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Relationship between Temporomandibular Joint Disorders and Orthodontics- Current Insights

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ABSTRACT
Temporomandibular disorders (TMDs) include musculoskeletal and neuromuscular conditions affecting the temporomandibular joint (TMJ), arising from multifactorial causes such as anatomical, pathophysiological, genetic, and psychosocial influences. Their association with orthodontic therapy has been a subject of longstanding debate. This paper reviews historical viewpoints, TMJ anatomy, and contemporary evidence to elucidate the orthodontics–TMD relationship. Epidemiological research indicates that signs of TMD are prevalent among healthy individuals and increase with age, implying a coincidental rather than causal association during orthodontic treatment. Longitudinal research consistently demonstrates that orthodontic interventions—such as extractions, appliances, elastics, and orthognathic surgery—neither initiate nor exacerbate TMD, nor reliably prevent it. In some cases, orthodontic correction improves muscular TMD symptoms. Overall, orthodontics should be viewed as restoring dental harmony, while TMD management requires accurate diagnosis and conservative therapy.
Keywords: *Temporomandibular disorders (TMDs), temporomandibular joint, conservative therapy*

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INTRODUCTION

The temporomandibular joint (TMJ) is a specialized anatomical structure distinguished by the presence of a fibrocartilaginous, avascular articular disc. Classified as a diarthrodial ginglymoid joint, it is formed where the bilateral condyles of the mandible articulate with the concave fossae of the temporal bone, situated anteriorly to the ear. This articulation permits movement along both transverse and vertical planes. The two TMJs operate simultaneously in coordination with the dentition, occlusal forces, and masticatory musculature to sustain the integrity of the stomatognathic system. A compromise in any one of these elements can adversely affect overall joint function.

Several characteristics make the TMJ anatomically and functionally distinctive:

1. The TMJ serves as a growth center and undergoes adaptive remodeling throughout an individual's lifespan.
2. It represents a paired synovial articulation connecting the mandible to the temporal bone, with both joints operating in synchronized harmony.
3. As a ginglymoarthrodial joint, it is uniquely capable of performing both rotational and translatory movements — a combination found in no other joint in the human body.
4. An avascular fibrocartilaginous disc occupies the joint space, physically separating the condylar head from the temporal bone.
5. This articular disc is not a static structure; its position and movement are actively governed by the lateral pterygoid muscle during mandibular function.
6. The TMJ does not function in isolation — it is integrally connected to the broader stomatognathic system, requiring precise coordination among occlusal forces and surrounding musculature for normal operation.
7. Functionally, the joint plays an indispensable role in vital activities including mastication and speech production.
8. Optimal TMJ performance depends on the seamless interaction among the articular disc, the osseous components of the joint, and the muscles responsible for controlling jaw movement.

HISTORICAL PERSPECTIVE

Over the course of the last five decades, the orthodontic profession has undergone a significant evolution in its perception of temporomandibular disorders, moving from treating them as a peripheral issue to recognizing them as a matter of considerable clinical importance. Thompson [1-3] was among the earliest to note that patients presenting with atypical vertical jaw dimensions appeared to be at greater risk of developing temporomandibular joint complications, bringing attention to the necessity of achieving appropriate vertical dimension. Building on this foundation, Graber [4-5] broadened the conceptual framework surrounding these disorders by acknowledging their multifactorial nature, incorporating elements such as psychological stress, nocturnal bruxism, and emotional influences, while also cautioning practitioners against overly rigid or mechanically driven treatment philosophies. Ricketts [6-9] further advanced the field through comprehensive investigations involving more than 400 subjects, through which he underscored the fundamental role that musculature plays in the overall function of the jaw joint. Despite these cumulative contributions, the orthodontic community was relatively slow to fully integrate temporomandibular disorder research into mainstream practice. It was not until the close of the 1980s that a wave of emerging studies elevated TMDs to a position of central relevance within dental healthcare, a shift that mirrored a wider movement in medicine toward more holistic and patient-centered approaches to care.

