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PROGNOSTIC MODEL OF PAIN SYNDROME OF TEMPOROMANDIBULAR JOINT DYSFUNCTION IN PATIENTS WITH OCCLUSION-ARTICULATION DISORDERS

Andriy Proshchenko

Bogomolets National Medical University, Kyiv

Andriy Proshchenko - PhD, Associate Professor of Department of dentistry of the Institute of Postgraduate Education Bogomolets National Medical University, Kyiv.
andrey.proschenko@gmail.com, https://orcid.org/0000-0003-0847-1408

Abstract

Resume. Diagnostic efficiency and treatment of TMJ dysfunction was and remains an important problem modern dentistry. The urgency of this problem is determined by the great the prevalence of this pathology, the annual increase in the number of patient appeals, variety of clinical manifestations, significant difficulties in diagnosis and treatment. **The aim of the work** was to predict the pain syndrome of functional disorders of the masticatory apparatus when planning orthopedic treatment. **Research materials and methods.** Clinical and laboratory examination and orthopedic treatment of 150 patients with various variants of occlusal disorders were carried out, in 90 of them functional disorders of the masticatory apparatus were not accompanied by pain syndrome (comparison group), in 60 patients (main group) - TMJ dysfunction with pain syndrome **Research results.** The statistically significant data obtained by us demonstrate that the multi-level mechanism of changes in microarchitectonics due to occlusal and articulatory disorders, the influence of gender and age, and other unmodified factor balance

of the work of muscle-articular structures of the dento-maxillary system can clinically manifest as a pain syndrome, and therefore requires orthopedic treatment taking into account correction of intra-articular disorders. **Conclusions.** Multivariate analysis of the cumulative effect of factors on the risk of pain syndrome development of functional disorders of the masticatory apparatus in case of violation of occlusal-articulatory relations allowed to create a prognostic model (model sensitivity - 0.967%, specificity - 0.971%) with a Youden index of 1.0. This prognostic model can serve as an accurate tool for the development of TMJ dysfunction pain syndrome at the stage of orthopedic treatment planning.

Key words: prognosis; TMJ dysfunction pain syndrome; TMJ intra-articular disorders; occlusal-articulation disorders.

Topicality. The prevalence of this disease is high, and it is usually late diagnosis, long-term treatment allow to attribute this pathology to diseases that have medical and social significance and require prudence in part of timely pre-hospital diagnosis Temporomandibular joint (TMJ) pathology, according to modern research, occurs in 26-67% of the population [1-3].

Temporomandibular joint dysfunction (TMJ) is a pathological condition in which the normal functioning of the joints connecting the lower jaw and the base of the skull is disrupted. The TMJ is highly mobile, providing jaw movements necessary for speaking, chewing food, and other functions. TMJ movement is controlled by muscles that attach to the joint and surrounding tissues. This joint is subjected to a significant load associated not only with the act of chewing, but also with speech, facial expressions and other facial movements. TMJ dysfunction can occur for a variety of reasons, which can lead to joint damage, inflammation, pain, and other disorders.

Pathology of one of the components leads to disturbances in the entire system, which can be compensated or decompensated depending on the severity of the process and individual characteristics of the organism [4-6]. The temporomandibular system is a complex and multifunctional structure in which the muscles, occlusal relations of the upper and lower jaws, TMJ, TM are interconnected. It is a single functional unity that is coordinated by the central nervous system and has stable self-regulation of all functioning parts [7-9].

The consequence of internal disorders of the TMJ is the pain syndrome of dysfunction, disturbances in chewing, speech and other important functions [10-12]. And the root cause of the TMJ and masticatory muscle dysfunction is considered to be a violation of functional occlusion

and parafunction of the masticatory muscles [13]. The etiopathogenesis of TMJ dysfunctional states is widely studied and to the end not studied problem of scientists all over the world today. Polyetiological nature of the disease and its multi-faceted pathogenesis prompt scientists of the world to conduct more and more new research for the purpose of its analysis and study.

Disturbance of the structure leads to a violation of function, but at the same time, functional disorders of the maxillofacial system are a multifactorial pathological process and depend on internal and external modified and unmodified factors: age, gender, malocclusion, the presence and duration of defects of the crown part of the teeth, dentitions of different lengths, maxillofacial deformation, forced position of the lower jaw (permanent functional displacement), excessive abrasion of the chewing surfaces of the teeth, traumatic injuries, systemic pathology of the muscular system. But taking into account the undeniable influence of articulatory and occlusive disorders in the formation of functional disorders of the masticatory apparatus with and without pain syndrome, the identification of these damaging factors remains important for the possibility of developing prognosis, ways of prevention, improving the effectiveness of orthopedic treatment and rehabilitation.

