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Diagnostic Imaging Modalities of Temporomandibular Joint

A Project Submitted to

The College of Dentistry, University of Baghdad, Department of Oral Diagnosis Clinic in Partial Fulfillment for the Bachelor of Dental Surgery

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وَمَا تَوْفِيقِيٓ إِلَّا بِٱللَّهِۚ
عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ

Dedication

To god almighty, who graced my life with opportunities, my source of inspiration and strength, the one who never give up on nobody.

To my parents, my mentors, for encouraging me and rising me believing that everything is possible.

To my brothers and sister, without whom none of this would be possible.

To my friends who I shared this journey and memories with.

Acknowledgment

I would like to express my gratitude to **Dr. Raghad alhashimi** Dean of College of Dentistry, University of Baghdad and **Dr. Bashar Hamid Abdullah** the Head of the Department of Oral Diagnosis and all the professors and seniors in the Department for their help especially my supervisor **Dr. Farah A. Hadi** for guiding me in this research and teaching me. Proud to be learning under your direction.

Certification of the Supervisor

I certify that this project entitled "Diagnostic Imaging Modalities in temporomandibular joint disorders" was prepared by the fifth-year students Shaimaa Shaker, and Shaimaa Daham under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name

Date

Certification of the Discussion Committee

We, the members of the discussion committee, certify that we have read and examined this graduation project and that in our opinion it of a graduation project. meets the standard.

Signature **Signature** **Signature**

Approved by the head of Oral diagnosis department at the college of dentistry, University of Baghdad.

Signature

List of abbreviation

Symbol	Abbreviation
CT	Computed Tomography
CBCT	Cone Beam Computed Tomography
MRI	Magnetic Resonance Imaging
ADDWR	Anterior disk displacement with reduction
ADDWoR	Anterior disk displacement without reduction
MDCT	Multi-Detector Computed Tomography
OA	Osteoarthritis
DJD	Degenerative Joint Disease
WHO	World Health Organization
TMD	Temporomandibular Disorder
PTML	Pterygomandibular ligament
STML	Stylomandibular ligament
SML	Sphenomandibular ligament

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Introduction

The temporomandibular joints (TMJ) are the two joints that connect the lower jaw to the skull. More specifically, they are the joints that slide and rotate in front of each ear, and consist of the mandible (the lower jaw) and the temporal bone (the side and base of the skull). The TMJs are among the most complex joints in the body. These joints, along with several muscles, allow the mandible to move up and down, side to side, and forward and back.

TMJ through its complex movements, on different orthogonal planes and multiple rotation axes, works in synergy with all the structures just listed (Bordoni et al,2019)

TMJ imaging may be necessary to supplement information obtained from the clinical examination, particularly when an osseous abnormality or infection is suspected, conservative treatment has failed, or symptoms are worsening. Diagnostic imaging also should be considered for patients with a history of trauma, significant dysfunction, alteration in range of motion, sensory or motor abnormalities, or significant changes in occlusion (Krishnamoorthy et al,2013)

The purposes of TMJ imaging are to evaluate the integrity and relationships of the hard and soft tissues, confirm the extent or stage of progression of known disease, and evaluate the effects of treatment (Larheim and Tore,1995)

Chapter 1

Review of Literature

Review of Literature

Chapter 1

1.1. TMJ anatomy

The temporomandibular joint (TMJ) is a diarthrosis, better defined as a ginglymoarthrodial joint. TMJ is composed of a synovial cavity, articular cartilage and a capsule that covers the same joint. We find the synovial fluid and several ligaments. The joint is the union of the temporal bone cavity with the mandibular condyle (Shaffer et al, 2014)

1.1.1. Condyle

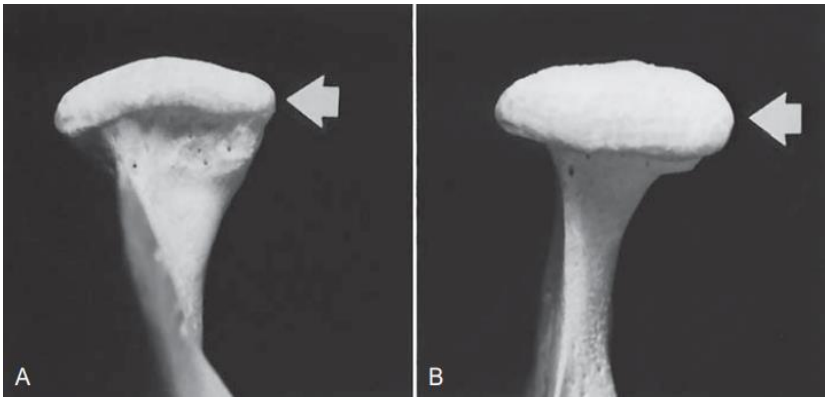
The condyle is a bony ellipsoid structure connected to the mandibular ramus by a narrow neck. The condyle is approximately 20 mm long mediolaterally and 8 to 10 mm thick anteroposteriorly.

The shape of the condyle varies considerably; the superior aspect may be flattened, rounded, or markedly convex, whereas the mediolateral contour usually is slightly convex as shown in **figure(1-1)**. These variations in shape may cause difficulty with radiographic interpretation (Alomar et al,2007)

The condyle presents an articular surface for articulation with the articular disk of the temporomandibular joint. The space between the mandibular condyle and the articular disc is considered inferior TMJ compartment (Bag et al,2014)

Although the mandibular and temporal components of the TMJ are calcified by 6 months of age, complete calcification of cortical borders

May not be completed until 20 years of age. As a result, radiographs of condyles in children may show little or no evidence of a cortical border. In the absence of disease, the cortical borders in adults are visible radiographically. A layer of fibrocartilage covers the condyle but is not visible radiographically (Ingervall et al,1976)



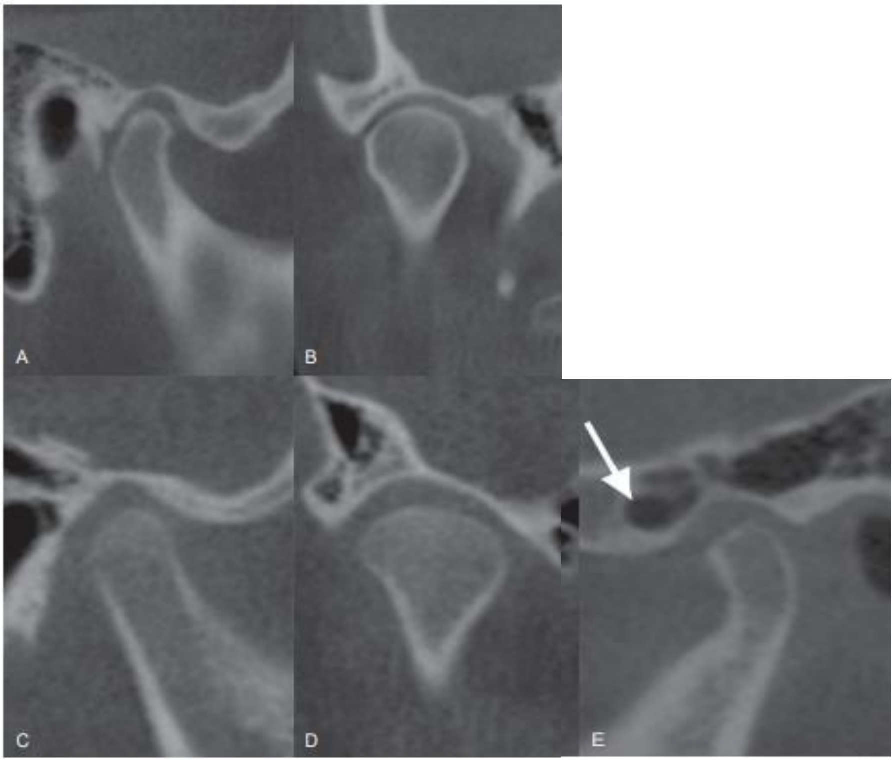
Figure(1-1): Mandibular Condyle. The medial pole (arrow) is on the right in each case. A, Anterior aspect. B, Superior aspect (Ingervall et al,1976)

1.1.2. Glenoid fossa

The glenoid (mandibular) fossa, located at the inferior aspect of the squamous part of the temporal bone, is composed of the glenoid fossa and articular eminence of the temporal bone. It is sometimes described as the temporal component of the TMJ .The anterior limit of the glenoid fossa of the temporal bone constitutes the articular eminence, which forms a medial bone prominence at the posterior border of the zygomatic bone. The glenoid fossa is wider in its mediolateral portion, compared to the anteroposterior area (Alomar et al,2007)

The fossa and articular eminence develop during the first 3 years and reach mature shape by the age of 4 years; young infants lack a definite fossa and articular eminence as shown in **figure (1-2)**(Wright et al, 1974)

All aspects of the temporal component may be pneumatized with small air cells derived from the mastoid air cell complex. Pneumatization of the articular eminence is seen radiographically in approximately 2% of patients. Like the condyle, the mandibular fossa is covered with a thin layer of fibrocartilage (Sülün et al,2001)



Figure(1-2): Sagittal reformat (A) and coronal reformat (B) cone-beam computed tomographic images of the right temporomandibular joint (TMJ) in an adult. Note the thick regular cortication of all articulating surfaces and development of the glenoid fossa and articular eminence. Sagittal reformat (C) and coronal reformat (D) cone-beam computed tomographic images of the right TMJ in a 7-year-old child. Note the thin cortication of the articulating surfaces, shallow glenoid fossa, and short articular eminence. E, Sagittal reformat cone beam computed tomographic image of the left TMJ (adult) showing pneumatization of the temporal component including the articular eminence (arrow) with mastoid air cells (Wright et al,1974)

1.1.3. Articular disc

The articular disc is a fibrous extension of the capsule that runs between the two articular surfaces of the temporomandibular joint.

The disc articulates with the mandibular fossa of the temporal bone above and the condyle of the mandible below. The disc divides the joint into two sections, each with its own synovial membrane. The disc is also attached to the condyle medially and laterally by the collateral ligaments (Alomar et al,2007)

A normal disk has a biconcave shape with a thick anterior band, thicker posterior band, and a thin middle part. The disk also is thicker medially than laterally. The medial and lateral margins of the disk blend with the capsule. The thin central portion normally serves as an articulating cushion between the condyle and articular eminence (Katzberg et al,1988)

The anterior band is thought to be attached to the superior head of the lateral pterygoid muscle, and the posterior band attaches to the posterior retrodiskal tissues (also called the posterior attachment). The junction between the posterior band and posterior attachment usually lies within 10 degrees of vertical above the condylar head. The disk and posterior attachment are collectively called the soft tissue components of the TMJ (Christo et al,2005)

The central area of the disc is avascular and lacks innervation. The peripheral region has both blood vessels and nerves.

Lateral disc ligaments attach the lateral edge of the disc to the lateral pole of the condyle. The anterior disc attaches to the joint capsule and the superior head of the lateral pterygoid.

The posterior portion attaches to the mandibular fossa and is referred to as the retrodiscal tissue (Helland and Michael, 1980)

1.1.4. Posterior attachment (retrodiskal tissue)

The posterior attachment consists of a bilaminar zone of vascularized and innervated loose fi broelastic tissue. The superior lamina, which is rich in elastin, inserts into the posterior wall of the mandibular fossa. The superior lamina stretches and allows the disk to move forward with condylar translation (Langendoen et al,1997)

The inferior lamina attaches to the posterior surface of the condyle. The posterior attachment is covered with a synovial membrane that secretes synovial fluid, which lubricates the joint. As the condyle moves forward, tissues of the posterior attachment expand in volume, primarily as a result of venous distention, and as the disk moves forward, tension is produced in the elastic posterior attachment. This tension is thought to be responsible for the smooth recoil of the disk posteriorly as the mandible closes (Langendoen et al,1997)

Several ligaments manage the TMJ forces and send multiple proprioceptive afferents. The proprioception of the joint is provided by various components, such as the capsule, masticatory muscles, skin receptors and receptors within the periodontal ligaments.

The tension perceived by the articular ligaments plays an important role in the function of TMJ (Bordoni & Varacallo,2019)

- Sphenomandibular ligament. The sphenomandibular ligament (SML) is a Meckel cartilage residue. It originates from the sphenoid spine (from which also originates the pterygospinous ligament) and in its path towards the jaw, is inserted in the medial wall of the TMJ joint capsule (Garg & Townsend,2001)

  Through the petrotympanic fissure, it involves the malleus and forms some fibers of the anterior ligament of the malleus. It continues its descent to attach itself to the lingula of the mandible (sphenoid, middle ear, jaw) (Vázquez et al,1992)

  The mylohyoid nerve and several vessels cross the ligament; has contacts with the pterygomandibular fascia. It is in a superior and lateral relationship with the lateral pterygoid muscle, the internal maxillary artery and the auriculotemporal nerve, the inferior alveolar nerve, and the medial meningeal artery. Its main task is to protect the TMJ from an excessive translation of the condyle, after 10 degrees of opening of the mouth (Bennett & Townsend,2001)

- Stylomandibular ligament. The stylomandibular ligament (STML) arises from the styloid process of the temporal bone up to the posterior margin of the jaw or the jaw angle. It is considered a thickening of the deep cervical fascia (in particular of the parotid fascia). It serves to limit excessive protrusion of the jaw. Its embryological derivation concerns the first and second branchial arch, from which the middle ear stapes will derive (through the Reichert cartilage). In its path, it covers the inner portion of the medial pterygoid muscle(Beukes et al,2013)

- Pterygomandibular ligament. The pterygomandibular ligament or raphe (PTML) is a thickening of the buccopharyngeal fascia. It arises from the apex of the hamulus of the internal pterygoid plane of the skull up to the posterior area of the retromolar trigone of the mandibular bone.

