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A comprehensive diagnostic analysis of the etiopathogenetic factors in the development of neuromuscular and occlusal-articulatory dysfunction of the temporomandibular joint, caused by prosthetic errors with implant support, and methods of their treatment

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Abstract: *a comprehensive diagnostic approach to the analysis and treatment of neuromuscular and occlusal-articulatory dysfunctional conditions of the temporomandibular joints, caused by irrational implant-supported prosthetics, represents a critical challenge in modern dentistry. In addressing this issue, advanced diagnostic methods were employed, enabling a thorough analysis of the etiopathogenetic factors involved in the development of these conditions. As a result of the data analysis, key factors contributing to the dysfunctions were identified, and a diagnostic protocol was proposed that significantly enhances the accuracy of diagnostics and the quality of treatment. The novelty of the research lies in the creation of a comprehensive diagnostic, analytical, and therapeutic algorithm, which minimizes the risk of treatment errors and improves the prognosis for patient rehabilitation. The relevance and significance of this work are confirmed by the following factors: reduction of the clinical manifestations of temporomandibular joint dysfunction, normalization of compensatory mechanisms that enhance the function of the temporomandibular joint, as well as improvements in the patients' psycho-emotional state and quality of life. The research results demonstrate the potential for widespread application of the proposed diagnostic and treatment methods in global practice, contributing to improved therapy outcomes and the prevention of complications associated with temporomandibular joint disorders.*

Keywords: Diagnostic Imaging; Prosthodontics; Dental Occlusion; Temporomandibular Joint; Temporomandibular Joint Dysfunction Syndrome; Dental Restoration Failure; Occlusal Splints; implant-supported prosthesis.

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Introduction

The problem of neuromuscular and occlusal-articulatory dysfunctions of the temporomandibular joint (TMJ) represents one of the most pressing and complex complications in modern dentistry. Improper implant-supported prosthetics often leads to changes in the stomatognathic system, resulting in significant functional and aesthetic impairments for patients. According to statistics, 10 to 15% of the adult population suffers from various forms of TMJ dysfunction, including those caused by inadequate prosthetics. Women aged 20 to 40 are more prone to these disorders (May, Blatter, Louvrier, & Broome, 2022). The primary manifestations of the pathology include crepitus, clicking during mouth opening, pain in the joint area, and restricted mandibular mobility (Souza, Lima, Souza, Martins, Melo, & Leite, 2020).

Key aspects of diagnosis include both clinical methods (inspection, palpation) and instrumental techniques, such as magnetic resonance imaging (MRI) of the TMJ, computed tomography (CT) of the facial bones, condylography, electromyography, intraoral scanning of the upper and lower jaws, and analysis of occlusal-articulatory relationships using a digital articulator (Scriboni, 2023). Treatment for TMJ dysfunction involves pharmacotherapy, physiotherapy, and orthopedic interventions (Omrani, 2020).

In this context, the study of the etiopathogenetic factors underlying these disorders, as well as the development of a comprehensive diagnostic and therapeutic algorithm, is of particular importance. Analysis of recent studies indicates that improperly performed prosthetics lead to changes in neuromuscular coordination and occlusal interactions, as confirmed by clinical and experimental data (Krzewski, Baranowski, Zubrzycki, Stachurski, & Borowicz, 2020). Contemporary diagnostic and therapeutic approaches to TMJ dysfunction emphasize the need for an integrated approach, combining both clinical and instrumental methods of investigation (Scriboni, 2023).

Nevertheless, despite significant advancements in this field, many aspects remain insufficiently studied. A key aspect of research is identifying specific etiopathogenetic factors contributing to the development of TMJ dysfunction. Recent studies suggest that dysfunctions may be associated not only with mechanical factors but also with neurogenic and vascular components (May et al., 2022). For instance, altered joint biomechanics can lead to secondary changes in muscle activity and neural regulation, complicating the clinical picture and making treatment more challenging (Omrani, 2020).

