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Exploring the association between orthodontic treatment and temporomandibular disorders in pediatric patient: A retrospective study

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Abstract

OBJECTIVE: This retrospective study aimed to investigate the association between orthodontic treatment and development of temporomandibular disorders (TMDs) in pediatric patients.

METHODS: This study analyzed 122 pediatric patients (age 10–18 years) who underwent orthodontic treatment. The inclusion criteria included comprehensive orthodontic records and substantial clinical documentation, while the exclusion criteria targeted preexisting TMDs or syndromes affecting the temporomandibular joint. Demographic details, treatment characteristics, and radiographic analyses, including standardized cephalometric measurements, were recorded. Clinical records were systematically reviewed for signs and symptoms of TMD, with categorization based on TMD severity using the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD).

RESULTS: Demographic characteristics revealed a mean age of 14.2 years, with a sex distribution of 36.9% males and 63.1% females. Pain, clicking/popping sounds, and limited jaw movement were reported by 23.0%, 16.4%, and 12.3% of the patients, respectively. TMD severity classification showed that 73.8% had no symptoms, 20.5% had mild symptoms, 4.1% had moderate symptoms, and 1.6% had severe symptoms. Statistical analyses revealed a significant association between TMD symptoms and sex ($P = 0.023$). Correlations among TMD severity, treatment duration ($P = 0.036$), and cephalometric changes were observed. Radiographic findings showed a moderate correlation with the gonial angle (r = 0.42) and a strong correlation with the condylar position (r = 0.58).

CONCLUSION: This study provides insights into the complex relationship between orthodontic treatment and TMD development in pediatric patients. These findings suggest potential associations between treatment characteristics, cephalometric changes, and TMD symptoms.

Keywords:

Cephalometric analysis, orthodontic treatment, pediatric patients, temporomandibular disorders

Introduction

Orthodontic treatments, designed to enhance dental and facial aesthetics, are predominantly carried out during childhood when the teeth are most readily be moved.[1] While the recognized benefits of such interventions are widely acknowledged, an emerging area of interest involves potential associations between orthodontic procedures and the onset of temporomandibular disorders (TMDs).[2] TMDs encompass a spectrum of conditions affecting the temporomandibular joint (TMJ) and associated structures, manifested through symptoms such as

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pain, clicking or popping sounds, and limited jaw movement.[3]

The temporomandibular joint undergoes dynamic changes during orthodontic treatment, particularly when fixed appliances are used. These changes may influence the biomechanics of the TMJ, potentially contributing to the onset or exacerbation of TMD symptoms.[4] Cephalometric radiographs serve as crucial tools for evaluating craniofacial alterations, including changes in condylar position and mandibular morphology.[5]

Existing literature offers valuable insights into the impact of orthodontic treatments on TMJ dynamics and the potential development of TMD symptoms.[2,6,7] However, several gaps and limitations persist, necessitating further investigation. Despite previous research exploring the relationship between orthodontic treatments and TMDs, comprehensive studies focusing on pediatric patients remain limited. Understanding the interplay between orthodontic treatments and TMDs is crucial for optimizing patient care.[8,9] Pediatric patients, undergoing a critical phase of craniofacial development, may exhibit unique responses to orthodontic interventions, warranting a dedicated exploration of TMD symptoms in this population.[10] Recognizing the influence of orthodontic changes on the temporomandibular joint can contribute to tailored treatment approaches, minimizing the risk of TMD development or progression.[11]

This study holds significance in the orthodontic field, as it aims to unravel the complex relationship between orthodontic treatments and TMDs in a pediatric context. These findings may guide orthodontic practitioners in identifying at-risk patients, implementing preventive measures, and facilitating early intervention for patients exhibiting TMD symptoms. Moreover, this research may contribute to the development of evidence-based guidelines for orthodontic treatment in pediatric populations, optimizing both aesthetic outcomes and TMJ health.

The study aims to evaluate the prevalence and severity of TMD symptoms in pediatric patients following orthodontic treatment and investigate potential correlations with specific treatment characteristics.

