

Advancements In Temporomandibular Joint Disorders: Diagnosis, Treatment, And Management Approaches

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Abstract

Temporomandibular Joint disorders are complex conditions that are influenced by anatomical, physiological, and psychological factors. The present paper discusses advancements in the diagnosis, treatment, and management of TMJ disorders and highlights the significance of a multidisciplinary approach as well as newer therapies. Anatomical abnormalities, psychological stress, hormonal influences, and parafunctional habits such as bruxism are identified as significant contributors to TMJ dysfunction. The etiology and pathophysiology are analyzed with particular focus on the interplay between structural and psychosocial factors. The advancements diagnostic imaging techniques, such as MRI and CT, have improved an understanding of TMJ pathology with their ability to look in greater detail into both soft and hard tissue changes. First-line conservative strategies are made up of physical therapies, lifestyle modifications, as well as pharmacological therapy. Psychological therapies, including CBT, are known to address psychosocial components of TMJ disorders. Emerging therapies, which include platelet-rich plasma and stem cell treatments, have further been proven to regenerate the TMJ tissues and offer better long-term outcomes. More severe cases are talked about using surgical interventions involving arthrocentesis and arthroscopy, as well as more advanced degeneration of the joint requiring solid solutions from TMJ prosthetics. The paper underlines the necessity of a holistic approach in TMJ management, where all the physical, psychological, and surgical modalities are integrated to optimize patient outcomes. Future studies are therefore recommended to determine the long-term effectiveness of the newly developed treatments as well as standardizing the diagnostic criteria. The present comprehensive review explores the multifactorial basis of TMJ disorders in order to help clinicians work towards giving more tailored treatment to individuals suffering from this disorder for improved quality of life.

Keywords Temporomandibular Joint Disorders; TMJ Syndrome; Diagnosis; Magnetic Resonance Imaging; Cone-Beam Computed Tomography; Arthrocentesis and Arthroscopy.

1. Introduction

One of the main anatomical causes of TMJ disorders is craniofacial asymmetry. It has been documented that there is strong association between craniofacial asymmetry and unilateral TMJ sounds, common

complaints of some form of joint dysfunction (Yáñez-Vico et al., 2012). Altered biomechanics from structural abnormalities at the TMJ may induce pain and limited movement. Further, congenital anomalies of TMJ are documented, and it has been estimated that a substantial percentage of individuals undergo symptoms of dysfunctioning of TMJ and anatomical factors have emerged significant in the incidence of this disorder (Stangret et al., 2020). The psychological factor also contributes to the development and worsening of the TMJ. According to studies, people who have high levels of anxiety, depression, or psychological disturbance are more at risk of having chronic pain conditions such as TMJ disorders (Schiffman et al., 2014). Chronic stress is alleged by Zanelatto et al. in 2023 as a predisposing factor in the development of painful TMJ conditions from studies relating stress and TMJ disorders. The present study suggests that the evidence revealed in the stress-evoked nociceptive behaviour of the animal models portrays the causation of physical alteration and the exacerbating tendency in TMJ dysfunction brought on by psychological stress.

Dietary habits, especially with respect to eating hard foods, have also been involved in the frequency of TMJ disorders. In research done with patients seeking treatment in a dental clinic, a substantial percentage reported their diet of eating hard foods, possibly related to mechanical stress within the TMJ (Alshaban & Waheed, 2018). Hormonal influences have been established to be associated with the occurrence of TMJ disorders, especially in women. It has been reported that epidemiological studies show a higher prevalence of TMJ disorders in women than in men, being 2-5 times more prevalent (Rosanto & Rahajoe, 2020). The hormonal fluctuations, particularly the menopausal transitions, have been associated with TMJ changes like anterior disc displacement that might lead to pain and dysfunction (Rosanto & Rahajoe, 2020). Besides these, parafunctional habits like bruxism (teeth grinding) and clenching also play an important role. Such habits often worsen due to psychological stress and result in muscular fatigue and spasm, further contributing to TMJ dysfunction (Shetty & Hegde, 2019). Besides, comorbid conditions like tinnitus have also been associated with TMJ disorders, suggesting that TMJ dysfunction might have a broader effect than pain at the site itself to quality of life in general (Vielsmeier et al., 2011).

Extensive studies have been conducted to establish whether or not conservative management for TMJ symptoms is effective; some of these studies involve physical therapy, occlusal splints, and medication. For instance, a TMJ pain management study that was based on I-PRF proved that scores concerning patient satisfaction and quality of life were highly improved (Kumar, 2024). Results are suggestive of the fact that it is not about pain relief but about general improvement in well-being; thus, pain can be managed effectively, improving everyday functioning and psychological well-being. This would be consistent with knowing that conditions, especially chronic pain conditions like TMJ disorders, can significantly affect QoL in emotional, social, and physical wellbeing outcomes (Yap et al., 2021). Surgical interventions, particularly in cases of TMJ disorders that may be more severe such as ankylosis or articular disc injuries, largely contribute to patient outcomes. Surgical management aims to improve the functioning of the joint and remove the symptoms, and therefore it can lead to huge improvement in QoL. For instance, in children, gap arthroplasty and reconstruction procedures have been proven to produce excellent results, while it has been found that prompt intervention is very essential in achieving the best long-term outcomes (Vagha, 2024). A case series of surgical management of articular disc injuries also showed some promising results, indicating that surgical interventions can be an effective way of addressing the root causes of TMJ dysfunction and improving patient satisfaction (Sinha et al., 2023).

