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Review Article **Oral Medicine**

Diagnostic Imaging of Temporomandibular Joint- A Review

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Abstract

The Temporomandibular Joint (TMJ) articulation is classified as a ginglymodiarthrodial joint, namely, a joint that is able of hinge-type movements (ginglymos) and gliding movements, with the bony components enclosed and connected by a fibrous capsule [1]. Temporomandibular disorders (TMD) affect more than 5% of the general population. *Radiographic investigation of the temporomandibular joints (TMJ) offers information adding to the clinical examination, and establishing the final diagnosis* [3]. A wide range of diagnostic tools creates a possibility of a multidisciplinary insight into temporomandibular disorders in order to diagnose them correctly [6]. The goals of TMJ radiography are to evaluate cortical and trabecular architecture of the bony structures and confirm their integrity, to assess the extent and monitor progression of osseous changes, and to evaluate the response to treatment [9].

Keywords: Temporomandibular disorders; temporomandibular joint; TMD, diagnostic tools, TMJ radiography.

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1. INTRODUCTION

TMJ has a disk, articular surfaces, fibrous capsule, synovial fluid, synovial membrane, and ligaments. Uniqueness of TMJ is the articular surfaces are covered by fibrocartilage instead of hyaline cartilage. The articular surfaces of the TMJ are formed inferiorly by the mandibular condyle and superiorly by the glenoid fossa (also known as mandibular fossa) and articular eminence of the temporal bone [2]. The diagnosis and management of the most common cause of non-dental pain in the maxillofacial region, namely temporomandibular disorders (TMD), remains a challenge for clinicians [8]. The American Academy of Orofacial Pain classifies TMD as masticatory muscle disorders and articular disorders. The latter group includes developmental and acquired disorders, articular disc disorders, inflammatory disorders, osteoarthritis, condylar dislocation, ankylosis and fracture. Clinical examination alone is insufficient to fully assess the osseous and soft tissue components of the TMJ [9]. Different imaging modalities are available to image the TMJ, each with inherent strengths and weaknesses [2].

Various diagnostic imaging tools for detection of TMDs:

Many diagnostic means have been indicated for the diagnosis of temporomandibular disorders (TMD) [4].

A variety of modalities can be used to image the TMJ.

This includes:	**(1) Non-Invasive Imaging Modalities**
	(2) Invasive Imaging
	(1) Ionizing radiation
	(2) Non ionizing radiation
	(1) Hard tissue examination
	(2) Soft tissue examination

These include such as:

- Conventional radiographs
- Ultrasound
- CBCT (cone beam computed tomography
- Computed tomography (CT)
- MRI

Invasive Imaging modalities such as:

- Arthrography

- Radionuclide examination
- Scintygraphy
- Electromyography
- Electronic thermograph [2]

In this article we will be discussing about non invasive imaging modalities.

Conventionl radiography:

This radiography includes transcranial projection, taranspharyngal projection, Transorbital and Reverse Open Towne's Projection, submentovertex projection, orthopentomograph.

Transcranial Projection (Lateral Oblique):

The transcranial projection is useful for an overall view of the joint and allows identification of gross osseous abnormalities of the lateral aspect of the joint, condylar fractures, and range of motion (open views).

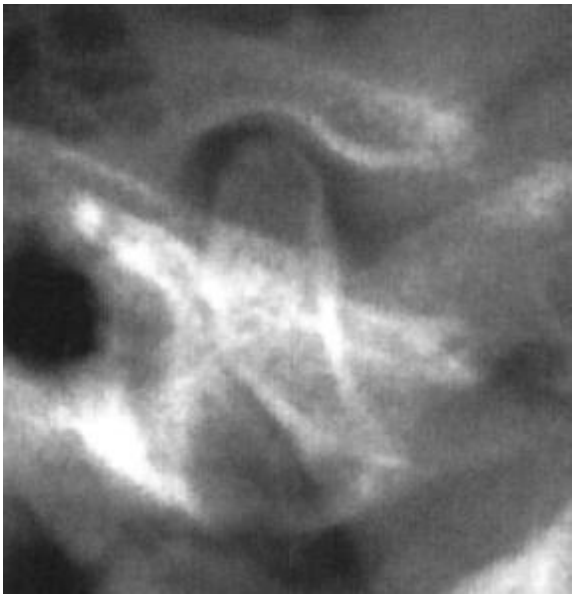

Figure 1: Transcranial projection taken in the maximally closed mandibular position. The lateral aspect of the condylar head and glenoid fossa are visible

Transpharyngeal (Parma) Projection:

This projection may depict only gross osseous abnormalities of the condyle, such as large erosions, osteophytes, or fracture.

