TMJ Imaging: A Review

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ABSTRACT

Background: Our understanding and interest in the diagnosis and management of patients with various types of temporomandibular joint disorders has increased as research has identified structural abnormalities and disease mechanisms associated with some of these disorders. Clinical examination only cannot lead to the correct diagnosis of TMJ dysfunctions. Among the basic examinations used are: Xray examination (RTG), computer tomography (CT) and magnetic resonance imaging (MRI). Radionuclide examination (scintigraphy), ultrasonography and arthroscopy are less used secondary methods of imaging. Arthroscopy is classed as a therapeutic method. The present paper attempts to highlight the various imaging modalities for TMJ diagnosis.

Conclusion: Conventional radiography helps identify gross bone abnormalities. CT, especially multisection CT, is the modality of choice for assessing the hard tissue of the TMJ. Magnetic resonant imaging is a standardized imaging protocol for depicting the soft-tissue anatomy. Because of the operator dependence of sonography and the invasiveness and propensity for severe complications of arthrography, these modalities are not a part of routine work-up of the TMJ.

Keywords: TMJ, TMJ Imaging, MRI of TMJ

INTRODUCTION

A multitude of terms have been used to describe patients presenting with pain and dysfunction of the temporomandibular joint (TMJ) and related masticatory muscles: such as Costen's syndrome, dysfunctional temporomandibular joint and muscle pain, myofascial pain dysfunction (MPD), temporomandibular joint syndrome, mandibular dysfunction and craniomandibular disorders. These terms include several entities that have different etiology, but present with similar signs and symptoms.[1]

Temporomandibular disorders (TMD) are one subgroup of any of these terms, and they embrace a number of clinical problems that involve the masticatory muscles and/or the temporomandibular joint. This term is most frequently used in clinical practice.[1]

Most studies agree that TMD cannot be diagnosed only on the basis of findings by clinical examinations. The purpose of an imaging assessment of the temporomandibular joint (TMJ) is to graphically depict clinically suspected disorders of the joint. Diagnostic imaging has been helpful in substantiating temporomandibular joint (TMJ) disorders such as internal disk derangements.[1-3]

There seems to be growing confusion among dentists, both specialists and general practitioners, as to when imaging should be used, if at all and when each modality can be expected to be most useful. The need for imaging of the TMJ should be established on the basis of selection criteria. Selection criteria represent those clinical signs and symptoms that suggest that a radiographic examination would contribute to the proper diagnosis and care of the patient.[4] It provides a rationale for selecting among the various imaging modalities, with the purpose of obtaining the important diagnostic information with less radiation exposure. The most accurate diagnostic techniques are those that provide new information that will influence the patient care. The decision on selecting an examination should be made after considering the history, clinical findings, diagnosis, cost of the examination and radiation exposure.[2] This review paper describes the alternative imaging methods for TMJ Disorders and makes recommendations for their appropriate use.

PLAIN RADIOGRAPHY

The most common and most well-established plain film technique for examination of the TMJ is the transcranial projection of both the right and left sides with the jaw closed and opened. The lateral aspect of the joint is well visualized, but the central and medial parts of the joint are not clearly seen because the X-ray beam is not tangent to these articular surfaces. This disadvantage is partly compensated for by the fact that most of the early osseous changes occur laterally in the joint. It is recommended that, in addition to the transcranial projection, an anteroposterior projection should be used to depict the central and medial parts of the condyle. A transorbital and a transpharengeal projection is also suggested. These images are acquired as a screening evaluation but are not useful in depicting the soft-tissue elements of the articulation. Positive findings observed on transcranial radiographs are those of degenerative joint disease of TMJ in the range of 5%-10%.[2]

PANORAMIC RADIOGRAPHY

Previously, orthopantomograph was considered a gold standard for imaging TMJ since teeth and other structures of the jaws were also seen on the image. However, the superimposition of the base of the skull and zygomatic arch restricted the evaluation of the condyle and glenoid fossa in the panoramic film.[1]

TOMOGRAPHY

Conventional tomography has been used extensively to evaluate the osseous components of the TMJ, generally in a lateral orientation but sometimes in combination with frontal views. When compared to oblique transcranial projection, computed tomography has been found to help in revealing a vast number