This study presents a detailed clinical case of a patient with neuromuscular and occlusal-articulatory TMJ dysfunction, which developed due to errors made during the fabrication of implant-supported suprastructures. The patient sought treatment following implant therapy and prosthetic work, presenting with a medial bite and Angle's Class III malocclusion. After prosthetic treatment and selective grinding of the suprastructures and natural teeth, the patient was left without stable static contacts between the teeth, which led to severe pain and muscle spasms in the maxillofacial region. We conducted a comprehensive clinical examination and provided treatment using a myorelaxation-repositioning splint based on Rudolf Slavicek's methodology (Krzewski et al., 2020).

Thus, this research aims to address several issues related to the diagnosis and treatment of neuromuscular and occlusal-articulatory TMJ dysfunctions that arise from improper prosthetics. The findings may contribute to the development of new standards in dental prosthetics and TMJ dysfunction management, ultimately improving patient quality of life and reducing the risk of complications and recurrence in treatment (Scriboni, 2023).

Aim

To develop an algorithm for a series of diagnostic measures and a treatment method for neuromuscular and occlusal-articulatory dysfunction of the temporomandibular joint caused by improper implant-supported prosthetics, aimed at improving clinical outcomes and preventing such complications in the future.

Materials and Methods

A 45-year-old female patient sought consultation at the Department of Prosthodontics, Bogomolets National Medical University. Initially, a visual examination of the face was performed to assess asymmetry. This was followed by a clinical postural diagnosis, after which a photo protocol

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was established to determine the starting point for treatment and for subsequent digital analysis.

The patient was interviewed, and medical history was taken, along with a questionnaire to gather comprehensive and accurate information. A clinical examination was then conducted, which included palpation of the masticatory muscles, temporal, sternocleidomastoid, trapezius, medial pterygoid muscles, and the muscles of the floor of the mouth, as well as palpation of the temporomandibular joints (TMJ) during mouth opening (Migliore, 2023). The degree of mouth opening was assessed using a Gamma dental ruler. A neurological examination of the 12 cranial nerve pairs was also conducted. An intraoral examination was performed to assess the condition of the teeth and existing suprastructures. Condylography was carried out using the Cadiax 4 system (Gamma Dental, Austria), a method for recording and analyzing the parameters of mandibular movements.

The upper and lower jaws were scanned using the Primescan Connect intraoral scanner (Dentsply Sirona, Germany), and bite registration was taken for further analysis using the Amann Girrbach AG digital articulator (Austria) – Artex CT. Electromyography was performed using an 8-channel Bio-EMG-III electromyograph, and the data was analyzed with BioPAK version 8.80 software (BioResearch Associates, Inc., Milwaukee, WI, USA) (Szyszka-Sommerfeld, 2019).

Computed tomography (CT) of the facial bones was performed using the MyRay Hyperion X9 PRO 3D/2D scanner (Cefla S.C., Italy) (Y. Balel, 2023).

To determine the musculoskeletal position of the mandible, an individual deprogrammer made from PEEK and A-silicone (Futar D) was used for bite registration, followed by verification of the reproducibility of this position (Kwang-Ho, Choi, 2017).

Results

The patient visited a private dental clinic 9 months ago with complaints of missing posterior teeth in the lower jaw, which made chewing difficult, as well as a pronounced aesthetic defect in the anterior maxillary teeth. As part of the treatment, dental implants were placed in regions 1.1, 2.1, 3.5, 3.6, 4.6, and 4.7, followed by prosthetics on the implants several months later.

After the completion of the prosthetic phase, the patient began experiencing discomfort during occlusion and pain when chewing in the area of the lower posterior teeth, accompanied by marked muscle discomfort and spasms. To address these symptoms, the dentist repeatedly adjusted the occlusal contacts, but no improvement was observed. These adjustments resulted in the patient's natural teeth being ground down, leading to the loss of occlusal contacts and worsening muscle pain.

