Clinical and laboratory assessment of dental status: age characteristics, dynamics of indicators of resistance of oral fluid

O.Ya. Barabash

UDC: 616.314-07+616.314.17+616.314.18-002.4

Abstract. As a result of aging process, the state of human body homeostasis undergoes the changes. In the tooth-jaw system, such changes lead to a shift of the balance in the remodeling-demineralization processes. Their intensity and dynamics depend on the properties of oral fluid, which plays an important role for the ensuring of physiological processes of oral cavity. The purpose of the work was clinical assessment of the dental status, examination of calcium homeostasis, activity of phosphatases and protein metabolism of oral fluid in patients of different age groups and their features under conditions of dental prosthetics. 103 patients aged from 18 to 89 years were examined who were assessed for the intensity of dental caries damage (DMF index), the state of its acid-base balance (pH) were determined in the oral fluid. It was found that with the age in the oral fluid the concentration of total and ionized calcium increases, acid and alkaline phosphatases become active, the content of total protein rises against the background of a decrease the intensity of salivation, the acid-base balance shifts to the alkaline side, the mineralization of tooth enamel increases, and the risk of hard dental deposits formation increases.

Age characteristics of oral fluid resistance correlate with the intensity of dental caries damage, the state of hygiene and periodontal tissues. The changes of studied parameters in persons of the older age groups correlate with the results, that were found in patients with significant tooth loss (most of them are advanced and senile). It was found that the use of prostheses for replacement of toothless areas leads to a shift of the balance in the remodeling-demineralization processes. Their intensity and dynamics depend on the properties of oral fluid which ensure the resistance of hard teeth tissues and the bone base of the alveolar processes.

Key words: dental status, age groups, oral fluid, biochemical parameters, dental defects, dentures.

Statement of the problem and analysis of the latest research. The highest prevalence and intensity of dental diseases are found among the elderly population. Such dynamics can be caused by the aging of a person, which leads to the changes of homeostasis, a decrease in the productivity of the functioning of some organs and systems. With the age, the body’s ability to counteract harmful factors and somatic diseases decreases, the...
recovery times become longer, and prognosis of the disease course worsens [1].

The tooth -jaw system deserves a special attention, because it is the beginning of the digestive tract, so the quality of food digestion and the physiological status of its below located departments depend on its condition. The reasons for the fact that diseases of oral cavity organs may occur more often in older people are the changes in the microbiocenosis, local tissue resistance, disruption of the differentiation processes of mucous membrane cells of oral cavity, increased their dehydration, deterioration of the vascularization of soft tissues and the bone base, which develop as a result of organism aging [2]. Against the background of a decreased salivation, the content of total protein in the oral fluid increases, the Ca/P ratio decreases, and its viscosity also increases. Such changes lead to an increase the frequency of dysplastic and hyperplastic disorders, the occurrence of decubitus ulcers, leukoplakia, etc. Dentures and smoking can be harmful factors [3]. In addition, with the age, people begin to pay less attention to oral hygiene, as a result, there is a large amount of plaque and tartar on the preserved natural teeth and on the dentures of denture wearers.

The most common dental problem that directly correlates with the increasing age is tooth loss. It is known that only a third of the elderly population have 20 and more preserved natural teeth, and in 15 % of the population the total adentia is diagnosed. However, among the preserved teeth there are a large number of those that have complete destruction of the crown due to the carious process or the third degree of mobility. Therefore, such teeth need to be removed, as they cannot fully provide their functions. Taking into account the essential need to remove the teeth, it can be assumed that their real number with preserved chewing function is much smaller and is on average 13 teeth [4, 5]. Such tendency leads to the fact that among the elderly people there is a rather high need for dental treatment and prosthesis of the population. The predominant cause of tooth loss in young people is complications of the carious process and periodontal tissue disease, and in older one – atrophy of the alveolar process.

According to literature data, about 70 % of elderly people need the orthopedic treatment to restore chewing function. Due to extensive tooth loss, 60 % of those who need prosthesis require partial removable dentures, 17 % from them require partial removable dentures for both jaws. 21 % of the examined need complete removable prosthesis, 5.5 % of them for both jaws [4, 5]. The main method of restoring the chewing function in the case of significant tooth loss is partial or complete prosthesis with laminar dentures. This type of prosthesis predominates because the elderly, as a rule, are unable to pay for more expensive methods of treatment with modern orthopedic constructions using implants. However, sometimes the patients remain dissatisfied with this type of dentures, and complain on problems with biting and chewing the food. Despite the certain polyetiological nature of the diseases mentioned above, the general regularity of their occurrence is a shift of the dynamic equilibrium in the remodeling-demineralization processes towards demineralization. These processes largely depend on the properties of oral fluid, in particular on its ionic composition (especially calcium homeostasis), the activity of alkaline and acid phosphatases enzymes, which play an important role in the course of physiological processes in the oral cavity tissues.

