DIAGNOSTIC IMAGING OF THE TMJ: A REVIEW

Sandeep Kaur¹, Kirandeep Kaur², Satvinder Singh³, Shalu Rai⁴

¹Senior Registrar, M.D.S, Department of Oral Medicine & Radiology, Indira Gandhi Government Dental College & Hospital, Jammu (J&K), India.
²P.G Student, Department of Periodontology, Institute of Dental Studies & technologies, Kadrabad, Modi Nagar, Uttar Pradesh - 201 201, India.
³Lecturer, M.D.S, Department of Oral Medicine & Radiology, Indira Gandhi Government Dental College & Hospital, Jammu (J&K), India.
⁴Prof & HOD, Department of Oral Medicine & Radiology, Institute of Dental Studies & technologies, Kadrabad, Modi Nagar, Uttar Pradesh - 201 201, India.

CORRESPONDENCE: Dr. Sandeep Kaur, Registrar, Indira Gandhi Government Dental College & Hospital (IGGDC), Jammu (J&K), India. Department of Oral Medicine & Radiology, Mobile: +9796807111, Email: dr.sandeepkour@gmail.com.

ABSTRACT: The purpose of this article is to review imaging diagnosis of temporomandibular joint disorders. A variety of diseases affecting the temporomandibular joint (TMJ) causes changes in articular entities including both hard as well as soft tissue component of TMJ. A radiological examination is an essential part of the diagnosis and management of temporomandibular joint disorder. Accurate evaluation of TMJ has been difficult due to superimposition of other structure in conventional radiographs. Diagnostic imaging of the temporomandibular joint has undergone a revolutionary development during the last two decades. With advanced modalities we have been able to differentiate between different articular entities in patients with temporomandibular joint disorder.

Keywords: TMJ, Condyle, Reconstruction, Articular Disk, Joint.

INTRODUCTION

Unique anatomical configuration and complex relations in temporomandibular joint (TMJ) ask for special imaging techniques in radiological evaluation of the (TMJ). First report of temporomandibular joint internal derangement dated in 1877 when this term was introduced in clinical praxis.[1] Term temporomandibular internal joint derangement explain changes of condyle-disc-fossa articularis relationship. The type of imaging technique selected depends on the specific clinical problem, whether imaging of hard or soft tissues is desired, the amount of diagnostic information available from a particular imaging modality, the cost of the examination, and the radiation dose. In most cases the imaging protocol begins with hard tissue imaging to evaluate the osseous contours, the positional relationship of the condyle and fossa, and the range of motion, although a combination of imaging techniques may be indicated. Soft tissue imaging is indicated when information about disk position, morphology, or integrity is needed or to image abnormalities in the muscles or surrounding tissues. Advanced imaging modalities like Ultrasonography, Computed tomography, Magnetic Resonance Imaging (MRI), Cone Beam computed tomography (CBCT) and Nucleide imaging are indicated for imaging bony alterations that occur in TMJ disorders like erosions, osteophytes, pneumatisation of articular eminence that are difficult to be detected in conventional radiographs due to overlapping of the anatomic structures.

HARD TISSUE IMAGING
Panoramic Projection
Panoramic technique demonstrated very well the osseous structures of TMJ and is screening method for internal join derangement (Fig. 1). It is method of choice for:
1. Detection of degenerative bony changes;
2. Diagnosis of unspecific pathological changes;
3. Classification of the degree of pathological changes;
4. Evaluation of underwent therapeutic measures;
5. Primary diagnostic technique of TMJ (fractures, cysts, tumors, inflammation, aplasya, hypoplasia, hyperplasia and degenerative changes).

Some panoramic machines have specific TMJ programs, but these are of limited usefulness because of thick image layers and the oblique, distorted view of the joint they provide, which severely limits image quality. Gross osseous changes in the condyles may be identified, such as asymmetries, extensive erosions, large osteophytes, tumors or fractures. However, no information about condylar position or function is provided because the mandible is partly opened and protruded when this radiograph is exposed. Also, mild osseous changes may be obscured, and only marked changes in articular eminence morphology can be seen as a result of superimposition by the skull base and zygomatic arch. For these reasons, the panoramic view should not be used as the sole imaging modality and should be supplemented.[2]

Plain Film Imaging Modalities
Plain films, usually consisting of a combination of transcranial, transpharyngeal (Parma), transorbital projections allow visualization of the TMJs in various planes

