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Article

Modern Approaches to The Diagnosis and Treatment of Temporomandibular Joint Disorders

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Abstract: Temporomandibular joint (TMJ) dysfunction is one of the most common pathologies resulting from disturbances in the function of the temporomandibular joint and its surrounding muscles, ranking third among dental diseases after caries and periodontal disease and affecting approximately 27–75% of the population worldwide. It is characterized by pain, restricted jaw movement, joint sounds, and impaired chewing function, and disproportionately affects women aged 20–40 due to hormonal and psychoemotional factors. This article reviews the etiology, clinical presentation, and modern methods of diagnosing and treating TMJ disorders, with the aim of informing preventive and therapeutic strategies. The review was prepared through a qualitative synthesis of scientific literature retrieved from the PubMed and Google Scholar databases, together with standard textbooks on maxillofacial surgery, focusing on studies addressing etiology, diagnostic imaging, artificial intelligence-assisted diagnostics, the DC/TMD diagnostic criteria, and conservative through minimally invasive treatment approaches. The findings indicate that TMJ disorders are polyetiological, involving predisposing, initiating, and perpetuating factors such as occlusal disturbances, bruxism, trauma, psychological stress, and estrogen-related effects. Diagnostic imaging (CBCT, CT, MRI) and artificial intelligence algorithms substantially improve diagnostic accuracy, while DC/TMD remains the most reliable standardized clinical protocol. Conservative treatment, including physiotherapy, occlusal splints, and pharmacotherapy, is recommended as first-line therapy, with minimally invasive options such as arthrocentesis and platelet-rich plasma therapy reserved for refractory cases. A comprehensive, individualized approach combining these modalities, together with psychological support, offers the most effective strategy for reducing pain and restoring joint function in patients with TMJ disorders.

Keywords: Temporomandibular joint (TMJ) dysfunction, etiology, artificial intelligence (AI)-assisted diagnostics, DC/TMD, platelet-rich plasma (PRP) therapy

Introduction

The temporomandibular joint (TMJ) is a bilateral synovial articulation connecting the mandible to the temporal bone of the skull, and together with the associated masticatory muscles, it enables essential functions such as chewing, speaking, and swallowing. Temporomandibular disorders (TMD) encompass a heterogeneous group of conditions affecting the TMJ, the masticatory muscles, and associated structures, ranging from purely muscular (myogenous) dysfunction to intra-articular disc displacement, degenerative joint disease, and inflammatory arthropathies. Because of this heterogeneity, TMD is best understood not as a single disease entity but as a family of related musculoskeletal and pain disorders sharing overlapping clinical features.

Temporomandibular joint disorders rank third among dental diseases after caries and periodontal disease, occurring in approximately 40–75% of the population worldwide [1]. They mainly affect people aged 20–40, occurring 2–5 times more frequently in women than in men due to hormonal and psychoemotional factors. According to 2025 data, the prevalence of temporomandibular joint dysfunction is 33.8% in Europe, 27.95% in Asia, 27.3% in South America, and 19.4% in North American countries. Among the symptoms of this disease, myalgia accounts for 37.2%, joint clicking for 29.8%, arthralgia for 16.8%, and restricted mouth opening for 8.1%. Beyond these symptom frequencies, TMD carries a substantial burden on patients' daily functioning: systematic reviews using validated oral health-related quality-of-life instruments consistently report that patients with TMD experience significantly poorer physical, psychological, and social well-being than healthy individuals, with the severity of impairment correlating with pain intensity [2].

Historically, TMD was understood primarily through a mechanical lens, with early twentieth-century clinicians such as Costen attributing joint dysfunction largely to occlusal disharmony and loss of vertical dimension. Subsequent decades of research have progressively broadened this view: contemporary conceptual models frame TMD as a biopsychosocial condition in which physical (structural and biomechanical) factors interact with psychological state, behavioral habits, and social context to determine both the onset and the chronicity of symptoms [3]. This shift has direct clinical implications, since it implies that effective diagnosis and management cannot rely on structural findings alone but must also account for the patient's psychosocial profile — a principle later formalized in the dual-axis structure of the DC/TMD system discussed below.