Therefore the purpose of the work was clinical assessment of the dental status, examination of calcium homeostasis, activity of phosphatases and protein metabolism of oral fluid in patients of different age groups and their features under conditions of dental prosthetics.

Materials and methods

To achieve the goal, 103 patients without pronounced concomitant somatic pathology were examined, who were divided according to age categories into the following groups: I – adolescence (18-24 years, n=25), II – young (25–44 years, n =21), III – middle (45–59 years, n =22), IV – advanced (60–74 years, n=19) and V – senile (75–89 years, n=16). The examination of oral cavity was performed using a standard set of tools in the dental office. The intensity of dental caries damage was determined using the DMF index (where D – results was carried out in accordance with WHO recommendations [6]. The hygienic status was determined on the basis of the simplified oral hygiene index according to Green-Vermillion Oral Hygiene Index Simplified (OHI-S) [7]. The condition of the periodontal tissues was assessed by the values of the papillary-marginal-alveolar index (PMA) by Parma modification [8]. During the examination of dental rows, their integrity was assessed, and defects were distributed according to Kennedy classification. The degree of alveolar processes atrophy and the condition of the oral cavity mucous membrane in the examined with edentulous jaws was characterized according to the classification of Schroeder for the upper jaw and Keller for the lower jaw [9].

The examined with intact dentition (A) were taken into account, under the conditions of partial tooth loss (without correction – B, against the background of correction with bridge – C and partial removable laminar dentures – D) and complete adentia (without correction – E and under the conditions of complete removable laminar dentures use – F).

The activity of acid and alkaline phosphatases, the level of total and ionized calcium, the content of total protein, and the indicator of acid-base balance (pH) were determined in the oral fluid. Oral fluid was taken in the morning, on an empty stomach, without stimulation, pre-cleaning and rinsing of the oral cavity for prevention the qualitative and quantitative changes of the studied parameters. Before the examination, all patients gave informed consent for carrying out the above-mentioned studies.

Statistical processing of the results was performed
based on the Exel package of Microsoft Office 365 ProPlus using the methods of variation statistics with the help of Student’s t-criterion. The difference between the studied indices was considered reliable at a value of $p<0.05$.

**Results and discussion**

As a result of examination, it was found that the DMF index naturally increases with age (Fig. 1a). At the same time, in the examined of IV and V groups the “removed” component significantly prevailed, while in I-III – “caries” and “filling”. The most common cause of tooth loss is the complication of the carious process. The main pathogenic factors of the caries occurrence are a large number of plaque bacteria, especially anaerobic microflora, which produces organic acids that dissolve enamel minerals; frequent consumption of easily digestible carbohydrates (glucose, sucrose, fructose, etc.); reduction of the general body resistance and local protective factors (in particular, the resistance of the teeth hard tissues); changes of the composition and properties of oral fluid (insufficient immune defense, deficiency of macro- and microelements, hyposalivation) [10].

The highest OHI-S index was found in the III group of examined - 2.33±0.14 units, while in the I and II the mentioned index was 0.92±0.13 and 1.20±0.15 units, respectively. Such values characterize the satisfactory hygienic condition of the oral cavity in the examined of I and II groups, and unsatisfactory – in the patients of III group. The dynamics of the index in the III group of examined can be associated with age-related changes of the organism’s resistance, depletion of functional systems reserve that maintains homeostasis parameters. It cannot be neglected the factor of deterioration of conditions for carrying out hygienic procedures, which may be caused by the use of bridge dentures construction, that prevailed in this group. In the patients of IV and V groups, this index was not determined due to defects of the dental rows that did not meet the examined criteria.

![Fig. 1. The intensity of dental caries damage (DMF index), the oral hygiene index according to Green-Vermillion Oral Hygiene Index Simplified (OHI-S), the condition of periodontal tissues (the papillary-marginal-alveolar index – PMA) according to age (a) and dental status (b) (M±m)](image-url)

Notes. Here and on the following figures a: I – adolescence (18–24 years), II – young (25–44 years), III – middle (45–59 years), IV – advanced (60–74 years), V – senile (75–89 years); reliable differences ($p<0.05$) * – in relation to I group, # – in relation to II group, ∆ – in relation to III group; b: with intact dentition – A, under the conditions of partial tooth loss: without correction – B, against the background of correction with bridge – C and partial removable laminar dentures – D, complete adentia: without correction – E, under the conditions of complete removable laminar dentures use – F; reliable differences ($p<0.05$) * – in relation to group A, # – in relation to group B, reliable differences ($p<0.05$) – in relation to group C, ∆ – in relation to group D.
activity and structural potential decrease in general, which leads to a slowdown in the formation of new bone with the subsequent development of senile atrophy of the alveolar process [12].

