DIAGNOSTIC IMAGING OF TEMPEROMANDIBULAR JOINT DISORDERS

CONTENTS

DIAGNOSTIC IMAGING OF TMJ DISORDERS

Introduction

Disorders of the temporomandibular joint are -that interfere with the normal form or function of the joint. These disorders include dysfunction of the articular disk and associated ligaments and muscles, joint arthritides, inflammatory lesions, neoplasms, and growth or developmental abnormalities.[1] The purpose of an imaging assessment of the temporomandibular joint (TMJ) is to graphically depict clinically suspected disorders of the joint. For many years, plain film radiography done mainly in a transcranial projection was the most commonly used method of making this assessment. This modality has major limitations because it is sensitive only to changes in the osseous components and depicts just the lateral aspect of the joint. With the evolution of newer imaging modalities such as arthrography, computed tomography (CT), and, most importantly, magnetic resonance (MR) imaging, the soft tissues of the joint could be appreciated. This allowed a better understanding of the anatomy and pathophysiology of TMJ disorders.[2]

DEFINITION:

Temporomandibular disorders (TMD) are a collection of disorders involving the temporomandibular joint, the soft-tissue structures within the joint, and the muscles of mastication with common symptoms such as pain, restricted movement,muscle tenderness and intermittent joint sounds (Dimitroulis 1998).[3]

EPIDEMIOLOGY

Signs of TMD are seen in 60 – 70 % of general population where as 5% report to the physicians due to severity of symptoms. Females are more predominantly affected than males. Comparing the various age groups TMD are seen to affect individuals in early adulthood.[3]

ETIOLOGY

- Direct Trauma

- Iatrogenic Injury During Dental Or Medical Treatment
- Developmental Defects
- Systemic Disorders - Autoimmune Diseases
- Parafunctional Jaw Activities
- Behavioral Disorders: Stress, Depression
- Major Discrepancies In Dental Occlusion
- Unknown Factors
- Hormonal

CLASSIFICATION SYSTEM FOR DIAGNOSING TEMPOROMANDIBULAR DISORDERS [4]

I MASTICATORY MUSCLE DISORDERS

- Protective co-contracture
- Local muscle soreness
- Myofacial pain
- Myospasm
- Centrally mediated myalgia

II. TEMPOROMANDIBULAR DISORDERS

A. Derangement of the condyle-disc complex

- Disc displacements
- Disc dislocation with reduction
- Disc dislocation without reduction

B. Strcutural incompatibility of the articular surfaces

1. Deviation in form

- Disc
- Condyle
- Fossa

2. Adhesions

- Disc to condyle
- Disc to fossa

3. Subluxation (hypermobility)

4. Spontaneous dislocation

C.Inflammatory disorders of the TMJ

1. Synovitis/ capsulitis

2. Retrodiscitis

3. Arthiritides

a .Osteoarthiritis

b. Osteoarthrosis

c. Polyarthritides

D. Inflammatory disorders of associated structures

a. Temporalis tendonitis

b. Stylomandibular ligament inflammation

III. CHRONIC MANDIBULAR HYPOMOBILITY

A. Ankylosis

- Fibrous
- Bony

B. Muscle contracture

- Myostatic
- Myofibrotic

C. Coronoid impedance

IV. GROWTH DISORDERS

A. Congenital and developmental bone disorders

- Agenesis
- Hypoplasia

- Hyperplasia
- Neoplasia

B. Congenital and developmental muscle disorders

- Hypotrophy
- Hypertrophy
- Neoplasia

I. CONGENITAL AND DEVELOPMENTAL ABNORMALITIES

Developmental abnormalities may be broadly categorized as anomalies in the form and size of joint components.The most striking radiographic changes usually are seen in the condyle, although the temporal component also may be deformed, often remodeling to accommodate the abnormal condyle. Condylar articular cartilage is a mandibular growth site, and as a result, developmental abnormalities at this location may manifest as altered growth on the affected side of the condyle, mandibular ramus, mandibular body, and alveolar process on the affected side.[1]

A) Congenital and Developmental Disorders of Condyle Process[5]

i. Aplasia
ii. Hyperplasia
iii. Hypoplasia
iv. Bifid condyle

CONDYLAR HYPERPLASIA

Definition: Condylar hyperplasia is a developmental abnormality that results in enlargement and occasionally deformity of the condylar head; this may have a secondary effect on the mandibular fossa as it remodels to accommodate the abnormal condyle. The etiology may be overactive cartilage or persistent cartilaginous rests, increasing the thickness of the entire cartilaginous and precartilaginous layers. This condition usually is unilateral and may be accompanied by varying degre~s of hyperplasia of the ipsilateral mandible.'

Clinical Features

Condylar hyperplasia is more common in males, and it usually is discovered before the age of 20 years. The condition is self-limiting and tends to arrest with termination of skeletal

growth, although in a small number of cases continued growth and adult onset have been reported. Other features include:

- Mandibular asymmetry (severity- depending on the degree of condylar enlargement)
- Deviation
- Increase in the vertical dimension
- Posterior open bite
- Crossbite on opposite side

Radiographic Features:

- Condyle – symmetrically enlarged or altered shape (e.g.conical, spherical, elongated, lobulated) or irregular in outline
- Increased radiopacity
- Elongation and thickening of condylar head - 'Inverted L' appearance
- Normal cortical thickness and trabecular pattern
- Enlargement of glenoid fossa, mandibular ramus and body
- Increased vertical depth of ramus

Histologically;- [6]

- Bony trabeculae were often thickened and irregular
- Consistently large volume of trabecular bone
- Presence of hypertrophic cartilage (increased thickness)
- Islands of chondrocytes in the subchondral trabecular bone(typical)

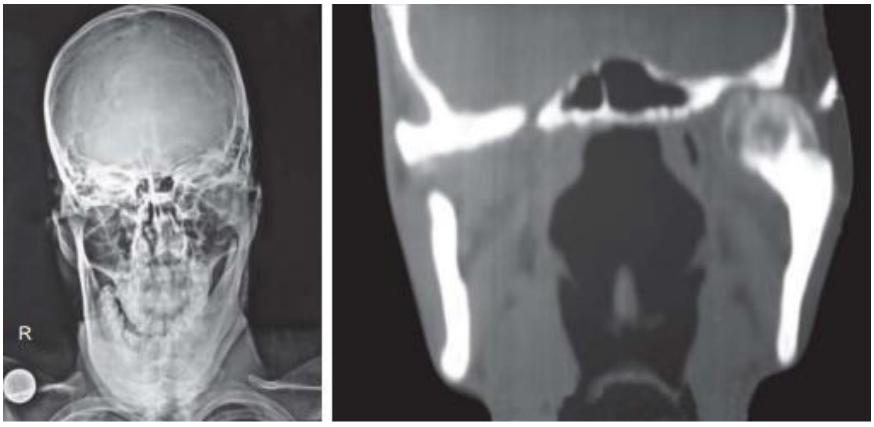


Fig-1 Left Condylar Hyperplasia

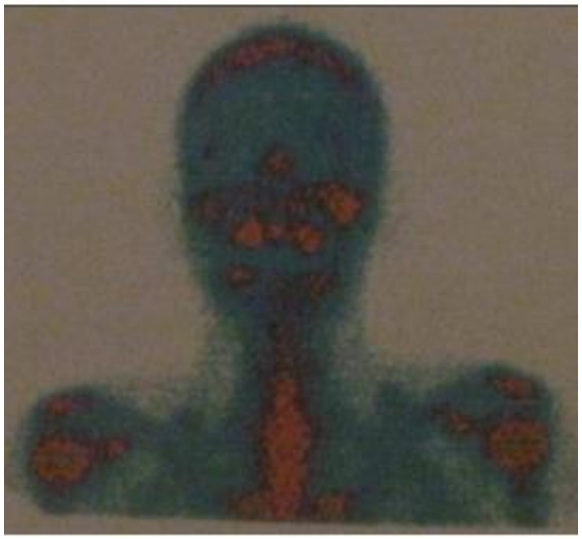


Fig-2 Bone SPECT Scintigraphy showing increased radionuclide uptake on left condyle ; > 55% - abnormal

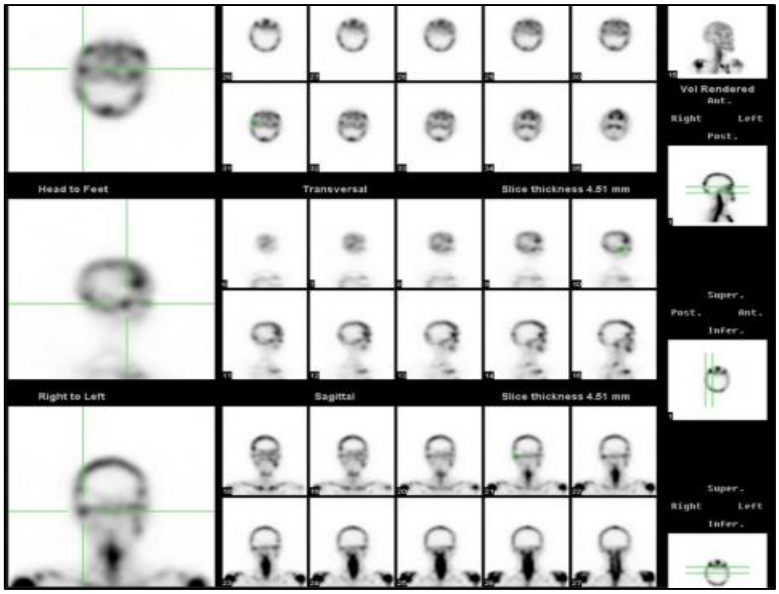


Fig-3 Bone Scintigraphy showing hot spots

BIFID CONDYLE

Definition

A bifid condyle has a vertical depression, notch, or deep cleft in the center of the condylar head seen in the frontal or sagittal plane or an actual duplication of the condyle, resulting in the appearance of a "double" or "bifid" condylar head. This condition may be unilateral or

bilateral. It may result from an obstructed blood -supply or other embryopathy, although a traumatic cause has been postulated as a result of a longitudinal linear fracture of the condyle.

Clinical Features

Bifid condyle usually is an incidental finding in panoramic views or anteroposterior projections. Some patients have signs and symptoms of temporomandibular dysfunction, including joint noises and pain.

Radiographic features:

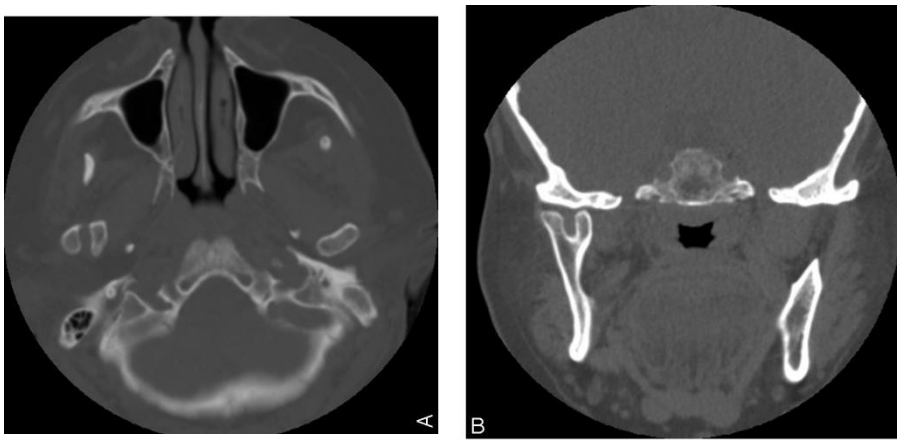


Fig-4Axial (A) and coronal (B) thin-cut CT images through the mandible demonstrate a bifid mandibular condyle on the right side with mediolaterally oriented heads[7]

Syndromes associated congenital and developmental anomalies of TMJ:

- Hemifacial Microsomia
- Treacher Collins Syndrome
- Hallermann-Steiff Syndrome
- Pierre Robin Syndrome
- Oculo mandibulo dyscephaly
- Progeria

CONDYLAR HYPOPLASIA

Definition

Condylar hypoplasia is failure of the condyle to attain normal size because of congenital and developmental abnormalities or acquired diseases that affect condylar growth. The condyle is small, but condylar morphology usually is normal. The condition may be inherited or may appear spontaneously.

