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Internal derangement of temporomandibular joint etiology, pathophysiology, diagnosis and management: A review of literature

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Abstract
Temporomandibular joint (TMJ) is a highly complex, multiaxial, synovial; diarthroidal joint in which there is articulation between head of condyle and the gleniod fossa. Temporomandibular disorders (TMD) are a class of degenerative musculoskeletal conditions associated with the morphologic and functional disorders of the joint. The most frequent structural cause of TMD is internal derangements, which involves progressive slippage of the articular disc ahead of the condylar head during opening and closure of the jaw. Internal derangement often get progressively worsen with time. Pain and alterations in function can become quite debilitating, greatly affecting oral health care and diminishing the quality of life for such individuals. In the anatomically demanding and biochemically active environment of the TMJ, therapeutic conservative and surgical approaches that can restore the normal joint functionality of the joint have become an essential tool.

Keywords: Arthrocentesis, temporomandibular joint (TMJ), internal disc derangement, meniscus

Introduction
The temporomandibular joint is basically a complex synovial joint attributed to the presence of the articular disc [1]. (Fig 1) Temporomandibular joint (TMJ) disorders may have intracapsular, extracapsular or combined origins. Extracapsular disorders generally result from the muscles surrounding the TMJ. In contrast intracapsular disorders are the result of the pathology of the articular surfaces or abnormalities in the mechanical relationship of articular structures [2]. The most frequent structural causes of temporomandibular joint dysfunction are internal derangements, which involve slipping or displacement of a component of the temporomandibular joint called the articular disc [3].
Internal derangement of the temporomandibular joint is an abnormal relationship of the articular disc to the glenoid fossa, mandibular condyle and articular eminence and may include a deformation, perforation or displacement of the disc and/or posterior attachment of the disc [4].

Etiology of internal derangement
Internal derangements are related to either acute or chronic insult of TMJ complex. In general, causes of internal derangements can be classified as follows –

1. Macrotrauma
Macrotrauma can be subdivided into two types:

a. **Direct trauma:** significant direct trauma to the mandible, such as a blow to the chin or any other region, can instantly create an intracapsular disorder. Intubation procedures, third molar extractions and long dental appointments are few examples of direct iatrogenic trauma [5].
b. **Indirect trauma:** it refers to injury that may occur to the TMJ secondary to a sudden force, but not one that occurs directly to the mandible. The most common type of indirect trauma reported is associated with a cervical extension/flexion injury (whiplash injury).

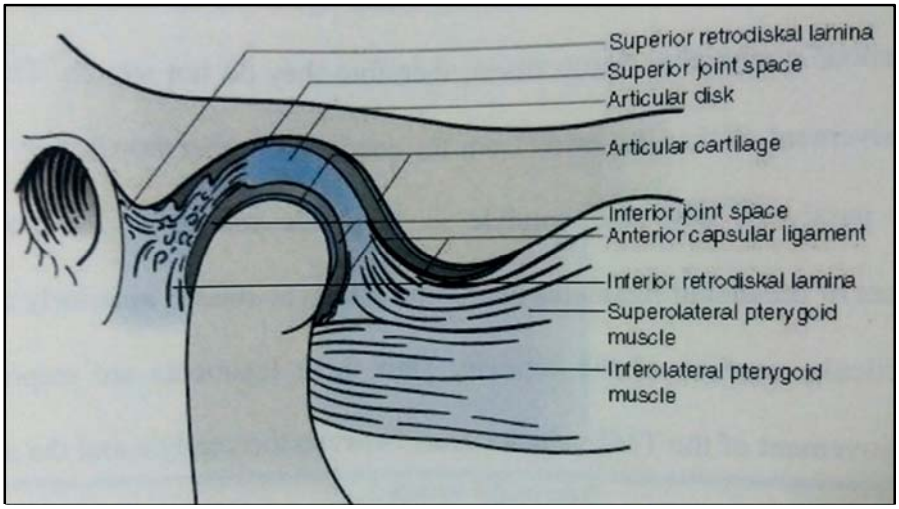

Fig 1: Normal Anatomy of TMJ

2. Microtrauma

Microtrauma refers to any small force repeatedly applied to the joint structures over a long period of time, such as trauma arising from loss of posterior teeth, malocclusions or ill-fitting dentures.

3. Joint laxity

Increase in the laxity of ligaments of the joint, which makes the joint hypermobile in more than two-thirds of the cases is another common cause of derangement of the TMJ [7].