  Some muscles are in contact with PTML: the buccinator muscle (anterior) and the pharyngeal constrictor muscle (posteriorly). Embryologically, the ligament derives from the mesenchymal connection of two branchial arches (first and second). PTML limits excessive jaw movements (Khoury et al,2011)

- Pinto or malleolomandibular or discomalleolar ligament. From an embryological point of view, it derives from the tympanic portion. The ligament has two portions. The first concerns the middle ear involves the malleus relative to the anterior ligament of the malleus; the second involves the extra-tympanic area, that is, the portion of the TMJ joint capsule, posterosuperior, in contact with the retro-discal tissues (passing through the petro-tympanic fissure) (Bordoni & Varacallo,2019)

  The functions are twofold. For TMJ protects the synovial membrane with respect to the tensions of surrounding structures. For the middle ear, it would seem to manage or influence adequate pressure for this area of the ear.

- The collateral ligament consists of 2 bundles of symmetrical fibers that originate at the level of the intermediate fascia of the articular disk and insert at the medial and lateral poles of the mandibular condyle. It serves to anchor the disk to the condyle (Bordoni & Varacallo,2019)

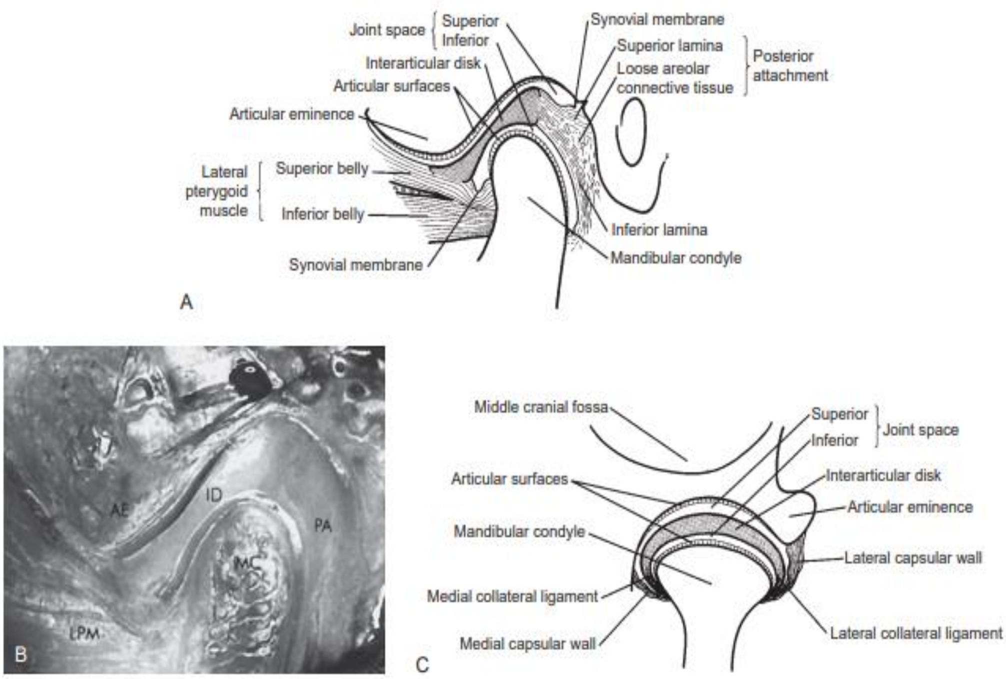
1.2. Temporomandibular joint bony relationship

Radiographic joint space is a general term used to describe the radiolucent area between the condyle and temporal component. This general term should not be confused with the terms superior joint space and inferior joint space described earlier, which refer to soft tissue spaces above and below the disk. The radiographic joint space contains the soft tissue components of the joint. The left and right condylar positions within the fossa can be determined and compared by the dimensions of the radiographic joint space viewed on corrected lateral images as shown in **figure (1-3)** (Blaschke et al,1981)

A condyle is positioned concentrically when the anterior and posterior aspects of the radiolucent joint space are uniform in width. The condyle is retruded when the posterior joint space width is less than the anterior and protruded when the posterior joint space is wider than the anterior (Blaschke et al,1981)

However, because the radiographic outline of the glenoid fossa and the condyle do not match like a smooth ball-and-socket joint, the joint space often varies from medial to lateral aspects of the joint. The diagnostic significance of mild or moderate condylar eccentricity is not clear; condylar eccentricity is seen in one third to one half of asymptomatic individuals and is not a reliable indicator of the soft tissue status of the joint, particularly because the shape of the condylar head is not concentric to the shape of the fossa (Türp et al ,2016)

Markedly eccentric condylar positioning usually represents an abnormality. For example, inferior condylar positioning (widened joint space) may be seen in cases involving fluid or blood within the joint and superior condylar positioning (decreased joint space or no joint space, with osseous contact of joint components) may indicate loss, displacement, or perforation of intracapsular soft tissue components. Marked posterior condylar positioning is seen in some cases of disk displacement, and marked anterior condylar positioning may be seen in juvenile rheumatoid arthritis (Türp et al,2016)



Figure(1-3): Temporomandibular Joint Anatomy. A, Lateral view. B, Sectioned cadaver specimen in the same orientation. AE, Articular eminence; ID, interarticular disk; LPM, lateral pterygoid muscle; MC, mandibular condyle; PA, posterior attachment. C, Coronal view (Blaschke, D.D. and Blaschke, T.J., 1981)

1.3. Condyle movement

Mandibular Movements: Movement of the condyle occurs along the posterior slop of the articular eminence and extends as far forward as its crest. In some instances, movements may involve part of the anterior slope (Hylander, W.L., 2006)

Mandibular movements may be divided into two types either basic or functional movement.

1.3.1. Basic movements: This movements occurs at the level of TMJ it may be divided into two types:

a- Rotational movement: The rotational movement occurs between the condyle and the inferior surface of the articular disk, i.e. in the lower compartment of the TMJ. Centric relation which is called uppermost, rearmost, midmost or most posterior position is purely rotary movement about the transverse horizontal axis (Fukui et al ,2002)

b- Translatory or gliding movement: It takes place in the upper compartment of the TMJ, i.e. between the superior surface of the articular disk and the glenoid fossa. These called mandibular border movement. Mandibular movement, except the opening and closing in its most posterior position (posterior terminal hing movement) are combination of rotation and translation, and referred to as functional movements (Fukui et al,2002)

1.3.2. Functional movement: All mandibular movements except the terminal hinge movement, are combination of rotational and transitional, are most frequently and are referred to as being functional movement. They are including:

- Opening and closing movements
- Symmetrical forward and backward movements.
- Asymmetrical side wise movement or lateral movement.

The opening and closing movements are considered the most important mandibular movements and they are divided into Habitual movement. - Border movement (Fukui et al,2002)

The condyle undergoes complex movement during mandibular opening. Downward and forward translation (sliding) of the condyle occurs where the superior surface of the disk slides against the articular eminence; at the same time a hinge like, rotatory movement occurs with the superior surface of the condyle against the inferior surface of the disk. The extent of normal condylar translation varies consider ably (Baragar& Osborn,1984)

In most individuals, at maximal opening the condyle moves down and forward to the summit of the articular eminence or slightly anterior to it. The condyle typically is found within a range of 2 to 5 mm posterior and 5 to 8 mm anterior to the crest of the eminence (Alomar et al,2007)

Reduced condylar translation, in which the condyle has little or no downward and forward movement and does not leave the mandibular fossa, is seen in patients who clinically have a reduced degree of mouth opening. Hypermobility of the joint may be suspected if the condyle translates more than 5 mm anterior to the eminence. This may permit anterior locking or dislocation of the condyle if a superior movement also occurs above and anterior to the summit of the articular eminence (Bedran et al,2019)

1.4. Imaging Modalities of Temporomandibular Joint

1.4.1. Plain Film Imaging Modalities

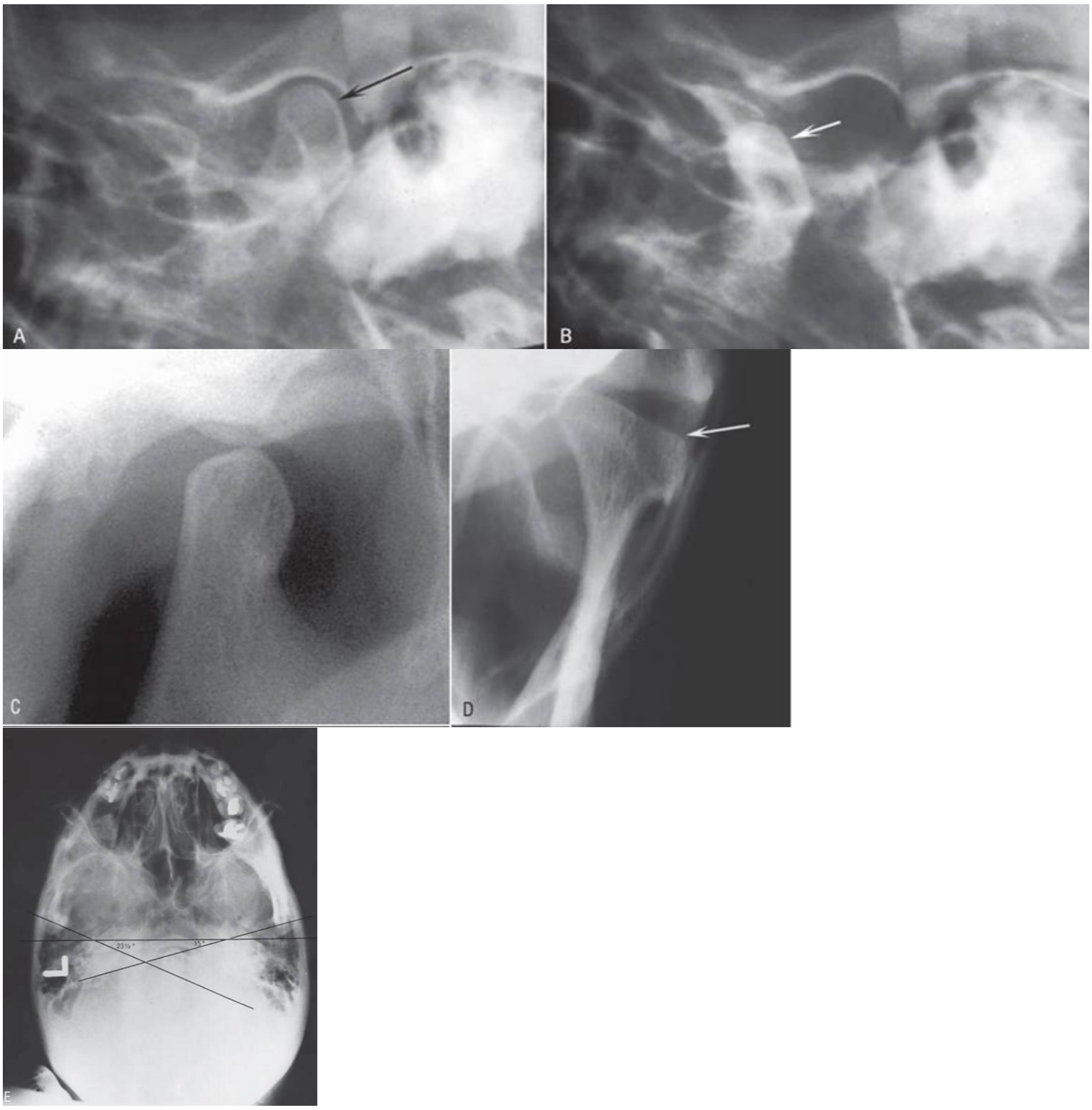
Conventional radiographs have a limited role in evaluation of the TMJ. They can be used to evaluate only the bony elements of the TMJ. They do not give useful information when it comes to the non-bony elements such as cartilage or adjacent soft tissues. They also do not give useful information concerning joint effusions, which are commonly associated with pain and disc displacements. Another disadvantage concerning conventional radiographs is the problem of superimposition of adjacent structures. Many different views such as the submentovertex, transmaxillary, and the transcranial are used to reduce superimposition (Vilanova et al,2007)

Plain film, usually consisting of a combination of transcranial, transpharyngeal (Parma), transorbital, and submentovertex (basal) projections allow visualization of the TMJs in various planes as shown in **Figure(1-4)**.

