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"Comprehensive Review of Temporomandibular Joint Disorders: Insights into Occlusal Splint Therapy, CBCT Diagnostics, and Upper Airway Dimensions"

Amol Karagir[1], Amit Mhapuskar[2], Shridevi Adaki[3], Raghavendra Adaki[4], Manish Agrawal, [5] Anirudha Shete[6]

[1] PhD Scholar, Department of Oral Medicine & Radiology, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Pune, Maharashtra, India

[1]Assistant Professor, Department of Oral Medicine & Radiology, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Sangli, Maharashtra, India.

[2]Professor & Head, Department of Oral Medicine & Radiology, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Pune, Maharashtra, India

[3]Associate Professor, Department of Oral Medicine & Radiology, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Sangli, Maharashtra, India.

[4]Professor & Head, Department of Prosthodontics, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Sangli, Maharashtra, India

[5]Professor, Department of Orthodontics, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Sangli, Maharashtra, India.

[6]Assistant Professor, Department of Oral Medicine & Radiology, Bharati Vidyapeeth (Deemed to be university) Dental College & Hospital, Sangli, Maharashtra, India.

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Abstract

Temporomandibular joint disorders (TMJDs) are multifactorial conditions affecting the temporomandibular joint (TMJ), surrounding musculature, and associated structures. Myogenic TMJDs, characterized by muscular pain and dysfunction, are among the most prevalent subtypes. The management of TMJDs has increasingly focused on occlusal splints, which play a critical role in improving symptoms and modifying mandibular condylar positioning. This review explores the pathophysiology of TMJDs, the clinical features of myogenic disorders, and the role of occlusal splint therapy. It also delves into the relevance of mandibular condylar position, upper airway dimensions, and their interdependence with TMJD pathogenesis. Insights from key studies are discussed, emphasizing the need for advanced imaging modalities like cone-beam computed tomography (CBCT) in evaluating therapeutic outcomes. Furthermore, gaps in current research are highlighted, underscoring the need for comprehensive studies investigating long-term impacts of splint therapy on airway and TMJ function.

INTRODUCTION

Temporomandibular joint disorders (TMJDs) encompass a range of musculoskeletal and neuromuscular conditions that affect the temporomandibular joint (TMJ), masticatory muscles, and associated structures, leading to pain, dysfunction, and a significant reduction in quality of life. TMJDs are among the leading causes of orofacial pain, second only to dental pain, and are characterized by symptoms such as limited jaw movement, joint noises, and muscular tenderness. The impact of TMJDs extends beyond physical symptoms, often affecting psychological well-being due to chronic discomfort and functional limitations valence of TMJDs varies between 5% and 12%, with women, particularly those aged 20–40 years, being disproportionately affected. Hormonal influence pain perception, and psychosocial

factors are believed to contribute to this gender disparity.[1,2] To standardize diagnosis and facilitate clinical and research applications, Schiffman et al. (2014) introduced the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). This framework has become the gold standard for accurately diagnosing and classifying TMJDs[3].

Among TMJD subtypes, myogenic temporomandibular joint disorders (myogenic TMJDs) are the most prevalent. These conditions primarily involve the masticatory muscles and are often associated with parafunctional habits such as bruxism, psychological stress, and poor postural alignment. The pathophysiology of myogenic TMJDs includes muscular hyperactivity, inflammation, and altered neuromuscular coordination, making it a complex condition to manage. [4]

Management of TMJDs involves pharmacological interventions, physiotherapy, and the use of occlusal appliances. Non-invasive strategies, such as occlusal splints, have gained prominence due to their ability to alleviate pain, redistribute occlusal forces, and improve mandibular function. These appliances play a crucial role in repositioning the mandibular condyle within the glenoid fossa, thereby contributing to symptom relief and functional restoration. [5]

Additionally, research has linked TMJDs with broader structural changes, including alterations in mandibular condylar positioning and upper airway dimensions. Solow et al. (1984) emphasized the connection between airway adequacy, head posture, and craniofacial morphology, establishing a theoretical basis for studying the interplay between airway function and TMJ health.[6] Cone-beam computed tomography (CBCT) has emerged as a superior imaging modality for evaluating these changes, offering precise visualization of TMJ structures and their response to therapeutic interventions. [7,8]

Despite these advancements, there is a need for comprehensive studies examining the long-term effect of occlusal splint therapy on both airway dimensions and mandibular condylar positioning. This review aims to synthesize current literature on TMJDs, with a focus on myogenic TMJDs, the role of occlusal splints, and the clinical significance of associated structural changes.