The aim of the research was to predict the pain syndrome of functional disorders of the masticatory apparatus when planning orthopedic treatment.

Research materials and methods. Clinical and laboratory examination and orthopedic treatment of 150 patients with various variants of occlusal disorders were carried out, in 90 of them functional disorders of the masticatory apparatus were not accompanied by pain syndrome (comparison group), in 60 patients (main group) - TMJ dysfunction with pain syndrome. This distribution of the sample of patients is justified by the need, in our opinion, to determine the leading predictors of the occurrence of pain syndrome and to create a diagnostic algorithm of a prognostic model of the development of such a condition already at the stage of planning orthopedic treatment.

Risk factors were identified during a clinical dental examination, anamnestic data. The criteria for inclusion in the study were patients aged 20-80 years, with articulatory and occlusive disorders and with functional disorders of the masticatory apparatus, the patient's consent to participate in the study. Exclusion criteria: injuries, contusions of the maxillofacial region in the anamnesis, severe somatic diseases that formed a premorbid background, refusal of patients to participate in the study.

Statistical analysis was performed in R statistical programming (r-project.org, ver. 4.0). The random forest method was chosen as a multivariate method, which is a whole ensemble of models consisting of many classification and regression trees (CART). The method creates many "equally" good models and then combines them all into one model that has a better ability to classify the data. His algorithm creates sufficiently accurate models, since the ensemble of trees eliminates the instability that can be observed in the case of a single classification tree. Therefore, this ability makes it very robust to noise (variables that have no or very little relationship with the dependent variable). The randomness used in random forests has to do with the choice of both the observations and the variables on which to classify at each node. The method has the ability to correctly classify the data, as well as to identify statistically significant loci that are associated with the disease, as well as to distinguish them from noise (variables that had no or very little influence on the dependent variable). The search for the optimal cutoff value was performed using Youden's J statistic, which is used to find the optimal cutoff threshold for a binary classifier. It is defined as: J=Sensitivity+Specificity−1, where: Sensitivity (TPR) - sensitivity, Specificity - specificity (calculated as 1 - FPR). The optimal cutoff threshold is chosen as the one that maximizes the Youden index. This cut-off value provides the best balance between sensitivity and specificity, minimizing both false-positive and false-negative errors. This method is used to select a threshold that provides the most accurate prediction for a specific classification task, based on the benefits of a balance between different types of errors.

Research is based on ethical standards in accordance with the Helsinki Declaration of the World Medical Association. All questions regarding the possibility of conducting these studies were agreed with the commission on bioethical expertise and ethics of scientific research of the Bogomolets National Medical University, protocol No. 185, 27/05/2024).

The study was carried out as part of the research work of the Department of Dentistry at Bogomolets National Medical University " An interdisciplinary approach in the prevention, treatment and rehabilitation of patients with parodontal diseases and impaired functional occlusion" (state registry № 0123U105134).

Obtained results and their discussion

Age categories of examined patients:

• age 20-39 years – 27 - 45.00% in the main group, against 45 - 50.00% in the comparison group

• age 40-49 years – 19 - 31.67% in the main group, against 18 - 20.00% in the comparison group

• age over 50 years – 14 - 23.33% in the main group, against 27 - 30.00% in the comparison group.

Moreover, 42-70.00% of the main group were women compared to 49-54.44% in the comparison group. The greater prevalence of TMJ dysfunction pain syndrome among women during the menopausal transition may indicate a hormonal component of the development of this condition.

The obtained clinical and anamnestic results indicate the following factors:

• History of orthodontic treatment – 21 - 35.00% in the main group, against 33 - 36.67% in the comparison group,

• Availability of direct and indirect restorations - 57 - 95.00% in the main group, against 74 - 82.22% in the comparison group. Apparently, such percentages in the main group may indicate the irrationality of the pre-treatment and reproduction of occlusal surfaces without taking into account the correction of unrecognized functional disorders of the masticatory apparatus, which they caused.

