

CLINICAL ASSESSMENT OF THE MOST COMMON TMJ IMAGING MODALITIES INCLUDING MAGNETIC RESONANCE IMAGING (MRI)

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Review of Literature

An accurate diagnosis of the temporomandibular joint (TMJ) status requires a thorough knowledge of the normal and abnormal anatomy of the joint as well as the mechanics of its movement [Figs. 1a and b]. The TMJ is a synovial joint consisting of the mandibular condyle, glenoid fossa and articular eminence soft tissue disc,^{1,2} and posterior attachment (bilaminar zone)^{3,4}. The disc, also termed a meniscus, is a biconcave structure consisting mainly of dense fibrous tissue interposed between the condyle and the glenoid fossa. Posteriorly, the disc is attached by the bilaminar zone, a fibroelastic tissue, rich in nerves and vessels.^{3,4} The medial and lateral attachments anchor the disc to the condylar poles. Anteriorly, the disc fuses with the fibrous joint capsule and antero-medially it attaches to the superior belly of the lateral pterygoid muscle. The disc and its attachments divide the joint into upper and lower joint spaces. These joint spaces, with the exception of the disc surfaces, are lined by synovial tissue. Surrounding the joint is a tough, fibrous capsule reinforced laterally by the lateral ligament.³

Normal jaw opening depends on the coordinated activity of the hard and soft tissues of the joint as well as the muscles of mastication.^{3,5,6} As the condyle moves anteriorly or posteriorly, the disc maintains its position superiorly on the condyle

[Figs. 1a and b]. Any disturbance of this complex mechanism of jaw movement may give rise to TMJ pain and dysfunction.⁵

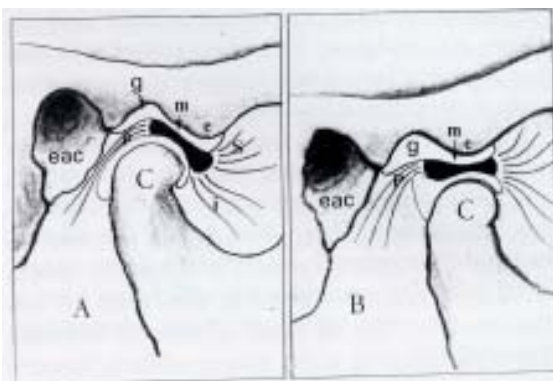


Figure 1a. Schematic illustration of a sagittal view of a normal TMJ inclosed jaw position. The meniscus (m) is in a normal position with the posterior band at the 12:00 o'clock position in the glenoid fossa (g), and superior to the head of the condyl (c). Also noted are: eac = external auditory canal; e = articular eminence; p = posterior attachments S = superior belly of the lateral pterygoid, and i = interior belly of the lateral pterygoid.

Figure 1b. Schematic illustration of a sagittal view of a normal TMJ in the open jaw position. The meniscus (m) is located superior to the condylar head (c), and inferior to the articular eminence (e).

Two of the more common abnormalities of this articular mechanism are internal disc derangements and degenerative arthritis.^{5,7-12} The most common form of disc derangement is the anteriorly displaced disc [Figs. 2a and 3a]. With this abnormality, the disc is located anterior or antero-medially to the condylar head. Sometimes the anterior displaced disc will "reduce" or return to its position over the condyle on jaw opening and produce an audible clicking sound [Fig. 2b].^{5,7-17} On closure, the disc slips off the condyle to an anterior position producing a closing or reciprocal click. This condition is referred to disc displacement with

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reduction [Figs. 2a and b]. Clinically, one can often note deviation of the jaw to the affected side prior to the clicking sound.

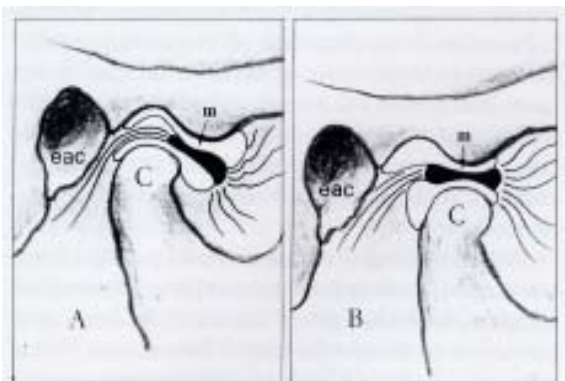


Figure 2a. Illustration of a meniscus displacement with reduction (MDcR). Note the meniscus (m) appears anterior to the condylar head (c) along the posterior inferior slope of the articular eminence (e) in the closed jaw position.

