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Temporomandibular Joint Disorders: Current Concepts in Etiology and Management

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Abstract

Temporomandibular disorders are a range of musculoskeletal conditions characterized by pain, discomfort, and limited jaw movements in the Temporomandibular joint. The disorder affects 5% of the population and is most common in individuals aged 18 to 45, with a higher incidence in women. Diagnosis and treatment of temporomandibular disorders remain challenging due to their complex etiology, involving multiple contributing factors, including psychosocial components and morphological and functional deformities of the joint and supporting structures. Treatment options range from non-invasive to fully invasive and depend on the stage of degenerative changes in the joint and associated structures. Clinicians must adopt a comprehensive, interdisciplinary, and multimodal approach when addressing temporomandibular dysfunction to consider all potential causes.

Keywords: Temporomandibular joint dysfunction, Temporomandibular joint, Masticatory muscle pain, Occlusal splints

INTRODUCTION

The articulation between the mandibular condyle and the glenoid fossa of the temporal bone forms the Temporomandibular Joint (TMJ). A non-ossified bone made of dense fibrous connective tissue called an articular disc separates the condylar head and the fossa, allowing the TMJ to function as both a ginglymoid and an arthrodial joint, giving it the designation of ginglymoarthrodial joint [1]. The muscles of mastication are mainly responsible for the movement of this joint [2]. Any changes in the biomechanics of the masticatory system can result in a musculoskeletal disorder known as Temporomandibular Disorder (TMD).

TMD is a broad term that encompasses a range of diseases, including pain and discomfort in the TMJ and surrounding musculoskeletal system, headaches, joint sounds, and limited mandibular movements. Intraoral examination reveals increased teeth sensitivity due to abrasion and pathological attrition, gum recession, bone loss causing teeth mobility, and tooth impressions on the tongue and cheek mucosa. TMD is associated with a distinctive intraoral finding, non-caries tooth defects (wear facets), caused by the combination of hyperactivity of the TMJ muscles and coexisting parafunction [3, 4].

Epidemiological data indicate that five percent of the population shows at least one sign of joint dysfunction, while 33% experience at least one symptom, such as facial pain. However, only five percent of those with symptoms seek treatment. TMD is most common in people between 18 and 45 years of age, with a higher incidence in women who seek treatment four times more often than men [5-10].

Despite extensive clinical research, diagnosing and managing temporomandibular disorders (TMDs) remains challenging [11]. The etiology of TMD is complex and involves multiple contributing factors, including psychosocial components and morphological and functional deformities of the joints and supporting structures [10]. For this reason, experts advocate a multidisciplinary approach with conservative interventions for treating TMD [12]. The stage of degenerative changes in the TMJ and associated structures determines the type of treatment, which can range from non-invasive to fully invasive [10].

METHODS

A literature search was conducted to identify relevant studies on the etiology and therapy of temporomandibular joint disorders (TMJ) in four databases: PubMed, Google Scholar, Scopus, and Cochrane. The search was limited to articles written in English and had no restrictions on publication dates.

The following search terms in different combinations using the Boolean operators "AND" and "OR" were used: ("Temporomandibular joint disorders") OR TMJ OR ("Temporomandibular disorders") OR TMD OR ("TMJ dysfunction") OR ("Musculoskeletal disorder of TMJ") AND (etiology OR "risk factors") AND (therapy OR therapeutic OR treatment OR management).

After the initial screening of the titles and abstracts, the full texts of the selected articles were critically evaluated and included in the study based on the following selection criteria: studies that addressed the etiology and management of temporomandibular joint disorders. Studies that

were irrelevant to the scope of the review or had insufficient data were excluded. The authors reviewed all types of studies, including observational (cohort and cross-sectional), experimental and analytical (randomized and non-randomized), systematic reviews, meta-analyses, literature reviews, and books. They then compiled the database results using the EndNote X9 reference manager.

RESULTS

The literature search resulted in 123 papers, from which the authors selected 80 relevant studies for final analysis regarding the risk factors and therapy of TMJ. The selected articles included clinical and laboratory studies, randomized controlled trials, systematic reviews, and literature review articles.

ETIOLOGY

The causes of temporomandibular joint disorders (TMD) are complex and multi-faceted and are divided into three categories: predisposing, initiating, and perpetuating factors.

