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IMAGING OF TEMPOROMANDIBULAR JOINT DISORDERS

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Summary

Complicated anatomical configuration of the temporomandibular joint was the reason for developing standardized radiographic techniques which would provide accurate anatomical images.

Tomography provides excellent bony details but no in formation of the soft tissue component of the joint. This technique is useful in demonstrating suspected hypoplasia, hypertrophy or malformation of the condyles, in the case of maxillofacial trauma with fracture description, infections and tumors.

Artrography is performed to determine the status of the condyle-disk-glenoid fossa and eminence relationship with rxegard to the closed and open mouth position.

Computerized tomography (CT) is superior to conventional radiograšhy and conventional tomography for evaluating internal derangements of temporomandibular joint, trauma, degenerative processes and tumors. CT demonstrated good evaluation of soft tissue and excellent evaluation of bony structures.

Magnetic resonance (MR) has shown exquisite soft tissue contrast and provides a view of the structures of temporomandibular joint which cannot be differentiated by conventional radiography, conventional tomography and computerized tomography. MR of temporomandibular joint can distinguish internal anatomical features of the joint to a degree that no other imaging procedure can match. An image of the articular disk without contrast media as well an image of the posterior band has made the magnetic resonance the golden standard of temporomandibular joint imaging.

Key words: Temporomandibular joint; conventional radiography; artrography; computerized tomography; magnetic resonance.

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 condyl-disc-fossa articularis relationship.

Conventional radiography

First diagnostic radiological method for bone analysis was conventional x-ray technique with different angulation and rotation of patient head towards x-ray beam, to avoid superposition of opposite joint. Inadequate x-ray positioning, due to anatomic variations of bony structures of the joint, often resulted in image distortion [2].

Contact technique of imaging TMJ introduced by Parma was deserted due to high dose of radiation. Imaging technique introduced in clinical praxis by Schueller in 1905. demonstrated first evaluation of dynamic imaging using open and shut mouth images which enable some kind of function evaluation of TMJ. Oblique projections, of conventional films, which are rarely used demonstrate more distortion of articular head compare to Shueller projections. Posterior-anterior craniogram (Clementcshitch projection) is used when neck condyl fracture is assumed. Conventional radiological techniques, besides the osseous structures, are not able to demonstrate soft tissue like cartilage and disk of TMJ.

Conventional radiographic techniques were inadequate for evaluation of motility disorders and dynamics of TMJ because they lack possibility to standardize mouth opening during imaging.

Conventional tomography

Linear tomography was introduced in 1939. There were various methods for standardization and radiographic angle correction. Development of conventional tomography with hypocycloid movement of the tube introduced by Rosenberg and Sinkha in 1982., and improvements of the method, developed by Rosenberg and Kratchik enabled much better visualization of TMJ than conventional techniques used before [3,4], (Fig. 1). This technique included determination of horizontal and vertical angulation of the condyl in positioning the patient for imaging. This is called corrective lateral cephalometric technique which include cephalostat for supporting the head for precise positioning [5].

Cephalostat enables condyl orientation with mobile coordinate system. Adjustable ear fixates enables precise head positioning. Radiopaque markers incorporated in ears fixates enables measuring the intermeatal line which is important

to determine the angle and linear measuring. Lateral corrected cephalometric tomograms are made by patient head positioning with horizontal and vertical angle measuring from submental verteks zonogram and AP tomograms. According to measured results lateral tomograms are taken with the slice thickness of 2mm. The number of slices is determined by width of capitulum artikulare. Imaging includes open and closed mouth.

These techniques are used when osseous pathology is present such as:

a) Trauma of TMJ;
b) Development anomalies: (hypoplasia, hypertrophy, condyl malformation);
c) Inflammatory diseases;
d) Tumors (osteoplastic or osteolityc);
e) Degenerative diseases.

Described techniques enabled very good radiological description of TMJ osseous changes [6]. Clinical demands for demonstration of internal structure of the joint and soft tissues, asked for new imaging methods and was found in arthrography introduced by Norgaard in the mid 1940s.

