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Стаття надійшла 19.03.2023 р.

DOI 10.26724/2079-8334-2024-2-88-123-128

UDC 616.724:616.314.13-001.4]-089.23-036.82-073.178

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## FEATURES OF AXIOGRAMS IN PATIENTS WITH TEMPOROMANDIBULAR DISORDERS AND EXCESSIVE TOOTH WEAR AFTER PROSTHETIC REHABILITATION

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Despite controversial statements about the correlation between temporomandibular disorders and occlusal disorders, most researchers believe that occlusion plays an important role in the etiology of temporomandibular disorders. Excessive tooth wear leads to changes in interdental relationships, insufficient interarch space for restoration or replacement of missing teeth, and positional changes in the mandible. This can result in an increased occlusal vertical dimension after prosthetic treatment, enhancing occlusal load and contributing to symptoms of temporomandibular disorders. In clinical examinations, in addition to the clinical analysis of subjective, objective, and additional methods, the method of electronic axiography with the analysis of functional occlusion in the articulator was employed. A comparative analysis of axiography results in patient groups with increased tooth wear (bruxism) combined with possible other occlusal defects (comparison group) and various forms of temporomandibular disorders: muscular, articulation, combined (main group) before and after occlusal therapy and prosthetic rehabilitation allowed us to establish a significant increase in the quality indicators of axiograms in 78.3 % of patients in the main group out of 37 examined. In the comparison group, the optimal quality of axiogram indicators increased in 83.9 % of patients, compared to 22.6 % before treatment.

**Key words:** temporomandibular disorders, bruxism, increased tooth wear, axiography, occlusal therapy.

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## ОСОБЛИВОСТІ АКСІОГРАМ ХВОРИХ ЗІ СКРОНЕВО-НИЖНЬОЩЕЛЕПНИМИ РОЗЛАДАМИ ТА НАДМІРНОЮ СТЕРТІСТЮ ЗУБІВ ПІСЛЯ ОРТОПЕДИЧНОЇ РЕАБІЛІТАЦІЇ

Незважаючи на дискусійні твердження про взаємозв'язок скронево-нижньощелепних розладів з розладами оклюзії, більшість дослідників вважають, що оклюзія відіграє важливу роль у сукупності етіологічних чинників розвитку скронево-нижньощелепних розладів. Наявність надмірного стирання зубів, призводить до змін в міжзубному співвідношенні, недостатнього міждугового простору для відновлення або заміни відсутніх зубів, а також спричиняє позиційні зміни нижньої щелепи, що може спричинити збільшення оклюзійного вертикального розміру після проведеного ортопедичного лікування, посилювати силові навантаження на оклюзію і сприяти появі симптомів скронево-нижньощелепних розладів. У клінічному обстеженні, окрім власне клінічного аналізу суб'єктивних, об'єктивних та додаткових методів, був задіяний метод електронної аксіографії з аналізом функціональної оклюзії в артикуляторі. Порівняльний аналіз результатів аксіографії в групах дослідження хворих з підвищеною стертістю зубів (бруксизмом) у комбінації з можливими іншими оклюзійними дефектами (група порівняння) та різними формами скронево-нижньощелепних розладів: м'язовими, суглобовими, комбінованими (основна група) до та після оклюзіотерапії та ортопедичної реабілітації дозволив встановити достовірне зростання якісних показників аксіограм хворих основної групи у 78,3 % осіб з 37 обстежених, а у хворих групи порівняння оптимальна якість показників аксіограм збільшилася у 83,9 % осіб, проти 22,6 % осіб до лікування.

**Ключові слова:** скронево-нижньощелепні розлади, бруксизм, підвищена стертість зубів, аксіографія, оклюзійна терапія.

*The study is a fragment of the research project "Metabolic disorders and their impact on the development of combined dental and somatic pathology", state registration No. 0120U002131.*

Temporomandibular disorders (TMD) are a heterogeneous group of conditions affecting the temporomandibular joints (TMJ), masticatory muscles, and associated structures [7, 14]. They have a multifactorial etiology involving systemic, psychosocial, genetic, traumatic, hormonal, neurological factors, and anatomical structure and facial morphology factors [13, 15].

