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Identification of the main risk factors for occlusal disorders.

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Abstract

Background: Violations of occlusive relationships are an urgent problem in dental practice due to the high prevalence, complexity of diagnosis and treatment, as well as the connection with common somatic diseases. These pathologies reduce the quality of life of patients and complicate the process of medical rehabilitation. Prevention aimed at early detection of risk factors is especially important.The purpose of this study is to identify the main risk factors for the development of disorders of occlusive relationships.

Materials and methods: A randomized controlled trial was conducted with 120 patients aged 18 to 44 years. The assessment included clinical examination, cone beam computed tomography (CBCT), electromyography (EMG), ultrasound examination of the temporomandibular joint (TMJ) and occlusion analysis. Methods of 3D modeling and analysis of the symmetry of the skull were used, as well as the Hamburg test to assess the functional state of the TMJ. The results of the clinical examination were subjected to a hierarchical cluster analysis.

Results: Clinical and functional examination revealed three key components of occlusive disorders: muscle, joint and jaw complexes. The main factors, such as the size of the articular gap, electromyography of the masticatory muscles and the area of occlusal contacts, turned out to be the most significant, covering 68% of all information. The addition of face symmetry and ANB angle parameters increased the classification accuracy to 85%. The study confirmed a high correlation between the functional features of the temporomandibular joint (TMJ), the muscle complex and bone-dental factors, which emphasizes the need for a preventive approach in early diagnosis.

Conclusion: The study identified key risk factors for the development of occlusive disorders through a comprehensive analysis of clinical and functional parameters. Cluster analysis revealed three primary components—muscle, joint, and jaw complexes—accounting for most occlusal risk factors. The use of advanced technologies, such as 3D modeling and artificial intelligence, enabled detailed assessment of occlusal relationships and helped improve diagnostic accuracy. The study results demonstrate the importance of early identification significantly enhancing the effectiveness of both prevention and treatment of occlusal disorders.

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Introduction

Currently, it has been revealed that violations of occlusive relationships are an urgent problem in practical dentistry [1]. This is due to the high prevalence of pathology, the complexity of therapeutic and diagnostic measures, as well as a significant role in the development and progression of general somatic diseases [2].

The presence of violations of occlusive relationships in patients leads to a decrease in the quality of life, complexity and duration of medical rehabilitation, and requires significant economic costs [3].

The interest of many scientists is devoted to the clinical and diagnostic picture of disorders of occlusive relationships. However, it is necessary to note the importance of preventive orientation, which is a priority in the formation of health protection principles [4,5,6].

In addition, the prevalence of occlusion disorders in young people has increased significantly in recent years, which can be explained by the early formation of lesions of the stomatognathic system as a result of the combined effects of risk factors for the development of pathology. This takes on the character of a socially significant health problem, as it significantly reduces the effectiveness of long-term dental rehabilitation and the quality of life of patients [7].

An urgent direction to reduce the prevalence of violations of occlusive relationships is an individual preventive orientation. This strategy is based on the principle of early detection of risk factors for the development of pathology and determining their degree of influence. This direction will allow us to form a comprehensive diagnostic approach to the management of patients with disorders of occlusive relationships [8,9].

An urgent issue in the development of the scientific orientation of violations of occlusive relationships is compliance with the prenosological principle, which provides for the development and justification of diagnostic methods for early detection of the disease at the upper limit of the norm, including in the absence of symptoms, subclinical picture [10].

The aim of the study was to identify the most significant risk factors for the development of disorders of occlusive relationships in dental patients.

Materials and methods

To achieve this goal, a randomized controlled trial of 120 patients was conducted as part of the grant requirements. The work was carried out on the basis of the Department of Dentistry of the Institute of Continuing Medical and Pharmaceutical Education of the Federal State Budgetary educational institution "Volgograd State Medical University" of the Ministry of Health of the Russian Federation (FGBOU VO VolgSMU of the Ministry of Health of the Russian Federation). The selection of subjects was carried out during the examination of patients on the basis of the state autonomous healthcare institution "Volgograd Regional Clinical Dental Clinic". The study was approved by the Ethics Committee of Volgograd State Medical University (No. 089, 15/04/2024).

Inclusion criteria: Availability of signed voluntary informed consent, Age from 18 to 44 years old, Criteria for non-inclusion, Interpretation of the Hamburg test results in the range from 0 to 1 points, Age less than 18 or more than 44 years, Lack of informed consent from patients, Socially vulnerable groups of the population, Acute infectious diseases and decompensated forms of chronic somatic diseases, Inflammatory periodontal diseases in the acute stage, The presence of a mental illness in the patient, Oncological diseases, Exclusion criteria, The patient's refusal to participate during the study.