Predisposing factors increase the risk of TMD and can be related to physiological, psychological, or structural factors. Initiating factors, on the other hand, are usually related to trauma or improper loading of the TMJ's musculoskeletal system. Finally, perpetuating factors can be behavioral, emotional, social, or cognitive and often interfere with the healing process or worsen the disorder [13].

Occlusal Factors

Costen was the first to link occlusion to TMD [1, 13]. Although occlusion is recognized as only one of many factors contributing to TMD, some studies suggest that orthodontic treatment, which changes occlusion, could increase the risk of TMD [14, 15].

Contrary to these findings, systematic reviews by Mohlin et al. [16] and Macfarlane et al. [17] found no evidence of a relationship between orthodontic treatment and TMD. Additionally, the studies conducted by Gesch et al. [18, 19] showed no significant relationship between functional occlusion factors and TMD symptoms.

Psychological Factors

Emotional stress is a factor that can impact masticatory function. Although evidence suggests the importance of psychological and psychosocial factors in understanding TMD, there is not

enough research to establish these factors as causes. Several studies have found a strong connection between depression, stress, and TMDs [13, 20-22].

Some research suggests that anxiety symptoms are more closely related to muscle pain, while depression symptoms are more closely associated with joint pain [11, 23]. For individuals who already have TMD, stressful situations can worsen their symptoms. For example, during the COVID-19 pandemic, studies have shown a relationship between depressive symptoms, stress, and TMD pain [24, 25]. Literature has also shown that patients with masticatory muscle pain or myogenic pain with arthralgia or osteoarthritis tend to have more severe stages of depression and somatization compared to those with disc displacement [13].

In conclusion, psychological factors can play a role in causing or perpetuating temporomandibular joint pain. The Orofacial Pain: Prospective Evaluation and Risk Assessment (OPPERA) study found several psychological factors that can contribute to the onset of TMD pain, but the development of TMD was also associated with the adverse effects of previous life events and perceived stress [26].

Hormonal Factors

Females are four times more likely to experience symptoms of TMD than males, and researchers believe this is due to the female reproductive hormone estrogen. Evidence of estrogen receptors in the temporomandibular joint and other parts of the stomatognathic system has led to an interest in the potential impact of estrogen on TMD [27].

Some studies, such as those conducted by Landi et al. [28, 29], have established a direct correlation between high estrogen levels and TMD pain. Conversely, studies by Dao et al. [30], LeResche et al. [31, 32], and Sherman et al. [33] found reduced TMD pain with high estrogen levels. In contrast, studies by Hatch et al. [34] and Nekora-Azak et al. [35] showed no connection between TMD and estrogen levels. Research has also reported an increase in TMD pain among women taking estrogen replacement therapy or oral contraceptives [31]. However, LeResche et al. [36] found no significant differences in pain between women on oral contraceptives and normal cycling women.

The results of studies investigating the direct correlation between estrogen and TMD are inconsistent and contradictory. A systematic review found insufficient data to support the hypothesis that estrogen levels directly affect TMD [27].

Trauma

Macrotrauma

Trauma such as head and neck injuries, prolonged mouth opening during dental procedures, and whiplash from cervical flexion-extension are macrotrauma and can contribute to TMD [37].

A third of whiplash cases have the potential to lead to TMD symptoms. [38] De Boever and colleagues found that external jaw injury and head and neck trauma may contribute to TMD in their study of 400 patients [39]. However, a study of 20,673 road traffic accident patients in Australia showed that TMD is rarely associated with whiplash injuries [40]. Heise et al. [41] found no strong clinical evidence supporting the connection between whiplash injuries and TMD. The OPPERA study found that external jaw trauma may cause TMD immediately after an injury or through a delayed reaction, but the cause-effect relationship is unclear [26].

Endotracheal intubation during anesthesia can also contribute to TMD. Patients with a history of TMD should have their preoperative TMD pain and non-pain symptoms assessed before undergoing general anesthesia [13, 42].

Microtrauma

Microtrauma can result from parafunctional habits, such as grinding teeth, clenching the jaw, thrusting the mandible, chewing gum, and biting fingernails [13].

Lobbezoo et al. [43] established a definition and diagnostic system for bruxism, described as repetitive jaw muscle activity involving clenching, grinding of teeth, and bracing or thrusting of the mandible. It can occur during sleep (sleep bruxism) or awake (awake bruxism). Bruxism is more strongly linked to muscle dysfunction than joint dysfunction, such as disc displacement, but can still result in degradation of the articular cartilage and remodeling of the condylar bone, leading to osteoarthritis in the TMJ [44, 45].