Some studies indicate that the association between TMD and occlusal disorders is insufficiently supported [6, 9, 12]. Despite this fact, most patients with TMD require comprehensive rehabilitation to normalize functional occlusion. Concerning bruxism, several systematic literature reviews suggest that it is more related to mechanical rather than biological causes [1, 10, 11]. Changes in interocclusal relationships can be caused by an increase in the occlusal vertical dimension (OVD) and mandibular repositioning treatment [4]. An increase in OVD may lead to clinical issues such as occlusal overload, muscle hypersensitivity, TMD symptoms, phonetic limitations, and tooth sensitivity. Additionally, increasing or decreasing OVD can cause severe problems such as muscle pain, TMD, headaches, jaw clenching, and teeth grinding. There are no evidence-based recommendations on how to increase the initial OVD in patients with bruxism or TMD. Excessive tooth wear, insufficient interarch space for restoration or replacement of missing teeth, and aesthetic reasons may necessitate prosthetics, leading to positional changes in the mandible and an increase in OVD [2, 5, 8]. The occlusal scheme for extensive rehabilitation in patients with bruxism should be as simple as possible. Patients with bruxism can be treated with occlusal splints. Generally, an occlusal splint is used to treat muscle hyperactivity [6]. Several studies have shown that these splints can reduce bruxism activity during periods of stress. Patients affected by a certain type of bruxism should be provided with a maximally functional occlusal construction, especially when they have already lost part of the tooth structure. Moreover, these restorations should be performed following proper anterior and canine guidance. Therefore, preventive measures such as night or daytime splints are recommended to reduce the risk of failure, especially in patients with bruxism [1, 5, 11]. Practically, the clinician should take a safe and cautious approach to the patient with bruxism requiring prosthetics, using strategies to mitigate the potentially negative consequences of bruxism [2, 12].

The relationship between TMD, bruxism, and prosthetics is a topic that requires further discussion. An important factor in treating patients with bruxism and TMD is the response of the mandibular joints to occlusal therapy followed by prosthetic rehabilitation.

**The purpose** of the study was to identify the features of condylar translation according to axiograms before and after occlusal therapy and orthopedic rehabilitation in patients with temporomandibular disorders and bruxism.

**Materials and methods.** The study included 68 patients, with 31 (45.6 %) male and 37 (54.4 %) female patients aged 21 to 70 years. The patients were divided into two groups: a comparison group and a main group. The comparison group included patients diagnosed only with increased tooth wear (bruxism) combined with possible other occlusal defects (31 individuals). The main group consisted of 37 patients with increased tooth wear (bruxism), possible other occlusal disorders, and various forms of temporomandibular disorders: muscular, articulation, and combined.

Clinical examination of patients involved both subjective and objective methods, including electronic axiography – a graphical recording of the condylar translation amplitude (axiograph – Denar Cadiax Compact2 (Austria) and software (Gamma Dental Software)). Axiography data were analyzed according to the following criteria: quality of axiograms, condylar translation amplitude, discrepancies between excursive and incursive axiographic trajectories, the difference in the beginning/end of the condylar translation, determining the sagittal and transversal condylar inclinations, functional occlusion analysis in an articulator, radiographic methods, and the Spielberger method of determining personal and reactive anxiety.

Statistical analysis of the primary data was conducted using Microsoft Excel and Statistica (2003). The method of relative values analysis – calculation of extensive indicators (results are presented as percentages) – and the method of assessing the reliability of differences in the results of comparative groups were applied. For this, 2x2 tables were constructed, and calculations were made using the chi-squared test (this non-parametric method was chosen because only two groups with different numbers were compared). A statistically significant difference was considered at  $p < 0.05$ . Summary characteristics of qualitative features were performed using relative values expressed as percentages (%).