As part of the project, a database of occlusive disorders was created based on the examination of 120 patients at risk of developing occlusive disorders or with occlusive disorders of various etiologies and severity based on the short Hamburg test. Basic and additional methods were included in the clinical examination scheme. The main ones included a survey to clarify the nature of complaints, to clarify the development of the disease, an external examination of the maxillofacial region, an examination of the oral cavity and dentition, probing of hard tissues of teeth, palpation of soft tissues, chewing muscles and temporomandibular joint (TMJ).

The additional examination scheme included cone beam computed tomography (CBCT) to visualize the bone structures of the stomatognathic system, ultrasound examination of the TMJ, registration of the ratio of dentition using an occlusogram, as well as electromyography (EMG) of the masticatory muscles.

The method of calculating the symmetry of a person's face was used to analyze bone structures. For these purposes, the data of the CBCT format.dcm (the standard format for presenting 3D X-ray images) was transformed from a set of voxels into a polygonal 3D model in the .stl format using the Invesalius 3.1.1 program. When translating from the data, we were guided by the principle of maximum preservation of bone structures and reduction of noise present on the CBCT data. The selection was made in a manual format. To work with bone landmarks, the following were

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necessarily segmented: lower jaw, zygomatic bones, upper jaws, frontal bone, temporal bones.

To analyze the symmetry on each 3d model, model processing was performed, which includes the search and detection of the main craniometric points: Po – porion (The uppermost point of the external auditory canal), Or – orbital (The lowest point of the edge of the orbit), An - Antegonial notch (The highest point of the antegonial notch of the mandible). Planes were formed based on the selected points: Plane 1 (Frankfurt horizontal) – Or – Po, Plane 2 - An – Or. Thanks to the obtained points and planes, it turned out to form 5 main fragments for analyzing the symmetry of the skull: the upper jaw, the zygomatic bone, the body of the lower jaw, the branch of the lower jaw. For further analysis of articular signs, at this stage, the following were additionally identified: articular processes of the mandible and articular surfaces of the temporal bone.

For further symmetry analysis, mirrored 3D models in the sagittal plane were additionally formed. The resulting copies were superimposed on the original models in the HP 3D Scan program using the maximum matching algorithm, and then deviations in the distances between the original model and its mirrored counterpart in mm were calculated. Based on this information, a color map was formed for better visualization.

For the analysis of the muscular component, the registration of movements of the lower jaw was carried out according to the author's method (patent RU 2817471 C1) and the registration of biopotentials of the masticatory muscles (actually masticatory and temporal).

EMG activity of the masticatory and temporal muscles proper was recorded simultaneously on both sides. In order to remove biopotentials, cutaneous bipolar round electrodes were used, which were fixed at the points of greatest muscle tension, determined by palpation. The amplitude was recorded in MV EMG at rest, maximum fisure-tubercle contact, floating and left laterotrusions.

To assess the state of the TMJ, an ultrasound examination of the TMJ was used with registration of the main parameters of the size of the articular gap using the LOGICSCAN 128 EXT device, as well as a short Hamburg test. Objective methods of its assessment were used by digitizing each of its components to exclude subjective assessment. This method is considered a method of preliminary examination of the TMJ function and includes six questions: Is the mouth opening asymmetrical, Is the opening of the mouth sharply limited or too large, Are intraarticular noises detected, Is the occlusive sound asynchronous, Is palpation of the chewing muscles painful, Is eccentric occlusion of teeth traumatic.

After receiving the test results (from 0 to 6 points, 1 point for a positive answer to each of the questions), it is possible to assess the function of the TMJ: the functional norm is 0-1 points, the risk of dysfunction (risk group) is 2 points, TMJ dysfunction is 3-6 points.

To analyze the teeth and dentition, they were digitized by scanning the jaws and occlusion keys using a 3D scanner. Obtaining digital occlusion registers using the OccluSense system for the diagnosis of occlusion. The obtained digital models were combined with data obtained during the analysis of the kinematics of the mandible to form the results of the analysis of the patient's occlusion: localization of the first contact, distribution of balance in the maximum interlobular position (MMP), the presence of supracontacts and the area of their occurrence, the time spent to achieve MMP, the time of separation on the working side during laterotrusion movement.