ANATOMY 0F THE TMJ

- The temporomandibular joint is a bilateral synovial diarthrodial joint that operates in a synchronized manner on both sides. Its structure encompasses several key elements, including the articular eminence, glenoid fossa, mandibular condyle, articular disc, supporting ligaments, synovial lining, joint capsule, and associated extracapsular ligaments.
- The condyle itself has an ovoid morphology and is surfaced by fibrocartilaginous tissue, with its dimensions spanning approximately 15 to 20 mm in the mediolateral plane and 8 to 10 mm in the anteroposterior direction. Positioned between the condylar head and the temporal bone is the articular disc, which adopts a biconcave configuration and is anatomically described in three regions — the anterior band, intermediate zone, and posterior band — all consisting of avascular fibrocartilage. The joint is lubricated by synovial fluid, with the superior compartment holding an average volume of around 1.2 ml and the inferior compartment approximately 0.9 ml, both sustained under conditions of negative intra-articular pressure [10,11].
- Unlike other joints, the TMJ permits both rotational and translational movements. Rotation occurs in the early phase of mandibular opening within the inferior joint space, while translation begins as the condyle moves against the articular eminence, even at the onset of opening.

FUNCTIONAL ANATOMY OF TMJ

- The temporomandibular joint is formed at the articulation between the condylar process of the mandible and the squamous portion of the temporal bone. In terms of dimensions, the mediolateral width of the condyle is roughly double that of its anteroposterior measurement. The mandibular fossa, also referred to as the glenoid fossa, is defined anteriorly by the articular eminence, medially by a relatively narrow bony wall, and posteriorly by the postglenoid process. Situated just posterior to this region is the squamotympanic fissure, which subsequently divides into the petrotympanic and petrosquamosal fissures.
- These fissures serve as a passage for the chorda tympani nerve and the anterior tympanic vessels, which are naturally shielded from condylar compression by this anatomical arrangement. Notably, the roof of the glenoid fossa is quite thin and is not designed to withstand loading forces; rather, it is the articular eminence that bears both functional and parafunctional forces transmitted through the joint. Another distinguishing feature of the temporomandibular joint is the nature of its articular surfaces — unlike the majority of synovial joints whose surfaces are lined by hyaline cartilage, those of the TMJ are composed of dense, fibrous, avascular connective tissue.
- The capsule encases the eminence and is reinforced laterally by the temporomandibular ligament, limiting retrusion and defining the reproducible "ligamentous position," similar to centric relation. The articular disc, adaptive under pressure, distributes forces and aids lubrication. Proteoglycans, particularly aggrecan, enhance hydration and resilience, cushioning compressive loads.

TEMPOROMANDIBULAR JOINT DISORDERS

Temporomandibular disorders encompass a broad spectrum of musculoskeletal and neuromuscular conditions affecting the temporomandibular joint, along with associated morphological and functional abnormalities [10, 12, 13]. These conditions may involve disturbances in the position or structural integrity of the intraarticular disc, as well as dysfunction of the surrounding musculature [14]. The disorder[15] is relatively prevalent in the general population, with a particular predilection for individuals between the ages of 20 and 40. Clinically, patients typically present with pain in the region of the temporomandibular joint, fatigue of the cranial and facial musculature, restricted or irregular mandibular movements, disc displacement, and audible clicking [2] or joint sounds. From an epidemiological standpoint, temporomandibular disorders affect a considerable proportion of the population, with estimates suggesting that between 60 and 70 percent of individuals experience some degree of symptoms at some point in their lives. However, despite this relatively high prevalence, only approximately 25 of those affected ultimately seek professional treatment [11, 6], suggesting that a substantial number of cases remain unaddressed within the broader community. The causes of TMD are varied and complex, involving anatomical, pathophysiological, and psychosocial aspects. Effective treatment requires identifying risk factors and distinguishing between myofascial pain and joint-specific disorders [15].

