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FEATURES OF HARD TOOTH TISSUES COMPOSITION AND BONE METABOLISM IN PATIENTS WITH CHRONIC PARODONTITE

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Summary: Dates of analyzes of chemical and mineral composition of hard tooth tissues and parameters of bone metabolism were evaluated in 70 patients with chronic generalized parodontite and 25 patients without parodontite. It is shown, that nonstoichiometric calcium-deficient carbon bearing hydroxyapatite is the main mineral component of the investigated dental hard tissues. The broad spectrum of microelements could be isomorphically included in crystalline structure of apatite of hard tooth tissues was detected. We find out decreased mineralization in mantle dentin. We checked decreased bone mineral density and changes in biochemical markers of bone mineralization.

Key words: mineral and chemical composition of hard tooth tissues, bone metabolism, chronic generalized parodontite.

Резюме. Проведена оценка химического состава твердых тканей зубов и показателей костного метаболизма у 70 пациентов с хроническим генерализованным пародонтитом и 25 человек без заболеваний пародонта. Показано, что основной минеральной составляющей твердых тканей зубов всех обследованных пациентов является нестехиометрический кальций-дефицитный карбонат-содержащий гидроксилапатит, в структуру которого изоморфно входят различные микроэлементы. У больных с хроническим пародонтитом установлено снижение уровня минерализации в плащевом слое дентина, определено снижение минеральной плотности костей, сопровождающееся изменением биохимических маркеров костного метаболизма.

Ключевые слова: минеральный и химический состав твердых тканей зубов, метаболизм костной ткани, хронический генерализованный пародонтит.

The problem of bone metabolism disorders today attracts the attention of doctors of various specialties [Shcheplagina, Moiseeva, 2003; Kostik, 2005; Tyrtova, 2007; Novikova et al., 2011; Bishop et al., 2008]. A number of authors have studied the state of bone metabolism in patients with caries [Kuzmina et al., 2011], however, systemic changes in bone tissue and features of bone metabolism in periodontal diseases have not been studied enough [Shtorina et al., 2005; Tsimbalistov et al., 2005b]. Most of the works are devoted to the morpho-functional state of periodontal tissues [Danilevsky, Kolesova, 1980; Zhizhina and Prokhonchukov, 1981; Sosnina, 2009] in normal and pathological conditions. The study of the composition and structure of hard tissues of human teeth was previously carried out without comparison with markers of bone metabolism. [Tsimbalistov et al., 2004a, Frank-Kamenetskaya et al., 2004; Pan, 2002].

Purpose of the study: To study the mineral and chemical composition of dental hard tissues and biochemical markers of inert metabolism in patients with chronic periodontitis.

Materials and methods of research: The study included 95 patients of both sexes aged 14 to 45 years, permanently residing in St. Petersburg. Among them, 70 people suffered from generalized periodontitis, 25 people made up the control group (without periodontal tissue diseases). All groups were comparable in terms of sex and age. The material of the study was the teeth of patients (78 samples), removed for medical reasons (III degree of mobility and exacerbation of chronic periodontitis). The mineral composition of tooth samples and the degree of their crystallinity were studied by the method of polycrystal X-ray diffraction (diffractometer DRON-2.0, Russia). The chemical composition of the teeth was determined by X-ray spectral microprobe analysis (XMA) using a microprobe attachment to a LINK AN 10000/S85 electron microscope (England) and mass spectrometry with inductively coupled argon plasma on a TRACE Analyzer ICAP61E spectrometer (USA).

Data on the presence of different types of water in the studied solid tissues, as well as on the presence of OH groups and CO3 ions in the structure of hydroxylapatites, were obtained by infrared spectroscopy (IR spectroscopy) on a UR-20 two-beam spectrometer. The mineral content in bone tissue and bone mineral density were assessed by dual-energy X-ray absorptiometry DXA (L2-L4) on a Hologic QDR-4500 C osteodensitometer. According to the WHO criteria, normal bone mineral density was diagnosed when Z-score > -1.0 SD; osteopenia with Z-score 2.5 SD; osteoporosis - with Z-score < 2.5 SD. Osteocalcin (OC) in blood serum was determined by enzyme immunoassay using the Nordic Bioscience Diagnostics A/S N-MID TM test system, which is based on the use of two highly specific monoclonal antibodies (Mabs) to human osteocalcin. The Elecsys □-CrossLaps/serum test system was used to determine type I collagen degradation products in serum and plasma of β-CrossLaps. The obtained results were processed using the methods of parametric statistics using the software system "Statistica for Windows" (v. 6.0).

The correspondence of the statistical distribution of empirical indicators to the theoretical Gaussian normal distribution was assessed using the Kolmogorov-Smirnov test. To assess intergroup differences in indicators with a normal distribution, one-way analysis of variance and Student's t test were used. The critical significance level (p) of the null statistical hypothesis (about the absence of significant differences or factorial influences) was taken equal to 0.05.

Results of the study and their discussion: As a result of the study, it was found that the mineral density of bone tissue in the examined patients depends on the presence of chronic periodontitis. Thus, the mineral content in bone tissue in patients with generalized periodontitis was 26.66±10.76 g, in patients of the control group - 27.32±7.45 g (F=0.09, p=0.97), and the mineral density of bone tissue in generalized periodontitis was 0.81±0.15 g/cm2, in patients of the control group – 0.99±0.11 g/cm2 (F=10.38, p=0.0001). Indicators of markers of osteosynthesis and bone resorption, reflecting the processes of bone modeling/remodulation are presented in the table. Analysis of the mean levels of osteocalcin (a marker of osteosynthesis) in the blood serum of patients revealed statistically significant differences in patients with and without chronic periodontitis.