4. Changes in the synovial fluid and joint lubrication-

Increase in the friction of the joint may be caused due to changes in the synovial fluid [9] The hyaluronic acid has been assumed to keep the articular surfaces apart due to its high viscosity, and degradation of the hyaluronic acid likely reduces the viscosity of the synovial fluid, which prevents the articular disc to glide smoothly [10]

Pathophysiology

In the normal joint, the disc fits over the head of the condyle. The complex sequence of rotational and transitional movements of the joint in the upper and lower joint cavities are initiated and controlled by the muscles of mastication. Since the articular disc is firmly adherent to the medial and lateral poles, it moves freely with the head of condyle. The superior head of lateral pterygoid has been found to trace the meniscus against the posterior slope of the articular eminence. In internal derangement increased persistent tone has been found in the upper head of lateral pterygoid. Hence it tends to pull the meniscus antero-medial to the head of condyle. When the disc moves anterior to the condylar head, a clicking sound is heard in the early opening as the condyle reseats into the thin central portion of the disc. The disc snaps behind faster ahead of the condyle, which gives rise to clicking sound during the closing movement (Fig 2). The constant stretching and pulling causes degenerative changes in the disc. When the meniscus is pushed ahead of the condylar head during opening, it gets trapped between the articular eminence and the condyle. This results in impediment that prevents the full mouth opening [11] (Fig 3). Further degenerative changes lead to morphological changes in the disc, its attachment and bony components of the joint.

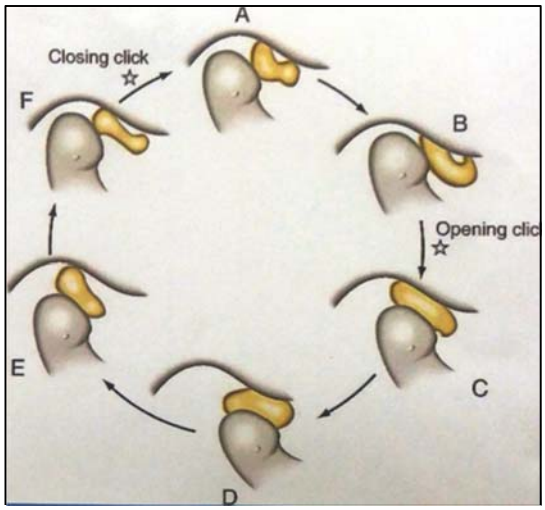

Fig 2: Anterior disc displacement with reduction

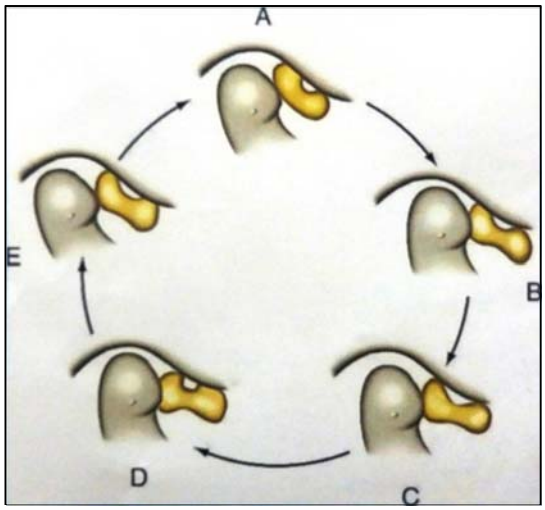

Fig 3: Ant disc displacement without reduction

Classification

Wilkes staging classification of internal derangement based on clinical, radiologic and anatomic divisions [12]

1. Early stage

a) Clinical: no significant mechanical symptoms other than opening reciprocal clicking; no pain or limitation of motion.
b) Radiologic: slight forward displacement; good anatomic contour of the disk; negative tomograms.
c) Anatomic pathologic: excellent anatomic form; slight anterior displacement; passive in-coordination demonstrable.

2. Early intermediate stage

a) Clinical: one or more episodes of pain; beginning major mechanical problems consisting of mod-to-late opening loud clicking; transient catching and locking.
b) Radiologic: slight forward displacement; beginning disk deformity of slight thickening of posterior edge; negative tomograms.
c) Anatomic pathologic: anterior disk displacement; early anatomic disk deformity; good central articulation.

3. Intermediate stage

a) Clinical: multiple episodes of pain; major mechanical symptoms consisting of locking (intermediate or fully closed); restriction of motion; and difficulty with function.
b) Radiologic: anterior disk displacement with significant deformity or prolapse of disk (increased thickening of posterior edge); negative tomograms.
c) Anatomic pathologic: marked anatomic disk deformity with anterior displacement; no hard tissue changes.