Congenital : As a component of mandibular growth deficiency

May appear as a manifestation of generalized disorders as seen in Treacher Collin's syndrome , Goldenhar syndrome, micrognathia

Acquired abnormalities: May occur as a result of damage during the growth period due to sources such as therapeutic radiation,Infections etc

Clinical features:

- Underdeveloped ramus and (occasionally), mandibular body
- Unilateral or bilateral
- Mandibular asymmetry
- Chin commonly deviated to affected side
- Deviation of mandible to the affected side during mandibular opening
- Degenerative joint disease - a common long-term sequela

Fig-5 Panoramic view (B) shows normal configuration on the right side of the mandible. The left side shows shortening of the ramus and regressive remodeling of the left condyle

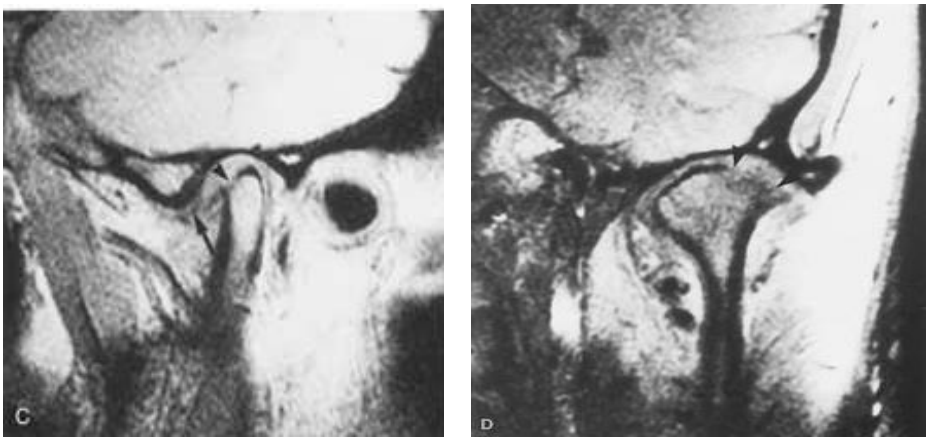


Fig-6 Sagittal MR image. D, Coronal MR image. MR images (C and D) show erosive changes of the condyle (arrowheads) and anterior disk displacement (arrow). The diminished size of the left condyle is the cause of the asymmetry.

CORONOID HYPERPLASIA

Definition

Coronoid process hyperplasia may be acquired or developmental, resulting in elongation of the coronoid process. In the developmental variant, the condition usually is bilateral. Acquired types may be unilateral or bilateral and usually are a response to restricted condylar movement caused by abnormalities such as ankylosis.

Clinical Features

- Males are affected often; commencing at the onset of puberty
- Progressive inability to open the mouth
- Painless

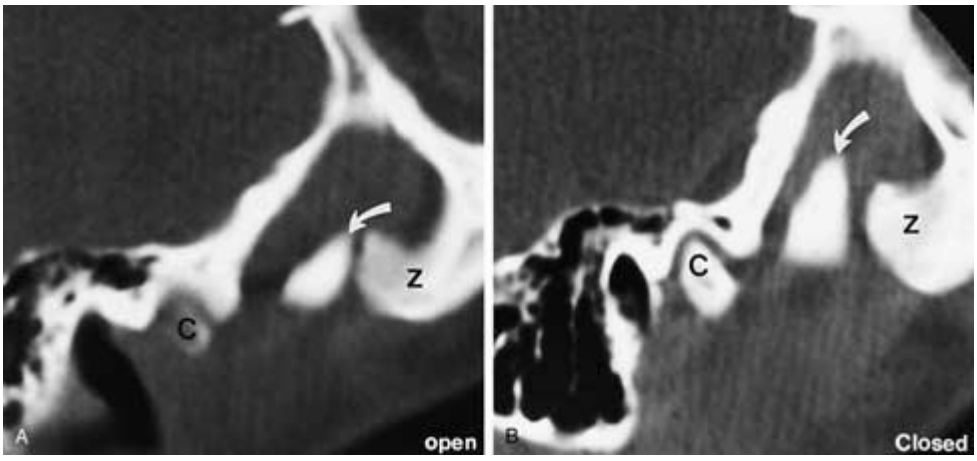


Fig-7 A and B, Direct sagittal CT scans in the open-mouth and closed-mouth positions showing the elongated coronoid process (*arrows)*

DISC ABNORMALITIES: INTERNAL DERANGEMENTS

Internal derangement is a general orthopedic term implying a mechanical fault that interferes with the smooth action of a joint. Internal derangement is thus a functional diagnosis.

Definition: Internal derangement of the temporomandibular joint (TMJ) may be defined as a disruption within the internal aspects of the TMJ in which there is a displacement of the disc from its normal functional relationship with the mandibular condyle and the articular portion of the temporal bone.[8]

The internal derangements are the most common noninflammatory abnormalities of the TMJ, being observed even in asymptomatic subjects. It largely involves the function of the articular disc. Therefore, these alterations have been also referred to as disc derangements.They differ from degeneration because the quality and structure of the TMJ tissues are not necessarily altered.

CLASSIFICATION [4]

DERANGEMENT OF THE CONDYLE-DISC COMPLEX

I. Disc displacements
II. Disc dislocation with reduction
III. Disc dislocation without reduction

Etiology

Many etiologic factors have been proposed to explain disc derangements.[9]

1. Trauma: Events which may cause stretching, tearing, or rupture of the disc, lateral ligament, or capsule. When bleeding occurs, fibrotic or hyperplastic intra-articular reactions may lead to restricted mobility and pain.

2. Bruxism has been also reported as a potential cause of disc derangements, since compressive overloading may alter the connective tissue of the TMJ.

3. Changes in the composition of the synovial fluid: It may increase the intra-articular friction, leading to unstable disc motion.These biochemical changes may also affect the joint lubrication and nutritional requirements of the articular surfaces.

4. An improper activity of the lateral pterygoid muscle (LPM) during TMJ motion has been also related to disc derangements. Morphologic changes of LPM, such as hypertrophy,

atrophy, or contracture, have been found in patients with anterior disc displacement without reduction. A higher propensity toward anterior disc displacement has also been found in subjects in which the LPM attaches to the disc but not to the condyle.

Pathophysiology

An initial adaptative response, triggered by overloading, induces structural changes in the TMJ. This is a slow but continuous process of modeling that involves all the elements of the TMJ, within tissue-specific limits. Although physiological changes occur in the disc, its ability to remodel is lower than that of other tissues of the TMJ, such as the capsule, capsular ligaments, and retrodiscal tissues.

However, as long as the system preserves the ability to adapt to the new functional status, the altered mechanical loading is compensated by the structural modeling of the TMJ. Although the coordination of the disc-condyle complex may be lost, in this stage the patient is usually asymptomatic. The exposure to excessive or prolonged loading may overcome the biomechanical limits of the TMJ. When the reserve of adaptative and compensatory responses is exhausted, the changes taking place in the TMJ are known as regressive modeling (ie, maladaptation). At this stage, decompensated and destructive morphologic changes are usually revealed with pain and other clinically evident signs and symptoms

Clinical staging

A common approach, used in reporting magnetic resonance imaging examinations of the TMJ, is to assess the direction of disc displacement, which may be anterior, medial, lateral, or even posterior. Multidirectional displacements are considered more frequently than unidirectional ones. Posterior derangements are rare. The oblique orientation of the lateral pterygoid muscle and the angulation of the condyle direct most meniscal displacements in an anterior-medial path.

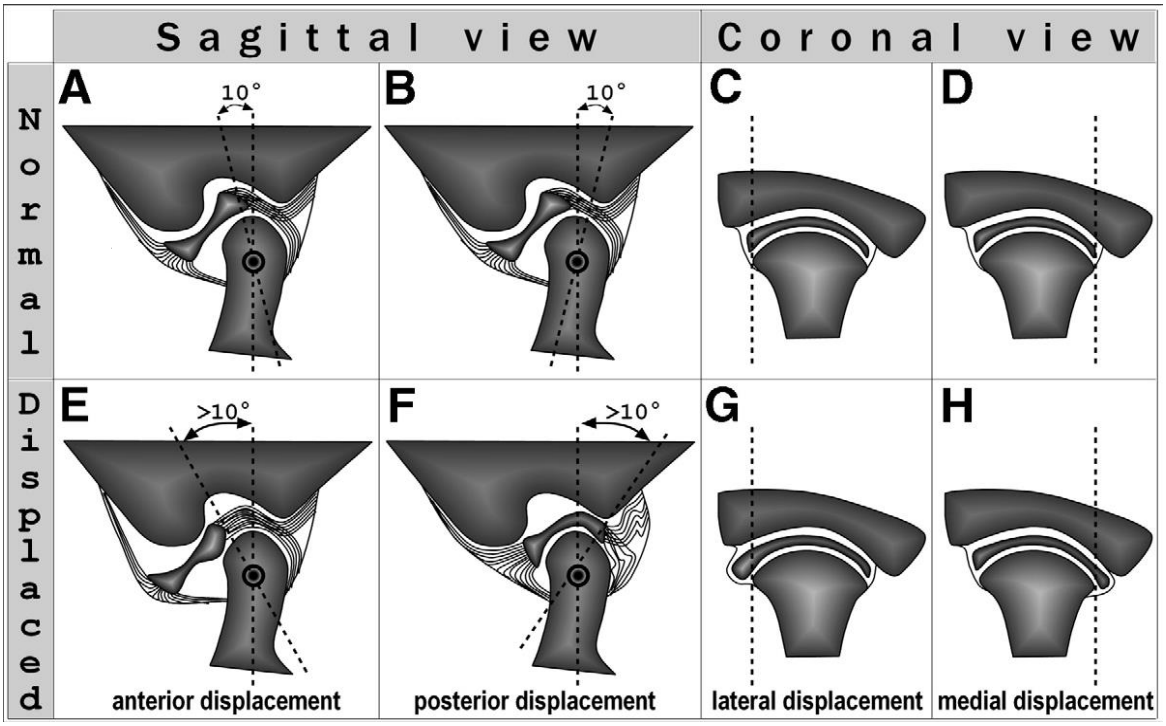


Fig- 8 Disc derangements

ANTERIOR DISC DERANGEMENTS

Posterior band of disk terminates ahead of condylar apex

Anterior disc derangements are grouped into four categories based on the degree of dislocation, reversibility during the opening-closing movement, and changes in disc shape.

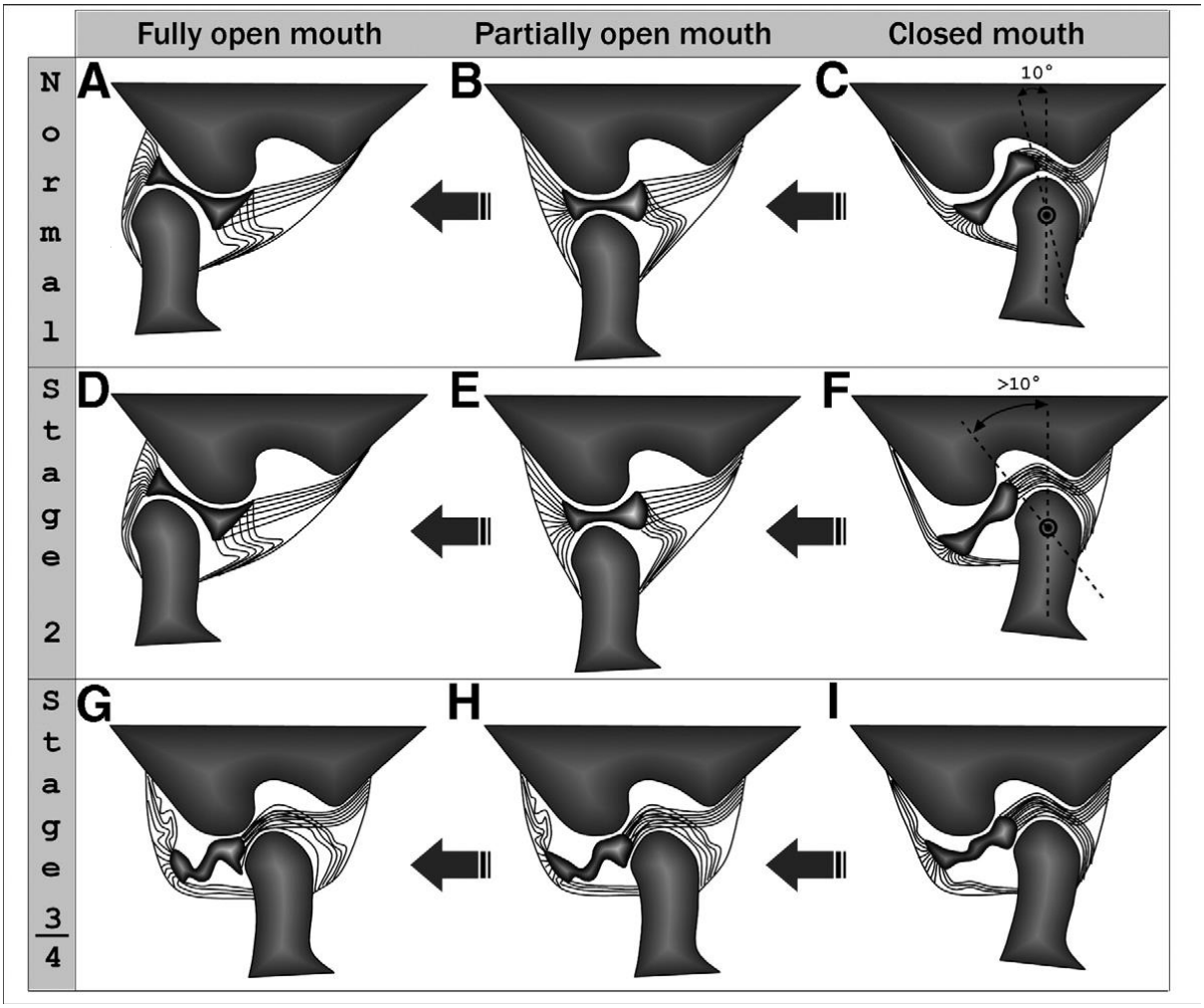


Fig-9 ANTERIOR DISC DERANGEMENTS

Stage I : Incoordination

In the early stage, joint noise or dysfunction is not evident. However, at mouth opening, the patients may feel a slight catching sensation. This may be the earliest sign that a change in the frictional properties of the joint has occurred. Therefore, this stage of derangement has been referred to as TMJ disc incoordination.

