Recent Advances in Temporomandibular Joint Imaging: An Update

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Abstract: Temporomandibular joint (TMJ) abnormalities cannot be reliably assessed by a clinical examination. Radiographic examination forms an integral component of the clinical assessment routine in patients with temporomandibular joint disorders. There are several imaging modalities to visualize the TMJ. Definitive and rational diagnoses or treatments can only be achieved through a comprehensive understanding of the etiologies, predisposing factors, and pathogenesis of TMJ diseases. Our understanding and interest in the diagnosis and management of patients with various types of temporomandibular disorders had increased as research has identified structural abnormalities and disease mechanisms associated with some of these disorders there has also been remarkable progress in the imaging of the TMJ. To make a diagnosis more efficient, miniinvasive diagnostic methods are becoming necessary. So it is possible that, together with the improvement of the equipment, development of the diagnostic methods used during the treatment of temporomandibular joint defects could continue in this direction. Latest imaging modality is making life easy for those clinicians who must evaluate the hard tissues of the temporomandibular joint complex in patients with orofacial pain. Recent advances in imaging technology have greatly contributed to the understanding of diseases of the temporomandibular joint.

Key words: Temporomandibular Joint, Orofacial Pain, Comprehensive, Imaging

INTRODUCTION

The TMJ is one of the most complex joints to image, and there has only been limited success in performing true dynamic MR imaging. The articular disk is a biconcave fibrous structure located between the surface of the condyle inferiorly and the articular eminence superiorly. Internal derangement is defined as an abnormal anatomic relationship between the disk and the mandibular condyle Complex etiologic factors like trauma, emotional stress, orthopaedic instability, muscular hyperactivity, inflammatory and degenerative diseases, which compromise the equilibrium of the temporomandibular joint (TMJ), have been implicated in the development of temporomandibular joint disorders (TMD). Radiological investigations are of paramount importance in the diagnostic assessment of a patient with TMD. Functional and dysfunctional aspects of disk physiology include the following: 1) Coordinated (normal) disk function; 2) Disk displacement with reduction; and 3) Disk displacement without reduction.

Conventional radiographic TMJ projections like transpharyngeal, transcranial, panoramic radiograph, conventional tomographic sections of TMJ may be adequate in a number of clinical situations. But there are bony alterations that occur in these disorders like erosions, osteophytes, pneumatisation of articular eminence that are difficult to be detected in conventional radiographs due to overlapping of the anatomic structures. This warrants the use of advanced imaging modalities like Ultrasonography, computed tomography, Magnetic Resonance Imaging (MRI), Cone Beam computed tomography (CBCT) and Nucleide imaging.

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. The use of ultrasonography for the diagnosis of temporomandibular joint (TMJ) disorders is uncommon, although several reports have been found in the literature suggesting evident advantages of the utilization of such procedure that is inexpensive and noninvasive compared to the other imaging tools habitually used, such as MRI, arthrography and CT scan. 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. Studies comparing the results of MRI and sonography showed 70–85% agreement.

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.

Technique

US uses a transducer that functions as a transmitter and a receiver of acoustic energy. Ultrasound 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 ultrasound, translating them into images.

The TMJ area, which includes bones (condylar and temporal bone), connective (joint capsule and retrodiscal tissues), fibrocartilaginous (disk), and muscular (lateral pterygoid and masseter muscles) tissues, has some peculiarities with respect to other musculoskeletal areas. The small examination area, with limited accessibility to the deep structures, and the high risk of
ultrasound reflecting off bone tissues make the interpretation of images complex. The ultrasonograph waves, generated by this system, are able to penetrate easily through the small aperture between the glenoid fossa and the condyle. This new ring transducer has a high focus depth and narrow wave beam. The bone surface rebounds as much as 2/3 of the waves, only 1/3 propagating down to deeper 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. 

US has been applied to the study of many diarthroidal joints, and it has been suggested that it can provide useful information for the assessment of TMJ disorders. (Usg pdf) The US findings related to condylar changes demonstrated that the method does not present yet significant sensitivity in the diagnosis of disorders related to the morphology and changes of the condylar cortical bone, a fact that was also observed by Emshoff et al. (en5v) Tognini et al. have developed studies demonstrating values sensitivity and specificity of about 75% for US in the detection of intraarticular fluid. (en5v) US has been widely employed to detect effusion in many musculoskeletal areas; it is accurate at depicting the presence of intrarticular inflammatory fluids in larger joints.

A recent autopsy study by Rudisch et al. showed that condylar erosion was sonographically detected with a sensitivity of 95%, specificity of 90%, and accuracy of 93%. The positive and negative predictive values were 95% and 90%, respectively.

COMPUTED TOMOGRAPHY

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. CT is very often used in diagnosing disc dislocation, condylar fractures, degenerative bone changes and ankylosis. CT has been the method of choice to assess the contours of the cortical bone and TMJ dynamics. Computed tomography (CT) imaging brings to radiologists and clinicians the possibility of evaluating complex cases in the maxillofacial field and giving information that leads to more accurate and specific diagnosis of some TMJ pathologic conditions. Tomography provides a sectional view through the joint, with slice thickness of about 2 mm with hypocycloidal or trispiral technique, up to about 7 mm 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. Artrography is combined with computer tomography, which enhances the accuracy of the diagnosis of internal TMJ disorders. The first studies showed, in comparison with the surgical findings, that the disc dislocations represent about 81% of the total number of TMD (later and more extensive studies proved only 66%). The same result was proved also by the studies of degenerative bone changes. It was also found that CT failed to reveal smaller disc perforations.

