DOI 10.26724/2079-8334-2018-4-66-131-136
UDC 616.212.5 -07-037-089

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IMPROVEMENT OF METHODS FOR DIAGNOSIS AND PREDICTION AT SURGICAL CORRECTION OF NASAL SEPTUM DEVIATION

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This paper suggests approaches to improving methods for diagnosis and prediction at surgical correction of the nasal septum deviation. A method is introduced to assess the effect of air flow on the nasal cavity walls at micro level. The computer planning method of surgical endonasal plasty is suggested, based on the construction of a volumetric aerodynamic model of the nasal cavity according to the computer tomography and rhinomanometry data. The issues connected with diagnostics and surgical treatment of respiratory-olfactory disorders are considered.

Key words: nasal septum deviation, surgical endonasal plasty, aerodynamic model of nasal cavity, computer tomography, rhinomanometry.

In the conditions of endonasal rhinosurgery, the interest in surgical correction of intranasal structures has significantly grown in recent years [6, 5, 9]. The most common cause of intranasal structures surgical correction is the nasal breathing function disorder, which pathogenesis is closely connected with the nasal septum condition. However, various deformations of the latter are often accompanied by a variety of structural and functional changes in the nasal cavity [4, 8]. Thus, as a result of the observations performed, the authors highlight one of the causes for respiratory olfactory dysfunction in the nasal septum deviation in the form of the olfactory fissure lumen narrowing and the aerodynamics disorder of the air flow passing through this area [8].

But, in this case, correcting the septum deviation near the olfactory fissure and eliminating the "obstacles" troubling the nasal breathing do not always lead to the restoration of the olfactory function. For that purpose, to evaluate structural changes in the nasal cavity, video endoscopic imaging and CT scans are used to provide a sufficiently complete picture of the internal structures of the skull and paranasal sinuses, paying attention to the ratio of intranasal anatomical objects, namely the nasal septum, the middle nasal concha and lateral dorsum of the nose [8].

These studies contain a large amount of information and allow the surgeon to feel clearly confident in the anatomical and topographic features of the offending area. However, it is not the very fact of structural changes that is of interest to the surgeon, but the restoration of the nasal cavity functional capabilities which is one of the most difficult issues in rhinology.

Topicality of the subject under study lies in the following. In most cases, assessment of the nose functionality is based on the air exchange nature, changes in the air flow as related to to the walls of the nasal cavity, visualization of which provides information on the nasal cavity macrostructure as condition features of the nasal lateral dorsum, nasal concha, contralateral deformation of the nasal septum, ethmoidal infundibulum blockade etc., but at this, the microlevel of disorders is not taken into account [8, 2]. Diagnosed by this method, the intranasal structures ratio disorder only gives a unidirectional view on the problem of the disturbed aerodynamics in the nasal cavity, which is estimated by clinicists independently of one another and does not permit speaking on the complete restoration of the organ’s functional activity.

Taking the above said into account, it is considered reasonable to carry out endonasal interventions aimed at normalizing the anatomical structures of the nasal cavity lateral dorsum, restoring secure airway of the airflow, while preserving the nasal cavity archonectonicsto the greatest possible extent, not only at the macro, but also at the micro level [1, 3]. From this point of view, the most appropriate approaches are those aimed at the simultaneous restoration of the adequate nasal architectonics and elimination at the microlevel of the aerodynamic processes imbalance in the nasal cavity. In this connection, it is nowadays preferable to use surgical techniques, with account of the nasal breathing characteristics assessment, by calculating the aerodynamic parameters, as well as the functional capabilities features of respiration and olfaction [2, 1, 3, 11].

Therefore, the **purpose** of the present study is to improve the methods of diagnosing and predicting surgical correction of the nasal septum deviation.

Materials and methods. Under our supervision, there were 167 patients with the nasal septum deviation, who were subject to the endoscopic rhinosurgical intervention. The patients’ average age varied within the range of 25-60 years. The diagnosis was made based on complaints, anamnesis, clinical examination data, nasal cavity endoscopy, computed tomography and respiratory olfactory function studies.