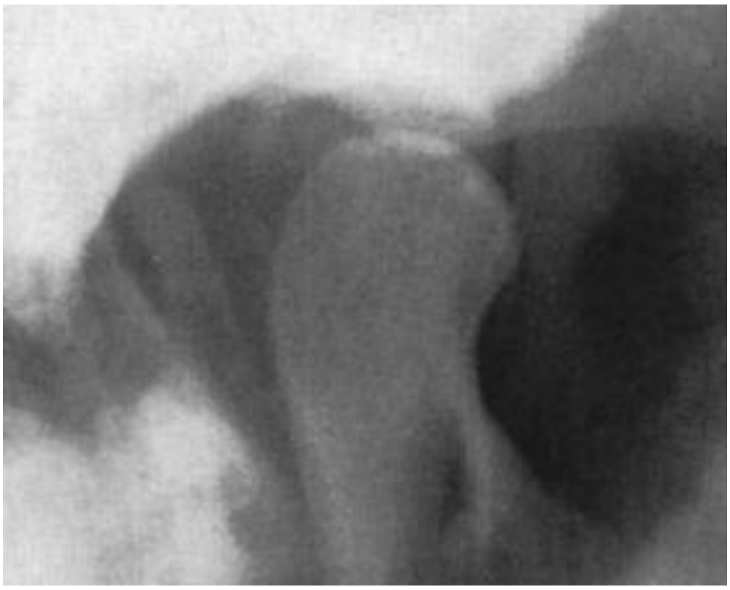

Figure 2: Transpharyngeal projection taken in the maximally open position. The medial aspect of the condylar head is visible, but the temporal component is obscured due to superimposition from the skull base

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Transorbital and Reverse Open Towne's Projection:

The transorbital and reverse open Towne's projections provide a coronal (frontal) view of the condyle(s) perpendicular to transcranial and transpharyngeal projections. The reverse open Towne's view is a similar projection to the transorbital but is taken without turning the patient's head and with a steeper vertical beam angle.

Figure 3: Transorbital view taken with the mandible protruded. The entire medial-lateral dimension of the condylar head and articulating surface of the articular eminence are visible

Submentovertex (Basal) Projection:

This projection provides a view of the skull base and condyles superimposed on the condylar necks and rami. It is often used to determine the angulations of the condylar long axes in corrected transcranial or tomographic projections.

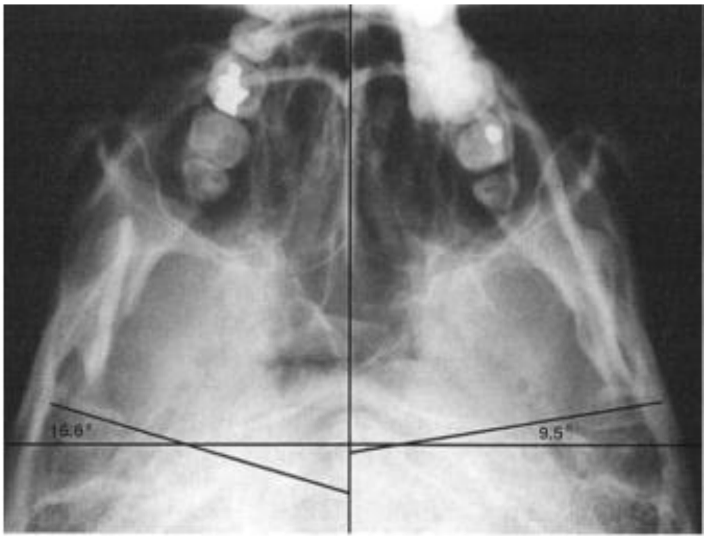

Figure 4: Submentovertex projection illustrating determination of condylar long axis for corrected tomography [15]

CBCT imaging appearances of com

The diagnostic efficacy of CBCT for detecting these osseous changes is superior to that of panoramic radiography, linear tomography and MRI. The goals of TMJ imaging by CBCT are to evaluate the integrity of the bony structures when disorders are suspected, to confirm the extent and stage of progression of disorders, and to evaluate the effects of treatment. Below we describe common conditions of the TMJ where CBCT imaging plays an important role in diagnosis and treatment planning.