Classification

Classification systems for TMD have been developed based on various criteria, including signs and symptoms, tissue origin, underlying causes, structural and functional abnormalities, prevalence, and medical categorization. Clinically, TMD can be grouped into the following categories:

1. Disorders of the masticatory muscles
2. Disk-related interference disorders
3. Joint inflammatory conditions
4. Chronic limitations in mandibular mobility
5. Growth-related joint disorders.

ETIOLOGICAL FACTORS OF TMD

- The etiology of temporomandibular disorders is neither simple nor attributable to a single cause, arising instead from a complex interaction of multiple contributing factors. These are broadly classified into three categories: predisposing factors, which heighten individual susceptibility; initiating factors, which trigger the onset of the condition; and perpetuating factors, which hinder recovery or accelerate disease progression.
- In some instances, one factor may simultaneously fulfil multiple roles. Effective management therefore, depends on accurately identifying and addressing all relevant contributors.
- The condition has been associated with a wide range of influences, including occlusal discrepancies, bruxism, orthodontic treatment, orthopaedic instability, macro and microtrauma, joint hyperlaxity, and hereditary predisposition. Psychological elements such as chronic stress, anxiety, emotional tension, and depression have equally been recognized as significant contributing or aggravating factors in its development [16].
- Factors that trigger the initial onset of symptoms are often linked to trauma or excessive stress on the masticatory system. Factors that sustain or worsen the condition may include:
    - **Behavioral factors**: such as teeth grinding, jaw clenching, and poor head posture.
    - **Social factors**: which impact how pain is perceived and how individuals learn to respond to it.
    - **Emotional factors**: including conditions like depression and anxiety.
    - **Cognitive factors**: which refer to how an individual processes and reacts to pain and stress [17].

A. **Trauma**

Trauma occurs when the force applied to the masticatory structures exceeds normal functional load. It can be categorized into macrotrauma (both direct and indirect) and microtrauma.

- **Direct Trauma**

  Direct trauma occurs when a sudden, typically isolated blow impacts the structures. In the context of temporomandibular disorders (TMDs), this includes injury to the mandible and/or temporomandibular joint (TMJ), leading to structural failure and loss of function. Examples include wide or prolonged mouth opening, self-reported jaw injury from yawning or extended mouth opening, intubation, third molar extractions, and temporary or permanent TMJ dysfunction after upper airway management procedures [18].

- **Indirect Trauma**

  Indirect trauma happens when a sudden force impacts without direct contact with the affected structures. For TMDs, this often involves acceleration-deceleration (whiplash) injuries, where there is no direct impact to the face, though the causal relationship remains debated. TMD symptoms may arise not from direct mandibular strain, but due to referred pain traveling from the cervical area to the trigeminal area [19].

- **Microtrauma**
  Microtrauma develops from continuous, repetitive forces exerted over an extended period. It may arise from persistent unfavorable loading of the masticatory system due to postural discrepancies or parafunctional activities. Behaviors such as forward head posture or muscle bracing during phone use can contribute to musculoskeletal discomfort, including headaches, in individuals with TMD. However, the association between TMD manifestations and parafunctional habits remains unclear.

B. Anatomical Factors

- **Skeletal Factors**
  Factors like severe skeletal malformations, discrepancies in the arches (both between and within the arches), and previous dental injuries may contribute to TMDs,[20] though the evidence is not conclusive.
- **Occlusal Relationships**
  Occlusal issues, such as discrepancies in posterior contacts or between the retruded contact position (RCP) and intercuspal position (ICP), have traditionally been linked to TMDs. However, recent studies indicate that occlusion plays a minimal role in the onset and progression of TMDs.