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. 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. 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.

CT scanning of the TMJ enjoyed a great deal of success and interest soon after the development of TMJ arthrography partly due to its own rapid technological development and non-invasive nature. We still use CT scanning when fine detail in bone anatomy is of primary importance. Three-dimensional CT is valuable in the assessment of osseous deformities of the jaw.

MAGNETIC REASONANCE IMAGING

Magnetic reasonance 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 that arthrography, and more reliable than radiography. (13 scan) MRI is a unique imaging modality that produces crosssectional multiplanar images without using ionizing radiation. Using MRI, the evaluation of the internal derangement of TMJ (the depicition and localization of the disc) can be detected. MRI uses a magnetic field and radiofrequency pulses rather than ionizing 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. 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.

MRI is the standard imaging modality for the diagnosis of TMJ disorders. From axial localizing images, sagittal and coronal planes are prescribed. Imaging is most commonly performed in these planes in order to document the position of the disk. Oblique sagittal and coronal images can be oriented to the condyle, but are unnecessary to demonstrate internal derangements. T1-weighted sagittal images are the cornerstone of the TMJ examination; the anatomy is clearly depicted, and the imaging plane is optimal for assessing articular disk position. T2-weighted images are useful for detecting degenerative periartricular changes and the presence of a joint effusion. Fat saturation or inversion recovery renders these findings more conspicuous. Gradient-echo techniques have been implemented to obtain cine-loop motion studies. 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.

With the introduction of surface-coil-assisted MR imaging the utilization of CT and arthrography has decreased significantly for the diagnosis of TMJ disorders. There are obvious advantages of MR imaging over arthrography, such as being less invasive, less dependent on operator skill, and more accurate for medial and lateral disc displacements. 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. From a clinical point of view, it is important to know that the magnetic field strength of the MR imager has a significant impact on the signal-to-noise ratio and the image quality. Studies have shown that images obtained with a 0.3 Tesla MR scanner are significantly less accurate than those obtained on a high-field system with a 1.5 Tesla magnetic field strength.

MRI does not have the morbidity associated with the introduction of needles into the joint( as occurs in arthrography), but MRI is more expensive examination and is contradicted in patients who are pregnant, or who have pacemakers, intracranial vascular clips, or metal particles in vital structures. Some patients may not be able to tolerate the procedure because of claustrophobia or an inability to remain motionless.

MRI is an excellent modality for the follow-up of various
CONCLUSION

Several radiographic methods are used to assess the TMJ, an area that is difficult to be imaged due to factors like superimposition of adjacent structures and morphological variations. Basic X–ray examination is the most readily available method of imaging which usually has no contraindications. A good quality X–ray image allows us to confirm or to exclude possible traumatic damage of the joint bone structures. Recent advances in imaging technology have greatly contributed to the understanding of diseases related to the TMJ. The complexity of the TMD however, demands a clear and precise image of the region for effective management of the patient. The use of computer-aided diagnosis and treatment planning can be very helpful in these cases.

RADIOLUMINgraphic 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.

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.

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.

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 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 specific i 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.

Pogrel and colleagues (1995) studied the effectiveness of SPECT for quantitative skeletal scintigraphy of the mandibular condyle. SPECT provided more reproducible measurements of radionuclide uptake in the condyle and was recommended for use in establishing bone metabolism and physiologic status in the condyle in conditions such as condylar hyperplasia and condylar resorption.(critical review)

De Bois and colleagues (1994) compared the use of 99mTc-labeled human immunoglobulin G (IgG) with late-phase bone scanning for the quantification of synovitis of multiple joints in the body. They showed that 99mTc-labeled IgG scintigraphy was a specific test for the identification of active disease and that uptake of this agent was significantly higher in rheumatoid arthritis than in osteoarthritis.

CONCLUSION

Several radiographic methods are used to assess the TMJ, an area that is difficult to be imaged due to factors like superimposition of adjacent structures and morphological variations. Basic X–ray examination is the most readily available method of imaging which usually has no contraindications. A good quality X–ray image allows us to confirm or to exclude possible traumatic damage of the joint bone structures. Recent advances in imaging technology have greatly contributed to the understanding of diseases related to the TMJ. The complexity of the TMD however, demands a clear and precise image of the region for effective management of the patient. The use of computer-aided diagnosis and treatment planning can be very helpful in these cases.
Ultrasonography, as a completely non-invasive procedure, commonly used in many branches of medicine and applied even in diagnosing functional temporomandibular defects. MRI is capable of demonstrating abnormalities of the disk, its supporting structures, synovium, and periauricular structures associated with internal derangement, degenerative and inflammatory structures, synovium, and periarticular structures associated with internal derangement, degenerative and inflammatory structures, synovium, and periarticular structures associated with internal derangement, degenerative and inflammatory structures, and periarticular structures associated with internal derangement, degenerative and inflammatory structures. 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.

REFERENCES


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LIST OF PHOTOGRAPHS

Fig: 1 - MRI IMAGE OF TMJ

Fig: 2 - TMJ-evaluation-web CT

Fig: 3 - CBCT image of TMJ