After receiving the data from the clinical and functional examination of patients, an exploratory cluster analysis was conducted to determine whether a group of 120 patients contained natural subgroups of similar patients. 40 quantitative indicators were selected ("Is mouth opening asymmetric?", "Is mouth opening sharply limited or too large?", "Are intraarticular noises detected?", "Is occlusive sound asynchronous?", "Is palpation of the chewing muscles painful (Temporal (right, left), Chewing (right, left))?", "Is eccentric occlusion of teeth traumatic?", electromyography at rest (mkV): (10, 11, 12, 13) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left, electromyography in the state of "maximum compression" (mkV): (14, 15, 16, 17) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left, electromyography in the state of "protrusion" (mkV): (18, 19, 20, 21) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left, electromyography in the state of "laterotrusion right" (mkV): (22, 23, 24, 25) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left, electromyography in the state of "laterotrusion left" (mkV): (26, 27, 28, 29) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, The temporal

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muscle on the left, joint gap size (mm): (30, 31, 32, 33, 34, 35) Anterior right, Upper right, Posterior right, Anterior left, Upper left, Posterior left, facial symmetry (mm), angle ANB (°), First occlusal contact (Premolar, Molar), total the area of occlusal contacts), the values of which are available in all patients, a standardization procedure was performed and then a hierarchical cluster analysis of patients by the Word method with the choice of a Euclidean metric was carried out. The use of factor analysis made it possible to conduct an analysis of the main components (GC), designed to identify the structure of the relationship of indicators and verify the uniformity of the clinical contingent.

The statistical analysis was carried out using Microsoft Excel 2016 and Statistica 13.0 programs.

Results

Based on the results of the clinical and functional examination of patients, a wide base of risk factors for the development of disorders of occlusive relationships was formed, we found the results of the relationship of these clinical symptoms, and combined effects were revealed. In addition, data were obtained on the main and secondary risk factors for the development of the pathology under study. The average age of the examined patients was 29.4±3.22 years.

As a result of the examination of patients, quantitative indicators reflecting the state of the stomatognathic system for the identified five main components were obtained (Table 1).

The results of the distribution of persons based on the Hamburg test are presented in Table 2.

Table 1. Clinical and functional quantitative characteristics of the main components of the examined patients.

The parameter of the survey of the main components	Quantitative survey results
Symmetry of the face (("ZR-AGR"-"ZL-AGL") / ("ZR-AGR"+"ZL-AGL")) (mm)	3,32±1,08
ANB Angle (°)	2,34±2,09
The size of the articular gap for TMJ (mm)	
Front right	3,19±1,09
Top right	2,69±0,85
Rear right	2,24±0,7
Front left	3,3±1,04
Top left	1,95±0,77
Rear left	2,41±0,77
Resting electromyography (mkV)	
of the masticatory muscle on the right	47,23±12,66
Chewing muscle on the left	50,87±16,25
The temporal muscle on the right	56±12,18
The temporal muscle on the left	49,18±13,29
Mouth opening value mm	54,52±2,81
Total area of occlusal contacts (mm2)	131,08±40,74

Table 2. The results of the Hamburg test in patients.

Parameter	Number of people, n (%)
Risk of dysfunction (2 points)	45 (37,5 %)
The presence of dysfunction (3-6 points)	85 (62,5 %)

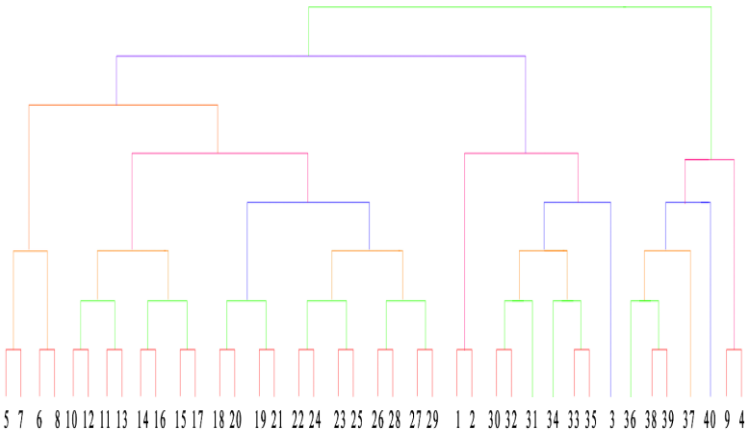

Figure 1. The scheme of the result of the cluster analysis of the main components of the risk of developing disorders of occlusive relationships.
Note: (1) "Is the opening of the mouth asymmetrical?", (2) "Is the opening of the mouth sharply limited or too

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large?", (3) "Are intraarticular noises detected?", (4) "Is the occlusive sound asynchronous?", (5,6) "Is palpation of the masticatory muscles painful (Temporal (right, left), (7,8) Chewing (right, left))?", (9) "Is eccentric occlusion of teeth traumatic?".

