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TMJ Internal Derangement Part 1: Non-Surgical Management. A Narrative Review

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Abstract

The term internal derangement of the temporomandibular joint widely used to describe the displacement of the articular disc anterior to the condyle, and the eminence. The concept of system failure extends the term of internal derangement beyond this definition to include any interference with smooth joint movement, and functional rehabilitation is the primary goal of treatment regardless of the disk position. TMJ internal derangement is not a disease by itself, but it is a biomechanical dysfunction leading to system failure. Understanding the normal biomechanical function of the TMJ is important for successful management and expecting the treatment outcome understanding the consequences of internal derangement is important for understanding the disease progression. The aim of the current review is to discuss the biomechanical pathogenesis of the internal derangement and non-surgical treatment modalities based on the rationale of system failure.

Keywords: TMJ internal derangement; Hegab classification; Pharmacological treatment; Physiotherapy; Occlusal appliance therapy; Hegab non-surgical protocol

Biomechanical Pathogenesis of the Internal Derangement

The normal disk condyle fossa relationship is important for distribution of the force within the joint. The presence of the disk in between the condyle and the fossa makes it to act as shock absorber. Moreover, it keeps smooth movement of the condyle within the fossa and on the posterior slope of the articular eminence. Mandibular movements induce two types of loading, static loading (associated with clenching, grinding and bruxism) and dynamic loading (associated talking and chewing). By joint loading, the condylar and temporal cartilages and the TMJ disc suffer from deformations to absorb the joint loading while the subchondral bone is also responsible for bearing static and dynamic loading [1], with under normal circumstances, there is a balance between extracellular matrix synthesis and degradation in the TMJ disc, resulting in a state of dynamic equilibrium (adaptive capacity). If the loading of the joint exceeds the adaptive capacity, the net effect results in cartilage breakdown. According to the concept of a n system failure, changes in synovial fluid composition to high-molecular weight hyaluronic acid occur early in the process. This reduces lubrication capacity and leads to increased friction. The reduced synovial fluid volume impairs nutritional support to the cartilage, which leads to gradual loss of the cartilage matrix. This triggers an immune response that initiates inflammatory changes with release of cytokines and other proinflammatory substances as well as proteinases, which results in degradation and abrasion of joint cartilage and may evoke pain [2,3]. The proinflammatory cytokines, such as Interleukin-1 (IL-1), Tumor Necrosis Factor-a (TNF-a) and Interleukin-6 (IL-6) in synovial fluid were related to the pathogenesis of synovitis and degenerative changes of the TMJ [4,5].

Increase the level of the inflammatory cytokines and inflammatory mediators in the synovial fluids led to tissue destruction because of the generation of free radicals and reactive oxygen species by macrophages and polymorphonuclear leukocytes. This will result in the degradation of proteins and proteoglycans in the synovial fluid, cartilage, bone, and connective tissues. Synovial fluid viscosity is increased, which results in further tissue destruction and impaired lubrication and nutrition of the articular cartilage and disc. As the joint cartilage breaks down, the underlying subchondral bone may be affected and begins to remodel, ultimately leading to DJD. Besides, this is associated with high level of RANKL which is responsible for the increase of the differentiation of osteoclasts with subsequent increasing the bone resorption resulting in osteoarthritis changes [6].

Impaired joint lubrication (with/without other factors) results in disk displacement. Once the disk displaced, the action of the disk as shock absorber is no longer present, which leads to traumatic

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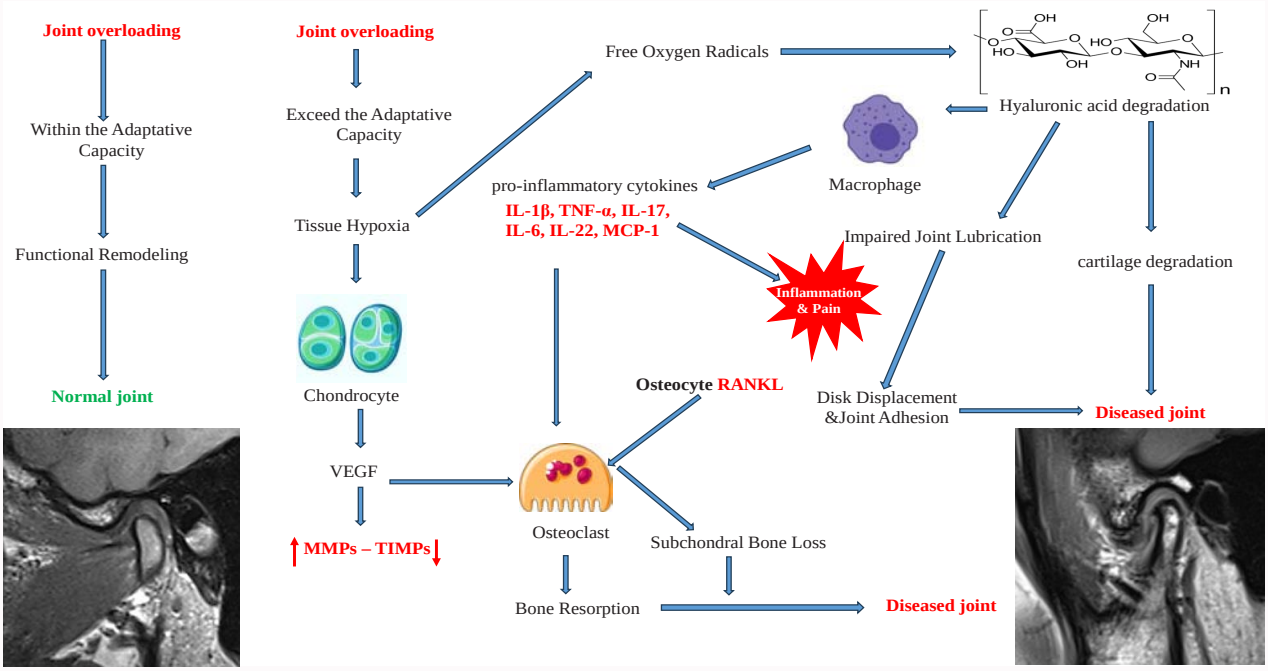