Material and Methods

Data collection

The present study included 122 pediatric patients (aged 10–18 years) who underwent orthodontic treatment between January 2015 and December 2023.

Ethical Approval: Ethical approval was obtained from the Institutional Review Board (IRB) to ensure compliance with ethical standards. Ensured adherence to data protection regulations and maintained confidentiality throughout the study.

Patient confidentiality was rigorously maintained throughout the study to ensure compliance with ethical standards and data protection regulations. All clinical records were handled with strict confidentiality measures in place. Patient identifiers such as names, contact information, and any other identifying details were anonymized or removed from the records before analysis. Access to the clinical records was restricted to authorized personnel involved in the study, and data were stored securely in password-protected electronic databases or locked cabinets. Additionally, all research activities were conducted in accordance with the guidelines set forth by the Institutional Review Board (IRB) to safeguard patient privacy and confidentiality.

Inclusion criteria

Orthodontic Records: The study involved patients with comprehensive orthodontic records encompassing both pretreatment and posttreatment cephalometric radiographs. These records provided detailed insights into the craniofacial changes associated with orthodontic treatment.

Clinical Documentation: The inclusion of patients with substantial clinical documentation for each case was ensured. This documentation includes detailed notes on the patient's medical history, orthodontic treatment plan, progress notes, and any additional relevant clinical observations. This comprehensive clinical information facilitates a holistic understanding of the orthodontic journey of each patient.

Exclusion criteria

Preexisting temporomandibular disorders (TMDs): Patients who presented with preexisting TMDs before orthodontic treatment initiation were excluded. This criterion focused specifically on the development of TMD symptoms in correlation with orthodontic interventions, rather than preexisting conditions influencing the outcomes.

Syndromes or medical conditions affecting the TMJ: Patients with known syndromes or underlying medical conditions that could potentially influence the temporomandibular joint, conditions such as rheumatoid arthritis, systemic lupus erythematosus, or any other medical condition known to affect the TMJ were also excluded. This ensured that the study primarily addressed TMDs arising from orthodontic interventions rather than from preexisting systemic conditions.

Patient Demographics: Detailed demographic information for each included patient, including age, sex, and other relevant characteristics, was recorded. These demographic data allowed for the stratification of results and analysis based on different patient profiles.

Treatment Characteristics: Data on specific treatment characteristics, such as the duration of orthodontic treatment and types of appliances utilized, were collected. This information is crucial for identifying potential correlations between the duration or type of treatment and development of TMD symptoms.

Radiographic analysis

Cephalometric radiograph selection: Pretreatment and posttreatment cephalometric radiographs of each patient included in the orthodontic records were identified and retrieved. This selection ensured a comprehensive assessment of the craniofacial changes before and after orthodontic treatment.

Image Standardization: All cephalometric radiographs obtained were of high quality and were standardized for consistent image quality. This step involved assessing factors such as proper head positioning, exposure settings, and image resolution to minimize variability in radiographic data.[12]

Evaluation of the condylar position: The condylar position was systematically evaluated by comparing pretreatment and posttreatment radiographs, with a focus on identifying any anterior, posterior, superior, or inferior changes in the condylar position. This study aimed to understand the impact of orthodontic treatment on the temporomandibular joint (TMJ) and its components.

Assessment of mandibular morphology: Changes in mandibular morphology on cephalometric radiographs were examined by analyzing parameters such as the gonial angle, ramus height, and mandibular length. This detailed assessment provided insights into alterations in the structural components of the mandible resulting from orthodontic interventions.

Utilization of Standardized Cephalometric Analysis: Established cephalometric analysis methods, such as Steiner, Downs, Rakosi, and McNamara analysis, were employed to quantify and measure observed alterations in condylar position and mandibular morphology.[13,14] Standardization ensured the reliability and reproducibility of the measurements across all cases.

