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DIAGNOSTIC RADIOLOGY IN TEMPOROMANDIBULAR JOINT DISORDERS

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Abstract:

The temporomandibular joint disorders (TMDs) are a group of complicated and multifactorial disorders. Identifying the primary etiologic variables is crucial for the effectiveness of any treatment method. TMDs are primarily diagnosed by a comprehensive clinical examination and investigation of presenting signs and symptoms. Occasionally, additional diagnostic tests are required to acquire more information or to corroborate the clinical diagnosis. Various imaging modalities are used to identify the morphology of the joint as well as to study the functional relationship of the condyle to the fossa. The purpose of this article is to cover briefly the various TMD imaging modalities.

Introduction:

Temporomandibular joint (TMJ) is a ginglymoid-arthrodial composite joint made up of an articular disc, two bones (mandible and temporal bone), a fibrous capsule, an intra-articular fluid, a synovial membrane, and ligaments[1].

Temporomandibular joint disorders (TMDs) have been thoroughly researched but remain a mystery after all these years. AAOP (American Academy Of Orofacial Pain) defines TMD as a complicated term that encompasses a variety of clinical disorders affecting the masticatory muscles, the joint, and the related structures. Pain, restricted mouth opening, and joint noises (clicking, crepitation) are the most prevalent clinical symptoms.[2]

The most critical step in diagnosing TMDs is a thorough clinical examination. The joint's complicated anatomy and location need the use of many imaging methods for diagnosis and treatment planning. In each clinical situation, the sort of imaging to be performed is determined by the clinician's experience and expertise.

In a variety of clinical conditions, standard radiography TMJ projections such as transpharyngeal, transcranial, panoramic radiographs, and conventional tomographic sections of TMJ may be appropriate. Bony changes, such as erosions, osteophytes, and pneumatization of the articular eminence, are difficult to identify on standard radiographs [3] because of the overlapping anatomical structures. This necessitates the utilisation of modern imaging techniques such as computed tomography, magnetic resonance imaging (MRI), cone beam computed tomography (CBCT), ultrasonography, and nuclide imaging.[4]