Figure 1: Schematic drawing of Pathogenesis of TMJ internal derangement with Bone and Cartilage Degradation and Pain in Temporomandibular Joint. Disorders under normal circumstances, the joint response to overloading by adaptive change and functional remodeling. If the joint overload exceeds the adaptive changes of the joint, it will lead to tissue hypoxia. This leads to the production of free radicals that causes degradation of Hyaluronic Acid (HA) and release of Vascular Endothelial Growth Factor (VEGF) from chondrocytes in the condylar cartilage and disc. HA degradation will lead to three events, first stimulation of the macrophage to secrete the proinflammatory cytokines which responsible for pain and inflammation beside activation of osteoclast to which leads to bone resorption and stimulates chondrocytes to release MMPs. Of these cytokines, tumor necrosis factor-α and interleukin-1 and -6 play crucial roles in the pathogenesis of osteoarthritis with respect to the acceleration and progression of cartilage degradation. Second impaired joint lubrication with increase HA viscosity led to joint adhesion and disk displacement. Third, cartilage degradation with subsequent degenerative changes in the joint. The increase joint level of VEGF secreted from the chondrocytes led to increase the level of Matrix Metalloproteinases (MMPs) and decrease level of their Tissue Inhibitors (TIMPs), which led to degradation of collagens and proteoglycans and cartilage destruction. This is associated with high level of RANKL which is responsible for the increase of the differentiation of osteoclasts which responsible for subchondral bone loss. The process is like a cycle and different cells from different tissues are acting together concurrently.

movements of the condyle within the fossa. This structure positional changes within the joint lead to pathological changes within the joint starting with synovitis of the synovial membrane. This led to failure of the production of the synovial fluid which resulted in more impairment of joint lubrication [3]. The presence of disk anterior to the condyle results in presence of the retrodiscal tissue above the condyle. This results in pressure from the condyle on the retrodiscal tissue, which affects the blood supply to the joint as it came from the retrodiscal tissue. Decreasing the blood supply and the pressure from the condylar head over the retrodiscal tissue for long time led to change of the elastic fibers within the retrodiscal tissues with loss of the elastic recoil properties of the retrodiscal tissues. This will result of change from disk displacement with reduction to without reduction. With subsequent degenerative changes of the condyle because of traumatic forces from the joint movement as a results of displaced disk position. The traumatic compressive forces on the condyle led to the loss of the most superficial layer of the condyle. This layer is the superficial fibrocartilage stem cell layer containing the progenitor cell population responsible for regeneration and repair of cartilage and joint injury [7]. The degenerative bony changes are not limited to the condyle only but also extended to the bony structure of the fossa and eminence.

Once the disk reaches the stage of displacement without reduction it will act as mechanical obstacle in front of the condyle leading to limited mouth opening. With time, the changes that occur within the retrodiscal tissues will lead to laxity and elongation of it, with subsequent increase of the range of mandibular movement and subsequent change of the situation to anterior disk displacement without reduction without limited mouth opening.

Hence, the concept of system failure means that the process of internal derangement of the joint is not limited to the disk displacement but extended to any interference with smooth joint movement such as synovitis, disk degeneration, disk perforation, joint adhesion, stuck disk, and osteoarthritis of the TMJ. Figure 1 represent schematic drawing of pathogenesis of TMJ internal derangement.

The course of TMJ ID without treatment was shown that some patients heal spontaneously and the length of time for symptoms to resolve is variable depending on the adaptation capacity of the joint and the healing capacity of the individuals. This finding supported the rationale of non-surgical treatment of TMJ ID [8].

Rational of Non-Surgical Treatment

Previously, internal derangement was viewed as mechanical disorder resulting in displacement of the disk away from the condyle. That is lead to development of the concept of disk recapture as the only treatment of this mechanical disorder. As a result, oral appliances designed to reposition the disc, as well as mandibular manipulations, were considered mainstays of conservative therapy. However, the idea of internal derangement management extends beyond the restoring the normal disk condyle fossa relationship to restoring the normal function of the joint. A clear understanding of this concept is essential and has significant consequences on patient management and the outcome of therapy.

Table 1: The medication used in treatment of pain associated with TMJ internal derangement.

