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Impact of Orthodontic Treatment on Temporomandibular Joint

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Abstract

Temporomandibular disorders [TMDs] present a complex array of signs and symptoms representing dysfunction in the temporomandibular joint [TMJ] and associated structures. There has been longstanding controversy about whether orthodontic treatment influences TMJ health, either positively by correcting malocclusion or negatively by altering occlusal relationships and condylar position. This review synthesizes the available evidence on the association between orthodontic therapy and TMJ outcomes. Using systematic search and PRISMA-based screening, existing literature including systematic reviews, cohort studies, and observational research were analyzed to evaluate whether orthodontic treatment predisposes, ameliorates, or has negligible effects on TMJ function. Current evidence remains inconsistent; several studies suggest no clear cause-effect relationship between orthodontic treatment and TMD, while some meta-analyses indicate a statistical association between treatment and TMD incidence. Many clinical studies demonstrate transient TMJ symptoms during treatment phases, but lack long-term adverse sequelae. The heterogeneity in diagnostic criteria, study design, and follow-up duration complicates definitive conclusions. Future high-quality longitudinal research with standardised diagnostic protocols for TMD is essential to clarify the impact of orthodontic interventions on the TMJ.

Keywords: Temporomandibular joint, Temporomandibular disorders, Orthodontic treatment, Malocclusion, TMJ function, Systematic review

Introduction

Temporomandibular disorders [TMDs] constitute a heterogeneous group of conditions affecting the temporomandibular joint [TMJ], the masticatory muscles, and associated craniofacial structures. These disorders are among the most common causes of non-dental orofacial pain and functional limitation, affecting approximately 5–12% of the general population, with a higher prevalence in females and young adults [1,2]. Clinical manifestations of TMD include joint pain, muscle tenderness, joint sounds such as clicking or crepitus, deviations in mandibular movement, and restricted mouth opening. Given the multifactorial etiology of TMD, identifying specific causative or contributing factors has remained a significant challenge in dental research and clinical practice.

The TMJ is a unique synovial joint characterized by its bilateral function, adaptive capacity, and dependence on neuromuscular coordination. Any alteration in occlusion, mandibular position, or muscular balance has the potential to influence joint loading and biomechanics. Consequently, dental occlusion has long been considered a possible etiological factor in TMD development. Historically, malocclusion was believed to disrupt harmonious mandibular movement, thereby predisposing individuals to TMJ dysfunction. This belief strongly influenced orthodontic philosophy throughout much of the twentieth century, where correction of malocclusion was often justified as a preventive or therapeutic measure for TMD [3]. Orthodontic treatment aims to establish optimal dental alignment and occlusal relationships through controlled tooth movement and, in some cases, skeletal modification. While orthodontic therapy has well-established benefits in terms of aesthetics, function, and oral health, its relationship with TMJ health remains controversial. Some clinicians propose that orthodontic correction of malocclusion improves TMJ function by redistributing occlusal forces and eliminating occlusal interferences. Others argue that orthodontic treatment, particularly involving extractions, prolonged treatment duration, or alteration of vertical dimension, may adversely affect TMJ structures by modifying mandibular position and condylar dynamics [4].

Early clinical reports and anecdotal observations suggested associations between orthodontic treatment and the onset of TMJ symptoms. However, these reports were often limited by small sample sizes, lack of control groups, and non-standardized diagnostic criteria for TMD. With the advancement of evidence-based dentistry, numerous longitudinal studies, cohort analyses, and systematic reviews have sought to clarify whether orthodontic treatment is a risk factor for TMD, a protective intervention, or largely neutral in its effect on TMJ health [5].

Despite the increasing volume of research, the literature continues to present conflicting findings. Several systematic reviews have concluded that there is insufficient evidence to support a causal relationship

between orthodontic treatment and TMD development [3]. Conversely, recent meta-analyses have reported a statistically significant association between orthodontic treatment and the prevalence of TMD, raising concerns regarding potential iatrogenic effects [3,6]. These inconsistencies may be attributed to heterogeneity in study design, differences in patient populations, variability in orthodontic mechanics, and the evolving diagnostic frameworks for TMD such as the Research Diagnostic Criteria for TMD [RDC/TMD] and the Diagnostic Criteria for TMD [DC/TMD].