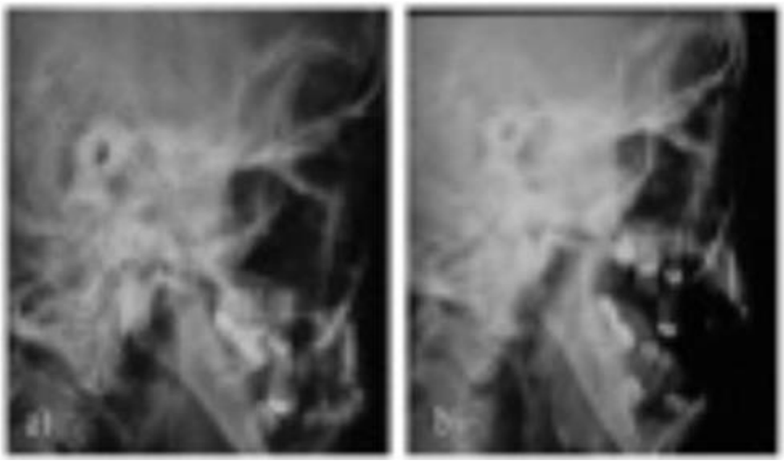
Transcranial and transpharyngeal projections provide lateral views. The transcranial view is taken in the closed and open mouth positions and depicts the lateral aspect of the TMJ, whereas the transpharyngeal projection is taken in the mouth open position only and depicts the medial aspect of the condyle. The transorbital projection is taken in the open or protruded position and depicts the entire medial-lateral aspect of the condyle in the frontal plane and is very useful in detecting condylar neck fractures. A submentovertex projection provides a view of skull base and condyles in the horizontal plane; it is often used to determine the angulation of the long axes of the condylar heads for corrected tomography.

These imaging techniques are gradually being replaced with more advanced imaging such as cone-beam computed tomography (CT) (White and Pharoah,2009)

Contact technique introduced by Parma is not recommended due to high radiation dose and superposition of bony structures **Figure(1-5)**. Plain radiography is useful in depicting degenerative joint disease in advanced stages as shown in (Brooks et al,1997)



Figure(1-4): A and B, Transcranial projections providing a profile of the lateral aspect of the condylar head (arrow) in the closed view and the degree of translatory movement (arrow) in the open view. C, An example of a transpharyngeal projection showing a medial profile of the condyle. D, An example of a transorbital projection showing a frontal view of the condyle. The lateral pole is indicated with an arrow. This submentovertex projection (E) shows the measurement of the angle of the long axis of the condylar heads used for tomography(White and Pharoah, 2009)



Figure(1-5): Contact technique (Parma incidence) of imaging the TMJ: mouth closed (a), mouth opened (b) (Brooks et al,1997)

The condyle position could also be assessed, but large variations of condyle position in the glenoid fossa were found, even in asymptomatic population (Blaschke et al,1981;Pullinger et al,1985) Some studies have shown that the position of the condyle in the fossa is of little clinical significance (Paknahad et al,2015)

Other studies suggest that the posterior position of the mandibular condyle in regard to the fossa, could represent an indirect sign of an anterior disc displacement (Ozawa et al,1999; Paknahad et al,2015)

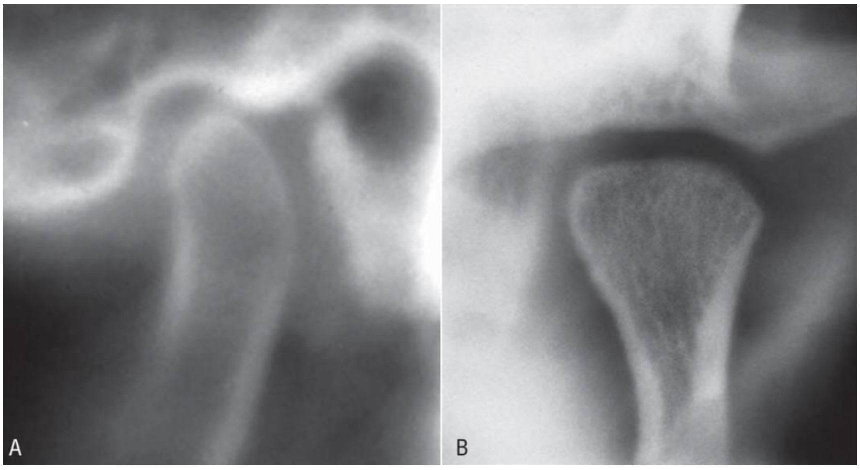
The position of the head during the examination could influence the joint space, which could influence the interpretation of the radiography (Smith et al,1989)

The use of flat plane films for TMJ pathology is not sufficient, because this joint requires three dimensional imaging views. CT has been reported to be more suitable in identifying TMJ changes than conventional radiography (Brooks et al,1997)

1.4.2. Conventional Tomography

Tomography is a radiographic technique that produces multiple thin image slices, permitting visualization of the osseous structures. essentially free of superimpositions of overlapping structures. This technique can provide multiple image slices at right angles through the joint, depicting true condylar position and revealing osseous changes. Conventional tomography is gradually being replaced by cone-beam CT (CBCT) as the imaging technique of choice for assessing the osseous structures of the TMJ. Tomography typically are exposed in the sagittal (lateral) plane, corrected to the condylar long axis, with several image slices in the closed (maximal intercuspation) position and usually only one image in the maximal open position. It is desirable to supplement the sagittal images with coronal (frontal) tomographs as shown in **Figure(1-6).**

Particularly when morphologic abnormalities or erosive changes of the condylar head are suspected. The entire condylar head is visible in the mediolateral plane (White and Pharoah, 2009)



Figure(1-6): A, Sagittal tomographic image through the mid region of the joint. B, Frontal tomographic image of the mandibular condyle (White and Pharoah, 2009)

Because this technique can provide multiple image slices at right angle through the joint, it is superior to the transcranial view in depicting true condylar position and revealing osseous changes. For these reasons, tomography is a valuable adjunct to plain film radiography and can provide information that may not be available with plain films alone (White and Pharoah, 2009)

1.4.3. Computed Tomography (CT)

First used for TMJ evaluation in 1980 (Baba et al,2016), CT is considered to be the best method for assessing osseous pathologic conditions of TMJ. It allows a multi planar reconstruction (sagittal, axial, and coronal) of TMJ structures, obtaining 3D images in closed and opened-mouth positions (Brocks et al,1997)

There are two CT devices available, conventional CT (sometimes referred to as medical CT and CBCT. Both modalities can give excellent images of the osseous structures, but only conventional CT provides images of the surrounding soft tissues; however, this is only required in a minimal number of specific situations. CBCT has the advantage of reduced patient dose compared with medical CT and is likely to replace conventional tomography.

In CBCT the patient is usually scanned in the closed position and low-resolution scans can be done in the open or other positions. Data from the axial slices can be manipulated to produce (reformat) corrected lateral and frontal images of the TMJs. Panoramic and three-dimensional reformatted images also can be produced. These are useful for assessing osseous deformities of the jaws or surrounding structures. Conventional and CBCT cannot produce accurate images of the articular disk. CT is also useful for determining the presence and extent of ankylosis and neoplasms and the degree of bone involvement in some arthritides, for imaging complex fractures, and for evaluating complications From the use of polytetrafluoroethylene or silicon sheet implants, such as erosions into the middle cranial fossa and heterotopic bone growth (White and Pharoah, 2009)

Some studies have reported that radiographic changes in the joint are not always related to pain (Brocks et al,1997;Sano et al,2000;Bertam et al,2001)

Therefore, some patients with osseous abnormalities may experience pain, others may be pain free. Changes in the shape and location of the loading zone can also be seen on CT. Basically, any CT examination of the TMJ should focus on the following: intactness of the cortex, normal size and shape of the condyles and their centered position in the fossa, the adequate joint spaces, centric relation loading zone.

Autopsy studies performed for the assessment of condylar abnormalities showed better results for CT than MRI (Tanimoto et al,1990)

Wesetesson et al. in 1987 found a sensitivity of 75 % and a specificity of 100% for the diagnosis of condylar bony changes. Regarding the visualization of the soft tissues of TMJ (disc, synovial membrane, ligaments, lateral pterygoid muscle), CT is not used as a primary diagnostic method. The disc could be visualized on CT scans only with injection of contrast media in the joint (arthrography). Arthrography is a dynamic investigation, but was never widely used, due to its invasiveness, pain and allergic reactions (Maffe et al,1988)

A review published by Caruso et al. in 2017 stated the main contributions of cone beam CT in the field of TMJ:

• allows the calculation of volume and surface of the condyle.

• improves qualitative analyses of condylar surface and allows detecting the mandibular condyle shape.

• improves the accuracy of linear measurements of mandibular condyle

• clarifies that, in case of facial asymmetry, the condyles are often symmetric, while joint space can change between the two sides.

• clarifies the position of the condyle in the fossa.

Although CT provides important information regarding the osseous components of TMJ, it has several limitations, like the artifact which can appear due to the patient's accidental movement during examination (especially in children). Also, a decrease in radiation dose (for cone beam CT) can affect the image quality (Hintze et al,2007;Talaaat et al,2016)

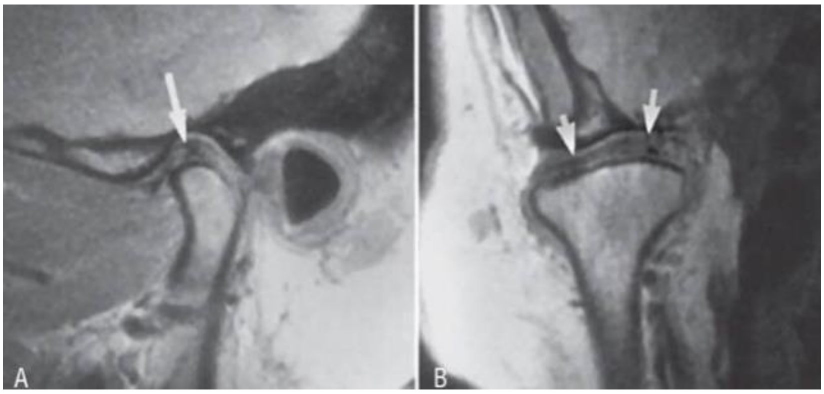
1.4.4. Magnetic Resonance Imaging (MRI)

MRI uses a magnetic field and radiofrequency pulses rather than ionizing radiation to produce multiple digital image slices. Because MRI can provide superb images of soft tissues, this technique can be used for imaging the articular disk. aMRI allows construction of images in the sagittal and coronal planes without repositioning the patient as shown in **Figure(1-7)**.

These images usually are acquired in open and closed mandibular positions with use of surface coils to improve image resolution. Sagittal slices should be oriented perpendicular to the condylar long axis.

The examinations usually are performed with use of T1-weighted, proton-weighted, or T2-weighted pulse sequences. T1-weighted and proton-weighted images best demonstrate osseous and diskal tissues, whereas T2-weighted images demonstrate inflammation and joint effusion. Motion MRI studies during opening and closing can be obtained by having the patient open in a series of stepped distances and with use of rapid image acquisition ("fast scan") techniques.

MRI is contraindicated in patients who are pregnant or who have pacemakers, intracranial vascular clips, or metal particles in vital structures. Some patients may not be able to tolerate the procedure because of claustrophobia or an inability to remain motionless (White and Pharoah,2014)

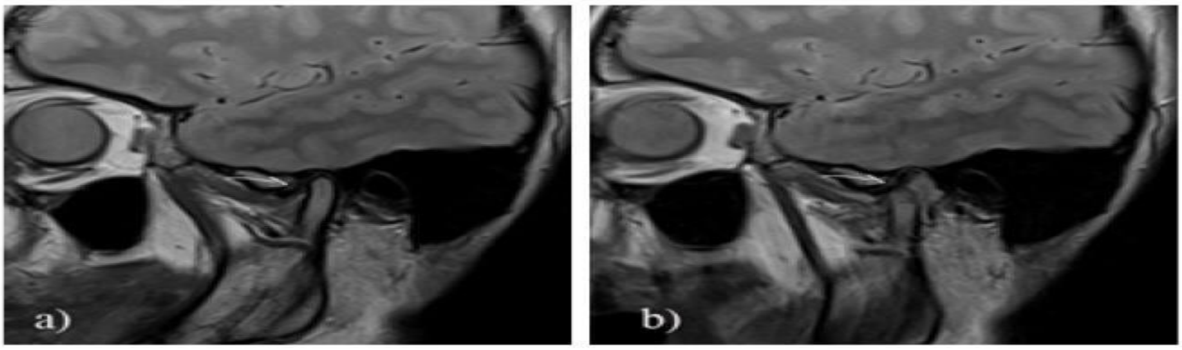


Figure(1-7): MRI image of Normal TMJ .A, Closed sagittal view showing the condyle and temporal component. The biconcave disk is located with its posterior band (arrow) over the condyle. B, Closed coronal view showing the osseous components and disk (arrows) superior to the condyle (White and Pharoah,2014)

In MRI examination, a pathological condition is considered to be present relative to the intermediate zone of the meniscus (as a point of reference) and its interposition between the condyle and the temporal bone as shown in **Figure(1-8)** (Helms and Kaplan,1990)

Normal disc position, evaluated in the sagittal plane, is with the junction of posterior band (aligned approximately at 12 o'clock, position relative to the condyle. Disc displacement is diagnosed when the posterior band sits in an anterior, posterior, medial or lateral position with regard to the condylar surface (Drace and Enzmann,1990)

In the closed-mouth position, teeth should be in contact, whereas in the opened-mouth position, the jaw should be at the widest comfortable opening. This way, misinterpreted disc positions could be avoided (Gibbs and Simmons,1998)



Figure(1-8): Sagittal, proton density, MRI of an anterior disc displacement with reduction: mouth-closed (a), mouth-opened (b). The displaced disc (arrow) returns to its normal position at maximal mouth opening (Helms and Kaplan,1990)

Some studies have investigated the relationship between the articular eminence morphology and disc patterns in patients with disc displacements. The results showed that changes in the morphology of articular eminence (flattened) and disc could contribute to the appearance of disc displacement without reduction on that side (Hirata et al,2007)

Other studies also found changes in disc shape and dimension in cases of TMJ disc displacement (Almasan et al,2013)

Among the disadvantages of the MRI investigation, the following can be mentioned (Larheim,1995:Sinha et al,2012):

• It is costly and time consuming.