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of structural variations. In certain TMJ specimens evaluated for autopsy, computed tomography has been more specific in evaluating the anatomic structures better than transcranial radiography.[2] Some studies have indicated that tomography can provide unanticipated information that may lead to a change in treatment plan. 4°-41 In contrast, however, other investigations have concluded that the presence or extent of radiographic signs of osseous pathoses are of little prognostic value in the outcome of treatment 42 and that tomography has little effect on the diagnosis or treatment plan of patients with TMJ disorders.[2-5]

ARTHROGRAPHY

Early attempts at TMJ arthrography were undertaken by Nørgaard in the 1940s. Toward the end of the 1970s several articles appeared, describing the clinical and arthrographic characteristics of internal derangement related to displacement of the disk.[1] These arthrographic studies were actually the first to depict displacement of the disk, a pathologic entity that had been suspected earlier.[2,3] During the following years, considerable enthusiasm developed for TMJ arthrography, and a large number of publications describing the usefulness of the technique appeared. The changed attitude toward TMJ arthrography can be traced to the following factors: (1) use of an image intensifier to facilitate joint puncture and to study and document joint dynamics, (2) identification of disk displacement as a common cause of TMJ pain and dysfunction, and, probably most important, (3) introduction of new, conservative surgical methods for treating disk displacement. Arthrography is indicated for an evaluation of the soft-tissue components of the TMJ, especially disk position, function, and morphology in those patients presenting with a suspected internal derangement. There are two important imaging modalities for TMJ arthrography. In single-contrast arthrography, radiopaque material is injected into either the lower or upper joint space, or into both compartments. In double-contrast arthrography, a small amount of air is injected into the joint space after the injection of contrast materials.[2,3] Several studies have shown that arthrography is an accurate imaging method for evaluating anterior disc displacement. The accuracy for diagnosing the position of the disc ranged from 84% to 100% compared with the corresponding cryosectional morphology and surgical. Perforation and also adhesion of the disc can also be evaluated by such techniques.

COMPUTED TOMOGRAPHY

In the 1980s, computed tomography (CT) began to be applied in the diagnosis of TMJ ankylosis, condyle fracture, disc displacement and osseous changes.[3] In an earlier report, the accuracy for disc displacement was high (81%) when comparing imaging observations of CT and surgical findings. Some reports considered that CT might replace the technically difficult and invasive arthrography in the diagnosis of disc displacement in TMD. However, the accuracy of the disc displacement was only 40%-67% in CT in studies of autopsy specimen materials. The accuracy of osseous changes of TMJ in CT compared with cadaver material was 66%-87%. Some reports pointed out that radiographic evidence of arthrosis may or may not be associated with clinical symptoms of pain dysfunction. Thus patients without osseous changes in TMJ may have pain, and those with clear signs of bony abnormalities may be pain-free.[5-10]

MRI

Computed tomography (CT) has been replaced by Magnetic resonance imaging (MRI) and arthrography as the primary diagnostic tool in the evaluation of the temporomandibular joint (TMJ) disorders.[11-12] MRI evaluation of TMJ disk offers a distinct advantage over TMJ arthrography. Despite the superior resolution of CT and limited visualization of cortical bone by MRI, most osseous pathology is accurately depicted. Intra-articular abnormalities are readily visible on MRI images, providing further information not available with other imaging modalities.[13-15]

Magnetic resonance imaging (MRI) is unique in that there is no associated risk of ionizing x-ray. For MRI, the patient placed in a strong static magnetic field. The hydrogen nuclei, or protons, in the body align with the direction of the main magnetic field, a short radiofrequency (RF) pulse at the proper frequency and duration is then transmitted into the body.[1] The protons absorb RF energy and flip over into a plane that is at an angle with the direction of the main magnetic field, the protons reemit some of the absorbed energy, which induces an electric current in a specially designed RF receiver coil. The induced current, *so-called the magnetic resonance (MR) signal*, is then transformed into an image by computerized mathematical methods.[1,7,9]