In the study attracts attention the dynamics of age features of calcium homeostasis in the oral fluid. Calcium in oral fluid exists in two forms: ionized and bound. At the same time, the total content of calcium in saliva is close to its content in blood plasma, while the concentration of ionized is significantly lower. In particular, ionized calcium is 50 %, bound with phosphates and citrates – 35 %, bound with proteins – 15 % [13, 14]. A significant increase of calcium level in the oral fluid was established, especially in advanced patients (Fig. 2a). In particular, the content of total and ionized calcium in the oral fluid of the examined in IV group exceeded the data of the I in 2.11 times (pI-IV<0.05) and by 18.92 % (p I-IV<0.05), respectively. The same tendency was observed in persons of senile age. Thus, in the examined of V group, the concentration of total and ionized calcium exceeded the data of the I by 44.17 % (pV<0.05) and 26.83 % (pV<0.05), respectively. It is important that increase of calcium concentration facilitates its penetration from oral fluid in the enamel, which increases its mineralization.

The change of calcium content may be related to other characteristics of the oral fluid: reaction of the environment, buffer capacity, micellar structure [15, 16]. The optimal for the processes of mineralization and remineralization of tooth tissues is the slightly alkaline pH value of the oral fluid (7.2-7.8), and changes of the parameter reflect an excess or lack of acidic products. In general, a shift of pH towards the alkaline side in persons of old age was observed. In particular, in persons of senile age the indicator of acid-alkaline balance was 7.37±0.61 units, while in the group of young people, it was most shifted to the acidic side and it was 6.72±0.53 units. A decrease of the oral fluid pH can be caused by the vital activity of dental plaque and carious cavities microflora. At the same time, the increase in the acidity of the oral fluid contributes to the demineralization and caries development, alkalization of oral fluid – to the formation of tartar [17]. Therefore, the data obtained by us characterize the risks of dental status violation of examined.

An important criterion for assessing the destruction of the periodontal complex and diagnosing the intensity of the carious process is the level of phosphatases. It is known that acid (optimum action at pH 3.4-6.2) and alkaline (optimum action at pH 9.2-9.6) phosphatases play a significant role in the metabolism of bone tissue, especially with pronounced resorption of it (in particular, against the background of periodontitis) [18]. As a result of the study, it was established the reliable differences in the activity of the specified enzymes in the oral fluid of the examined of different age groups (Fig. 3a). Thus, the activity of alkaline phosphatase of the oral fluid was the highest in the examined of V group, exceeding the lowest value of index, which was found among the examined in II group, by 47.78 % (pIII-V<0.05). The acid phosphatase activity was the highest in the IV group, which was by 46.70 % (pIII-IV<0.05) higher the value in the II group of patients. It is important that the main sources of phosphatases synthesis are osteoclasts and neutrophils (the enzyme is found in the lysosomes of these cells), which can be attributed to peculiar factors of tissue destruction in case of periodontitis [19]. Therefore, the increased enzymes activity can be considered as biochemical markers of dental risks.

A tendency towards an increase the content of total protein in the oral fluid was established in examined, especially in advanced and senile patients (Fig. 4a). This indicator in young and middle-aged patients had an increasing tendency, but such data were not reliable, while in persons of the IV and V groups it exceeded the value in the oral fluid of adolescence in 2.14 (pIV<0.05) and 2.51 (pV<0.05) times, respectively. The oral fluid proteins play an important role in ensuring the physiological homeostasis of the biological environment. By binding organic and inorganic compounds, proteins stabilize the micellar structure of oral fluid, accumulate a reserve of biologically active substances, create the favorable conditions for the mineralization of tooth enamel [20]. They also contain many biologically active molecules, including protective proteins, hormones, and enzymes.

In our opinion, the increase of protein concentration has a compensatory nature, which contributes to maintaining the stability of internal environment against the background of a decrease the overall body resistance. Such dynamics may be associated with a decrease the intensity of salivation with age, which leads to an increase of the total protein concentration against the background of a decrease the produced oral fluid amount.

As a result of comparative analysis the significant changes of studied parameters in patients with dentition defects compared to the examined of the same age with preserved dentitions were established. Thus, under the conditions of partial tooth loss (especially in patients with dentition correction by dentures), the values of OHIS and DMF indexes significantly increased (see fig. 1b). In particular, the OHIS and DMF indexes in examined with partial tooth loss without correction were higher by 48.79 % (p<0.05) and in 3.79 (p<0.05) times, in patients with correction of dentition defects by bridge dentures – in 2.84 (p<0.05) and 10.78 (p<0.05) times, partial removable laminar dentures – in 2.47 (p<0.05) and 9.55 (p<0.05) times, respectively, in comparison to the data under the conditions of intact dentition.