Imaging Features (MRI) : None

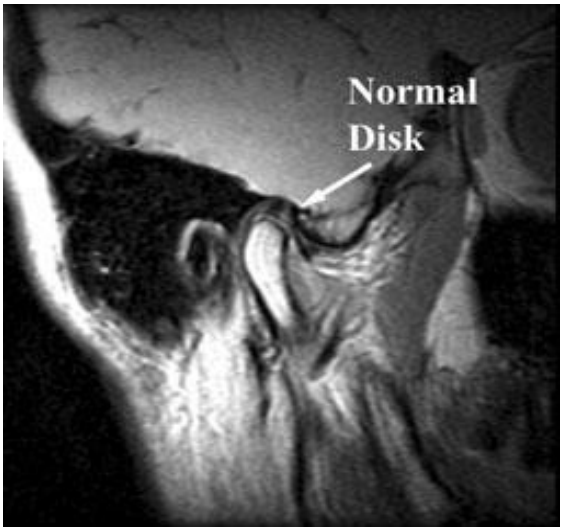
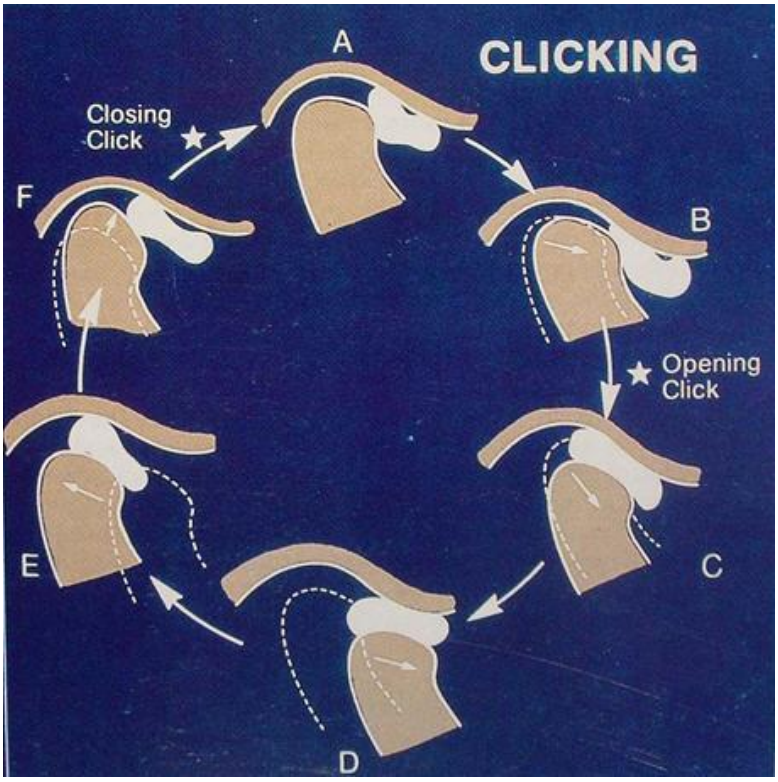


Fig-10 Stage I (incoordination

Stage II (Intermittent locking): Displacement with reduction

In the next stage, the articular disc has slipped forward in an anterior-medial position. In rest position and in centric occlusion, the posterior band of the disc is located behind the apex of the condylar head. Mouth opening occurs with a clicking or popping sound, because the posterior band of the disc slips back over the condylar head. As a result, in the open-mouth position the intermediate zone of the disc will be placed correctly between
the condylar head and the eminence of the temporal bone. Because the opening movement relocates the disc in the joint, this stage is referred to as disc displacement with reduction. Occasionally, a second clicking sound is heard during mouth closure ("reciprocal click"), because the posterior band of the disc slips forward off the condyle.

Imaging features: Disc displacement in centric occlusion
Normally located disc in open-mouth position



Stage II (Intermittent locking): Displacement with reduction (reciprocal click)

Radiographic features:

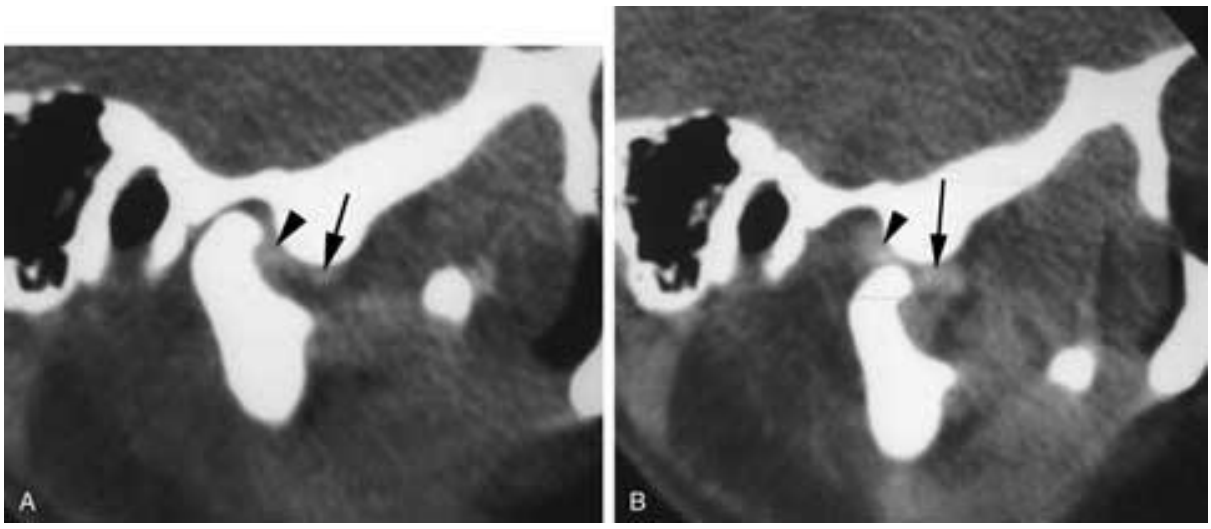


Fig-11 Direct sagittal CT. Anteriorly displaced disk with recapture (reciprocal click)

A) Soft-tissue window - condyle positioned posteriorly in glenoid fossa. Posterior thick band (arrowhead) demonstrated anterior to the condyle. Anterior thick band (arrow) is seen just inferior to the articular eminence.

B) Open-mouth position.- Condyle now has a normal relationship to the disk articulating with the thin area between posterior thick band (arrowhead) and anterior thick band (arrow). The disk has been recaptured.

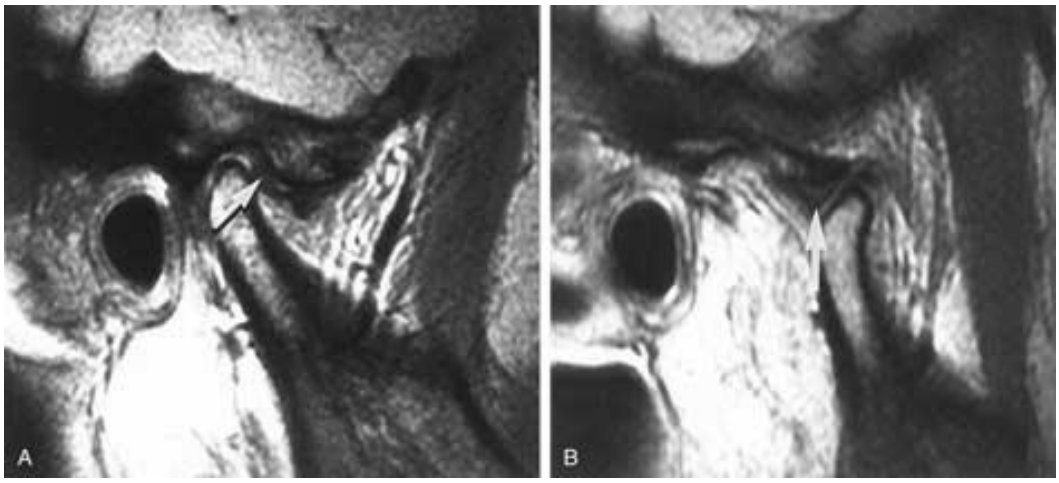


Fig-12 Disk displacement with Reduction

A) Posterior band of the displaced disk (*arrow) is anterior* to the condyle.

B) Open-mouth image shows the posterior band (*arrow) in a normal relationship posterior to the* condyle. This indicates reduction on opening

Stage III (closed lock): Displacement without reduction

In the third category of internal derangement, a greater degree of anterior displacement of the disc is found. The disc also acts as an obstacle, preventing the condyle to overcome the posterior band when mouth opening is attempted. In this condition the joint appears as "locked."

Clinical hallmarks:

- Clicking noises disappear (Referred history of clicking or popping)
- Localized pain in the TMJ increasing with attempted mouth opening and chewing
- Severe limitation in mouth opening (maximum= 25 to 30mm)
- Joint tenderness
- Deviation of mandible to the affected side
- Chronic cases - crepitus may be present

Imaging features: Disc displacement in both centric occlusion and maximal open-mouth positions.

Limited condylar translation and morphological and pathologic changes of disc (rounded, irregular disc etc) may be evident.

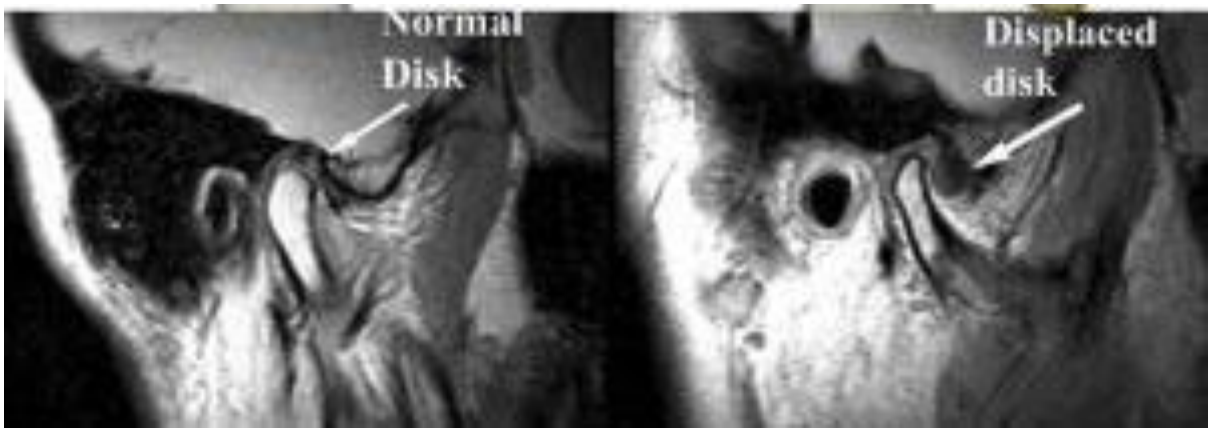


Fig-13 Stage III: Displacement without reduction

Stage IV (disc adhesion): The fourth category is characterized by a limitation of mouth opening. However this limitation may not be caused by disc displacement. The disc may be in a normal position but advanced degenerative changes have occurred. Adherences are usually found with the disc and the articular eminence, so that only condylar rotation is allowed. On the other hand, adherences also limit the mobility of the disc (ie, "stuck," "fixed," or "frozen disc"). In addition, late-stage changes in disc morphologic and magnetic resonance signal become more evident. A biconvex, rounded, irregular, or flat disc usually indicates more advanced disease. Tear and perforations of the disc may also occur.