Given the high prevalence of both orthodontic treatment and TMD in adolescent and young adult populations, understanding the relationship between these entities is of substantial clinical importance. Orthodontists must be able to counsel patients accurately regarding potential TMJ risks, identify patients with pre-existing TMD, and distinguish treatment-related transient symptoms from true pathological joint changes. Therefore, a critical and updated review of the available evidence is necessary to inform clinical decision-making and guide future research.

Aim

This review aims to critically assess current evidence regarding the impact of orthodontic treatment on TMJ function, including:

1. Whether orthodontic treatment contributes to the development or exacerbation of TMD.
2. Whether orthodontic interventions improve pre-existing TMD symptoms.
3. The magnitude and clinical significance of any association between orthodontic therapy and TMJ outcomes.

Materials and Methods

Search Strategy

A systematic search of peer-reviewed literature was carried out according to PRISMA principles. The electronic databases PubMed/Medline, Scopus, Web of Science, and Google Scholar were queried using combinations of the following keywords:

- “orthodontic treatment AND temporomandibular disorders”
- “orthodontics AND TMJ function”
- “malocclusion AND TMD”
- “orthodontic therapy AND temporomandibular joint”

The search timeframe covered articles published from January 1985 to November 2025. Inclusion criteria were original research, systematic reviews, meta-analyses, and cohort or case-control studies examining the relationship between orthodontic treatment and TMJ outcomes. Exclusion criteria included case reports, commentaries, non-clinical studies, and non-English publications.

Screening Process

From an initial pool of records retrieved across databases:

1. Identification: All records were compiled and duplicates removed.
2. Screening: Titles and abstracts were screened for relevance to orthodontic treatment and TMJ outcomes.
3. Eligibility: Full texts of relevant studies were assessed against inclusion criteria.
4. Inclusion: Final studies included systematic reviews, meta-analyses, cohort and observational studies meeting quality thresholds.

Results of Search

Stage	Records
Records identified through database search	1500
Duplicates removed	312
Titles and abstracts screened	1188
Full-text articles assessed for eligibility	92
Studies meeting inclusion criteria	20

Summary of Included Studies

- Systematic reviews/meta-analyses: 3 major reviews evaluated the association between orthodontics and TMD, with inconsistent conclusions regarding causality and strength of association.
- Cohort and case-control studies: Several observational studies assessed TMJ symptoms before, during, and after orthodontic treatment in adolescent and adult populations.
- Longitudinal clinical studies: Indicate transient TMJ symptoms during treatment phases with limited long-term functional compromise.

Discussion

Complexity of the Orthodontics–TMJ Relationship

The relationship between orthodontic treatment and temporomandibular joint health is complex and cannot be adequately explained through a single mechanistic pathway. Temporomandibular disorders are currently understood as multifactorial conditions influenced by anatomical, functional, psychological, behavioral, and environmental factors [7]. Within this multifactorial model, orthodontic treatment represents only one of many potential modifying variables rather than a dominant etiological factor. This understanding marks a paradigm shift from earlier occlusion-based theories that heavily implicated dental malocclusion as a primary cause of TMD.

Orthodontic treatment inevitably alters occlusal relationships, mandibular positioning, and neuromuscular coordination. These changes, however, occur gradually and within the physiological adaptive capacity of the stomatognathic system. The TMJ is uniquely capable of remodeling in response to altered functional demands, particularly in adolescents and young adults, who constitute the majority of orthodontic patients [8]. This adaptive capacity likely explains why most orthodontic patients do not develop persistent TMJ dysfunction despite significant occlusal modifications during treatment.

Malocclusion, Occlusion, and TMJ Biomechanics

The presumed link between malocclusion and TMD has been extensively investigated, yet remains unsubstantiated by strong evidence. While certain occlusal characteristics—such as anterior open bite, posterior crossbite, and large overjet—have been associated with TMD signs in some studies, these associations are generally weak and inconsistent [9,10].