To normalize occlusal contacts, the dentist fabricated a direct overlay for the lower teeth using a bis-acrylic composite material, which led to a slight improvement in the patient's condition. However, severe muscle pain and spasms persisted. Subsequently, the patient sought consultation and treatment at the Department of Prosthodontics, Bogomolets National Medical University, where detailed diagnostics were conducted to analyze occlusal relationships and formulate a treatment plan.

Palpation revealed tenderness in the temporal, masseter, and sternocleidomastoid muscles on both sides. Particularly pronounced tenderness was noted in the right masseter and digastric muscles. The sternocleidomastoid muscles exhibited sharp pain when the head was turned to the opposite side of the palpated muscle, leading to significant spasms in the masticatory muscles. During the patient interview, she also reported issues with her vestibular system, manifesting as balance disturbances.

Following axiography, the following results were obtained:

1. Maximum Excursion Distance:
- Protrusion: Right side – 4.39 mm, Left side – 8.97 mm.
- Mediotrusion to the right: Right side – 11.98 mm, Left side – 1.42 mm.
- Mediotrusion to the left: Right side – 1.38 mm, Left side – 9.88 mm.
- Opening/Closing: Right side – 12.43 mm, Left side – 13.65 mm.

Conclusion: Significant asymmetry is observed in protrusive movements, with the right side showing reduced movement compared to the left, which is within normal limits.

2. Reproducibility:
- Protrusion: Right side – 0.05 (3 mm), Left side – 0.09 (3 mm), 0.15 (5 mm).

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– Mediotrusion to the right: Right side – 0.18-0.22, Left side – no data.
– Mediotrusion to the left: Right side – no data, Left side – 0.07-0.11.
– Opening/Closing: Right side – 0.36-0.78, Left side – 0.50-1.32.

Conclusion: Reproducibility is greater on the left side during protrusion and mediotrusion to the left, indicating more stable movements of the left joint, which is within normal limits compared to the right.

3. Retral Stability:
– Protrusion: Right side – 0.01-0.13 mm, Left side – 0.15 mm.
– Mediotrusion to the right: Right side – 0.01-2.01 mm, Left side – 0.01-0.26 mm.
– Mediotrusion to the left: Right side – no data, Left side – 0.01-0.21 mm.
– Opening/Closing: Right side – 0.01-0.24 mm, Left side – 0.01-0.21 mm.

Conclusion: Retral stability shows minor changes in both joints, with greater variability observed on the right side during mediotrusion to the right.

4. SCI and TCI Angles:
– *SCI Angles:*
– Protrusion: Right side – 38.51°, Left side – 28.78°.
– Mediotrusion to the right: Right side – 39.53° (3 mm), Left side – no data.
– Mediotrusion to the left: Right side – no data, Left side – 28.44° (3 mm).
– Opening/Closing: Right side – 41.49° (3 mm), Left side – 36.76° (3 mm).
– TCI Angles:
– Protrusion: Right side – 0.00°, Left side – -0.22°.
– Mediotrusion to the right: Right side – 12.56° (3 mm), Left side – no data.
– Mediotrusion to the left: Right side – no data, Left side – 1.74° (3 mm).
– Opening/Closing: Right side – 3.56° (3 mm), Left side – -2.38° (3 mm).

Conclusion: The SCI and TCI angles indicate significant differences in the inclination and rotation of the joints during protrusion and mediotrusion. However, during opening/closing, the angles are more symmetrical.

5. Start/End Difference:
– Protrusion: Right side – 3.41 mm, Left side – 8.38 mm.
– Mediotrusion to the right: Right side – 1.13 mm, Left side – 0.70 mm.
– Mediotrusion to the left: Right side – 1.18 mm, Left side – 9.80 mm.
– Opening/Closing: Right side – 12.13 mm, Left side – 13.35 mm.