Imaging features: Osseous changes consist of flattening and osteophytosis of the mandibular condyle and flattening of the temporal component of the articulation. These changes are more commonly observed in the lateral part of the joint and can be detected on plain film imaging. It should be noted that osseous changes are relatively late findings in the disease process, and it is often difficult to differentiate radiographically between advanced remodeling and degenerative joint disease.[2]

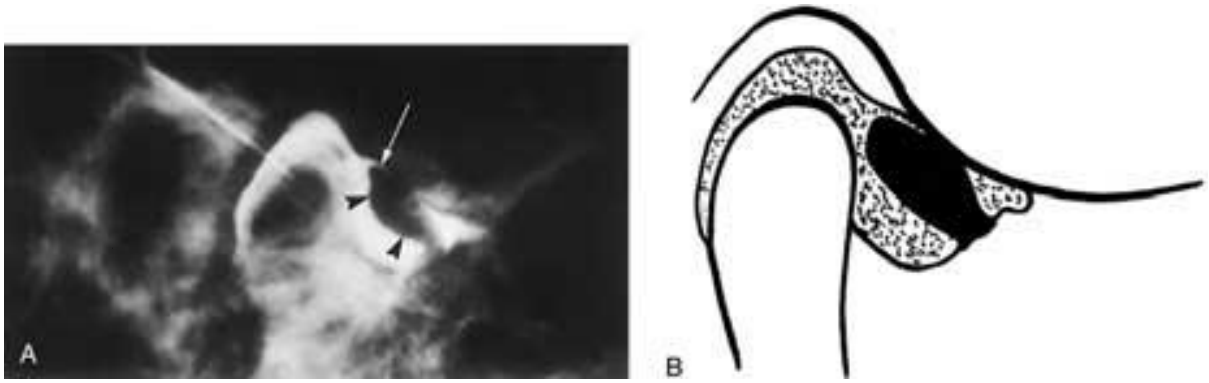


Fig- 14 A, Contrast material was injected into the lower joint space, and there is an overflow (arrow) to the upper joint space indicating perforation.

The disk (arrowheads) is anteriorly displaced and deformed. B, Schematic drawing of A

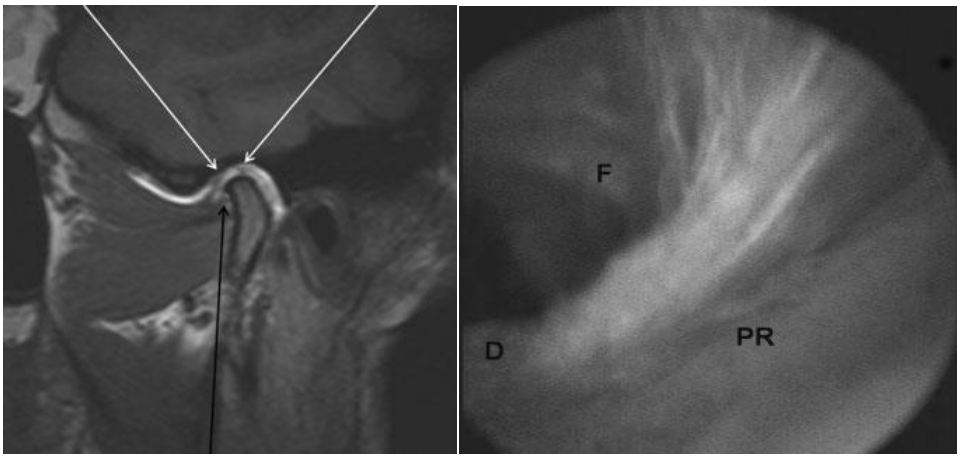


Fig-15 Anterior disc displacement without Reduction: left TMJ

(a) Sagittal T1 weighted magnetic resonance arthrography, with closed mouth. Adhesions (white arrows). Between adhesions a possible leak of the contrast medium into the lower compartment suggests disc perforation (black arrow).

(b) Arthroscopy reveals adhesions, but a perforation is not observed between them.

Lundh et al reported that 9% of reducing disc derangements progressed to non-reducing ones within 3 years. However, reducing disc displacements can also remain constant for many years, suggesting that the clicking joint does not necessarily progress to locking derangement.[9]

Clinical Assessment and Diagnostic Protocols

In the clinical setting a careful evaluation of the history of the patient (dental, medical, and psycho-social data) and a detailed examination of signs and symptoms should be incorporated

in the staging of the disease (Stages I to IV). Clinical assessment should be always performed before imaging.

Disc derangements may have clinical manifestations similar to those of other disorders of the facial region. Pain and jaw dysfunction can be related to toothache, pericoronitis maxillary sinusitis, earache, salivary gland pathosis, temporal arteritis, neuralgias, and tension-type headache. All these conditions should be excluded when assessing patients with clinical suspicion of disc derangements. In addition, two other temporomandibular disorders (TMDs) must be considered in the differential diagnosis of symptomatic disc derangements: myofascial pain and dysfunction (MPD), and painful inflammatory or degenerative conditions of the TMJ.[9]

However, the clinical assessment of the TMJ has definite limitations. Multiple studies have shown that the accuracy of the physical examination in predicting the status of the joint is about 70%.[2] Hence in a patient who presents with symptoms, imaging must be done to define the anatomy of the joint and to determine the relationship of the disk to the condyle. The choice of imaging studies must depend on the clinical evaluation.If the patient's history and clinical findings suggest an intracapsular joint problem, the assessment of the TMJ should be performed using MRI.[9]

Diagnostic Imaging of Internal Derrangement

ARTHROGRAPHY

Displacement of the disk with reduction and without reduction are the most frequent pathologic findings in TMJ arthrography.An arthrographic sign of disk displacement in single-contrast lower compartment arthrography is enlargement of the anterior recess of the lower joint space.

In disk displacement with reduction the disk is usually biconcave, although there may be some minor enlargement of the posterior band. In disk displacement without reduction a more extensive deformity of the disk is frequently encountered. Perforation of the posterior disk attachment is another sign of late-stage internal derangement. Perforation is indicated by passage of contrast medium from the lower to the upper joint space when only the inferior space is injected.[2]

This technique is difficult to perform and often painful to the patient. With the advent of noninvasive imaging techniques such as CT and MR imaging, the arthrographic technique has been generally abandoned.

COMPUTED TOMOGRAPHY

CT scanning gives excellent definition of the bony contours of the mandibular head and the glenoid fossa .When the disk is anteriorly displaced, it appears as a high-attenuation small mass anterior to the condyle, inferior to the tubercle, and within the low-attenuation lateral pterygoid fat pad. The depiction of the disk on CT depends on the disk's density and size. Thus, if the disk is thin and small, it usually is not identified on CT, leading to a higher incidence of false-negative diagnoses.[4]CT has also been abandoned due to relatively poor anatomic resolution and the high radiation dose to the lens of the eye.

MRI

Magnetic resonance imaging has rapidly proved to be a valuable tool for analysing soft tissue structures. Major advantages of MR imaging over other radiographic imaging techniques like CT and arthrography is the absence of radiation and the ability to visualize the soft-tissue structures around the joint respectively.

Displacements of the disk in the anterior, anteromedial, or anterolateral direction are the most common findings observed in MR images of patients with clinical signs and symptoms of internal derangement. In the sagittal plane the disk is noted to be displaced when its posterior band is anterior to the condyle. An empty fossa sign seen in the sagittal images is an indication of a medial or lateral disk displacement.[2]

MR images obtained at maximum mouth opening determine whether the disk displacement reduces. In displacement with reduction the disk position normalizes during jaw opening. In disk displacement without reduction the disk remains anterior to the condyle in all mandibular positions. This can be best visualized with the help of a more advanced version of MRI called as Dynamic MRI.[10]

Dynamic MRI : 3D dynamic magnetic resonance imaging (MRI) is well suited to evaluate the TMJ in all stages of internal derangement. The disk and the normal mechanics of the TMJ could be visualized during the entire course of jaw opening and closing as well as the dynamics of internal derangement. Dynamic imaging in open and closed mouth in both sagittal and coronal oblique planes aids in determining the exact size, shape, position, and displacement of disk and as well as status of retrodiskal tissue, joints, and surrounding muscles and thus helps in detection of early TMJ internal derangement.

It is important for the radiologist to detect early MR imaging signs of dysfunction, thereby avoiding the evolution of this condition to more advanced and irreversible osteoarthritic stage.[11]

Therapeutic Outlines

A wide consensus has been reached through the years on considering conservative and reversible approaches as first-line therapy of symptomatic disc derangement. Included in this group are various medications, such as nonsteroidal anti-inflammatory drugs and muscle relaxant, oral appliances, home care procedures, and cognitive-behavioral information program.

When these approaches fail to produce clinical improvements on painful dysfunctional conditions of the TMJ, surgical procedures may be indicated.[9]

DISPLACEMENT OF DISK CONDYLE COMPLEX

SUBLUXATION (Hypermobility / Partial dislocation)

Self reducible displacement of condyles out of mandibular fossa and past the articular eminence

Etiology:

- Due to joint laxity (genetic) eg: Ehlers -Danlos syndrome
- Prolonged mouth opening (dental procedures)
- Excessive yawning
- During endotracheal intubation

Clinical Features:

- Sudden forward movement with sound
- Usually painless unless chronic
- Pt exhibits a tapered or long face
- Click associated only with wide opening and absence of closing click
- Self- reducible condition [12]

DISLOCATION (open lock)

Displacement of condyle past the articular eminence which is not self reducible.

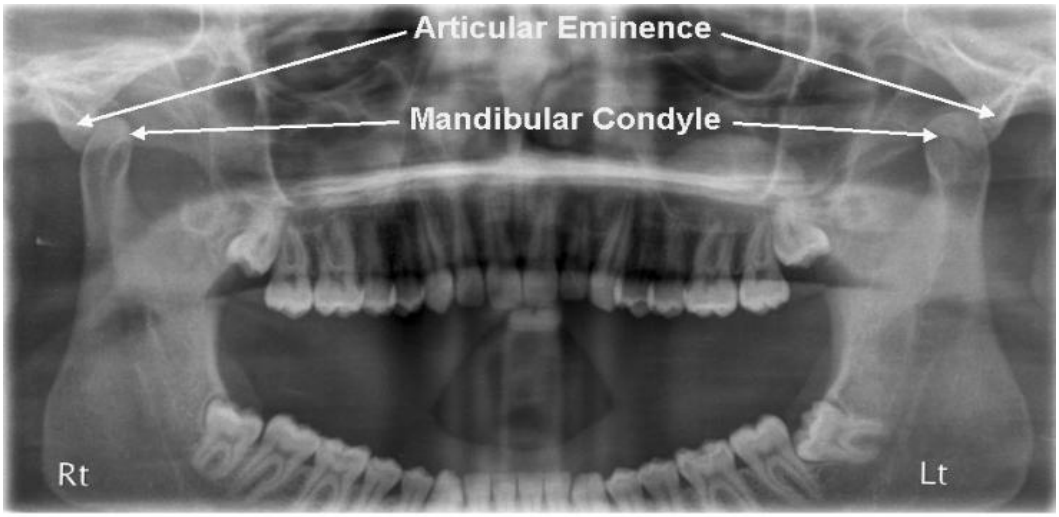
Acute or chronic form

Predisposing factors:

- Muscle incoordination , shallow articular eminence, laxity of capsular ligament, trauma
- Defect in collagen synthesis- EH Syndrome, Marfan syndrome
- Internal derangements, edentulous patients

Clinical features**:**

- Most common: Anterior & bilateral dislocation
- In Unilateral dislocation chin deviated to contralateral side
- On Palpation - empty joint - condyle anterior to the joint
- Inability to close mouth – spasm of muscles



X-Ray showing a Bilateral Dislocation of the Mandible.
Notice how open the patient's mouth is.

Fig-16

ANKYLOSIS[13]

Definition

Ankylosis is a condition in which condylar movement is limited by a mechanical problem in the joint ("true" ankylosis) or by a mechanical cause not related to joint components ("false" ankylosis).

Classification:

I. True Ankylosis

i)Bony ii) Fibrous iii) Fibro-osseous

II. Peudoankylosis may occur due to

- Muscle Spasm
- Myositis Ossificans
- Coronoid process Hyperplasia

III. Unilateral/Bilateral

IV. Partial/complete

V. Intraarticular/Extraarticular

Etiology[14]

A. Trauma in 90% of cases

- Fall
- Intra-uterine trauma
- Trauma at birth
- Road Traffic Accident

Laskin (1978) - Factors implicated in ankylosis following trauma[13]:

1. Age of the patient
2. Type of fracture
3. Damage to articular disc
4. Period of immobilization/ muscle splinting

B. Local Infections

Otitis media, mastoiditis, parotid abscess, infratemporal, submassetric, parapharyngeal infections, actinomycosis etc

C. Systemic Conditions

TB, meningitis, ankylosing spondylitis etc (hematogeneous spread)

D. Athritis / Inflammatory Conditions

Juvenile RA

E. Neoplasms

Sarcoma, osteoma, chondroma

GRADING OF TMJ ANKYLOSIS :

- Type I : Flattening of the condyle with little joint space

  Minimal bony fusion, extensive fibrous adhesions around the

  joint - with some movement

- Type II : Bony fusion on the outer edge of articular surface
- Type III : A bridge of bone exists between ramus and zygomatic arch

  Intact upper articular surface and articular disk

  Results from a fracture displaced condyle

  Type I, II – Crushing types of condylar injuries

- Type IV : Total TMJ obliteration between ramus and skull - Most common

Clinical Features: Depends on Type of ankylosis and age of onset and duration

Severe deformity if it occurs before 5 yrs of age

Clinical features of unilateral ankylosis

- Facial features:
- Asymmetry
- Deviation to affected side
- Roundness/fullness on affected side
- Flatness/elongation on normal side
- Well- defined ante-gonial notch on affected side

  Intra-oral features:

- Midline shift to affected side
- Class II Angle‘ malocclusion on affected side

- Unilateral crossbite on opposite side
- Restricted mouth opening

Clinical features of bilateral ankylosis :