Risk factors for the development of pain syndrome of TMJ dysfunction revealed during a dental examination:

• functional stable displacement of the lower jaw - 60 - 100.00% in the main group, against 75 - 83.33% in the comparison group, can be significant - 46 - 76.67% in the main group, against 11 - 12.22% in comparison group; or insignificant - 14 - 23.33% in the main group, against 64 - 71.11% in the comparison group;

• decrease in interalveolar height from minimal (less than 0.5mm – 13 - 21.67% in the main group, against 45 – 50.00% in the comparison group), moderate (0.5-2.5mm – 34 - 56.67% in the main group, against 33 - 36.67% in the comparison group) to significant (2.5 mm and more - 13 - 21.67% in the main group, against 9 - 10.00% in the comparison group), which may be a consequence long-term existence of a generalized form of excessive wear of the chewing surface of the teeth and lead to vicarious hypertrophy of the alveolar ridge;

• the presence of supracontacts - 60 - 100.00% in the main group, against 85 - 94.44% in the comparison group, both centric and eccentric, which confirms the theory of violation of occlusal-articulation ratios as a cause-and-effect mechanism for the development of functional

disorders of the maxillofacial system, including with pain syndrome. It should be noted that the installation of supracontacts was in such conditions as the presence of maxillofacial deformations, multiple defects of the tooth rows, excessive wear of the chewing surface of the teeth, irrationally modeled direct and indirect restorations,

• maxillofacial deformities – 25 - 41.67% in the main group, against 44 - 48.89% in the comparison group,

• defects of dental rows – 49 - 81.67% in the main group, against 67 - 74.44% in the comparison group, of which single defects of dental rows and the crown part of teeth - 23 - 38.33% in the main group, against 34 - 37.78% in the comparison group; multiple defects of dental rows - 26 - 43.33% in the main group, against 33 - 36.67% in the comparison group,

• excessive abrasion of the chewing surface of the teeth - 55-91.67% in the main group, against 78 - 86.67% in the comparison group, of which generalized - 37 - 61.67% in the main group, against 40 - 44.44% in comparison group; localized - 18 - 30.00% in the main group, against 38 - 42.22% in the comparison group

• unfixed bite - 38-63.33% in the main group, against 34-37.78% in the comparison group

• bite pathology - 26-43.33% in the main group, against 29-32.22% in the comparison group

• hypertonus and hypertrophy of the masticatory muscles both unilaterally and bilaterally - 49-81.67% in the main group, against 38-42.22% in the comparison group, which were observed simultaneously with the parafunction of the masticatory muscles (15-25.00% in the main group, against 18 - 20.00% in the comparison group), which indicated the predominance of the muscular component of functional disorders of the masticatory apparatus

• crunching and clicking in the TMJ - 43-71.67% in the main group, against 50-55.56% in the comparison group

On the basis of multivariate analysis using the random forest method, the most significant predictors were established, for example, significant or minor displacement of the lower jaw, restriction of mouth opening, decreased interalveolar height, age over 50 years, multiple defects of the dentition, history of orthodontic treatment, presence of direct or indirect restorations, excessive attrition of the dentition (generalized), parafunction of the masticatory muscles , unfixed bite, etc, which all showed their contribution to the classification ability of the prognostic model.

Random Forest is an ensemble machine learning algorithm used for classification and regression tasks. The main ideas of the method include:

• Ensemble decision trees: A random forest consists of many decision trees trained on different samples of input data.

• Bagging (Bootstrap Aggregating): for each tree, a subsample of the original data is randomly selected with return (bootstrap), that is, some objects may fall into the sample several times, and some may not fall into the sample at all.

• Random subset of features: When building each tree node, a subset of features is randomly selected, which adds additional randomness and reduces correlation between trees.

• Voting/Averaging: A random forest uses voting for classification: each tree "votes" for a certain class, and the class with the most votes becomes the model's prediction; For regression, the prediction is the average value over the trees.

The advantages of the random forest method include high accuracy, robustness to overtraining, and the ability to handle large amounts of data and a large number of features.

The ROC curve (Receiver Operating Characteristic curve) - is a graphical tool used to evaluate the quality of binary classifiers and has high specificity and sensitivity.

It is built on the basis of two indicators: True Positive Rate (TPR, sensitivity): the share of correctly predicted positive examples among all real positive examples; False Positive Rate (FPR, specificity): The proportion of incorrectly predicted positive examples among all true negative examples. The graph of the ROC curve is constructed in the coordinates of TPR vertically and FPR horizontally (Fig. 1). The quality of the classifier is evaluated by the area under the ROC curve (AUC – Area Under Curve). The larger the area (maximum - 1), the better the classifier. The sensitivity of our model is 0.967%, the specificity is 0.971%, thus allowing us to calculate the risk of developing a pain syndrome with high accuracy. That was tested on 30 cases of observations.