Taking into account the age, gender, presence of the nasal cavity pathology, attention was paid to the duration of the disease, leading to the olfaction disorder. Based on the results of a comprehensive survey, including assessment of patients' complaints, anamnestic data, and the physical examination data, all patients were clustered into three groups. The first group consisted of 44 patients with the nasal septum deviation without structural changes in the lateral dorsum of the nose. The second group comprised 75 patients with the nasal septum deviation and chronic hypertrophic rhinitis. The third group included 48 patients with the nasal septum deviation and changes in the middle nasal concha area - conchabullosa.

Indication for the study was the presence of the nasal septum deviation in patients planned to undergo functional endonasal surgery. All patients were subject to the cone-beam computed tomography (CT) of the nasal cavity and paranasal sinuses with obtaining two-dimensional cuts (axial and coronary), followed by pre-treatment and segmentation and with the photo and video recording of the image at the direct and lateral angular fields [7]. All patients underwent rhinomanometry with computer olfactometry recording the respiration energy characteristics under the action of the appropriate odorivectors. For instance, an olfactory set of valerian solution in the concentration of 0.5% was used to study olfactive sensitivity.

Trigeminal sensitivity was determined with account of the 0.2% solution of acetic acid. Parameters of the breathing power and energy were determined under the action of odorivectors in the dynamics before and after the surgical intervention. The change in these indicators was recorded as a percentage of the initial ones. Then, based on the results of CT, a spatial model of the upper respiratory tract was built and then a complex aerodynamic model of the nasal cavity was formed based on integration of anatomical CT data and rhinomanometry indices [8].

The main measured parameters were areas and perimeters of the nasal cavity cross sections, as well as the pressure drop and the air flow rate caused by it. Based on these data the Reynolds number was determined: the airflow turbulence value characteristic, and the width of the laminar air boundary layer near the nasal cavity dorsum and characterizing aerodynamic processes at the micro level, namely the location of the microscopic irregularities of the upper nasal mucosa layer with respect to δ parietal air flow width [8].

Planning of surgical intervention was carried out based on the virtual modeling of morphing 3D model of the nasal cavity, which resulted in prediction of nasal respiration functional parameters depending on the type and the degree of endonasal structures correction.

Results of the study and their discussion. The nasal septum pathology was detected in 167 (100%) patients admitted for inpatient treatment to the ORL-clinic. In 44 (26.3 %%) of them, the respiratory function disorder was only associated with the septum deviation; in 48 (28.7%) patients nasal breathing disorders were accompanied by the nasal septum deviation and changes in the area of the middle nasal conchabullosa; in 72 (43.1%) nasal breathing difficulty with the nasal septum deviation was accompanied by chronic hypertrophic rhinitis; 1.9% of patients had a unilateral nasal septum deformation.

It was revealed that olfactory dysfunction was observed in all patients with reduction of the both olfactory and trigeminal sensitivity (according to the computer olfactometry data, increased power and respiratory energy were recorded at the average by 65% relative to the norm). As a result of the performed intranasal structures analysis, namely, the nasal septum, the middle nasal concha and the lateral dorsum of the nose, the nasal cavity obstruction was detected at the level of the middle nasal meatus caused by conchabullosa and the contra-lateral nasal septum deformation in the form of a ridge. In group II, in 25 cases, the anterior end of the inferior nasal concha was not enlarged, while the middle and the posterior sections were significantly enlarged.

Blockade of the olfactory fissure according to CT study was diagnosed in 20 cases, in the third group of observations. In 3 patients, the aggernasi cells process was diagnosed, the total involvement in the ethmoidal labyrinth process was detected in 4 patients.

Functional studies of the nasal breathing were carried out by means of the posterior active rhinomanometry and testing patients at different respiration modes [11]. According .to the rhinomanometry data, the pronounced depression of the total nasal breathing characteristics was observed, which testifies to a pronounced negative effect of the nasal septum deviation on the respiratory function of the nose as a whole.