Term	Description
Normal joint	Normal anatomical relationship between articular disk, mandibular condyle, joint fossa, and articular eminence
Closed mouth position	The condyle seated in the middle of the joint fossa with the articular disk in between and a line passing through center of the condyle, disk and posterior slope of the articular eminence result in the so-called ''11 or 1 o'clock position''
Open mouth position	The condyle moves to reach the tip of the articular eminence with the articular disk in between and a line passing through center of the condyle, disk and the articular eminence result in the so-called '12 o'clock position''
Internal derangement	Abnormal Condyle-Disk-Fossa Relationship or recently defined as any interference with smooth joint movement
Anterior Disk displacement	Mal-positioning of the articular disc anterior to the condyle and eminence in closed mouth position
With reduction	The articular disc resumes its normal position on top of the condyle on mouth opening
Without reduction	The articular disc cannot resume its normal position on top of the condyle on mouth opening and stay displaced anterior to the condyle
Posterior disk displacement	Mal-positioning of the articular disc posterior to the condyle and eminence in closed open position
Disk degeneration	Cartilage degradation represented as disk deformity, thinning out, or disk perforation
Disk perforation	Discontinuity of the articular disk or retrodiscal tissue
Disk adhesion (stuck disk)	Adherence of the disc either to the fossa or to the articular eminence
Pseudo disk formation	Thickening of the retrodiscal tissue forming a fibrous band in between the condyle and fossa with the disk anteriorly displaced
Joint effusion	An abnormal collection of fluid in the joint space
Hypermobility/ hyper translation	An overextension of the disc–condyle complex on opening beyond the tip of the articular eminence
Subluxation	An overextension of the disc–condyle complex on opening beyond the tip of the articular eminence with ability to return passively into the fossa by the patient
Dislocation	A dislocation of the entire disc–condyle complex beyond the tip of the articular eminence combined with the inability to return passively into the fossa
Degenerative joint disease	chronic debilitating disease resulting in altered joint structure due to degradation and loss of articular cartilage, along with changes in the subchondral bone and other soft tissues and affects all joint structures, including the articular cartilage, synovium, subchondral bone, and capsule
Osteoarthritis	defined as a low-inflammatory arthritic condition, either primary or secondary to trauma or other acute or chronic overload situations, characterized by erosion of articular cartilage that becomes soft, frayed, and thinned resulting in eburnation of subchondral bone and outgrowths of marginal osteophytes.

The rational of non-surgical treatment is mainly based on functional rehabilitation of the joint regardless of the disk position. That is mean presence of the disk anterior to the condyle not necessary to be considered as a disorder. The change of the retrodiscal tissue into fibrous band (pseudo disk) will return the joint function to near normal state. The rational considering the joint as self-treated joint, and if this disorder is self-limiting disorder, then one might question any need for aggressive surgical interventions.

Dealing with TMJ internal must be extended beyond the joint structure. The factors related to muscles disorders and occlusion should be considered.

Confusion is one of the most important factors that can lead to malpractice during TMD treatment. Confusion mainly related to the misunderstanding of the terms related to TMJ disorders. Different terms were used in the literature describing the same TMJ disorders which lead to confusion regarding the description. Table 1 descried in details the terms related to TMJ disorders.

Diagnosis represents the keystone of the treatment of TMJ internal derangement. Depending on just clinical examination and joint sounds is insufficient for accurate diagnosis. Joints sounds can represent a wide range of joint disorders include disk displacement, disk degeneration and perforation, osteoarthritis, subluxation, dislocation, and combination of any previously mentioned disorders. The cost of correct diagnosis including different diagnostic imaging in much less than the cost of Misdiagnosis & and subsequently unsuitable treatment.

The diagnosis and classification systems of TMJ internal derangement are often indefinable, although there has been much excellent research on the validation of classification systems, such as Diagnostic Criteria (DC) [9] for TMDs but still unclear for many reasons. First, the DC divided the TMD into two main groups, Pain-disorders group (local myalgia, myofascial pain, myofascial pain with referral, arthralgia, and headache attributed to TMD) and Joint-Disorders group (disk displacement, degenerative joint disease, and subluxation) which not necessary to be associated with pain. That is mean we can have painful joint without biomechanical changes or tissue destruction, and we can have biomechanical disorder with tissue destruction without pain. Second, there are many studies that compare clinical diagnoses according to RDC/TMD with findings on MRI. They found that, abnormal TMJ findings on MRI images were registered in both groups of patients (myofascial pain group and arthrogenous group). That is mean the clinical diagnoses according to RDC/TMD could not be confirmed with the MRI findings [9,10]. While the Wilkes Staging System [11] provide a guide for treatment based on the severity of the joint damage. That's why it is useful for planning of the surgical procedure.

From the clinical point of view, there are failings in these current classification systems that may further confuse diagnosis led to multiple treatment modalities ranging from no treatment to total joint replacement.

Recently, Hegab et al. establish a new classification system for TMJ internal derangement based on MRI in correlation with clinical findings contributing to a nonsurgical treatment protocol.

The new classification system which primarily based on MRI divided the internal derangement into 5 stages (from stage 0 to stage 4) with stage 0 represent normal TMJ and stage 4 represent posterior disk displacement. Hegab classification system based on the rational

Table 2: Detailed the Description, strength, and weakness with the different proposed classification system of the TMJ internal derangement since 1947.