Despite this conceptual progress, diagnosis and management of TMD in everyday clinical practice remain inconsistent. Diagnostic criteria have historically varied across studies and clinicians, complicating comparison of prevalence and treatment-outcome data; imaging technologies of differing sensitivity and cost are used interchangeably without clear guidance; and treatment selection often depends more on clinician preference than on a structured, severity-based algorithm. At the same time, the past decade has introduced substantial innovations — including standardized diagnostic criteria (DC/TMD), advanced imaging modalities such as cone-beam computed tomography (CBCT), artificial intelligence-assisted image analysis, and minimally invasive regenerative treatments such as platelet-rich plasma therapy — that have the potential to make TMD diagnosis and treatment more precise, reproducible, and individualized.

Against this background, the present article reviews the etiology, clinical presentation, and modern diagnostic and treatment approaches for TMJ disorders, with particular attention to how standardized diagnostic criteria, imaging and artificial intelligence-assisted technologies, and a stepwise conservative-to-minimally-invasive treatment framework can together inform more consistent, evidence-based clinical decision-making.

Materials and Methods

This article was prepared as a narrative literature review on the etiology, diagnostics, and treatment of temporomandibular joint disorders. Foundational anatomical and surgical background was drawn from standard textbooks on surgical dentistry and maxillofacial surgery [4], [5]. The literature search was conducted using the PubMed and Google Scholar databases, without restriction

on publication date, to capture both classic etiological studies and recent (2019–2025) systematic reviews and meta-analyses addressing diagnostic imaging, artificial intelligence-assisted diagnostics, the DC/TMD diagnostic criteria, and conservative through minimally invasive treatment approaches. Search terms included combinations of "temporomandibular joint disorder," "TMJ dysfunction," "etiology," "diagnosis," "artificial intelligence," "DC/TMD," "platelet-rich plasma," and "arthrocentesis." Sources were selected for relevance to the review's scope and synthesized qualitatively; no statistical meta-analysis was performed as part of this review, and quantitative findings reported below (e.g., diagnostic accuracy, treatment effect sizes) are drawn directly from the cited primary and secondary sources.

Results

Etiology and Risk Factors

The cause of a disease plays a crucial role in its treatment; when the etiology [6] of a disease is accurately identified, the patient's recovery rate is higher. Temporomandibular joint disorders belong to the group of polyetiological diseases, in whose development several groups of factors play an important role. These are divided into factors that increase predisposition to TMJ disorders (predisposing factors), factors that trigger the disease (initiating factors), and factors that delay recovery or intensify disease progression (perpetuating factors). In some cases, a single cause may encompass all of these categories. Common causes of TMJ disorders include occlusal defects, macrotrauma and microtrauma, poor general health, improper nutrition, defects related to orthodontic treatment, bruxism, poorly made prosthetic constructions, and elevated estrogen levels. In addition, social and psychological factors [7] are also of great importance in the development of the disease. These factors include psychological tension, chronic stress, anxiety, and depression, which lead to increased muscle spasm and parafunctional habits (such as biting pens, pencils, or nails, and bruxism). Some studies have also examined the relationship between sleep disturbance and depression in the emergence of TMJ disorders. Another important causative factor is occlusion. James B. Costen concluded that a decrease in the vertical distance between the teeth, related to occlusion, was a cause of TMJ dysfunction. Today, occlusion is considered a predisposing, initiating, and perpetuating factor in the development of the disease.

Initiating factors of the disease include:

Behavioral factors: teeth grinding, forcefully clenching the upper teeth against the lower teeth (clenching), as well as social, emotional, and cognitive factors.

Perpetuating factors are mainly related to occlusion. Examples include an open bite, a shift of 4 mm or more between RCP (retruded contact position) and ICP (intercuspal position), and the loss of 5 or more posterior teeth. In addition, patients with occlusal disturbances more frequently experience headaches and a higher frequency of headache recurrence.

The effect of estrogen [8] on temporomandibular joint disorders has not been fully studied, but some research has shown its role. As with other joints, the main effect of estrogen on the TMJ is related to the presence of estrogen-sensitive ERα and ERβ receptors, which alter pain signaling in the central and peripheral nervous systems—that is, they increase nerve sensitivity to pain. Estrogen is also thought to affect inflammatory mediators by stimulating the production of interleukin-1β, interleukin-6, and tumor necrosis factor-alpha (TNF-α), which intensify cartilage degradation, damage the articular disc, alter collagen synthesis, and reduce proteoglycan levels, thereby decreasing the mechanical resistance of the cartilage.