**Results of the study and their discussion.** To identify possible cause-and-effect relationships between increased tooth wear combined with other occlusal disorders and temporomandibular disorders and, subsequently, to determine the features of therapeutic approaches after diagnosis, depending on the identified disorders and their combinations, patients were grouped into two groups.

Comparison group: subjects with increased tooth wear (bruxism) and occlusal pathology without TMD signs. Occlusal disorders, in addition to increased tooth wear, included orthodontic pathology, pathological eruption of third molars, multiple dentition defects (loss of five or more teeth), secondary dentition defects, iatrogenic pathology, and periodontal tissue diseases. In the comparison group of 31 patients, increased tooth wear without other occlusal pathology was diagnosed only in 3 patients,

constituting 9.7 %. In the other 28 patients of this group, a range of concomitant occlusal disorders was identified.

Main group: subjects with increased tooth wear (bruxism) and temporomandibular disorders. In the main group of 37 patients, only increased tooth wear without other occlusal disorders was diagnosed in 6 patients, constituting 16.2 %. In the other 31 patients of this group, a range of other occlusal disorders was found, among which “orthodontic pathology” prevailed –  $38.7 \pm 8.75$  %, as well as “pathological eruption of third molars” and “iatrogenic pathology” –  $19.1 \pm 6.61$  %, respectively.

Calculations revealed that the frequency of other occlusal disorders in the comparison and main groups is not statistically significant, indicating that other occlusal pathology is not a determining factor in the development of TMD.

Dental rehabilitation of patients was aimed at the complete or partial restoration of functional disturbances in the masticatory muscles and temporomandibular joints and the compensation of lost functions of affected organs or systems (restoration of teeth and dentitions). The effectiveness of treatment is achieved by individualizing therapeutic and rehabilitation measures, which should include the use of therapeutic and diagnostic devices (hard mouth guards, combined mouth guard-prostheses, temporary orthodontic devices). The purpose of these measures is to position the articular discs and mandibular condyles in the optimal position, which is a prerequisite for complete morphofunctional rehabilitation. Adequate restoration of the function of the masticatory apparatus is achieved by remodeling periodontal-muscular and myostatic reflexes using therapeutic-diagnostic devices and gradually transitioning to temporary and, subsequently, to one of the options of permanent prosthetics (removable or fixed). The basis of a treatment plan for increased tooth wear was the diagnosis of static and dynamic occlusion in the habitual bite (central occlusion) and the central jaw relationship. The diagnosis was carried out in an articulator customized for individual function. In the articulator, diagnostic wax modeling of teeth in the central jaw relationship was performed with the reproduction of incisal and canine movement. Occlusal surfaces of masticatory teeth were modeled considering the occlusal compass.

Orthodontic treatment using splintline therapy was conducted in cases of increased tooth wear caused by orthodontic pathology or secondary deformation of dentitions. Occlusal therapy was conducted in the main and comparison groups to reprogram the tone of masticatory muscles and adapt to the modeled therapeutic occlusion in the central jaw relationship. For this purpose, various types of occlusal splints were used as indicated: separating, myorelaxation, repositioning, distraction, and stabilization. After completing occlusal therapy in the study groups, to create a balanced occlusion, occlusion correction was conducted as indicated by: direct restoration of tooth crowns with composite materials using silicone templates based on wax modeling in an articulator; lumineers, veneers, crowns, bridges, and clasp prostheses were used. If the patient refused to continue prosthetic rehabilitation, a permanent occlusal splint was used, intended for continuous use (night, full-time). Based on these principles, treatment of patients with increased tooth wear was carried out individually, considering occlusal and articulation disorders and the presence of temporomandibular disorders.

The functional state of the temporomandibular joints of patients in the study groups after treatment was evaluated based on the axiography of the condylar displacements. Analysis of axiogram indicators in the study groups before and after treatment is presented in Table 1.

