

Features of the morphological state of bone tissue of the lower wall of the maxillary sinus with the use of fixed orthodontic appliances

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The aim of the study was to identify the consequences of the use of fixed orthodontic appliances (FOAs) on the morphological state of the tissues of the lower wall of the maxillary sinus, depending on the duration of their use.

Materials and methods. The study involved 115 male and female patients aged 18 to 25 years. All patients were divided into 2 research groups depending on the period of wearing brace systems. The control group consisted of patients who did not require orthodontic treatment orthodontic appliances. The density and thickness of the lower wall of the maxillary sinus were calculated in all groups.

Results. In the control group, the average minimum thickness of the lower wall of the maxillary sinus was 4.6±1.5 mm, the minimum density was 13.46±132.6 Hu, in prolonged wearing of FOAs (from 2 to 3 years) these indicators were: 4.96±1.22 mm and -160±187.4 Hu, respectively. In less severe malocclusion in people with a period of FOAs wearing from 1 to 1.5 years, these indicators were 5.03±1.06 mm and -80.98±167.7 Hu. When measuring the density after one year, it increased and amounted to 25.6±184.4 Hu in wearing FOAs up to 1.5 years and 105.47±173.84 Hu in prolonged wearing of brace systems.

Conclusions. It can be assumed that wearing of braces affects the morphological state of not only the enamel of the teeth, but also of the surrounding tissues, and this effect is more intense in prolonged wearing of FOAs.

Key words: fixed orthodontic appliances, bone density, bone thickness, spiral computed tomography

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Konsekwencje stosowania stałego aparatu ortodontycznego na stan morfologiczny tkanki kostnej dolnej ściany zatoki szczękowej

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Celem pracy była ocena wpływu stosowania stałego aparatu ortodontycznego (SAO) na stan morfologiczny tkanek dolnej ściany zatoki szczękowej w zależności od czasu ich stosowania.

Materiały i metody. Badaniem objęto 115 chorych płci męskiej i żeńskiej w wieku od 18 do 25 lat. Wszyscy zostali podzieleni na 2 grupy badawcze w zależności od czasu noszenia SAO. Grupa kontrolna składała się z chorych, którzy nie posiadali aparatów ortodontycznych. We wszystkich badanych grupach obliczono gęstość i grubość dolnej ściany zatoki szczękowej.

Wyniki. Stwierdzono, że w grupie kontrolnej średnia minimalna grubość dolnej ściany zatoki szczękowej wynosi 4,6±1,5 mm, minimalna gęstość wynosi 13,46±132,6 Hu, przy dłuższym zużyciu SAO (od 2 do 3 lat) wskaźniki te są: 4,96±1,22 mm i -160±187,4 Hu odpowiednio. Przy mniej wyrażonych naruszeniach ugryzienia u osób z terminem noszenia SAO od 1 do 1,5 roku podane wskaźniki wyniosły 5,03±1,06 mm oraz -80,98±167,7 Hu. Przy pomiarze gęstości po jednym roku wzrosła i osiągnęła -25,6±184,4 Hu przy noszeniu SAO do 1,5 roku oraz -105,47±173,84 Hu przy długim noszeniu aparatów ortodontycznych.

Wnioski. Wykazano, że noszenie SAO wpływa nie tylko na twarde tkanki zębów, ale także na otaczające je tkanki, przy czym siła oddziaływania bezpośrednio zależy od czasu noszenia SAO.

Słowa kluczowe: stały aparat ortodontyczny, gęstość kości, grubość kości, spiralna tomografia komputerowa

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The use of fixed orthodontic appliances (FOAs) is by far one of the most effective and progressive methods for correcting congenital or acquired anomalies in the development of the dentofacial system, which significantly improves the prognosis for this group of diseases and eliminates cosmetic defects and the arrangement of teeth in their physiological state [4,18]. At the same time, this treatment method is associated with a number of complications both in the oral cavity and in the surrounding tissues. First of all, the use of non-removable equipment is associated with enamel damage [1,8]. Long-term ischemia of surrounding tissues, which inevitably occurs when using the brace system, leads to pathological changes in neighbo-

ring organs and tissues, which are manifested by destructive changes, including bone tissue [20,11].