Figure 2b. In an open jaw position, the meniscus (m) assumes a more normal position between the condylar head and articular eminence (e). Such reduction is often associated with audible joint noise (clicking).

In some cases, the disc may maintain its anterior position regardless of the degree of jaw opening [Figs. 3a and b].^{5,77} This situation is classified as disc displacement without reduction. Clinically, these patients may or may not have limitation of movement or deviation of the jaw. In an early meniscal displacement without reduction, translation is usually limited and there is a persistent deviation of the jaw on opening to the affected side. In patients with chronic displacement, but without reduction, there may be no limitation of translation and no deviation of the lower jaw on opening.

Clinical examination alone including evaluation of joint noise and degree of translation may lead to an erroneous diagnosis. Not all patients with audible clicking have disc displacement with reduction.¹⁶⁻¹⁷ Also, limitation of translation may not indicate an intra-articular disturbance.¹⁸ Complete examination of the TMJ requires imaging of both the hard and soft tissues of the joint. Due to the complexity of the joint, three-dimensional evaluation is necessary to accurately assess joint form and function. Another consideration in imaging the TMJ is its location at the base of the skull with superimpositions of other bony structures.

When evaluation is done with plain films, superimposition of other bony structures limits both the diagnostic accuracy and number of useful radiographic views.

Epidemiological surveys demonstrate that signs and symptoms of temporomandibular joint (TMJ) dysfunction are common in the adult population.^{19,20} Clinical joint sounds have been found in up to 28% of adults, and are considered a common sign of TMJ dysfunction, which is often related to disc displacement.²¹

The aim of this clinical assessment is to present, as well as to clinically evaluate, current modalities used in the diagnosis of internal derangements of the temporomandibular joints.

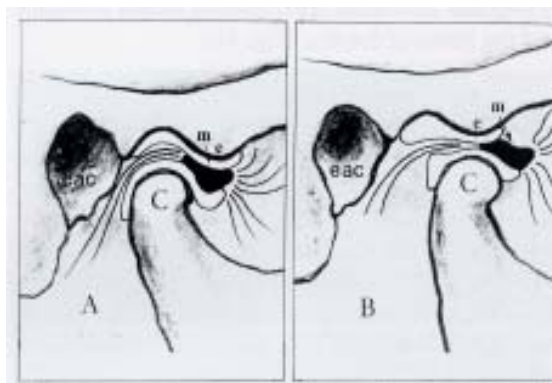


Figure 3a. Illustration of a meniscus displacement without reduction (MDsR). In the closed jaw position, the meniscus (m) is located anterior to the condylar head (c), between the condylar head and posterior inferior slope of the articular eminence (e).

Figure 3b. In an open jaw position, the meniscus (m) remains anterior to the condylar head (c) and does not assume a normal position even at maximal jaw opening.

Clinical Evaluation of the Imaging Techniques:

TMJ imaging provides information about the status and function of the joint that helps in establishing a definitive diagnosis. The most common techniques for the TMJ imaging are the transcranial radiography, tomography, arthrography, computed tomography (CT), and magnetic resonance imaging. However, panoramic radiographs with specific setting for TMJ imaging are used by some dental clinicians for TMJ evaluation.

1. Panoramic Radiographs

Conventional panoramic radiography has been used as a screening tool for the entire maxillo-

man- dibular region, including the TMJ [Fig. 4a]. However, conventional panoramic views for TMJ evaluation are subjected to distortions and limitations.²²⁻²⁵ Several techniques involving changing the usual positioning of the patient were recommended so as to provide for a more specific panoramic radiograph of the TMJ area.^{24, 26-28} Separate images are taken of the left and right sides with two to four projections taken on one film for open and closed TMJ positions. These provide clearer views of the bony TMJ area allowing for bilateral evaluation and comparison of the general morphology of the bony condyles as well as their relative translation. Disadvantages of this technique are inability to determine the exact condylar fossa relationship, and inability to provide diagnostic informations of the position and the status of the disc [Fig. 4b].



Figure 4a. A conventional panoramic projection showing the TMJ.