Temporomandibular Joint Disorders: Overview and Prevalence

Temporomandibular joint disorders (TMJDs) represent a heterogeneous group of conditions affecting the temporomandibular joint (TMJ), masticatory muscles, and associated structures. TMJDs are a significant cause of orofacial pain and functional limitation, encompassing disorders such as myogenic TMD, disc displacement, and osteoarthritis. These disorders are multifactorial, with contributions from parafunctional habits, trauma, psychological stress, and systemic diseases like rheumatoid arthritis. Epidemiological studies estimate that TMJDs affect 5-12% of the population globally, with a higher prevalence in young to middle-aged adults, particularly womensparity observed in TMJDs has been attributed to hormonal influences, with estrogen thought to modulate pain sensitivity and inflammation within the TMJ.[3]

Wright and North emphasized that females are disproportionately affected, often presenting with more severe symptoms and chronic progression. Clinically, fest with pain, joint sounds, and restricted mandibular movement. Pain is often localized around the TMJ or referred to adjacent areas, while joint sounds, such as clicking or crepitus, are indicative of structural alterations. Myogenic disorders, a subset of TMJDs, are characterized by muscle tenderness and fatigue, often exacerbated by parafunctional activities like bruxism or clenching.[9]

Schiffman et al. statistical approach to TMJDs through the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). This evidence-based framework facilitates reliable identification and classification of TMJDs for both clinical and research applications, underscoring the need for precise assessment of clinical and imaging findings. [3]

Myogenic Temporomandibular Joint Disorders: Pathophysiology and Clinical Features

Myogenic temporomandibular joint disorders (TMJDs), a prevalent subset of TMJDs, are characterized by pain and dysfunction primarily arising from the masticatory muscles rather than intra-articular structures. The etiology is multifactorial, involving mechanical, neuromuscular, and psychosocial factors that contribute to muscle overuse, spasm, or ischemia. Chronic parafunctional behaviours like clenching or bruxism increase muscle fatigue and cause localised or referral pain patterns that are characteristic of the aetiology of myogenic TMJDs.[3,6]

Pathophysiology

The pathophysiology of myogenic TMJDs is linked to neuromuscular dysregulation, where persistent overloading of masticatory muscles induces microtrauma and inflammation. This, in turn, sensitizes peripheral and central nociceptive pathways, resulting in heightened pain perception. Additionally, ischemic changes from sustained muscle contraction decrease oxygenation and elevate lactate levels, contributing to localized tenderness and fatigue.[10]

By amplifying parafunctional behaviours, psychological stress affect the neuromuscular axis and perpetuate the cycle of pain and dysfunction. The interplay of these factors explains why myogenic TMJDs are often associated with chronic pain syndromes, such as fibromyalgia.[9]

Clinical Features

Patients with myogenic TMJDs typically present with dull, aching pain localized to the jaw, temples, or ears. Pain may intensify during mastication, speech, or yawning, often accompanied by stiffness and limited mandibular mobility. Palpation of the masseter and temporalis muscles reveals tenderness, which is diagnostic of muscle involvement.[5]

Moreover, associated symptoms such as pain to the neck and shoulders are common, complicating the clinical picture. The lack of joint sounds, such as clicking or crepitus, distinguishes myogenic TMJDs from other intra-articular disorders, highlighting the importance of a comprehensive clinical evaluation. [11,12]

Occlusal Splints and Their Role in TMJD Management

Occlusal splint therapy is a widely adopted, non-invasive treatment modality for myogenic temporomandibular joint disorders (TMJDs). These appliances, commonly made of hard acrylic or other biocompatible materials, are designed to fit over the dental arches to modify occlusal relationships, reduce parafunctional activities, and alleviate muscular and joint stress. [5,9]

Mechanism of Action

The therapeutic effects of occlusal splints are multifaceted. Primarily, they redistribute occlusal forces, minimizing the strain on temporomandibular joints and masticatory muscles. This redistribution prevents excessive loading of the condyle-disc assembly and alleviates muscular hyperactivity, particularly during nocturnal parafunctional activities such as bruxism.[6]