Clinical Presentation

Before making a diagnosis, the presence or absence of disease symptoms was determined. The most common symptom of TMJ disorders is pain in the joint or masticatory muscle region, which typically intensifies during chewing, speaking, or wide opening of the mouth. The pain may be unilateral or bilateral and may radiate to the temple, ear, face, and neck regions.

Patients with TMJ disorders experience restricted mouth opening, difficulty in mandibular movement, and in some cases temporary jaw "locking." Due to displacement of the intra-articular disc or degenerative changes, grinding, clicking, or crepitation sounds may be heard during mouth opening and closing.

Other common symptoms of the disease include fatigue and stiffness of the masticatory muscles—especially morning muscle pain—headache, tinnitus (ringing in the ears), a sensation of ear pressure, and dizziness. Although clinical examination plays the primary role in diagnosing these clinical signs, additional methods are also needed to establish an accurate diagnosis. Today, magnetic resonance imaging (MRI), computed tomography (CT), orthopantomography (OPG, plain panoramic radiography), and cone-beam computed tomography (CBCT) are widely used.

Diagnostic Imaging

Because plain panoramic radiography provides only a two-dimensional image, it does not show the complete anatomy of the joint; therefore, it is used mainly to assess the disease at its early stage. CT and CBCT, on the other hand, allow precise assessment of bony components and joint condition. Using CBCT [9], changes in the TMJ head—including erosion, ankylosis, osteophytes, subchondral sclerosis, and osteochondrosis—can be identified. MRI provides more information about soft tissues, especially the condition of the articular disc: anterior disc displacement, deformation, intra-articular fluid, and inflammatory processes.

Artificial Intelligence-Assisted Diagnostics

In recent years, the use of artificial intelligence technologies has been advancing. In TMJ disorders, AI algorithms automatically detect and evaluate pathological changes on CBCT, MRI, and CT images. In a systematic review and meta-analysis conducted by Jha, Lee, and Kim [10], existing scientific studies on AI-assisted TMD diagnostics were evaluated. This analysis included 17 scientific studies examining the diagnostic performance of AI models. According to the results, the diagnostic accuracy of artificial intelligence algorithms ranged from 84–99.9%, and specificity ranged from 73–100%. The overall meta-analysis found that the average diagnostic accuracy of AI systems in detecting TMJ disorders was 91%. Various artificial intelligence algorithms were used in these studies. One of the most commonly used methods is convolutional neural networks (CNN), primarily used for the automatic analysis of CBCT, MRI, and X-ray images. Artificial neural networks (ANN), Support Vector Machine (SVM), Decision Tree, and other machine learning algorithms have also been applied in the diagnostics of TMJ disorders. Researchers have further explored CBCT-based artificial intelligence diagnostics in depth. In one such study, 150 CBCT images were analyzed using a CNN model. The images were divided into categories of healthy joints, mild TMJ disorders, and severe TMJ disorders. The results showed that the AI model achieved 92.4% accuracy [11], 90.8% sensitivity, and 93.7% specificity in distinguishing between these categories. ROC analysis yielded an AUC of 0.95, indicating high diagnostic reliability of the model.

Through the automatic detection of these signs, AI enables earlier detection of diseases, faster clinical decision-making, and additional diagnostic support for physicians. In addition, AI-assisted analysis of CBCT images reduces variability due to human factors. In researchers' studies, a high level of agreement ($\kappa = 0.89$) was found between AI conclusions and expert radiologist assessments, indicating that AI systems can be used as a helpful tool in clinical practice.

DC/TMD Diagnostic Criteria

Another diagnostic system that is currently the most widely used and internationally recognized for identifying temporomandibular joint disorders is DC/TMD [12] (Diagnostic Criteria for Temporomandibular Disorders). These criteria were developed in 2014 as an improved version of the RDC/TMD system and enable a comprehensive clinical and psychosocial assessment of TMJ disorders. DC/TMD consists of two main components. Axis I focuses on clinical diagnosis and is based on the patient's complaints, history, and physical examination findings. At this stage, pain-related disorders (myalgia, myofascial pain, arthralgia, and TMD-related headache), disc displacements, and degenerative joint diseases are identified. Axis II is used to assess the patient's

psychosocial status and examines pain intensity, stress, depression, anxiety level, and the disease's impact on quality of life. During examination under the DC/TMD protocol, mouth-opening amplitude is measured, the masticatory muscles and joint area are palpated, jaw movements are assessed, and joint sounds are identified. When necessary, imaging methods such as MRI and CBCT are used. According to research findings, DC/TMD criteria have high diagnostic accuracy in identifying pain-related TMJ disorders, with sensitivity above 86% and specificity above 98%. For this reason, the DC/TMD system is currently recommended as the main diagnostic standard for diagnosing TMJ disorders.