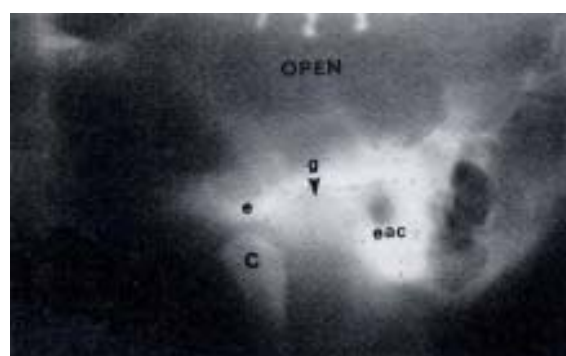
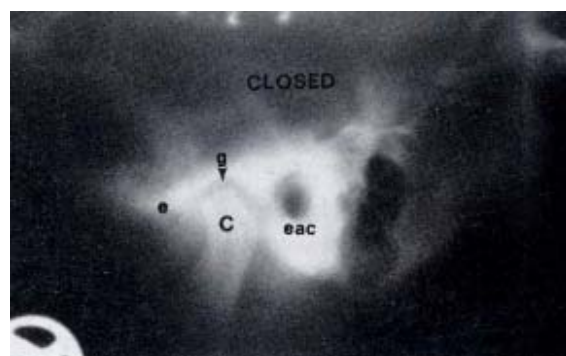
Figure 4b. A panoramic radiograph specific for the TMJ showing the image of the bony condylar morphology of the right and left temporomandibular joints.

2. Transcranial Radiographs and Tomography

Even though these two techniques utilize two different technical radiographical concepts, they are considered first among the means of studying TMJ anatomy. Transcranial radiography provides a basic screening image of the TMJ that is relatively easy to use and inexpensive since it could be produced by utilizing the standard dental radiographic equipment with minor modifications.²⁹ It provides gross information concerning the anteroposterior

relationship of the condyle in the fossa or in translation. However, transcranial films have been the subject of much controversy because they can be readily misinterpreted or over interpreted. The difficulty arises from distortion of the osseous structures, superimposition of other anatomic structures, and inability to visualize anything but the lateral third of the condyle and articular fossa. In addition, transcranial radiographs fail to show definite changes in the soft tissue disc or the disc condyle relationship.

TMJ tomography exceeds the capacity of the transcranial radiography in providing information about surface changes of the condyle, fossa and eminence in the medio-lateral dimensions.^{30,31} It provides a better description of the anteroposterior position of the condyle in the fossa by providing a radiographic image of the planes passing through the lateral, central, and medial aspects of the TMJ. However, like the transcranial radiography, soft tissue disc changes can not be determined by tomography [Figs. 5a & b].

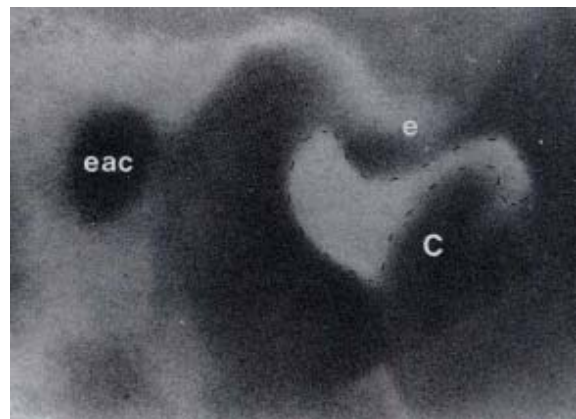
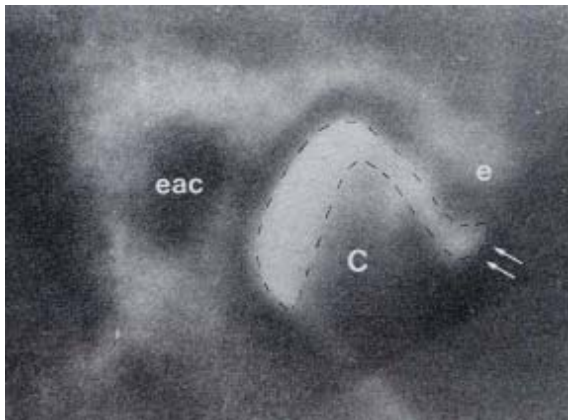
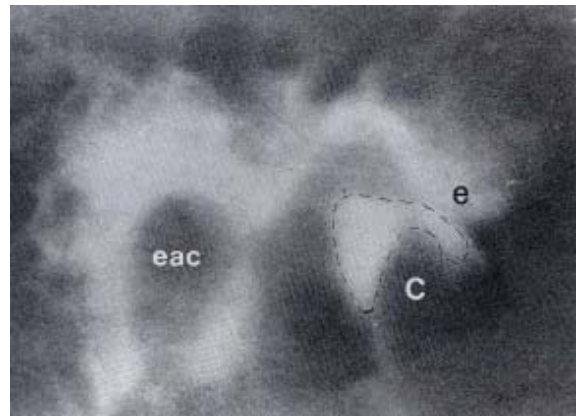
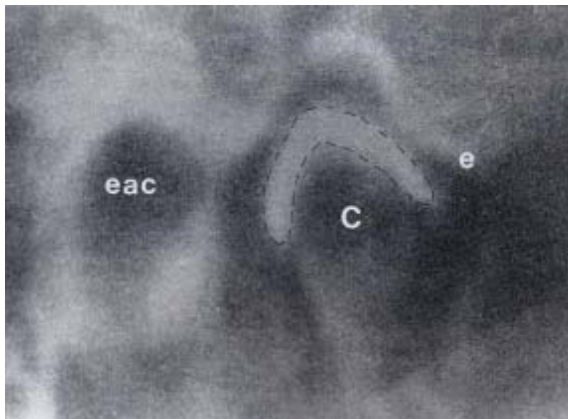