C. **Pathophysiologic Factors**

- **Systemic Factors**
- Systemic disorders including degenerative, endocrine, infectious, metabolic, neoplastic, neurologic, rheumatologic, and vascular diseases may play a role in TMDs. These factors can impact both central mechanisms and peripheral (local) structures[15]. Such conditions require management in coordination with a primary care physician or relevant medical specialists.
- **Local (Peripheral) Factors**
  Several local factors have been linked to temporomandibular disorders (TMDs), such as chewing efficiency, sensitivity in the jaw muscles, activity in the cervical muscles, and joint-related conditions like osteoarthritis affecting the TMJ. Additional contributors include variations in cytokine activity, friction within the disc, changes in intracapsular pressure, hormonal effects, structural deterioration of the articular disc, and the buildup of free radicals triggered by mechanical strain.[16,17].
- **Genetic Factors**
  Genetic factors, such as specific haplotypes of the gene encoding catechol-O-methyltransferase (COMT), have been linked to experimental pain sensitivity and the risk of developing myogenous TMDs[18].Evidence supports genetic associations in several pain-related phenotypes, suggesting that multiple genetic and biological pathways contribute to TMD risk [19].
- **Psychosocial Factors**
  Psychosocial influences play a significant role in how patients adapt and function, encompassing personal, relational, and situational aspects. Individuals with temporomandibular disorders (TMDs) tend to experience higher levels of anxiety compared to those without the condition. For some, emotional stress alone can act as a trigger for TMD or orofacial pain symptoms [20]. Psychological difficulties in TMD patients are frequently linked to persistent pain, a pattern not typically observed in healthy groups. Findings from the Orofacial Pain Prospective Evaluation and Risk Assessment (OPPERA) [21] study highlight that TMD patients differ from control subjects across multiple domains, including demographics, clinical features, psychological health, pain sensitivity, autonomic responses, and genetic predispositions [22-24].

HOW THE CONDYLAR GROWTH CENTER IS INFLUENCED

Various explanations have been suggested to interpret how external pressures alter the structure of the condylar head. Initially, Brodie introduced a genetics-based concept [25-31], suggesting that mandibular development follows a DNA-programmed path downward and forward, similar to how long bones develop at their growth plates.

Research by Chatelier [32] and colleagues, followed by Petrovic and McNamara [33], put forth the Lateral Pterygoid Muscle Activity Theory. This hypothesis suggested this muscle connected to either the condylar head or joint disc. However, this idea was disproven when anatomical studies failed to verify such attachments. Additionally, research demonstrated that pulling forces from this muscle had minimal impact on condylar development.

The Soft Tissue Growth [34] Model proposed that adjacent pliable tissues largely determine patterns of bone formation. Nevertheless, investigators questioned the validity of this concept because it failed to adequately clarify the precise mechanisms responsible for condylar growth.

Subsequently, Enlow and Hans presented a broader perspective, explaining mandibular development as a complex interaction between local influences and growth-modulating factors, each responding to stimuli arising beyond the condyle. This concept later developed into the Growth Relativity Theory, which is presently regarded as the most widely accepted explanation.

OCCURRENCE OF SIGNS AND SYMPTOMS OF TMD IN HEALTHY INDIVIDUALS

Multiple epidemiological investigations have examined TMD manifestations across varied populations. The results demonstrate considerable prevalence rates: nearly one-third of individuals report experiencing TMD symptoms, while over half display observable clinical indicators[35]. Research focusing on specific adult populations not actively pursuing treatment reveals that 40-75% present at least one clinical sign, and approximately one-third acknowledge experiencing symptoms [36]. Montegi and colleagues [37] found that younger populations - children and adolescents - demonstrate reduced rates, with symptom prevalence spanning from 12% to 20%.

Considering that orthodontic treatment extends over substantial durations (typically 2-3 years for teenagers and 5-7 years for early mixed dentition cases involving two-phase protocols), comprehending how TMD patterns naturally progress in healthy individuals becomes essential. Studies suggest that both frequency and severity of TMD signs and symptoms generally increase from adolescence onward [38].

Particularly significant is Wänman and Agerberg's [39] observation that joint sounds may emerge in approximately 17.5% of late-teenage individuals within merely a two-year period. This discovery underscores the necessity of assessing TMD developments during orthodontic treatment against comparable age-matched untreated populations to establish appropriate context.

This version preserves scientific accuracy while presenting the information in a more compelling manner, highlighting the temporal dimensions of TMD progression and their relevance for orthodontic treatment evaluation.

DOES ORTHODONTIC TREATMENT RESULT IN AN INCREASED INCIDENCE OF TMD?