Diagnostic classification	Description	Strengths	Weaknesses
Block [13]	Classification based on neurological and orthopaedic models of pain and dysfunction	• Simple and broad classification system	• Non-specific classification • Its main contribution is classification from a strictly medical perspective (fundamentally neurological and rheumatological), and the establishment of a clinical parallelism between myofascial pain-dysfunction and the observations in other parts of the body
Farrar [14]	Classification that considers eight dimensions within the global concept of dysfunction: hyperactivity of the masticatory muscles, capsulitis and synovitis, rupture or distension of the capsular ligaments, anterior disc displacement, muscle incoordination, and reduction of the mandibular movement range secondary to degenerative joint disease	• Covered wide range of disorders	• The TMJ literature presents numerous observations and comments about these various dysfunctions. However, they have never been satisfactorily described in relation to the examination of patients and diagnosis. Therefore, a logical system of clinical differentiation has not been developed.
Welden E. Bell [15]	a classification based on an orthopaedic-mechanical model- The system differentiates the following major categories of temporomandibular disorders (TMD): masticatory pain, restriction of mandibular movements, joint interference during mandibular movements, and acute malocclusion.	• The classification identifies the following muscular processes: myositis, muscle spasm, myofascial pain, late-onset muscle irritation and protective co-contraction or protective stiffness.	• Missing details about disk displacement and osteoarthritis
Stegenga et al. [16]	Categorized the Internal derangement into initial, semi- permanent and permanent stages	• Simple classification	• No definite outline and description for each stage with No clear separation between different stages • Didn't covered all the types of Internal derangement and not correlated with radiographic findings
Wilkes Stages [11]	Considered internal derangement a progressive disorder starting from stage I to stage V.	• Most widely used classification system • its widespread adoption is linked to its simplicity in describing escalating joint pathology in 5 stages	• Focuses on only two disorders (internal derangement and osteoarthritis) and fails to include other TMJ disorders, such as pathologic changes in the LPM, joint effusion, and state of posterior attachment. In addition, Wilkes did not propose a treatment protocol, and its predictive value for the TMJ is still unclear. • Didn't covered all the types of Internal derangement. • Cannot explain the cases of disk perforation without disk displacement (not a progressive disorders)
the American Academy of Craniomandibular Disorders (AACD) [17]	a taxonomic system integrated within the classification project of the International Headache Society (IHS). Category 11 of this classification corresponds to the taxonomic proposal of the AACD.	• The principal contributions on one hand comprise the distinction between two major categories - one for joint disorders and the other for muscle disorders	• On the other hand the possibility of establishing multiple diagnoses.
Dworkin and LeResche [18]	the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), with the aim of establishing standardized criteria for research, based on the available knowledge on TMJ pathology. The system comprises two classification axes. The first axis (clinical aspects of temporomandibular disorders) contemplates three groups: 1.- muscle diagnosis; 2.- disc displacement; and 3.- arthralgia, arthritis and arthrosis. The second axis in turn contemplates disabilities related to pain and the psychological condition of the patient.	• This system is a relevant contribution, since for the first-time psychological factors are included in the diagnosis and are evaluated by means of reliable and reproducible instruments.	• Debate about the validity the RDC/TMD in the clinical practice.
Bermejo [19]	A classification based on the "temporomandibular joint complex" – a concept that postulates the existence of two clearly differentiated joints: menisco-condylar and temporo-meniscal. T	• Two large diagnostic groups are established. The first comprises alterations of the masticatory muscles, while the second corresponds to disorders of the temporomandibular joint complex. Both include functional disorders, traumatisms, inflammatory disorders, degenerative processes and hereditary and developmental alterations.	• Unspecific classification because these alterations can affect both the menisco-condylar joint and the temporo-meniscal joint.
Tasaki et al. [20]	Consisted of 10 stages focused on the direction of the disk displacement	• Detailed and expanding classification	• Didn't covered all the types of Internal derangement. • Unspecified stage (NO.10) enrolled no clear image of the disk prevented classification into any of the other categories.

The Japanese Society [21]	5 types include masticatory muscles disorders, capsule- ligament disorders, disk disorders, degenerative joint diseases, and types V which includes cases not included in type I-IV	• Covered muscles, capsule-ligament and joint disorders	• Didn't covered all the types of Internal derangement. • Type V enrolled cases not included in type I-IV
Dimitroulis [22]	Using a category scale from 1 to 5, with category 1 being normal, and category 5 referring to catastrophic changes to the joint, the classification provides the basis for enhanced quantitative and descriptive data collection that can be used in the field of TMJ surgery research and clinical practice.	• specify the role of TMJ surgery in all TMJ disorders in a graded fashion across a spectrum of 5 categories of escalating degrees of joint disease.	• Good for surgical cases
DC/TMJ- (2014- updated at 2017) [9]	The DC-TMD classification is the most widely used by TMD researchers who stress the importance of psychosocial dysfunction (Axis II) as opposed to physical disorders (Axis I) and come up with a wide variety of complex calculations that often have little bearing on clinical practice.	• Covered both physical and psychological axis of the TMJ internal derangement	• The RDC-TMD has remained firmly embedded in the research world with little use in clinical practice.
Kowalchuk et al. [23]	The presence of the following Six MRI Findings was assessed and recorded as present or absent: Joint Effusion, Disc Displacement, Disc Non-recapture, Disc Degeneration, Abnormal Condylar Translation, and Condylar Arthritis. 1 point was assigned for each MRI finding per side. The TMJ Internal Derangement Score (TIDS) was the summation score. Possible total score values ranged from 0 (normal MRI examination) to 12 (bilateral presence of all of the above-mentioned findings), and from 0 to 6 for either right or left sides alone.	• Covered most of the pathologic changes of the internal derangement. • Simple scoring system	• Giving same score for different pathologic changes with different severity (e.g., joint effusion scores 1 point and condylar arthritis scores 1 point)
Hegab [12] Classification	Primarily based on MRI, internal derangement of the TMJ is divided into 5stages. Stage 0: Normal MRI study Stage 1A: MRI shows a normal condyle-disk-fossa relationship associated with pathologic changes of the LPM+/joint effusion. Stage 1B: MRI shows a normal condyle-disk-fossa relationship associated with pathologic changes of the disk+/Bone degenerative process of the condyle. Stage 2A: MRI shows anterior disk displacement in the closed mouth position with reduction to the normal position in the open mouth position associated with pathologic changes of the LPM+/joint effusion. Stage 2B: MRI shows anterior disk displacement in the closed mouth position with reduction to the normal position in the open mouth position associated with pathologic changes of the disk+/Bone degenerative process of the condyle. Stage 2C: MRI shows anterior disk displacement in the closed mouth position with reduction to the normal position in the open mouth position with condylar hypertranslation. Stage 3A: MRI shows anterior disk displacement in the closed mouth position without reduction to the normal position in the open mouth position associated with pathologic changes of the LPM+/joint effusion. Stage 3B: MRI shows anterior disk displacement in the closed mouth position without reduction to the normal position in the open mouth position associated with pathologic changes of the disk+/Bone degenerative process of the condyle. Stage 3C: MRI shows anterior disk displacement in the closed mouth position without reduction to the normal position in the open mouth position associated with normal translation movement of the mandibular condyle (no limitation of the mouth opening). Stage 4: MRI shows posterior disk displacement	• Cover all the • Pathological changes associated with the internal derangement of the TMJ. • The new classification system includes the state of LPM, joint effusion, degenerative disk changes, osteoarthritic changes of the condyle, translation of the condyle, integrity retrodiscal layers (pseudo-disk) and direction of disk displacement (anterior/posterior). • Proposed a nonsurgical treatment protocol based on the MRI finding per each stage of the new classification system	• Not includes the psychosocial dysfunction. • Required detailed understanding of the MRI of TMJ