Informative diagnosis of the state of the dentofacial system, assessment of the functional state and anatomical structure of surrounding tissues requires the employment of computed tomography. In dental practice, at the stage of examining patients, computed tomography provides instant, accurate, intravital three-dimensional image of teeth, determining the thickness and density of anatomical formations, and identifying pathological processes [13,5,19].

In connection with the above, the purpose of our study was to identify the consequences of the use of FOAs on the morpho-

logical state of the tissues of the lower wall of the maxillary sinus, depending on the duration of their use.

MATERIALS AND METHODS

The study was conducted on the basis of Dnipro Medical Academy and Novomoskovsk City Dental Clinic of the Dnipropetrovsk Regional Council in 2015-2019. The study involved 115 female and male patients aged 18 to 25 years (tab.1).

Table 1. Distribution of patients according to gender
Tabela 1. Charakterystyka chorych według płci

| Gender | Groups of patients | | |
|---------|--------------------|------------------------------------|----------------------------------|
| | Control group | Wearing braces from 1.5 to 2 years | Wearing braces from 2 to 3 years |
| Males | 17 | 20 | 18 |
| Females | 19 | 19 | 22 |
| Total | 36 | 39 | 40 |

All patients were divided into 3 groups. The first group included patients with severe malocclusion. The period of wearing brace systems in this case was from 2 to 3 years. In this group, the index of need for orthodontic treatment (IOTN) corresponded to level 4, 5. The second study group included patients with less severe changes in the occlusion, the IOTN

was initially dangerous in terms of the development of complications with the spread of the inflammatory process to surrounding tissues. The density varied along the lower wall of the sinus, as close as possible to its cavity (fig. 1).

It should be noted that the study was conducted immediately after removal of the brace systems (no later than one month after this procedure) and one year after the procedure for their removal to determine the prolonged action of FOAs on tissue. Preference was given to metallic vestibular ligature brace systems. The criterion for exclusion from the study was the presence of any pathological changes in the paranasal sinuses of an inflammatory or other nature (cysts, benign or malignant neoplasms). In all the studied groups, bone density and thickness of the lower wall of the maxillary sinus were calculated. Emphasis was placed on the minimum thickness, as a potentially dangerous indicator for the possible adverse effects of the use of FOAs. Also, the minimum density was determined on all studied sections. The density was determined using the Hounsfield scale, given that the density of water is 0 Hu, air – 1000 Hu. Coronary reconstruction of CT scans of patients was studied [10].

The obtained digital data were statistically processed. Correspondence of the distribution to normal was determined by the *Shapiro-Wilk's* test. The *Student-Fischer* test was used to determine the average value for each variation series (X) and the standard deviation (SX). Statistical processing was carried out on a personal computer using Microsoft Office Excel 2010 (USA). The results were considered statistically significant at $p < 0.05$.

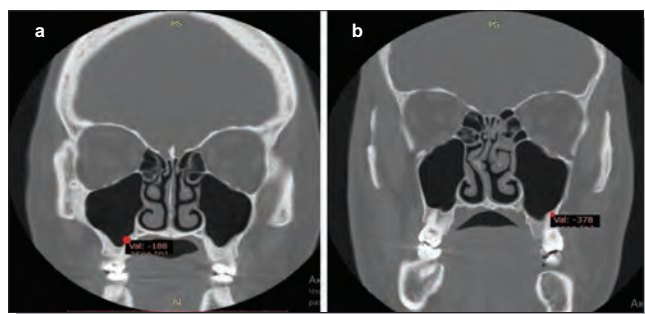


Figure 1. Measurement of bone density of the lower wall of the maxillary sinus after wearing braces (a) and in the control group (b). Coronary reconstruction

Rycina 1. Pomiar gęstości kości dolnej ściany zatoki szczękowej po założeniu aparatów ortodontycznych (a) oraz w grupie kontrolnej (b). Odbudowa wieńcowa

RESULTS

The results of the studies are presented in tables 2 and 3.