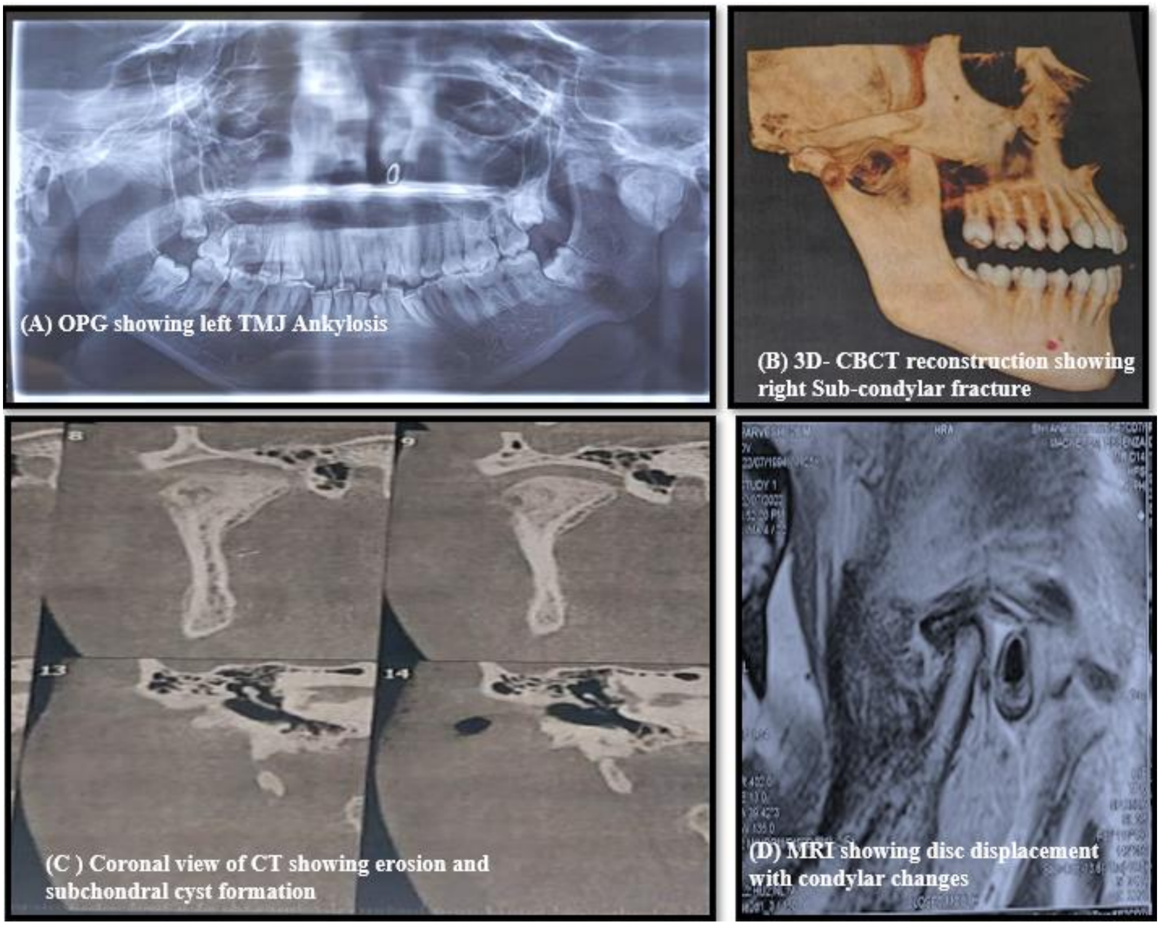

Figure 1: Different radiographic techniques utilized for TMDs.

Conventional Radiographic Techniques [1]

Panoramic imaging

Lateral transcranial view

Trans-pharyngeal view

Trans maxillary (anteroposterior [AP]) view

Panoramic Imaging

As its use results in the little superimposition of structures over the condyles, it has been frequently utilised in dental clinics for the screening of condyles.[1] It aids in finding any periodontal or odontogenic source of orofacial discomfort.

It is useful for evaluating [5]:

Late stages of degenerative bone alterations

Asymmetrical condyles

Hyperplasia, hypoplasia

Trauma

Tumours

Even though it is frequently used and useful for analysing osseous features, it has several drawbacks, such as[1]:

In circumstances of restricted mouth opening, superimposition is present.

Articular fossae are often fully or partially concealed.

As this is an infracranial image, the lateral pole is superimposed over the condylar head, and the region that represents the superior subarticular surface of the condyle is really the subarticular surface of the medial pole.

Compared to CT, it has relatively low specificity and sensitivity. [6,7]

Changes in head posture may alter the TMJ, imitating various bone disorders.[8]

Bony alterations of the condyle can be detected by panoramic radiography, but when these changes are suspected and the radiographs are normal, CT should be performed.[9]

Transcranial Projection

X-rays are directed inferiorly across the skull (above the midface) to the contralateral TMJ and recorded.[1]

It can be beneficial in

Identifying advanced phases of degenerative joint changes.[10]

Evaluation of condylar location relative to the fossa.[10]

However, restrictions include:

Even in asymptomatic individuals, the condylar position varies widely[14,15].

the medial pole of the condyle is superimposed under the central subarticular surface and lateral pole[1].

Transpharyngeal view:

Even though this image is comparable to the panoramic view, the direction of the x-rays (from below the angle of the mandible or through the sigmoid notch) causes the angle at which the condyles are projected to be less than in the panoramic view.[1] This view is more akin to a real lateral view. This image demonstrates the condyles adequately, although the mandibular fossae are not clearly visible.

Transmaxillary Projection:

It is acquired with the mouth wide open and the condyles translated out of the fossae, proceeding from anterior to posterior. It assists in acquiring a clear picture of the condyle's superior subarticular bone and provides excellent visibility of the medial and lateral poles

A great view for assessing a fracture of the condyle neck.