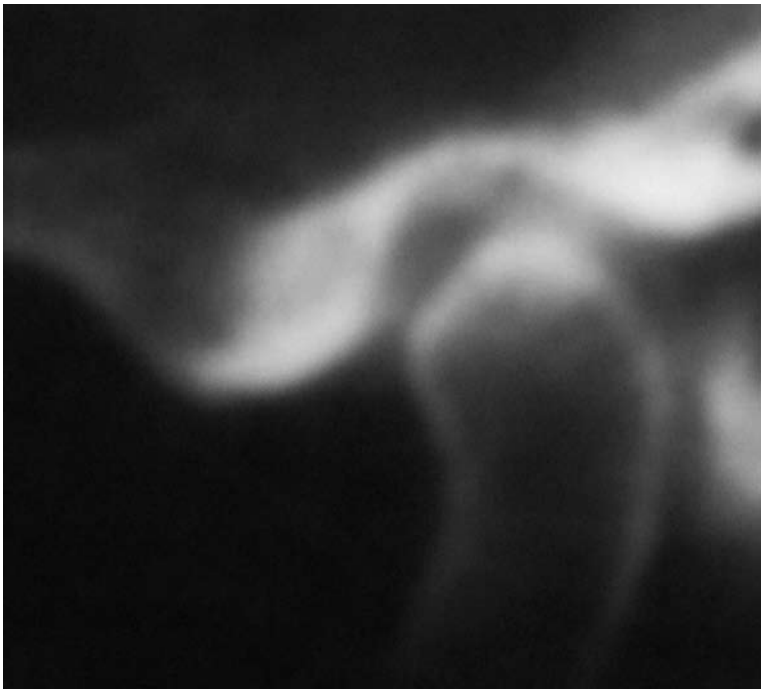

Fig. 1. Conventional thomography of normal TMJ

Arthrography

Arthrography is a method in which injection of contrast media (negative contrast media – air, positive contrast media -iodine contrast) is used with preauricular or transmeatal puncture site. With this technique internal structure of the joint as well joint discus is very well demonstrated [7]. Three techniques are in use:

a) demonstration of lower TMJ joint space with monocontrast (iodine contrast);
b) demonstration of upper and lower joint space with double contrast (iodine contrast + air);
c) demonstration of upper and lower joint space with monocontrast (iodine contrast).

The elements that can be evaluated by arthrography are the osseous anatomy, disc position, size, or shape, presence of perforated disc, reduction of the disc to normal position, disc dislocation without reduction, dynamic anatomy and movement of the joint [7].

Arthrography was never widely used and was the ultimate imaging method in the patients in whom the diagnosis of internal TMJ was not possible by other imaging methods. Arthrography was also used in diagnostic dilemmas and in the precise planning for surgery.

Orthopantomography

Orthopan technique demonstrated very well the osseous structures of TMJ and is screening method for internal join derangement (Fig. 2). 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).

Enlargement factor of TMJ for orthopantomography is from 7% to 27% according to various authors. Radiological anatomy of TMJ on the orthopanthomography does not reveal the functional status of the joint. Sometimes radiological changes can be find in 90% of otherwise asymptomatic patients, which preclude the low specificity and relative high sensitivity of the method.

The skin dose in orthopantomograpy is 20mSy. Introduction of digital ethnology reduce the dose for 43%. Diagnostic results of orthopantomography are comparable in 60-70% to that of linear and hypocycloid tomography. The osseous contour of the capitulum articulare and fossa articularis resemble the actual chondral plate in 14% of the patients only.

Conventional linear tomography introduced by Petrilli and Gurly in 1939 demonstrated better specificity in the diagnosis of degenerative diseases of TMJ than orthopanthomography. Linear conventional tomography as well as orthopantomography are inadequate for the early detection of suptile osseous erosions. Linear conventional tomography as well as hypocycloid tomography has higher x-ray dose than orthopanthomography.