Figures 5a,b. A tomogram of a temporomandibular joint in closed and open jaw positions, showing the bony condyle (c), and the joint space within the glenoid fossa (g).

3. Arthrography and videofluoroscopy

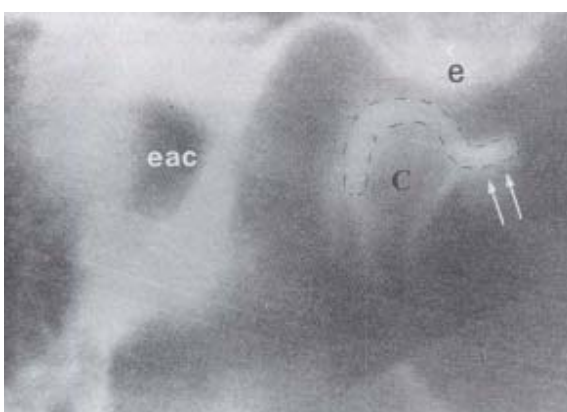
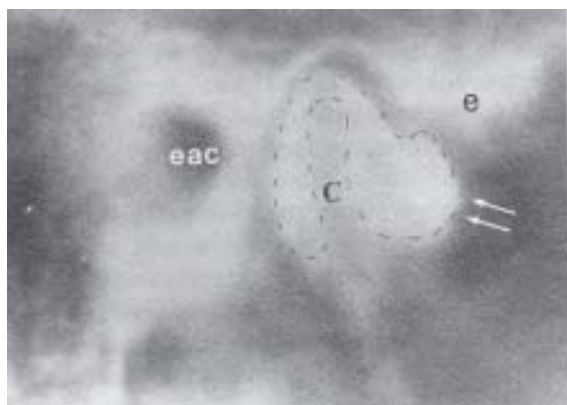
Arthrography is basically tomography in addition to injecting a radiopaque dye into a single joint space or in both upper and lower joint spaces.^{21,32} Following the dye injection and videofluoroscopy, specialized lateral arthrograms can be performed with the jaw closed and open. Most information is obtained from the closed-mouth tomographic cuts, because these images demonstrate specific morphologic changes within the meniscus and the relative position of the disc to the condyle. An open-mouth view is important in demonstrating the presence or absence of meniscus reduction [Figs. 6a-f]. Arthrography with the use of videofluoroscopy is vitally important for evaluating disc derangements of the TMJ.^{6,9,31,32,33-38} Such corn-

binated technique provides dynamic functional information of the pathologic meniscus function during translation, which is not available with any of the other imaging techniques. It is considered as the most or the only effective imaging modality in depicting soft tissue-disc-perforations. Therefore, its advantages are its ability to evaluate both the soft tissue disc and the bony condyle with accuracy, depicts soft tissue-disc perforations and provides dynamic visualization. However, its disadvantages include (1) being an invasive radiographic procedure which may produce moderate patient discomfort, (2) the need for radiology specialist with fluoroscopic viewing, (3) using ionizing radiations and, (4) inability to perform in patients with TMJ ankylosis and/or fibrosis.