Measurement Calibration: Calibrated measurements were recorded using anatomical landmarks to enhance the accuracy. Landmarks such as the sella, nasion, orbitale, porion, articulare, condylion, subspinale, supramentale, gonion, gnathion, and menton were precisely located on the radiographs, and measurements were performed using standardized reference planes to minimize measurement errors.

Clinical record review

Systematic Retrieval of Clinical Records: The clinical records of each patient included in the study were retrieved and systematically organized. Comprehensive records encompassing the entire orthodontic treatment duration, from initiation to completion, were ensured.

Signs and symptom identification: The clinical notes and observations in the records were systematically reviewed to identify the signs and symptoms indicative of TMDs. The focus was on key indicators, such as pain, clicking or popping sounds, and limitations in jaw movement.

Pain Assessment: Detailed descriptions of any reported pain, including location, intensity, and frequency, were examined. Information regarding the presence of pain during activities such as chewing, speaking, or jaw movements at rest was recorded.

Clicking or hopping sound analysis: Reports of clicking or popping sounds during jaw movements were investigated, and the nature of these sounds, their frequency, and whether they were associated with specific jaw movements were recorded.

Limited Jaw Movement Assessment: Clinical records were assessed for any documented limitations in jaw movements, including restrictions in mouth opening or closing. The degree of limitation and any associated factors reported by the patients or observed by orthodontic professionals were recorded.

Application of RDC/TMD Criteria: The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were applied to systematically categorize the patients based on the presence and severity of TMD symptoms. The established criteria were applied to standardize the classification of TMD cases and facilitate comparison across the study population.[15]

RDC/TMD Criteria Components: Specific components of the RDC/TMD, including Axis I, were considered for clinical diagnoses, and Axis II for psychosocial factors to comprehensively characterize TMD cases. This involved assessing parameters such as muscle pain, joint pain, and limitations in jaw movements.[15]

Severity Grading: Severity grades were assigned to TMD cases based on the RDC/TMD criteria. This

allowed for differentiation between mild, moderate, and severe TMD cases, providing a nuanced understanding of the impact of orthodontic treatment on TMD symptomatology.

Data Analysis: Statistical analyses were conducted using IBM SPSS Statistics version 24. Descriptive statistics, including mean age, sex distribution, and treatment variables, were generated to provide a summary of the demographic and orthodontic characteristics of the pediatric cohort that underwent orthodontic treatment. For categorical analyses, Chi-square tests were used to examine the associations between sex and the prevalence of TMDs. Correlation analyses utilizing Pearson coefficients were conducted to investigate the relationship between TMD severity and cephalometric changes, specifically the gonial angle and condylar position. Logistic regression was used to identify potential predictors of TMD development, considering age, sex, and treatment characteristics. Linear regression was used to explore the associations between continuous variables, such as treatment duration and TMD severity. Statistical significance was set at $P < 0.05$, and sensitivity analyses were performed to ensure robustness of the results.

Results

The demographic characteristics of the study population are shown in Table 1. The pediatric patients who underwent orthodontic treatment had a mean age of 14.2 years, with a sex distribution of 36.9% male and 63.1% female [Table 2]. The mean treatment duration was 24.5 months, with 69.7% of the patients receiving treatment with fixed appliances and 30.3% opting for removable appliances.

Table 3 illustrates the prevalence of specific TMD symptoms among the participants. Pain was reported by 23.0%, clicking/popping sounds by 16.4%, and limited jaw movements by 12.3%. Table 4 categorizes patients based on TMD severity. The majority had no TMD symptoms (73.8%), 20.5% exhibited mild symptoms, 4.1% had moderate symptoms, and 1.6% experienced severe symptoms. Overall, 26.2% of the study population had various degrees of TMDs.

Table 5 shows the association between TMD symptoms and sex. The Chi-square test indicated a statistically significant association ($P = 0.023$), revealing a higher prevalence of TMD symptoms in females (38.9%) than in males (34.4%). Table 6 shows the correlations between TMD severity and treatment duration. Linear regression analysis revealed a statistically significant association ($P = 0.036$), suggesting that longer treatment duration may be linked to increased TMD severity.

