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PHYSICAL-CHEMICAL AND METABOLIC PROCESSES IN ORAL CAVITY: THEIR INTERACTION IN DENTAL PERI-IMPLANTITIS AND CHRONIC PERIODONTITIS

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ABSTRACT

Intraosseous dental implantation is considered to be the most effective and technologically advanced method employed to restore individual and multiple dentition issues. It offers potential for significant improvement of comprehensive rehabilitation in dental patients. However, positive outcomes of the implantation that enable restoration of the dentition integrity, complete compensation of the patient's chewing function and aesthetic looks, does not rule out complications involving inflammation. It still remains relatively high, within the range of 8 to 15%.

Peri-implantitis, if taken as inflammation affecting the soft tissues around the implant, bears signs of bone destruction and accounts for one of the most common complication. The comprehensive study described here was aimed at evaluating the dental status, as well as the physical-chemical and metabolic parameters of the oral fluid in patients with dental peri-implantitis (n=31), chronic localized periodontitis (n=30) and chronic generalized periodontitis (n=30).

The control group included patients (n=30) with no signs of dental pathology, all comparable in terms of their age and gender. In patients with dental peri-implantitis, chronic localized periodontitis and chronic generalized periodontitis, we revealed unidirectional dynamics of the oral fluid parameters (electrical conductivity, redox potential, concentration of calcium, magnesium, ammonium cation), the values being different, though. The identified features of the metabolic status of oral fluid will increase our understanding of pathogenetic mechanisms underlying peri-implantitis.

Keywords: dental implantation, peri-implantitis, periodontitis, oral fluid, metabolic criteria, inflammation.

INTRODUCTION

Dental peri-implantitis (DP) is an inflammatory response revealed by the tissues surrounding an osteointegrated implant, whereas such response comes associated with loss of the supporting bone. The risk factors behind the onset of peri-implantitis include hematomas above the plug of the implant intraosseous element and their suppuration; failure to comply with the bone bed atraumatic preparation principles; improper wound closure that is traumatic and causes ischemia of the postoperative wound edges; occlusive trauma; irrational dental prosthesis design; poor oral hygiene; defects of the gum soft tissues at the implantation area; systemic diseases [1, 2].

Identifying the specific features pertaining to changes in the oral fluid (OF) in case of peri-implantitis will

take matching them with similar indicators in other most common inflammatory processes affecting the maxillofacial area. We have opted for generalized chronic periodontitis (GCP) as well as for its localized type (LCP). Recent years have been witnessing an increase in various types of periodontal issues [3], with their prevalence remains a high and featuring no signs of any decrease [4]. Periodontal diseases come along with pathogenic microflora to be found in the oral cavity [5]. Nowadays, the list of indications for implantation in case of periodontal diseases is expanding [11,12].

As the respective literature data holds it, the etiology as well as the clinical presentation of dental peri-implantitis has something in common with chronic periodontitis, which allows a comparative analysis thus aiming at identifying not similarities alone, yet also differences between the two.

Both diseases are associated with poor oral hygiene [6]. The microflora observed in case of these health issues produces enzymes (phosphatases, proteases, glycosides, as well as hyaluronidase, fibrinolysin) that destroy intracellular structures. Bacteria in the peri-implant and periodontal pockets can secrete cytotoxic products, which results in altered composition and properties of the oral fluid [7-10]. This served as the basis for a more detailed study, namely, the metabolic processes in the OF in case of the said pathological conditions.

Aim of study: to study the relationship between physical & chemical and metabolic processes going on in the oral cavity in case of dental peri-implantitis and chronic periodontitis, localized and generalized.

MATERIALS AND METHODS

We observed 93 patients (age – 25 to 60), including 31 patients (33.3%) with DP (Group 1), 30 patients (32.3%) with LCP (Group 2), and 32 patients (34.4%) with GCP (Group 3). Seeking to develop criteria for normal values of the studied OF indicators, a control group involving healthy individuals (30 persons), featuring similar age and gender pattern, was examined, while these participants revealed no signs of dental pathology or any acute somatic issue at the time of the examination. The patients' dental status was evaluated relying on such indices as Green-Vermillion, Russell, Muhlemann.

Identifying the oral cavity homeostasis status implied studying a number of indicators pertaining to the patients' OF metabolism, while such fluid is a multicomponent solution including electrolytes and non-electrolytes. The various ions to be found in the OF explain its electrical conductivity. The specific electrical conductivity (EC) was measured by a Conductivity Meter, type: OK-102/1, with the obtained data evaluated in mS. The pH (ionometry) as well as the redox potential (ROP) identification was performed on a pH meter (pH Meter 220 by Mettler Toledo, Switzerland). The ROP index (expressed in mV), which depends on the concentration of oxidized and reduced forms of body fluid compounds, can be employed as an integral indicator of the status of those systems that are involved in OF redox.