of a system failure. The biomechanical dysfunction in cases of internal derangement leads to system failure. The classification covered all aspects of the pathologic joint conditions that can be evaluated by MRI with the proposed nonsurgical treatment protocol for every stage in the classification system [12].

Table 2 showed the description, strength, and weakness with

the different proposed classification system of the TMJ internal derangement since 1947 [12-24].

The Non-Surgical Treatment Modalities

Patient education, behavioral therapy and functional modification

This treatment modality based on the rational considering the joint as self-treated joint. Some authors believed that whatever the stage of internal derangement, with time the joint will adapt and change to restore the normal function by itself, and no treatment is required by this group of authors. Self-treatment related to the elimination of harmful oral behaviors by identifying and avoiding activities that are potentially harmful to the TMJ. This includes patient education, diet modification, improving sleep, parafunctional habit awareness [25].

For patients suffering from a chronic TMD, there may be a significant role of psychological factors contributing to their symptoms, such as a stressful life event or a psychiatric disorder such as depression, anxiety, or post-traumatic stress disorder. With psychological distress, there is increased arousal of the central nervous system that can lead to parafunctional bruxism and consequent chronic microtrauma to the TMJ. Cognitive behavioral therapy can help patients to increase their mental self-control over their perceived pain. Acceptance and Commitment Therapy (ACT) is a form of cognitive behavioral therapy that is evidence based to help patients learn coping skills to live with chronic pain. The goal of ACT is to reframe negative thoughts and feelings, such as pain, and accept them without judgment, ultimately allowing a person to focus on personal values and life goals. Other behavioral therapy techniques include biofeedback, which are predominantly targeted toward reducing parafunctional jaw clenching and grinding habits that can contribute to a TMJ arthropathy [25].

Pharmacological Treatment

The goal of prescribing drugs is not to cure the internal derangement rather than management of chronic TMD pain while waiting for a more definitive treatment. NSAIDs are first-line agents typically used for 10 to 14 days for initial treatment of acute pain. NSAIDs can be grouped as being Nonselective COX inhibitors (inhibit COX-1 & COX-2). Muscle relaxants can be prescribed with NSAIDs if there is evidence of a muscular component to TMD. Tricyclic antidepressants are used for the management of chronic TMD pain. Benzodiazepines are also used but are generally limited to two to four weeks in the initial phase of treatment. Opioids are not recommended and, if prescribed, should be used for a short period because of the potential for dependence in the case of severe pain.

Anticonvulsants medications, such as gabapentin and pregabalin, have shown some promise as an effective agent to reduce the severity of body pain, improving quality of sleep and reducing fatigue in fibromyalgia [26].

The importance of psychological factors has been thoroughly investigated in the etiopathogenesis of TMDs over the years. Regardless of whether preexisting psychosocial factors play an important role in causing the symptoms associated with TMDs or whether they are the result of the disease process itself, the psychosocial factors must be addressed when considering the overall management of the patient [26]. Table 3 showed the medication used in treatment of pain associated with TMJ internal derangement [27-34].

Physiotherapy

Physical therapy is well recognized as a conservative method for the management of symptoms associated with TMD. Physical therapy is a non-invasive, conservative therapy that helps to relieve musculoskeletal pain and restore function by altering sensory input, reducing inflammation, increasing mandibular range of motion, promoting repair and regeneration of tissue, and helping in reestablishment of oral motor function. Types of physical therapy include manual manipulation, massage, TMJ distraction and mobilization, therapeutic exercises, coolant therapy (spray and stretch technique), photo biomodulation, ultrasound therapy, ionophoresis, and Transcutaneous Electrical Nerve Stimulation (TENS) [34,35].

Contradictory use of ice and heat to increase local blood flow in the painful muscle. One definite advantage of ice is that it will decrease nerve activity with subsequent pain relief. Application of the hot pack over the joint itself will decrease the pain because of increasing the blood supply to the joint. These methods increase intramuscular blood flow, reduce muscle tension, and generally relieve muscle pain for a period [35].

Manual manipulation and massage therapy consist of controlled soft tissue and TMJ mobilization and stretching. Similarly, if performed in concomitance with vapocoolant spray, it is referred to as coolant therapy or spray- and stretch therapy. It is usually merged with therapeutic exercises, such as isometric tension exercises, and opening and closing jaw movements with guidance. Manual therapies have been effective in increasing mandibular range of motion and decreasing pain intensity in adult patients with TMJAD. Although scarce evidence exists for pediatric population with TMJAD, this modality has promising effects and is associated with no adverse events [34,35].