Moreover, psycho-emotional effects of TMJ disorders cannot be omitted. Long-term pain and functioning impairment lead to a strong probability of anxiety and depression, and even social phobia, in most of the patients. Thereby, researchers concluded that psychosocial QoL component is drastically changed in TMJ disorder suffers most of them complaint of comorbid sleep disorders that further degrade the life quality (Yap et al., 2021). Management strategies need to focus on both the physical and psychological elements of TMJ disorders for patients' improved outcomes. For example, one study underlined the importance of managing psychological discomfort along with the symptoms in the body and pointed out that the holistic treatment approach may give better results for QoL (Chantaracherd et al., 2015). Patient care results have

also improved in this regard with the advent of multidisciplinary treatment for TMJ disorders. Along with arthrocentesis, injectable therapy combined modalities also achieved some promising clinical results through which patient outcomes and satisfactory levels have been enhanced by several folds (Abbadi et al., 2022).

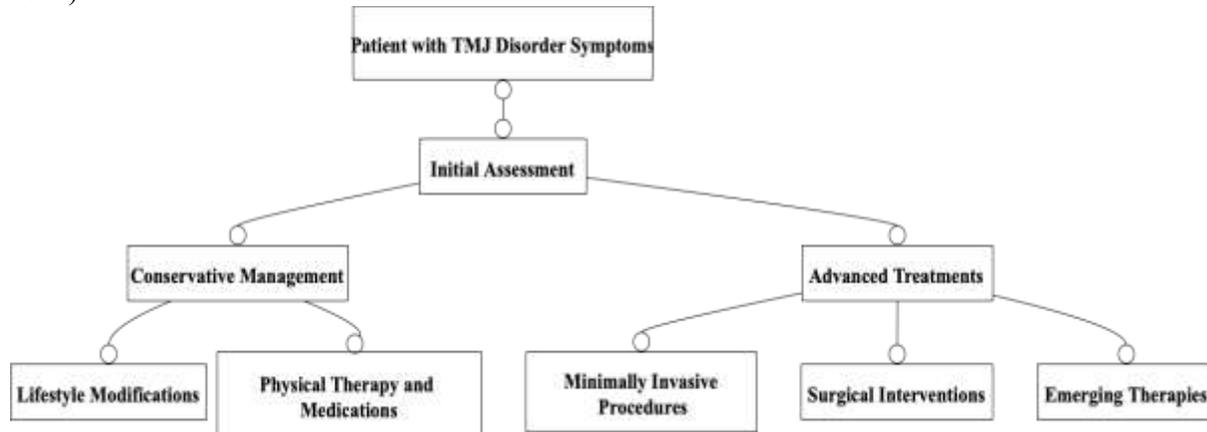


Figure 1. This diagram illustrates the treatment pathway for Temporomandibular Joint (TMJ) disorders. The process begins with the initial assessment of symptoms, followed by two primary approaches:

Conservative Management and Advanced Treatments

This is quite because of the multimodal treatment, not only improving immediate symptoms but also affecting better overall improvement in their health status and wellbeing overall. Besides the direct results of treatment, management of TMJ disorders may influence patients' perceptions of their health and functionality. Some studies have indicated that, although intra-articular disorders may have little influence on reported pain and disability, the overall management of TMJ disorders may result in significant improvements in perceived quality of life (Chantaracherd et al., 2015). This would mean that successful treatment boosts the self-efficacy and confidence of patients in managing their condition, which contributes to their QoL. This being stated, long-term implications of TMJ management methods would explain and appreciate the impact a patient has on quality of life. Longitudinal studies are conducted on the outcomes of treatments based on diverse approaches, which provide knowledge regarding how different methods of management result in long-lasting improvement in QoL with time (Sinha et al., 2023).

2. Etiology and Pathophysiology

The most important anatomical feature predisposing the TMJ to dysfunction is its complexity, including the mandibular condyle, the articular disc, and the ligaments and muscles surrounding it. The TMJ is regarded as a ginglymoarthrodial joint that permits both hinge and gliding movements, which is very important for functional activities such as chewing and speaking Fan et al. (2020). It is an important fibrocartilaginous structure that allows distribution of loads and maintains the joint stability; however, its location and integrity are extremely sensitive to changes in the environment due to trauma, overuse, or degenerative processes and typically result in conditions such as disc displacement (Kirupa et al., 2023). Physiologically, TMJ is also affected by several factors that include muscle activity and neuromuscular control. The masticatory muscles—the muscles that move the mandible—become hyperactive due to stress or habits like bruxism that involves grinding of the teeth (Alshaban & Waheed, 2018). This leads to muscular fatigue and spasm, thereby contributing to the condition of TMJ dysfunction. The literature widely documents strong evidence regarding the relationship of psychological stress with TMJ disorders. The evidence shows a high level of stress resulted in increased muscle tension with altered jaw mechanics, further leading to pain and dysfunction (Schiffman et al., 2014).

Another great contributor to TMJ dysfunction is occlusal disorder. Malocclusion causes imbalances in the forces exerted on the TMJ during function and results in abnormal wear patterns and stress to the joint. The relationship of occlusion to TMJ health is complex. The corrective changes made for improper alignment

of the teeth cause compensatory changes in the joint and its surroundings, which may cause pain and limited range of motion. This interplay underlines the necessity for an overall assessment of occlusion in patients with TMJ disorders (Hakobyan, 2022). In addition to occlusal factors, trauma plays a key role in the pathogenesis of TMJ dysfunction. Macrotrauma, like whiplash injuries or direct trauma to the jaw, can set off a series of pathological changes in the joint (Chisnoiu et al., 2015). Such injuries will cause disruption of the normal anatomical relationship and inflammation, pain, and functional impairment. The forces and anatomical location during common activities such as talking or chewing worsen this situation. The anatomical and physiological nature of TMJ makes it prone to degenerative changes. It has been known that some diseases such as osteoarthritis or rheumatoid arthritis cause damage to the joint by destroying cartilage with resultant alteration in the joint's mechanics (Shoohanizad et al., 2019). These degenerative conditions will lead to pain, swelling, and reduced motion and have a tremendous impact on the quality of life of the patient. The special feature of the TMJ as a fulcrum, under the control of both the morphology of the joint and the dentition, makes it crucial to keep its integrity for optimal functioning (Kirupa et al., 2023).