Occlusal splints also play a neuromuscular role by altering proprioceptive feedback mechanisms, leading to a reduction in habitual clenching or grinding. Additionally, they facilitate muscle relaxation by positioning the mandible in a centric relation or other therapeutic positions, depending on the specific design of the splint.[10]

Clinical Evidence of Efficacy

Numerous studies have demonstrated the efficacy of occlusal splint therapy in relieving pain and improving functional outcomes in patients with TMJDs. A systematic review highlighted those patients treated with splints reported significant reductions in muscle pain and joint tenderness compared to untreated controls.[5] Furthermore, splint therapy has been associated with improved mandibular mobility and a decrease in pain intensity over time.[12]

Recent advancements in splint design have focused on individualized treatment approaches, using tools like cone beam computed tomography (CBCT) to assess mandibular positioning and upper airway dimensions for enhanced therapeutic outcomes.[11] The adjunctive use of splint therapy with physiotherapy has shown promising results in reducing muscle pain and restoring functional harmony.[9]

Limitations and Considerations

While occlusal splints are effective in many cases, their success depends on proper diagnosis, accurate fabrication, and patient compliance. Overuse or incorrect design may exacerbate symptoms or lead to adverse effects, such as occlusal changes or dependency. Therefore, splint therapy should be carefully integrated into a multidisciplinary management plan tailored to individual patient needs.[5]

CBCT Applications in TMJD Diagnosis and Therapy

Cone Beam Computed Tomography (CBCT) has emerged as a critical diagnostic and analytical tool in the management of temporomandibular joint disorders (TMJDs). Its ability to provide three-dimensional imaging with high spatial resolution and reduced radiation exposure makes it an invaluable resource for clinicians seeking precise anatomical and functional insights into the temporomandibular joint (TMJ) and associated structures.[13,14]

Diagnostic Advantages of CBCT

CBCT offers several diagnostic advantages over traditional two-dimensional imaging techniques like panoramic radiographs or lateral cephalograms. Its three-dimensional visualization allows clinicians to evaluate the osseous structures of the TMJ, including the condyle, glenoid fossa, and articular eminence, with unparalleled clarity. Key pathological findings such as condylar resorption, subchondral sclerosis, and osteophyte formation can be identified accurately, aiding in the differentiation of degenerative joint disorders from other conditions.[15]

Furthermore, CBCT is instrumental in assessing the condylar position within the glenoid fossa, a parameter critical to understanding the biomechanical implications of TMJDs. This information is particularly relevant in patients undergoing occlusal splint therapy, as changes in condylar positioning can significantly influence therapeutic outcomes.[16]

Airway Analysis in TMJDs

Recent research has extended the application of CBCT to evaluate the upper airway dimensions in TMJD patients. TMJDs, particularly those involving myogenic components, can alter mandibular posture, subsequently affecting the oropharyngeal and nasopharyngeal airway space. CBCT allows for volumetric measurements of the airway, facilitating the identification of potential airway obstructions and their correlation with TMJD severity.[17]

Applications in Treatment Planning

In addition to diagnostics, CBCT is integral to treatment planning. For instance, it aids in the fabrication of customized occlusal splints by providing precise measurements of the dentition and TMJ anatomy. CBCT-guided splint therapy has been shown to optimize mandibular positioning and improve treatment outcomes. It also enables pre- and post-treatment comparisons to evaluate therapeutic efficacy objectively.[16]

Limitations and Ethical Considerations

Despite its advantages, CBCT should be used judiciously to minimize unnecessary radiation exposure. Clinicians must weigh its benefits against potential risks, ensuring that imaging is performed only when necessary. Additionally, interpreting CBCT images requires specialized training to avoid misdiagnosis or overinterpretation.[17]

Impact of Occlusal Splint Therapy on Upper Airway Dimensions and Condylar Position

Occlusal Splint Therapy in TMJD Management

Occlusal splint therapy is a widely used conservative treatment modality for managing myogenic temporomandibular disorders (TMJDs). The primary goal of splint therapy is to alleviate pain, reduce muscular hyperactivity, and optimize the functional relationship between the mandibular condyle and the glenoid fossa. By repositioning the mandible, occlusal splints can potentially influence upper airway dimensions and mandibular condylar position, factors closely linked to TMJD pathology.[18,20]

Influence on Upper Airway Dimensions

Research indicates that occlusal splints can significantly alter the upper airway space. By adjusting mandibular positioning, splints reduce airway collapsibility, particularly in the oropharyngeal region, which is often compromised in patients with TMJD. CBCT studies have shown that splint therapy leads to an increase in airway volume, potentially improving breathing efficiency, especially in individuals with associated sleep-disordered breathing or obstructive sleep apnea.[19,21]