As a result of the study, it was found that after the nasal mucosa anemisation in patients with nasal breathing disorder, the nasal resistance parameters decreased 2 times as compared to the initial ones and reached the values that significantly correlated (the correlation coefficient was equal to k = 0.83) with the resulting assessment of the nasal respiratory function in these patients in the postoperative period. Improvement of the olfactory function (on average by 25%) was recorded in 80% of patients in the period of 2 months after the surgery by the criterion of breathing strength and energy under the action of odorivectors.

When studying the aerodynamics of the nasal cavity, in most cases, when the nasal concha is overhanging the semilunar hiatus and when the concha adjoins the nasal septum, the air exchange is disrupted, the airflow changes, which leads to the development of various pathological conditions. Examples of computer models for virtual simulation of surgical intervention are shown in fig. 1.

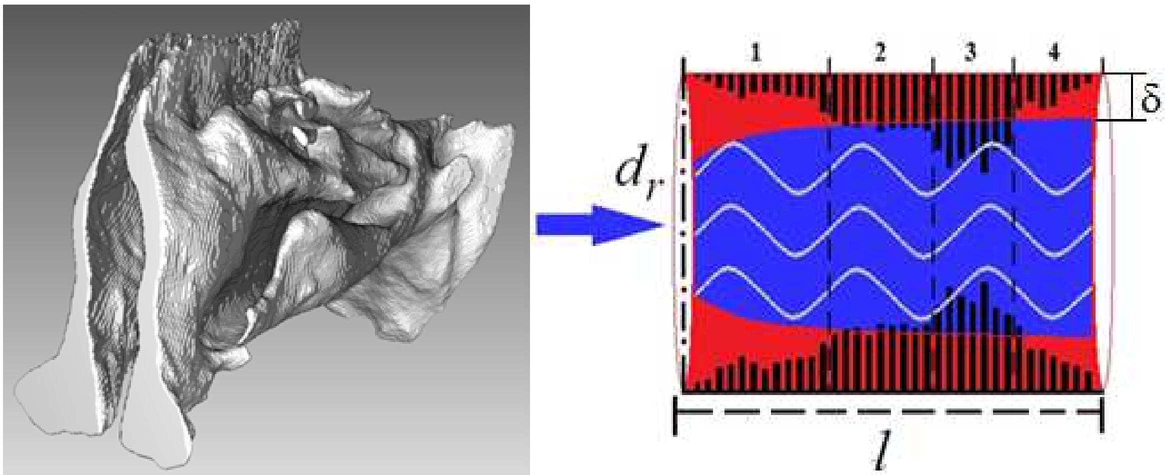

Figure 1. - Illustration of the spatial model of the nasal cavity from CT data (a); schematic illustration of the concept of the laminar boundary layer width δ in the channel with the diameter d and length l (b).