Table 1

**Analysis of axiogram indices in patients of study groups before and after treatment**

Study Groups		Number of Patients		Quality		
				Optimal	Average	Poor
Main	Before Treatment	n	37	5	18	14
		%	100.0	13.5	48.6	37.8
	After Treatment	n	37	29	7	1
		%	100.0	78.3***	18.9*	2.7***
Comparison	Before Treatment	n	31	7	15	9
		%	100.0	22.6	48.4	29.0
	After Treatment	n	31	26	5	0
		%	100.0	83.9***	16.1*	0.0**

Note: 1. The percentage was calculated from the total number of patients in the group; 2. Significance of differences in indicators before and after treatment in the study groups \* –  $p < 0.05$ ; \*\* –  $p < 0.01$ ; \*\*\* –  $p < 0.001$

As a result of the treatment, an increase in the quality indicators of axiograms in patients with increased tooth wear and TMD (main group) was noted in 78.3 % of individuals ( $p < 0.001$ ), leading to a significant decrease in patients with poor axiogram quality indicators from 37.8 % to 2.7 % of individuals

after occlusal therapy ( $p < 0.001$ ). Such an increase in the axiogram quality indicators occurred due to a decrease in the mean axiogram quality indicators from 48.6 % to 18.9 % of patients ( $p < 0.05$ ). Significant changes also occurred in patients of the comparison group due to the treatment. Thus, the optimal quality of axiogram indices increased in 83.9 % of individuals after treatment, against 22.6 % of patients before treatment, and the number of individuals with poor quality of axiogram indicators decreased from 29.0 % to 0 % ( $p < 0.01$ ), and with mean quality from 48.4 % to 16.1 % of individuals ( $p < 0.05$ ). A comparative analysis of the deviations in the condylar translation amplitude and analysis of the “beginning/end” of the condylar translation in patients of the study groups before and after treatment are presented in Table 2.

Table 2

**Results of evaluation of the deviations in the condylar translation amplitude and analysis of the “beginning/end” of the condylar translation in patients of the study groups before and after treatment**

Study Groups		Number of Patients (n)/ %			Protrusion/ Retrusion		Mediotrusion		Mouth Opening/ Closing	
					N	>N	N	>N	N	>N
Main	Before Treatment	n	37	A	27	10	15	22	8	29
		%			73.0	27.0	40.6	59.4	21.6	78.4
		n	37	B	21	16	16	21	22	15
		%			56.8	43.2	43.3	56.7	59.5	40.5
		n	37	C	6	31	7	30	5	32
		%			16.3	83.7	19.0	81.0	13.5	86.5
	After Treatment	n	37	A	34	3	33	4	32	5
		%			91.9	8.1	89.2***	10.8***	86.5***	13.5***
		n	37	B	32	5	31	6	33	4
		%			86.5**	13.5**	83.8**	16.2**	89.2**	10.8**
		n	37	C	30	7	23	14	29	8
		%			81.1***	18.9***	62.2***	37.8***	78.4***	21.6***
Comparison	Before Treatment	n	37	A	26	5	19	12	13	18
		%			83.9	16.1	61.3	38.7	41.9	58.1
		n	37	B	22	9	16	15	24	7
		%			71.0	29.0	51.6	48.4	77.4	22.6
		n	37	C	15	16	10	21	14	17
		%			48.4	51.6	32.3	67.7	45.1	54.9
	After Treatment	n	37	A	29	2	26	5	28	3
		%			93.5	6.5	83.9	16.1	90.3***	9.7***
		n	37	B	29	2	28	3	30	1
		%			93.5*	6.5*	90.3**	9.7**	96.8	3.2
		n	37	C	28	3	25	6	28	3
		%			90.3***	9.7***	80.6***	19.4***	90.3***	9.7***

Note: A: Deviations in the condylar translation amplitude in the study groups before and after treatment; B: Condylar translation amplitude in the study groups before and after treatment; C: “beginning/end” of the condylar translation in the study groups ( $N < 0.2$ ) before and after treatment; 1. The percentage was calculated from the total number of patients in the group; 2. Significance of differences in indicators before and after treatment in the study groups \* –  $p < 0.05$ ; \*\* –  $p < 0.01$ ; \*\*\* –  $p < 0.001$

In terms of the condylar translation amplitude, significant positive changes occurred in patients of the main group due to comprehensive treatment. Thus, the normative values for the “protrusion/retrusion” index were determined in 56.8 % of individuals before treatment. The number of such individuals was 86.5 % after treatment ( $p < 0.05$ ). Accordingly, the number of individuals with deviations from the normative values before treatment constituted 43.2 %, and it was 13.5 % after treatment ( $p < 0.01$ ).