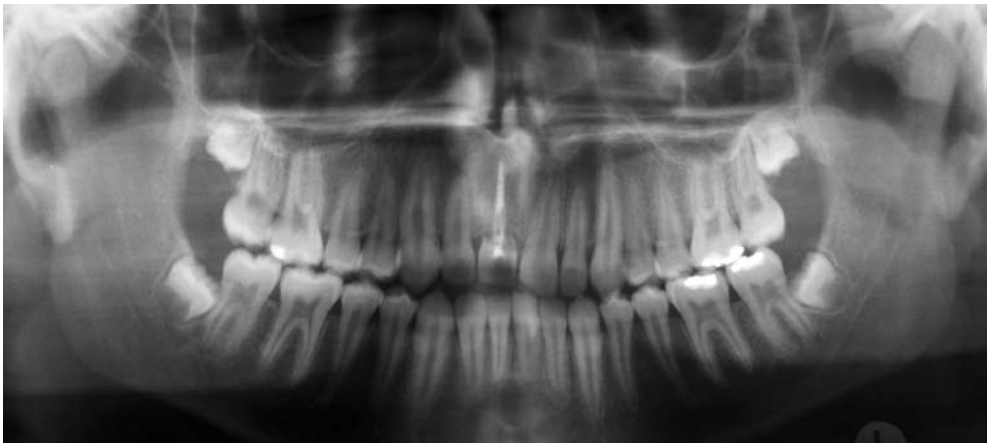

Fig. 2. Orthopantomography – Normal TMJ

Computed tomography

The introduction of computed tomography (CT) in clinical praxis and in the diagnosis of TMJ disorders, enabled much better delineation of anatomical structures of the joint due to lack of tissue superposition [8]. CT enabled the reconstruction in the coronal and sagittal plane. For the direct imaging in the sagittal projection there should be special head support devices as well possibility of the CT gantry to image in an angular position. Conventional CT devices enabled reconstruction in the coronal and sagittal planes but the quality of reconstructed images were poor comparing to spiral CT and MSCT machines.

Nowadays, MSCT ethnology with volume imaging and isotropic voxel design enable various software possibilities such as MIP (multiple imaging projec-

tions) and volume rendering as well the same quality of images in all possible planes. These new software possibilities enable demonstration of TMJ in three dimensional projections which improves sensitivity and specificity of the imaging method (Fig. 3).

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 [9,10]. Computed tomography is excellent in the demonstration of bony structure remodeling in the patient with internal joint derangements which usually can be found in cases of degenerative changes [11]. Remodeling includes enlargement of fossa glenoidalis, aplanation of articular condyl and osseous sclerotic changes on the articular surfaces of the joint. These changes in the end stage disease lead to degenerative osteoarthritis.

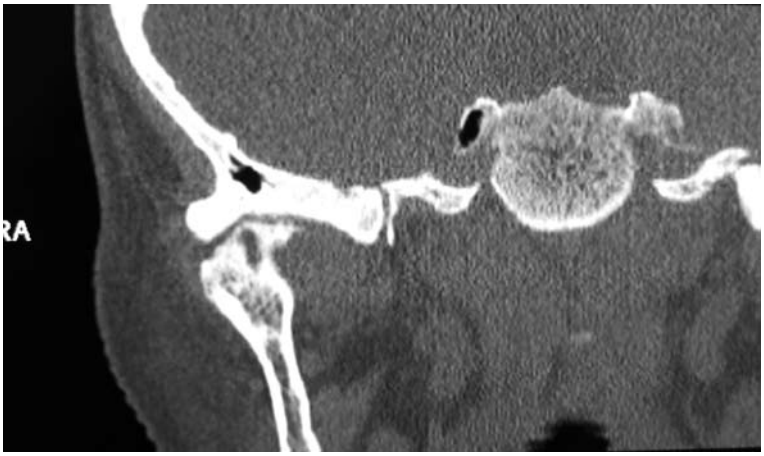

Fig. 3. MSCT – osteoarthritis (coronal plane). Small lytic lesion of capitulum articulare

Magnetic resonance

In order to use correctly this method one should know the MR anatomy of temporomandibular joint. TMJ is complex synovial joint which include capitulum articulare on the mandibular condyl and fossa articularis in the temporal bone. TMJ is divided with fibrocartilagenous disk in upper and lower part. The disk can be classified in five shapes.