Table 7 illustrates a positive correlation between the severity of TMD symptoms and cephalometric changes in pediatric patients who underwent orthodontic treatment. Patients with no TMD symptoms exhibited an average change of 1.5° in gonial angle, whereas

Table 1: Demographic characteristics

Demographic Variable	Mean (SD) or Frequency (%)
Age (years)	14.2 (2.1)
Gender	
Male	45 (36.9%)
Female	77 (63.1%)

Table 2: Treatment characteristics

Treatment Variable	Mean (SD) or Frequency (%)
Duration of Treatment (months)	24.5 (4.8)
Type of Orthodontic Appliances	
Fixed	85 (69.7%)
Removable	37 (30.3%)

Table 3: Prevalence of signs and symptoms

TMD Symptom	Frequency (%)
Pain	28 (23.0%)
Clicking/Popping Sounds	20 (16.4%)
Limited Jaw Movement	15 (12.3%)

Table 4: Prevalence of temporomandibular disorders (TMDs)

TMD Symptoms	Number of Patients (%)
No TMD Symptoms	90 (73.8%)
Mild TMD Symptoms	25 (20.5%)
Moderate TMD Symptoms	5 (4.1%)
Severe TMD Symptoms	2 (1.6%)

Table 5: Association between TMD symptoms and gender

Gender	No TMD Symptoms	Mild TMD Symptoms	Moderate TMD Symptoms	Severe TMD Symptoms
Male	35 (38.9%)	5 (20%)	1 (20%)	1 (50%)
Female	55 (61.1%)	20 (80%)	4 (80%)	1 (50%)

Chi-square test P=0.023 (statistically significant)

Table 6: Correlation between TMD severity and treatment duration

TMD Severity	Mean Treatment Duration (months)
No TMD Symptoms	22.5
Mild TMD Symptoms	24.8
Moderate TMD Symptoms	26.4
Severe TMD Symptoms	28.0

Linear regression P=0.036 (statistically significant)

Table 7: Correlation between TMD severity and cephalometric findings

TMD Severity	Mean Change in Gonial Angle	Mean Change in Condylar Position (mm)
No TMD Symptoms	1.5 degrees	0.2
Mild TMD Symptoms	2.0 degrees	0.5
Moderate TMD Symptoms	2.5 degrees	0.8
Severe TMD Symptoms	3.0 degrees	1.0

Pearson correlation coefficient for Gonial Angle=0.42 (moderate correlation); Pearson correlation coefficient for Condylar Position=0.58 (strong correlation)

those with severe TMD symptoms showed the highest average change of 3.0°. Similarly, changes in condylar position ranged from 0.2 mm in patients without TMD symptoms to 1.0 mm in those with severe TMD symptoms. The Pearson correlation coefficients of 0.42 for the gonial angle and 0.58 for condylar position indicate a moderate to strong positive linear relationship between TMD severity and these cephalometric changes.

Discussion

The findings of this study shed light on the intricate relationship between orthodontic treatment and the development of TMDs in pediatric patients. This comprehensive approach, encompassing data collection, radiographic analysis, clinical record review, and statistical analyses, provides valuable insights into the potential factors influencing the occurrence and severity of TMD symptoms.

Demographic characteristics

The demographic profile of the study population revealed a mean age of 14.2 years, with a sex distribution of 36.9% males and 63.1% females. In terms of treatment characteristics, the study indicates a mean treatment duration of 24.5 months.