• Restricted use in patients with claustrophobia.

• There is a possibility of missing the portion of condyle having a pseudo cyst.).

• May miss different bone conditions and soft tissue calcifications with inflammatory diseases or tumors; in these cases, CT is the preferable imaging modality.

1.5. Abnormalities of the Temporomandibular Joint

1.5.1. 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(s) (White and Pharoah,2009)

1.5.1.1. Condylar Hyperplasia

1.5.1.1.1. 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. Some proposed etiologic factors include hormonal influences, trauma, infection, heredity, intrauterine factors, and hypervascularity. The mechanism may be overactive cartilage or persistent cartilaginous rests, which increases the thickness of the entire cartilaginous and precartilaginous layers. This condition usually is unilateral and may be accompanied by varying degrees of hyperplasia of the ipsilateral mandible (White and Pharoah,2009)

Mandibular condylar hyperplasia was first described by Robert Adams in 1836, while describing a case of rheumatoid arthritis (Rushton,1946)

1.5.1.1.2. Clinical Features

In 1986, Obwegeser and Madek have classified mandibular condylar hyperplasia in two major types: hemimandibular elongation and hemimandibular hyperplasia. However, the disease may manifest as hybrid unilateral or combined bilateral (Obwegeser and Makek,1986)

In general, there is maxillary occlusal plane inclination and minimum deviation of the chin and of the lower dental midline in the contralateral sense, being even more frequent an ipsilateral deviation. In case of mandibular condylar hyperactivity in a post-puberty phase, there might be ipsilateral posterior open bite due to lack of maxillary compensation (Posnick,2014)

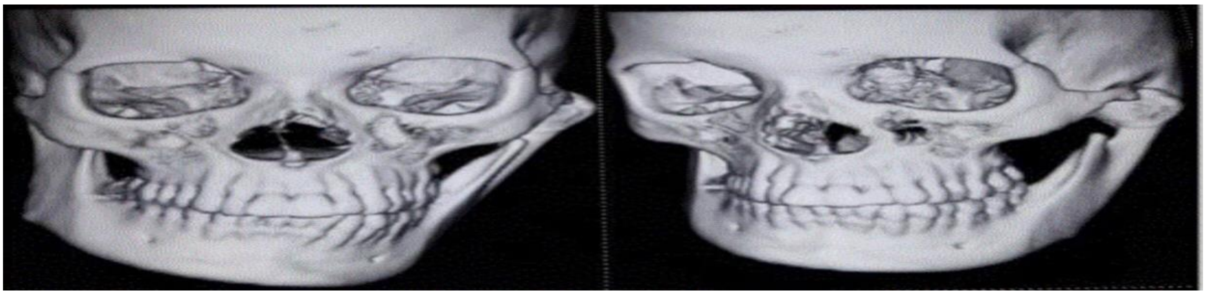
In functional terms, mandibular condylar hyperplasia may course with phonetic, chewing and swallowing difficulties due to occlusal disharmony, nasal obstruction by nasal septum deviation and turbinates hypertrophy, temporomandibular joint disorder and esthetic and self-esteem problems (Wolford et al,2009;Posnick,2014)

1.5.1.1.3. Radiographic Features

The condyle may appear relatively normal but symmetrically enlarged, or it may be altered in shape (e.g., conical, spherical, elongated, lobulated) or irregular in outline. It may be more radiopaque because of the additional bone present. A morphologic variation manifesting as elongation of the condylar head and neck with a compensating forward bend, forming an inverted L, may be seen. Also, the condylar neck may be elongated and thickened and may bend laterally when viewed in the coronal (anteroposterior) plane. The cortical thickness and trabecular pattern of the enlarged condyle usually are normal, which helps to distinguish this condition from a condylar neoplasm.

The glenoid fossa may be enlarged, usually at the expense of the posterior slope of the articular eminence. The ramus and mandibular body on the affected side also may be enlarged, resulting in a characteristic depression of the inferior mandibular border at the midline, where the enlarged side joins the contralateral normal mandible. The affected ramus may have increased vertical depth and may be thicker in the anteroposterior dimension (White and Pharoah,2009)

Face X-rays, such as panoramic and face frontal and profile teleradiography, are useful to evidence skeletal changes typical of mandibular condylar hyperplasia (Wolford et al,2009)



Figure(1-9): CT scan showing hyperplastic condyle, elongated ramus and slanted occlusal plane , OPG reveals gross enlargement of the left condyle and loss of antegonial notching with downward bowing of the inferior border on the mandible (Gelada et al,2018)

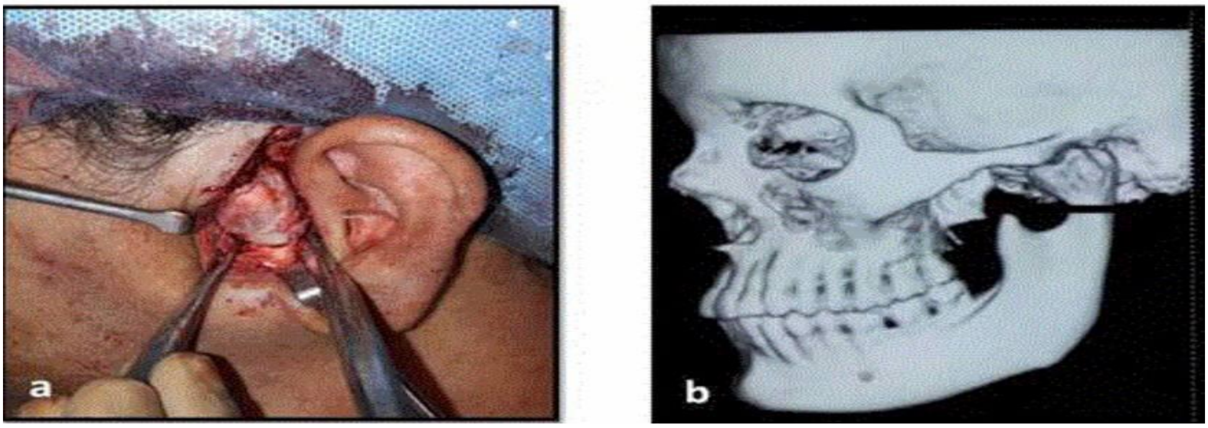


Figure (1-10): (a) Bony cut taken on the neck of the condyle, operative site exposed with preauricular incision.(b) Diagrammatic representation of the surgery performed (Gelada et al,2018)

1.5.1.2. Condylar Hypoplasia

1.5.1.2.1. 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 (White and Pharoah,2009)

Condylar hypoplasia results from congenital or developmental disturbances or due to acquired causes. The acquired causes that result in hypoplasia of the condyle include traumatic injuries sustained during the growth and development of the mandible, therapeutic radiation and arthritis (Ongole and Praveen,2013)

1.5.1.2.2. Clinical Features

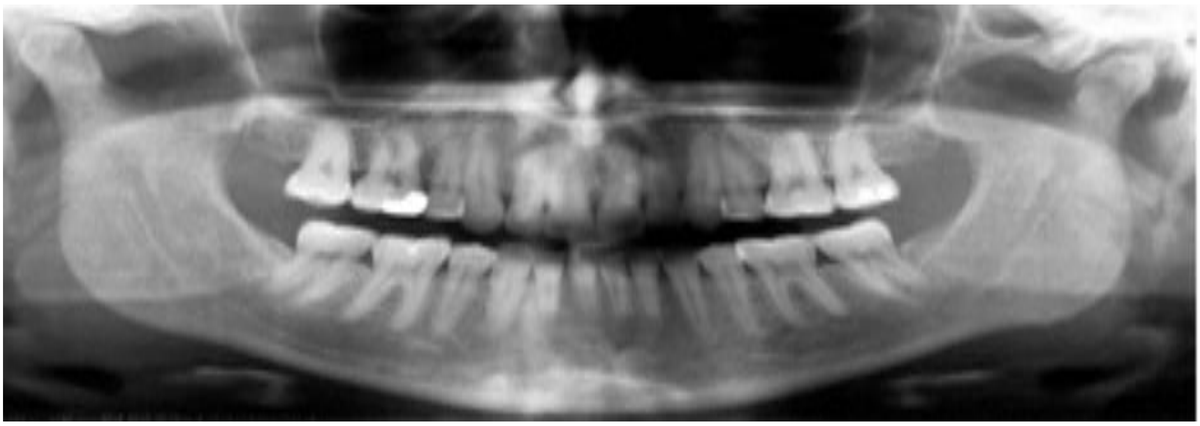
Condylar hypoplasia is more commonly unilateral, unless it is a feature of a syndrome (e.g., Treacher Collins syndrome, Pierre Robin sequence)

The condyle is a mandibular growth center; therefore, condylar hypoplasia is usually associated with some degree of unilateral mandibular hypoplasia and facial asymmetry. Deviation of the mandibular midline to the affected side and accentuation of this deviation on mandibular opening and malocclusion may develop. The amount of growth disturbance of the mandible is related to how early the onset of the disturbance to condylar growth occurs; earlier onset results in more severe underdevelopment of the ramus and mandibular body. Patients with condylar hypoplasia may develop symptoms of TMJ dysfunction (White and Pharoah,2014)

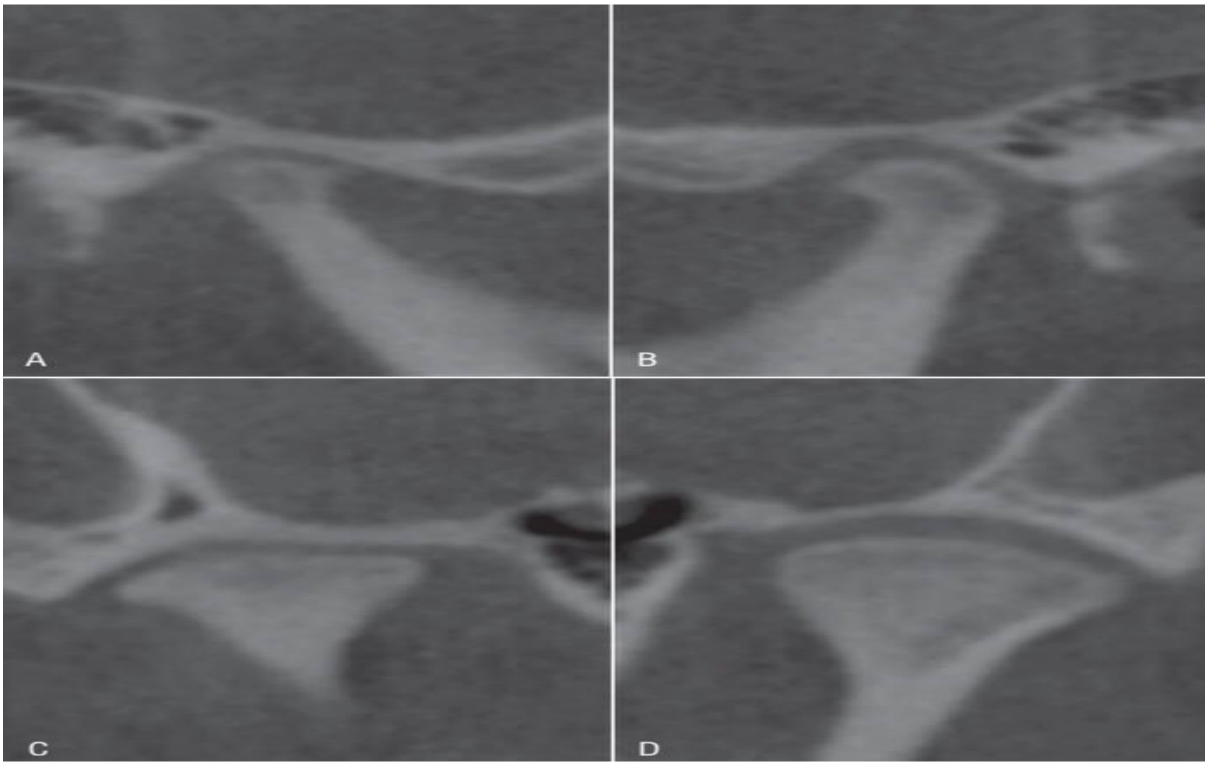
In this condition the condyle usually retains its shape but appears smaller. Most of these patients also present with a proportionately smaller ramus and body of the mandible. A prominent antigonial notch may be seen (Ongole and Praveen,2013)

1.5.1.2.3. Radiographic Features

The condyle may be normal in shape and structure but is diminished in size, and the mandibular fossa is proportionally small. The condylar neck is thinner and may appear short or elongated. The coronoid process is usually slender. The posterior border of the ramus and condylar neck may have a dorsal (posterior) inclination, creating a concavity in the outline of the posterior surface of the mandible in the panoramic image. If there is an associated mandibular hypoplasia, it manifests with a deepened antegonial notch and decreased vertical height of the mandibular body as shown in **Figure(1-11)**. Occasional dental crowding may also result. Degenerative changes in the affected joint may be detected as shown in **Figure(1-12)** (White and pharoah,2014)