The mineral and ion content in the OF, such as the calcium, magnesium, ammonium cation and nitrate anion concentration, was evaluated employing the ion-selective method using specialized membrane electrodes on the pH meter I-130. The electrode potential magnitude allowed identifying the concentration of ions. This would take calibrating each electrode and building a calibration graph to estimate the ion content expressed in mmol/L. Studying the content of ammonium cation and nitrate anion was performed in order to identify the microbial invasion degree, since these ions are mostly products of microorganisms metabolism.

The obtained results were used to carry out statistical processing (SPSS 25 software package) thus calculating the arithmetic mean (M), the standard deviation (SD) of quantitative features and the percentage for nominal data. The groups were compared relying on the Student, Mann-Whitney, and Pearson chi-square ($\chi 2$) criteria with the Yates correction. The obtained outcomes were considered as featuring difference in case of $p<0.05$.

RESULTS AND DISCUSSION

When carrying out a comparative analysis of the obtained hygiene indices, the indices of peri-implant tissues and periodontium (see Table 1), it is to be noted that, in all groups, they fail to match the values falling within the norm.

Table 1. *Index evaluation of oral hygiene and tissue status in case of periodontitis and peri-implantitis.*

Indicator	Green-Vermillion index (OHI-S)	Russell's periodontal index	Muhlemann index
Group 1 (n=31)	3.24±0.23*	2.53±0.21*	1.96±0.21*
Group 2 (n=30)	2.57±0.22*	1.51±0.13*	1.75±0.15*
Group 3 (n=32)	3.31±0.26*	2.58±0.19*	2.21±0.17*
Control group (n=30)	1.3±0.01	1.2±0.09	1.1±0.10

** – p<0.05*

In Group 2, though, the Russel and Muhlemann indices feature the smallest deviation from the normal criteria. It is typical that in Group 3, the lowest indicators are to be observed both for oral hygiene and the periodontal index, which is the reason behind inflammation-related issues. This, further, means all groups have a microbial environment that complicates the disease course, as well as constitutes a common etiological factor.

Table 2 shows OF physical & chemical parameters.

Table 2. *Physical & chemical parameters of oral fluid in patients with chronic periodontitis and dental peri-implantitis*

Indicator	pH	Redox potential (mV)	Electrical conductivity (mS)
Group 1 (n=31)	7.63±0.25	-22.80±4.05***	4.52±0.89**
Group 2 (n=30)	7.43±0.54	-7.31±3.59**	3.27±0.41*
Group 3 (n=32)	7.48±0.66	-21.64±2.24***	4.20±0.25**
Control group (n=30)	7.19±0.15	10.74±2.89	2.59±0.20

** – p<0.05, ** – p<0.01, *** – p<0.001*

The study focusing on the identified OF indicators in patients with GCP and LCP showed that, if matched against the control values, there was a significant ROP decrease (-201.5%, p<0.01). This is also observed in case of DP. Noteworthy is that patients with LCP have change in OF mineral components and ions (see Table 3) that, by its nature, is in many ways similar to cases with DP. LCP, for instance, comes along with an increase in the calcium content by 164.9% (p<0.001), magnesium – by 264.3% (p<0.001) and ammonium cations by 26.9% (p<0.05), whereas in patients with DP the same indices are elevated by 148.6% (p<0.001), 296.4% (p<0.001) and 99.4% (p<0.01), respectively. In cases with LCP, however, unlike those with DP, no significant changes in the OF nitrate anions content are to be observed.

Table 3. *Mineral components contained in oral fluid of patients with chronic periodontitis and peri-implantitis*

Indicator	Calcium (mmol/L)	Magnesium (mmol/l)	Ammonium cation (mmol/l)	Nitrate anion (mmol/L)

Group 1 (n=31)	0.92±0.21***	1.11±0.66***	6.22±0.72**	6.52±0.88***
Group 2 (n=30)	0.98±0.15***	1.02±0.45***	3.96±0.39*	2.48±0.43
Group 3 (n=32)	1.26±0.76***	0.77±0.06***	3.97±0.41*	2.88±0.65
Control group (n=30)	0.37±0.08	0.28±0.09	3.12±0.31	2.76±0.39

** – p<0.05, ** – p<0.01, *** – p<0.001*

Patients with GCP have the nature of change in OF mineral components and ions (based on the major indicators) similar to that in patients with localized form of the same health issue: elevated calcium content (by 240.5%; p<0.001), magnesium (by 175.0%; p<0.001) and ammonium cations (by 27.2%; p<0.05), which is also similar to changes in case of DP. Patients with GCP, though, just like in case of its localized form, featured no change in the nitrate anion concentration, which increases significantly in patients with DP (+136.2%, p<0.001).

CONCLUSION

Therefore, the analysis of physical-chemical as well as metabolic parameters of the oral fluid of patients with dental peri-implantitis, chronic periodontitis (both localized and generalized) allowed to establish the relationship and unidirectional nature in a number of parameters, such as electrical conductivity, redox potential, concentration of calcium and magnesium, an ammonium cation. However, these indicators vary significantly. Besides, in patients with LCP the nature of changes in oral fluid mineral components and ions, is similar in many respects to the parameters observed in DP cases, yet reveals differences in the content of nitrate anions. All this provides significant criteria for objectification of the diagnosis.

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