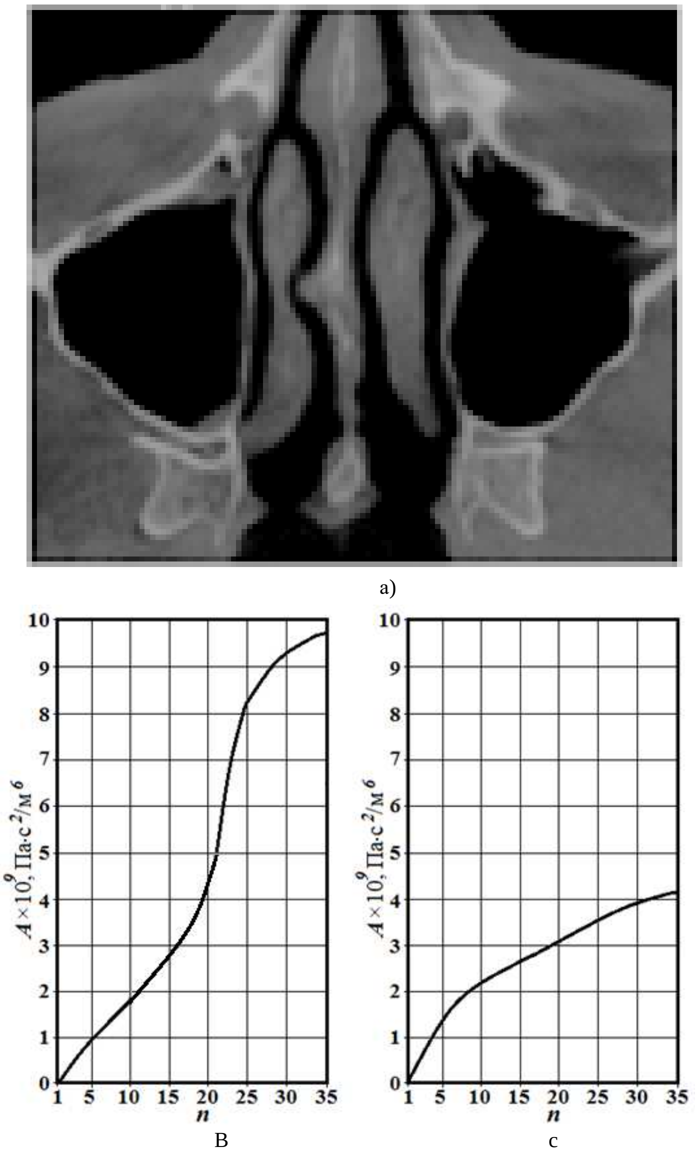

Figure 2. – Illustration of determining the coefficient of nasal aerodynamic resistance A when the nasal septum is deviated to the right: a - the initial axial CT-section, b - the slice by slice accumulation of the coefficient A in the right half of the nose, c- the same in the left half.

The importance of determining the width δ of the air boundary layer is illustrated in Figure 3, where figures 1, 2, 3 and 4 show different areas of the boundary layer's influence on the microroughness of the nasal cavity mucous membrane: in 1, 4 - microroughness are within the laminar sublayer, in 2 – at the boundary and in 3 - are subjected to drying by the turbulent airflow core.

According to the aerodynamic models presented in fig. 2, the coefficient A of aerodynamic nasal resistance is calculated for both halves of the nose, as illustrated in Fig. 2. It can be seen that the stylosteophyte (thorn) of the nasal septum (see fig. 2, b) almost 2.5 times increases the resistance to air flow on the deformed side of the nose (A = 9.8 • 10-9 Pa • s^2 / m^6) compared to with an intact half (A = 4.2 • 10-9 Pa • s^2 / m^6), which is shown in fig. 2, c. This is also confirmed by independent results of the posterior active rhinomanometry with alternate testing of the nasal halves.

Whereas it is necessary to evaluate the aerodynamics, it is advisable to study the air flow effect at the micro level in the area immediately adjacent to the nasal cavity boundaries - the parietal airflow, and particularly in the places of ultimate narrowing of the nasal passages. To determine the characteristics of the parietal flow, studies on the theory of the boundary layer in the nasal cavity are applicable. Studies on the degree of the boundary layer's influence on the nasal cavity mucosa are performed using the CT data in accordance with the mucosal microroughness size and with the laminar parietal flow's width. Calculations are carried out according to the formula [3]

$$\delta=\frac{32{,}4\cdot d_r}{Re^{0{,}875}},$$

where d_h is the hydraulic diameter of the nasal cavity, calculated as for complex shape channels; Re is the Reynolds number, which characterizes the airflow regime (the larger the value is, the greater is the tendency to turbulize the flow). From the above formula it is obvious that with the increase of Reynolds number and the decrease of the hydraulic diameter, the width of the boundary layer reduces sharply. This puts the characteristic requirements to the surgical approach: in the problem areas it is necessary to configure the widest sections as possible.