An MR image is produced from signals coming from the hydrogen nuclei, or protons, in the body. The contrast of the image is provided by differences in signal intensity from protons in different tissues. Magnetic resonance imaging (MRI) is preferably appropriate to assess variations of the disk. Spin-echo pulse sequences typically are used for MR imaging of the TMJ. The most frequently used ones in TMJ images are *T_1-weighted* image (short TR and TE), *T_2-weighted* image (long TR and TE) and proton-density (*PD*) image (long TR and short TE). Typical values for T_2 in tissue range from 0.02 to 0.30 seconds. In general, the more water a tissue contains, the longer the T_2. Thus, areas of long T_2 can be interpreted as areas of edema, effusion, or inflammation.[4] Typical T_1 values for tissue range from 0.2 to 3 seconds. Much of the power of MRI comes from the fact that various tissues have different values of T_1 and T_2 and contrast can be varied over a wide range by adjusting TE and TR. The intrinsic contrast of the anatomy in the region makes T1-weighed images satisfactory in majority of cases. When joint fluid, tumor, edema or infections are doubted, T2-weighted images are more useful. Sagittal and coronal images are attained with the patient's mouth opened and closed. Because of the small size of the structures of concern here, surface coils are essential for acceptable signal-to-noise (S/N) ratio. The significant landmarks for valuation of TMJ function comprise the articular fossa of the temporal bone, the mandibular condyle, the disk, and the bilaminar zone.[11,14,15] The closed-mouth scans are inspected first. Damage to the bilaminar zone permits the unopposed lateral pterygoid muscle to shift the disk anteriorly. This is perceived as displacement of the disk anteriorly in relation to the articular fossa.

Furthermore, the relationship of the disk and the mandibular condyle with the patient's mouth opened is assessed. Normally the disk and the condyle move as a unit anteriorly when the mouth opens.[12] If the disk gets displaced with mouth closed

position and retakes it's physiological relationship with the condyle then anterior dislocation with reduction is present. While on the other hand if when the mouth is opened, the condyle and the disk do not come to physiological relationship, anterior displacement without reduction is present (Table-1).

Direct and Indirect Magnetic resonant imaging Signs of TMJ Dysfunction

Direct signs

1. Abnormal disk morphologic features
- Crumpled
- Rounded
- Flat
- Perforated

2. Abnormal disk displacement in closed-mouth position
- Anterior displacement
- More frequently observed
- Posterior band exceeds 10° or 30° from vertical
- Posterior displacement
- Rare
- Posterior band exceeds 10° or 30° from vertical
- Lateral or medial displacement

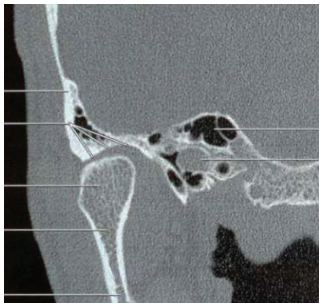
3. Abnormal disk movement in open-mouth position
- Anterior disk displacement with reduction
- Anterior disk displacement without reduction
- Stuck disk (disk remains fixed)

4. Osteoarthritic changes of the condyle
- Flattening
- Osteophytes
- Erosion
- Sclerosis

Indirect signs
- Large amount of joint fluid (joint effusion)
- Increased thickness of LPM attachments
- Rupture of retro-diskal layers [5]

Numerous studies have equated MRI of TMJ with arthrography and CT. The MRI findings were also compared with anatomical and histological observations. In studies on autopsy specimens, the accuracy of MRI in evaluating osseous changes in TMJ was 60% to100% and the accuracy in evaluating disc displacement was 73% to 95%. All these studies showed that MRI was the best method of imaging both the hard and soft tissues of the TMJ.[15]

Although many studies agree that muscular pain is another major aspect of TMD, the evidence of pathological changes of the masticatory muscles may have been ignored in imaging diagnosis. The reportsshown in few previous studies suggest that MRI is not only an accurate method to detect the position of the disk but also helps in evaluation of the pathological changes of the masticatory apparatus in Temporo mandibular joint disorders.[10]



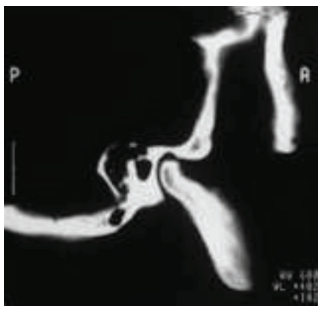
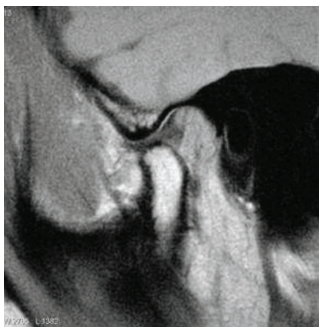