When an inflammatory disorder of the TMJ issuspected, CBCT is recommended for evaluation ofsubtle osseous abnormalities.

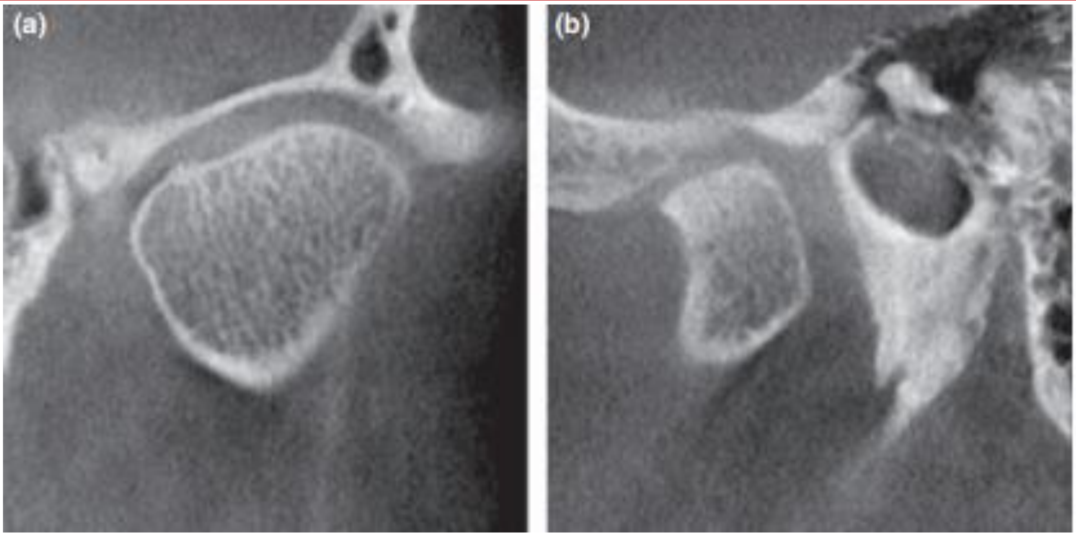

Figure 5: a) Corrected frontal and (b) corrected sagittal CBCT sections. Note flattening of the antero-superior surface of the condy(lar head with cortical thickening and subchondral sclerosis