The proposition that various orthodontic methods including functional appliances, Class I/II elastics, chin cup, headgear, fixed or removable appliances act as etiological contributors to TMD has been evaluated in numerous investigations. Dibbets and Van der Weele [44] assessed children managed with different treatment approaches. Patients were followed for a 20-year duration from the initiation of orthodontic therapy. Although signs and symptoms of TMD increased with advancing age, after 20 years no orthodontic treatment demonstrated a causal association with TMD signs and symptoms. Henrikson and Nilner [45] compared Class II division 1 treated and untreated females with normal occlusion (11–15 years old) observed for 2 years. They noted individual variations of TMD symptoms in all three groups. Orthodontic therapy did not elevate the risk of worsening pre-treatment TMD signs. Conversely, subjects with Class II malocclusion and muscular TMD appeared to show improvement. Rey et al [47] evaluated a group of Class III patients treated with mandibular cervical headgear, Class I patients treated orthodontically, and untreated subjects. No difference in TMD prevalence was detected among the three groups after 2–3 years. Concerning orthognathic surgery,

ORTHODONTIC TREATMENT FACTORS AND THEIR RELATION TO TMD

1. Extractions vs TMD

Orthodontic interventions using fixed appliances, irrespective of whether treatment involved extractions, have shown no negative impact on temporomandibular disorder (TMD) symptoms; rather, patients presenting with specific occlusal discrepancies and muscle-related TMD signs demonstrated functional improvement following orthodontic therapy over a three-year period. The findings indicate that dental correction procedures do not initiate or exacerbate TMD, that individuals with Class II malocclusion may derive functional benefits from well-planned orthodontic mechanics, and that muscular TMD symptoms can be alleviated through appropriate dental alignment, with therapeutic effects becoming apparent within a relatively short duration. Overall, these observations suggest that contemporary orthodontic treatment is not limited to aesthetic correction but may also contribute to meaningful physiological rehabilitation in patients with certain jaw and muscular dysfunctions.

2. Condylar position vs TMD [40, 41]

Posteriorly directed forces on the mandible can contribute to temporomandibular disorders by altering the position of the temporomandibular joint. Investigations assessing Class II Division I malocclusion managed with maxillary first premolar extractions and Class I cases treated without extractions, through tomographic evaluation, demonstrated that extraction groups had a more posteriorly located condyle, a pattern likewise observed in individuals presenting with joint clicking. This relationship between joint noises and posterior condylar positioning highlights the intricate biomechanical interplay among orthodontic therapy, mandibular alignment, and temporomandibular joint integrity

3. Reverse pull Head Gear) and class III elastics

When orthodontists apply reverse-pull headgear along with Class III elastics, these devices exert a backward force on the mandible and its condyle. This mechanical effect results in two outcomes: the articular disc moves forward in response, and at the same time, it exerts pressure on the tissues located behind the disc.

4. Cross Elastics Vs TMD

The application of cross elastics leads to a sideways shift of both the lower jaw and its joint, creating a one-sided backward pressure on the joint. These orthodontic elastics are most effective when used exclusively during daytime hours, as the natural resting tension in the jaw muscles helps balance out the backward-directed forces. This understanding aids in establishing effective orthodontic and jaw joint treatment protocols.

5. Herbst Appliance Vs TMD [44, 45]

In research performed on patients using mandibular advancement devices, all jaw joints showed notable anterior displacement but reverted to their original position once the device was discontinued. Mild joint inflammation occurred throughout the therapeutic period, but lacked sufficient severity to trigger temporomandibular dysfunction.

6. Head Gear and Class II Elastics [42, 43]

Orthodontic mechano-therapies, such as Class II treatments and extractions, have minimal or no effect on general signs and symptoms of temporomandibular disorders (TMD). There is no immediate benefit or risk for children undergoing early Class II treatment with bionator, headgear, or bite planes concerning their temporomandibular joint health

DOES ORTHODONTIC TREATMENT PREVENT TMD?