4. Late intermediate stage

a) Clinical: slight increase in severity over intermediate stage.
b) Radiologic: increase in severity over intermediate stage; positive tomograms showing early to moderate degenerative changes – flattening of eminence, deformed condylar head, sclerosis.
c) Anatomic pathologic: increase in severity over intermediate stage; hard tissue degenerative remodeling of both bearing surfaces; multiple adhesions in anterior and posterior recesses; no perforation of disk or attachments.

5. Late stage

a) Clinical: characterized by crepitus; variable and episodic pain; chronic restriction of motion and difficulty with function.
b) Radiologic: disk or attachment perforation; filling defects; gross anatomic deformity of disk and hard tissues; positive; positive tomograms with essentially degenerative arthritic changes.
c) Anatomic pathologic: gross degenerative changes of disk and hard tissues; perforation of posterior attachment; multiple adhesions; osteophytosis; flattening of condyle and eminence; subcortical cyst formation.

Clinical features

Clinically internal derangements can be categorized into four phases [13, 14]

Phase I (*In-coordination phase)*: Earliest indication of internal derangement has been referred to as an incoordination phase. Generally the patient is unaware of the condition as there is no joint noise or pain. However when asked to open or close the mouth, patient usually complaints of a catching sensation.

Phase II (Anterior disc displacement with reduction): In this phase the articular disc slips anteromedially to the head of condyle and mouth opening is accompanied by a clicking or popping sound. This percussive sound is produced as the condyle passes over the posterior band and returns to a normal relationship with the disk.

In some patients a second clicking sound is heard during mouth closure, this is referred to as a reciprocal click and it occurs on the posterior band of the disc as it slips forward of the condyle during closing.

Phase III (Anterior disc displacement without reduction): In this category of internal derangement, the disk is located even further forward and the condyle is unable to pass over the posterior band on attempted opening.

Phase IV (Disc adhesion to the articular eminence): This is the terminal stage in which due to continuous stretching, there is perforation followed by adhesion of the disc to the articular eminence. Pain, crepitus and muscle tenderness becomes a predominant feature with limitation of mouth opening.

Diagnosis

The diagnosis depends upon

1. Taking a proper history
2. Clinical examination
3. Investigations

1. Taking a proper history: A detailed history of the type, intensity, duration and frequency of pain must be recorded. History of joint sounds, locking, any occlusal disharmony, and history of previous treatment and pschyological background of the patient should be thoroughly evaluated.

2. Clinical examination: This includes Muscle examination, Inter-incisal mouth opening and TMJ examination.

Muscle examination: A widely accepted method of determining muscle tenderness and pain is by digital palpation [15] Routine muscle examination includes palpation of the following group of muscles - Temporalis, masseter, sternocleidomastoid and posterior cervical. The medial and lateral pterygoid muscles can be evaluated by functional manipulation as these groups of muscles are nearly impossible to palpate manually.

When a muscle is palpated, the patient's response is placed into four categories [16]

Zero (0) – no pain or tenderness.
One (1) – slight tenderness or soreness.
Two (2) – definite pain or discomfort.
Three (3) – The patient shows evasive action or eye tearing or verbalizes a desire not to have the area palpated again.

Interincisal mouth opening: A muscle examination is not complete until the effect of muscle function on mandibular movement has been evaluated. The patient is asked to slowly open the mouth until pain is felt first. The interincisal opening is measured, followed by measurement of maximum mouth opening. The end feel can be evaluated by placing the fingers between the upper and lower the teeth. If the end feel is "soft" increased opening can be achieved and suggests muscle-induced restriction. Similarly if the end feel is "hard" it suggests intracapsular source. (Fig 4)

Examination of the muscles and mouth opening helps in differentiating between the intracapsular and extracapsular

cause of pain. Intracapsular joint disorders (functional disorders of joint, inflammatory disorder) elicits pain with increased interarticular pressure and movement. It occurs only in one joint and limits mandibular opening in that joint primarily to rotation. Extracapsular restrictions typically occur with elevator muscles spasms and pain. These muscles tend to restrict translation and thus limit mouth opening. If the restricting muscle is lateral to the joint (as with masseter) the deflection during opening will be towards ipsilateral side and if the restricting muscle is medial (as with medial pterygoid) the deflection will be towards contralateral side.

Fig 4: Checking the end feel

Temporomandibular joint examination: Pain or tenderness of the Temporomandibular joint is determined by digital palpation of the joint when the mandible is both stationary and during dynamic movement. Joint sounds such as clicks or crepitation should be evaluated during palpation or with the use of sthetoscope. A click is a single sound of short duration. Crepitation is a multiple gravel-like sound described as grating and is commonly associated with osteoarthritic changes of the articular surfaces of the joint.