- Symmetrical defect
- Retrognathic mandible
- Convex profile
- Bird face deformity
- Obstructive sleep apnoea

Intra-oral Features:

- Mouth opening < 5mm
- Class II malocclusion
- Incompetant lips and proclined lower anteriors
- Openbite
- Severe crowding , multiple impacted teeth, periodontal problems

Diagnostic Imaging for TMJ Ankylosis

1. Plain radiography and Panoramic radiograph
2. CT
3. 3-D CT

   Size and extent of defect clearly observable

   Entire scan procedure lasts about a minute

   Motion artifacts are minimum

4. CBCT : superior to CT for visualizing bone changes in the TMJ, analysing lateral slices in isolation and combining coronal and lateral slices

Radiographic Features [15]

- Partial /Complete loss of joint space
- Irregular articular surface
- Secondary degenarative changes common
- Compensatory elongation of coronoid process

- Deepening of aantegonial notch
- Eraly stages – inhibited mandibular growth

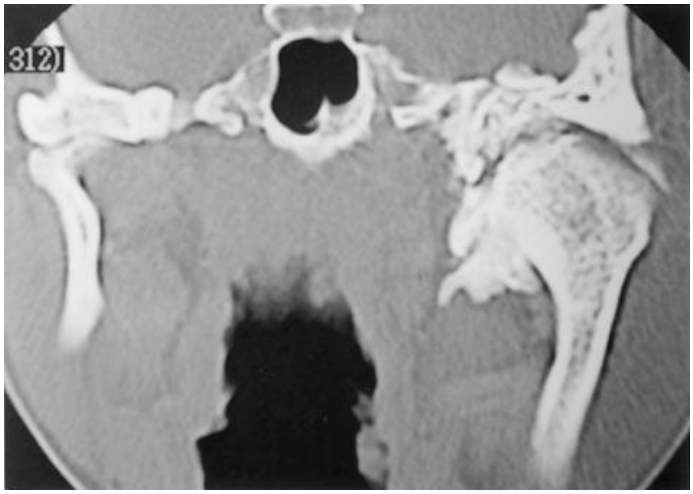


Fig-17 Coronal CT showing bony exostoses in the glenoid fossa superiorly as well as medial on the condylar head, resulting in bony ankylosis

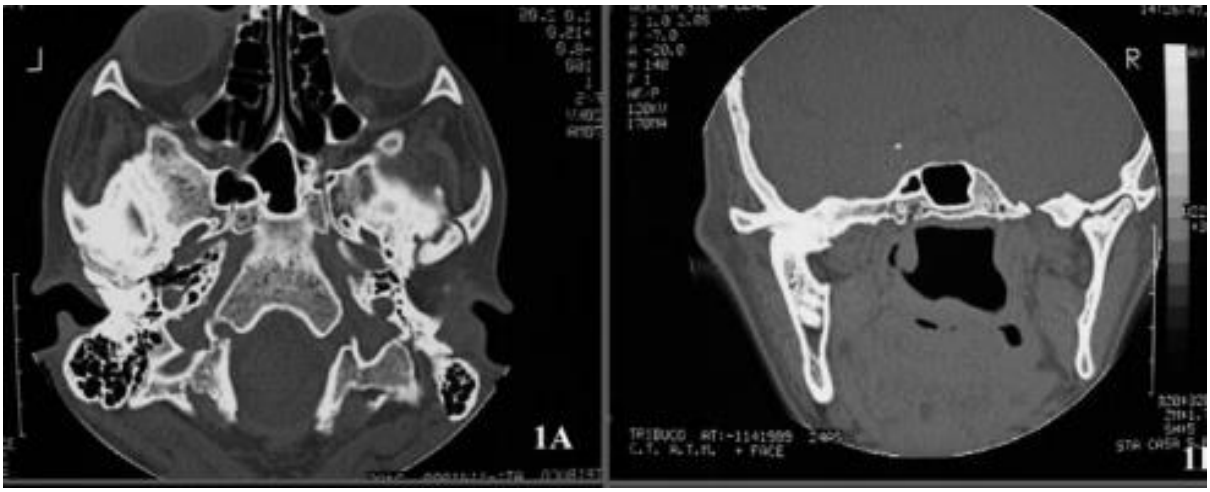


Fig-18 1A shows an axial slice of CT, revealing a fusion of the left mandibular condyle to the base of the skull. On the right TMJ, there is a condyle rearrangement- visualized in the coronal slice (Fig1B). The coronal slice also shows an effect on the mandibular fossa, remodeling in a flat shape to accommodate the abnormal condyle

INFLAMMATORY JOINT DISORDERS

SYNOVITIS/ CAPSULTIS

Etiology:

- Excessive mouth opening
- Trauma
- Chronic condylar displacement in posterior direction
- Direct spread of inflammatory products from surrounding structures

C/F:

- Continous pain that exacerbates during function
- Limitation in jaw movement
- Malocclusion in posterior teeth due to inferior displacement of condyle resulting from edema

RETRODISCTIS

Defined as Inflammation of retrodiscal tissues

Causes:

- Traumatic injury- condylar head impinging on retrodiscal tissues
- Chronic disc displacement
- Dislocation

REMODELING

Definition: An adaptive response of cartilage and osseous tissue to forces applied to the joint that may be excessive, resulting in alteration of the shape of the condyle and articular eminence.

It is characterised by

- Flattening of curved joint surfaces
- Cortical thickening of articulating surfaces
- Sclerosis of subchondral cancellous bone

DEGENERATIVE JOINT DISEASES

OSTEOARTHRITIS

Degenerative joint disease (DJD) is a non-inflammatory disorder of joints characterized by joint deterioration and proliferation. Joint deterioration is characterized by loss of articular

cartilage and bone erosion. The proliferative component is characterized by new bone formation at the articular surface and in the subchondral region.Usually a variable combination of deterioration and proliferation occurs, but occasionally one aspect predominates; deterioration is more common in acute disease, and proliferation predominates in chronic disease. DJD is thought to occur when the ability of the joint to adapt to excessive forces (remodel) is exceeded.

Common etiological factors are Trauma, Hypermobility, Excessive load, Internal derangement

Clinical Features:

- Age – incidence increases with age.
- Female preponderence
- Restricted movement
- Crepitus
- Masticatory muscle spasm
- Recurring cycles of signs and symptoms

Radiographic Features

Erosion

Loss of joint space

Subchondral bone cyst (ELY CYST): In some cases small, round, radiolucent areas with irregular margins surrounded by a varying area of increased density are visible deep to the articulating surfaces. These lesions are called Ely cysts. They are not true cysts; but are areas of degeneration that contain fibrous tissue, granulation tissue, and osteoid.

Osteophytes (Joint Mice): Later in the course of the disease, bony proliferation occurs at the periphery of the articulating surface, increasing the articulating surface area. This new bone is called an osteophyte wh ich typically appears on the anterosuperior surface of the condyle, lateral aspect of the temporal component, or both . Osteophytes also may form on the lateral, medial, and posterosuperior aspect of the condyle. In severe cases, osteophyte formation originating in the glenoid fossa extends from the articular eminence to almost encase the condylar head. Osteophytes may break off and lie free within the joint space (these fragments are known as **Joint Mice**), and these must be differentiated from other conditions that cause joint space radiopacities.

In severe DJD, the glenoid fossa may appear grossly enlarged because of erosion of the posterior slope of the articular eminence, and the condyle may be markedly diminished in size and altered in shape because of destruction and erosion of the condylar head. This in turn

may allow the condylar head to move forward and superiorly into an abnormal anterior position that may result in an anterior open bite.

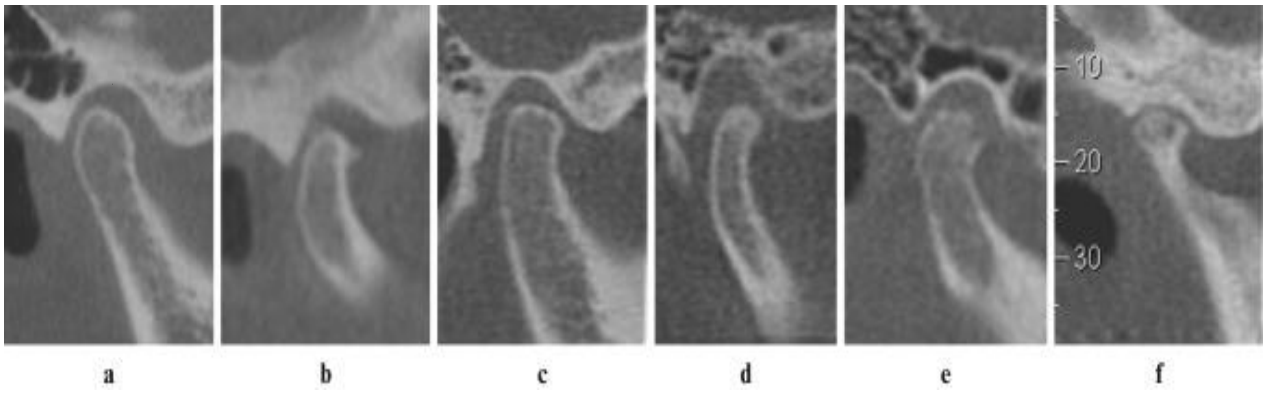


Fig-19 Lateral slices of the temporomandibular joint (TMJ) in maximum intercuspation. The classification of the condyle morphology was (a) no bone change; (b) osteophyte; (c) flattening; (d) sclerosis; (e) erosion and (f) pseudocyst

Fig-20 Ely's Cyst

RHEUMATOID ARTHRITIS

Definition

Rheumatoid arthritis (RA) is a heterogeneous group of systemic disorders that manifests mainly as synovial membrane inflammation in several joints.

The TMJ becomes involved in approximately half of affected patients. The characteristic radiographic findings are a result of villous synovitis, which leads to formation of synovial

granulomatous tissue (pannus) that grows into fibrocartilage and bone, releasing enzymes that destroy articular surfaces and underlying bone

Clinical Features

- Gradual onset
- Bilateral, symmetric fashion
- Small joints of the hands, wrists, knees, and feet affected
- Pain in early stages - exacerbates after function and relieves by rest
- Joint stiffness
- Limited range of movement
- Anterior open bite ±
- Crepitus
- Myositis

The 2010 American College of Rheumatology/European League Against Rheumatism classification

Target population (Who should be tested?): Patients who

1) have at least 1 joint with definite clinical synovitis (swelling)

2) with the synovitis not better explained by another disease

Classification criteria for RA (score-based algorithm)

Score of 6/10 is needed for classification of a patient as having definite RA

A. Joint involvement	Score
1 large joint	0
2 -10 large joints	1
1- 3 small joints (with or without involvement of large joints)#	2
4- 10 small joints (with or without involvement of large joints)	3
10 joints (at least 1 small joint)	5

B. Serology (at least 1 test result is needed for classification)

Negative RF and negative ACPA	0
Low-positive RF or low-positive ACPA	2
(anticitrullinated protein antibody)	

- High-positive RF or high-positive ACPA 3

C. Acute-phase reactants (at least 1 test result is needed for classification)

- Normal CRP and normal ESR 0
- Abnormal CRP or abnormal ESR 1

D. Duration of symptoms score

- <6 weeks 0
- >6 weeks 1

Radiographic Features

The initial changes may be generalized osteopenia (decreased density) of the condyle and temporal component.The pannus may destroy the disk, resulting in diminished width of the joint space. Bone erosions bythe pannus most often involve the articular eminence and the anterior aspect of the condylar head, which permits anterosuperior positioning of the condyle when the teeth are in maximal intercuspation and results in an anterior open bite.

Erosion of the anterior and posterior condylar surfaces at the attachment of the synovial lining may result in a **"sharpened pencil"** appearance of the condyle.

Erosive changes may be so severe that the entire condylar head is destroyed, with only the neck remaining as the articulating surface. Similarly, the articular eminence may be destroyed to the extent that a concavity replaces the normally convex eminence. Joint destruction eventually leads to secondary DJD. Subchondral sclerosis and flattening of articulating surfaces may occur, as well as **subchondral "cyst"** and **osteophyte** formation. Fibrous ankylosis or, in rare cases, osseous ankylosis,may occur; reduced mobility is related to the duration and severity of the disease.