The first category is biconcave formatted disk with anterior and posterior fibers and intermedial zone.

The second type includes uniformly wide disk without biconcavity.

Third type includes funnelary shaped disk without demonstration of billaminar zones. The disk is placed in front of condyl. This shape of the disk usually demonstrates strong bony remodeling.

Forth disk type demonstrate biconcave contour with deformity of the transitional zone. This disk type is often in concordance with functional deformity (dislocation without reduction) and bony osteoarthritic changes.

Fifth disk has triangle shape with strongly remodeled retrodiskal tissue which is reduced to tiny line. There is also atrophy of posterior ligament.

Radiography and conventional tomography are unable to demonstrate soft tissue of TMJ. Computed tomography is limited in the evaluation of inner structure of TMJ.

Magnetic resonance is the newest imaging method in the diagnosis of TMJ. The method is established on different imaging basis than conventional radiography and computed tomography which rely on X-ray. Tissue differentiation on magnetic resonance imaging (MRI) is based on measuring magnetic behavior and number of hydrogen proton in the human tissues placed in the strong magnetic field.

Basic advantages of MRI are:

a) soft tissue structure differentiation;
b) imaging in various imaging planes;
c) excellent tissue contrast resolution.

The MRI demonstrate internal anatomic structure of TMJ with great precision, excellent contrast resolution and surpass all known imaging methods in the diagnosis of TMJ disorders. There is a lack of the signal of the cortical bone (black) on the all MRI sequences because there are low quantity of hydrogen protons in the cortical bone [12].

Bone marrow on the contrary demonstrates high signal intensities on all imaging sequences due to high fat content. Articular condyl and fossa glenoidals are easily shown on MRI due to this specific structure. Cartilaginous disk structure demonstrates also lack of signal on all imaging sequences and therefore is shown as black area [13].

There is good contrast differentiation between low disk signal on T1 weighted images and high signal of synovial parts of the joint as well bony parts of capitulum articulare and fossa glenoidalis. The best demonstration of anatomic details of the TMJ is on the T1 weighted images [14].

The disk is S shaped structure due to shape of capitulum articulare and articular eminence. Posterior fibrous connection on sagittal plane is placed on 12 hours with the thickness of 3mm.

It is important to evaluate the position of capitulum articulare with open and close mouth. With close mouth, the position of the capitulum articulare in fossa articularis can be discrete anterior or posterior which are only anatomical variants. With mouth open, position of capitulum articulare should be under articular tubercul. This position is seen in only 50% patients with normal TMJ. Other demonstrate slight anterior position in front of articular tubercul and some slight posterior position. Capitulum articulare and fossa articularis are very well seen due to thin black cortical line and high signal of the bone marrow which give the MR image exquisite contrast.

The normal disk has sharp margins with bow-tie shape in the open mouth position (Fig. 4-6). Retrodiscal structures are best seen on sagittal plane with medium to high signal intensity. Bilaminar zone is attached on the posterior part of fibrose part of the disk and include neurovascular bundle. Peripheral part of the disk is connected to joint capsule.