Dental examination: Intraoral examination should focus primarily on the occlusion for any disharmony, missing teeth especially posterior teeth, any prosthesis or high point restorations and generalized attrition of teeth (bruxism).

3. Investigations

1. Transcranial view – Provides good visualization of both the condyle and the fossa.
2. Transorbital and Reverse Towne's projection – Depicts the entire mediolateral dimension of the articular eminence, condyle and condylar neck.
3. Tomography – Useful only in assessing the osseous changes in condyle and eminence.
4. Arthrography – Includes injecting a contrast material into the joint prior to radiography. It helps in evaluating the morphology and position of the disc. However it is not commonly practiced due to the risk of infection, allergy and potential damage to the disk or capsule.
5. Computerized Tomography – Currently the best method for assessing the bony pathologic changes in the joint [17] (Fig 5)
6. Magnetic Resonance Imaging – It has become a gold standard for evaluating the soft tissue of the Temporomandibular joint [15] (Fig 6)
7. Temporomandibular joint arthroscopy – It permits direct visualization of the interior of joint with the help of a small telescope. This technique is utilized for diagnostic and therapeutic modalities [11]

Fig 5: TMJ image reconstructed with Cone beam computed tomography

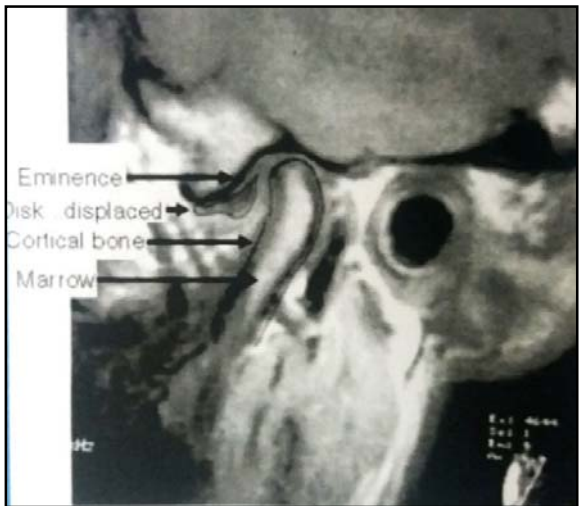

Fig 6: MRI showing the disc centered over the condyle

Fig 7: Stabilization splint

Management

The primary goal of treatment is to alleviate pain and/or mandibular dysfunction. Internal derangements can be managed by non-surgical or surgical therapies.

Nonsurgical therapy

1. Pharmacotherapy
2. Physical therapy
3. Stress reduction techniques
4. Occlusal appliances

1. Pharmacotherapy

The most common pharmacologic agents used are-

a) Analgesics: include opiate (oxycodone, propoxyphene) and non-opiate (salicylates, acetaminophen) are prescribed for mild to moderate pain.

b) **Anti-inflammatory agents:** include NSAID's (ibuprofen, diclofenac) provide anti-inflammatory properties along with analgesia. Corticosteroids have been directly injected into the TMJ in an attempt to decrease inflammation.
c) **Anxiolytic agents:** include benzodiazepines tend to reduce the anxiety, insomnia and muscle hyperactivity associated with internal derangement.
d) **Antidepressants:** Antidepressants such as amitriptyline, desipramine are prescribed for chronic pain or patients with sleeping disorders.
e) **Muscle relaxants:** Centrally acting muscle relaxants such as cyclobenzaprine, methocarbomol can be used to relax hyperactive muscles and may also act as sedatives [18].
f) **Local anaesthetics:** can be used as diagnostic blocks intra-articularly and/or intramuscularly to alleviate pain and increase range of motion.

2. Physical therapy

Physical therapy and exercise is also important part of any TMJ disorder program. Jaw exercise therapy can be described as-

Passive jaw exercises, which allow patients to increase interincisal opening manually or with a device (such as Therabite jaw motion rehabilitation system). It is also effective for patients with muscular trismus and myofacial pain dysfunction. Active jaw exercises, in which patients are advised to open their mouth until they perceive pain and then advised to hold for several seconds and repeat this exercise for several times a day.

Yuasa and kurita suggested that physical therapy along with administration of NSAID's (for a period of 4 weeks) is a more effective way to treat TMJ disk displacement without osseous changes [19]

3. Stress reduction techniques

These techniques can be useful in patients under constant mental and physical stress and include techniques such as relaxation, biofeedback, acupressure [20] and acupuncture.