Local trigger-point injection and dry needling of myofascial trigger points in the masseter of patients with TMD has been shown to increase pain threshold levels and maximum mouth opening [36], and dry needling of myofascial trigger points in the masseter, temporalis, and cervical muscles has been shown to reduce severity of symptoms in patients with myofascial pain and headache [36].

Photobiomodulation therapy or Low-Level Laser Therapy (LLLT) is a therapeutic modality that generates light of a single wavelength. Exposure to LLLT results in photochemical reactions within the cells, which is referred to as photo biomodulation or photobiostimulation. LLLT involves the use of visible red or near-infrared light. Light energy is absorbed within the cells by cellular photoreceptors called cytochromophores. Low-Level Laser Therapy (LLLT) refers to a light-based therapy that produces monochromatic and coherent light of a single wavelength. LLLT may act via release of endogenous opioids, augmenting tissue repair and cellular respiration, increasing vasodilatation and pain threshold, and decreasing inflammation. Literature review of the efficacy of laser treatment showed that it was effective in relieving pain in patients with TMD and had good efficacy in both myogenic and arthrogenic TMD. In addition, laser treatment improved maximum mouth opening, and lateral movement in patients with TMD [36].

Ultrasound therapy is another physical treatment modality that can significantly reduce the pain and improve TMJ function and increase the range of mouth opening. Ultrasound therapy is a frequently used physical treatment modality for musculoskeletal disorders such as cervical pain disorder, back pain, and TMD. The

Table 3: Detailed description of the medication used in treatment of pain associated with TMJ internal derangement.

Medication		Dosage	Mode of action	Side effects	Contraindication	Evidence	Study
NSAIDs	Celecoxib (Celebrex)	100 mg two times per day	inhibit COX-2, resulting in decreased synthesis of prostaglandinE2, a key mediator in inflammation and pain sensitization	block structurally similar COX-1, which negatively affects platelet aggregation, kidney function, and protection of gastrointestinal mucosa	patients taking antiplatelet and anticoagulant drugs, due to increased bleeding risk, especially in the GI tract.	No statistically significant reduction in pain	Double-blind, placebo controlled RCT (n=68) [27]
	Diclofenac	50 mg three times per day				No statistically significant reduction in pain	Double-blind, placebo controlled RCT (n=32) [28]
	Ibuprofen	600 mg four times per day				No statistically significant reduction in pain; combination of ibuprofen and diazepam was more effective than placebo	Double-blind, placebo controlled RCT (n=39) [29]
	Naproxen (Naprosyn)	500 mg two times per day				Statistically significant reduction in pain	Double-blind RCT (n=68) [27]
	Piroxicam (Feldene)	20 mg per day				No statistically significant reduction in pain	Double-blind, placebo controlled RCT (n=41) [30]
Tricyclic antidepressant:	amitriptyline	25 mg per day	blocking the reuptake of both serotonin and norepinephrine neurotransmitters	Side effects: sedation, dizziness, blurred vision, constipation, and xerostomia	acute porphyria, arrhythmias, heart block, severe hepatic and renal impairment	Statistically significant reduction in pain	Double-blind RCT (n=12) [31]
Anticonvulsant:	gabapentin (Neurontin)	300 mg/day, increased by 300 mg every three days until the pain is controlled with no adverse effects	Gabapentin increases non-synaptic GABA responses from neuronal tissues and reduces the release of several mono-amine neurotransmitters.	drowsiness, dizziness, weakness. problems with balance or muscle movement Diarrhoea. Mood changes. Swollen arms and legs. Blurred vision. Dry mouth.	Hypersensitivity, pregnancy, or plan to be pregnant	Statistically significant reduction in pain	Double-blind, placebo controlled RCT (n=44) [32]
Benzodiazepines	Clonazepam (Klonopin)	0.25 mg every night, increased by 0.25 mg each week to a maximum of 1 mg per day	facilitate GABAergic transmission in the brain by a direct effect on benzodiazepine receptors.	drowsiness, confusion, amnesia, impaired coordination, withdrawal symptoms (anxiety, agitation, restlessness, insomnia, and seizures)	Narrow-angle Glaucoma	Conflicting data showing benefit for reduction in pain	Double-blind, placebo controlled RCT (n=20) [33]
	Diazepam (Valium)	2.5 mg four times per day for one week, then 5 mg four times per day for three weeks	binding to the benzodiazepine site on the GABAA receptor to enhance the affinity of channel opening by the agonist GABA	drowsiness, confusion, amnesia, impaired coordination, withdrawal symptoms (anxiety, agitation, restlessness, insomnia, and seizures)	myasthenia gravis, sleep apnea	Statistically significant reduction in pain	Double-blind RCT (n=39) [29]
	Triazolam (Halcion)	0.125 mg every night	binding to the benzodiazepine site of the gamma-aminobutyric acid-A (GABAA) receptors in the brain and enhances GABA-mediated synaptic inhibition.	drowsiness, confusion, amnesia, impaired coordination, withdrawal symptoms (anxiety, agitation, restlessness, insomnia, and seizures)	hypersensitive to triazolam or other benzodiazepine drugs	Improved sleep function, but no statistically significant reduction in symptoms	Double-blind RCT, two period crossover study (n=20) [34]

Muscle relaxant:	cyclobenzaprine (Flexeril)	10 mg every night	reduced skeletal muscle hyperactivity	drowsiness, tiredness, headache, dizziness, xerostomia, stomach upset, nausea, and constipation	hyperthyroidism, severe cardiovascular disease, and the administration of a MAO inhibitor within the previous 14 days	More effective than clonazepam and placebo for reduction in pain	Double-blind, placebo controlled RCT (n=39) [31]

NSAIDs: Nonsteroidal Anti-Inflammatory Drugs; COX-2: Cyclooxygenase 2; COX-1: Cyclooxygenase 2; GABAA: Gamma-Aminobutyric Acid-A; MAO: Monoamine Oxidase Inhibitors

high-frequency oscillations produce ultrasound waves that result in stimulation of cellular pathways. It is proposed to result in reduced pain and inflammation and to induce repair and growth with low Evidence for its efficacy [35].