Figures 6a, b. Normal meniscus position in both close and open jaw positions. Uniform distribution of the dye in the lower joint space around the condylar head (c) during closed jaw position (in dotted lines). While upon wide open, the lower joint space shows expansion posterior to the condyle (in dotted lines.) e = articular eminence.

Figures 6c,d. Meniscus displacement with reduction. An anterior recess of the lower joint space (in arrows) could be seen in front of the condyle upon closure. Whereas at wide jaw opening, the normal expanded lower joint space is seen posterior to the condyle (c).



Figures *be, f*. Meniscus displacement without reduction. The anterior recess of the lower joint space could be seen in front of the condyle (c), both at jaw closed as well as at wide open (in arrows).

4. Computed Tomography (CT)

Computed tomography [Fig.7] is a useful and versatile imaging technique. It was introduced with the advantages of being non-invasive with the ability to evaluate hard tissues as well as soft tissues. CT and its 3D display - three dimensional-imaging are most useful in the initial imaging of conditions such as congenital anomalies, degenerative bony changes, and fractures due to the high spatial resolutions of bony structure.³⁹⁻⁴² The negative aspects of CT are the involvement of ionizing radiation, lack of dynamic visualization, and most important is its substandard resolution of the soft tissue structures of the TMJ.⁴³ Accordingly, at present, CT may not be the ideal imaging modality in the diagnosis of internal derangement of the TMJ.

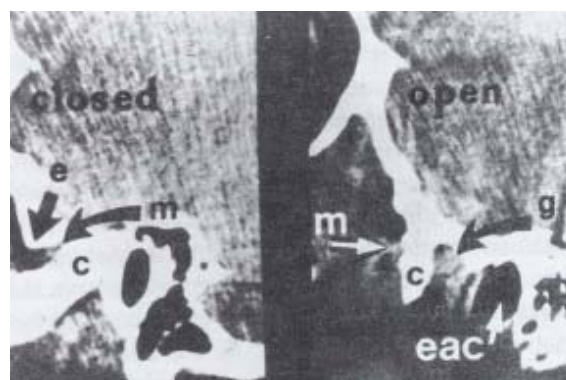


Figure 7. Computed tomographic images of a temporomandibular joint in the closed and open jaw positions showing meniscus displacement without reduction, eac = external auditory canal; c = the bony outline of the condyle; g = glenoid fossa; e = articular eminence; m = meniscus.

5. Magnetic Resonance Imaging (MRI)

MRI is the most recent, versatile, and exciting technology in the field of medical imaging⁴⁴⁻⁴⁸ due to its superior resolution of both soft tissues as well as hard tissues of the temporomandibular joint [Figs.8a and b]. It is considered as the imaging of choice in the diagnosis of TMJ internal derangement; both displacements with reduction [Figs. 9a and b] and without reduction [Figs. 10a and b], as well as degenerative condylar conditions with high degree of accuracy [Fig. 11],^{48,52} The chief advantages of MRI are the absence of ionizing radiation, non-invasive, superior soft tissue resolution, ability of examination by the technician, and multiplaner

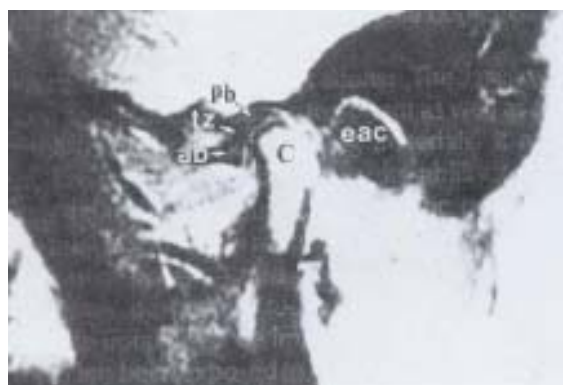


Figure 8a. Magnetic Resonance image (MRI) showing normal TMJ in the closed jaw position. The meniscus (in arrows) can be visualized between the condyle (c) and glenoid fossa. The posterior band (Pb), thin zone (tz) and anterior band (ab) can be visualized.