Figure(1-11): Panoramic image reveals hypoplasia of the left condyle. In this case, hypoplasia is restricted to the condylar head and neck with minimal involvement of the mandibular ramus and body (White and Pharoah,2014)



Figure(1-12): Cone-beam CT of unilateral condylar hypoplasia, sagittal (A and B) and coronal (C and D) reformatted images. A and C, The right condyle is hypoplastic and there is secondary remodelling. The articular surfaces of the condyle and anterior aspect of the glenoid fossa are flattened and the superior joint space is thinner compared with the left. B and D, Left side of same patient showing normal condyle (White and Pharoah,2014)

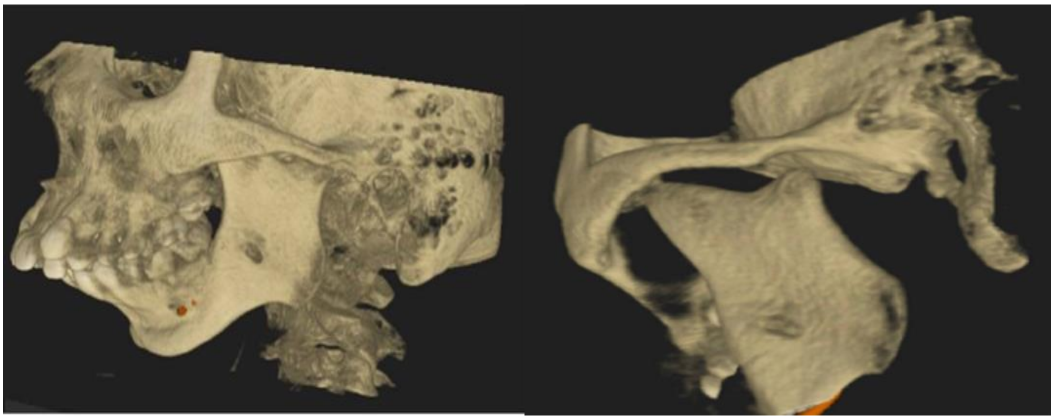


Figure (1-13): (A and B) 3D CBCT left lateral shows hypoplasia of glenoid fossa and condyle (Shivhare et al,2013)

1.5.1.3. Coronoid Hyperplasia

1.5.1.3.1. 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 (White and Pharoah,2009)

1.5.1.3.2. Clinical Features

Coronoid hyperplasia is one of the rare causes of progressive limitation of mouth opening due to impingement of the enlarged coronoid process of the mandible on the zygomatic bone (Goh et al,2020)

The shape of the coronoid process usually does not change, however it only increases in size.

On clinical examination there is no apparent facial asymmetry or pain. It usually begins at puberty. Males are more commonly affected than females (5:1). Apart from genetic inheritance other causes for coronoid hyperplasia to occur have been proposed such as trauma, increased activity of the temporalis muscle and endocrinal stimulus (Ongole and Praveen,2013)

1.5.1.3.3. Radiographic Features

Waters' view and orthopantomograph are usually sufficient to evaluate coronoid hyperplasia. It is believed that the projection of the tips of the coronoid processes at least 1 cm over the inferior rim of the zygomatic arch is pathognomonic of coronoid hyperplasia. The impingement of the elongated coronoid process over the zygomas can be best appreciated by an axial CT image with the mouth open (Ongole and Praveen, 2013)

Remodelling of the posterior surface of the zygomatic process of the maxilla, to accommodate the enlarged coronoid process during function, may also be seen. Because this condition is often bilateral, both sides should be examined for abnormality. The radiographic appearance of the TMJs usually is normal (White and Pharoah, 2014)

Figure (1-14): Sagittal Tomogram of Coronoid Hyperplasia. The coronoid process is elongated and extends above the inferior rim of the zygomatic arch (arrow) but otherwise is shaped normally (White and pharoah, 2009)

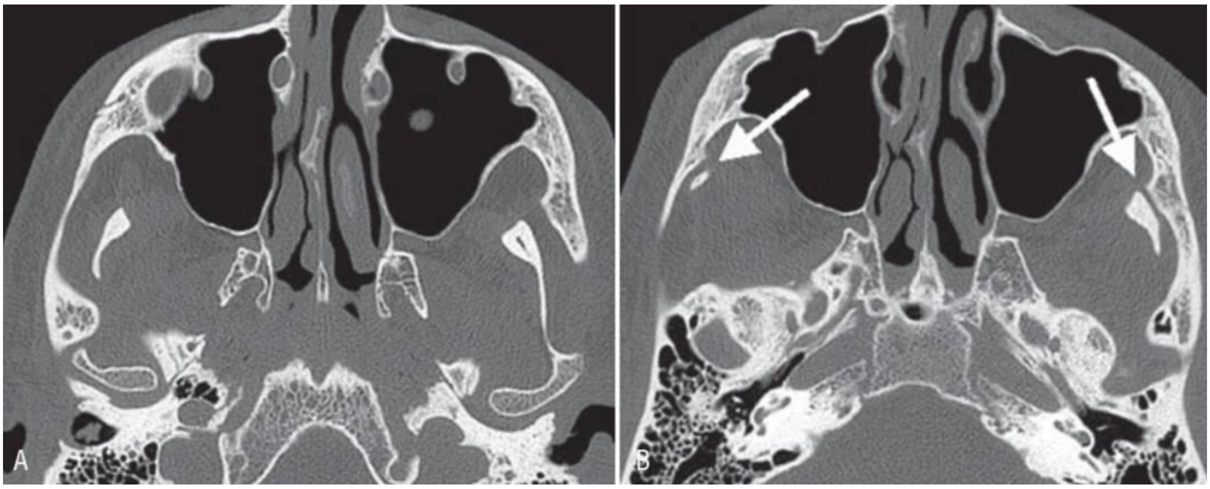


Figure (1-15): Two axial CT images taken in the closed mouth (A) and open mouth (B) positions showing impingement of hyperplastic coronoid processes with the medial aspect of the zygomatic arch (arrows). Note the hyperostosis on the medial surface of the zygomatic process at the point of impingement (White and Pharoah, 2009)

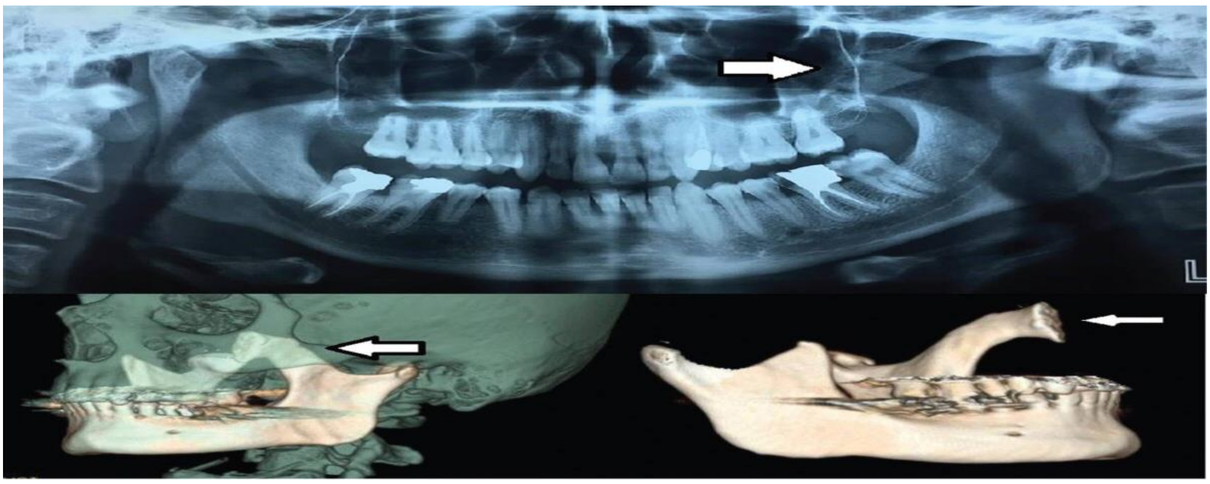


Figure (1-16): Patient's panoramic radiography (high) and CT scan (low). Arrow in all the images shows the bony process (Samandari et al, 2020)

1.5.2. Soft Tissue Abnormalities

1.5.2.1. Internal Derangements

1.5.2.1.1. Definition

Internal derangement of TMJ is defined as an abnormal positional relationship of the disc relative to the mandibular condyle and the articular eminence OR Internal derangement of the temporomandibular joint (TMJ) is 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. These are the disturbances in the arrangements of components within joint itself primarily disc. It is most common disorder of TMJ. These derangements are clicking joint type or locking joint type (Kulkani,2019)

The disk most often is displaced in an anterior direction, but it may be displaced anteromedially, medially, or anterolaterally. Lateral and posterior displacements are extremely rare.

The cause of internal derangements is unknown; although parafunction, jaw injuries (e.g., direct trauma), whiplash injury, and forced opening beyond the normal range have been implicated internal derangements can be diagnosed by MRI (White and Pharoah,2009)

Disk displacement with reduction when The disk is displaced from its position between the condyle and eminence to an anterior and medial or lateral position (more common is anterior or anteromedial) but is reduced in full mouth opening usually resulting in a noise. Click occurs on both vertical opening and closing. Pain may be present when chewing hard foods. This condition can be seen in chronic clicking condition in patients who tend to clench and grind the teeth at night and in patients with missing posterior teeth with subsequent overclosure of bite (Kulkarni,2019)

Disk displacement without reduction when Disc displacement (medially, laterally and anteriorly) does not assume the normal position. It is also called closed lock. In this case the disc has been permanently displaced and its shape has been deformed so that it prevents the condyle of the mandible from translating to a full open position. It can be seen with and without limited opening. It is diagnosed mainly by absence of joint sounds and deflection (Kulkarni,2019)

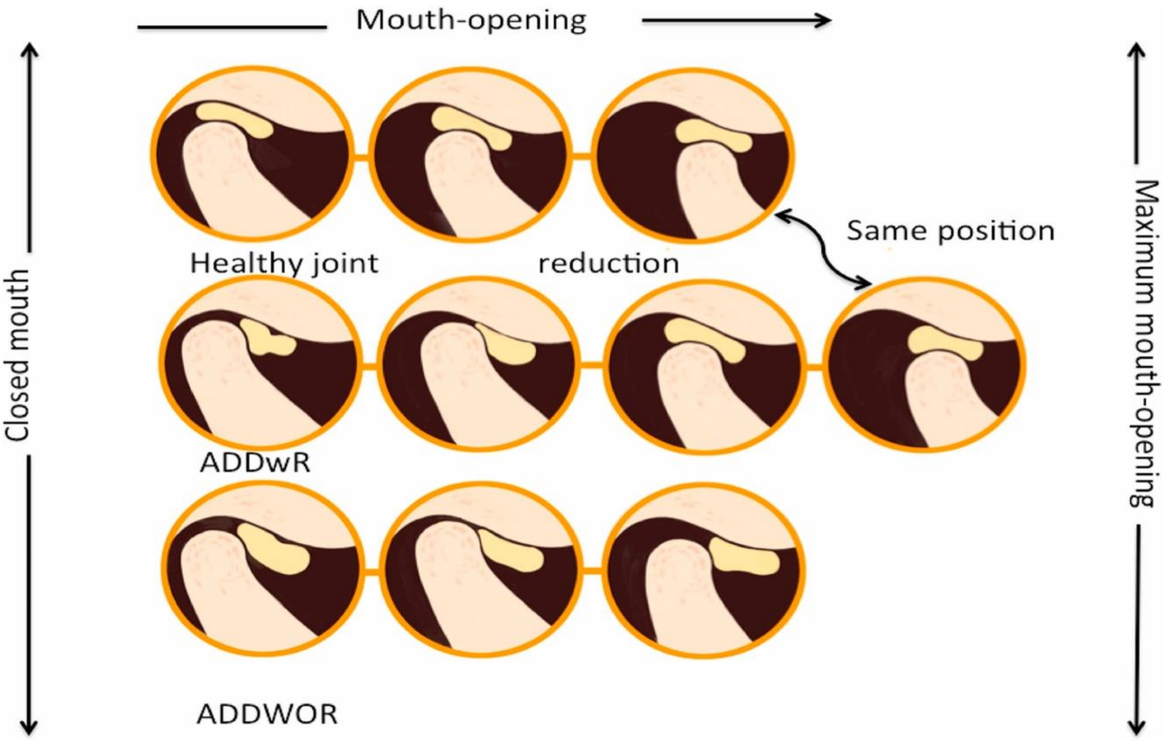


Figure (1-17): Position and movement of the disk during jaw opening (Bermejo and femoll,2010).

1.5.2.1.2. Clinical Features

Disk displacement has been found both in symptomatic patients and in healthy volunteers, suggesting that it may be a normal variant and not necessarily a predisposing factor in TMJ dysfunction. Symptomatic patients may have a decreased range of mandibular motion.