Manfredini et al. [46] found that bruxism strongly correlated with TMD pain when using self-reported diagnostic criteria, but the correlation weakened when using more specific methods. The study also found that wear on the front teeth was not a significant risk factor for developing TMJ dysfunction. However, the lack of comprehensive studies made it challenging to determine the relationship between specific TMD signs and symptoms and bruxism. Raphael

et al. [47] did not find an association between sleep bruxism and TMD based on their polysomnographic data.

Genetics

Cell signaling pathways influence the etiology of temporomandibular disorders (TMDs), and studies have shown a correlation between specific genes, pain response, and pain processing. Researchers have identified catechol O-methyltransferase (COMT) as a potential biomarker for TMD dysfunctions [48-50]. A study conducted on adolescents concluded that the gene catechol O-methyltransferase (COMT) had a connection to myofascial pain, but its association with disc displacement and painful TMD was less significant. In contrast, the serotonin transporter gene (5HTT) strongly links with painful TMD [50].

Patients with painful TMD often display markers of inflammation, such as cytokines and cartilage-degrading biomarkers like prostaglandin and matrix metalloproteinases. Chronic TMD cases revealed molecular markers, including neurotransmitters, neuropeptides, and cytokines [51]. The OPPERA study supports the hypothesis that genetic mutations play a role in TMD development. The study identified several genes, including the glucocorticoid receptor gene (NR3C1), the calcium/calmodulin-dependent protein kinase 4 (CAMK4) gene, the Cholinergic Receptor Muscarinic 2 (CHRM2) gene, the interferon-related developmental regulator 1 gene (IFRD1), and the G protein-coupled receptor kinase 5 (GRK5), as having the potential to increase TMD risk [49]. A study also suggested that women with TMJ dysfunction may experience significant pain during the low-estrogen phase of their menstrual cycle [48].

Mandibular Asymmetry

A study by Toh et al. has indicated that mandibular asymmetry may be a factor in the development of TMD. The statistical analysis of the study showed that patients with asymmetries in their jaw had a higher occurrence of TMD than those without any asymmetry or other dentofacial abnormalities [52].

Third-Molar Extraction

A study by Huang et al. with 34,491 participants found that young adults and adolescents with their third-molars extracted had a 60% higher likelihood of developing temporomandibular joint disorders (TMDs), suggesting that the removal of third-molar teeth may contribute to the onset of TMDs [53].

CLINICAL MANAGEMENT

Patients diagnosed with myogenic dysfunction, bruxism, and headaches should undergo a comprehensive program that includes education, cognitive training, and relaxation exercises. This approach will enhance their understanding of their symptoms and help them break the habit [3].

Early treatment is recommended for Temporomandibular Disorders (TMDs) as chronic pain becomes increasingly difficult to manage over time. A range of treatment options is available, from non-invasive to invasive. Conservative treatments, which have a lower risk of side effects, are usually recommended in the early stages of treatment. However, there is no consensus on how long conservative treatment should be used before alternative options are considered if no improvement is seen. All treatments aim to reduce TMD pain and improve jaw function, improving the patient's quality of life [10, 11].

Non-Invasive Treatment

Temporomandibular joint disorders (TMDs) are common conditions that can cause pain and discomfort in the jaw, neck, and head. Physical therapy and manual techniques are often recommended to relieve this pain and enhance mobility [1, 10]. The physical techniques used to treat TMDs include Thermal therapy, Ultrasound therapy, Electro-galvanic stimulation (EGS), Transcutaneous electrical nerve stimulation (TENS), Phonophoresis and iontophoresis, and Laser therapy. These techniques are designed to increase blood flow, reduce inflammation, relieve pain, and stimulate muscles [1, 10]. Hecht et al. conducted a study on the effectiveness of thermal therapy in reducing inflammation. They found that cold therapy was more effective in reducing inflammation than heat therapy. The study concluded that topical cold therapy could temporarily relieve pain due to its ability to reduce inflammation and relieve pain [54, 55]. Manual therapy (MT) is another non-invasive technique that has shown promise in improving mobility and reducing pain in the musculoskeletal system. MT may include techniques such as massage, stretching, and joint mobilization. Combining manual therapy with therapeutic exercises is often effective in enhancing mobility and reducing pain [10, 56-58].

