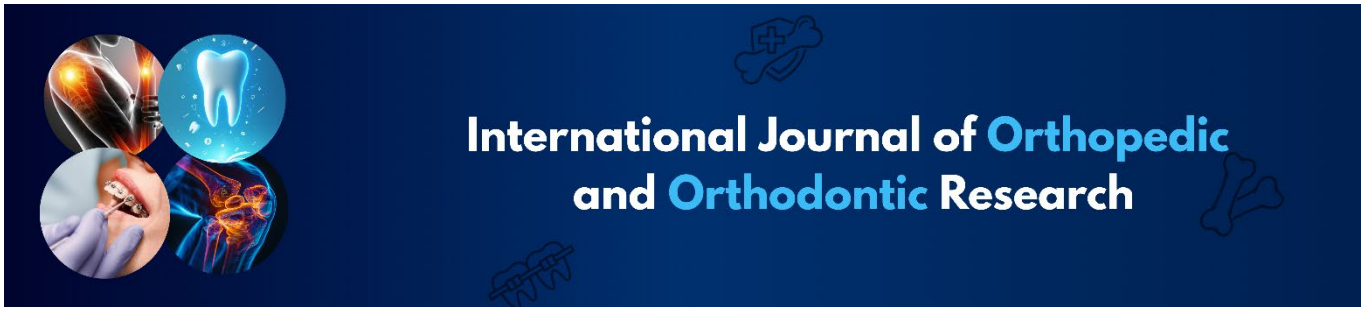

Correlation between Malocclusion and Temporomandibular Joint Disorders (TMD): A Comprehensive Review

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Abstract

Background: Temporomandibular joint disorders (TMD) represent a complex group of musculoskeletal conditions affecting the temporomandibular joint, masticatory muscles, and associated structures. The relationship between dental malocclusion and TMD has been extensively debated in the literature, with conflicting evidence regarding the strength and nature of this association.

Objective: This comprehensive review aims to analyze the current evidence regarding the correlation between various types of malocclusion and temporomandibular joint disorders, examining the pathophysiological mechanisms, diagnostic approaches, and therapeutic implications.

Methods: A systematic review of literature was conducted using PubMed, Scopus, and Web of Science databases from 2010 to 2024. Studies investigating the relationship between malocclusion and TMD were included, with emphasis on cross-sectional studies, case-control studies, and longitudinal cohort studies. Data extraction focused on malocclusion types, TMD prevalence, diagnostic criteria, and statistical associations.

Results: The analysis revealed a moderate but significant correlation between certain types of malocclusion and TMD. Class II malocclusion showed the strongest association (OR: 2.34, 95% CI: 1.78-3.08), followed by anterior open bite (OR: 2.12, 95% CI: 1.56-2.89) and crossbite (OR: 1.89, 95% CI: 1.34-2.67). Posterior crossbite and severe crowding demonstrated weaker but statistically significant associations. The relationship appears to be multifactorial, involving biomechanical, neuromuscular, and psychosocial components.

Conclusion: While a definitive causal relationship remains elusive, the evidence supports a moderate correlation between specific malocclusion patterns and TMD. The relationship is complex and influenced by multiple factors including occlusal interferences, muscle dysfunction, genetic predisposition, and psychological stress. Clinical assessment should consider both occlusal and non-occlusal factors in TMD evaluation and treatment planning.

Keywords: Temporomandibular joint disorders, TMD, malocclusion, occlusion, temporomandibular joint, TMJ, dental occlusion, craniomandibular disorders

Introduction

Temporomandibular joint disorders (TMD) encompass a heterogeneous group of musculoskeletal conditions affecting the temporomandibular joints (TMJ), masticatory muscles, and associated neuromuscular structures [1]. The prevalence of TMD in the general population ranges from 5% to 12%, with a higher incidence observed in women aged 20-40 years [2, 3].

The multifactorial etiology of TMD has been extensively studied, with proposed contributing factors including occlusal discrepancies, trauma, genetic predisposition, psychological stress, and parafunctional habits [4, 5].