4. Occlusal appliance therapy

Occlusal appliances are removable devices usually made of hard acrylic, which is custom fit over the occlusal surfaces of the maxillary and mandibular teeth. The splint is constructed so that there is even occlusal contact with the teeth of opposing arch in centric and anterior contact only, in lateral and protrusive excursions of the mandible. There are generally two types of appliances: stabilization (flat plane) and anterior repositioning.

Stabilization (flat plane) appliance: A stabilization appliance covers all the teeth in one arch (primarily fabricated on the maxillary arch) and is indicated to relax the muscles of mastication, aid in joint stability, and protect teeth from bruxism [21]. With a stabilization appliance the condyles are placed in the most muscularly stable position. The appliance should be worn 24 hours a day and taken out at mealtimes [22]. (Fig 7)

Anterior repositioning appliance: The anterior repositioning appliance is an interocclusal appliance that permits the mandible to assume a position more anterior than normal. The purpose of these appliances is to alter the structural condyle-disk-fossa relationship in an effort to decrease joint loading. (Fig 8)

Fig 8: Anterior repositioning splint

Surgical management

This includes:
1. Arthrocentesis and lavage
2. Arthroscopy
3. Arthrotomy
4. Condylotomy.

1. Arthrocentesis and lavage: Arthrocentesis is defined as a method of flushing out the Temporomandibular joint by placing two needles into the upper joint compartment using local anesthesia or sedation. It is a minimally invasive procedure and considered as the first line of surgical treatment for patients who do not respond to conservative treatment [32]

The technique involves insertion of two separate needles 19G through two separate puncture sites into the upper joint compartment taking Holmund line as the indicator. Ringer's lactate solution (upto300 ml) is flushed through the first inserted needle which outflows through the second needle. (Fig 9)

Fig 9: Artherocentesis

2. Arthroscopy: It consists of insertion of a specially designed fiberoptic endoscope into the joint compartment and irrigation is carried out under direct visualization on the video monitor using trocar and cannulae.

3. Arthrotomy: It consists of surgical exposure of the joint capsule by preauricular or endural approach followed by mobilization and corrects anatomic positioning of the disk. Arthrotomy can be performed with diskectomy, autologous graft or alloplastic TMJ prosthesis [35, 38, 39]

4. Condylotomy: TMJ condylotomy is the only TMJ surgical procedure that does not invade the joint structures [24] It is a modified form of transoral vertical ramus osteotomy used in orthognathic surgery. [30, 31] It seems to be most successful when used to treat painful TMJ internal derangement without reduced mouth opening. [34, 36]

Recent advances

Low Level Laser Therapy: Clinical studies of LLLT used on patients with disc derangement disorders using either AlGaAs 830 nm diode laser in continuous wave mode or He Ne laser 632 nm combined with a diode laser 904 nm in pulsed mode have shown clinical benefits in terms of reduction in pain and clicking. When a local effect is desired, laser is effective by stimulating microcirculation and local cell tropism. Advantages include aseptic, noninvasive, painless, nonpharmaceutical and reversible therapy, if used properly has no side effects. [40]

Tissue engineering of the TMJ Disc: Early studies exploring tissue engineering of the TMJ disc laid the foundation and demonstrated the potential effort but lacked the characterization information needed for validation and progress in optimizing the criteria of the designs. The disc shows biomechanical properties that may be matched more easily in tissue-engineered constructs in contrast to other musculoskeletal soft tissues. With respect to shear stimulation, shear stress is experienced *in vivo* by the disc during joint rotation and translation and may be simulated in culture via a rotating wall bioreactor [41]

Conclusion

Internal derangement is a term which summarizes disk displacement with or without displacement, perforation of the articular disk or of the retrodiskal tissue and various degenerative changes of the disk and/or the articulating surfaces. In regards to internal derangement of TMJ, it is not possible to eliminate the disease because the etiopathogenesis is not known. It is possible to arrest the disease or identify and eliminate some of its disturbing manifestations. The initial treatment consists of medications with nonsteriodal anti-inflammatory drugs and muscle relaxants for 1 to 2 weeks, the second phase consists of manual mandibular manipulation, arthrocentesis and the final phase include use of a pivot splint for 12 weeks. The surgical intervention which includes arthroscopy, arthrotomy and even total TMJ replacement is indicated only when non-surgical therapy has been ineffective. The continued interest in developing new methods of therapy for management of adhesions of the temporomandibular joint conceptually validates the concern, that no available method is full proof and effective.

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