The observed mean age aligns with the typical age for orthodontic intervention, reflecting the standard practice in clinical settings.[16] The longer treatment durations, as evidenced in this study, may be attributed to the complexity of cases or the requirement for comprehensive correction, a finding consistent with existing literature that suggests a substantial proportion of orthodontic patients belong to the younger age group.[17]

The higher proportion of female participants, constituting 63.1%, is consistent with findings reported by Lai *et al*.[18] and Almăşan *et al*.[19] This trend is supported by the observation that females tend to be more proactive in seeking orthodontic care than males, reflecting a broader societal trends related to beauty and self-image.[17]

Treatment characteristics

This study's focus on treatment characteristics, including the mean treatment duration and types of appliances used, provides a valuable context for understanding the potential correlations with the development of TMDS. Longer treatment duration, as evidenced by a mean of 24.5 months, may be associated with increased TMD severity, as suggested by the statistically significant correlation.

The predominance of fixed appliances (69.7%) compared with removable appliances (30.3%) suggests the need to explore whether different appliance types influence TMD symptoms differently. This aligns with existing literature, which suggests that appliance types may impact temporomandibular joint dynamics.[20]

Prevalence of signs and symptoms

Investigating the interplay between orthodontic treatment and TMJ health is clinically important, particularly when considering the prevalence of TMD symptoms. Among the patients studied, 23.0% reported experiencing pain, 16.4% reported clicking or popping sounds, and 12.3% reported limited jaw movements. These findings align with earlier research, such as Conti *et al*.'s[21] study in pediatric patients with orthodontic appliances, which identified joint noises in 12.5% of participants. Similarly, Egermark *et al*.[22] reported TMJ clicking in 21% of orthodontic patients. Bourzgui *et al*.[23] found joint noise in 14% of orthodontic patients, with 44% experiencing joint clicking. These figures provide additional context, and when compared to these observations, Yan *et al*.[10] reported a higher prevalence of TMJ noise, reaching 62.4% among orthodontic patients. These variations highlight the variability in reported TMJ symptoms within the orthodontic patient population, suggesting a complex relationship between orthodontic treatment and the manifestation of TMD signs and symptoms.

Prevalence of temporomandibular disorders (TMDs)

The prevalence and classification of patients based on the severity of TMDs is pivotal for understanding the potential impact of orthodontic treatment on TMDs development. Within our study population, approximately 26.2% of patients experienced varying degrees of TMD symptoms. This differs notably from the findings of Macfarlane *et al*.,[24] who reported TMDs in 3.2% of pediatric orthodontic patients, indicating a lower prevalence compared to our study. On the other end of the spectrum, Yan *et al*.[10] reported a substantially higher rate of TMDs (52.7%) in orthodontic patients under 18 years of age.

In terms of severity categorization in our study, the majority (73.8%) exhibited no TMD symptoms, 20.5% presented with mild symptoms, 4.1% had moderate symptoms, and 1.6% experienced severe symptoms. This distribution contrasts with Conti *et al*.'s study,[21] where 34% of subjects had mild TMD and 3.5% had moderate TMD. Similarly, Yap *et al*.[25] reported 28% had mild TMD and 10% had moderate TMD. These variations underscore the complexity of TMD manifestation within orthodontic populations, emphasizing the need for a nuanced approach in assessing TMD severity and its potential association with orthodontic treatment.

Association between TMD symptoms and gender

The identification of an association between temporomandibular disorder (TMD) symptoms and sex adds a compelling layer to the study's findings. A statistically significant correlation revealed a higher prevalence of TMD symptoms in females (38.9%) than in males (34.4%), consistent with similar observations in the existing literature. This consistency across studies underscores the relevance of sex as a potential influencing factor in the manifestation of TMD symptoms.

Biological factors, encompassing genes, hormones, pain perception, psychosocial elements, and environmental influences, may contribute to the observed gender-based disparities in TMD prevalence.[24,26] The intricate interplay of these factors underscores the multifaceted nature of TMD development. These findings echo those of Conti *et al*.,[21] Bourzgui *et al*.,[23] Jain *et al*.,[27] and Macfarlane *et al*.,[24] emphasizing the recurring pattern of higher TMD prevalence in females.

However, it is noteworthy that Yan *et al*.[10] reported no discernible difference in gender distribution concerning TMD symptoms, introducing a degree of variability in the literature. This discrepancy highlights the complexity of the factors influencing TMD and suggests the need for further research to explore the nuances of sex-specific manifestations and their underlying mechanisms.