Transcranial Projection
The transcranial projection provides a sagittal view of the lateral aspects of the condyle and temporal component. Changes on the central and medial surfaces are not seen. The cassette is placed flat against the facial skin parallel to the sagittal plane. The patient’s head is adjusted so that the sagittal plane is vertical. The ala tragus line is parallel to the floor. This view is taken with the patient’s mouth in the three positions: Open mouth, rest position and closed mouth. The point of entry is different according to the technique used. According to Lindblow approach, the central ray should be directed from posteriorly so that it passes along the long axis of the condyle. The point of entry of the central ray is 1/2” behind and 2” above the auditory meatus. According to Grewcock approach, the central ray enters a point 2” above the external auditory meatus. According to Gill’s approach, the central ray enters through a point ½” anterior and 2” above the external auditory meatus. In all the three techniques the central ray is directed caudally at an angle of +20° to 25°. The point of exit is through the TMJ of interest. The transcranial projection is useful for identifying gross osseous changes on the lateral aspect of the joint only, displaced condylar fractures, and range of motion (open views).[3,4] (Fig 2)

Transpharyngeal (parma) Projection
This view is a lateral projection showing medial surface of the condylar head and neck, usually taken in the open mouth position, so that the joint is projected into the shadow of air containing spaces of the nasopharynx, which helps to increase the contrast of the various parts of the joint. The cassette is placed flat against the patient’s ear and is centered to a point ½” anterior to the external auditory meatus, over the TMJ of interest, against the facial skin parallel to the sagittal plane. The patient is positioned so that the sagittal plane is vertical and parallel to the film, with the TMJ joint of interest adjacent to the film. The film is centered to a point ½” anterior to the external auditory meatus. The occlusal plane should be parallel to the transverse axis of the film so that the soft parts of nasopharynx are in one line with the TM Joint. The patient is instructed to slowly inhale through the nose during exposure, so as to ensure filling of the nasopharynx with air during the exposure. The patient should open his mouth so that the condyles move away from the base of the skull and the mandibular notch of the opposite side is enlarged. The central ray is directed from the opposite side cranially, at an angle of -5° to -10° posteriorly. It is directed through the mandibular notch, that is a window between the coronoïd, condyle and the zygomatic arch, of the opposite side below the base of the skull to the TM joint of interest (Fig. 3). The transpharyngeal projection is effective for visualizing erosive changes of the condyle rather than more subtle changes.[3,4]
This is the conventional frontal TM joint projection which is most successful in delineating the joint with minimal super impositions, leading to the production of a relatively true enface projection. The anterior view of the temporomandibular joint and medial displacement of fractured condyle and fracture of neck of condyle are clearly seen in this view. The film is positioned behind the patient’s head at an angle of 45° to the sagittal plane. The patient is positioned so that the sagittal plane is vertical. The canthometal line should be 10° to the horizontal with the head tipped downwards. The mouth should be wide open. The mouth should be wide open. The tube head is placed in front of the patient’s face. The central ray is directed to the joint of interest, at an angle of +20° to strike the cassette at right angles. The point of entry may be taken at pupil of same eye, asking the patient to look straight ahead, medial canthus of same eye and medial canthus of opposite eye. The morphology of the convex surface of the condylar head can be evaluated, making this projection a useful adjunct to transcranial and transpharyngeal projections in the diagnosis of gross degenerative changes or other anomalies (Fig. 4). A similar projection is the reverse open Towne's projection, which sometimes is used to image condylar neck fractures, particularly if medial displacement has occurred, because the condylar head and neck are visualized in the frontal plane.[3,4]

**Computed Tomography (CT)**
The use of CT in diagnosing TMJ disorders dates back to the late 1980s. Huls et al (supported by Siemens) have collected the most comprehensive case studies of patients with TMJ examined by CT. [5] Tomography provides a sectional view through the joint, with slice thickness of about 2mm with hypocycloidal or trispiral technique, up to about 7mm with linear technique. With the tomographic techniques, objects outside the tomographic layer will be blurred to such an extent that they are not visualized in the images.[6] Arthrography is combined with computed tomography, which enhances the accuracy of the diagnosis of internal TMJ disorders.(Fig.5) Computed tomography is excellent in demonstration of osseous structures of TMJ while the disk cannot be demonstrated without CT arthrography which implicated injection of contrast media in the joint. CT is indicated when more information is needed about the three dimensional shape and internal structure of the osseous components of the joint or of information regarding the surrounding soft tissue is required, CT produces digital image slices.(Fig.6) Multiple image slices are made in both the axial and coronal planes. In the most recent studies CT was evaluated as a good method, but less convenient than magnetic resonance.[7,8] CT imaging provides exquisite detail for bony abnormalities, such as ankylosis, fractures, osseous tumors, and arthrosis. The technique provides some information about soft tissues, but is not recommended as a primary imaging modality for diagnosis of disc displacement.[6] CT scanning of the TMJ enjoyed a great deal of success and interest soon after the development of TMJ arthroscopy partly due to its own rapid technological development and non invasive nature. [9]