Internal derangements can be unilateral or bilateral; unilateral cases may manifest clinically as mandibular deviation to the affected side on opening. Patients may complain of pain in the preauricular region or headaches and may have episodes of closed or open locking of the joint. Patients may have to manipulate the mandible to open it fully past an apparent closed lock by applying medially directed pressure to the affected joint or mandible with the hand (White and Pharoah,2009)

1.5.2.1.3. Radiographic Features

Normal Disc Position. The articular disc cannot be visualized with conventional radiography or CBCT or MDCT imaging; MRI is the technique of choice. On MRI, the normal disc has a low signal intensity (i.e., is dark, between bone and muscle), and the signal intensity of the posterior attachment is usually higher (i.e., lighter). In a sagittal image slice, the normal biconcave disc appears as a “bow tie” shape. In the closed mouth position, the normal disc is positioned with the posterior band either directly superior to or slightly anterior to the condylar head (around the 11 o’clock position). The thin intermediate part of the disc sits between the anterosuperior surface of the condyle and the posterior surface of the articular eminence as shown in **Figure (1-7)**. In all positions of mouth opening, the thin intermediate part should remain the articulating surface of the disc between the condyle and articular eminence (White and Pharoah,2014)

MRI imaging is required for identification of a displaced disc. Although a retruded condylar position, seen in CBCT or MDCT imaging, has been associated with an anteriorly displaced disc, condylar position in maximal intercuspation is an unreliable indicator of disc displacement. Anterior displacement is the most common disc displacement. A disc is considered anteriorly displaced when its posterior band sits anterior to its normal position and the thin intermediate zone is no longer positioned between the condyle and articular eminence. This displacement may range from partial to full displacement with the posterior band sitting between the condyle and articular eminence in a mild partial displacement to sitting well anterior to the condylar head in a severe, full dislocation as shown in **Figure (1-18)**.

When the disc is severely anteriorly displaced, partial folding of the disc within the anterior joint space may be seen. Sometimes identification of the posterior band is difficult because of deformation of this part of the disc. Also, when the disc is chronically anteriorly positioned, the posterior attachment is pulled between the articulating surfaces of the condyle and temporal bone, and owing to resulting fibrosis, its tissue signal may become lower and approximate that of the posterior band.

It is helpful to identify the position of the thin intermediate part of the disc to determine if it is anteriorly displaced from its normal position between the articulating surfaces of the condyle and articular eminence.

Anteromedial displacement is indicated in sagittal image slices when the disc is in a normal position in the medial images of the joint but anteriorly positioned in the lateral images of the same joint.

Medial or lateral displacement is indicated on coronal MRI when the body of the disc is positioned at the medial or lateral aspect of the condyle, respectively, as shown in Figure **(1-18-C)**. Posterior disc displacement is rare (White and Pharoah,2014)

Disc Reduction and Non reduction. During mouth opening, an anteriorly displaced disc may reduce to a normal relationship with the condylar head during any part of the opening movement.

In motion studies, this is usually a rapid posterior movement of the disc, and it is often accompanied by an audible click. This condition is referred to as disc reduction and can be diagnosed on MRI if the disc is anteriorly displaced in closed mouth views but is in a normal position in open mouth views as shown in **Figure (1-18)**. If the disc remains anteriorly displaced on opening, it is diagnosed as non-reducing.

Fibrotic changes of the posterior attachment of a displaced disc may alter its tissue signal to approximate the signal of the disc and make identification of the disc itself difficult or impossible. In such cases, the disc may be erroneously interpreted as occupying a normal position at maximal opening. Identification of excessive tissue with low signal intensity anterior to the condylar head, representing the true disc tissue, should help confirm the nonreducing state of the disc (White and Pharoah,2014)

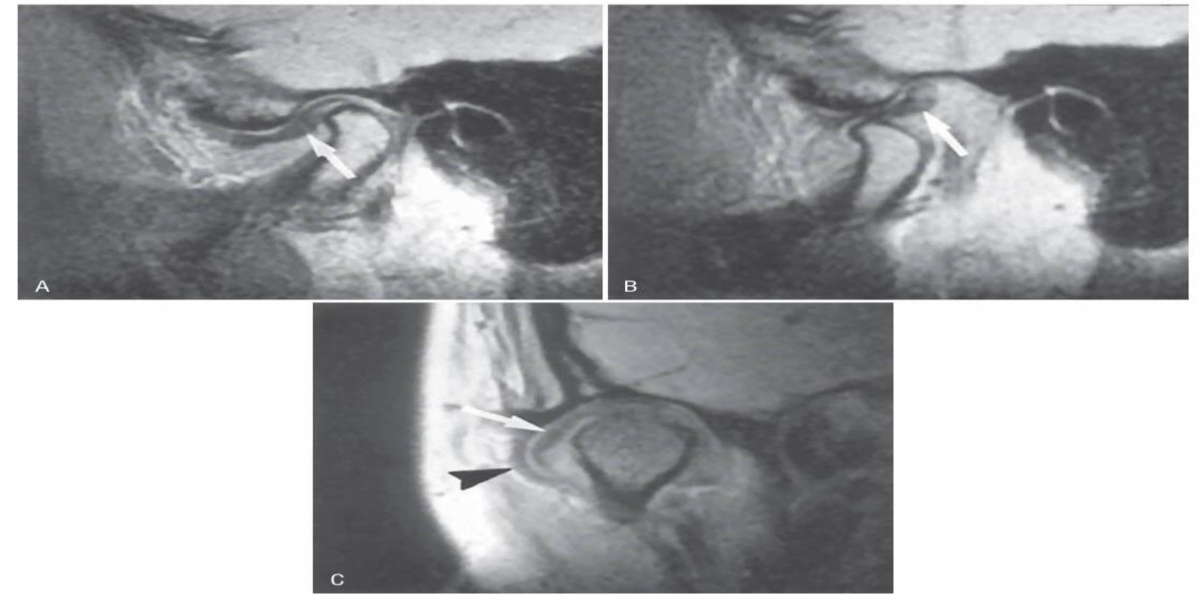


Figure (1-18): MRI of anterior disk displacement with reduction. A, Closed sagittal view showing the disk with its posterior band (arrow) anterior to the condyle; note the anterior position of the thin intermediate section of the disk. B, Open view showing the normal relationship of the disk and condyle and the posterior band of the disk (arrow). C, Coronal view showing the disk (white arrow) laterally displaced. The joint capsule (black arrowhead) bulges laterally (White and Pharoah,2014)

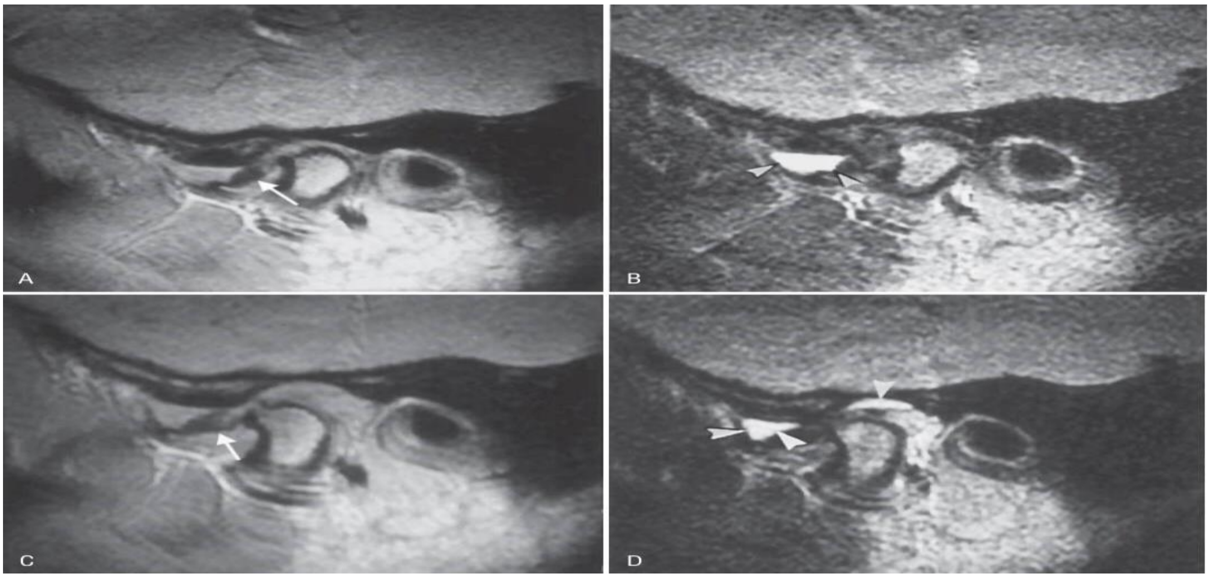


Figure (1-19): MRI of disk displacement without reduction in the presence of joint effusion. A, The disk (arrow) is anteriorly displaced in this closed T1-weighted image. B, A T2-weighted image of the same section shows the collection of joint effusion (arrowheads) in the anterior recess of the upper joint space. C, Open T1-weighted image showing the disk remains anterior to the condyle. The posterior band of the disk is indicated with an arrow. D, This T2-weighted image is at the same level as C. Note the joint effusion (arrowheads) in the anterior and posterior recesses of the upper joint space (White and Pharoah,2014)

1.5.3. Remodelling and Arthritic Conditions

1.5.3.1. Remodeling

1.5.3.1.1. Definition

Remodelling is 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. This adaptive response may result in flattening of curved joint surfaces, which effectively distributes forces over a greater surface area. The number of trabeculae also increases, increasing the density of subchondral cancellous bone (sclerosis) to better resist applied forces. No destruction or degeneration of articular soft tissues occurs.

TMJ remodelling occurs throughout adult life and is considered abnormal only if it is accompanied by clinical signs and symptoms of pain or dysfunction or if the degree of remodelling seen radiographically is judged to be severe. Remodelling may be unilateral and does not invariably serve as a precursor to degenerative joint disease (White and Pharoah,2009)

1.5.3.1.2. Clinical Features

Remodelling may be asymptomatic, or patients may have signs and symptoms of temporomandibular dysfunction that may be related to the soft tissue components, associated muscles, or ligaments. Accompanying internal derangement of the disk may be a factor (White and Pharoah,2009)

1.5.3.1.3. Radiographic Features

Changes noted in the diagnostic images may affect the condyle, temporal component, or both; they first occur on the anterosuperior surface of the condyle and the posterior slope of the articular eminence.

The lateral aspect of the joint is affected in early stages, and the central and medial aspects become involved as remodelling progresses. These changes may include one or a combination of the following: flattening, thickening of the cortex of the articulating surfaces, and subchondral sclerosis as shown in **Figure (1-20)** (White and Pharoah, 2014)

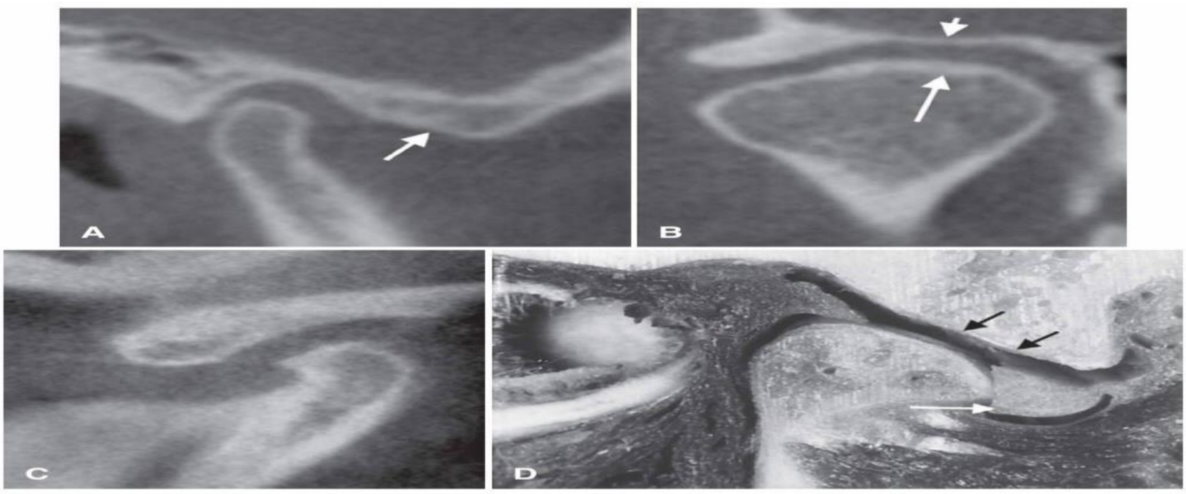


Figure (1-20): Sagittal (A) and coronal (B) reformat CBCT images of the right TMJ show remodelling. A, The right temporal component shows subchondral sclerosis and flattening of the articular eminence (arrow). B, The right condyle shows mild flattening of the lateral aspect and sub- chondral sclerosis of the medial aspect (arrow). The right temporal component is also flattened (arrowhead). C, Sagit- tal CBCT image shows significant flattening of the condylar head. D, Cadaver specimen. Note the flattening of the temporal component (black arrows) and large perforation posterior to a residual deformed disc (white arrow) (White and Pharoah,2014)

1.5.3.2. Degenerative Joint Disease

1.5.3.2.1. Osteoarthritis

1.5.3.2.1.1. Definition

Osteoarthritis (OA) is defined as a degenerative condition of the joint characterized by deterioration of articular tissue and concomitant remodelling of underlying subchondral bone (Hayashi et al,2004)