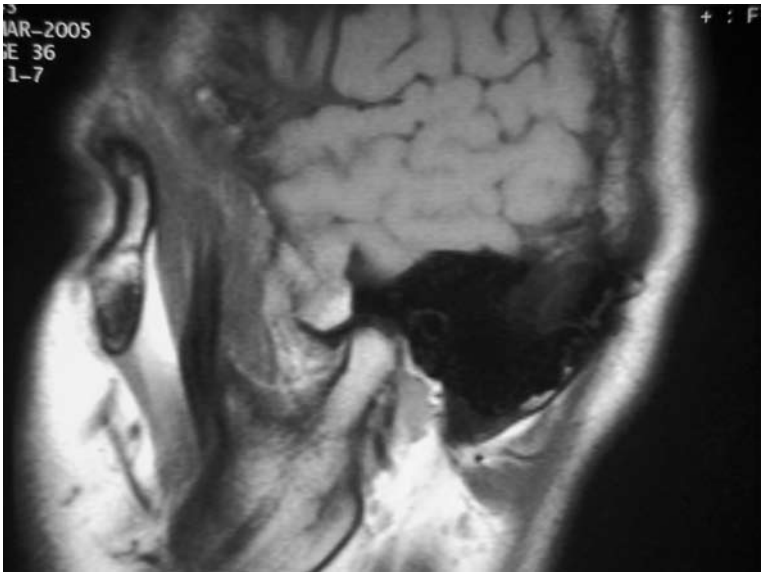

Fig. 4. MR – Normal disc (mouth closed)

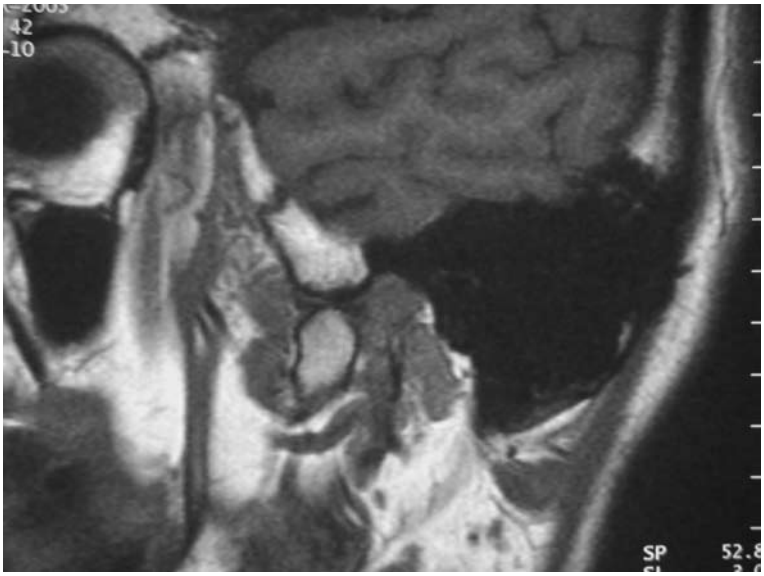

Fig. 5. MR – Normal disc (mouth opened)

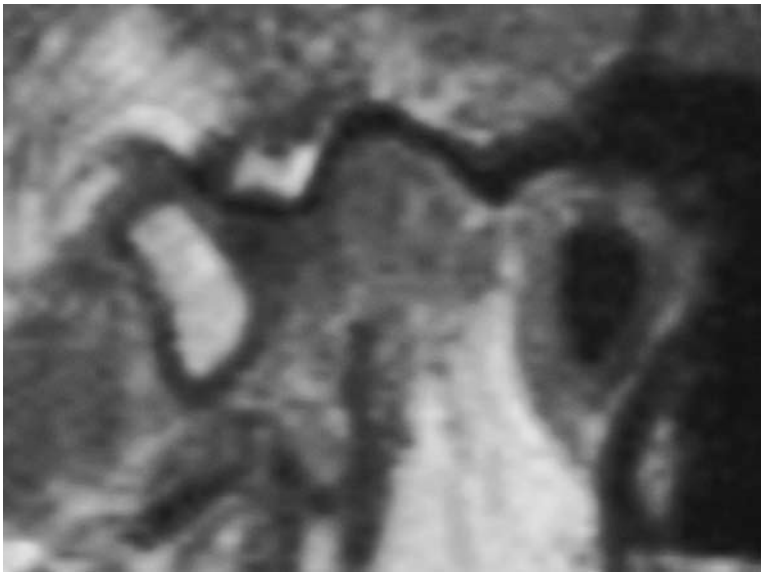

Fig. 6. MR – TMJ subluxation

PATHOLOGICAL CHANGES OF TMJ

Congenital anomalies of TMJ can affect one or both joints. Condylar agenesis is rare condition connected to few syndromes which results in face deformity. The reason is lack of growth center in the mandibular condyl.