**COMPUTED BEAM COMPUTED TOMOGRAPHY**
CBCT also known as volumetric CT (VCT), in which a cone-shaped X-ray beam centered on a two dimensional (2D) detector produces a series of 2D images. The reconstruction of these images in a 3 dimensional (3D) data set is done using the modified Feldkamp algorithm.[10,11] Hence data can be reformatted in a volume rather than a slice, thereby giving 3D information (Figure 7). The tube-detectors system performs a 3608 rotation around the head of the patient using a constant beam angle. This rotation produces the initial data, so called raw data, which are presented as a lateral tomogram. The raw data are used for primary reconstruction. The options for the thickness of the layers to be reconstructed are 0.3 mm, 1.0 mm, and 3.0 mm, and the reconstruction angles are determined by the clinician. The primary images can be used for further secondary reconstructions in all planes and for three-dimensional (3D) reconstructions.[9] CBCT also allows multiplanar reformation i.e., 2D images in axial, coronal, sagittal and even oblique or curved image planes.[3]Advancements in flat panel detector (FPD) technology (digital FPDs which enable direct conversion of x-ray energy into a digital signal with high spatial resolution), improved computing power and relatively low power requirements of x-ray tubes in CBCT have resulted in an exponential use of CBCT.[11] large body of literature has been published in recent times due to the fact that CBCT has inspired research in TMJ imaging. An important advantage of CBCT imaging of TMJ is that it allows accurate measurements of the volume and surface of the condyle. These measurements are extremely advantageous in clinical practice when treating patients with TMJ dysfunctions.[9] As with any new technology, CBCT has been criticized just as it has been lauded. The most researched applications for head and neck CBCT are in sinus, middle and inner ear implant and dentomaxillofacial imaging.[11] TMJ imaging has also benefitted tremendously from the exponential.

Available online at www.ijapbs.com
research in this field. According to Tsiklakis et al and Koyama et al, CBCT should be used instead of CT because the dose of radiation to which the patient is exposed is much lower. Furthermore, CBCT is superior to CT for visualizing bone changes in the TMJ, analysing lateral slices in isolation and combining coronal and lateral slices.[12]

But preliminary experiments have not yet translated into systematic clinical and prospective studies that convincingly demonstrate the superiority of CBCT over existing modalities in TMJ imaging that can reinforce its use clinically. The presented technique provides a complete radiographic investigation of the bony components of the TMJ. The reconstructed images are of high diagnostic quality, the examination time is shorter, and patient dose is lower than that with conventional CT. It may therefore be considered as the imaging technique of choice when investigation of bony changes of the TMJ is the task at hand.

SOFT TISSUE IMAGING

The soft tissues of the joint can be imaged with magnetic resonance imaging (MRI) or arthrography. Conventional imaging techniques do not demonstrate disk position, morphology, or function. Soft tissue imaging is indicated when TMJ pain and dysfunction are present or when the clinical findings suggest disk displacement along with symptoms that are unresponsive to conservative therapy. MRI and arthrography should be used only when information about the condition of the soft tissue components of the joint is required to formulate a treatment plan. The choice of technique depends on patient factors, such as allergy to contrast agents and claustrophobia, as well as on the cost, availability, and objectives of the imaging technique. Arthrography is superior for diagnosis of small disk perforations and joint adhesions. MRI can indicate a pathologic condition of the soft tissue through altered tissue signal, allowing evaluation of the disk and surrounding muscles, and can image joint effusion. The technique is noninvasive and does not use ionizing radiation. Arthrography with videofluoroscopy provides a superior motion study of the joint, although some MRI techniques can provide limited dynamic information.