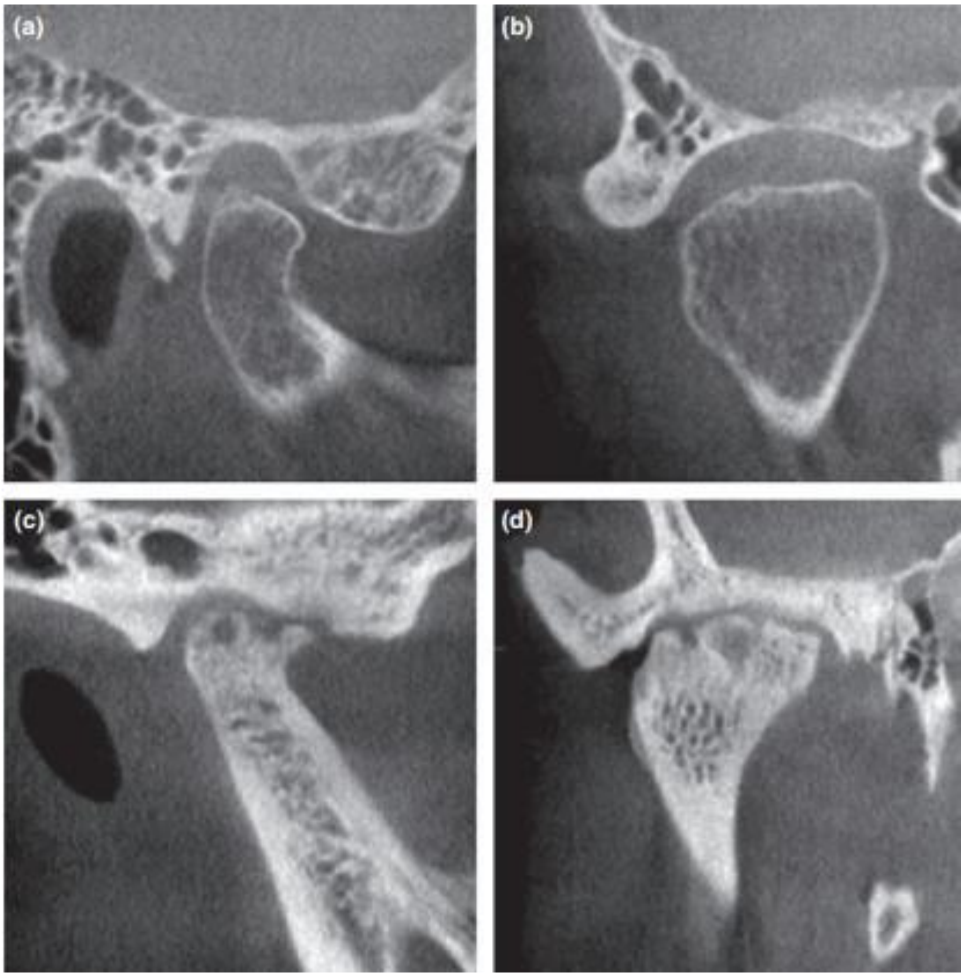

Figure 6: Osseous changes characteristic of osteoarthritis. (a and c) Corrected sagittal and (b and d) corrected frontal sections using limited FOV CBCT. (a and b) Mild erosion of the condylar head and normal glenoid fossa. (c and d) Severe erosion, bone sclerosis, osteophyte formation, subcondral cysts and reduced joint space

Ultrasound

Ultrasonography (US) has emerged in recent years as an alternative diagnostic method, as it is less expensive, not invasive, and does not demand special facilities.

A large proportion of patients affected by TMJ arthritis are completely asymptomatic during the early stages of the disease (complaining of neither pain nor impaired TMJ function) and present a normal TMJ clinical examination, radiographic signs of TMJ damage may still be revealed even in the early phases of the disease.

To overcome the limitations, a promising alternative diagnostic tool seems to be represented by US, which is relatively inexpensive and potentially accessible in most outpatient clinics, after an adequate operator's training. The examination only takes 10–15 min ordinarily, a tolerable time even for the youngest patients; in the absence of radiation or any other risk, it is pain-free, and it allows dynamic real-time assessment, while the mouth is closed or opened, with the option of direct communication with the patient that can guide examination to painful regions. Furthermore, it does not require any sedation in children. However, it is unclear whether it can identify the active inflammation and arthritic sequelae as accurately as CE-MRI [7].