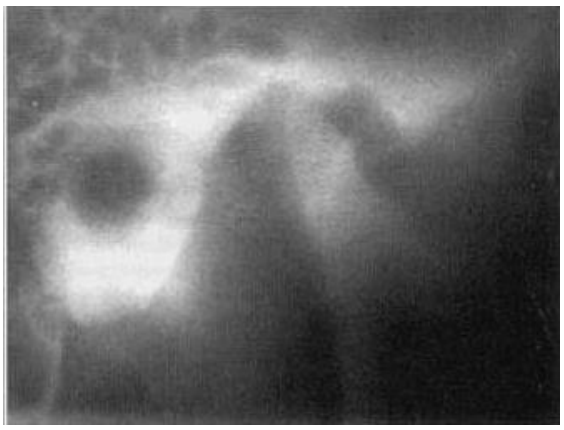


Fig-21 A, Lateral cephalometric view illustrating a steep mandibular plane and anterior open bite. B, Lateral tomogram illustrating a large erosion of the anterosuperior condylar head accompanied by severe erosions of the temporal component, including the articular eminence

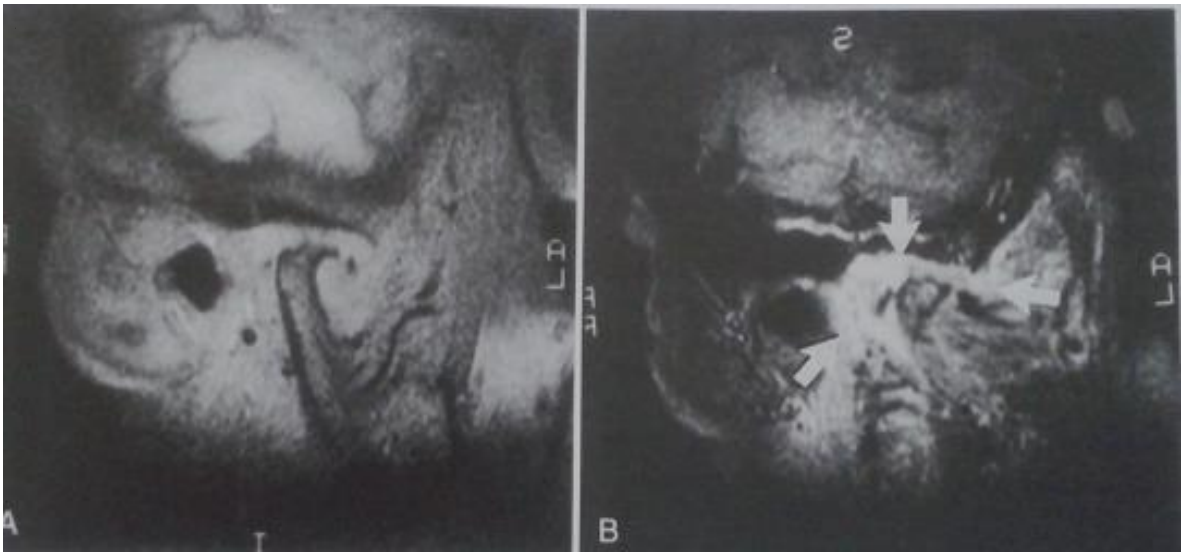


Fig-22 Contrast enhanced MRI showing significant enhancement in the joint and periarticular area - synovial proliferation

JUVENILE CHRONIC ARTHRITIS

Synonyms **: Juvenile rheumatoid arthritis and Still's disease**

Definition: Chronic, intermittent synovial inflammation that results in synovial hypertrophy, joint effusion, and swollen, painful joints. Formerly called juvenile rheumatoid arthritis, is a chronic inflammatory disease that appears before the age of 16 years (the mean age is 5 years)

As the disease progresses, cartilage and bone are destroyed. Rheumatoid factor may be absent, hence the preferred use of the term JCA rather than juvenile rheumatoid arthritis. JCA differs from adult RA in that it has an earlier onset, and systemic involvement usually is more severe. TMJ involvement occurs in approximately 40% of patients and may be unilateral or bilateral.

C/F:

Affects children and adolescents during growth period. The patient usually has pain and tenderness in the affected joint or joints, although the disease can be asymptomatic. Unilateral onset is common, but contralateral involvement may occur as the disease progresses.Severe TMJ involvement results in inhibition of mandibular growth and affected patients may have micrognathia and posteroinferior chin rotation, resulting in a facial appearance known as bird face, which may also be accompanied by an anterior open bite. The degree of micrognathia is proportional to the severity of joint involvement and the early onset of disease. Additionally, when only one TMJ is involved or if one side is more severely affected, the patient may have a mandibular asymmetry with the chin deviated to the affected side.

Radiographic Features:

- Osteopenia (decreased density) of the affected TMJ components may be the only initial radiographic finding. Radiographic findings are similar to those for the adult form except for the addition of impaired mandibular growth.
- Erosions may extend to the mandibular fossa, and the articular eminence may be destroyed. Similarly, erosion of the anterior or superior aspect of the condyle may occur, and in more severe cases only a pencil-shaped small condyle remains; the condyle may be destroyed. Because the inflammation is intermittent, during quiescent periods the cortex of the joint surfaces may reappear, and the surfaces will appear flattened.
- As a result of bone destruction, the condylar head typically is positioned anterosuperiorly in the mandibular fossa. Hypomobility at maximal opening is common, and fibrous ankylosis may occur in some cases.
- Secondary degenerative changes manifesting as sclerosis and osteophyte formation may be superimposed on the rheumatoid changes, and ankylosis may occur.
- Manifestations of inhibited mandibular growth, also may occur unilaterally or bilaterally such as :
- deepening of the antego nial notch,
- diminished height of the ramus
- dorsal bending of the ramus and condylar neck, resulting in an obtuse
- angle between the mandibular body and ascending ramus.

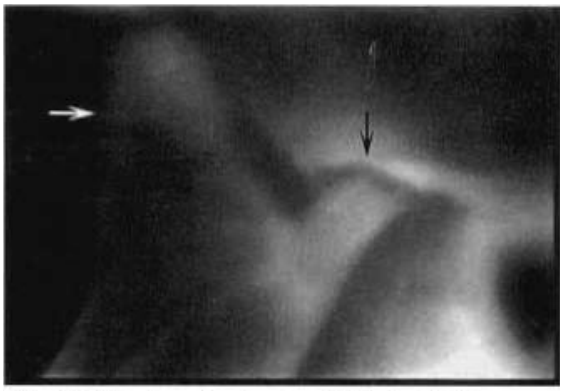


Fig-23 Juvenile chronic arthritis. Sagittal tomogram (closed position) showing irregular erosions of the superior aspect of the condyle and erosion of all of the articular eminence and an anterior positioning of the condyle over the former position of the articular eminence (black arrow). Note the secondary enlargement of the coronoid process (white arrow) as a result of fibrous ankylosis of the joint.

SEPTIC ARTHRITIS (Infectious arthritis)

Infection and inflammation of a joint that can result in joint destruction.

Rare in comparison

Caused by

1. Direct spread of organisms from an adjacent cellulitis, parotid, otic, or mastoid / middle ear infection
2. Direct extension of osteomyelitis of mandibular body and ramus
3. Hematogenous spread from a distant nidus

Clinical Features:

- Occurs at any age
- Unilateral
- Redness and swelling over the joint
- Trismus
- Severe pain on opening
- Inability to occlude the teeth
- Large, tender cervical lymph nodes; fever; and malaise
- Deviation to unaffected side as a result of joint effusion

Radiographic Features

- Only 7 to 10 days after the onset of clinical symptoms
- Inflammatory exudates may cause widening of joint space
- Osteopenic changes including mandibular ramus
- Osteolytic effects of inflammation- radiolucent cortex, discontinuity or irregularity of anterior cortical surface
- Destruction of condyle, articular eminence, disk (advanced stages)
- Osseous ankylosis - after infection subsides
- If it occurs during the period of mandibular growth radiographic manifestations of inhibited mandibular growth will be evident

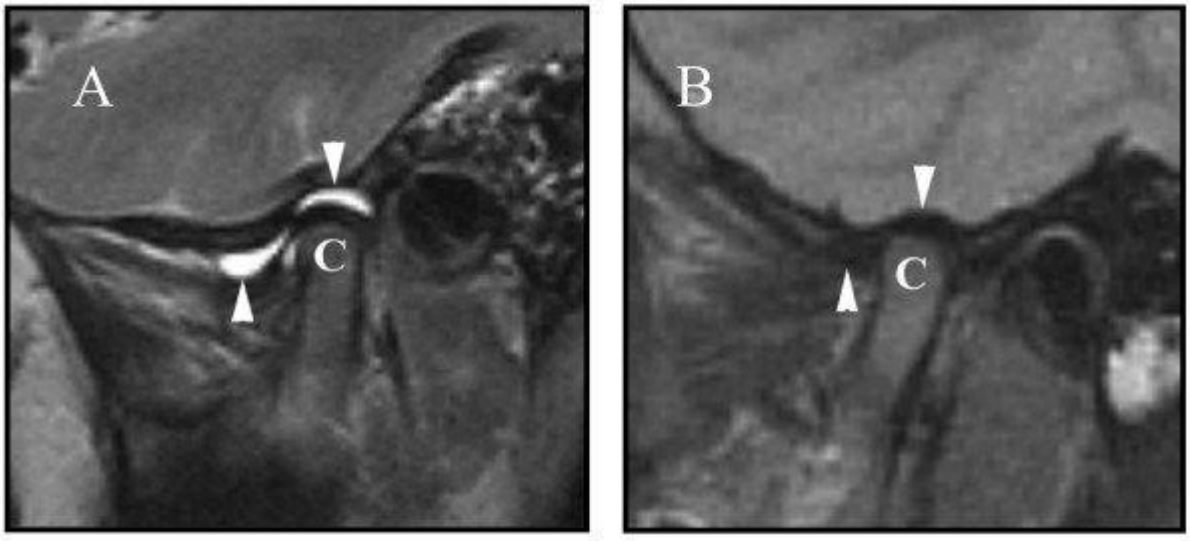


Fig-24 Image A is a T2-weighted proton density parasagittal MR image through the right TMJ showing effusions (arrows) just anterior to the condyle (C) in the superior and inferior synovial spaces. Follow up T2 MR image 4 weeks later (image B) is normal[18]

SYNOVIAL CHONDROMATOSIS

(Synovial chondrometaplasia and osteochondromatosis)

Definition

Synovial chondromatosis is an uncommon disorder characterized by metaplastic formation of multiple cartilaginous and osteocartilaginous nodules within connective tissue of the synovial membrane of joints. Some of these nodules may detach and form loose bodies in the joint space, where they persist and may increase in size, being nourished by synovial fluid. This

condition is more common in the axial skeleton than in the TMJ. When the cartilaginous nodules ossify, the term synovial osteochondromatomsiasy be used.

Clinical Features

Asymptomatic or associated with

- preauricular swelling, pain
- decreased range of motion
- Some patients have crepitus or other joint noises.
- usually occurs unilaterally.

Radiographic Features

- Widened joint space
- A radiopaque mass or several radiopaque loose bodies surrounding the condylar head
- CT imaging helps in identifying the location of the calcifications and erosion into the middle cranial fossa

Fig-25 Panoramic radiograph shows calcified nodular lesions (arrows) in the right temporomandibular joint space[19]

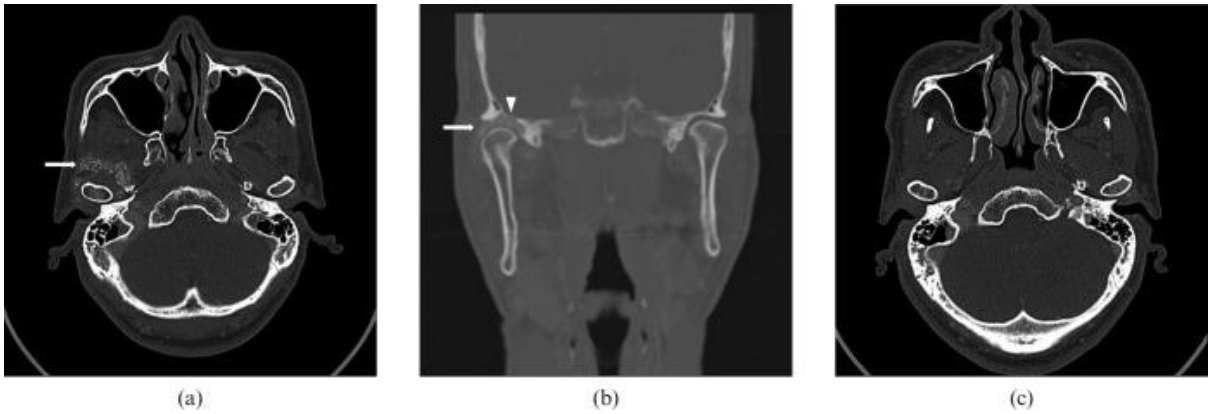
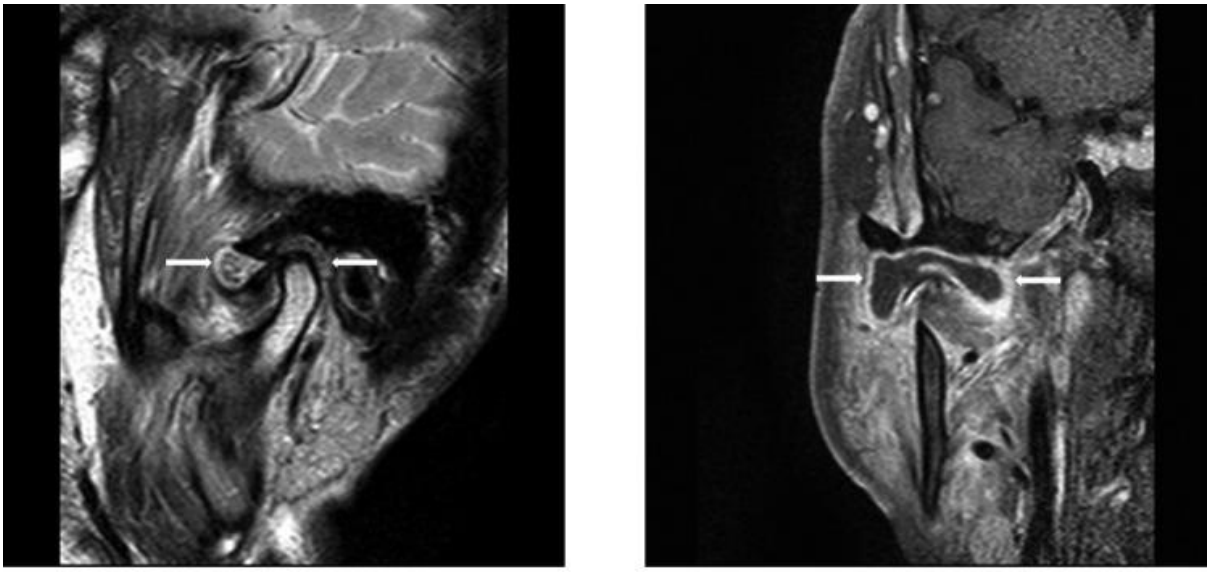


Fig-26 (a)Axial CT image shows multifocal calcified loose bodies (arrow) within a low-attenuated soft tissue image also shows loose bodies (arrow). It shows bony erosion of glenoid fossa (arrowhead)

(c) Follow-up CT obtained after 10 months confirms complete removal of intra-articular mass and calcifications and the absence of recurrence

Fig-27 An axial CT image using bone algorithm of synovial osteochondromatosis, note the ossification surrounding the condylar head (arrows).