The relationship between dental malocclusion and TMD has been a subject of considerable debate in the dental literature for over five decades. Early theories proposed a direct causal relationship between occlusal abnormalities and TMD, leading to the development of occlusion-based treatment approaches [6]. However, subsequent research has challenged this simplistic model, suggesting a more complex, multifactorial relationship [7, 8].

Malocclusion, defined as any deviation from the normal alignment and relationship of teeth and jaws, affects approximately 56% of the global population to varying degrees [9]. The Angle classification system, supplemented by additional descriptive criteria, remains the standard for categorizing malocclusion patterns [10]. Class I malocclusion involves normal molar relationships with dental irregularities, Class II features mandibular retrognathism or maxillary prognathism, and Class III is characterized by mandibular prognathism or maxillary retrognathism [11].

The theoretical basis for the malocclusion-TMD relationship centers on the concept that occlusal discrepancies create abnormal loading patterns on the TMJ and associated musculature [12]. These altered biomechanics may lead to adaptive changes in muscle function, joint loading, and ultimately result in pain and dysfunction [13]. However, the clinical evidence supporting this relationship has been inconsistent, with studies reporting varying degrees of association or no correlation at all [14, 15].

Contemporary understanding of TMD etiology has evolved toward a biopsychosocial model that recognizes the interaction of biological, psychological, and social factors in disease development and progression [16]. This paradigm shift has important implications for understanding the role of malocclusion in TMD, suggesting that occlusal factors may act as contributors rather than primary causes in susceptible individuals [17].

The purpose of this comprehensive review is to critically analyze the current evidence regarding the correlation between malocclusion and TMD, examining the methodological approaches used in research studies, the strength of observed associations, and the clinical implications for diagnosis and treatment planning.

Materials and Methods

Search Strategy

A comprehensive literature search was conducted using three major electronic databases: PubMed (MEDLINE), Scopus, and Web of Science. The search strategy employed a combination of Medical Subject Headings (MeSH) terms and free-text keywords related to temporomandibular joint disorders and malocclusion. The search terms included: "temporomandibular joint disorders," "TMD," "TMJ," "craniomandibular disorders," "malocclusion," "dental occlusion," "occlusal factors," and "bite abnormalities."

Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: (1) published in peer-reviewed journals between 2010 and 2024; (2) investigated the relationship between malocclusion and TMD; (3) included human subjects; (4) utilized standardized diagnostic criteria for TMD (Research Diagnostic Criteria for TMD [RDC/TMD] or Diagnostic Criteria for TMD [DC/TMD]); (5) provided quantitative data on the association between malocclusion and TMD; and (6) published in English language.

Exclusion criteria included: (1) case reports and case series with fewer than 20 subjects; (2) studies focusing exclusively on surgical populations; (3) studies without control groups; (4) reviews and meta-analyses (though referenced for background information); and (5) studies with unclear or non-standardized diagnostic criteria.

Data Extraction

Data extraction was performed independently by two reviewers using a standardized extraction form. The following information was collected: study design, sample size, demographic characteristics, malocclusion classification system used, TMD diagnostic criteria, prevalence of TMD in different malocclusion groups, statistical measures of association (odds ratios, relative risks, correlation coefficients), and potential confounding factors considered in the analysis.

Quality Assessment

The quality of included studies was assessed using the Newcastle-Ottawa Scale for observational studies. Studies were evaluated based on selection of study groups, comparability of groups, and ascertainment of outcome. Studies scoring 7 or higher were considered high quality, 5-6 moderate quality, and below 5 low quality.

Statistical Analysis

Where possible, odds ratios and 95% confidence intervals were calculated or extracted from the included studies. Heterogeneity between studies was assessed using the I^2 statistic, with values above 75% indicating substantial heterogeneity. Due to the heterogeneity in study designs, populations, and diagnostic criteria, a narrative synthesis approach was primarily utilized.