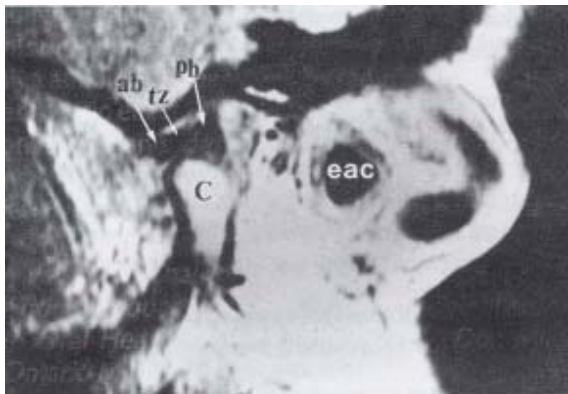


Figure 8b. Normal MRI of the TMJ in an open jaw position. The meniscus can be seen in its "bow-tie" configuration with the posterior band (Pb), thin zone (tZ) and anterior band (ab) clearly visualized superior to the condylar head (c).

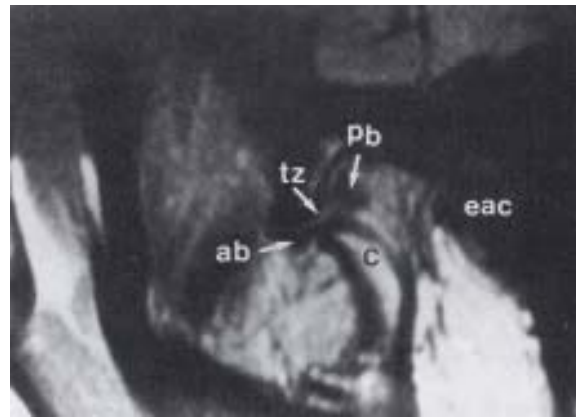


Figure 9b. With jaw opening, the meniscus can be seen assuming the normal position. The posterior band (Pb), thin zone (tZ) and anterior band (ab) located between the condylar head (c).

cross-sectional imaging capability. MRI image slices could be obtained in any plane or depth, which allows for simultaneous evaluation of the joint's soft and hard tissue relationship in both sagittal, as well as coronal planes resulting in a more precise and accurate diagnosis in all three planes. Negative aspects include high cost of examination, may not be widely available, inability to accurately depict soft tissue perforations, and lack of dynamic visualization. With time and further improvements that is taking place in the field of MRI technology, imaging time and expenses may be reduced and development of a true cinematic MRI, color MR! and three-dimensional capabilities as well as the ability to accurately depict soft tissue perforation are expected.

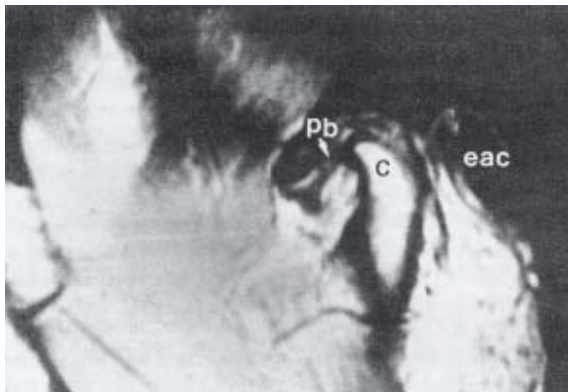


Figure 9a. MRI showing meniscus displacement with reduction (MDCR). In the closed jaw position, the posterior band (Pb) of the meniscus is anterior to the condylar head (c) in the closed jaw position.

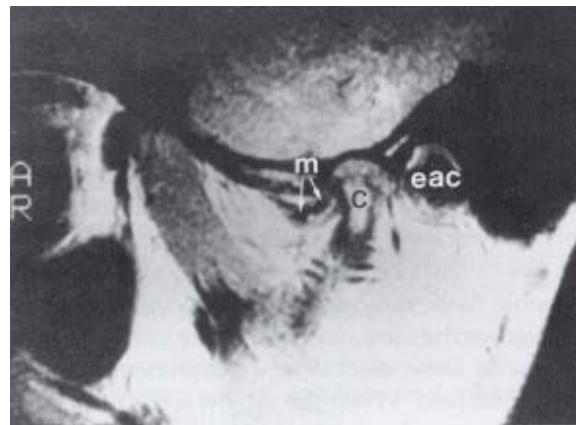


Figure 10a. MRI showing meniscus displacement without reduction (MDsR) in the closed jaw position, The deformed meniscus (m) is anterior to the condylar head (c) along the slope of the articular eminence.