The question of whether orthodontic treatment can prevent temporomandibular disorders (TMD) has long been debated. Signs and symptoms of TMD are frequently observed in otherwise healthy individuals, making causality difficult to establish. While some opinion pieces have promoted non-extraction approaches, functional appliances, or unconventional methods such as second molar extraction and third molar replacement, these claims remain largely unsupported.

Most comparative studies show no significant differences in TMD prevalence between treated and untreated populations. Notably, Egermark & Thilander [37] followed 402 children and adolescents for 5–10 years, finding that although bruxism and subjective symptoms increased with age, treated individuals demonstrated fewer dysfunctions, with some clicking sounds resolving over time. Using the Helkimo index, treated subjects showed lower dysfunction scores at age 25. Similarly, Olsson & Lindqvist studied 245 patients and reported a decline in TMD symptoms from 17% pre-treatment to 7% post-treatment, with symptom-free individuals rising from 27% to 46%. Taken together, these findings suggest orthodontic treatment may alleviate or limit progression of TMD, though current evidence does not confirm a consistent preventive effect

ORTHODONTIST ROLE IN TMD MANAGEMENT

Temporomandibular joint disorders are frequently seen by orthodontists in routine clinical practice, making accurate diagnosis and proper management essential. Clinical features of TMJ disorders comprise pain (arthralgia), disco-condylar incoordination (disc displacement), and structural or degenerative alterations.

When a patient exhibits signs or symptoms of TMD prior to initiating orthodontic therapy, the initial step is establishing a precise diagnosis while evaluating potential differential diagnoses. If TMD is confirmed, conservative approaches such as medications, patient counseling, behavioral modification, home-based exercises, physiotherapy, and/or occlusal splints should be instituted to control symptoms. Generally, orthodontic therapy should be deferred when significant TMD pain is present [34]. Additionally, individuals with a previous history of TMD may have a higher likelihood of experiencing symptoms during treatment, and in some cases, TMD may first arise while undergoing orthodontic therapy. In such situations, an accurate diagnosis is required, active orthodontic mechanics (for example, intermaxillary elastics) should be temporarily paused or minimized, and symptoms managed until resolution. Once the patient becomes pain-free or symptoms are minimal, orthodontic therapy may proceed as originally intended or be adjusted according to the patient's status. Furthermore, clinicians must highlight that TMDs are common within the general population, have multifactorial causes, and current evidence does not demonstrate a direct cause-and-effect association between orthodontic treatment and TMD.

SUMMARY AND CONCLUSIONS

- TMD serves as an umbrella term covering a range of clinical conditions involving the masticatory musculature and the temporomandibular joints.
- This comprehensive review examines the complex association between orthodontic treatment and temporomandibular disorders. Although orthodontists have long been intrigued by this connection, it drew considerable attention from dental professionals and legal circles during the late 1980s, prompting extensive scientific inquiry over the following decade.
- Contemporary scientific evidence has yielded several important findings regarding the orthodontics-TMD relationship:
- TMD signs and symptoms can arise naturally in otherwise healthy individuals. Furthermore, their prevalence tends to increase with age, with a notable rise during adolescence through to the onset of menopause, suggesting that TMD emergence during orthodontic treatment may reflect coincidence rather than causation.
- Evidence indicates that orthodontic intervention during adolescence neither increases nor decreases the likelihood of subsequent TMD development. Likewise, extractions carried out as part of orthodontic planning demonstrate no association with heightened TMD risk, and no link has been identified between particular orthodontic approaches and greater TMD incidence.
- Although achieving harmonious occlusal balance remains a central orthodontic goal, failing to meet precise gnathological criteria does not inevitably lead to TMD manifestation. Present evidence offers limited support for orthodontic treatment as a preventive strategy against TMD, though the potential benefits of correcting unilateral posterior crossbite in younger patients may warrant further investigation.
- The profession now broadly acknowledges that TMDs are multifactorial conditions shaped by influences extending well beyond orthodontic care, a recognition that has meaningfully informed both clinical practice and medicolegal considerations within dentistry.

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