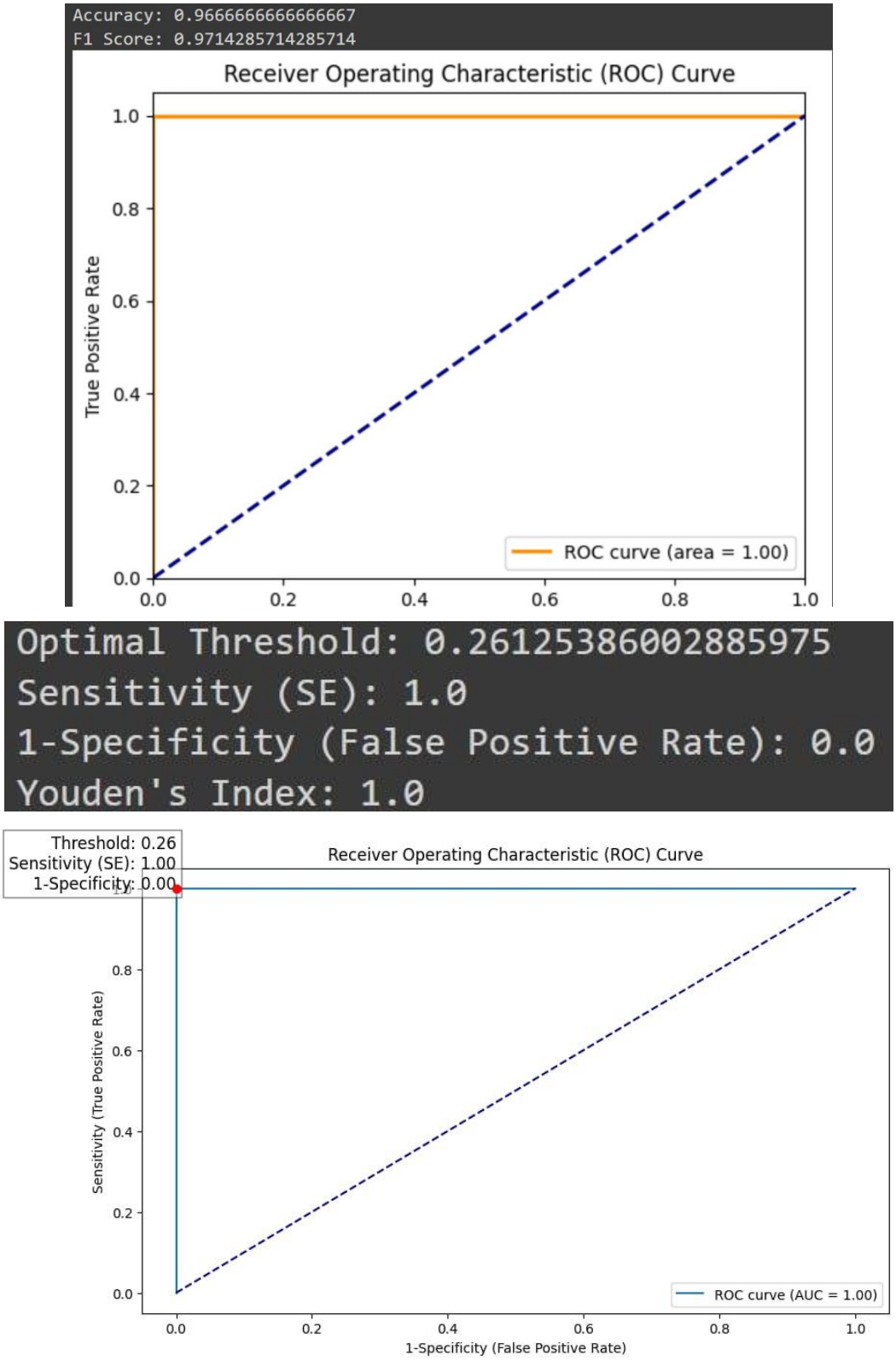

Figure 1 Graph of specificity and sensitivity of the prognostic model on the ROC curve

At the same time, the search for the optimal cut-off value was performed using the Youden's J statistic. It is used to find the optimal cutoff threshold for a binary classifier. The optimal cutoff threshold is chosen as the one that maximizes the Youden index. This cut-off value provides the best balance between sensitivity and specificity, minimizing both false-positive and false-negative errors. This method is used to select a threshold that provides the most accurate prediction for a specific classification task, based on the benefits of a balance between different types of errors.