For the “mediotrusion” indicator, the number of individuals with the normative values of this indicator constituted 43.3 % before treatment. However, after treatment, it reached 83.8 % of patients ( $p < 0.001$ ), and accordingly, the number of individuals with deviations from the normative values decreased from 56.7 % to 16.2 % of individuals in the main group ( $p < 0.001$ ).

Positive changes also occurred for the “mouth opening/closing” index, normative values of which were detected only in 59.5 % of individuals before treatment, and in 89.2 % of patients after treatment ( $p < 0.01$ ), accordingly, reducing the number of patients with deviations from normative values from 40.5 % before treatment to 10.8 % of individuals after treatment ( $p < 0.01$ ).

Positive changes for the indices of the condylar translation amplitude also occurred in patients of the comparison group. Thus, for the “protrusion/retrusion” indicator, normative values were determined in 71.0 % of individuals before treatment, and in 93.5 % of patients after treatment ( $p < 0.05$ ) and, accordingly, were reduced from 29.0 % to 6.5 % of individuals after treatment ( $p > 0.05$ ).

Similar positive changes in patients of this group occurred for the “mediotrusion” index, namely, the number of patients with normative values increased from 51.6 % before treatment to 90.3 % after treatment ( $p < 0.01$ ) and, accordingly, the number of patients with deviations from normative values decreased from 48.4 % to 9.7 % after treatment ( $p < 0.01$ ). For the “mouth opening/closing” indicator, changes in this group were not confirmed statistically ( $p > 0.05$ ).

The analysis of the results of complex treatment for the evaluation of the deviations of condylar translation amplitude in patients of the main group showed that there were no significant, statistically confirmed changes for the “protrusion/retrusion” indices ( $p > 0.01$ ). However, there is a tendency towards an increase in the number of patients for the normative indicator of this parameter (91.9 % after treatment vs. 73.0 % before treatment).

Statistically significant positive changes for the evaluation of the deviations of condylar translation amplitude in terms of “mediotrusion” and “mouth opening/closing” occurred in patients of the main group. Thus, for the “mediotrusion” indicators, a positive result was achieved in 89.2 % of individuals after treatment compared to 40.6 % of patients before treatment ( $p < 0.01$ ), and for the “mouth opening/closing” indicators in 86.5 % compared to 21.6 % before treatment ( $p < 0.01$ ).

In the comparison group, statistically significant changes for negative indicators of the divergence of condylar translation trajectories were found after treatment only regarding the position of “mouth opening/closing”, namely in 90.3 % of patients after treatment vs. 41.9 % before treatment ( $p < 0.001$ ).

As a result of the comprehensive treatment, it was determined that the normative indicators for the “beginning/end” of the condylar translation in the “protrusion/retrusion” position were present in 81.1% of patients after treatment, compared to 16.3% before treatment ( $p < 0.001$ ), and correspondingly decreased from 83.7% before treatment to 18.9% after treatment ( $p < 0.001$ ).

In terms of “mediotrusion”, the number of patients with normative values increased from 19.0 % of individuals before treatment to 62.2 % after treatment ( $p < 0.001$ ) and, accordingly, it was reduced from 81.0 % before treatment to 37.8 % of patients after treatment ( $p < 0.001$ ). For the “mouth opening/closing” indicators, the number of patients with normative values increased to 78.4 % after treatment vs. 13.5 % of individuals before treatment ( $p < 0.001$ ) and it decreased from 86.5 % to 21.5 % after treatment according to this changed index ( $p < 0.01$ ).