But its use is lost if the condyles cannot be translated to the crest of prominence, since subarticular bone will be superimposed.[1]

Innovative Imaging Methods

Tomography by Computed Tomography (CT)

Computed Tomography Using a Cone Beam (CBCT)

Magnetic Resonance Imaging (MRI)

Ultrasound imaging (USG)

Nuclide Imaging

Tomography by Computed Tomography (CT)

In the 1980s, CT entered the area of TMJ evaluation[16]. CT is regarded as the most accurate approach for diagnosing osseous abnormalities in the TMJ. It permits multiplanar reconstruction of TMJ components and 3D imaging in both the open and closed mouth positions. [5] CT can be used to evaluate degenerative joint changes[10], surface erosions, osteophytes, remodelling, subcortical sclerosis, articular surface flattening, alterations to the design and placement of the loading zone, Malignant tumours, abnormal growth development, and fractures.

Any CT examination of the TMJ should primarily concentrate on the following: intactness of the cortex, normal size and form of the condyles and their centred location within the fossa, appropriate joint spaces, and centric relation loading zone.[5]

However, CT scans have some drawbacks, including[5]:

The equipment is relatively costly and, hence, not always available.

CT scans expose patients to more radiation than conventional radiographs.

CT cannot see the soft tissues of the TMJ (disc, synovial membrane, ligaments, lateral pterygoid muscle).

Accidental patient movement during an examination might cause artefacts to emerge (especially in children).

Computed Tomography Using a Cone Beam (CBCT)

A CBCT equipment utilises a cone-shaped beam and a reciprocating solid-state flat panel detector, which revolves once around the subject (180-360 degrees), covering the defined anatomical volume (full dental/ maxillofacial volume or limited regional area of interest). This equipment's designation is not based on the idea of sectional pictures, but rather on the computer processing of a single rotating scan of the region of interest.[4]

Cone beam tomography is capable of imaging both hard and soft tissues; consequently, the disc-condyle interaction may be examined and analysed without disrupting the anatomical relationships already in place. Initiated in the 1990s for TMJ examination, cone beam CT is now widely accessible and allows high-resolution multiplanar reconstruction of the TMJ[17,18].

The major benefit of cone beam CT over CT is the decreased radiation exposure to the patient. [19,20,21] The spatial resolution of cone beam CT is higher than that of conventional CT.[22] The reconstructed pictures are of good diagnostic quality, and the examination time is shorter. When investigating bony changes of the TMJ, it is therefore the preferred imaging approach.[4]

The following are the key contributions of cone beam CT to the field of TMJ, as outlined in a review by Silvia Caruso et al:[23]

enables the computation of the condyle's volume and surface;

enables detection of the mandibular condyle form and facilitates qualitative evaluations of condylar surface;

Improves the precision of linear mandibular condyle measurements;

Clarifies that, in cases of face asymmetry, the condyles are typically symmetric, although the joint space may vary between the two sides;

The location of the condyle in the fossa is clarified.

Magnetic Resonance Imaging (MRI)

The MRI has become the gold standard for assessing the TMJ's soft tissue, particularly disc position. It employs a powerful magnetic field to alter the energy level of soft tissue molecules (principally hydrogen ions). These variations in energy levels provide a picture akin to a CT scan in a computer.[1] Imaging of soft tissues is superior to computed tomography, less invasive than arthrography, and more reliable than radiography.[4]

Images may be obtained in all planes (sagittal, axial, coronal). In the majority of scanning sequences, T1-, T2-, and proton-density (PD) pictures are produced. The PD images serve to visualise the disc-condyle relationship, whereas T2-weighted images are used to diagnose inflammation in the joint. [25,26] T1-weighted sagittal images are the foundation of the TMJ examination; the anatomy is clearly depicted, and the imaging plane is ideal for assessing articular disc position. T2-weighted imaging can reveal degenerative periarticular changes and joint effusion.[27]

Important for picture quality is the slice thickness. The most common section thickness is 3 millimetres. Reducing the slice thickness enhances the picture quality, but increases the scanning time.[28]

In MRI examination, a pathological condition is considered to exist relative to the intermediate zone of the meniscus (as a reference point) and its interposition between the condyle and the temporal bone.[29] Normal disc position, evaluated in the sagittal plane, has the junction of the posterior band aligned approximately at 12 o'clock, position relative to the condyle. When the posterior band sits anterior, posterior, medial, or laterally in relation to the condylar surface, disc displacement is diagnosed.[30] Synovitis is plainly seen on MRI imaging.[31]

The benefits of MRI include [22]:

It requires no ionising radiation for picture capturing

It enables direct observation of the joint and disc architecture.