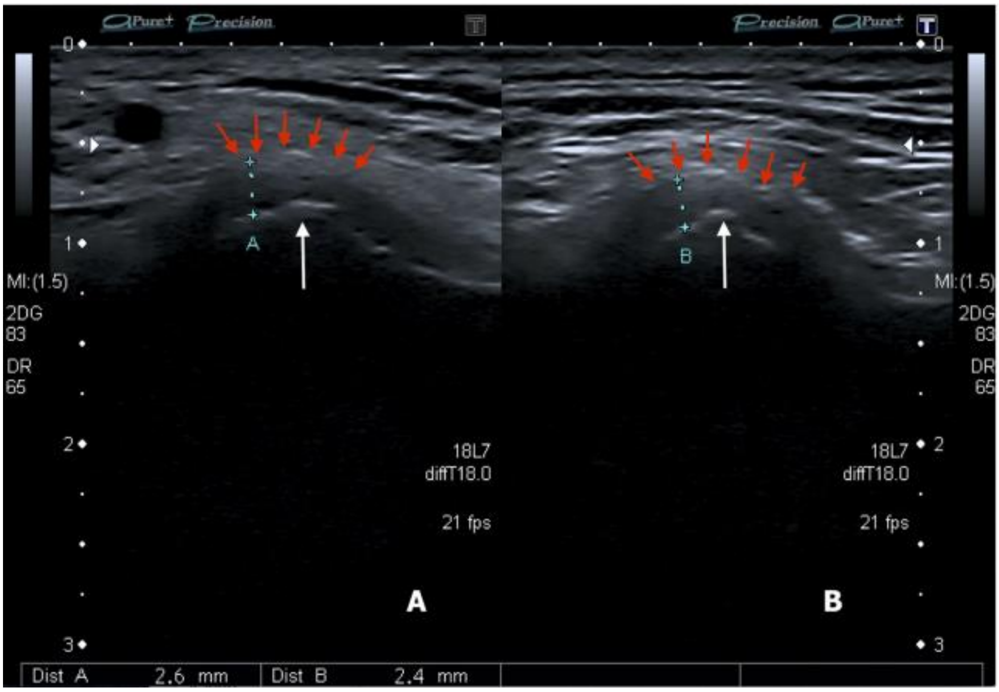

Figure 7: Transverse image of the right (A) and left (B) TMJs showing the condyle and capsular width (distance between markers). White arrows show the condylar process and red arrows show the articular capsule

Magnetic Resonance Imaging

MRI allows excellent depiction of the TMJ anatomy and abnormalities because of its inherent tissue contrast and high resolution, and the use of surface coils. MRI has become the examination of choice in evaluating the TMJ. MRI studies are noninvasive and display the meniscus, but also differentiate the cortex, marrow, hyaline cartilage, muscle, fluid, and fibrous tissue. The inherent soft-tissue discrimination facilitates thin-section acquisitions. The development of faster imaging techniques and dual-coil imaging has facilitated routine bilateral examination with functional or kinematic positioning of the joint [10].

Conventional MRI Protocols and Manifestations:

Conventional MRI of TMD is usually performed with 1.5T or 3.0T scanners with a head coil or TMJ surface coil.24,25 Clinical examination often includes static T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), and proton density-weighted imaging (PDWI) in open- and closed mouth positions, which are usually generated by a fast spin echo (FSE) sequence,26 showing the anatomical and pathological changes of TMD. Typically, the normal TMJ disc is biconcave in shape, presenting as hypointensity on T1WI, T2WI, and PDWI. The soft tissues of the bilaminar zone and LPM show moderate signal on T2WI but still lower than the T1WI in a healthy TMJ. Additionally, the cortex of the condyle and articular eminence shows no signal on MRI, while its marrow manifests a relative high signal due to a higher lipid content.

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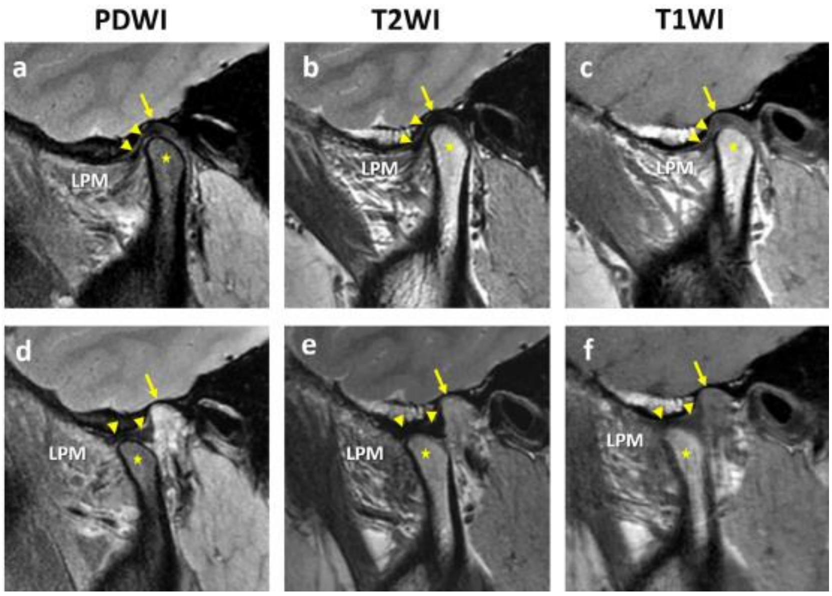