Conclusion: During protrusion, the length of the track from start to end is significantly shorter on the right side. A substantial difference is also noted during mediotrusion to the left. Movements during opening/closing are symmetrical.

6. Maximum Speed:
– Protrusion: Right side – no data, Left side – 7.011 sec.
– Mediotrusion to the right: Right side – 52.22 mm/sec.
– Mediotrusion to the left: Left side – 48.89 mm/sec.
– Opening/Closing: Right side – 58.89 mm/sec, Left side – 52.22 mm/sec.

Conclusion: The maximum speed of movements during protrusion and mediotrusion shows minimal differences.

7. Straightness and Rotation:
– *Kobs Coefficient:*
– Protrusion: Right side – 0.02, Left side – 0.03.
– Mediotrusion to the right: Right side – 0.10.
– Mediotrusion to the left: Left side – 0.02.
– Opening/Closing: Right side – 0.14, Left side – 0.09.
– *Rotation Angle* (*Gamma*):
– Protrusion: Right side – 2.790 over 8.352 sec.
– Mediotrusion to the right: Right side – 5.63°.
– Mediotrusion to the left: Left side – 1.82°.
– Opening/Closing: Right side – 33.03°, Left side – 67.01°/mm.

Conclusion: Deviations in straightness and rotation angles show minor asymmetrical movements. However, during opening/closing, the rotation angles are significantly larger.

Based on the electromyography data of the masticatory muscles in a seated position, the following results were identified:

In the resting state, increased bioelectrical activity was observed in all masticatory muscles,

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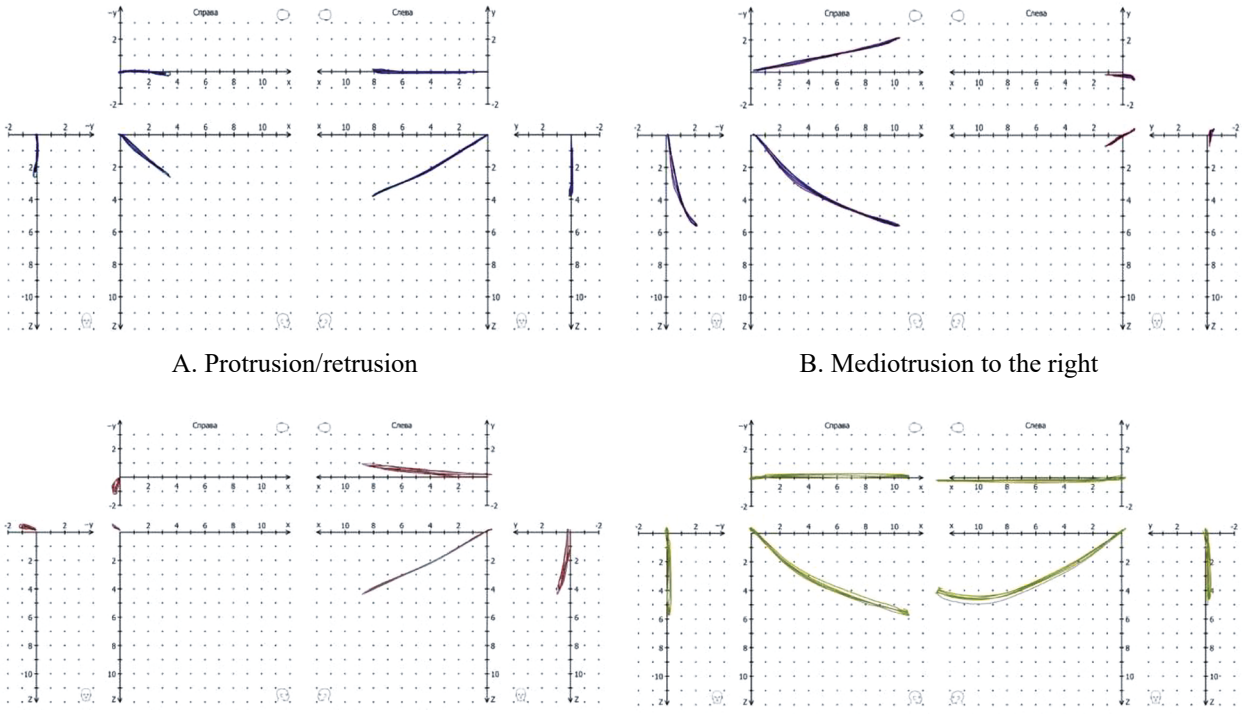