Furthermore, the TMJ is closely anatomically associated with the cervical spine and orofacial region. This is yet another level of complexity in the factor of susceptibility to dysfunction. Dysfunction in the TMJ leads to referred pain in the areas; thus, this complicates the clinical picture and makes diagnosis difficult (Vielsmeier et al., 2011). The first primary way in which psychological stress contributes to TMJ disorders is through the phenomenon of bruxism, or teeth grinding. Studies have shown that the more stressed a person is, the more likely he or she is to exhibit bruxism, thus raising the load on the masticatory system and possibly leading to TMJ dysfunction Alshaban & Waheed (2018). A large, comprehensive study by Schiffman et al. further indicated a variety of psychosocial factors such as anxiety, depression, and psychological distress that contributed to the chronicity of TMJ disorders. Such factors can contribute to maladaptive coping, like avoidance behaviors or catastrophizing, which can be very provocative of pain and functional limitation. Avoidance beliefs due to fear can contribute to the persistence of pain by evading the execution of activities for fear. This intermingles with psychological factors and the somatic expressions, which shows the need for the treatment of TMJ disorders to take care of mental health issues also (Schiffman et al., 2014).

The COVID-19 pandemic has highlighted even more the role of psychological stress in TMJ disorders. During this period, there was a study that had shown psychological stress to be a strong predictor of increased depression levels in patients with painful TMJ disorders (Lee & Auh, 2022). Another possible cause would be the physiological effects stress brings to the body's structures. For instance, muscle activity alterations and increments of pro-inflammatory cytokines such as IL-1 β and TNF- α have been found as psychological stress results in increased pro-inflammatory cytokines mandibular condylar cartilage (Lv et al., 2012). These mediators degrade the cartilage and give joint dysfunction that further stresses the TMJ. The biological response to stress, therefore, affects the muscle tension and has direct implications for the health of TMJ itself. And beyond that, studies have shown that patients suffering from TMJ disorders reveal higher levels of anxiety and depression than patients without TMJ disorders (Sadrzadeh-Afshar, 2023).

This correlation suggests that the experience of chronic pain and dysfunction may lead to psychological distress, creating a vicious cycle in which pain increases anxiety and anxiety, conversely, heightens the perception of pain. The cycle may significantly impair a person's quality of life, so effective psychological interventions are integral to the management of TMJ disorder. Personality traits and psychologic profiles in the etiopathogenesis of TMJ disorders have also been researched. Findings of many studies suggest that neurotic personality traits might be at higher risk for developing TMJ dysfunction as their nervous nature tends to increase level of stress and anxiety (Meldolesi et al., 2000). This is an area of study most vigorously done under dental and medical research: it is believed that bruxism could be a contributory factor in the development and exacerbation of temporomandibular joint dysfunction. Bruxism refers to involuntary grinding or clenching of teeth, often occurring while a patient is asleep but may also occur when they are awake. This relationship, therefore, will involve an examination of mechanical, physiological, and psychological factors between these two conditions. Increased mechanical stress on the TMJ and its surrounding structures is one of the primary ways through which bruxism contributes to TMJ disorders.

Arafa et al. also found that the severity of bruxism correlates with an increase in joint sounds, suggesting that over time, bruxism may lead to structural changes in the TMJ; Arafa et al. (2019).

The mechanical loading may lead to inflammation, pain, and alterations in the mechanics of the joint that would eventually lead to TMJ disorders. Other research works have supported the relationship of bruxism and TMJ disorders. Bruxism was said to be linked to an increased prevalence of painful temporomandibular disorders (TMD). According to Huhtela et al., women who are experiencing bruxism manifested higher pain and functional impairments caused by dysfunction in TMJ (Amaral et al., 2020). This means that bruxism not only causes TMJ disorders but also aggravates the already caused disorders, making it a vicious cycle of pain and dysfunction. In the etiology of TMJ disorders, findings further emphasize parafunctional habits, among which is bruxism, because these habits alter the harmony of the stomatognathic system (Magalhães et al., 2018). For that, parafunctional habits, muscle hyperactivity and fatigue, are probably the major contributors to TMJ dysfunction may be induced. According to Hashemipour et al., there existed important correlations between bruxism and several different signs of TMJ disorders; among others, limitations of jaw movements and pain in these individuals were reported by Hashemipour et al. (2018). Hence, bruxism should be treated along with the treatment of TMJ disorders since, in general, bruxism considerably can affect the outcome of the treatment.

Psychological factors are also part of the interrelation between bruxism and TMJ disorders. Anxiety and stress have been reported as risk factors in developing bruxism which, in turn, exacerbates the severity of TMJ dysfunction (Amalia et al., 2023). Many bruxisms are involuntary acts that, in the short term, may serve as an individual's coping mechanism, increasing their muscle tension and pressure against the TMJ. In this relationship, there's a holistic way of handling treatment, bringing psychological aspects into physical interventions in bruxism management as well as in TMJ disorders management. There are also links between the existence of dental occlusion features and bruxism, as well as TMJ disorders. Cadar's research revealed that there was a significant relationship between bruxism and dental interferences leading to TMJ pain and dysfunction (Cadar, 2023). This condition could be induced by the presence of premature contacts or malocclusions, making a vicious cycle that would degenerate TMJ disorders. This relationship highlights the significance of conducting a proper dental examination for patients diagnosed with bruxism and symptoms of TMJ. Studies regarding bruxism prevalence among children have also been conducted lately. This relationship has included many important correlations such as gastrointestinal disorders and family history (Shahbour et al., 2022).