OA is caused primarily by the degeneration of collagens and proteoglycans in cartilage leading to fibrillation, erosion, and cracking in the superficial cartilage layer (Breedveld,2004)

This process spreads to a deeper layer of cartilage and eventually enlarges to form erosions. The articular surface of TMJ has the remarkable adaptive capacity. Hyaline cartilage of the load-bearing joints of the body are more resistant to compressive loading, but the fibrocartilage of TMJ better withstands shear force . When functional demand exceeds the adaptive capacity of the TMJ or if the affected individual is susceptible to maladaptive response, then the disease state will ensue (Milam,2005)

1.5.3.2.1.2. Clinical Features

OA is an age-related disease, and the WHO estimates that globally 25% of adults aged over 65 years suffer from pain and disability associated with this disease (Breedveld,2004)

The clinical features are tenderness in the joint region, pain on movement of the joint during mouth opening and lateral excursion, and hard grating or crepitus (Emshoff and Rudisch 2001; Al-Sadhan,2008)

Some studies report that the disease eventually “burns out” and symptoms disappear or markedly decrease in severity in long-standing cases (White and Pharoah,2009)

1.5.3.2.1.3. Radiographic Features

Osseous changes in DJD are more accurately depicted on CT images, although osseous changes may also be detected on MRI, particularly T1-weighted images. Erosions are a sign of the deteriorating component of DJD. They manifest as small to large bites or scoops out of the articulating surfaces of the joint, resulting in loss of the continuity of the cortices and eventual loss of bone volume as shown in **Figure(1-22)** (White and Pharoah,2014)

In severe DJD, the glenoid fossa may appear grossly enlarged because of erosion of the posterior slope of the articular eminence. This erosion may allow the condylar head to move forward and superiorly into an abnormal anterior position that may result in an anterior open bite. The condyle may also be markedly diminished in size and altered in shape because of severe erosions. 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 or subchondral bone cysts, but they are not true cysts; they are areas of degeneration that contain fibrous tissue, granulation tissue, and osteoid (see **Figure (1-22)**, A and B). When the patient is in maximal intercuspation, the joint space may be narrow or absent. This finding often correlates with a displaced disc and frequently with a perforation of the disc or posterior attachment, resulting in bone-to-bone contact of the joint components (White and Pharoah,2014)

In the proliferative phase of the disease, bone formation occurs at the periphery of the articulating surfaces. These projections of new bone are called osteophytes, and although they may form on any part of the joint, they are usually seen on the anterosuperior surface of the condyle, the lateral aspect of the temporal component, or both as shown in **Figure (1-24)**. Osteophytes create broader, flatter articulating surfaces and serve to distribute the load on the joint over a greater area. In severe cases, osteophyte formation may extend from the articular eminence almost to encase the condylar head.

Osteophytes may also break off and lie free within the joint space. These fragments are known as “joint mice,” and they must be differentiated from other conditions that cause joint space radiopacities as shown in **Figure (1-25)**. Variable degrees of sclerosis of the subchondral bone may accompany any of the changes described (White and Pharoah,2014)

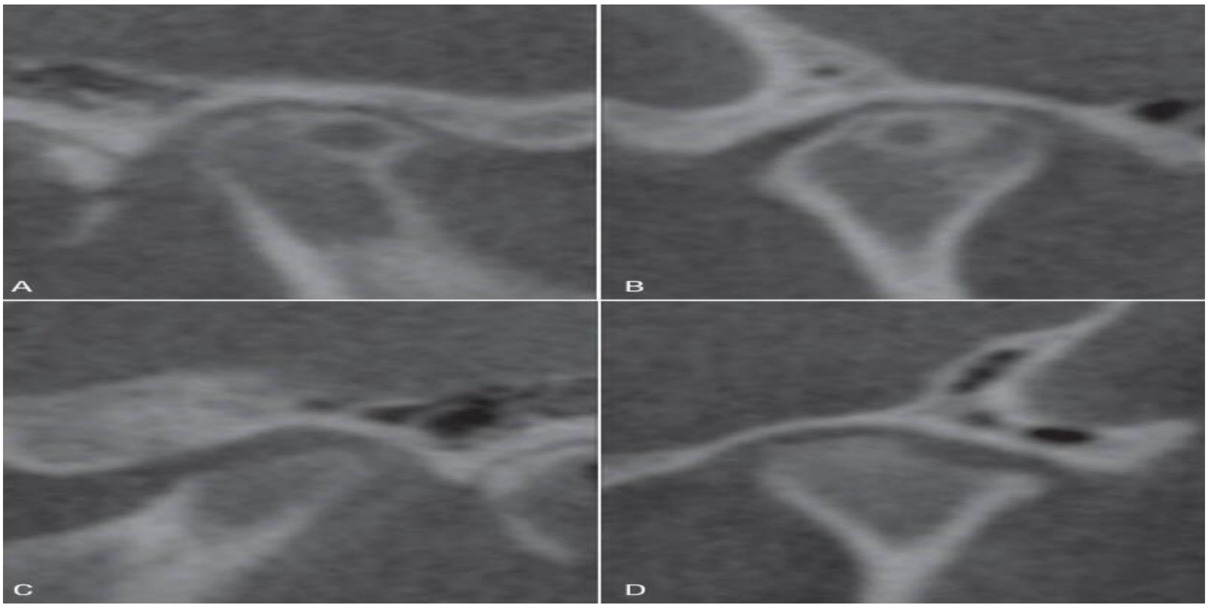


Figure (1-21): Cone-beam CT, closed position depicting various erosions in degenerative joint disease. A and B, Same patient, right side. Large subchondral cyst like erosion ("Ely cyst") of the condyle surrounded by a AB broad zone of sclerosis. Note also the thin joint space. C and D, Same patient, left side. Broad erosion of the anterolateral condylar surface. Note also the lack of cortication of the remaining condylar surface and flattening of the temporal component (White and Pharoah,2014)

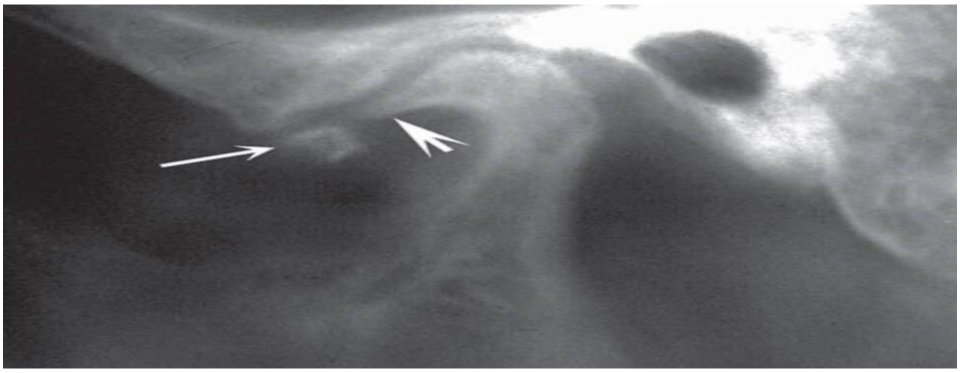


Figure (1-22): Sagittal tomogram of the left temporomandibular joint. A large osteophyte emanating from the anterior aspect of the condyle (short arrow) and a "joint mouse" (long arrow) positioned anterior to the condyle in the joint space (White and Pharoah,2014)

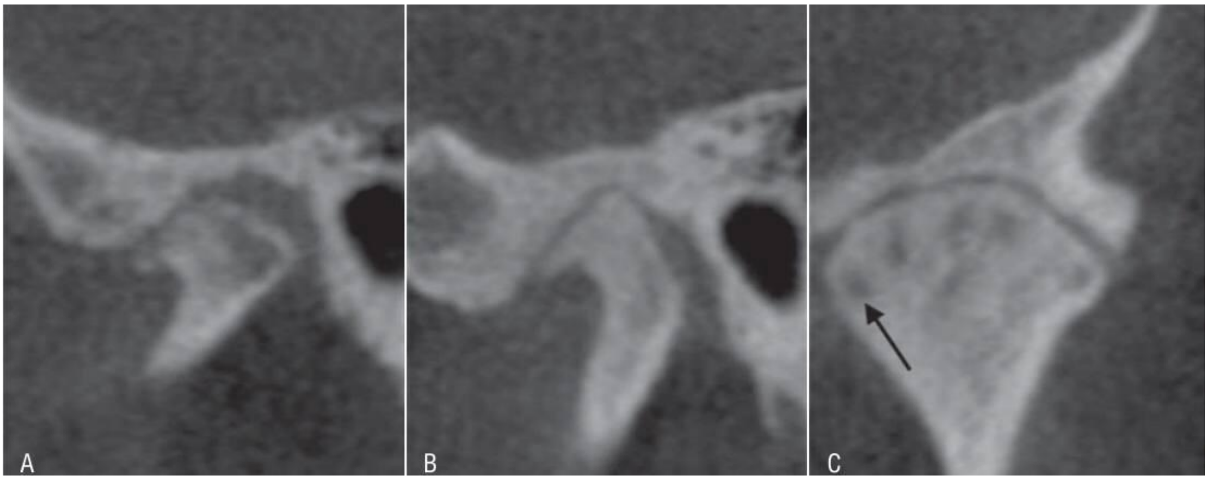


Figure (1-23): Cone-beam CT, closed position displaying two cases of degenerative joint disease (different patients). A, Sagittal reformat. Surface erosions of the condyle with osteophyte formation at the anterior aspect. Subchondral sclerosis, flattening and erosions of the temporal component. The condyle is also anteriorly positioned in the glenoid fossa. B, Sagittal reformat. Prominent osteophyte formation at the anterior aspect of the condyle, flattening and subchondral sclerosis of all joint components, with decreased width of the joint space. C, Coronal reformat, same patient as B. Multiple subchondral erosions not visible in the sagittal reformat (arrow, one example) (White and Pharoah,2014)

1.5.4. Trauma

1.5.4.1. Fracture

1.5.4.1.1. Definition

Fractures of the TMJ usually occur at the condylar neck and often are accompanied by dislocation of the condylar head. Fractures may be classified according to the anatomic location of the fracture: condylar head, condylar neck, and subchondral region. Occasionally more than one anatomic location is involved. On rare occasions the fracture may involve the temporal component (White and Pharoah,2009)

1.5.4.1.2. Clinical Features

Unilateral fractures, which are more common than bilateral fractures, may be accompanied by a parasymphyseal or mandibular body fracture on the contralateral side. The patient may have swelling over the TMJ, pain, limited range of motion, and an anterior open bite. Some TMJ fractures are relatively asymptomatic and may not be discovered at the time of trauma; instead, these come to light as incidental findings at a later time when radiographs are taken for other reasons. Condylar fractures should be ruled out if the patient has a history of a blow to the mandible, especially to the anterior aspect. If a condylar fracture occurs during the period of mandibular growth, growth may be inhibited because of damage to the condylar growth center.

The degree of subsequent hypoplasia is related to the stage of mandibular development at the time of injury (younger patients have more profound hypoplasia) and the severity of the injury (White and Pharoah,2009)

1.5.4.1.3. Radiographic Features

In relatively recent condylar neck fractures, a radiolucent line limited to the outline of the neck is visible. This line may vary in width, depending on whether the bone fragments are still aligned (narrow line) or displacement/dislocation has occurred (wider line).

If the bone fragments overlap, an area of apparent increase in radiopacity may be seen instead of a radiolucent line as shown in **Figure (1-24)**. Also, the outer cortical boundary may have an irregular outline or a step defect.

Approximately 60% of condylar fractures show evidence of fragment angulation and a variable degree of displacement (dislocation) of the fracture ends. Fractures of the condylar head are less common and may be of the vertical (responsible for the traumatic type of bifid condyle) or compressive type as shown in **Figure (1-25)**.

CT is the preferred imaging modality to evaluate condylar fractures because there is no superimposition of adjacent structures and TMJ reformats provide images in several different planes. Two- and three-dimensional reformatted images are useful to accurately locate a fractured fragment. Alternatively, if CT is not available, multiple right-angle radiographic projections from the lateral, frontal, and basilar aspects may be used to detect a fracture.

The amount of remodelling seen in the TMJ after a condylar fracture with medial displacement varies considerably.