ARTHROGRAPHY

Imaging of the hard tissues should be completed before arthrographic imaging is performed. Arthrography is a technique in which an indirect image of the disk is obtained by injecting a radiopaque contrast agent into one or both joint spaces under fluoroscopic guidance. Arthrography can be done with both single- and double-contrast techniques. In single-contrast arthrography, radioopaque contrast material is injected into either the lower or upper joint space, or into both compartments, usually under fluoroscopic guidance. In double-contrast arthrography, a small amount of air is injected into the joint space after the injection of contrast material. A side-by-side comparison of the two techniques showed double-contrast arthrography to delineate the morphology of the joint with greater detail than the single-contrast counterpart.[13] Single-contrast arthrography has the strength of being able to demonstrate the dynamics of the joint. Plain films and/or tomograms are obtained after contrast injection. After both spaces are filled, disk function is studied using fluoroscopy during open and closing movements. The fluoroscopic study usually is supplemented with tomographs of the joint. Arthrography is indicated when information about disk position, function, morphology, and the integrity of diskal attachments is required for treatment planning. It is accurate for anterior displacement of the disc, but relatively insensitive for medial and lateral displacements. Arthrography is, to a large degree, dependent upon the skill and knowledge of the radiologist performing the study. The risks of this procedure include allergic reaction to the nonionic iodine contrast agent and infection. Draw backs of this procedure are its invasive nature and its association with postoperative discomfort.[3]

ULTRASONOGRAPHY

TMJ ultrasonography is a non-invasive, readily available and relatively cheap dynamic “real time” examination, featuring soft joint tissues. It serves both for diagnosis and differential diagnosis and for the comparison of therapeutic results in treating internal joint defects.[7] The first reports of TMJ sonography date back to 2000. It uses currently available types of ultrasonic equipment with a linear scanning transducer of 7.5 12 MHz frequency, which makes it possible to depict the narrow space of the jaw joint and the position of the joint disc and it reveals fluid or ligament adhesion.[6] Studies comparing the results of MRI and sonography showed 70 85 % agreement.[14]
The principle of ultrasonography is based on the fact that ultrasonic sound waves emitted by a device (transducer), travel through the tissue against which they are aimed, and are partly reflected on transiting through dissimilar anatomical structures. The reflected sound waves are then read by the same emitting device, and translated into images.[15] US uses a transducer that functions as a transmitter and a receiver of acoustic energy. Ultrasound waves emitted by the transducer are partly reflected when they pass through the tissues, with a coefficient of reflection that depends on the characteristics of different anatomical structures (e.g. cortical bone has the highest echogenicity, which reflects most of the ultrasound waves; soft tissues have a lower echogenicity). The same transducer receives the reflected ultrasounds, translating them into images.[16] Doppler ultrasound is particularly useful in identifying soft tissue vascular lesions. High resolution ultrasonography was described to show satisfying result. A great advantage of high resolution ultrasonography is that real time imaging can be performed which can be used to view the articular disc during the mouth opening movement and gives a clear position of disc. High-resolution ultrasonography is also useful in diagnosing degenerative changes and joint effusion.[17]

MAGNETIC RESONANCE IMAGING
Magnetic resonance imaging (MRI) is a reliable effective means of imaging the temporomandibular joint. Imaging of soft tissues is superior to that of computed tomography, less invasive than arthrography, and more accurate for medial and lateral disc displacements. MRI is unique imaging modality that produces cross sectional multiplanar images without using ionization. Using MRI, the evaluation of the internal derangement of TMJ (the depiction and localization of the disc) can be detected. MRI uses a magnetic field and radiofrequency pulses rather than ionization radiation to produce multiple digital image slice. The objective of MRI is to document both soft and osseous tissue abnormalities of the joint and its surrounding structures. (Fig 8) Because MRI can provide superb images of soft tissue, this technique can be used for imaging the articular disc. MRI is helpful to indicate the neoplastic, arthritic, and traumatic pathology around TMJ. Rapid scan MRI methods provide us with a good method for the functional imaging of the TMJ.[3]