Multiplanar imaging is commonly available and easier to understand.

The following drawbacks of the MRI examination might be mentioned: [32,33,34]

It is expensive and time-intensive.

Use with caution in patients with claustrophobia or incapacity to keep still.

Contradicted in pregnant patients, those with pacemakers, intracranial vascular clamps, or metal particles in essential structures.

There is a chance of missing the section of the condyle containing the pseudo cyst.

May overlook diverse bone problems and soft tissue calcifications with inflammatory illnesses or malignancies; CT is the preferred imaging modality in these instances.

Typically, it is a static picture.

The doctor should be aware that the appearance of a displaced disc on an MRI does not always indicate a pathological result. It has been observed that between 26% and 38% of normal, asymptomatic people exhibit aberrant disc positions on MRIs. These studies demonstrate that false positives and false negatives are widespread with these imaging methods; as a result, caution must be exercised while utilising them.[1]

Ultrasound imaging (USG)

Using a 3.5 MHz transducer, Nabeih et al. used High-resolution ultrasonography (USG) for the first time in TMJ exploration in 1991.[35] The principle behind USG is that ultrasonic sound waves emitted by the transducer propagate through the tissue against which they are aimed and are partially reflected when passing through dissimilar anatomical structures. The reflected sound waves are then read by the same emitting device and translated into images.[36] It uses current types of ultrasonic equipment with a linear scanning transducer with a frequency of 7.5–12 MHz, which makes it possible to depict the narrow space of the jaw joint and the position of the joint disc, as well as revealing fluid or ligament adhesion.[37]

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The varying degrees of sensitivity and specificity described in the scientific literature are a result of the varying USG frequencies in various devices. The use of high-resolution USG (transducer at least 7.5 MHz or higher) considerably enhances the diagnostic utility of this procedure. [38,39]

USG can aid in the detection of disc displacement and effusion to a limited degree. Typically, the disc is located between two hyperechoic lines, which are the mandibular condyle and the articular eminence. If the disc is displaced in the mouth-closed posture, disc displacement is the diagnosis. If the disc returns to its usual position during othe pening, disc displacement with reduction is the diagnosis. If not, disc displacement without reduction is the diagnosis.[5]

The benefits of USG include [4]:

non-invasive

dynamic

affordable method

rapid examination method

offered in the majority of healthcare facilities.

The downsides include[4,5,40]:

not advised in the diagnosis of TMJ degenerative changes

Due to overlaying osseous structures, acquiring crisp pictures is challenging.

The medial portion of the disc cannot be seen.

Diagnostic value is totally dependent on the expertise of the clinician and the equipment utilised.

Lack of consistency in conducting USG (selection and settings of transducer, mouth opening position, interpretation of results)

Future usage of better resolution technology will enhance USG's sensitivity, accuracy, and positive predictive value, making it a dependable imaging modality.[41]

Nuclide Imaging

Nuclear medicine is the medical speciality concerned with the investigation, diagnosis, and treatment of radioactive substances. Radiopharmaceuticals are medicines comprising a radioactive isotope as a tracer and a ligand, which is a molecule, chemical substance, or cell (e.g. granulocyte) with an affinity for a certain tissue or organ .[42]

A single static gamma camera (also known as a scintillation camera), one or more spinning gamma cameras, or multi-headed gamma cameras can be used to register radiation.

Depending on the type of registration equipment, imaging techniques are categorised as follows:

Scintigraphy,

SPECT (single-photon emission computed tomography) and

Positron emission tomography (PET).