Traumatic and inflammatory changes are the usual reason of hypoplastic condyl growth and rarely congenital. Hypoplasia is usually unilateral and in the most cases diagnosed with orthopantomography. MSCT and MRI also can demonstrate these anatomical disorders.

Hyperplasic condyl is usually connected with hereditary syndrome like Klinefelter, gigantism or acromegaly. Unilateral hyperplastic condyl result in face deformity and asymmetry. X-ray demonstrate length enlargement of mandibular ramus and face asymmetry. TMJ can be affected with various inflammatory diseases which involve other joints. The most often are infectious arthritis, posttraumatic arthritis, psoriatic arthritis, rheumatoid arthritis and metabolic arthritis (giht). Osteoarthritis of TMJ is of degenerative nature and symptomatology is mild.

Secondary osteoarthritis developed in younger population is often due to acute trauma or chronic muscular pain. Radiographicaly osteoarthritis demonstrate subchondral sclerosation of TMJ articular surfaces and is very well seen on all conventional X-ray exams and MSCT which are better than MRI. Advanced cases of osteoarthritis demonstrate aplanation of articular surfaces, erosions, osteophytosis and cyst forming structures.

Rheumatoid arthritis

With rheumatoid arthritis 50% of patients demonstrates some involvement of TMJ. Patients complain for pain, swelling and reduction in mouth opening. These changes are most prominent in the morning and usually came periodically dependent of main illness activity.

Conventional X-ray techniques in the early stage of the disease are not diagnostic because the pathological changes start in the synovial tissue which is not seen by these techniques and yet there are no bony changes [15].

MRI demonstrate very well early changes in the synovial part of the joint and is very sensitive. The most sensitive sequence is STIR. After illness progression bony changes develop and demineralization is seen in 50-80% of the patients, with articular surface applanation and bony erosions. Erosions are usually placed on the anterior part of the articular surface. Articular surfaces by progression of the illness developed irregularity, erosions and loose the normal articular shape. Erosions can be find even in the fossa glenoidalis.

Unilateral involvement of TMJ is often seen in the psoriatic arthritis and ankylosing spondylitis [16,17]. Pain, swelling, opening mouth reduction and crepitations are identical to symptoms of rheumatoid arthritis.

Ankylosing spondylitis

Ankylosing spondylitis is much rarer and involvement of TMJ is seen in advanced cases of disease only. Radiographicaly the changes are similar to other inflammatory diseases with in some cases developed fibrous ankylosis. Differential x-ray diagnosis of various inflammatory diseases is in the most cases impossible.

Traumatic arthritis

Traumatic arthritis develops haemarthros and inflammation with widening of intraarticular space. MSCT and especially MRI which directly demonstrate haemarthros is the golden standard in that cases.

Metabolic and infectious arthritis

Metabolic arthritis like uric diathesis or chondrocalcinosis are very rare and involve the patient over 40 years. There are no anatomical x-ray bony changes in the early stage of the disease. In the advanced stages the x-ray changes are similar to other inflammatory diseases. Infectious arthritis of TMJ develops from direct spread of inflammation from dental, parotid or ear area. Very rare gonorrhea, syphilis or tuberculosis can affect TMJ. MRI detect intraarticular puss in the early stage of the disease while conventional radiological techniques are insensitive until bony changes develop.

In the advance stages bony destruction is visible on all imaging techniques. In the end stage of inflammatory disease fibrose or bony ankylosis can develop. In the young population these advance difficult cases may end with disturbance of mandibular growth and asymmetry of the face.