In some cases the condyle remodels to a form that is essentially normal, whereas in other cases the condyle and mandibular fossa become flattened, with loss of vertical height on the affected side. The condyle eventually may show degenerative changes, including flattening, erosion, osteophyte formation, and ankylosis. These changes are more severe if the condyle is displaced. Condylar fractures can also be associated with damage of the intracapsular soft tissues, including the disk, joint capsule and retrodiskal tissues, and with hemarthrosis and joint effusion (White and Pharoah,2009)

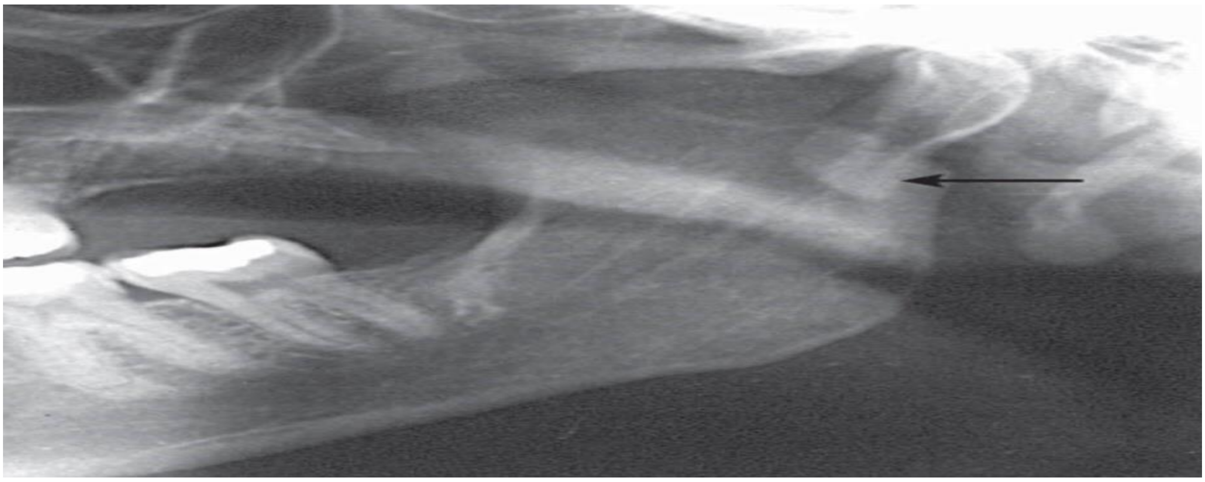


Figure (1-24): Condylar neck fracture (panoramic image). The arrow points to overlapped fragments, as evidenced by increased radiopacity (White and Pharoah,2009)

Figure (1-25): Open Towne's view of a compression fracture of the right condylar head (arrow) (White and Pharoah,2009)

1.5.5. Tumours

1.5.5.1. Benign Tumours

1.5.5.1.1. Definition

The most common benign tumour to affect the TMJ is osteoma followed by osteochondroma. Osteomas may occur as single isolated lesion or as a part of Gardner's syndrome. These benign tumours often produce a tender swelling and patients usually give a history of trauma (Ongole and Praveen,2013)

1.5.5.1.2. Clinical Features

Benign tumours all the benign tumours share the similar features of slow growth of the tumour mass, gradually developing malocclusion (generally unilateral posterior open bite, deflection of the mandible to the unaffected side, facial asymmetry, joint noises and restriction in jaw movements. Benign tumours are usually painless (Ongole and Praveen,2013)

1.5.5.1.3. Radiographic Features

Condylar tumours cause condylar enlargement that often is irregular in outline. They may radiographically present as a well- defined nodular mass extending from the condylar head, unlike hyperplasia where there is uniform enlargement of the condylar head. Another distinguished feature between the two is that the hyperplasia occurs usually as a reactive lesion to trauma, whereas benign tumours arise spontaneously. **Figure (1-26)** (Ongole and Praveen,2013)

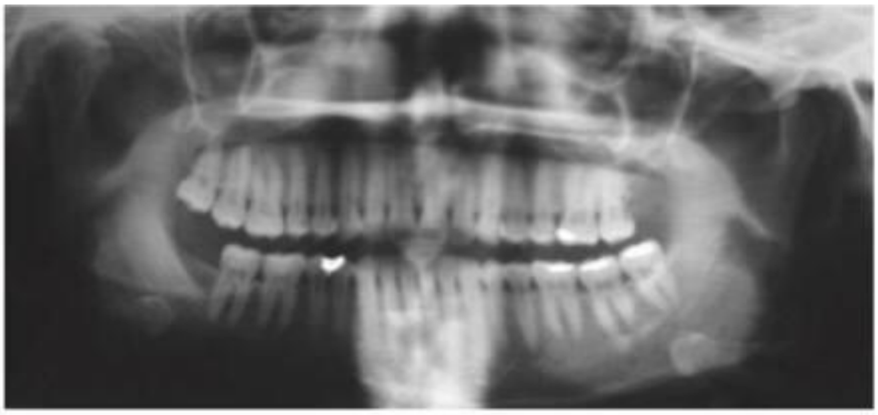


Figure (1-26): Orthopantomograph showing uniform enlargement of the condylar head on the right side (Ongole and Praveen,2013)

There may be decreased trabecular density owing to bony destruction or increased density owing to new, abnormal bone formed by the tumour.

An osteoma or osteochondroma appears as an irregular, often pedunculated radiopaque mass attached to, or growing from, the condyle. Osteochondromas are benign tumours that most often extend from the anterior surface of the condyle near the attachment of the lateral pterygoid muscle. These bony growths usually have a cartilaginous cap. To differentiate these from osteomas, it is important to note that the internal cancellous bone of the condyle is continuous with the internal structure of the osteochondroma as shown in **Figure (1-27)**.

Langerhans' histiocytosis creates well-defined radiolucent defects within the bone, and a laminated periosteal reaction may be seen along the adjacent cortices. Osteoblastomas manifest with mixed radiolucent and radiopaque patterns .Because benign tumours may interfere with normal joint function, secondary bone remodelling or degenerative changes may be seen in the affected joint.

Tumours of the coronoid process may also affect TMJ function, which emphasizes the need to image and evaluate the coronoid process when evaluating joint abnormalities (White and Pharoah,2014)

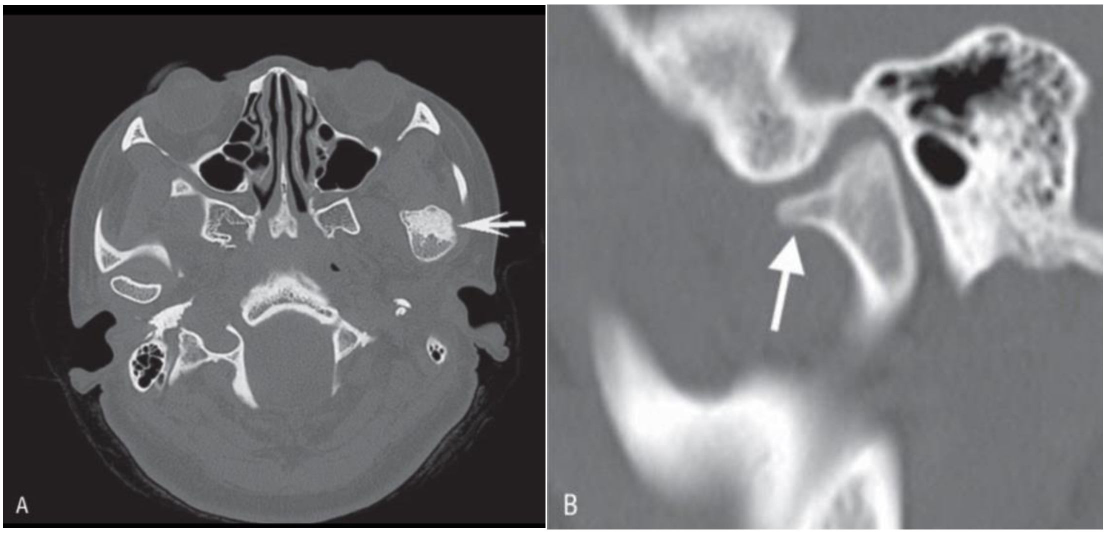


Figure (1-27): A, Axial bone algorithm CT image of an osteochondroma extending from the anterior surface of the left condylar head (arrow). B, Sagittal reformat CT image of a different case; the internal aspect of the osteochondroma (arrow) is continuous with the cancellous portion of the condylar head (White and Pharoah,2014)

1.5.5.2. Malignant Tumours

Chondrosarcomas account for about 1–3% of the sarcomas affecting the facial bones and jaws. Low-grade tumours have excellent prognosis (however high recurrence rates are common), whereas high-grade tumours may metastasize through the lymphatics. Many of the patients complain of a rapidly growing swelling (in the pre- auricular region) and pain, diminished hearing and restricted mouth opening (Ongole and Praveen,2013)

Synovial chondrosarcoma (SC) may usually originate as a primary from the synovium or secondarily in an already existing synovial chondromatosis. SC presents as a soft tissue mass resulting in TMJ dysfunction and pain. Radiographs reveal clumps of calcifications occurring in a soft tissue mass. The articulating surfaces may show erosion. Joint space may occasionally exhibit freely lying cartilaginous nodules. The clinical features include mild pain, malocclusion and restricted mouth opening and other mandibular movements. Radiographs reveal extensive destruction of bone. Metastasis to the lungs is common (Ongole and Praveen,2013)

1.5.5.2.1. Radiographic Features

Malignant primary and metastatic TMJ tumours appear as a variable degree of bone destruction with ill-defined, irregular margins. Most lack tumour bone formation, with the exception of osteogenic sarcoma. Chondrosarcoma may appear as an indistinct, essentially radiolucent destructive lesion of the condyle with surrounding discrete soft tissue calcifications that may simulate the appearance of the articular loose bodies seen in chondrocalcinosis or pseudogout as shown in **Figure (1-28)**. In the case of metastatic tumours, the radiographic appearance usually is nonspecific condylar destruction (with a few exceptions, such as metastatic prostate carcinoma) and does not indicate the site of origin as shown in **Figure (1-29)**. CT is the imaging modality of choice to view bone involvement and MRI is useful for displaying the extent of involvement into the surrounding soft tissues (White and Pharoah,2009)

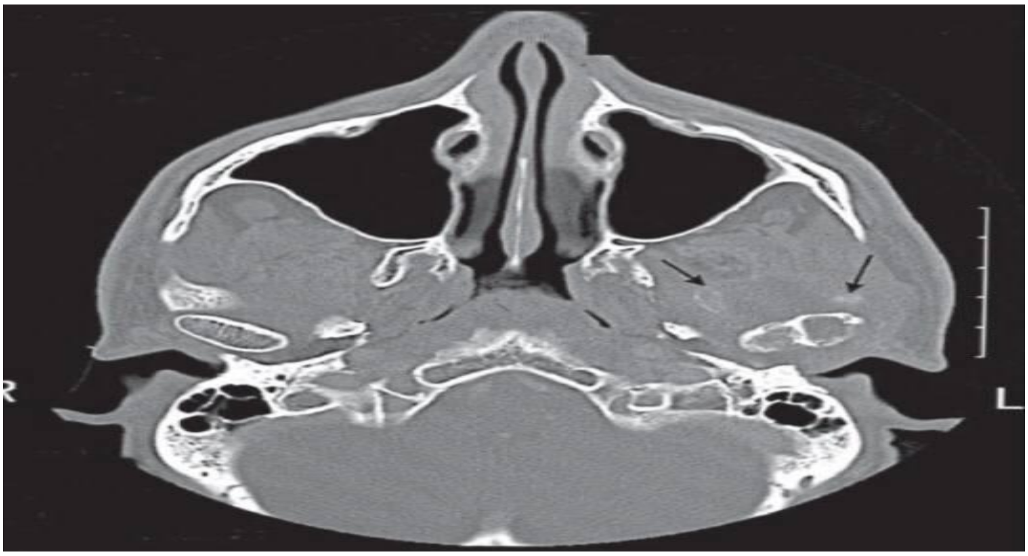


Figure (1-28): Chondrosarcoma (CT, axial section, bone algorithm). A radiolucent destructive lesion is present in the left condylar head, and faint radiopacities (soft tissue calcifications) are visible anterior to the Condylar head (arrows) (White and Pharoah,2009)

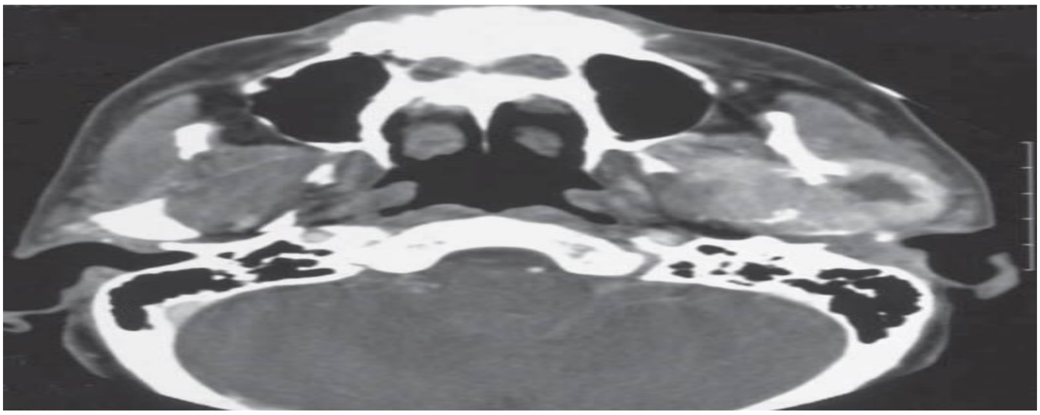


Figure (1-29): An axial, soft tissue algorithm, CT image of a metastatic lesion from a carcinoma of the thyroid gland that has destroyed all of the left mandibular condyle (White and Pharoah,2009)

Chapter 2

Conclusion

Chapter 2

2.1. Conclusion

- Although the clinical examination is the most important step in the diagnosis of TMJ pathology, special imaging techniques are needed due to the complex anatomy and pathology. It is very common to take an image of the joint when there is locking, pain and articular sounds.

- The clinician should properly decide which patients would need special imaging techniques depending on the clinical examination, the amount of diagnostic information available from a particular imaging modality, the cost of the examination, and the radiation dose.

- One important thing to consider when imaging the TMJ is the interpretation of the joint function, which can be accomplished by comparing the condyle in the closed and opened mouth position.

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