3. Clinical Presentation and Diagnosis

Pain is a very common symptom of TMD, felt in the jaw, face, neck, and sometimes in the ears. Pain usually manifests as a dull ache or sharp, stabbing pain, particularly during movement of the jaw such as chewing and speaking (Chisnoiu et al., 2015). It may come and go, accompanied by tenderness of the muscles around the TMJ. According to Stangret et al., the discomfort experienced by people affected by TMD is greatly enhanced by pain, with an estimated substantial percentage of the population suffering from TMJ-related pain (Stangret et al., 2020).

The second common sign of TMD is clicking or popping in the jaw while it is moving. These sounds occur when the mandible opens or closes. They are generally indicative of dysfunction in the joint, including a displaced disc or alterations to the joint mechanics (Dujoncquoy et al., 2010). It is very alarming for these patients and increases anxiety relating to their condition. In addition, some people describe a sensation of the jaw locking or catching, which will further complicate jaw function, and therefore make it impossible to perform most daily activities.

The characteristic symptoms of TMD include limited jaw opening. Patients cannot open their mouths widely and, hence, cannot easily perform most everyday activities like eating and speaking (Lai et al., 2019). This limitation is due to either muscle spasms, inflammation of the joint, or mechanical obstruction within the joint itself. Such a situation can severely affect a person's quality of life by causing frustration and social withdrawal. Headaches are commonly expressed by TMD patients often with the features of a tension-type

headache or of a migraine. These types of headaches are due to muscle tension and strain stemming from bruxism as well as clenching, both common in those suffering from TMD symptoms (Messina, 2020). The interface between TMJ disorders as it relates to headaches makes diagnosis more comprehensive as treatment of such TMJ dysfunction may allow headache symptoms to resolve by themselves.

Apart from these physical symptoms, there are also psychological factors in patients with TMD. Anxiety and stress are reported by many patients, and these tend to exacerbate pain and discomfort (Ying et al., 2020). The psychological impact of living with chronic pain leads to a vicious cycle of increased stress and muscle tension, further complicating the clinical picture. Some research indicates that more individuals suffering from TMD experience depression and anxiety conditions compared to non-sufferers; thus, dealing with psychological problems should feature as a critical part in managing the TMD disease (Arzi et al., 2013). In addition, TMD has mixed prevalence rates within the symptoms of TMD because the demographics are different based on age and gender. Apparently, the incidence of TMD is said to be more prevalent in females than in males although they complain about a much higher frequency of symptoms; Chisnoiu et al. 2015. This is partly due to gender differences because of differences in hormones, perception of pain, and differences in coping mechanisms. This knowledge about the demographics would enable doctors to identify populations at risk and then deliver appropriate treatment tailored to that demographic.

The two most advanced diagnostic tools that have been applied include MRI and CT, and the use of such has dramatically helped in TMJ dysfunction determination. From the imaging modalities used, detailed anatomical and physiological changes in the TMJ become apparent, on which basis health care professionals shall base their treatment plan. This discourse demonstrates how MRI and CT help diagnose TMJ disorders while also indicating their unique advantages and applications. MRI is the gold standard for examination of soft tissues in TMJ, the articular disc, its ligamentous support structures, as well as musculature surrounding the said joint space (Maranini et al., 2022). Among these benefits in MRI is an ability of showing position as well as morphology of an articular disc that critically helps doctors diagnose a set of patients with conditions disc displacement, and internal derangement, among others. According to Maranini et al., MRI can thoroughly evaluate the TMJ, which offers essential information about the soft tissue components often involved in TMJ dysfunction (Maranini et al., 2022). This ability is crucial in cases where patients present with symptoms such as joint clicking or locking, since MRI can determine whether these symptoms are related to disc displacement or other soft tissue abnormalities.

Besides its soft tissue imaging capability, MRI is non-invasive and does not involve ionizing radiation, thus safer for patients, especially children and those requiring multiple imaging studies (Hauser et al., 2014). Contrast agents in MRI may also enhance the visualization of the joint structures, and thereby further allow for the assessment of inflammatory changes such as synovitis or arthritis, which may contribute to TMJ dysfunction (Hauser et al., 2014). This is especially important in juvenile idiopathic arthritis, where early detection of TMJ involvement can prevent long-term complications (Hauser et al., 2014). In contrast, CT imaging offers the highest resolution for the bony architecture of the TMJ and is highly valuable for osseous changes that may be seen with TMJ disorders. The work of Jadeja reported that CBCT was significantly superior in its ability to diagnose TMJ disorders as compared to MRI, with special regard to bony abnormalities, including osteophytes, flattening of the condylar head, and joint space narrowing (Jadeja, 2024). High-resolution images produced by CT can measure joint morphology with very good accuracy, which can be critical in diagnosing degenerative changes and planning surgical interventions.

Second to the above, CT is additionally very useful in trauma for it can quickly point to fractures or other acute forms of injury to the TMJ (Sodhi et al., 2015). The visualization ability of the three-dimensional representation of the bony complexities about TMJ ensures appropriate depiction of the anatomy of a joint, which may ease the diagnosis and the necessary treatment planning. This goes without saying that the situations are more complex and usually involve multiple factors contributing towards its dysfunction. The two imaging modalities have strengths; the choice of which depends more often on the specific clinical scenario. For example, where soft tissue evaluation is a priority, MRI would be preferred, but for cases like

bony changes or trauma, CT would be favored (Salamah, 2024). However, the combination of the two imaging modalities gives a more complete understanding of TMJ disorders and will help in giving an exhaustive account of the soft tissue and hard tissue components involved. US has also emerged as a supplementary diagnostic tool for TMJ disorders, which offers real-time imaging and dynamic assessment of joint function (Kumar et al., 2019). Though US cannot replace MRI or CT, it can be used as an initial screening tool, especially in pediatric populations or patients with claustrophobia. It will be useful in understanding the pathophysiology of TMJ disorders by visualizing soft tissue structures and joint movement during function, hence guiding further imaging if required (Kumar et al., 2019).