A. Protrusion/retrusion

B. Mediotrusion to the right

C. Mediotrusion to the left

D. Opening/closing

Fig. 1. Recording of movements of the lower jaw obtained using condylography

especially in the right temporal muscle. Periodic sharp increases in muscle activity, accompanied by spasms, were noted.

During tooth clenching, the bioelectrical activity of all masticatory muscles was significantly reduced, with a particularly pronounced decrease in the right masseter muscle. The symmetry of the temporal muscles' function remained high, but the symmetry of the masseter muscles' activity was unsatisfactory: the temporal muscle activity was higher on the right side, while the masseter muscle activity was higher on the left. Muscle activity synchronization was disrupted, with the right temporal muscle being the first to activate, and the right masseter muscle being the last. The spasms that occurred after tooth clenching made it difficult to continue recording.

During chewing, a mixed type of chewing movements was registered. The bioelectrical activity of the temporal muscles and the right masseter muscle was within normal limits, while the activity of the left masseter muscle was moderately reduced. The symmetry of the temporal muscles' function was assessed as satisfactory, while the symmetry of the masseter muscles' function remained low. Temporal muscle activity was higher on the right side, and masseter muscle activity was higher on the left. Muscle synchronization was rated as satisfactory. However, after tooth clenching, spasms reoccurred, complicating the data recording process.

During swallowing, bioelectrical activity readings were satisfactory, although increased activity in the right temporal muscle was observed.

Analysis of cephalometric radiography revealed the following data:

Skeletal characteristics
- Skeletal Class III (severe)
- Maxilla: normal
- Mandible: protrusion (severe)
- Chin: protrusion (severe)
- Mesocephalic type

Dental characteristics
- Class II molar relationship (severe)
- Overbite: anterior crossbite (severe)
- Deep overbite: deep bite (mild)
- Inclination of upper incisors: normal
- Inclination of lower incisors: severe linguoversion
- Interincisal angle: large (severe)
- Incisor exposure: gingival smile (moderate)

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Muscle	State of calm (μV)	Clenching (μV)	Chewing (μV)	Swallowing (μV)	Clenching/Chewing symmetry (%)	Clenching/Chewing synchronicity (ms)
m. TA (R)	6.86	40.7	46.9	39.2	86/61	19.0/0
m. TA (L)	4.64	34.9	28.7	19.9		25.5/89.0
m. MM (R)	2.19	13.6	16.4	10.8	47/45	3329.5/182
m. MM (L)	3.64	28.9	36.1	19.8		570/73.0

Fig. 2. Electromyography data

Soft tissue profile
– Upper lip: severe retrusion
– Lower lip: severe retrusion

After thorough diagnostics and analysis of the data obtained, the occlusal splint was removed from the patient's lower teeth, resulting in the absence of occlusal contacts; the remaining contacts were maintained exclusively on the splint. Subsequently, the upper and lower jaws were scanned using an intraoral scanner, and bite registration was performed in a musculoskeletal stable position. These data were used to position the models of the upper and lower jaws in a virtual, fully adjustable articulator, considering the individual parameters determined