Ionophoresis is a technique that is used to carry drug ions across a tissue barrier. A weak current is used to enhance transport of the medication through the skin to deeper tissues. It has been proposed to be beneficial in management of inflammatory TMJ disease disorders such as juvenile idiopathic arthritis. However, literature is limited by a lack of randomized controlled trials, control groups, and short-term follow-up [37].

Transcutaneous Electrical Nerve Stimulation (TENS) [38] is a therapeutic stimulus using electrical current, applied through skin surface electrodes to stimulate peripheral nerves for the relief of pain. TENS therapy uses a low-voltage, low amperage biphasic current of varying frequency, it is broadly classified into 3 categories according to the amplitude and frequency of the applied electrical current: 1) conventional TENS, 2) acupuncture-like TENS, and 3) intense TENS. Although a few clinical studies showed the effectiveness of TENS for pain, there are still much scientific controversies over clinical application of TENS [38].

As an adjunctive therapy, it has been shown to be effective in improving TMJ function by reducing pain and improving range of motion in patients with TMJ arthralgia and disc displacement disorders. However, like other physical therapy modalities, literature is limited by the presence of multiple methodological limitations [39].

Botulinum Toxin Injection

Botulinum Toxin (BTX) is used in various ways such as temporarily resolving muscular problems in musculoskeletal temporomandibular disorders, inducing a decrease in bruxism through a change in muscular patterns in a patient's bruxism, and solving problems in patients with tension headache. Clinical injection of BTX-A in masticatory musculatures of TMD patients can be considered as a useful supportive treatment option for controlling complex TMD and helping its associated symptoms [40,41].

Occlusal Appliance Therapy

Although, there are different types of occlusal appliances have been used a long time ago to treat temporomandibular disorders, till now still there is considerable debate about the design of occlusal appliances, how they should be used, and mode of action. different types and designs of occlusal splints with different classification were reported in the literature. Classification of occlusal appliances according to Okeson [42] include 1) Muscle relaxation appliance/ stabilization appliance used to reduce muscle activity 2) Anterior repositioning appliances/orthopedic repositioning appliance, 4) Anterior bite plane 5) Pivoting appliance 6) soft resilient appliance classification of occlusal appliances according to Dawson [43] include 1) Permissive splints/muscle deprogrammer 2) Directive splints/ non-permissive splints 3) Pseudo permissive splints (*e.g.* soft splints, Hydrostatic splint).

Some authors advocate the use of anterior repositioning appliances, so long as pain is present, and the clinician can reduce the disc. When designing these appliances, the clinician guides the patient's mandible forward until the disc or discs are reduced. This protruded occlusion is then indexed into the appliance, which is usually a full-coverage maxillary design. The principle behind this maxillo-mandibular relationship is restoring normal disc position prevents pressing of the retrodiscal tissue by moving the condyle anteriorly [44].

The purpose of stabilization appliance as outlined by the American Academy of Orofacial Pain guidelines is to "provide joint stabilization, protect the teeth, redistribute the occlusal forces, relax the elevator muscles, and decrease bruxism." Additionally, it is stated that "wearing the appliance increases the patient's awareness of jaw habits and helps alter the rest position of the mandible to a more relaxed, open position" [45].

Table 4 showed the description, strength, and weakness with the different occlusal appliance used in the treatment of TMJ internal derangement.

Hegab Non-Surgical Treatment Protocol

Hegab et al. [12] proposed a non-surgical treatment protocol for each stage and substage per Hegab classification. The protocol covered all the aspects of the internal derangement and directed mainly to restore normal function of the joint.

TMJ splint therapy (Hegab TMJ splint) which consider as the main nonsurgical treatment tool. The findings of the study conducted by Hegab et al. suggest that an increase in the vertical thickness of the occlusal splint is associated with better clinical outcomes for patients with internal derangement of the TMJ (Figure 2) [12]. Arthrocentesis is a highly safe procedure and facilitates quick removal of inflammatory tissue and tissue degradants, and its effectiveness in improving TMJ from the "dysfunctional state" to the "functional state" has been proven. The injection of PRP used in cases of Bone degenerative process [46]. while HA injection in cases of stuck disks or disk degeneration. Moreover, a combination of PRP and HA will provide more sustained results. PRP combined with HA has significant long-term clinical efficacy and clear advantages over HA and PRP independently [47].

One of the most difficult cases to be managed is the case of hypermobility with disk displacement. The hypermobility usually results in elongation of the retrodiscal tissue and disk displacement. The rationale of autologous blood injection is to normal range of mandibular movement by restricting the limit of mouth opening. Blood injected into the pericapsular tissues, and the superior joint

Table 4: Detailed the Description, strength, and weakness with the different occlusal appliance used in the treatment of TMJ internal derangement.