Dependence of the width on the Reynolds number shows that under different respiration regimes, the parietal flow can have different effects on the mucous membrane of the nasal cavity, which must be taken into account with patients of young age groups and those engaged in physical exertion. The width of the laminar boundary layer near the walls of the nasal cavity is normal at calm breathing of about 1.5 mm and asymptotically reduces with increasing flow velocity and, accordingly, turbulence. The illustration to determining the ratio of mucosal irregularities in the nasal cavity when compared to the width of the laminar boundary layer at different respiration regimes is given in fig. 3. Obviously, the width of the boundary layer depends significantly on the breathing intensity: it reduces significantly with increasing air discharge.

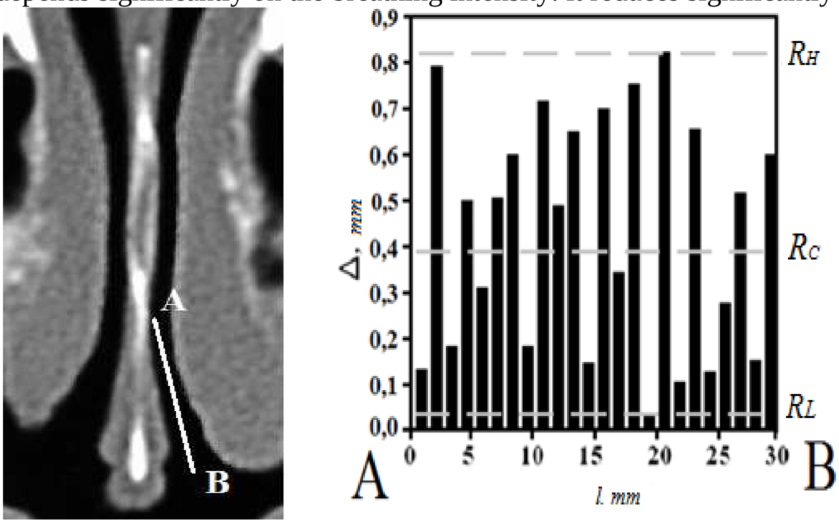

Figure 3. - Illustration to the definition of the laminar boundary layer at the nasal cavity A-B area: A - initial axial CT slice, b - value of the equivalent nasal cavity mucous membrane's Δ roughness with designations R_L, Rc and R_H - minimum, medium and maximum values, respectively.

Thus, the analysis of study results in 3 groups of observation showed that in the projection areas of ridges and stylosteophytes and the areas of deviated nasal septum bony structures, critical reducing of the laminar boundary layer's width is observed, wherein the increased airflow turbulence transition is determined.

At the same time, optical endoscopic control can significantly reduce the probability of injury to the mucosa in these areas during surgery. An important aspect of intranasal structures surgical correction performed for nasal breathing disorders is the prediction of the operation results, permitting the rhino-surgeon to better comprehend possible outcomes of the intervention in terms of its functional efficiency. The method for computer planning of surgical intervention, based on virtual modeling and predicting the anatomical and functional result of the surgery, lies in determining the best configuration of the nasal cavity as determined by reducing the nose resistance value. An illustration of the change in the virtual nasal cavity model by the 3D-warping method according to the sequence of reference points is presented in fig. 4.