Treatment Approaches

The main goal of treating TMJ disorders is to reduce pain, restore jaw function, and improve the patient's quality of life. Treatment [13] is selected according to the patient's condition, and accordingly treatment methods are divided into several groups. Currently, the most commonly used approaches include physiotherapy, occlusal splinting, pharmacological treatment, psychological therapy, arthrocentesis, PRP therapy, and manual therapy. Modern clinical guidelines emphasize that conservative treatment methods should be the first choice [14] for the majority of patients with TMJ disorders. According to studies and clinical guidelines published between 2020 and 2024, conservative approaches are effective in reducing pain and improving function in most patients, while surgical methods are recommended only in severe cases.

The first stage of conservative treatment consists of patient education and the elimination of harmful habits. Patients are advised to limit hard foods, avoid chewing gum, avoid excessive mouth opening, and reduce stress. Recent studies show that lifestyle changes and self-management strategies reduce pain intensity and lower the risk of symptom recurrence in many patients. Physiotherapy [13] is an important component of TMJ disorder treatment, including therapeutic exercises, manual therapy, massage, heat treatments, and other rehabilitation methods. According to studies from 2023–2024, physiotherapeutic treatments are effective in reducing pain and improving mouth-opening amplitude.

Occlusal splints [15] are widely used in cases associated with bruxism and excessive load on the muscles. According to research findings, occlusal splint therapy has a positive effect in reducing pain and muscle tension associated with TMJ disorders, especially in patients with nocturnal bruxism. Splints reduce the pressure placed on the joint, normalize muscle activity, and alleviate pain syndrome. Pharmacological treatment involves the use of nonsteroidal anti-inflammatory drugs, muscle relaxants, and in some cases antidepressants. These medications play an important role in reducing pain and inflammation and provide short-term symptomatic control. In certain cases, local injection therapy—including hyaluronic acid [16], corticosteroids [13], or platelet-rich plasma (PRP)—may be used.

PRP therapy [17] is platelet-rich plasma obtained from the patient's own blood, which stimulates tissue regeneration through growth factors (PDGF, TGF-β, and others). In TMJ disorders, PRP is injected into the joint with the primary goal of reducing inflammation and improving joint function. According to 2025 scientific sources, 31 studies involving 1,359 patients were analyzed, and the results showed that six months after PRP therapy, pain was significantly reduced and mouth-opening volume improved by 2.16 mm and 2.56 mm. PRP therapy is also frequently used following arthrocentesis procedures.

Arthrocentesis [18] is a minimally invasive treatment method for TMJ disorders, in which the joint cavity is irrigated with physiological saline solution to remove inflammatory mediators and degradation products. This invasive method is used in cases of disc displacement, restricted joint mobility, and when conservative treatment is ineffective. The combined use of arthrocentesis and PRP therapy [17] has produced effective results. This can be seen in a 2024 study that analyzed 12 randomized controlled trials; the results showed that the pain score decreased by 0.96 points at 1 month and by 1.61 points at 6 months, while maximum mouth opening improved by more than 2.98 mm at 6 months.

Discussion

The findings of this review indicate that TMJ disorders cannot be reduced to a single structural or biomechanical cause. The high prevalence figures reported globally, together with the marked female predominance, are consistent with a multifactorial model in which hormonal, psychological, occlusal, and traumatic factors interact rather than act independently. This has a direct clinical implication: a diagnostic work-up that focuses only on occlusion or only on joint imaging is likely to miss important contributing factors, particularly the psychosocial dimension captured by Axis II of the DC/TMD system.

Comparing the diagnostic approaches reviewed, clinical examination remains the cornerstone of TMD diagnosis, but the reported diagnostic performance of imaging and AI-assisted methods suggests they are best understood as complementary rather than competing tools. CBCT and CT provide precise assessment of bony change, MRI is superior for soft-tissue and disc evaluation, and AI algorithms applied to these images achieve diagnostic accuracy comparable to experienced radiologists while potentially reducing inter-observer variability. However, the AI studies reviewed are largely retrospective and based on relatively small, single-center image sets, so their reported accuracy should be interpreted as a proof of concept rather than as evidence ready for unsupervised clinical deployment.