Correlation between TMD severity and treatment duration

The correlation between TMD severity and treatment duration reveals a potential temporal aspect of TMD development in the context of orthodontic interventions. This statistically significant association suggests that longer treatment durations may be associated with increased TMD severity. This finding aligns with those of studies that emphasize the importance of longitudinal monitoring of TMD symptoms throughout orthodontic treatment.

Regrettably, there is a lack of comparative data from other studies to contextualize and corroborate these findings. Nevertheless, the observed association emphasizes the importance of considering the treatment duration as a potential factor influencing TMD severity. This highlights the need for continued investigation of the temporal aspects of TMD development during orthodontic intervention. Future research could further elucidate the intricate relationship between treatment duration and TMD severity, offering valuable insights for both orthodontic practitioners and researchers.

Correlation between radiographic findings and TMD symptoms

The strong and moderate correlations between radiographic findings and TMD symptoms signify a potential link between specific cephalometric changes and the clinical manifestations of TMD. The moderate correlation ($r = 0.42$) for the gonial angle and strong correlation ($r = 0.58$) for the condylar position underscores the importance of radiographic assessments in predicting and understanding TMD outcomes. These findings align with study by Yan *et al*.[10] suggesting a relationship between TMDs and particular craniofacial features in orthodontic patients.

Clinical implications

The findings of this study have practical implications for orthodontic practice. The identification of potential risk factors, including treatment duration and specific cephalometric changes, underscores the importance of vigilant monitoring and individualized treatment planning. Clinicians should consider sex-specific variations in TMD prevalence and tailored interventions accordingly.

Limitations of the study

Although this study provides valuable insights, several limitations should be acknowledged. The retrospective design introduces inherent biases, and reliance on clinical records for symptom identification may lead to underreporting or recall bias. Although the sample size was robust, it may limit the generalizability of the findings to broader populations. Additionally, this study did not explore psychosocial factors that could contribute to TMD symptomatology.

The findings of this study carry significant clinical implications for orthodontic practice, patient management, and future research directions. By uncovering the prevalence and severity of TMD symptoms in pediatric patients following orthodontic treatment, this research provides valuable insights for orthodontic practitioners. Understanding the interplay between orthodontic treatments and TMDs is crucial for optimizing patient care, guiding treatment planning, and minimizing the risk of TMD development or progression.

These findings underscore the importance of vigilant monitoring of TMD symptoms throughout orthodontic treatment and the need for tailored approaches to patient management. Furthermore, this study highlights the importance of future research focusing on longitudinal studies, comparative analyses, psychosocial factors, larger sample sizes, and multidisciplinary collaboration to further enhance our understanding of TMD development in pediatric orthodontic patients and inform evidence-based practices for optimizing patient outcomes.

Conclusions

This study evaluates the complex relationship between orthodontic treatment and TMDs in pediatric patients, uncovering significant insights crucial for clinical practice and future research. Through meticulous data collection, radiographic analysis, and statistical examination, the study revealed a notable prevalence of TMD symptoms among pediatric orthodontic patients, with pain, clicking/popping sounds, and limited jaw movements being the key manifestations. These findings underscore the importance of tailored treatment approaches, vigilant monitoring, and consideration of sex-specific variations in TMD prevalence. While this study offers valuable contributions, limitations such as its retrospective design and sample size constraints necessitate further investigation through longitudinal studies, exploration of psychosocial factors, and collaboration across disciplines. Overall, this study provides a foundation for optimizing patient care in pediatric orthodontics and highlights avenues for future research aimed at enhancing our understanding of TMD development of TMD and refining treatment strategies.

Ethical approval

Ethical approval was diligently sought from the Institutional Review Board (IRB), GGSCDS&RC/2021/IEC/022, Burhanpur, Madhya Pradesh, India.

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Conflicts of interest

There are no conflicts of interest.

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