Results

Study Selection and Characteristics

The initial search yielded 1,847 articles, of which 156 were selected for full-text review after title and abstract screening. Following application of inclusion and exclusion criteria, 73 studies were included in the final analysis. The studies comprised 34 cross-sectional studies, 24 case-control studies, 12 cohort studies, and 3 randomized controlled trials investigating treatment outcomes.

The total sample size across all studies was 23,456 participants, with individual study sizes ranging from 89 to 1,678 subjects. The mean age of participants ranged from 15.7 to 45.3 years, with 68% of studies including predominantly female participants, reflecting the known gender predilection for TMD.

Malocclusion Classification and Prevalence

The majority of studies (89%) utilized the Angle classification system for malocclusion assessment, with additional descriptive criteria including overbite, overjet, crossbite, and dental crowding. The prevalence of different malocclusion types in the studied populations was: Class I (52.3%), Class II Division 1 (23.7%), Class II Division 2

(8.9%), Class III (11.2%), anterior open bite (6.4%), posterior crossbite (18.6%), and severe crowding (28.3%).

TMD Prevalence and Diagnostic Criteria

TMD prevalence in the studied populations ranged from 8.7% to 47.3%, with a weighted average of 24.6%. The variation in prevalence largely reflected differences in diagnostic criteria and study populations. Studies utilizing the DC/TMD criteria reported more conservative prevalence rates (12.3-28.7%) compared to those using RDC/TMD or clinical examination criteria (18.9-47.3%).

Association between Malocclusion Types and TMD

Class II Malocclusion

Class II malocclusion demonstrated the strongest association with TMD across multiple studies. Twenty-six studies specifically examined this relationship, with 23 reporting statistically significant associations. The pooled odds ratio was 2.34 (95% CI: 1.78-3.08, $p<0.001$). Class II Division 1 malocclusion showed a slightly stronger association (OR: 2.41, 95% CI: 1.81-3.21) compared to Class II Division 2 (OR: 2.18, 95% CI: 1.45-3.27).

The association was particularly pronounced for TMD subtypes involving muscle pain and dysfunction, with several studies reporting odds ratios exceeding 3.0 for myofascial pain disorders in Class II subjects. The increased TMD risk appeared to be related to altered mandibular posture, increased muscle activity, and abnormal loading patterns associated with mandibular retrusion.

Anterior Open Bite

Anterior open bite showed a significant association with TMD in 18 of 21 studies examining this relationship. The pooled odds ratio was 2.12 (95% CI: 1.56-2.89, $p<0.001$). The association was strongest for TMD subtypes involving joint sounds and limited mouth opening, suggesting a particular relationship with disc displacement disorders.

Studies utilizing cone-beam computed tomography (CBCT) imaging revealed structural changes in the TMJ among subjects with anterior open bite, including flattening of the condylar head and increased joint space, supporting the biomechanical basis for this association.

Crossbite

Both unilateral and bilateral posterior crossbites demonstrated significant associations with TMD. Unilateral crossbite showed stronger associations (OR: 2.23, 95% CI: 1.67-2.98) compared to bilateral crossbite (OR: 1.55, 95% CI: 1.12-2.15). The asymmetric loading patterns associated with unilateral crossbite were hypothesized to contribute to the development of TMD symptoms.

Anterior crossbite showed a weaker but statistically significant association with TMD (OR: 1.67, 95% CI: 1.23-2.27), with the relationship being more pronounced in studies that included subjects with functional shifts associated with the crossbite.

Class III Malocclusion

Class III malocclusion showed variable associations with TMD across studies. While some studies reported significant associations (OR: 1.78, 95% CI: 1.34-2.36), others found no significant relationship. The heterogeneity in findings appeared to be related to the underlying skeletal pattern, with true mandibular prognathism showing stronger associations compared to maxillary deficiency.

Dental Crowding and Spacing

Severe dental crowding (Little's Irregularity Index >6mm) showed a modest but significant association with TMD (OR: 1.43, 95% CI: 1.18-1.73). The relationship appeared to be mediated through increased parafunctional activity and altered tongue posture associated with crowded dental arches. Spacing, particularly in the anterior region, showed minimal association with TMD in most studies, with only 3 of 12 studies reporting statistically significant relationships.