Figure-1: Coronal CT of TMJ; **Figure-2:** Sagittal CT of TMJ



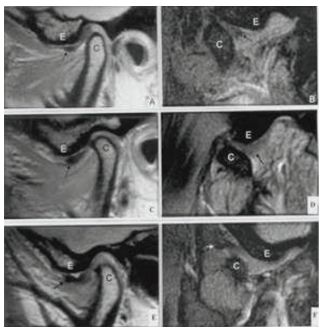


Figure-3: MRI of TMJ; **Figure-4:** MRI of TMJ

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 diff erential diagnosis and for the comparison of therapeutic results in treating internal joint defects. The first reports of TMJ sonography date back to 2000.[3] It uses presentlyavailable types of USG equipments with scanning transducer of 7.5–12 MHz frequency, which makes it easy to depict the narrow space of the jaw joint and the position of the joint disk and it reveals ligament adhesion. During the evaluation of the patient is in semi- reclining position, the transducer is placed over the joint parallel to the long axis of the mandible.The joint disk is scanned on the screen as a thin homogeny hypo, as far as the isoechogen strip adjacent to the condylar border. The condylar borders and articular eminence are seen as hyperechogen line. During the examination it is possible to directly observe the joint disk move when the mouth is opening and closing. A 70–85 % agreement was seen in studies comparing the results of MRI and USG. An ultrasonographic system using the high frequency

Diagnostic task	Panoramic	Transcranial	Skull views	Tomography	Arthrography	CT	MRI
Ankylosis Bony	0	0	0	++	0	+++	+
Ankylosis fibrous	0	0	0	0	0	++	+++
Arthritis	+	+	0	++	O	++	+++
Anomaly	+	+	+	++	0	+++	++
Disk position	0	0	0	0	++	+	+++
Fractures	++	+	++	++	0	+++	++
Inflammatory conditions	0	0	0	+	++	+	+++

Table–1: Radiographic appearances of TMJ anomalies in relation to various imaging techniques

and conveyors with a large diameter has been recently invented. The ultrasonograph waves, generated by this system, are able to penetrate easily through the small aperture between the glenoid fossa and the condyle. The new transducers invented have a a high focus depth and narrow wave beam. The rebound potential of bone surface is as much as 2/3 waves and only 1/3rd propogate down to deeper anatomic structures. For this reason the transmitter must be placed on a specific place, with the aim to transmit waves through the soft tissues, situated between the condyle and the eminence.[3,8]

RADIONUCLIDE IMAGING

This method of imaging provides the only means of assessing physiologic change that is direct result of biochemical alteration. It is based on radiotracer method, which assumes that radioactive atoms or molecules in an organism behave in a manner identical to that their stable counterparts because they are chemically indistinguishable. Scintigraphy aids in discovering the early changes in the TMJ apparatus which may also result in joint disc abnormalities. The temporomandibular joint is ideal for SPECT (single proton emission computed tomography), as TMJ is asmall joint situated close to the skull base, which is ideal for evaluation by SPECT. In normal individual, the perfusion is symmetrical, TMJ being perfused at same rate as rest of facial structure. 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. [3]

TMJ Imaging in Orthodontics

The initial appreciation of problematic cases provides valuables hints:

- To shun treatment errors and functional disorders, (preventive reasons)
- To develop the treatment planning, and decrease relapse.
- To treat TMD during the orthodontic Restoration.

The TMJ remodeling and bite jumping during the mandible progression depends not just on age, sex, maturity, timing, duration of treatment, and the facial growth pattern, but also on the state of TMJ, which is evidently related to the efficiency and stability of occlusal rehabilitation.[6]

CONCLUSION

The reliability of a complex joint such as that of the jaw is the result of a stable interaction of soft tissue and bony structures. In spite of its daily exposure to wear and tear, simple changes in the TMJ are rare. Trauma, internal derangement with conceivable sequel and inflammation are the most mutual forms of pathologic conditions.

The general radiologist is frequently challenged to manage the diagnostic pathway and to provide a good basis for planning the proper therapeutic strategy. A chart has been prepared to help the diagnostician in selecting proper imaging modality based on desired area of interest. (Table-1) Conventional radiography helps toidentify major bone abnormalities. Multislice CT, is the modality of choice for assessing the hard tissue of the TMJ. Soft-tissue anatomy is best showed with MR imaging and a standardized imaging protocol. Since the operator dependence of ultra sonography and the intrusiveness and propensity for severe complications of arthrography, these modalities are not part of a repetitive work-up of the TMJ.

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