Moreover, malocclusion is prevalent in the general population, whereas only a subset of individuals develop TMD, suggesting that occlusal factors alone are insufficient to cause joint pathology.

From a biomechanical perspective, orthodontic treatment modifies dental contacts rather than directly repositioning the mandibular condyle in the glenoid fossa. Contemporary imaging studies using cone-beam computed tomography [CBCT] and magnetic resonance imaging [MRI] demonstrate that orthodontic tooth movement does not consistently result in clinically significant changes in condylar position or disc–condyle relationships [11]. These findings challenge the notion that orthodontic therapy inherently disrupts TMJ biomechanics.

Orthodontic Treatment and TMJ Adaptation

A recurring observation in the literature is the transient nature of TMJ symptoms during orthodontic treatment. Joint noises, mild pain, or muscle fatigue are frequently reported during initial leveling and alignment phases, when occlusal contacts are unstable [8]. However, longitudinal studies consistently show that these symptoms diminish as treatment progresses and occlusion stabilizes [12,13].

The adaptive remodeling of TMJ structures in response to orthodontic forces has been documented in both animal and human studies. Controlled mechanical loading may induce changes in the fibrocartilage of the articular disc and condylar cartilage without precipitating pathological degeneration [14]. This adaptive response underscores the resilience of the TMJ and supports the view that orthodontic treatment, when properly managed, does not exceed physiological limits in most patients.

Role of Age and Growth Status

Age and skeletal maturity play critical roles in determining TMJ response to orthodontic treatment. Adolescents demonstrate greater adaptive potential due to ongoing craniofacial growth and increased remodeling capacity of the condylar cartilage [15]. Consequently, orthodontic treatment initiated during growth phases is less likely to induce adverse TMJ effects.

In contrast, adult patients may exhibit reduced adaptive capacity and a higher prevalence of pre-existing TMD symptoms. Studies indicate that adults undergoing orthodontic treatment may report higher levels of TMJ discomfort compared to adolescents, although these symptoms are not necessarily treatment-induced [16]. This highlights the importance of comprehensive pre-treatment TMJ assessment in adult orthodontic patients.

Extraction vs Non-Extraction Orthodontic Therapy

One of the most contentious issues in orthodontics is whether extraction therapy influences TMJ health. Historically, extraction-based treatment was criticized for allegedly retruding the mandible and increasing TMJ loading. However, multiple controlled studies and systematic reviews have found no consistent association between extraction orthodontics and increased TMD risk [17].

Cephalometric and imaging studies reveal that mandibular position is largely governed by neuromuscular control rather than dental arch length. Consequently, extractions do not inherently result in posterior displacement of the condyle. The current consensus suggests that extraction decisions should be based on dental and skeletal considerations rather than concerns regarding TMJ dysfunction.

Influence of Orthodontic Appliance Type

Recent investigations have explored whether different orthodontic modalities exert differential effects on TMJ health. Fixed appliances, removable functional appliances, and clear aligners apply forces with varying magnitudes, directions, and durations. Some observational studies report higher frequencies of TMJ symptoms in patients treated with fixed appliances compared to aligners [18]. However, these findings may reflect confounding factors such as treatment complexity, duration, and patient age rather than appliance type alone.

Functional appliances designed to advance the mandible have received particular attention due to their direct influence on mandibular position. Imaging studies suggest that these appliances may temporarily alter condylar position but do not cause long-term pathological changes in the TMJ [16]. In growing patients, functional appliances may even promote favorable adaptive remodeling of the joint.

Psychosocial and Behavioral Factors

Psychosocial factors such as stress, anxiety, depression, and parafunctional habits are now recognized as major contributors to TMD etiology [18]. Orthodontic treatment often coincides with adolescence—a period characterized by heightened emotional stress—which may independently increase the risk of TMD symptoms. Failure to account for these psychosocial variables may falsely attribute TMJ symptoms to orthodontic intervention.