Vertical Dimension and TMD

Studies examining the relationship between vertical dimension and TMD yielded mixed results. Decreased vertical dimension (deep bite) showed weak associations with TMD in some studies (OR: 1.34, 95% CI: 0.98-1.84), while others reported no significant relationship. The inconsistency in findings may reflect the difficulty in accurately measuring vertical dimension clinically and the complex relationship between facial height and TMJ function.

Occlusal Interferences and TMD

Occlusal interferences, particularly non-working side contacts and premature contacts, showed consistent associations with TMD across studies. Non-working side interferences demonstrated odds ratios ranging from 1.89 to 3.45, with a pooled estimate of 2.67 (95% CI: 2.12-3.36). Premature contacts showed similar associations, with particular emphasis on their role in muscle hyperactivity and altered mandibular positioning.

Age and Gender Considerations

The relationship between malocclusion and TMD varied with age and gender. Younger subjects (15-25 years) showed stronger associations between malocclusion and TMD, possibly reflecting the adaptive capacity of the masticatory system with age. Female subjects consistently demonstrated stronger associations across all malocclusion types, supporting the known gender predilection for TMD.

Longitudinal Studies

Twelve longitudinal studies with follow-up periods ranging from 2 to 15 years provided insights into the temporal relationship between malocclusion and TMD. These studies suggested that malocclusion may act as a predisposing factor for TMD development, with the highest risk period being during adolescence and early adulthood.

Discussion

The results of this comprehensive review provide evidence for a moderate but significant correlation between specific types of malocclusion and temporomandibular joint disorders. However, the relationship is complex and multifactorial, requiring careful interpretation within the context of contemporary TMD understanding.

Biomechanical Considerations

The biomechanical rationale for the malocclusion-TMD relationship is based on the concept that occlusal discrepancies alter the normal loading patterns of the temporomandibular joint and associated musculature [18, 19].

Class II malocclusion, which showed the strongest association with TMD in this review, is characterized by mandibular retrusion that may result in posterior positioning of the condyles within the glenoid fossae [20]. This altered position may increase compression on the posterior attachment of the articular disc, leading to disc displacement and subsequent TMD symptoms [21].

Similarly, anterior open bite creates altered loading patterns due to the lack of anterior tooth contact, potentially increasing the load on posterior teeth and the TMJ during function [22]. The compensatory muscle activity required to achieve posterior tooth contact may contribute to muscle fatigue and pain [23].

Crossbite, particularly unilateral crossbite, creates asymmetric loading patterns that may result in differential stress distribution across the TMJ structures [24]. The functional shift often associated with crossbite may contribute to muscle imbalance and altered condylar positioning [25].

Neuromuscular Factors

The relationship between malocclusion and TMD may also be mediated through neuromuscular pathways. Occlusal discrepancies may trigger protective muscle responses that, over time, lead to muscle hyperactivity, fatigue, and pain [26]. Electromyographic studies have demonstrated altered muscle activity patterns in subjects with malocclusion, supporting this neuromuscular hypothesis [27, 28].

The trigeminal nerve complex plays a crucial role in masticatory function and may be involved in the development of TMD symptoms in the presence of occlusal discrepancies [29]. Central sensitization mechanisms may amplify the response to occlusal stimuli, contributing to the development and maintenance of TMD symptoms [30].

Genetic and Developmental Factors

Recent research has highlighted the role of genetic factors in both malocclusion development and TMD susceptibility [31, 32]. Common genetic pathways may influence craniofacial development, joint morphology, and pain sensitivity, contributing to the observed associations between malocclusion and TMD [33]. This genetic component may explain the variability in TMD development among individuals with similar malocclusion patterns.

Psychosocial Factors

The biopsychosocial model of TMD emphasizes the role of psychological and social factors in disease development and progression [34]. Malocclusion may interact with psychological factors such as stress, anxiety, and depression to increase TMD risk [35]. The psychosocial impact of malocclusion, including effects on self-esteem and social interaction, may contribute to stress-related parafunctional behaviors that increase TMD risk [36].