The statistically significant data obtained by us demonstrate that the multi-level mechanism of changes in microarchitectonics due to occlusal and articulatory disorders, the influence of gender and age, and other unmodified factor balance of the work of muscle-articular structures of the dento-maxillary system can clinically manifest as a pain syndrome, and therefore requires orthopedic treatment taking into account correction of intra-articular disorders.

Based on the obtained clinical results, a prognostic model of the risk of developing a pain syndrome of TMJ dysfunction with articulatory-occlusal disorders was created that is easy to use, does not require additional examination methods, material costs, and allows to justify the need for a personalized application of the algorithm of orthopedic treatment with repositioning of the lower jaw, normalization work of the TMJ and masticatory muscles and the invention of new adapted rational occlusal-articulation ratios for the purpose of treatment and prevention of intra-articular disorders as a distant negative result of orthopedic treatment. The improvement of which is the perspective of our further research.

Conclusions. Multivariate analysis of the cumulative effect of factors on the risk of pain syndrome development of functional disorders of the masticatory apparatus in case of violation of occlusal-articulatory relations allowed to create a prognostic model (model sensitivity - 0.967%, specificity - 0.971%) with a Youden index of 1.0. This prognostic model can serve as an accurate tool for the development of TMJ dysfunction pain syndrome at the stage of orthopedic treatment planning.

References

1. Manfredini D, Arboretti R, Guarda Nardini L, Carrozzo E, Salmaso L. Statistical approaches to orofacial pain and temporomandibular disorders research. New York: Springer-Verlag; 2014. V, 84 p.

2. Laskin D. M., Charles G. S., William L. Hylander Temporomandibular Disorders: An Evidence-Based Approach to Diagnosis and Treatment. Chicago: Quintessence Publ., 2006. 560 p.,

3. Okeson J. P. Management of Temporomandibular Disorders and Occlusion. 7th ed. St. Louis: Mosby, 2012. 504 p.

4. Navratil L, Navratil V, Hajkova S, Hlinakova P, Dostalova T, Vranova J. Comprehensive treatment of temporomandibular joint disorders. Cranio. 2014 Jan; 32 (1): 24-30.

5. Raman P. Physiologic neuromuscular dental paradigm for the diagnosis and treatment of temporomandibular disorders. J Calif Dent Assoc. 2014 Aug; 42 (8): 563-71.

6. Shiga H, Kobayashi Y, Arakawa I, Yokoyama M, Tanaka A. Relationship between pattern of masticatory path and state of lateral occlusal contact. J Oral Rehabil. 2009 Apr; 36 (4): 250-6

7. Sicher IL. Functional anatomy of the temporomandibular joint. In Sarnat, B.G.: The temporomandibular joint. Springfield; 1964:28 – 58.

8. Sinha VP. Efficacy of plain radiographs, CT scan, MRI and ultrasonography in temporomandibular joint disorders. National Journal of maxillofacial surgery. 2012;3(1):2 – 13.

9. Shatrov IM. Electromyographic evaluation of the response of the chewing and temporal muscles to the load as an indicator of the functional adaptation of the dentoalveolar system. Problems of Dentistry. 2016;1(12):103 - 9.

10. Silveira A, Armijo-Olivo S, Gadotti IC, Magee D. Masticatory and cervical muscle tenderness and pain sensitivity in a remote area in subjects with a temporomandibular disorder and neck disability. J Oral Facial Pain Headache. 2014 Spring; 28 (2): 138-46.

11. Suvinen TI, Kemppainen P. Review of clinical EMG studies related to muscle and occlusal factors in healthy and TMD subjects. J Oral Rehabil. 2007 Sep; 34 (9): 631-44.

12. Jonathon R, Kirch DO. Associatean Osteopathic Manipulative Approachto: Temporomandibular Joint Dysfunction Associate Physician Neuromusculoskeletal Medicine. OMM Marshfield Clinic Stevens Point Center Stevens Point, Wisconsin. Presentingat WAOPSF all Seminar. 2015:34 – 8.

13. Sato M, Motoyoshi M, Hirabayashi M, Hosoi K, Mitsui N, Shimizu N. Inclination of the occlusal plane is associated with the direction of the masticatory movement path. Eur J Orthod. 2007 Feb; 29 (1): 21-5.

14. Thumati P, Manwani R, Mahantshetty M. The effect of reduced disclusion time in the treatment of myofascial pain dysfunction syndrome using immediate complete anterior guidance development protocol monitored by digital analysis of occlusion. Cranio. 2014 Oct; 32 (4): 289-99.