(a) (b)

Fig-28 (a) T_1 weighted (W) sagittal Image -multiple loose bodies, soft tissue mass shows high SI because of fluid collection in it which represents expanded articular cavity.

(b) Post-contrast T_1W coronal MR image shows a soft tissue mass (arrows) expanding into the right temporomandibular joint space. This mass shows peripheral wall enhancement representing thickened synovium.

CHONDROCALCINOSIS

(Pseudogout/ Calcium Pyrophosphate Dihydrate Deposition disease)

Definition: Acute or chronic synovitis and precipitation of calcium pyrophosphate dihydrate crystals in the joint space

Clinical features :

- Commonly affected- knee, wrist, hip, shoulder, and elbow
- Unilateral
- Common in males
- Asymptomatic / pain and joint swelling

Radiographic features:

- Fine radiopacities and more even distribution within the joint space than in osteochondromatosis
- Bone erosions
- Severe increase in condylar bone density
- Erosions of the glenoid fossa

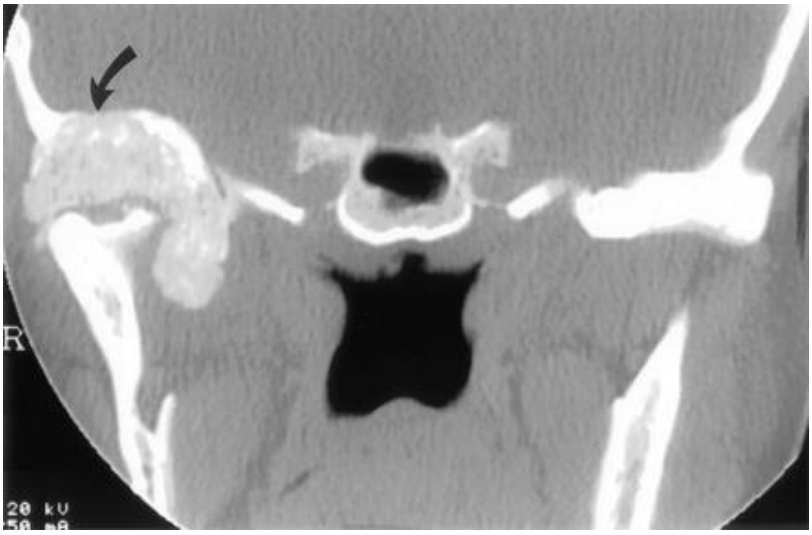
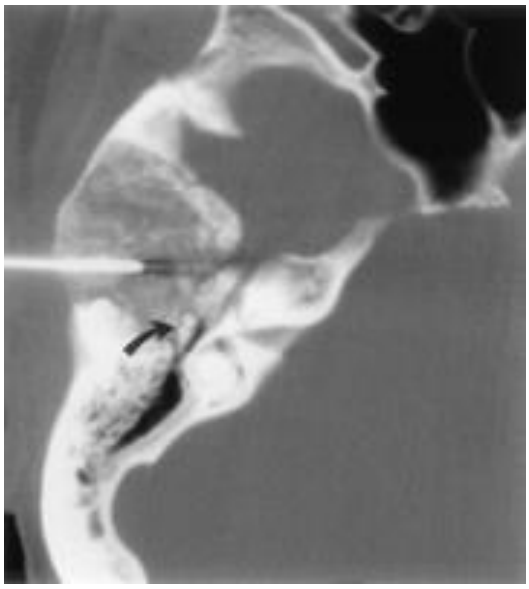


Fig-29 Coronal CT demonstrates a large calcified mass centered within the glenoid fossa bulging into the right middle cranial fossa (*arrows*).Note mass effect and remodeling of the right mandibular condyle



Needle biopsy under CT guidance

Fig-30 Axial section shows the central position of the needle within the lesion, which encroaches on the middle ear cavity and abuts the ossicles (*arrow*).

TRAUMA

EFFUSION: An influx of fluid into the joint, usually as a result of trauma (hemorrhage) or inflammation (exudate)

Clinical Features

- Swelling and pain in the TMJ, preauricular region, or ear

- Limited range of motion
- Sensation of fluid in the ear, tinnitus, and hearing difficulties

  Difficulty occluding the posterior teeth

Radiographic Features

- Commonly seen in conjunction with internal derangements
- Wide joint space
- T2-weighted MRI - a bright signal indicating fluid adjacent to the disk or posterior to the condyle

Differential Diagnosis

- Septic arthritis (accompanying signs and symptoms of infection will be present)

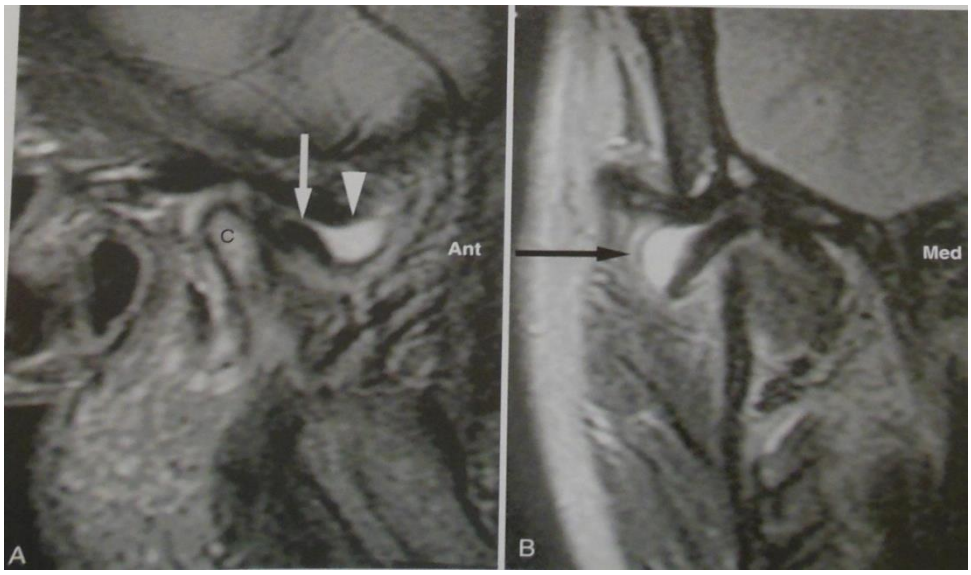


Fig-31 A. Disc anterior to condyle with a large effusion in upper joint space.There is perforation over the condyle.

B. Coronal image – a large effusion in the lateral upper joint space

FRACTURE

Fractures of the TMJ usually occur at the condylar neck and often are accompanied by dislocation of the condylar head. Fractures may be divided into those involving the condylar head and those involving the condylar neck, although occasionally both may be involved. On rare occasions the fracture.-may involve the temporal component.

Common site: condylar neck accompanied by dislocation of the condylar head.

Three sources of condylar injuries : LYNDHAL (1977)

1) Kinetic energy imparted to a static individual –
   Contralateral condylar neck fracture
2) Kinetic energy imparted to a moving individual-
   Bilateral condylar neck fracture
3) Moving individual strikes against another moving object
   Bilateral parasymphyseal and condylar neck fracture

Classification of Condylar fractures

MacLennan's classification :

1. No displacement
2. Fracture deviation
3. Fracture displacement
4. Fracture dislocation

Signs and symptoms :

- Swelling
- Bleeding from the ear
- Tenderness
- Ecchymosis
- Parasthesia of the lower lip
- Limited lateral excusion to opposite side
- Anterior open bite
- Associated with symphysis #
- Relationship of fracture line to lateral pterygoid muscle insertion

Fig-32 Condylar neck fracture {panoramic view}: The arrow points to overlapped fragments, as evidenced by increased radiopacity.

Fig-33 Open Town's view or a compression fracture of the right condylar head (arrow)

BENIGN TUMORS

The most common benign intrinsic tumors affecting the TMJ are

- Osteomas
- Osteochondromas
- Langerhans histiocytosis
- Osteoblastomas

Chondroblastomas, fibromyxomas, benign giant cell lesions aneurismal bone cysts also occur.

Benign tumors and cysts of the mandible (e.g., ameloblastomas, odontogenic keratocysts,

simple bone cysts) may involve the entire ramus and in rare cases the condyle.

Clinical features:

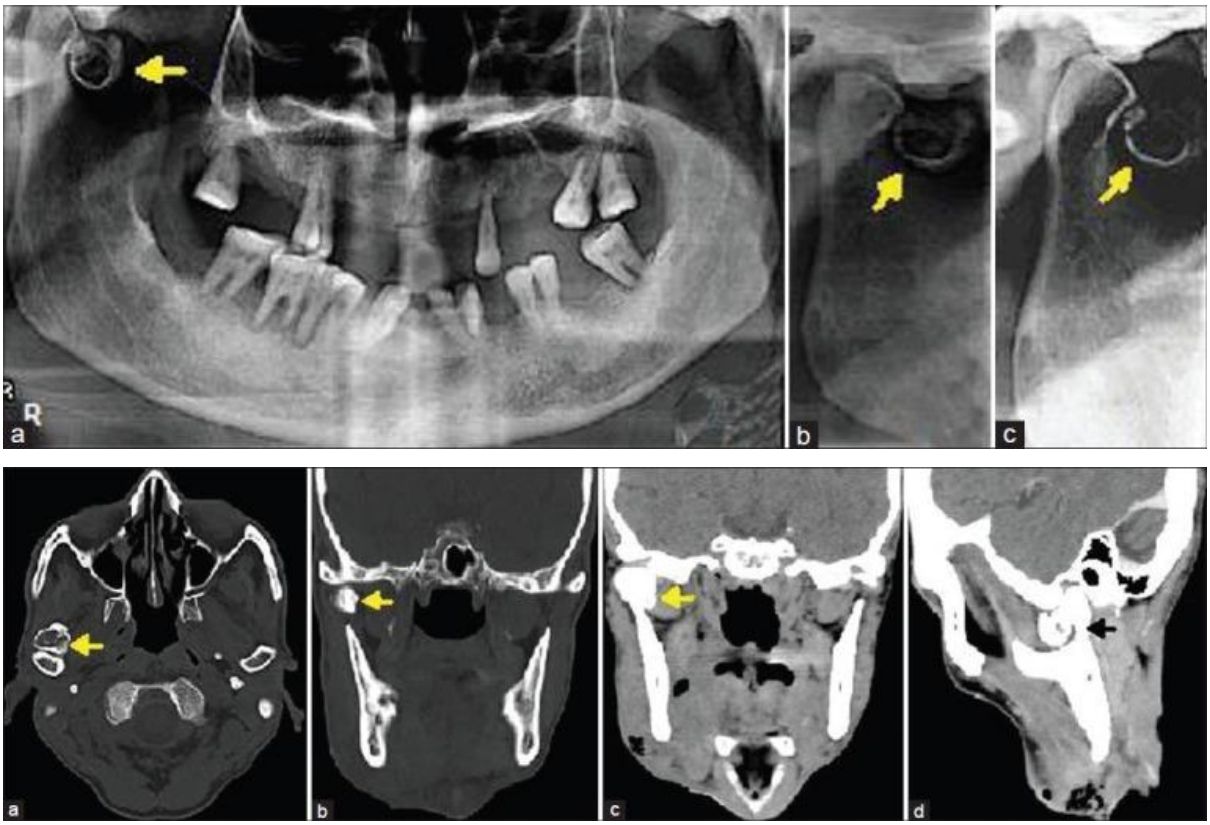
- Slow growth
- Swelling, pain decreased range of motion
- Facial asymmetry
- Malocclusion
- Deviation of mandible to opposite side
- Symptoms of TMJ dysfunction
- Tumours of coronoid process areusually painless and associated with progressive limitation of motion