The treatment evidence reviewed supports a stepwise model of care. Conservative, reversible interventions — patient education, physiotherapy, occlusal splints, and pharmacotherapy — are consistently reported as effective first-line options and are recommended before more invasive procedures. Minimally invasive options, particularly arthrocentesis and platelet-rich plasma injection, show measurable improvements in pain and mouth-opening amplitude, and their combined use appears more effective than either technique alone. This pattern is consistent with the general principle that treatment intensity should be escalated only when conservative measures fail, rather than applied uniformly to all patients regardless of severity.

The evidence on psychological factors deserves particular emphasis. Because stress, anxiety, and depressive symptoms are consistently overrepresented among patients with TMJ disorders, purely mechanical treatment strategies that do not address psychosocial contributors are unlikely to achieve durable results in this subgroup. This reinforces the practical value of the DC/TMD Axis II assessment as a screening step that can guide referral to psychological support alongside dental and physical therapy.

Because psychological factors also play an important role in the development of TMJ disorders, stress management, relaxation techniques, and cognitive-behavioral therapy increase the effectiveness of treatment. Recent studies have shown that stress, anxiety, and depressive symptoms occur significantly more often in patients with TMJ disorders than in healthy individuals. For this reason, psychological support is an important part of comprehensive treatment. When conservative treatment does not provide sufficient results, minimally invasive surgical methods such as arthrocentesis and arthroscopy may be used.

Thus, a comprehensive and individualized approach is the most effective way to treat TMJ disorders. The combined use of physiotherapy, splint therapy, pharmacological treatment, and psychological support serves to reduce pain and restore joint function.

This review has several limitations. As a narrative rather than systematic review, the selection of sources was not governed by a pre-registered protocol, and publication bias in the underlying primary studies cannot be excluded. Quantitative figures reported throughout (e.g., diagnostic accuracy percentages, mouth-opening improvements) are drawn from heterogeneous study designs and patient populations and should not be directly compared across studies as if derived from a single dataset. Future research should prioritize prospective, multicenter validation of AI diagnostic models and longer-term follow-up of combined arthrocentesis-PRP protocols to clarify their durability beyond six months.

Conclusion

Temporomandibular joint (TMJ) disorders are among the most common musculoskeletal pathologies encountered in dental practice. Studies show that the development of these disorders is not attributable to a single cause but rather to the interaction of several etiological factors. Psychoemotional stress, bruxism, traumatic effects, occlusal disturbances, imbalance in muscle function, hormonal factors—particularly the effect of estrogen—and degenerative and inflammatory processes in the joint are noted as the main factors in the development of TMJ pathologies. Modern diagnostic approaches play an important role in identifying the disease. Currently, the DC/TMD diagnostic criteria are the most reliable and standardized system used in clinical practice. This system enables a comprehensive assessment of the patient's complaints, clinical examination findings, and psychosocial state. Imaging diagnostic methods, including panoramic radiography, computed tomography (CT), cone-beam computed tomography (CBCT), and magnetic resonance imaging (MRI), are of high diagnostic value in detecting changes in the bone and soft tissues of the joint. In recent years, the application of artificial intelligence technologies in analyzing CBCT images has served to increase diagnostic accuracy and optimize the physician's workflow. Treatment strategy is chosen based on the etiology, clinical form, and severity of the disease. Conservative treatment methods are recommended as first-line therapy and include patient education, behavioral therapy, physiotherapy, therapeutic exercises, occlusal splints, and pharmacotherapy. Manual therapy is an effective adjunctive method for hypertonicity of the masticatory muscles and facial muscle pain. For intra-articular joint pathologies, arthrocentesis is one of the minimally invasive and effective treatment methods. Platelet-rich plasma (PRP) therapy, a promising direction in regenerative medicine, allows for reducing pain, improving joint function, and stimulating tissue healing processes. Thus, TMJ disorders are complex pathologies with a multifactorial etiology, and a comprehensive, individualized approach is required for their successful treatment. The harmonious application of modern diagnostic criteria, advanced imaging technologies, and conservative, minimally invasive, and regenerative treatment methods allows for improving patients' quality of life and achieving long-term clinical outcomes.

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