A decrease in osteosynthesis processes in terms of OC in chronic periodontitis can be the result of both genetically determined features of bone metabolism and a consequence of chronic inflammation. It is very difficult to interpret altered osteocalcin values in isolation, without other markers of bone metabolism and genetic testing. The analysis of blood β-CrossLaps bone tissue resorption parameters in patients with generalized periodontitis showed that the level of blood β-CrossLaps (1.58+0.87 ng/ml) is higher than that in patients of the control group (0.96□0, 41 ng/ml).

The data obtained indicate that in chronic periodontitis, the processes of bone modeling/remodulation are disturbed, which can play a pathogenetic role in the occurrence of periodontal diseases, as well as be a consequence of a chronic inflammatory process in periodontal tissues. Using the XMA method, it was found that the average content of calcium in the enamel of the studied teeth is 36.26, phosphorus - 17.17, sodium - 0.79, magnesium - 0.25, chlorine - 0.31, fluorine - 0.20, sulfur - 0.10 wt.%. The value of the coefficient Ca/P, which is a criterion for the resistance of hard tissues of teeth, primarily caries resistance, varies from 1.61 to 1.63. In dentin, the average content of calcium is 27.43, phosphorus, 13.31, magnesium, 0.82, sodium, 0.65, chlorine, 0.05, fluorine, 0.01, and sulfur, 0.11 wt %. The mean Ca/P ratio in dentine is 1.59. Microimpurities of about 45 chemical elements were found in the enamel of the studied teeth by atomic absorption spectroscopy.

Thus, the average content of zinc is 24.0 × 10–3 wt.%, strontium - 6.5 × 10–3 wt.%, potassium - 2.9 × 10 ×10–3 wt.%, copper – 1.4×10–3 wt.%, nickel – 0.7×10–3 wt.%, tungsten –•3.5×10–3 wt.%, cobalt – 2.7×10–3 wt. .%, chromium –•0.9×10–3 wt.%, manganese – 2.5×10–4 wt.%, lead – 3.5×10–4 wt.%, barium – 4.0×10–4 wt.%, tin – 2.0×10–4 wt.%, molybdenum –1.0×10–4 wt.%, beryllium – 0.35×10–5 wt.%. In a number of enamel samples, a significant content of rare earth elements from La to Ho (total content ~34 × 10–5 wt.%) was found, which was a distinctive feature of the hard tissues of the teeth of patients from St. Petersburg. In addition, there have been isolated cases of significant accumulation of a whole range of chemical elements (Fe, Cu, Ni, Co, Mo, Cr, W, Mn, Ba and some others) in the enamel of the teeth. X-ray spectral microprobe analysis made it possible to determine the level of mineralization of enamel and dentin of teeth in generalized periodontitis.

In the surface layer of enamel, the average values of mineralization in the region of the chewing surface or the cutting edge are 93.10 ± 0.30 wt.%, in the cervical region - 93.49 ± 0.40 wt.%; in the underlying enamel layer, 90.72±0.48 wt.% and 90.03±0.80 wt.%, respectively. Thus, the surface layer of enamel is more mineralized than the underlying one. There is no significant change in the level of mineralization of the surface and underlying enamel layers. The study of the level of mineralization of dentin shows that in generalized periodontitis there is a decrease in the mineralization of the mantle dentin relative to the near-pulp, which is most pronounced on the side of the chewing surface (66.20±0.52 wt.%) or the cutting edge (70.42±0.48 wt.%).

The revealed changes can occur as a result of reactive processes in the dental pulp, which leads to a violation of the dentin trophism and changes the level of its mineralization. In this case, mantle dentin suffers first of all [Bykov, 1996]. Using X-ray phase analysis, it was found that the mineral component of hard dental tissues is represented by non-stoichiometric calcium-deficient carbonate-containing hydroxyapatite. The results of radiographic studies have shown that enamel apatites are crystallized much better than dentin apatites, which is manifested on radiographs by a decrease in intensity and an increase in the half-width of diffraction reflections. IR spectroscopy data confirm the phosphate composition of the inorganic component of the hard tissues of the teeth. The above average values of Ca/P coefficients for the studied apatites are less than the value of 1.67, which is typical for stoichiometric apatite Ca5(PO4)3OH. This fact, as well as the established deficiency of OH groups in the channels, indicate the presence of vacancies in the calcium position in the crystal structure of apatite.

Thus, the main mineral of the inorganic component of the hard tissues of the teeth of patients with generalized periodontitis is calcium-deficient carbonate hydroxylapatite. In the structure of tooth enamel apatite, CO3 ions replace PO4 tetrahedra, and in the structure of dentine apatite, CO3 ions replace both PO4 tetrahedra and OH groups in the channels of the structure. With an increase in the age of patients in the structure of enamel apatites, in parallel with an increase in the proportion of vacancies in calcium positions, the number of water molecules, divalent anions [CO3] 2– and [HPO4] 2–, as well as fluorine anions increases. A wide range of trace elements found in the studied hard tissues of teeth reflects the influence of environmental factors on the human body. Impurities of these microelements can enter isomorphically into the crystal structure of apatite, which is characterized by numerous isovalent and heterovalent substitutions. A decrease in the mineral density of the bone tissue of the body, accompanied by a change in the biochemical markers of bone metabolism, variations in the chemical composition of the hard tissues of the teeth, which reflect the processes of de- and remineralization occurring in them, depend on many factors (environment, occupational hazards, concomitant somatic diseases, etc.) . Periodontal tissue diseases are accompanied by systemic and local changes that determine the state of mineralized tissues in the human body. Pathogenetic pathways of the relationship between bone metabolism and chronic periodontitis require further study.

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