Radiographic features:

- Irregular condylar surface
- Altered trabecular pattern- radiolucencies and radiopacities
- Abnormal pedunculated mass attached to the condyle

eg: Osteochondroma (anterior and superior surface)

Osteoma



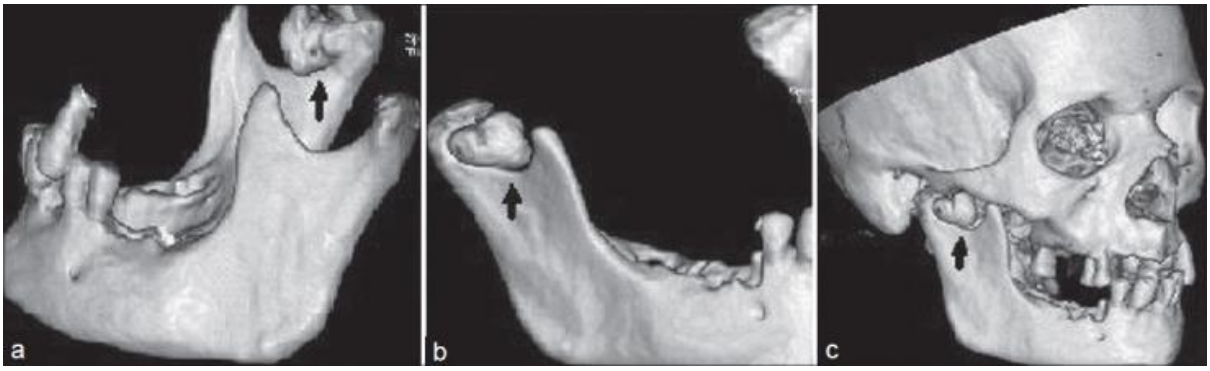


Fig-34 OPG and CTimages with 3-D reconstruction of Osteochondroma of right side condyle[20]

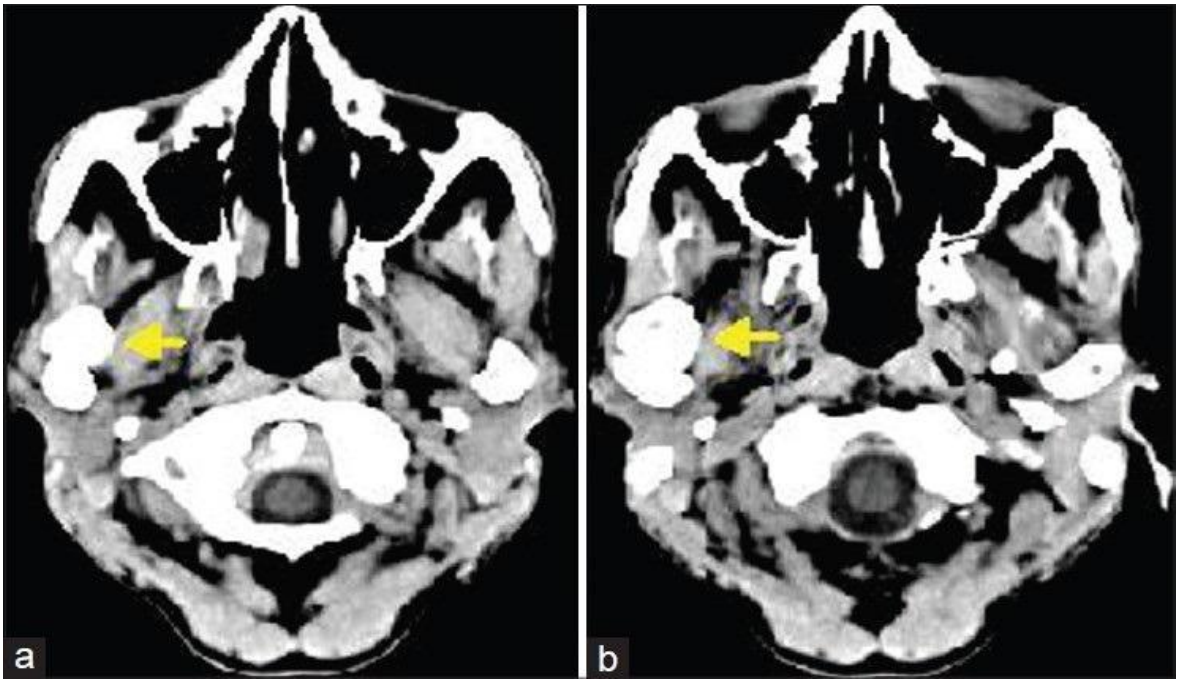


Fig-35 High uptake of contrast media by the bony mass

MALIGNANT TUMORS

- Primary or metastatic
- Primary intrinsic tumors – rare
  - chondrosarcoma, osteogenic sarcoma
  - synovial sarcoma
  - fibrosarcoma of the joint capsule
- Extrinsic tumors : direct extension of adjacent parotid salivary gland malignancies, rhabdomyosarcoma (in children), or other regional carcinomas- skin, ear, and nasopharynx.

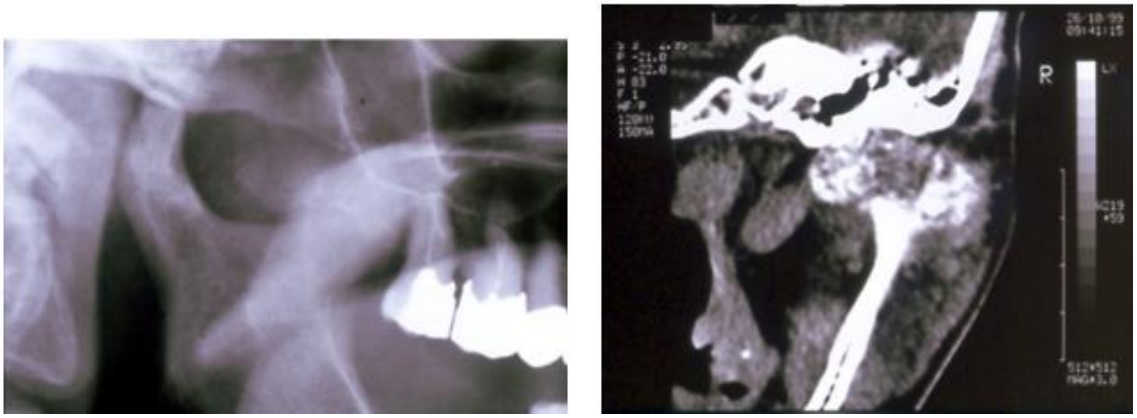
Clinical features:

- Asymptomatic or
- Symptoms of TMJ dysfunction
- eg: Pain
- Limited Mandibular Opening,
- Mandibular Deviation
- Swelling.

Radiographic features:

- Variable degree of bone destruction - with ill defined, irregular margins.
- Most lack tumor bone formation- except osteogenic sarcoma
- Chondrosarcoma - an indistinct, essentially radiolucent destructive lesion of the condyle with surrounding discrete soft tissue calcifications (simulate articular loose bodies seen in chondrocalcinosis or pseudogout)
- Widening of joint space

Fig:36 Chondrosarcoma: destructive lesion is present in the left condylar head, faint radiopacities (soft tissue calcifications) visible anterior to the condylar head (arrows).



(A) **(B)**

(C)

Fig-37 Chondrosarcoma of right TMJ- erosion and calcification[21]

A- OPG, B- CT, C- Scintigraphy

METASTATIC TUMOURS OF TMJ

Most common metastatic lesions arising in TMJ are neoplasms originating in

- Breast
- Kidney
- Lung
- Colon
- Prostate
- Thyroid gland

Radiographic appearance: Nonspecific condylar destruction

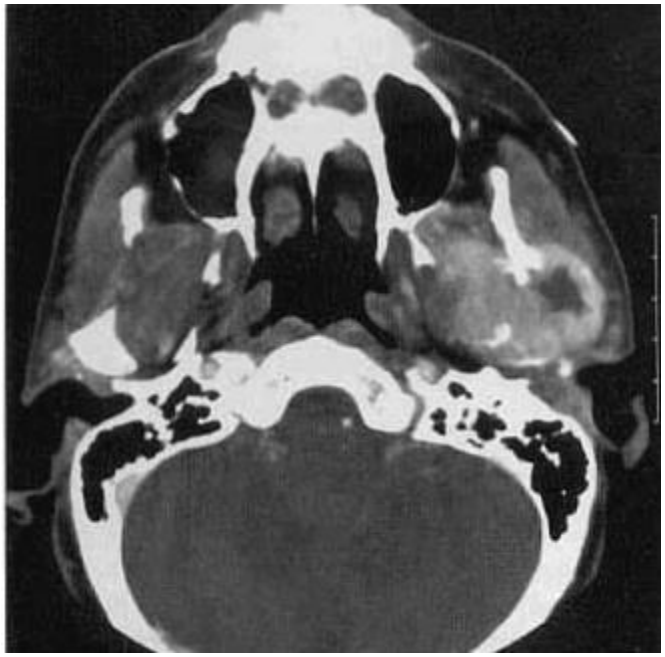


Fig-38 An axial CT image using soft tissue algorithm of a metastatic lesion from a carcinoma of the thyroid gland, which has destroyed all of the left mandibular condyle

MASTICATORY MUSCLE DISORDERS

I. Acute disorders

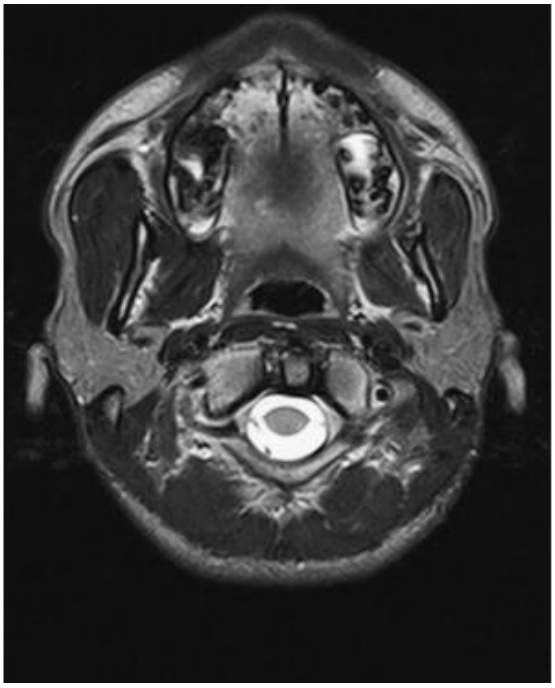
- Reflex muscle splinting
- Myositis
- Muscle spasm
- Myofascial pain

II. Chronic disorders

- Muscular hypertrophy
- Fibromyalgia

MASTICATORY MUSCLE HYPERTROPHY (MMH) is an uncommon condition that may occur with bony hyperostosis of the mandible. Untreated MMH may result into undesirable aesthetic appearance, pain and perpetuation of dysfunctional mastication for which patients seek surgical or pharmacotherapy. Known causes include bruxism, habitual

unilateral chewing, trauma, anabolic steroids and maladaptive behaviors to existing temporo-mandibular joint disorder. The hypertrophy seen in MMH largely involves type 1 fibers of the major jaw closers-the temporalis, medial pterygoid and masseter.



Conrast CT Axial T2 Weighted MRI

Fig-39 Massetric Muscle Hypertrophy

Coronal view of T1-weighted magnetic resonance image demonstrating hypertrophy of right muscles of mastication with pronounced asymmetry of the right masseter and temporalis muscles

CONCLUSION

Complicated anatomical configuration of the temporomandibular joint was the reason for developing standardized radiographic techniques which would provide accurate anatomical images.Tomography provides excellent bony details but no information of the soft tissue component of the joint. This technique is useful in demonstrating suspected hypoplasia, hypertrophy or malformation of the condyles, in the case of maxillofacial trauma with fracture description, infections and tumors.Artrography is performed to determine the status of the condyle-disk-glenoid fossa and eminence relationship with rxegard to the closed and open mouth position. Computerized tomography (CT) is superior to conventional radiograšhy and conventional tomography for evaluating internal derangements of temporomandibular joint, trauma, degenerative processes and tumors. CT demonstrated good evaluation of soft tissue and excellent evaluation of bony structures.Magnetic resonance (MR) has shown exquisite soft tissue contrast and provides a view of the structures of temporomandibular joint which cannot be differentiated by conventional radiography, conventional tomography and computerized tomography.MR of temporomandibular joint can distinguish internal anatomical features of the joint to a degree that no other imaging procedure can match. An

image of the articular disk without contrast media as well an image of the posterior band has made the magnetic resonance the golden standard of temporomandibular joint imaging.

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