Pharmacological agents such as Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), opioids, muscle relaxants, analgesics, anti-depressants, corticosteroids, anticonvulsants, and benzodiazepines are commonly used to reduce inflammation and TMD pain [5, 10, 11]. In one

study, taking naproxen at a dose of 500mg twice daily for six weeks improved TMD symptoms without causing severe adverse effects [59]. Topical methyl salicylate was also found to be more effective than a placebo in reducing TMD pain, but the long-term consequences are still uncertain [60, 61]. Further studies are needed to evaluate the long-term use of these drugs and determine whether the benefits of reducing pain and inflammation outweigh the potential adverse effects [8, 10, 62].

An occlusal splint is a commonly used removable device that affects the relationship between the lower and upper jaw, providing relief to the TMJ and reducing non-functional jaw activity [11]. Dentists often prefer occlusal splints as a treatment option due to their ease of fabrication and affordability [63]. The primary goal of the occlusal splint is to alleviate pressure on the temporomandibular joint (TMJ) and reduce non-functional jaw activity. By increasing the vertical dimension, the occlusal splint can alter the position of the TMJ and affect the movement of the jaw by altering the activity patterns of the jaw elevator muscles. Research has shown that the reduction of electrical activity in the masticatory muscles may contribute to the therapeutic effect of occlusal splint therapy for temporomandibular joint disorders (TMD) [64]. Additionally, using an occlusal splint can cause a localized increase in the temperature of the masticatory muscles, leading to improved blood flow and reduced pain in the masticatory musculature, providing additional justification for its use in relieving TMD discomfort [63].

There are several different occlusal splints on the market, such as prefabricated splints, anterior repositioning splints, Michigan splints, and mini-anterior splints. The most commonly used splints to treat myogenous and arthrogenous temporomandibular joint disorders (TMDs) are the stabilization splint and the anterior repositioning splint [65]. However, there is no consensus on the most effective design. Scientific data suggests that anterior repositioning splints can effectively treat disc displacements, while stabilization splints are best for moderate pain. Despite their effectiveness, it is important to use anterior repositioning splints with caution, as long-term use may result in a posterior open bite [11, 62, 64].

In conclusion, occlusal splints have the ability to ease the tension in the masticatory muscles, disengage the occlusion, reposition the condyle to its optimal position, and prevent further damage to the teeth from nocturnal parafunctional activity. While it is recommended for patients to use the splints during sleep, there is still ongoing debate about the length of time the splint should be worn [3, 64, 66-68].

Minimally Invasive Treatment

Minimally invasive treatments are an effective option for managing temporomandibular joint disorders (TMDs). Three common treatments include arthroscopy, arthrocentesis, and intra-articular injections.

Corticosteroids and hyaluronic acid are frequently used as injectables, as they have anti-inflammatory properties that can reduce pain and increase jaw movement. These treatments are safe and effective in reducing symptoms associated with TMDs [69].

Arthroscopic surgery and arthrocentesis function on the concept of lavage of inflammatory mediators and lysis of intra-articular adhesions by hydraulic irrigation of the superior compartment of the articular fossa [69]. During arthrocentesis, a sterile needle is introduced into the upper joint space through which a sterile solution is passed to distend the space. A second needle is placed in the now distended compartment through which debris and inflammatory cytokines are flushed out, followed by manual manipulation of the mandible [10, 70, 71]. Arthroscopy is a relatively more invasive surgical procedure performed with the help of an arthroscope. In addition to lavage and repositioning of the mandible, the surgeon performs lysis of the intra-articular adhesions, resulting in increased mandibular movements [10, 72].

In patients with internal derangement, restoring joint mobility improved the physiologic function of the TMJ by allowing for better diffusion of nutrients and the elimination of inflammatory by-products [69, 70]. Arthrocentesis is a relatively simple, affordable, low-risk procedure suggested as the initial treatment for arthritis [70, 73, 74].

Invasive Treatment

Surgery is only considered when other conservative treatments fail, typically in TMJ ankylosis and neoplasms. Chronic clicking, crepitus, severely limited mouth opening, and abnormal radiographic findings are indicators that surgical intervention is necessary [11, 62, 75]. Three surgical options exist for TMD: discectomy, condylectomy, and total joint replacement.