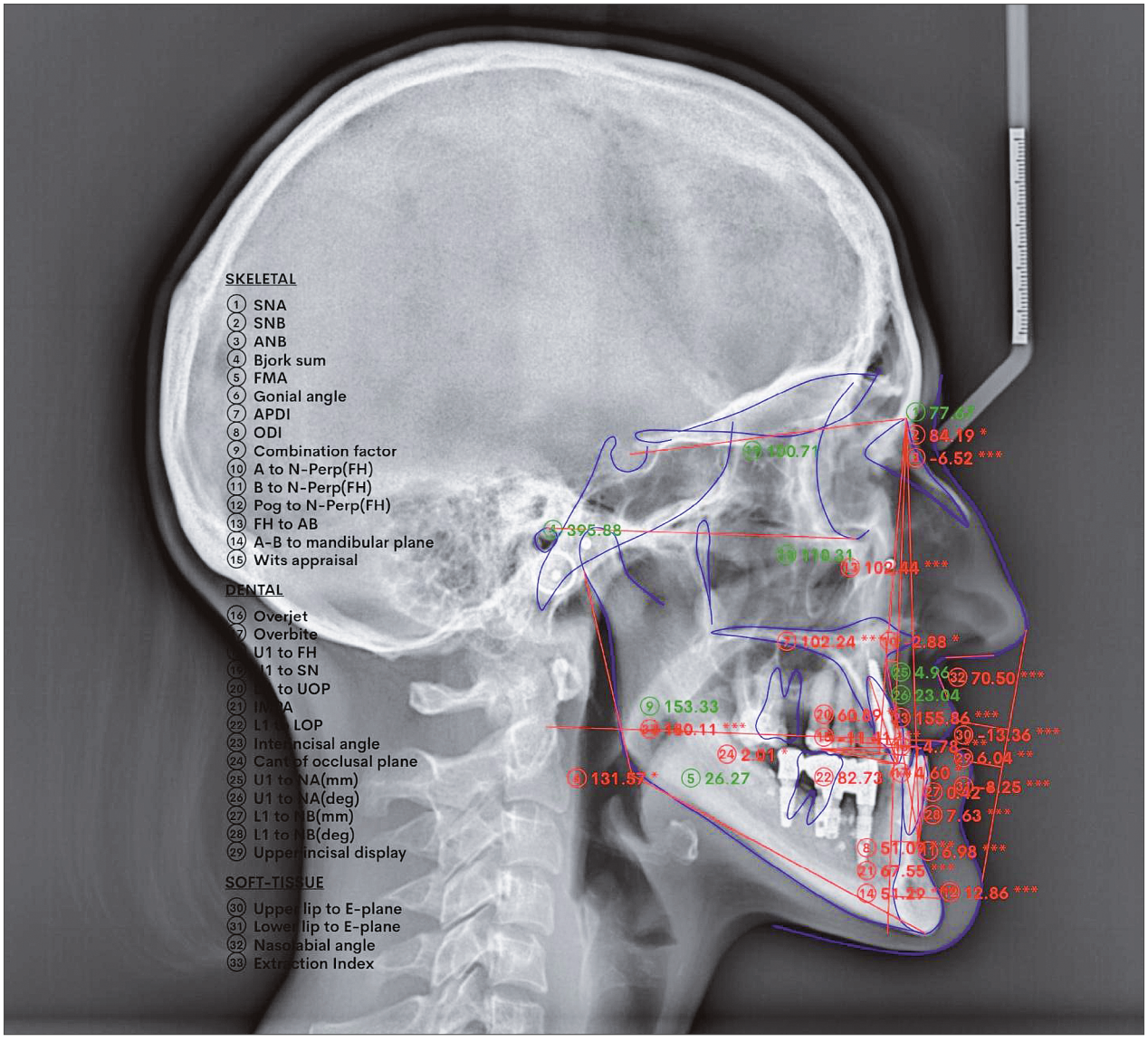

Fig. 3. Cephalometric analysis

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via axiography. The height of the lower third of the face was established based on cephalometric analysis according to Slavicek and the results of the cephalometric radiograph (CR). Based on this data, a repositioning and myorelaxation splint for the upper jaw was fabricated. Two hours after the start of splint use, the patient reported significant relief. Over the next 7 days, the patient experienced substantial relaxation of the masticatory muscles and normalization of vestibular function. Selective grinding of the splint was then performed under conditions of both static and dynamic occlusion. After 3 months of using the splint, the patient reported significant overall improvement, reduced pain levels, and a decrease in spasmodic contractions of the postural and masticatory muscles. The next stage involved the fabrication of temporary suprastructures, 3D-printed from composite material, based on the repositioned position established with the splint.

Conclusions

In this clinical case, a comprehensive diagnostic analysis was conducted on a patient with neuromuscular and occlusal-articulatory dysfunction of the temporomandibular joint, caused by improper prosthetics on dental implants. The diagnostic algorithm revealed significant asymmetry in mandibular movements, major occlusal contact disruption, and high bioelectrical activity of the masticatory muscles, indicating substantial functional impairments.

Axiographic and electromyographic studies demonstrated an imbalance in the function of the temporomandibular joints and associated muscles, with more pronounced dysfunction on the right side. Cephalometric radiography and cephalometric analysis confirmed the presence of a severe skeletal condition, including marked mandibular protrusion and a deep bite.

The treatment algorithm included the fabrication of a repositioning and myorelaxation splint for the upper jaw and the production of temporary suprastructures, resulting in a significant improvement in the patient's overall condition, a reduction in muscle pain, and normalization of vestibular function. To achieve stable and predictable results in similar cases, an individualized approach is required, based on the outcomes of comprehensive diagnostic and treatment algorithms, which help prevent further dysfunction and recurrence.