Electromyography at rest (mkV): (10, 11, 12, 13) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left.

Electromyography in the state of "maximum compression" (mkV): (14, 15, 16, 17) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left.

Electromyography in the "protrusion" state (mkV): (18, 19, 20, 21) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left.

Electromyography in the state of "laterotrusion right" (mkV): (22, 23, 24, 25) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left.

Electromyography in the state of "laterotrusion left" (mkV): (26, 27, 28, 29) Masticatory muscle on the right, Masticatory muscle on the left, Temporal muscle on the right, Temporal muscle on the left.

Joint Gap size (mm): (30, 31, 32, 33, 34, 35) Front Right, Top Right, Rear Right, Front Left, Top Left, Rear Left.

(36) Facial Symmetry (mm), (37) ANB Angle (°)

(38.39) First contact (Premolar, Molar)

(40) The total area of occlusal contacts.

Discussion

The results of our study emphasize the importance of preventive orientation in identifying risk factors for the development of disorders of occlusive relationships. Interpretation of the results of the Hamburg test shows that a significant part of the examined patients demonstrate pronounced dysfunctions of the musculoskeletal relationship. The average score of the Hamburg test was 3.79±0.73, which indicates the presence of pronounced problems in the field of TMJ.

The conducted exploratory analysis using cluster analysis and principal component analysis (GC) allowed us to identify three main clusters that reflect the structure of relationships between various factors:

The muscle complex covers 60% of all analyzed factors and includes indicators related to electromyography of the masticatory muscles, which indicate the functional state of the muscular apparatus.

The joint complex made up 22.5% of the main components. It includes data on the state of the articular gap, which is important for understanding the mechanics of movement of the mandible and its interaction with the temporal bone.

The jaw complex covers 17.5% of all factors and includes both dental and bone signs, which confirms the need for an integrated approach to the diagnosis and treatment of occlusion disorders.

The results also showed that the parameters related to the size of the articular gap, electromyography of the masticatory muscles and the total area of occlusal contacts are the most informative characteristics, including 68% of the information of all the main components. In addition, the addition of parameters such as facial symmetry and ANB angle revealed statistically significant differences ($p<0.001$) in the classification of patients, increasing the informative value of the analysis to 85%.

The high degree of positive correlation between the functional features of the TMJ and muscle, bone and dental occlusion factors confirms the need to integrate various approaches into the diagnosis and prevention of disorders of occlusive relationships. Thus, the results of our study emphasize the relevance of developing an integrated approach to the management of patients with occlusion disorders, which will not only improve the quality of diagnosis, but also increase the effectiveness of therapeutic measures, which, in turn, can contribute to improving the quality of life of patients and reducing the economic costs of medical rehabilitation.

Conclusion

Timely, accurate and informative identification of risk factors for the development of disorders of occlusive relationships is an urgent task of modern dentistry, which can be solved using various parameters of artificial intelligence. The basis for this is the conducted cluster analysis to find and identify hidden relationships, as well as grouped and dependent on each other clinical and functional parameters of the stomatognathic system. The results obtained will improve the effectiveness of diagnosis and treatment of patients with disorders of occlusive relationships, as well as the quality of dental care provided.

Statement of conflict of interest

The authors declare that there is no conflict of interest.

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Contribution of the authors:
V.V.S. - general guidance, final approval for the publication of the manuscript.
E.N.Y. - data collection, analysis and interpretation of the results
Y.A.M. - development of the concept and editing of the text, final approval for the publication of the manuscript.
D.Y.D. – collection, analysis and processing of the material, writing the text, checking critical intellectual content.
L.M.G. - collection, analysis and processing of material, writing text, checking critical intellectual content;
I.Y. – collection, analysis and processing of material, writing text, checking critical intellectual content;
The authors confirm the compliance of their authorship with the international ICMJE criteria (all authors made a significant contribution to the development of the concept, preparation of the article, reviewed and approved the final version before publication).

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