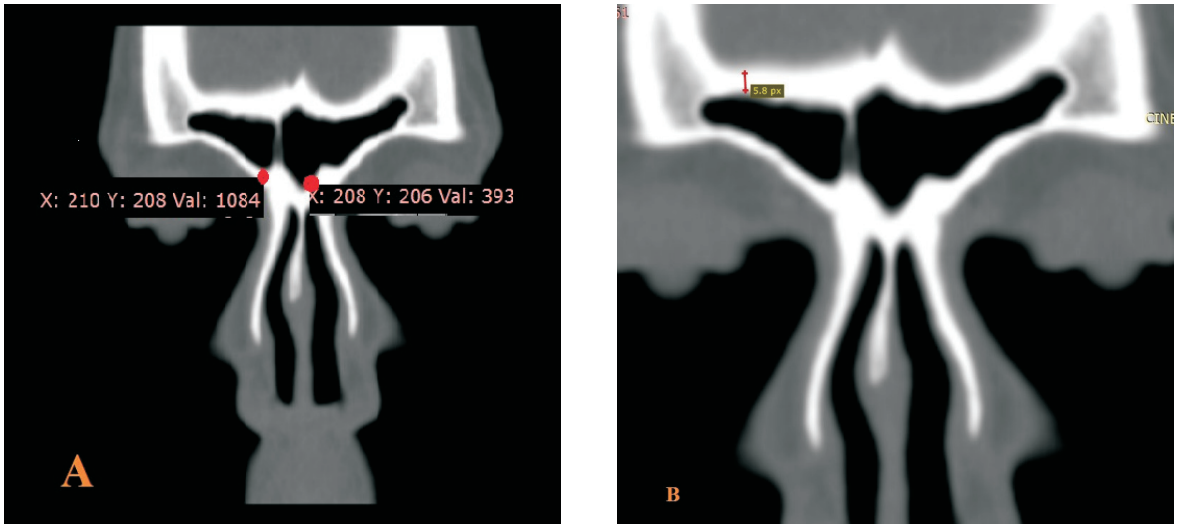


Fig. 4. An example of measuring bone density (A) and thickness. SCT, coronary reconstruction

Table 1

Density (HU) and thickness (mm) of the lower wall of the frontal sinus

Indicator	Without abnormalities		Parietal hyperplastic frontal sinusitis		Purulent polypous frontal sinusitis	
	Thickness	Density	Thickness	Density	Thickness	Density
M	4.05	107.96	4.002	2.68	2.32	-56.33
σ	2.04	201.64	2.07	160.88	1.16	78.51

Table 2

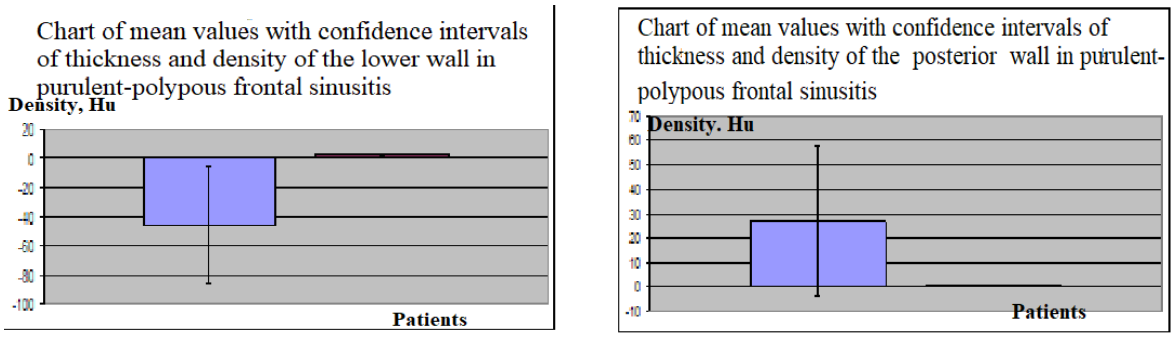
Density (HU) and thickness (mm) of the posterior wall of the frontal sinus

Indicator	Without abnormalities		Parietal hyperplastic frontal sinusitis		Purulent polypous frontal sinusitis	
	Thickness	Density	Thickness	Density	Thickness	Density
M	1.0006	27.42	0.82	-30. 29	0.91	-103.74
σ	0.538	168.76	0.169	202.4	0.26	195.37

for the spread of the inflammatory process intracranially than intraorbitally [9]. In addition, the likelihood of complications increased due to the lower density in the region of the posterior wall than the lower. Thus, the density of the posterior wall even under physiological conditions (27.42 ± 168.76 HU) was 25.4% lower than that of the lower one (107.96 ± 201.64 HU). In case

age-related variability [12]. SCT study helps to determine not only the main morphological aspects of the bone structure, but also to measure its density [13].

The study implied assessment of axial sections and coronary reconstructions. The thickness and density in the region of the lower (orbital) wall were calculated as the most significant in terms



A B

Fig. 5. Chart of mean values with confidence intervals of thickness and density of the lower (A) and posterior (B) walls in purulent-polypous frontal sinusitis

of the development of intraorbital complications [11], the posterior (cerebral) wall of the frontal sinus was studied, since it is of the greatest importance for endoscopic interventions [13]. There are data about changes of bone density depending of menopause [14].

As can be seen from *Tables 1* and *2*, bone thickness was a fairly constant indicator, less than the density changes under the influence of inflammatory changes in the sinus. Therefore, in assessing the degree of destructive changes in the sinus walls, we should rely more on density indicators [6, 15, 16]. In addition, both walls (both the lower and the posterior) were found to respond to the inflammatory process by decreasing the density, and it was most pronounced with the maximum degree of severity of the inflammatory process in the sinus, which was associated with the development of purulent-polypous frontal sinusitis. Thus, bone density depended on the severity of changes in the PNSs, since in the presence of a cyst it was maximal and slightly different from that normal. In purulent polypous process, it was minimal.

Conclusions

1. Our findings demonstrate that SCT can determine the minimum density and thickness of the lower and posterior walls of the frontal sinus under physiological conditions and with varying degrees of severity of inflammatory changes in it.

2. The posterior wall is the thinnest among all PNSs in all the studied groups. In addition, it has minimum density, which creates the conditions for the spread of purulent-inflammatory process in the skull.

3. It can be assumed that the larger the changes in PNSs, the lower the bone density. This, in turn, affects the prediction of possible complications during surgical treatment of chronic frontal sinusitis.

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Received: 07-Feb-2020
Accepted: 23-Jun-2020