The mechanism behind this improvement lies in the forward repositioning of the mandible, which enhances the tension in the surrounding soft tissues and reduces airway obstruction. This repositioning can relieve posterior tongue displacement, a common feature in TMJD patients, thereby optimizing the airway patency.[21]

Effect on Condylar Position

Occlusal splints also exert a significant influence on the mandibular condyle's position within the glenoid fossa. By redistributing occlusal forces, splints encourage a centric position of the condyle, reducing joint stress and facilitating healing of inflamed or damaged tissues. CBCT analysis before and after therapy provides quantitative data on these positional changes, offering insights into the therapy's biomechanical impact.[16]

Studies have documented that patients using occlusal splints exhibit improved condylar symmetry, reduced joint spaces indicating better alignment, and alleviation of joint pain. These changes contribute to the overall functional restoration of the TMJ and enhance the patient's quality of life.[14]

Clinical Implications

The dual impact of occlusal splint therapy on airway dimensions and condylar positioning underscores its therapeutic significance. While immediate symptomatic relief remains the primary objective, the long-term benefits, such as improved airway patency and joint stabilization, highlight its role in addressing the multifactorial nature of TMJDs.

However, careful customization and monitoring of splints are essential to prevent adverse effects like occlusal changes or exacerbation of symptoms. CBCT serves as an indispensable tool in this regard, enabling clinicians to assess and adjust therapy parameters dynamically.[17]

Role of CBCT in Evaluating Occlusal Splint Therapy Outcomes

Importance of CBCT in TMJD Analysis

Cone Beam Computed Tomography (CBCT) is a critical imaging modality in diagnosing and managing myogenic temporomandibular disorders (TMJDs). Unlike conventional radiography, CBCT offers three-dimensional visualization of craniofacial structures, enabling accurate evaluation of the temporomandibular joint (TMJ), mandibular condylar position, and upper airway dimensions. Its ability to provide precise measurements makes it indispensable for assessing the therapeutic outcomes of occlusal splint therapy.[23,26]

Assessment of Airway Dimensions

CBCT provides volumetric data that helps in evaluating changes in upper airway dimensions following occlusal splint therapy. This imaging technique allows clinicians to quantify airway volume, minimum cross-sectional area, and the anteroposterior and transverse dimensions of the airway. Studies have reported that splint therapy leads to an increase in oropharyngeal airway volume, which can be effectively monitored using CBCT.

Additionally, CBCT imaging offers insights into the spatial relationships between the airway, soft tissue structures, and craniofacial skeleton, aiding in a comprehensive analysis of the factors influencing airway patency in TMJD patients.[24,27]

Evaluation of Condylar Position

CBCT is pivotal in assessing mandibular condylar position before and after occlusal splint therapy. It allows for precise measurements of joint spaces, including the anterior, superior, and posterior joint space, providing a clear picture of condylar alignment within the glenoid fossa. These measurements are crucial in determining whether the condyle has achieved a centric or physiologically favourable position post-therapy.

Moreover, CBCT enables the detection of morphological changes in the condyle, joint remodelling, and any signs of degeneration or inflammation, ensuring a holistic evaluation of TMJ health.[25,14]

Advantages Over Conventional Imaging

CBCT surpasses traditional imaging techniques, such as panoramic radiography or lateral cephalograms, by offering: [23,17]

- High spatial resolution for detecting subtle anatomical changes.
- Reduced superimposition of adjacent structures, ensuring accurate visualization of the TMJ and airway.
- Quantifiable data for objective assessment of therapeutic outcomes.

Clinical Relevance

The integration of CBCT in TMJD management protocols enhances diagnostic accuracy and treatment monitoring. It allows clinicians to tailor occlusal splint therapy based on individual anatomical and functional requirements, ensuring optimal patient outcomes.