4. Conservative Management Strategies

Lifestyle changes are first-line treatments for TMJ disorders. These changes may consist of dietary habits, methods of stress management, or good sleep hygiene practices. For instance, the use of a hard or crunchy diet is often discouraged due to the irritation it would cause to the TMJ area, which leads to pain, while stress-reducing techniques are taught to decrease some of the known causes of bruxism and muscle tension (Agbaje et al., 2018). Agbaje et al. noted that simple analgesics, like NSAIDs, along with lifestyle modifications can help manage acute TMJ pain (Agbaje et al., 2018). This would, therefore, imply that an integration of lifestyle modifications and pharmacological management would translate to a better outcome for symptom management. Physical therapy is another mainstay in the conservative management of TMJ disorders. Other forms of physical therapy include exercises meant to expand the oral cavity, as well as physical and non-physical therapeutic modalities such as application of ultrasound or heat can reduce the pain and assist in recovering function (Al-Baghdadi et al., 2014). Al-Baghdadi et al. in a systematic review of conservative treatment strategies including physical therapy versus surgical interventions, revealed that conservative treatment, especially with splint therapy and exercises, were efficient in managing TMJ dysfunction without invasive procedures (Al-Baghdadi et al., 2014). This highlights the importance of physical therapy as a non-invasive measure which may bring about marked improvement in the outcomes of the patients.

Self-care protocols, among many self-regulatory practices, have also proven helpful in the management of TMJ disorders. Sura stated that the self-care practices, disease education, relaxation techniques, and heat or cold therapy would ease the pain and enable a progress in jaw function (Sura, 2023). These self-care practices enable a patient to become an active participant in the treatment they are receiving. This may result in better follow-through and self-management of one's symptoms in the long term. Exercise therapy has been notably implicated in the treatment of TMJ disorders in many studies. For instance, during the study by Mohamed and Elmorsy, the exercise therapy revealed a considerable reduction in the level of pain and improved the range of motion among patients following the performance of arthrocentesis on patients suffering from TMJ disc displacement (Mohamed & Elmorsy, 2022). This may imply adding targeted exercises to the treatment program to improve recovery and functional results in patients diagnosed with TMJ disorders. Exercise therapy can also ensure that there is improvement of muscle balance and general function of the jaw, which will be very important for long-term management.

While physical therapy and lifestyle changes cannot be ruled out, the psychological approach also must be addressed in the treatment of TMJ disorders. Stress and anxiety have been implicated in TMJ dysfunction for a long time and psychological treatment through cognitive-behavioral therapy (CBT) or other relaxation therapies can be helpful. Although the author could not source this claim, the literature widely supports that psychological interventions add a value layer to the efficacy of the treatment of TMJ disorders (Aratikatla, 2023). By incorporating psychological interventions in the conservative management plan, health care providers can be able to deal with the complex nature of TMJ disorders. Though conservative treatments can work for most patients, it does not mean that they could be the solution for every patient. Where conservative management fails, then the question of surgical interventions comes (Aratikatla, 2023). In pharmacological interventions, many drugs are available that take care of both short and long-term management of the temporomandibular joint disorders. Most interventions involve patients suffering from TMJ-related conditions, aiding the alleviation of pain and inflammation and restoration of functionality.

Pharmacological interventions could differ from one another by their type, time elapsed during administration, and patients' response. NSAIDs and analgesics generally constitute the first line of treatment in the short-term administration for the relief of acute pain in relation to TMJ disorders. Moccia et al note that the drugs are effective in controlling TMJ pain and inflammation states, thus bringing instant relief to patients suffering from acute symptoms (Moccia et al., 2020). The prompt effects of NSAIDs make them very useful in flare-ups of TMJ pain, thus allowing the patients to regain their functional capacity and enhance quality of life. Although NSAIDs can provide very significant short-term relief, long-term use is usually associated with adverse effects such as gastrointestinal and renal toxicity, limiting their suitability for chronic management (Moccia et al., 2020).

Some of the pharmacological alternatives used include glucosamine supplements that have been used to manage TMJ osteoarthritis. Melo et al. carried out a systematic review that showed that glucosamine played a significant role in reducing pain and improving joint function among the patients with TMJ osteoarthritis (Melo et al., 2018). Although the evidence is mixed regarding the efficacy of glucosamine, it represents an alternative approach for patients who would like to explore non-invasive options for long-term management of TMJ disorders.

In long-term management, the goals shift toward minimizing pain and avoiding disease progression. Newer intra-articular drug delivery systems may be capable of providing sustained pain relief with minimal systemic side effects. Mountziaris et al., for instance, discuss the role hyaluronic acid injections play in TMJ disorder treatment (Mountziaris et al., 2009). Intra-articular therapies are very effective at the focused treatment directly at the point of pain, decreasing the reliance on systemically administered medications that will then impact wider areas of the patient's body. Other drugs used for the long-term management of TMJ disorders include relaxants and antidepressants to be used in cases associated with bruxism in addition to other psychological issues. These reduce muscle tension pain, thus addressing all sides of TMJ dysfunction. The integration of pharmacological treatments with physical therapy and lifestyle modifications may improve overall treatment efficacy, as these approaches address the physical and psychological aspects of TMJ disorders. Even though pharmacological treatments work for most patients, it is important to note that they are not enough for everyone. When conservative management is not enough to provide adequate relief, surgical interventions can be considered (Festa et al., 2022).