Figure 8: Conventional MRI of normal TMJ in (a–c) closed-mouth position and (d–f) open-mouth position, showing the static anatomy of TMJ and related muscles, including TMJ disc (triangle), mandibular fossa (arrow), mandibular condyle (star), and lateral pterygoid muscle (LPM)

Electromyography

The Purposed Usefulness of Surface Electromyography:

A clincial use of SEMG (Surface Electromyography) has been proposed for the diagnosis and treatment of TMD. This is based on the assumption that various pathological or dysfunctional conditions can be discerned from SEMG(Surface Electromyography) recordings of masticatory muscle activity, activity including postural hyperactivity, abnormal occlusal positions, functional hyperactivity and hypoactivity, muscle spasms, and muscle imbalance.SEMG(Surface Electromyography) activity has been suggested to be useful in documenting changes in muscle function before and after therapeutic interventions as evidence of successful treatment. SEMG (Surface Electromyography) also has been used in biofeedback concerning the awareness and control of nocturnal and diurnal parafunctional habits [11].

Electronic Thermography

An alternative diagnostic imaging merbod, electronic rhermography (ET), is inexpensive, nonionizing, and noninvasive. Vascular beat emissions from the buman face (and especially the TMJ) may be imaged rapidly using noncontact infrared thermal imaging systems.

Electronic thermograpby already bas been shown to portray symmetric thermal patterns in normal subjects and asymmerric thermal patterns in parients with a variety of disorders,' including myofascial pain syndromes," myositis,' TMJ disorders,"" and motor and sensory radiculopathy," as well as rhe inflammation of arthritis" and bursitis.

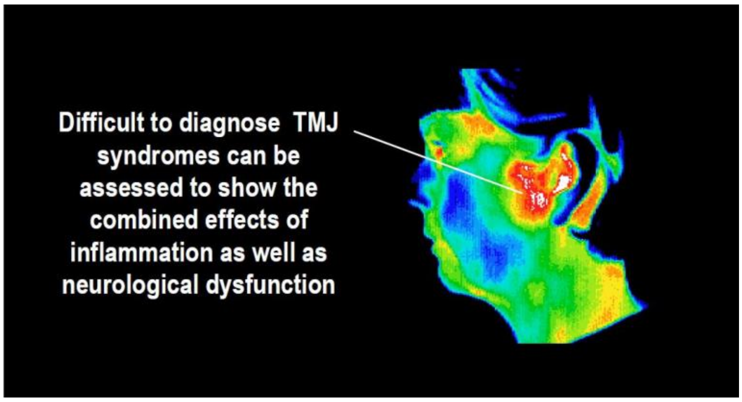

Figure 9

Facial thermography was conducted using an Agema 870 thermovision unit (infrared scanner, control unit, thermal image computer TIC-8000 and Meds 1.0 software, cables, stands, supports, and color monitor [all Agema Infrared Systems, Secaucus, NJ]) coupled to a 35-mm camera using color print film. Room conditions for thermographie examinations included a draft-free environment (no windows, closed doors), temperature control (ranging from 20°C to 22°C], variable lighting, a patient-positioning chair, and a small hand-held electric fan.

Figure 10: Frontal tomograph of the mandibular condyle with tbe jaw in a protruded position; note presence of a condylar bone erosion {ctrrou/) of at least 1.5 mm on thesuperior lateral aspect of the tundyle, which implies the classification of OA [12]

Radionuclide Examination

Scintigraphy aids to discover early changes in the TMJ skeleton which may also result in joint disc abnormalities. Radionuclide 99mTc is used for the examination. The temporomandibular joint is ideal for what is called SPECT (single proton emission computed tomography), because it is a quite small joint situated close to the skull base and paranasal sinuses. So SPECT can, unlike the double-dimension featuring, present TMJ separately from the parts of high bone density. The radionuclide examination sensitivity is high, its specificity is however low. Any inflammation, trauma or tumors increase the local isotope concentration. For this reason many studies state that radionuclide examination is relevant only as a screening method [13].