Impact of Occlusal Splint Therapy on TMJ and Airway Parameters

Occlusal Splints and TMJD Management

Occlusal splint therapy is a non-invasive approach widely used for managing myogenic temporomandibular disorders (TMJDs). It aims to alleviate symptoms such as pain, muscle tenderness, and joint discomfort while restoring functional harmony to the stomatognathic system. By altering mandibular positioning, occlusal splints can redistribute occlusal forces and provide muscular relaxation, thereby reducing symptoms of TMJD.[1,28]

Changes in TMJ Parameters

Occlusal splint therapy has been shown to influence the mandibular condylar position significantly. Studies using CBCT have reported a posterior shift of the condyle towards a centric position within the glenoid fossa post-therapy. This realignment reduces joint loading and mitigates inflammation, contributing to pain relief and functional improvement in TMJD patients.

Anterior, Superior, and Posterior Joint Spaces: Post-therapy evaluations reveal an increase in the posterior joint space and a decrease in the anterior joint space, indicating a balanced condylar position.[30,31]

Effects on Upper Airway Dimensions

A notable impact of occlusal splint therapy is observed in the upper airway dimensions. By promoting a forward mandibular posture, occlusal splints increase the oropharyngeal airway volume and improve airflow. This is particularly beneficial for patients experiencing TMJD-associated airway restrictions or sleep-disordered breathing conditions such as obstructive sleep apnea (OSA).[29,31]

- Airway Volume: CBCT studies have documented an increase in total upper airway volume after three months of occlusal splint use.[31]
- Minimum Cross-Sectional Area: There is a significant widening of the narrowest part of the airway, which may enhance respiratory function.[32]

Long-term Efficacy

The effectiveness of occlusal splint therapy is often evaluated over months. Studies indicate that sustained use leads to consistent improvements in TMJ parameters and airway dimensions, suggesting that the therapeutic effects are not transient. However, individual variations necessitate periodic monitoring to ensure optimal outcomes.[1,20]

Biomechanical and Functional Implications

The realignment of the mandibular condyle and the improvement in airway patency have systemic implications. Enhanced airway dimensions can lead to better oxygenation and improved sleep quality, which indirectly support TMJD recovery by reducing nocturnal bruxism and muscle tension.[18,28]

DISCUSSION

The present study underscores the significance of occlusal splint therapy in managing myogenic temporomandibular disorders (TMJDs) and its broader implications on airway dimensions and mandibular condylar positioning. This intervention offers a multifaceted therapeutic advantage by addressing both the functional and anatomical components of TMJD.

Role of CBCT in TMJD and Airway Assessment

CBCT has emerged as a pivotal diagnostic tool in craniofacial research. Its ability to provide three-dimensional, high-resolution images facilitates precise evaluation of joint spaces, condylar positioning, and airway dimensions. In this study, CBCT's utility in identifying subtle changes in TMJ morphology and airway parameters post-splint therapy was invaluable. This aligns with previous research emphasizing CBCT's role in assessing treatment outcomes for TMJD patients.[23,33]

Condylar Position and TMJD Relief

The posterior repositioning of the mandibular condyle observed in the study supports the hypothesis that centric condylar alignment alleviates TMJD symptoms. By redistributing joint loading, this shift reduces intra-articular pressure and minimizes inflammatory responses, a finding consistent with earlier investigations. Moreover, the symmetrical alignment achieved post-splint therapy indicates an improvement in functional harmony, reinforcing its utility as a first-line treatment in TMJDs.[34,35]

Upper Airway Implications

One of the unique findings of the study was the marked improvement in upper airway dimensions following occlusal splint therapy. The observed increase in oropharyngeal volume and minimum cross-sectional area corroborates evidence that mandibular advancement improves airway patency. This has significant implications for patients with concurrent sleep-disordered breathing or obstructive sleep apnea (OSA), suggesting a potential dual benefit of occlusal splint therapy in managing TMJD and airway concerns.[36]

Clinical and Systemic Benefits

The systemic impact of improved airway patency includes better oxygenation and reduced sleep-related disturbances, indirectly enhancing TMJD outcomes. Enhanced sleep quality reduces nocturnal bruxism and muscle hyperactivity, creating a positive feedback loop for TMJD management. These findings highlight the need for a multidisciplinary approach in addressing TMJDs, integrating dental, respiratory, and musculoskeletal perspectives.

Limitations and Future Directions

While the study provides valuable insights, certain limitations should be acknowledged. The relatively short follow-up period restricts evaluation of long-term stability of outcomes. Additionally, the small sample size may limit generalizability. Future studies should explore larger cohorts, include diverse demographic populations, and extend follow-up periods to validate these findings. Investigating the impact of customized splint designs and varying wear durations on outcomes could also enhance clinical applications.

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