5. Advanced Treatment Approaches

Internal derangements, such as disc displacement with or without reduction, are one of the most common indications for arthrocentesis and arthroscopy. Tan and Krishnaswamy reported that arthrocentesis is particularly effective for patients who have acute closed lock of the TMJ, where the articular disc becomes displaced and restricts jaw movement (Tan & Krishnaswamy, 2012). However, Murakami et al. reported that both arthrocentesis and arthroscopy may be effective, but sometimes arthroscopy may be more superior than arthrocentesis; therefore, arthrocentesis should not always be considered as a substitute or complete replacement for arthroscopy (Tan & Krishnaswamy, 2012). This presents an important role of such procedures in the management of acute mechanical problems in a joint. Some candidates for this procedure might include patients experiencing persistent pain within the TMJ where more conservative modalities in their management plan, which includes physical therapies or medical pharmacological agents, show ineffective responses to treatment. Arthrocentesis has proved an effective source of improvement and pain alleviation, not only with function among the patients that suffer with chronic TMJ disorders according to Kumar et al.'s recent finding (2018). This may remove all inflammatory mediators and perform joint lavage, ultimately resulting in considerable improvements with symptoms.

Arthrocentesis is recommended in cases suspected of adhesion between the articular disc and the mandibular fossa. According to Neeli et al., arthrocentesis is described as a procedure for the liberation of the articular disc by the washout of adhesions using hydraulic pressure from irrigation (Neeli et al., 2010). It significantly is important, especially to the patients with limited opening of the mouth and with stiffness

of the joint and it helps restore the mechanics of the joint along with offering scope to bring improvements in the range of motions. Arthroscopy works as not only a treatment interventional method but also provides the benefit of being utilized as a diagnostic tool. According to Riu et al., arthroscopy helps to visualize the joints and structures directly, which supports clinicians in evaluating the severity level of the internal derangement as well as other problems (Riu et al., 2013).

It is highly beneficial while working with complex cases whereby the source of TMJ dysfunction cannot be easily distinguished. The diagnostic aspect of arthroscopy can guide the subsequent decisions for treatment and improve outcomes for patients. Arthrocentesis has been proved to be effective in the management of TMJ osteoarthritis and other inflammatory conditions. Manfredini et al. carried out a trial showing that arthrocentesis with hyaluronic acid injections can be highly beneficial for patients suffering from TMJ osteoarthritis, and thus it is used in the management of degenerative joint diseases (Manfredini et al., 2009). This proves that arthrocentesis is not only useful in acute conditions but also for chronic inflammatory disorders. In acute intracapsular trauma, such as hemarthrosis of the TMJ, arthrocentesis may be indicated to remove blood and debris from the joint space. Malik and Shah noted that arthrocentesis and lavage remain effective treatment methods for an acute closed lock, potentially useful also in trauma-associated conditions (Malik & Shah, 2013). This speaks well to the adaptability of arthrocentesis toward the management of TMJ disorders. Both arthrocentesis and arthroscopy are preferably considered in patients who will not make good candidates for more invasive procedures. Keskinruzgar et al. pointed out that as conservative methods can be useless, arthrocentesis could be utilized as the next best method since the procedure is less invasive and not as risky than open surgery on the joint itself (Keskinruzgar et al., 2019).

Table 1. Corticosteroid Injections in the Management of TMJ Disorders.

Category	Details	Citations
1. Anti-Inflammatory Effects	Corticosteroids inhibit the inflammatory response within the joint. Significant improvement in pain and function with intra-articular methylprednisolone, particularly for TMJ arthralgia linked to inflammatory conditions like rheumatoid arthritis.	Isacsson et al. (2018)
2. Pain Relief	Corticosteroids reduce inflammation and provide long-term palliative effects on TMJ pain. Their rapid analgesic effects decrease inflammatory mediators, allowing patients to resume daily activities and improving quality of life.	Giraddi et al. (2011)
3. Improvement in Range of Motion	Corticosteroid injections restore joint function by reducing effusion and inflammation. Improved TMJ range of motion facilitates normal jaw activities such as chewing and speaking, which are often restricted in TMJ disorders.	Malahias et al. (2018)
4. Duration of Effect	Pain relief duration varies from days to weeks. Temporary but significant benefits of corticosteroid injections, particularly for inflammatory conditions like rheumatoid arthritis, provide a bridge to other therapies.	Kroese et al. (2021)
5. Comparison with Other Treatments	Corticosteroids offer faster and more substantial pain relief than hyaluronic acid for TMJ osteoarthritis. Their rapid efficacy makes them advantageous for acute symptom relief.	Malahias et al. (2018)
6. Safety and Efficacy	While generally safe, risks include cartilage degradation and joint infection. Long-term effects such as inhibited proteoglycan synthesis and cartilage disintegration require careful benefit-risk assessment, especially for repeated treatments.	Abubakr et al. (2018)

7. Indications for Use	Indicated for TMJ disorders with significant inflammation, pain, and dysfunction unresponsive to conservative management. Effective in inflammatory joint diseases like rheumatoid arthritis, offering localized treatment with minimal systemic effects.	Häggman-Henrikson et al. (2017)
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6. Emerging Therapies and Innovative Treatments

Stem cell therapies and platelet-rich plasma (PRP) have emerged as potentially promising regenerative treatments in TMJ disorders, more so when tissues are impaired. Both of these modalities aim to enhance healing of the TMJ, functionally compromised by osteoarthritis, rheumatoid arthritis, and trauma among others. The following review synthesizes current evidence regarding the effectiveness of these therapies in regenerating damaged TMJ tissues.