The concentration of calcium (total and ionized) in the oral fluid of the examined was the lowest in individuals with preserved dentition and increased as the number of teeth decreased, reaching maximum values under conditions of complete adentia (see fig. 2b). The level of total and ionized calcium in individuals with partial tooth loss and correction the defect with bridge dentures was, respectively, by 20.49 % (p<0.05) and 20.00 % (p<0.05) higher compared to the data in the examined with intact dentition. In examined with complete tooth loss
and correction of the defect with complete removable laminar dentures, the concentration of total and ionized calcium exceeded the values in persons without defects by 39.75 % ($p_{A,C}<0.05$) and 24.32 % ($p_{A,D}<0.05$), under conditions with partial tooth loss and correction the defect by bridge dentures – the content of total calcium increased by 24.22 % ($p_{A,C}<0.05$).

The phosphatases activity was the lowest in the individuals with intact dentition and increased with tooth loss (see fig. 3b). The highest activity of alkaline phosphatase was observed in patients with complete loss of dentition and defects correction by complete removable laminar dentures, and acidic – in the examined with complete tooth loss without correction. These values of enzyme activity by 46.06 % ($p_{A,C}<0.05$) and 45.87 % ($p_{A,E}<0.05$), respectively, exceeded the analogical data of oral fluid under the conditions of intact dentition.

The level of total protein reached the maximum values in patients who used the partial or complete dental laminar dentures (see fig. 4b). This index in people who used partial removable laminar dentures exceeded the value in the examined with intact dentition and patients with partial tooth loss without replacement of the defect and when it was replaced by bridge dentures by 50.47-10.86 % ($p_{A,B,C,D}<0.05$), and in persons with complete removable laminar dentures it was higher by 5.44-26.87 % ($p_{A,B,C,E}<0.05$) respectively. The increase of total protein concentration is largely associated with a decrease of saliva secretion that can be a consequence of a decrease in chewing function, the salivary glands atrophy, especially in elderly persons. In younger age groups, such changes can develop as a result of partial or complete tooth loss, widespread carious process, functional joint disorders, periodontal diseases. Therefore, the timely and maximum restoration of the tooth-jaw system functions will contribute to maintaining the homeostasis of oral fluid.

The obtained results are correlated with the data that were found in groups divided by age criteria. The changes of indexes in the older age groups correlate with the results detected in patients with significant tooth loss, as the vast majority of them belonged to the advanced and senile groups. It was found that the use of prostheses for the replacement of dentition defects has a positive effect on the indicators that ensure the resistance of the teeth hard tissues and the bone base of alveolar processes. The detected age-related changes of the studied biochemical parameters of the oral fluid under the influence of harmful environmental factors or the development of somatic diseases have a significant impact on the course of physiological processes of the tooth-jaw system. At the same time, the study of biochemical indexes of oral fluid is an accessible, informative, non-invasive research method in dentistry.

**Prospects for further research**

The examination of influence of exogenous and endogenous factors on markers of phosphorus-calcium homeostasis, enzymatic activity and active reaction of oral fluid in order to prevent the development of dental disorders.

**Conclusions**

The carried studies confirm that with age, the concentration of total and ionized calcium in the oral fluid increases, acid and alkaline phosphatases become active, a relative increase of total protein against the background of a decrease the intensity of salivation are observed. Such disorders develop simultaneously with a shift of the acid-alkaline balance to the alkaline side, which leads to an increase of the mineralization of tooth enamel and an increase the amount of hard dental deposits. More pronounced changes of the studied processes are observed under the conditions of dental rows defects. By affecting on the mentioned links of the dental status violations and the mechanisms of their development, it is possible to reduce the risk of pathological process development, which will contribute to the preservation of dental health and will increase the importance of preventive dentistry.

**Financial Disclosure.** The author declared no financial support.

**Conflict of Interests.** The author declare that no conflict of interests exist.

**References**


8. Vivcharenko TI, Rozhko MM. Assessment of periodontal
Fig. 2. The content of total and ionized calcium in oral fluid of examined according to age (a) and dental status (b) (M±m)

Fig. 3. The activity of acid and alkaline phosphatases in oral fluid of examined of different age (a) and dental status (b) (M±m)

Fig. 4. The content of total protein (g/l) in oral fluid of examined according to age (a) and dental status (b) (M±m)


Received: 12.12.2022
Revised: 21.12.2022
Accepted: 26.12.2022