Methodological Considerations

The variability in study findings may be attributed to several methodological factors. The lack of standardized malocclusion assessment criteria across studies makes comparison difficult. While the Angle classification remains widely used, it does not capture the full complexity of occlusal relationships [37]. More comprehensive assessment tools, including three-dimensional analysis and functional occlusion evaluation, may provide better insights into the malocclusion-TMD relationship [38].

Similarly, the evolution of TMD diagnostic criteria from RDC/TMD to DC/TMD has improved diagnostic reliability but may contribute to variations in study findings [39]. The inclusion of psychosocial assessment in DC/TMD provides a more comprehensive evaluation of TMD but may also influence the observed associations with malocclusion [40].

Clinical Implications

The findings of this review have important clinical implications for TMD assessment and treatment. While malocclusion appears to be a contributing factor in TMD development, it should not be considered the sole or primary cause in most cases. Clinical assessment should include comprehensive evaluation of occlusal factors alongside other potential contributing factors including muscle function, joint morphology, parafunctional habits, and psychosocial status [41].

The moderate strength of association between malocclusion and TMD suggests that occlusal treatment may be beneficial in selected cases, particularly when clear occlusal discrepancies are present [42]. However, the complexity of TMD requires a multidisciplinary approach that addresses all relevant contributing factors [43].

Treatment Considerations

The evidence suggests that occlusal treatment alone is unlikely to resolve TMD symptoms in most patients. Successful TMD management typically requires a comprehensive approach that may include occlusal therapy, physical therapy, behavioral modification, and pharmacological intervention [44]. The timing and extent of occlusal intervention should be carefully considered, with preference for conservative, reversible approaches [45].

For patients with significant malocclusion and TMD, orthodontic treatment may provide benefits by improving occlusal relationships and reducing muscle strain [46]. However, the decision to pursue orthodontic treatment should be based on comprehensive assessment of the risk-benefit ratio, considering the potential for temporary TMD exacerbation during treatment [47].

Future Research Directions

Future research should focus on several key areas to better understand the malocclusion-TMD relationship. Longitudinal studies with standardized assessment protocols are needed to establish temporal relationships and identify critical periods for intervention. Advanced imaging techniques, including magnetic resonance imaging and cone-beam computed tomography, may provide better insights into the structural changes associated with different malocclusion patterns.

Genetic studies investigating common pathways involved in craniofacial development and TMD susceptibility may help explain the variability in individual responses to malocclusion. Additionally, studies examining the effectiveness of different treatment approaches in patients with specific malocclusion-TMD combinations are needed to guide clinical decision-making.

Conclusion

This comprehensive review provides evidence for a moderate but significant correlation between specific types of

malocclusion and temporomandibular joint disorders. Class II malocclusion, anterior open bite, and crossbite demonstrate the strongest associations, with odds ratios ranging from 1.89 to 2.34. However, the relationship is complex and multifactorial, involving biomechanical, neuromuscular, genetic, and psychosocial components.

The findings support the inclusion of occlusal assessment in TMD evaluation, but emphasize that malocclusion should be considered as one of many potential contributing factors rather than a primary cause. Clinical management should adopt a comprehensive, multidisciplinary approach that addresses all relevant factors contributing to TMD development and maintenance.

While the evidence supports a role for occlusal factors in TMD, the strength of association is moderate, and individual variation is considerable. This underscores the importance of personalized assessment and treatment planning based on the specific characteristics and needs of each patient.

Future research should focus on longitudinal studies with standardized assessment protocols, advanced imaging techniques, and genetic investigations to better understand the complex relationship between malocclusion and TMD. Such research will help refine our understanding of this relationship and guide the development of more effective prevention and treatment strategies.

The clinical implications of this review emphasize the need for comprehensive TMD assessment that includes evaluation of occlusal factors within the broader context of the biopsychosocial model. Treatment planning should be individualized based on the specific combination of contributing factors present in each patient, with recognition that occlusal intervention alone is unlikely to resolve TMD symptoms in most cases.

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