Furthermore, increased awareness of oral sensations during orthodontic treatment may lead patients to report symptoms that would otherwise go unnoticed. This reporting bias may partially explain higher TMD prevalence observed in orthodontically treated populations in some studies [19].

Imaging Evidence and Structural Changes

Advanced imaging modalities have enhanced understanding of TMJ responses to orthodontic treatment. MRI studies evaluating disc position before and after orthodontic therapy reveal no consistent evidence of disc displacement attributable to treatment [20]. Similarly, CBCT analyses show minimal changes in condylar morphology or joint space dimensions following orthodontic intervention.

These findings are clinically significant, as structural TMJ pathology—rather than transient symptoms—is the hallmark of true joint disorder. The lack of consistent imaging evidence for orthodontic-induced joint damage supports the overall safety of orthodontic treatment with respect to TMJ health.

Clinical Implications for Orthodontic Practice

From a clinical standpoint, orthodontists must approach TMJ considerations with caution and evidence-based judgment. Orthodontic treatment should neither be promoted as a cure for TMD nor avoided out of unfounded fear of causing joint dysfunction. Instead, thorough pre-treatment evaluation, including TMJ history and examination, is essential to identify patients with existing TMD or risk factors.

Informed consent should include discussion of the possibility of transient TMJ symptoms during treatment, particularly in patients with pre-existing joint issues. Interdisciplinary collaboration with orofacial

pain specialists may be warranted in complex cases.
In summary, the expanded body of evidence indicates that orthodontic treatment does not play a primary causative role in temporomandibular disorders. While transient TMJ symptoms may occur during treatment, particularly during periods of occlusal instability, these symptoms typically resolve without long-term consequences. The development of TMD is better explained by a multifactorial model in which orthodontic treatment is a secondary or coincidental factor rather than a direct cause.

Limitations of Existing Evidence
The interpretation of existing literature is complicated by several methodological limitations. Diagnostic inconsistency remains a major concern, as studies employ varying criteria for defining TMD, ranging from patient-reported symptoms to clinical examination and imaging findings [19]. Additionally, many studies lack adequate control groups or long-term follow-up, limiting their ability to assess chronic TMJ outcomes.
Psychosocial factors such as stress, anxiety, and parafunctional habits are often inadequately controlled, despite their well-established role in TMD etiology. Failure to account for these confounders may overestimate the role of orthodontic treatment in TMJ symptom development [20].

Conclusion

Evidence regarding the impact of orthodontic treatment on the temporomandibular joint remains mixed and inconclusive. While traditional views held that malocclusion correction might improve TMJ health, robust clinical support for this claim is lacking. Many systematic analyses find no definitive cause–effect link between orthodontic therapy and permanent TMD outcomes. Conversely, some recent meta-analyses suggest an association between orthodontic intervention and TMD incidence, albeit with heterogeneity across studies and less consistent clinical relevance.
The majority of clinical studies indicate that transient TMJ symptoms may occur during active orthodontic treatment phases, but these typically resolve and do not progress to chronic dysfunction in the absence of other predisposing factors. Overall, the current evidence does not justify routine use of orthodontic treatment solely for TMD management, nor does it confirm that orthodontic therapy predisposes all patients to TMD.

Gaps in Research

Despite numerous studies, several gaps persist:

1. **Diagnostic Standardization:** Variability in diagnostic criteria [e.g., RDC/TMD, DC/TMD] limits comparability across studies.
2. **Long-Term Follow-Up:** Few studies extend follow-up beyond treatment completion, limiting understanding of chronic TMJ outcomes.
3. **Homogeneity of Populations:** Research often combines diverse age groups and malocclusion types, obscuring subgroup effects.
4. **Treatment Modalities:** Limited high-quality comparative evidence exists on differential effects of fixed, removable, and aligner therapies on TMJ outcomes.
5. **Mechanistic Insights:** Lack of robust biomechanical or biological studies clarifying how orthodontic forces affect TMJ tissues.

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