Single photon emission computed tomography (SPECT) imaging is superior to planar bone scintigraphy because of its enhanced spatial resolution. Adjacent structures of the cranium appear to be separated from the area of the TMJs. Visual evaluation of the SPECT images is usually made by comparing the afflicted and non afflicted joint Computer assisted color gradation does not depend on the existing amount of activity but refers to the pixel with the highest count rate in each image, and hence only reflects relative tracer distribution among osseous structures of the visceral and neurocranium. Intensive 99m Tc-MDP accumulation in the area of the TMJs can therefore give incorrect readings even in a normal patient.

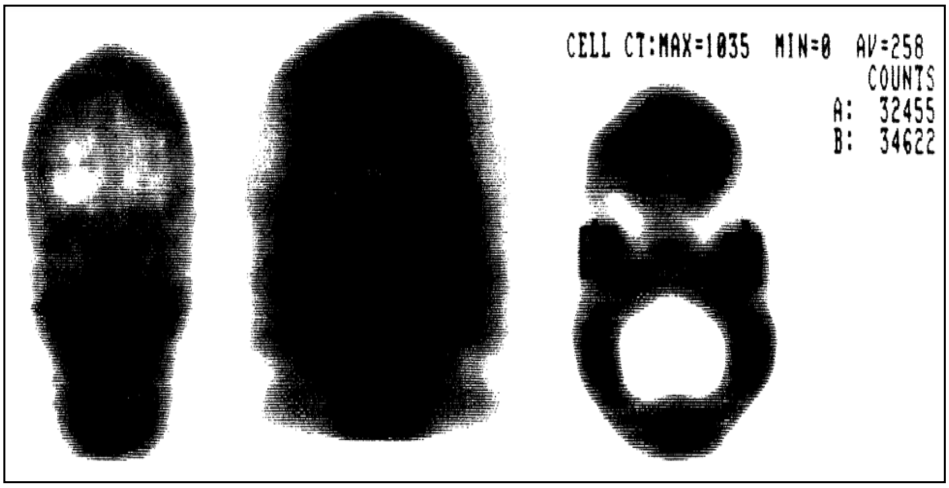

Figure 11: 99m Tc-MDP scans of the skull. Lefr. first image (IT-smoothed) of 64 projections of raw data acquisition with SPECT (360 degree camera rotation around the patient's head. The image was shifted vertically so that the patient's chin rested on the lower margin of the frame. Middle. cumulative image of 64 projections of 99m Tc-MDP SPECT raw data acquisition (360" rotation) to determine the total activity of the cranium

Arthrography

The basic objective of arthrography, whether performed in the knee, shoulder, or TMJ, is to opacify the joint synovial spaces so that subsequent radiography may provide images of the articular disk and its attachments. The procedure is performed by inserting, under fluoroscopic guidance, a needle or catheter into the joint space(s) and injecting a water soluble, iodine containing device, contrast medium (dye). Radiographs follow with the articulating members of the joint in various stages of function. The articular disk and its attachments are seen as radiolucent areas projecting between the pools of opaque contrast medium. Identifying the precise position and morphologic structure of these soft tissues is the main goal of any arthrographic procedure.

The examination should be performed with the patient under fluoroscopic observation usually this requires a medical radiology facility. Ideally, the arthrography facility will also have the capability for the tomographic technique. Local anesthesia of the preauricular soft tissues and the area of the joint is obtained with 1% lidocaine.

Radiography of the opacified joint spaces must be perform ed as soon as possible after filling with contrast medium, preferably within five minutes. (If epinephrine is incorporated into the contrast medium, a slightly longer time span is permissible but the possible systemic effects of the epinephrine must be carefully considered). The sooner radiographs are produced, the better the images of the joint spaces and the disk will be Tomography should be used to produce non distorted images through the crucial lateral and central aspects of the joint. Projections are routinely made with the jaws closed and at various degrees of opening and provide images of the joint soft tissues in function. In cases that involve a clicking joint, one of the several open jaw projections is made just as the patient thinks that a click is imminent [15].