A similar situation applies to patients in the comparison group. Thus, in terms of “protrusion/retrusion”, the number of patients with the normative indicator increased from 48.4 % before treatment to 90.3 % of individuals after treatment ( $p < 0.001$ ); for “mediotrusion” from 32.3 % before treatment to 80.6 % of patients after treatment ( $p < 0.001$ ); for “mouth opening/closing” from 45.1 % before treatment to 90.3 % of individuals after treatment ( $p < 0.001$ ).

As a result of the analysis of the sagittal condylar inclination (SCI) and the transversal condylar inclination (TCI) based on axiography data, it was found that the normative indicators of SCI in the main group of patients were identified in 59.5 % of individuals before treatment, and this number increased to 91.9% after treatment ( $p < 0.01$ ). TCI at “protrusion/retrusion” within normative values was not detected in any patient of the main group before treatment. However, it was normalized in 45.9 % of individuals as a result of complex treatment ( $p < 0.001$ ). According to TCI at “mediotrusion”, normative values were determined in 16.2 % of individuals before treatment and in 83.3 % after treatment ( $p < 0.001$ ). No patient was found with normative TCI values at opening and closing the mouth before treatment. However, their proportion was 40.5 % of the patients after treatment ( $p < 0.001$ ).

In patients of the comparison group, no significant changes were found in SCI indicators before and after treatment ( $p > 0.05$ ). However, positive changes in the indicators of the transversal condylar inclination were established: in patients before treatment at “protrusion/retrusion”, where normative values were determined only in 3.3 % of individuals vs. 45.2 % after treatment ( $p < 0.001$ ); at “mediotrusion”, normative values were determined in 45.1 % of individuals before treatment and in 93.5 % of patients after treatment ( $p < 0.001$ ); no patient was found with normative values at “mouth opening/closing” before treatment but it was found in 41.9 % of individuals after treatment ( $p < 0.001$ ).

The study revealed that the frequency indicators of other occlusal pathology in patients with increased tooth wear (bruxism) without TMD and those with increased tooth wear (bruxism) and TMD did not differ significantly (9.7 % out of 31 and 16.2 % out of 37 individuals, respectively), indicating that other occlusal pathology is not a determining factor in the development of TMD. Therefore, patients with TMD require comprehensive rehabilitation to normalize functional occlusion [6, 8, 10]. Occlusal therapy was conducted to restore functional impairments in the masticatory muscles and TMJ, reprogram masticatory muscle tone, and adapt to the modeled therapeutic occlusion in the central jaw relation for

patients in both study groups [5, 6]. Various types of occlusal splints were used as indicated: separating, myorelaxation, repositioning, distraction, and stabilization [8, 14].

As a result of the treatment, an increase in the quality indicators of axiograms was observed in 78.3 % of 37 patients with increased tooth wear and TMD (main group), reducing the number of individuals with poor-quality axiograms from 37.8 % to 2.7 % after occlusal therapy. In the comparison group, the optimal quality of axiogram indicators increased in 83.9 % of individuals after treatment, compared to 22.6 % before treatment, and the number of individuals with poor-quality axiograms decreased from 29.0 % to 0 % and with average quality from 48.4 % to 16.1 % of patients.

### Conclusion

Excessive tooth wear leads to changes in interdental relationships and insufficient interarch space to restore or replace missing teeth. It causes mandibular repositioning, contributing to the development of temporomandibular disorder (TMD) symptoms.

An important factor in the treatment of patients with bruxism and TMD is the response of the mandibular joints to occlusal therapy followed by prosthetic rehabilitation. Therefore, according to axiography data, it has been proven that the proposed comprehensive treatment approach normalizes functional occlusion and provides complete or partial rehabilitation for patients with bruxism and increased tooth wear, as well as those with increased tooth wear and TMD.

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Стаття надійшла 18.05.2023 р.