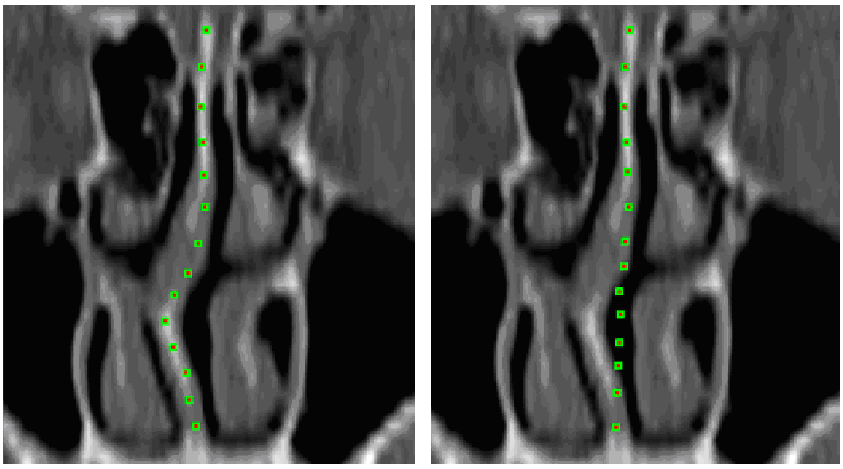

Figure 4. Illustration of the computer planning process by the method of two-dimensional warping by reference points on the coronary CT slices: a - input image; b - resulting image

The initial, predicted and resultant values of the aerodynamic nasal resistance coefficient for the studied pathologies are presented in Table 1, from which it can be seen that the predicted values differ from the initial ones by approximately 2 times (1.95, 2.1 and 1.98, respectively), but the actually obtained values after surgical treatment differ by an average of 1.7 times (1.69, 1.79 and 1.66, respectively).

Table 1

Initial, predicted and resultant values of the aerodynamic nasal resistance coefficient for the studied pathologies

Pathology	Aerodynamic nasal resistance coefficient, Pa·s^2/m^6		
	Initial value	Predicted value	Resultant value
Nasal septum deviation	7.8±2.3	4.0±1.1	4.6±1.3
Nasal septum deviation in combination with chronic hypertrophic rhinitis	9.5±2.8	4.4±1.5	5.3±2.1
Nasal septum deviation in combination with conchobullosis	8.3±2.6	4.2±1.3	5.0±1.8

Conclusion

When planning functional rinological interventions, it is advisable to carry out virtual modeling and predicting the results of nasal breathing restoration. The current intelligent technologies, on the basis of computer simulation with a probability of at least 80%, permit to perform a correct prognosis for restoring the respiratory-olfactory function. The prognosis accuracy depends on the severity of the pathology and the ability to implement the planned surgical measures. Thus, in a number of cases, in individuals of the 2nd and 3rd group with pronounced hypertrophic changes in the nasal cavity combined with the nasal septum deformation, the necessity arises to expand the surgical intervention volume in the form of one-step septoplasty and submucous reduction of nasal concha.

In most cases, the scope of corrective interventions in all the observed cases should be limited to the most sparing treatment of the nasal mucosa, the optimal choice of the site and the shape of the mucous membrane incision, the minimum area of the nasal mucous membrane detachment and complete comparison of the mucosa leaves followed by suturing the edges of the incision. This explains the great deviation of actual and predicted results, compared to the group, where the amount of intervention was actually limited by septoplasty only.

Therefore, improving the diagnostic methods and the prediction of the nasal septum deviation surgical correction takes studying the respiratory nasal breathing disorders to a new level, taking into account the structural and functional features of the nasal cavity, determined on the basis of the parietal air flow theory. The study demonstrates that the permanent turbulent flow has a drying effect on the mucous membrane’s areas of the nasal cavity, causing structural and functional disorders of the nasal mucosa. In this case, the width of the viscous layered laminar parietal flow in the nasal cavity will be reduced with increasing flow velocity and, accordingly, turbulence, i.e., with the increased respiration intensity. It should be taken into account when treating patients of young age groups and prone to frequent physical exertions.

Thus, predicting the results of intranasal structures functional surgery permits planning and implementing adequate volumes of surgical operations. The suggested diagnostic technique is physiological in real clinical conditions, and the results obtained are characterized by a high degree of correlation with a subjective assessment of nasal breathing.

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Реферати

ОПТИМІЗАЦІЯ МЕТОДІВ ДІАГНОСТИКИ І ПРОГНОЗУВАННЯ ХІРУРГІЧНОЇ КОРЕКЦІЇ ВИКРИВЛЕННЯ НОСОВОЇ ПЕРЕГОРОДКИ
Шушляпіна Н.О.