Table 2. Platelet-Rich Plasma (PRP) and Stem Cell Therapies in TMJ Disorders.

Category	Details	Citations
Platelet-Rich Plasma (PRP)		
1. Mechanism of Action	PRP is derived from autologous blood and contains a high concentration of platelets, releasing growth factors like PDGF and TGF- β , which promote angiogenesis, collagen synthesis, and cellular proliferation. This supports tissue repair and is beneficial for TMJ disorders with inflammation and tissue degeneration.	Moon et al. (2014)
2. Clinical Efficacy	PRP injections have shown positive outcomes, including reduced pain and improved function in TMJ disorders. Long-term follow-ups (6-12 months) reveal sustained benefits in pain reduction and mandibular mobility.	Moon et al. (2014); Sikora et al. (2022)
3. Regeneration of Cartilage and Bone	PRP may regenerate cartilage and bone. Studies in animal models show PRP's potential for tissue repair, and combining PRP with MSCs enhances cartilage regeneration, suggesting a synergistic effect for TMJ treatment.	Kütük et al. (2014); Gomez et al. (2020)
Stem Cell Therapies		
1. Types of Stem Cells	MSCs, sourced from bone marrow, adipose tissue, or synovial tissue, can differentiate into chondrocytes and osteoblasts, making them ideal for repairing TMJ articular surfaces and disc tissues.	Gong et al. (2022)
2. Preclinical and Clinical Studies	Preclinical studies demonstrate MSCs' ability to regenerate cartilage and bone in animal models of TMJ disorders. Clinical data remain limited, requiring further research to confirm efficacy and safety.	Acri et al. (2018); Gong et al. (2022)
3. Combination Therapies	Combining PRP with MSC therapies enhances regenerative outcomes. PRP's growth factors create a favorable environment for MSC proliferation and differentiation, making this approach particularly beneficial for extensive TMJ damage involving cartilage and bone regeneration.	Gomez et al. (2020)

Table 3. Advantages of TMJ Prosthetics.

Category	Details	Citations
1. Pain Relief and Improved Function	TMJ prosthetics significantly alleviate pain and restore mandibular function. Patients experience improved quality of life, particularly those with chronic pain due to osteoarthritis	Mercuri et al. (Popat et al., 2010)

	or severe internal derangement unresponsive to conservative treatments.	
2. Enhanced Range of Motion	Alloplastic TMJ replacements enhance jaw range of motion, improving speech and mastication capabilities. This restoration of function is crucial for better quality of life in patients with severe TMJ dysfunction.	Alkindi et al. (2019)
3. Avoidance of Donor Site Morbidity	Alloplastic materials eliminate the need for harvesting tissue from other body parts, reducing surgical complications and recovery time. This is particularly beneficial for patients unable to tolerate additional surgical sites.	Baykul et al. (2012)
4. Reduced Risk of Recurrent Ankylosis	TMJ prosthetics minimize the risk of re-ankylosis by providing stable and functional joint replacements. This is especially relevant for patients with a history of TMJ ankylosis where traditional methods may not prevent recurrence.	Lee et al. (2014)
5. Customization and Anatomical Restoration	Custom-fabricated TMJ prostheses allow precise anatomical restoration, leading to better functional outcomes. These are ideal for patients with severe degenerative changes or those needing skeletal and dental malocclusion correction.	Alkindi et al. (2019)
6. Long-Term Durability and Predictable Outcomes	Long-term studies highlight the durability and effectiveness of TMJ prosthetics, showing significant improvements in pain, function, and quality of life even after ten years.	Mercuri et al. (Popat et al., 2010)
7. Immediate Functionality	TMJ prosthetics enable immediate postoperative functionality, allowing patients to begin physical therapy right away and facilitating quicker recovery. This immediate functionality helps maintain muscle strength and joint mobility.	Bhardwaj & Arya (2016)
8. Minimally Invasive Options	Advances in surgical techniques have introduced minimally invasive approaches for TMJ joint replacement, reducing surgical time and complications. These options are particularly appealing for patients seeking effective treatment with shorter recovery periods.	Park et al. (2017)

7. Challenges and Limitations

Table 4. Long-Term Efficacy of TMJ Treatments.

Category	Details	Citations
1. Splint Therapy	Splint therapy is effective for managing TMJ disorders like disc displacement and muscle hyperactivity. It reduces pain, improves maximum mouth opening (MMO), and enhances function. Long-term studies show sustained symptom relief, making it a viable conservative management option.	Haketa et al. (2010)
2. Surgical Interventions	Surgical treatments, including arthrocentesis, arthroscopy, and total joint replacement, provide long-term relief for severe TMJ dysfunction. Procedures like temporalis myofascial flap and alloplastic TMJ replacements have shown significant functional improvements and pain reduction, with durability extending over 20 years in some cases.	Kang et al. (2015); Alba (2024); Wolford et al.