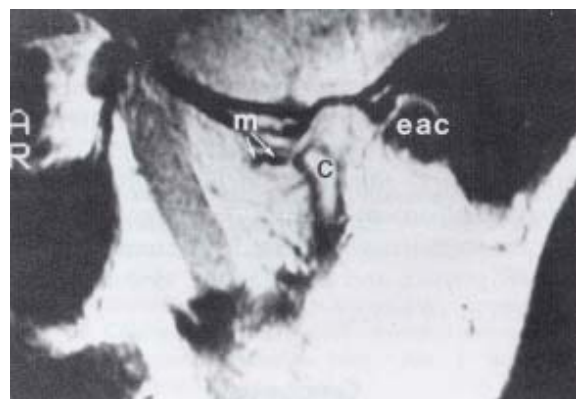


Figure 10b. Upon jaw opening, the meniscus (m) remains anterior to the condylar head (c),

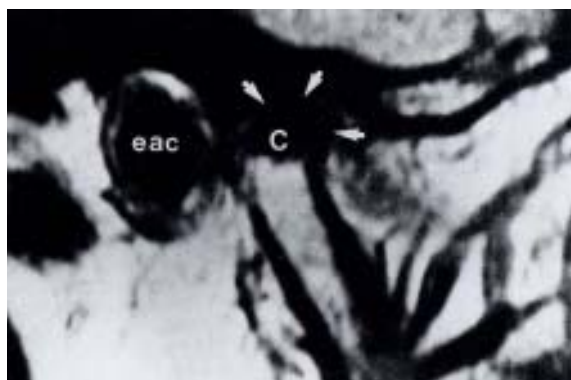


Figure 11. MRI showing bony degenerative changes of the condyle in arrows.

The basic difference between MRI and other conventional radiography lies in that the latter, as well as CT imaging, are based on X-rays (ionizing radiation), while MRI relies on the property of nuclei with an odd number of protons, neutrons, or both, to behave as magnets. Hydrogen, being the most abundant element in the body in the form of water, and being the most sensitive of the stable nuclei to a magnetic field, is ideally suited for MRI. The axes of these nuclei, when subjected to a strong magnetic field align within the field. Analogous to photographic flash, radiowaves of a specific frequency, termed as the "resonant frequency", may be used to excite these nuclei out of alignment with the magnetic field. When the radiowave is turned off, the nuclei tend to realign with the magnetic field releasing some of the energy absorbed by the incident radiowave. A signal is released in the form of a radiowave of the same frequency as the incident radiowave. The emitted radiowave or signal is picked up by the receiver coils and computer processed to create the final MR image. It follows then that tissues high in water and fat, such as bone marrow, appear bright on the MRI while tissues with very low water content, such as bone cortex, appears dark. Muscles and brain tissue, being intermediate in water density, have a grayish color. For a more thorough discussion and understanding of MR physics and applications, one may read references 44 to 52.

Conclusions

1. Accurate diagnosis of the internal derangements of TMJ requires in-depth knowledge of

the anatomical, physiological, and pathophysiological status of the joint.

2. The complex nature of temporomandibular joint in regards to its anatomical location, complex coordinated function and the integral role of the disc and its attachments, necessitates a mean of evaluating the soft tissue of the joint as well as the bony structures.
3. Imaging of the TMJ is an important adjunct to the case history and a thorough clinical examination.
4. Imaging of the TMJ is not designed to be under-taken by the average general practitioner with the exception of the panoramic radiographs, and to some extent transcranial radiographs. A radiology specialist with experience in each respective modality should technically perform and interpret the images.
5. The role of the average general practitioner is to have a background about the diagnostic capabilities of each imaging modality, and, he/ she may needs to have the basic knowledge of how each imaging modality is interpreted.
6. Not all commonly used imaging modalities are equally effective in the evaluation and diagnosis of the internal derangements of the TMJ.
7. At present, MRI appears to be a powerful zero radiation technique, aiding in the differential diagnosis of TMJ disorders. With yet a brighter future due to the on- going research and development in the field.

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