Discectomy involves removing the disc, enhancing joint function, and reducing pain. Condylectomy, for TMJ ankylosis involves resecting and replacing the upper part of the

mandibular condyle with an autograft, resulting in positive outcomes in 80% of cases. Total joint replacement is indicated for the most severe TMJ diseases and has been shown to significantly reduce TMD symptoms and improve the patient's quality of life in long-term studies [62, 76].

ADDITIONAL TREATMENT OPTIONS

Acupuncture

Acupuncture is an effective and safe treatment option for myogenous TMD with no osseous pathology. This treatment can be used as an auxiliary therapy to help relieve pain. A comprehensive review of available research found moderate evidence to support the short-term clinical benefits of acupuncture for TMD management [77-79].

Bio-Oxidative Ozone Therapy

Although ozone therapy has been used in dentistry for various applications, ranging from the management of incipient caries to peri-implantitis, its use in treating Temporomandibular Disorder (TMD) is relatively new. The highly reactive ozone molecule reacts with hydroxyl radicals, improving the peripheral oxygen supply. The gaseous ozone, when injected, balances oxygen metabolism, reducing TMD pain intensity. Therefore, bio-oxidative ozone therapy is a suitable option for treating TMD patients. However, due to a lack of literature, further studies are necessary to substantiate these results [80].

A study by Daif [81] demonstrated complete recovery of patients presenting with temporomandibular disorder (TMD) symptoms after administering ozone gas injections into the superior joint space. This finding was supported by the results of a study conducted by Celakil et al. [80] on the effectiveness of ozone therapy for TMD pain. The positive outcome of ozone therapy observed in these studies highlights its potential as a treatment option for TMD. However, as noted by Celakil et al., occlusal splint therapy remains the established and widely accepted gold standard for TMD treatment. Further research is necessary to fully establish the efficacy of ozone therapy as a treatment for TMD and to compare its outcomes with those of established treatments [80, 82].

Botulinum Toxin Injections

Botulinum toxin is a neurotoxin that can temporarily paralyze muscles. It works by blocking the release of acetylcholine, a neurotransmitter, at the neuromuscular junction, reducing muscle activity [83]. This has led to the use of Botulinum toxin in recent years to treat various disorders that result from excessive muscle activity [84]. The injections may be utilized as a secondary approach for patients who did not experience pain relief with non-invasive methods, such as a soft diet, medication, and oral appliances. Although further research is needed, there have been suggestions to use the toxin to relieve symptoms related to temporomandibular disorder (TMD) and muscle dystonia [83, 85, 86]

.Platelet-Rich Plasma (PRP)

Studies in the field of science have shown that PRP (platelet-rich plasma) has the ability to increase cell growth, encourage the development of cartilage and matrix by chondrocytes and mesenchymal stromal cells, and boost the production of hyaluronic acid by synoviocytes. Furthermore, PRP has demonstrated regenerative and anti-inflammatory effects. In a study by Zotti et al., using PRP to alleviate TMD (temporomandibular disorder) pain, improve joint function, and enhance mandibular movement resulted in positive outcomes [87].

Tissue Engineering

Researchers are exploring the temporomandibular joint (TMJ) as a potential treatment option through tissue engineering, which aims to replace degenerating tissues without resorting to invasive surgical procedures. Tissue engineering is a rapidly growing field that continues to advance in scaffold fabrication, cellularization strategies, and growth factor delivery. Researchers have made significant progress in creating scaffolds with the proper anatomical shape, and the materials used have shown promise in promoting tissue regeneration in TMD (temporomandibular disorder) models. Given the widespread incidence of TMD, tissue engineering of the TMJ is a critical area of research. However, more studies are needed to treat TMD and optimize clinical outcomes successfully [10, 62, 88].

CONCLUSION

Temporomandibular Disorders (TMDs) cause complex musculoskeletal conditions, including pain and discomfort in the TMJ and surrounding muscles, limited jaw movements, and non-caries tooth defects. Despite extensive research, diagnosing and managing TMD remains a challenge.

People between 18 and 45 years of age most commonly experience TMD, with women exhibiting a higher incidence. Clinicians recommend treating TMD with a multidisciplinary approach that includes conservative interventions. The appropriate type of treatment will depend on the stage of degenerative changes in the TMJ and associated structures.

Further research is necessary to understand the causes of TMD and develop better treatments. Clinicians must also adopt a comprehensive, interdisciplinary, and multimodal approach when addressing the signs and symptoms of TMD, taking into account all potential causes until a definitive etiology becomes clear.

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