Computed tomography

Computed tomography has been used to detect bony abnormalities of the TMJ and in rare conditions such as synovial osteochondromatosis. It has also previously been used for the diagnosis of internal disc derangement.

CT is useful when MRI is contraindicated or not accessible. With attention to technique and viewing conditions, CT is capable of showing internal disc derangement, arthritis, neoplasms and non-TMJ regional pathology at a relatively low radiation dose.

MDCT (16- to 64-detector row) is performed in the closed- and open-mouth positions, without the use of intravenous or intra-articular contrast medium. Multiplanar reconstructions are performed in the coronal oblique (i.e., parallel to the long axis of the mandibular condyle) and in the sagittal oblique (i.e., perpendicular to the long axis of the mandibular condyle) planes using both bone and soft-tissue reconstruction algorithms. Using currently available low-dose iterative reconstruction algorithms, the dose-length product (DLP) of the examination can be reduced to as low as 540 mGy cm, resulting in an effective dose (ED) of approximately 1.2 mSv (if the ED/DLP ratio of 2.2 for CT of the head is used). The multiplanar reconstructions are viewed by the radiologist on a DICOM viewer, which allows window width and window level to be adjusted, to optimise visualisation of the articular disc. The source axial images are also reviewed to detect any abnormalities in the imaged volume, which may be incidental or which may be the source of symptoms mimicking TMJ dysfunction. Disc displacements may also be visible on the axial images [16].

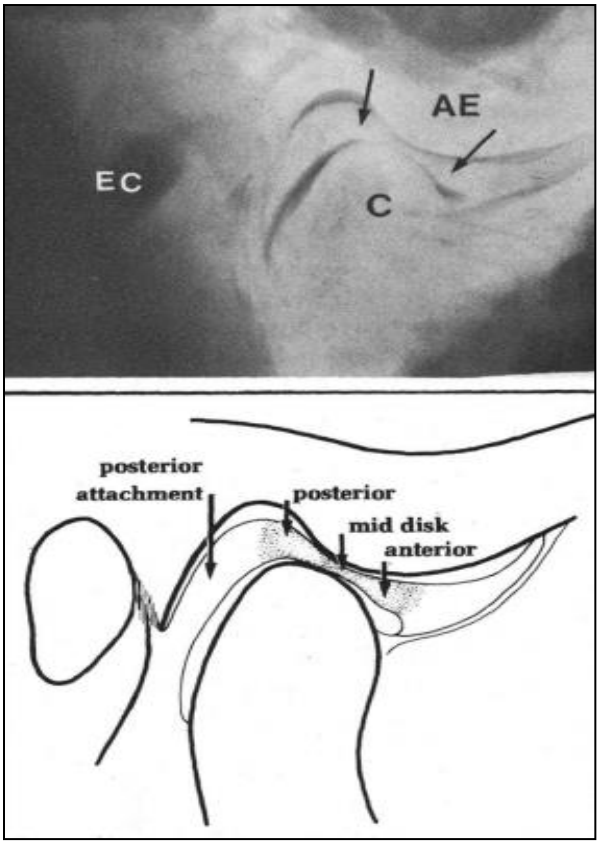

Figure 12: Anatomy of soft tissues of TMJ. Top, radiograph of decalcified human temporomandibular joint obtained at postmortem examination. Condyle (C), articular eminence (AE), and external ear canal (EC) are shown. Joint soft tissue and bony structures are seen at comparable radiographic densities. Notice biconcave shape of articular disk (arrows) with thinnest portion between bony surfaces. Radiolucent upper and lower joint spaces are seen in normal, nondistended state. Bottom, line drawing of decalcified human specimen shown above [5]

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CONCLUSION

Conventional radiography of the Temporomandibular Joint includes primarily transcranial lateral films and cephalometnc corrected tomography. Panorex filming also is used occasionally. All these procedures show only the bony structures of the Temporomandibular Joint and reveal virtually nothing about the soft tissues, namely, the disk. Several studies have shown that plain films, including tomograms, do not give any information about the position or status of the disk.

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