3. Efficacy of Physical Therapy	Physical therapy offers long-term benefits for TMJ disorders, often used alongside other treatments. However, additional research specific to TMJ disorders is needed to substantiate its efficacy, as some references focus on unrelated conditions like tinnitus.	Michiels et al. (2016)
4. PRP and Stem Cell Therapies	Emerging therapies like PRP and stem cell treatments show promise for long-term TMJ tissue regeneration. PRP provides pain relief and functional improvement due to its growth factors, while stem cell therapies demonstrate potential for cartilage regeneration. More research is required to confirm long-term effectiveness.	Gomez et al. (2020); Gong et al. (2022)
5. Challenges in Long-Term Efficacy Assessment	Assessing long-term efficacy is complicated by variability in patient populations, treatment protocols, and subjective symptom reporting. Comorbid conditions and psychological factors also influence outcomes, emphasizing the need for a comprehensive, individualized approach to TMJ treatment.	Kalyan et al. (2017)

7.1. Variability of Symptoms

TMJ disorders can exhibit the mildest symptoms; even pain and clicking might coexist with more profound cases of limited jaw movements, going so far as headaches, so it might be slightly undiagnosed in such cases of overlapping mimicry of other clinical syndromes. For example, Ralli et al reported that a considerable number of patients with TMJ disorder also presented with somatic tinnitus, complicating the clinical picture Ralli et al. (2018). Such overlaps with other orofacial pain conditions require thorough evaluation for discrimination between TMJ disorders and other possible diagnoses.

7.2. Dissing and Lack of Standardized Diagnostic Criteria

The use of standard, universal diagnostic criteria for TMJ disorders does not exist; hence, diagnosis and classification are quite inconsistent. Although the RDC/TMD provides a framework for classification, variations in interpretation and application can lead to discrepancies in diagnosis (Schiffman et al., 2014). Hellén-Halme et al. reported that the differences in diagnostic criteria among studies limit the comparison of results and lead to a lack of consensus on effective diagnostic practices (Hellén-Halme et al., 2012). This can lead to variability in patient management and treatment outcomes because of the lack of standardization.

7.3. Complexity of TMJ Anatomy and Function

In complexity, the diagnostic process would include the anatomy of the TMJ, such as its bony structures, ligaments, and surrounding musculature. The TMJ undergoes many pathological changes, among which internal derangement, osteoarthritis, and inflammatory conditions, all may manifest with the same presentation symptomatology (Arzi et al., 2013). Thus, a proper diagnosis requires knowledge of joint anatomy and interpretation of imaging studies. According to Arzi et al., as usually, the comprehensive evaluation of the TMJ is inevitable in cases with multiple disease processes complicating the disorders (Arzi et al., 2013).

7.4. Limitations of Imaging Methods

Diagnosis of TMJ disorders using imaging modalities such as MRI and CT is not entirely accurate because, although they are good diagnostic tools, they have limitations. For instance, MRI is regarded as the gold standard for assessing soft tissue structures, but its effectiveness can be hampered by variations in imaging protocols and interpretation (Hellén-Halme et al., 2012). Moreover, artifacts can occur with the use of imaging modalities, which, due to subjective assessment of images, might cause variable results. Kumar et al. mentioned that despite the potential of ultrasonography, it has undefined parameters for TMJ disorders assessment and hence not significantly helpful in diagnosis (Kumar et al., 2019). This can be summarized

as an encouragement to advance imaging modalities further and define standardized protocols for these imaging techniques.

7.5. Psychological Factors

The psychological factors, such as anxiety and depression, may influence the experience of pain and reporting symptoms, thereby complicating diagnosis. According to Schiffman et al., psychosocial factors are key contributors to chronicity, and this has been responsible for making assessments of severity and nature challenging in TMJ disorders (Schiffman et al., 2014). The psychological distress interplay and symptoms of TMJ necessitates a holistic diagnosis approach: considering both physical and psychological components.

7.6. Comorbid Conditions

The existence of comorbid conditions may even add to the complexity of the diagnosis for TMJ disorders. Many patients with TMJ dysfunction are associated with other musculoskeletal disorders: among them is cervical spine issues or fibromyalgia that tends to obscure the clinical picture (Kalyan et al., 2017). This creates another complexity layer into the diagnostic process in view of distinguishing between primary TMJ disorders and secondary disorders originating from other diseases. Rongo et al. stated that the diagnostic criteria specific for TMJ disorders could not be proved to exist within certain groups of juvenile idiopathic arthritis, reflecting on the difficulties involved in this procedure of TMJ disorder diagnosis, especially within the limits of comorbid conditions (Rongo et al., 2019).

Conclusion

TMJ disorders are a multifactorial condition that requires a comprehensive multidisciplinary approach to effectively treat the disorder. This article discusses the very important role anatomical, physiological, and psychological aspects play in the development and progression of TMJ disorders. Since there has been great improvement with the advent of diagnostic techniques like MRI and CT, structural and functional anomalies can be visualized for better treatment planning. Conservative management continues to form the cornerstone of TMJ disorder treatment. This will include lifestyle changes, physiotherapy, and pharmacological interventions for symptomatic relief and improvement of joint function. Psychological therapies such as cognitive-behavioral therapy are vital for helping patients overcome psychosocial components of TMJ disorders, breaking a vicious cycle of pain and psychological distress that often seems to fuel the condition. These newer therapeutic options, such as PRP and stem cell treatments, hold promise for regeneration care because they are addressed at the level of tissue damage. In severe and refractory cases, the surgical interventions, such as arthrocentesis, arthroscopy, and TMJ prosthetics, are effective in restoring function and improving quality of life. The findings indicate that a holistic, patient-centered approach must be adopted that includes physical, psychological, and surgical modalities. Multidisciplinary care models have been found to have better outcomes by considering the complex interplay of factors that contribute to TMJ disorders. Future research needs to be oriented toward long-term results of emerging therapies, standardization of diagnostic criteria, and innovative, minimally invasive treatments. Only with a holistic and personalized approach will clinicians improve the general health and well-being of people suffering from TMJ disorders and, subsequently, their quality of life.

Conflict of Interest

The authors declare they don't have any conflict of interest.

Author contributions

The first manuscript drafts are written by the original author and the cross-ponding author's supervisor. Each author helped write the document, collected data, prepared tables, edited it, and got permission to submit it to a journal for publication.

Ethical Approval

Not Applicable

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