Scintigraphy

Scintigraphy aids in the analysis of early TMJ alterations. In bone scintigraphy, osteotropic tracers, most frequently methylene diphosphonate (MDP) coupled with radioactive technetium (99mTc), are administered intravenously (arm, hand or foot). MDP targets bone tissue, and its absorption is dependent on bone mineralisation, collagen content, vascularization, and bone remodelling. Forming of hydroxyapatite crystals in the areas of production of new osteoid tissue by osteoblasts leads to an increased uptake of tagged MDP; thus, these areas accumulate more radioactive tracer and appear "hot".[43] Planar scintigraphy of TMJ is performed typically in anterior, posterior, right lateral, and left lateral projections with 500,000 counts per image.

SPECT stands for Single-Photon Emission Computed Tomography (SPECT)

SPECT relies on the registration of radiation emission with a rotating gamma camera in order to obtain projections from multiple angles. Despite using the same radiopharmaceuticals as scintigraphy, the obtained pictures are more exact in identifying regions of tracer uptake than those produced by scintigraphy. The temporomandibular joint is appropriate for SPECT due to its small size and proximity to the base of the skull and paranasal sinuses. [4]

The radionuclide examination has a high sensitivity but a low specificity. Local isotope concentration is increased by inflammation, trauma, and malignancies. Numerous studies conclude that radionuclide testing is only useful as a screening procedure .[47]

The following SPECT uses in TMJ imaging have been reported[42].

Unilateral hypertrophy of the condyles

Bone tracer uptake in individuals with TMJ discomfort.

Osteoarthritis

Evaluation quantitative of temporomandibular disorder (TMD)

Evaluating the efficacy of functional orthopaedic TMJ therapy.

Electron Positron Tomography

Positron Emission Tomography (PET) is an imaging technology used in nuclear medicine that offers cross-sectional data based on the three-dimensional localisation of positrons generated by radiotracers. PET has the following benefits over scintigraphy:[4]

its intersecting nature

enhanced sensitivity and spatial resolution

helps in assessing metabolic body responses

gives functional information based on the molecular interaction of the radiotracers.

Early detection of malignant tumours;

Staging of some tumours, such as lymphoma;

planned radiation treatment; and

Localization of a primary tumour whose metastases are known,

reaction to therapy,

Follow-up and distinction between recurring tumour and post-treatment lesions caused by, for instance, radiation.

PET data represents the distribution of the radiotracer within the imaging region, but does not give structural information on the patient's anatomy. Typically, PET is paired with computed tomography, which offers structural information about the patient, to allow anatomic localisation of regions of elevated radiotracer uptake.[48]

The first study to evaluate the clinical utility of PET/CT in patients with TMD was published in 2013 by Lee JW et al. [44]. They concluded that PET/CT demonstrated high TMJ uptake ratios in patients with osteoarthritis, while accuracy and sensitivity were greater than in conventional bone scintigraphy. Suh MS, et al examined patients with temporomandibular joint disorder (TMD) using PET-CT with 8 F-sodium fluoride (NaF) as a tracer and discovered that this imaging modality was useful in arthralgia TMJ and TMD osteoarthritis, and a correlation was found between the patients' response to splint therapy.[45]

Conclusion:

The accurate diagnosis and treatment planning of TMDs can be aided by a thorough case history, clinical examination, and imaging approach. Initial diagnostic phases are aided by radiographic evaluation, but the complicated anatomy and function of the TMJ makes it difficult to analyse the joint thoroughly using radiography. However, it is still utilised and has survived the test of time. CT is one of the most dependable imaging techniques for TMJs due to its ability to identify osseous abnormalities. The MRI is considered the gold standard for diagnosing TMDs. It is the only test that permits the identification of the disc, soft tissue, cortical bone shape, and bone marrow of the mandibular condyle, displaying the entire form of joint problems and highlighting the soft tissue and bone marrow abnormalities of the TMJ .[4]

CBCT is becoming increasingly prevalent today. Clinicians value it more due to its lower radiation dose compared to CT and its three-dimensional reconstruction. USG is a non-invasive, cost-effective method for identifying joint effusion and articular diseases. However, the technology utilised and the examiner's skill significantly impact USG interpretations. Nuclear medicine and its use in the investigation of TMJ is of interest to researchers since it can aid in the identification of the majority of TMDs.

All of these are only useful with a comprehensive understanding of the anatomy, physiology, and biomechanics of the TMJ.

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