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This study did not receive external funding.

Conflict of interest

Authors declare no conflict of interest.

Consent to publication

All authors have read the text of the article and article gave consent to its publication.

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

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Комплексний діагностичний аналіз етіопатогенетичних факторів розвитку нейром'язової та оклюзійно-артикуляційної дисфункції скронево-нижньощелепного суглоба, зумовленої погрішностями протезування з опорою на імплантати, та методи їх лікування

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Анотація: *комплексний діагностичний підхід до аналізу та лікування нейром'язових та оклюзійно-артикуляційних дисфункціональних станів скронево-нижньощелепних суглобів, зумовлених нераціональним протезуванням з опорою на імплантати, є критичною проблемою сучасної стоматології. Для вирішення цієї проблеми застосовувалися передові методи діагностики, що дозволили ретельно проаналізувати етіопатогенетичні фактори розвитку цих станів. У результаті аналізу отриманих даних було виявлено ключові фактори, що сприяють розвитку дисфункцій, і запропоновано діагностичний протокол, який суттєво підвищує точність діагностики та якість лікування. Новизна дослідження полягає у створенні комплексного діагностичного, аналітичного та терапевтичного алгоритму, який мінімізує ризик помилок у лікуванні та покращує прогноз реабілітації пацієнтів. Актуальність та значущість цієї роботи підтверджується такими факторами: зменшення клінічних проявів дисфункції скронево-нижньощелепного суглоба, нормалізація компенсаторних механізмів, що покращують функцію скронево-нижньощелепного суглоба, а також поліпшення психоемоційного стану та якості життя пацієнтів. Результати дослідження демонструють потенціал широкого застосування запропонованих методів діагностики та лікування у світовій практиці, що сприяє підвищенню ефективності терапії та профілактиці ускладнень, пов'язаних із порушеннями скронево-нижньощелепного суглоба.*

Ключові слова: діагностична візуалізація, протезування, зубна оклюзія, скронево-нижньощелепний суглоб, синдром дисфункції скронево-нижньощелепного суглоба, несправність зубної реставрації, протезування на імплантатах, оклюзійні шини.