MRI uses a magnetic field and radiofrequency pulses rather than ionizing radiation to produce multiple digital image slice. Because MRI can provide superb images of soft tissues, this technique can be used for imaging the articular disk. MRI allows construction of images in the sagittal and coronal planes without repositioning the patient images usually are acquired in open and closed mandibular positions using surface coils to improve image resolution. Sagittal slices should be oriented perpendicular to the condylar long axis. The examinations usually are performed using T1-weighted, protonweighted, or T2-weighted pulse sequences. T1-weighted or 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 using rapid image acquisition. ("fast scan") techniques. Medial disk displacements are best detected using MRI. The change in tissue signal that results from tissue changes in the disk and retrodiskal tissue may make accurate identification of the disk difficult. Three-dimensional volume acquisitions allow a volume of tissue to be imaged rapidly and subsequently viewed in any plane. The use of intraarticular and intravenous gadolinium may provide utility in certain clinical instances—for instance, the inflamed synovium or an inflamed arthropathy will avidly enhance after the administration of intravenous gadolinium.[16] With the introduction of surface-coil-assisted MR imaging the utilization of CT and arthrography has decreased significantly for the diagnosis of TMJ disorders. MRI to be the best method of displaying TMJ hard and soft tissues. With the help of MRI, it is possible to detect pathological changes of the chewing muscles.[14,18] MRI does not have the morbidity associated with the introduction of needles into the joint (as occurs in arthrography), but the disadvantages of MR imaging include high cost, inability to use with claustrophobic patients, and differences in image quality produced by different scanners and different surface coils.

RADIONUCLEIDE IMAGING
The advent of clinical nuclear imaging occurred in the early 1950's, when radiopharmaceuticals were first used to localize radioactive molecules in specific organs for diagnostic purposes.[19] Since the introduction of nuclear imaging, many technological advances have been made to expand the clinical and research applications of nuclear imaging; one of them is the improvement of image resolution of the scans.
Among other technical advances are that: (1) a variety of radiopharmaceuticals has been synthesized and made widely available for clinical use; (2) sophisticated computer-assisted imaging equipment has been developed; and (3) effective imaging protocols have been identified to meet a variety of research, diagnostic, and treatment planning objectives.[19]

There are three categories of imaging devices in use today: those used for planar nuclear imaging, those for single-photon emission computed tomography (SPECT), and those for Positron Emission Tomography (PET). Nuclear imaging has been reported to be useful in the evaluation of bone metabolism in bony components of the temporomandibular joint, for assessment of facial skeletal growth, for the detection of synovitis, and for the quantification of arthritis in patients with rheumatoid arthritis or osteoarthritis.[3] Scintigraphy aids to discover early changes in the TMJ skeleton which may also result in joint disc abnormalities. Radionuclide mTc is used for the examination. The temporomandibular joint is ideal for what is called SPECT (single photon 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.[14]

CONCLUSION

TMJ imaging is an adjunct to the clinical examination and provides useful information about the joint components. When selecting a TMJ imaging technique, the clinician must determine what type of information is needed from the imaging study and whether that information will affect patient management. This article reviewed various hard and soft tissue imaging techniques and this information will enable the clinician to choose the most appropriate imaging modality for their patients. Plain-film imaging modalities are basic imaging techniques for assessment of the temporomandibular joint. These can be used for evaluation of osseous disease and as a baseline for follow-up. Arthrography, computed tomography, and magnetic resonance imaging have all been used for evaluation of the soft-tissue components of the joints. Accuracy studies of these techniques have demonstrated the highest diagnostic accuracy for magnetic resonance imaging. Arthrography is relatively insensitive for detection of medial and lateral displacements. Magnetic resonance imaging accurately depicts both hard and soft tissues, and this technique is emerging as the prime diagnostic imaging technique in patients presenting with clinical signs and symptoms of a disorder of the temporomandibular joint. CBCT provides a definite advantage over other techniques due to its low radiation dose to patient, smaller equipment and ability to provide multiplanar reformation and 3D images. Nuclear medicine offers researchers a non-invasive and sensitive method for studies involving inflammations of oral structures, tumors, trauma, bone healing, and the temporomandibular joint. Its great advantage mainly consists in the possibility of depicting dynamic joint structures, particularly the condyle line and the joint disc position. The most frequent findings when patients with clinical symptoms of temporomandibular joint disorders are "imaged" are different forms of disc displacement and degenerative joint disease. Studies have demonstrated a high prevalence of different forms of disc displacement in patients, although these abnormalities are also seen in some asymptomatic volunteers. Future research should further refine imaging techniques to come closer to an understanding of the association between morphologic alterations and patient symptoms.

Legends for figures
Figure 1 Panoramic image that reveal right condylar hyperplasia.
Figure 2 Transcranial view
Figure 3 Transpharyngeal view
Figure 4 Transorbital view
Figure 5 3 D TMJ View
Figure 6 TMJ Joint Arthroscopy
Figure 7 TMJ and the Value of CBCT Scan
Figure 8 MRI examinations showing normal (left) and abnormal (right) TMJ.

REFERENCES