Occlusal appliance		Description	Strengths	Weaknesses
Full Coverage	Stabilization splint/Michigan splint	Flat Plane full-coverage device that fits over all the teeth in 1 dental arch about 2mm thickness. No ramp • Even, flat occlusal surface. When it is in place, the condyles are in their most musculoskeletally stable position at the time that the teeth are contacting evenly and simultaneously. Canine disocclusion of the posterior teeth during eccentric movement is also provided.	-no dental changes -can be used in parafunctional habits (bruxism) and joint disorders). -Stable appliance	-inconvenient for some patients
	Hegab splint	Maxillary full-arch hard stabilization splints fabricated with fluid resin. The splint attached to the upper jaw using ball clasps without any extensions of the acrylic resin on the buccal or labial surface of the upper jaw. The retention of the splint to the upper jaw is coming only from the ball clasps. The occlusal splint has indentations on its occlusal surface to guide and hold the mandible in centric relation The occlusal splint vertical thickness of 4 mm used for treatment of the cases with disk displacement with reduction (DDR-HTS4). While for cases of disk displacement without reduction, 6 mm vertical thickness of the occlusal splint was selected (DDNR-HTS6). The vertical thickness of the occlusal splint was measured at the molar area and the indentations help to achieve the Simultaneous equal contacts on all teeth. The selection of the vertical thickness of the occlusal splint based on evidence-based study using the MRI to evaluate the movement changes within the TMJ with different splint thickness	-no dental changes -can be used in parafunctional habits (bruxism), muscles and joint disorders). -Stable appliance -stimulate an isometric contraction -generates lower EMG activity, indicating a decreased bite force	-inconvenient for some patients especially with 6 mm thickness
	Soft resilient appliance	Fabricated from thermoplastic materials	-more convenient for patients than hard splints	-stimulate isotonic contraction -generates higher EMG activity, indicating an increased bite force. -Non-Stable (Easily worn) - can exacerbate bruxism,
Partial coverage	Anterior repositioning appliances (ARAs)	hard acrylic maxillary removable appliances with an anterior ramp that brings the mandible forward into a protrusive position. The appliance can have a flat occlusal plane, or it may have indentations for the posterior teeth to further retain the mandible in an anterior position	-Fast relief of pain	Documented cases of occlusal and even skeletal changes have been reported with continuous use of ARAs, even with only night-time wear
	Hawley anterior biteplate	maxillary appliance that has an occlusal platform from canine to canine	More convenient for the patients	Cause dental changes (open bite)
	Anterior bite plane	Occlusal appliance covered the anterior teeth only	More convenient for the patients	Cause dental changes (open bite)
	Distraction splint (Pivot Appliance)	allowing occlusal contact only with the most posterior teeth thus upon clenching the splint, the condyle is pulled downward, which removes the traumatic load and allows the disc to regain its normal position. As the mandible rotates around the splint, it reduces pressure within the TMJ by unloading the joint. It can also be used as a unilateral pivot appliance with only unilateral occlusal contact, when the mouth is closed, the pivot loads the TMJ on the opposite side and slightly unloads the TMJ on the same side.	Used for treatment of internal derangements and intracapsular inflammation	-Cause both occlusal and skeletal changes - posterior open bite in pivot area
	the nociceptive trigeminal inhibition tension suppression system (NTI-tss)	based on the concept that only 1 to 2 lower anterior teeth should strike the occlusal platform and that this will lead to reflexive relaxation of the masticatory muscles	-Can be used in muscles disorders	-Cannot be used in intraarticular disorders because it causes joint loading -Cause dental changes (open bite)
	anterior midpoints stop appliance (AMPSA)	based on the concept that only 1 to 2 lower anterior teeth should strike the occlusal platform and that this will lead to reflexive relaxation of the masticatory muscles	-Can be used in muscles disorders	-Cannot be used in intraarticular disorders because it causes joint loading -Cause dental changes (open bite)
	posterior bite plane/ mandibular orthopedic repositioning appliance (MORA)	this appliance featured a bilateral posterior-only coverage design	More convenient for the patients	-produce a massive occlusal change in the posterior teeth that ultimately required major dental restorations reestablish the occlusion at a new vertical dimension.
	Kois splint (deprogrammer splint)	The Kois Deprogrammer is a removable, plastic appliance that covers the hard palate and creates a single point of contact between the lower central incisor and the anterior bite plane.	-Can be used in muscles disorders -simplified diagnostic tool for evaluating occlusion	-Cannot be used in intraarticular disorders because it causes joint loading

Partial coverage	Hydrostatic splint	A bilateral water-filled plastic chamber attached to an acrylic palatal appliance, and the patient's posterior teeth occlude with water filled chambers. This appliance originally designed by Lerman. Later on, a modified design, retained under the upper lip, was suggested. The mode of mechanism of this appliance depends on the concept that the mandible finds its ideal position automatically as the appliance was not directing where the jaw should be.	-more convenient for patients than hard splints	-stimulate isotonic contraction -generates higher EMG activity, indicating an increased bite force. -Non-Stable (Easily worn) - can exacerbate bruxism. - No evidence support this claims till now.

Figure 2: Hegab TMJ Splint (HTS) -Maxillary full-arch hard stabilization splints fabricated with fluid resin. The splint attached to the upper jaw using ball clasps for retention with indentations on its occlusal surface to guide and hold the mandible in centric relation.

space will create a bed for the formation of fibrous tissue. Importantly, restrained mandibular movement is the key to the success of the procedure. This followed by application of Hegab TMJ splints to increase the joint space, decreasing the joint pressure, restoring the normal physiologic function of the masticatory mechanism and re-establish the disk condyle relationship [12].

Conclusion

Understanding the normal biomechanical function of the TMJ is important for successful management and expecting the treatment outcome. Understanding the consequences of internal derangement is important for understand the disease progression. The management of TMJ internal derangement need to be extend beyond the concept of restoring the normal disk condyle fossa relationship or disk recapture. The concept of system failure with functional rehabilitation of the joint regardless the disk position showing promising treatment results. The non-surgical treatment should be used as the first treatment modality of TMJ internal derangement with more effective results when used in combination to cover all the pathological aspect of the disorder.

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