Subluxation and dislocation

Subluxation of TMJ results as anterior position of capitulum articulare in front of tuberculum articulare on petrous bone. Unfortunately the same position of capitulum is seen in otherwise normal population. Conventional radiology techniques give satisfactory results in analysis.

Mandibular dislocation is radiographically similar to subluxation but the capitulum is placed in higher position concerning tuberculum articulare. Clinical

status is of mayor importance since this patient cannot spontaneously close the mouth.

Radiological exam without clinical status is non diagnostic.

Fractures

The condylar fracture are in majority of cases in subcondylar area. Real condylar fractures are in the intracapsular part of TMJ. The fracture can be unilateral or bilateral, impacted or dislocated. Conventional x-ray is usually diagnostic but some complicated or non-proved fracture with strong clinical suspicion sometimes need MSCT. MSCT demonstrate excellent bony structures of TMJ. Possibility of tree dimensional reconstructions enable proper fracture evaluation and surgery planning.

Ankilosys

Ankilosys of TMJ can be fibrous or osseous. Fibrous ankylosiys can not be diagnosed with conventional x-ray methods because fibrose tissue is transparent on conventional images. In osseous ankilosys articular space is partially or completely obliterated bridged with osseous tissue and detectable with conventional X-ray. MSCT is the golden standard in the diagnosis of TMJ ankilosys.

Tumors

The most of benign tumors of TMJ include hondromas, osteochondromas, osteomas, mixomas, fibromixomas, hondroblastomas and osteoblastomas. Fibrosarcomas, chondrosarcomas and synovial sarcomas are the most frequent malignant tumors as well as metastases.

Conventional radiology is helpful in the diagnosis of osseous tumors when there are osteolisys or osteoplastic growth. Reduction of articular space by tumor growth results in reduction of mouth opening. Enlargement of condylar and subcodnylar regions by tumor growth is irregular in shape. Osteolitic changes are easily seen on all imaging methods.

CONCLUSION

Although diagnostic radiology is of great importance in the diagnosis of TMJ disturbances clinical exam is the „sine qua non" in the managing of the patients. Multidisciplinary approach is the only way we can help the most majority of the patients with TMJ disturbances [18,19].

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Sažetak

Slikovni prikaz poremećaja temporomandibularnog zgloba

Složena anatomska konfiguracija temporomandibularnog zgloba razlog je razvitka standardiziranih tehnika koje omogućuju točan anatomski prikaz.

Linearna tomografija omogućuje dobre koštane detalje, ali ne prikazuje mekotkivnu komponentu zgloba. Ta tehnika uspješno pokazuje hipoplaziju, hipertrofiju ili malformaciju kondila, a u slučajevima maksilofacijalne traume dobar prikaz frakture pukotine. Infekcije i tumori također su prikazivi ovom metodom. Artrografiju izvodimo radi prikaza statusa kondila, diska, zglobne jamice te zglobne kvržice s otvorenim i zatvorenim ustima.

Kompjutorizirana tomografija (CT) nadmašuje konvencionalnu radiografiju i konvencionalnu tomografiju u procjeni unutarnjeg poremećaja temporomandibularnog zgloba, kod traumatskih promjena, degenerativnih procesa i tumora. CT omogućuje dobru procjenu mekih tkiva i odličnu procjenu koštanih struktura.

Magnetna rezonanca (MR) pokazuje izuzetan mekotkivni kontrast i omogućuje prikaz struktura temporomandibularnog zgloba, koje se ne mogu prikazati konvencionalnom radiografijom, konvencionalnom tomografijom ili kompjutoriziranom tomografijom. MR temporomandibularnih zglobova razlikuje unutarnje anatomske strukture zgloba takvom preciznošću kakvu druge metode ne mogu dostići. Prikaz diska bez kontrastnog sredstva, kao i područja bilamilarne zone, čine magnetnu rezonancu zlatnim standardom u dijagnostici bolesti temporomandibularnog zgloba.

Ključne riječi: Temporomandibularni zglob; konvencionalna radiografija; artrografija; kompjutorizirana tomografija; magnetna rezonanca.

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