У роботі пропонуються підходи до оптимізації методів діагностики і прогнозування хірургічної корекції викривлення носової перегородки. Вводиться метод оцінки впливу повітряного потоку на стінки носової порожнини на мікрорівні. Пропонується метод комп'ютерного планування хірургічної ендоназальної пластики, заснований на побудові об'ємної аеродінамічної моделі носової порожнини за даними комп'ютерної томографії та ріноманометріі. Розглядаються питання, пов'язані з діагностикою та хірургічним лікуванням респіраторно-нюхових порушень.

Ключові слова: відхилення носової перегородки, хірургічна ендоназальна пластика, аеродинамічна модель носової порожнини, комп'ютерна томографія, риноманометрія.

Стаття надійшла: 4.05.18 р.

ОПТИМИЗАЦИЯ МЕТОДОВ ДИАГНОСТИКИ И ПРОГНОЗИРОВАНИЯ ХИРУРГИЧЕСКОЙ КОРРЕКЦИИ ИСКРИВЛЕНИЯ НОСОВОЙ ПЕРЕГОРОДКИ
Шушляпина Н.О.

В работе предлагаются подходы к оптимизации методов диагностики и прогнозирования хирургической коррекции искривления носовй перегородки. Вводится метод оценки влияния воздушного потока на стенки носовй полости на микроуровне. Предлагается метод компьютерного планирования хирургической эндоназальной пластики, основанный на построении объемной аэродинамической модели носовй полости по данным компьютерной томографии и риноманометрии. Рассматриваются вопросы, связанные с диагностикой и хирургическим лечением респираторно-обонятельных нарушений.

Ключевые слова: отклонение носовой перегородки, хирургическая эндоназальная пластика, аэродинамическая модель носовой полости, компьютерная томография, риноманометрия.

Рецензент: Безшапочний С.Б.

DOI 10.26724/2079-8334-2018-4-66-136-140
UDK 616.314-089.843-085-039.77

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EFFICIENCY OF DIFFERENTIATED LONG TERM MAINTENANCE TREATMENT IN DENTAL IMPLANT SURGERY PATIENTS

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Purpose of this study was to evaluate the effectiveness of the proposed differential maintenance treatment in patients who underwent dental implantation, based on the results of the clinical dynamic observation and the data of laboratory tests (microbiological, immunological and rheological), depending on the initial level of the Green-Vermillion's HI after the implant prosthetics stage, according to the clinical and radiologic control in the long-term (1 year).

Key words: dental implantation, oral hygiene, differential treatment.

The present study is a fragment of the research project "Restoration of dental health in patients with major dental diseases and their rehabilitation" (state registration No. 0116U004191).

In present day, dental implantology as a science is developing rapidly. [1-2]. Despite undoubted achievements, an important problem of dental implantation is the risk of complications in the implants' functional period [3-4]. With the active functioning of the created biotechnical system, problems and complications can occur with both the biological and the technical component. The most common complication affecting the tissue surrounding the implant is peri-implantitis [5]. The leading cause of peri-implantitis of actively functioning implants is a compromised barrier function of the implant's gingival cuff, as a result of unsatisfactory oral hygiene. In this period, an important component of the hygienic measures is the regular professional hygiene of the oral cavity, whose task is to carefully remove the biofilm, plaque, supra- and subgingival calculus from all surfaces of the crown and root parts of the tooth, including furcations. Therefore, with careful individual and professional hygiene, one can count on the continued successful functioning of prosthetic structures with the support of implants [6]. However, despite a number of existing recommendations on the timing of hygienic examinations, up to the present time there are no scientifically substantiated approaches to support treatment with concrete practical recommendations for any of the stages of dental implantation, taking into account the condition of periodontal tissues and the level of the oral hygiene. Considering the above, we think it is advisable to posit