The study showed that in the control group, the average minimum thickness of the lower wall of the maxillary sinus was 4.6 ± 1.5 mm, the minimum density was 13.46 ± 132.6 Hu (tab.3), in prolonged wearing of FOAs (from 2 to 3 years) these indicators were: 4.96 ± 1.22 mm and -160 ± 187.4 Hu, respectively (tab.2). In less severe malocclusion in people with a period of FOAs wearing from 1 to 1.5 years, these indicators were 5.03 ± 1.06 mm and -80.98 ± 167.7 Hu. When measuring the density after one year, it increased and amounted to 25.6 ± 184.4 Hu in wearing FOAs up to 1.5 years and 105.47 ± 173.84 Hu in prolonged wearing of brace systems.

It was also revealed that after measuring bone density after 1 year, this indicator significantly increased in both groups studied ($p = 0.04$ and 0.028 , respectively, in long-term and short-term wearing of braces) (fig. 2 and 3).

Table 2. Thickness and density of bone tissue of the lower wall of the maxillary sinus when wearing FOAs
Tabela 2. Grubość i gęstość tkanki kostnej dolnej ściany zatoki szczękowej podczas noszenia FOA

| Indicator | | After FOAs removal | | In 1 year after FOAs removal | |
|----------------------------------|----------------|--------------------|-------|------------------------------|--------|
| | | X | Sx | X | Sx |
| Wearing FOAs from 1 to 1.5 years | Thickness (mm) | 5.03 | 1.06 | 4.98 | 0.99 |
| | Density (Hu) | -80.98 | 167.7 | -25.6 | 184.4 |
| Wearing FOAs from 2 to 3 years | Thickness (mm) | 4.96 | 1.22 | 4.95 | 1.2 |
| | Density (Hu) | -160.65 | 187.4 | -105.47 | 173.84 |

index corresponding to level 2-3 and the period of wearing brace systems from 1.5 years to 2 years. CT examination was recommended for all patients. The control group consisted of patients who did not require orthodontic treatment, and a CT study was performed due to a reason not related to abnormalities of the teeth and jaw system. The study was conducted on a Toshiba Aquilion-4 CT scanner. Attention was paid to the minimum indicators of bone density and thickness, as poten-

Table 3. Thickness and density of bone tissue of the lower wall of the maxillary sinus in the control group

Tabela 3. Grubość i gęstość tkanki kostnej dolnej ściany zatoki szczękowej w grupie kontrolnej

| Indicator | Thickness (mm) | Density (Hu) |
|-----------|----------------|--------------|
| X | 4.6 | 13.46 |
| Sx | 1.5 | 132.6 |



Figure 2. Diagram of average values of bone density of the lower wall of the maxillary sinus with confidence intervals in prolonged wearing of FOAs
Rycina 2. Schemat średnich wartości gęstości kości dolnej ściany zatoki szczękowej z przedziałami ufności przy przedłużonym zużyciu FOA

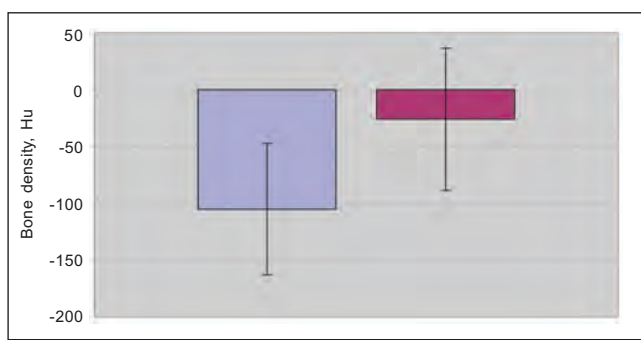


Figure 3. Diagram of average bone density of the lower wall of the maxillary sinus with confidence intervals in wearing FOAs up to 1.5 years
Rycina 3. Schemat średniej gęstości kości dolnej ściany zatoki szczękowej z przedziałami ufności w noszeniu FOA do 1,5 roku

DISCUSSION

To date, it is reliably known that wearing FOAs affects the degree of mineralization of tooth enamel [18]. This study also shows the degree of influence of FOAs on the surrounding tissue, in particular on the structure of the lower wall of the maxillary sinus. In addition, the study is representative not only of the condition of the lower wall 1 month after removal of the brace systems, but also in terms of the long-term effects of the use of FOAs.

As a result of the study, it can be affirmed about the relationship between the duration of wearing braces and changes in bone microarchitectonics, visualized during a CT scan, which is manifested by a decrease in its density. This parameter is of exceptional importance in dentistry, otolaryngology, maxillofacial surgery, as it is key in the development of pathological processes in this area [16,17]. Moreover, the assessment of density can be used to prevent the development of odontogenic iatrogenic inflammatory processes in the maxillary sinus by selecting the correct load during dental implantation [12]. Therefore, based on the results of the study, dentists need to be especially careful with patients who have used braces to correct their bite, since this method of treatment can lead to impaired bone mineralization of not only enamel, but also the alveolar process of the lower jaw, thereby making the lower wall more fragile, subject to additional trauma [6]. The mechanism of the development of these changes in the bone is not fully understood, however, it can be assumed that the leading link for the development of these pathological processes is long-term tissue ischemia, leading to hypoxia and, as a consequence, a violation of the mineralization of bone tissue, enamel, which in turn leads to a decrease in density. The question of the development of pathological processes in the surrounding tissues, in particular the oral mucosa with the subsequent attachment of a secondary infection and the development of stomatitis and gingivitis, remains quite debatable [14,21]. Nevertheless, significant changes can be assumed from nearby organs and tissues,

in particular bone tissue of the lower wall of the maxillary sinus. As can be seen from the tables, it is bone density that maximally responds to the use of FOAs. The bone thickness in all cases is a fairly stable indicator and does not change when wearing braces of different durations.

Given that the density in a shorter period of wearing FOAs decreases less than in a longer one, it can be assumed that dentists when installing brace systems should prefer to use them for shorter periods.

Being such an extremely significant parameter, density is at the same time a rather variable indicator. It depends on age, sex [7]. So, today there are studies showing its change in people of different gender and age under the influence of pathological processes of varying severity [3]. The study is the first to show the degree of impact of brace systems not only on the dentofacial system, but also on the state of the surrounding bone tissue. A significant decrease in its density allows us to separate a special category of patients who underwent prolonged wearing of brace systems [9]. This group of patients should receive particular attention from otolaryngologists due to possible development of complications of inflammatory processes in the paranasal sinuses, or from dentists due to the increased risk of developing odontogenic maxillary sinusitis.

The issue of the development of pathological processes in the surrounding tissues, in particular the oral mucosa with the subsequent attachment of a secondary infection and the development of stomatitis, gingivitis, remains quite debatable [2,15]. Nevertheless, significant changes can be assumed from nearby organs and tissues, in particular bone tissue of the lower wall of the maxillary sinus. As can be seen from the tables, it is bone density that maximally responds to the use of FOAs. The bone thickness in all cases is a fairly stable indicator and does not change when wearing braces of different durations.

CONCLUSIONS

It can be assumed that wearing of braces affects the morphological state of not only the enamel of the teeth, but also of the surrounding tissues, and this effect is more intense in prolonged wearing of FOAs. Ischemia is apparently the key pathogenic link in this case, leading to demineralization of the bone and being manifested by a decrease in its density in CT examination.

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