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Temporomandibular Joint Imaging

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Diagnostic imaging has had a recent and unique importance in substantiating the clinically suspected existence of internal derangements of the temporomandibular joint (TMJ) caused by disk displacement.[1] The purpose of this review is to demonstrate the relative merits of the differing imaging modalities in a rapidly evolving diagnostic armamentarium.

NORMAL AND ABNORMAL ANATOMY AND FUNCTION

The disk is a biconcave fibrous structure that is interposed between the surface of the condyle inferiorly and the articulating portion of the temporal bone, superiorly.[2,3] The posterior portion of the disk, termed the posterior band, lies at the 12 o'clock position relative to the condylar head when the jaw is closed and the condyle rests in the glenoid fossa (Figure 1a). When the jaw opens the condyle rotates and translates anteriorly toward the apex of the tubercle and the thin, midportion, of the disk remains interposed between the condyle and tubercle (Figure 1b).

The most common intra-articular abnormalities of the TMJ are: 1) internal derangement and 2) degenerative arthritis.[1] These two conditions appear to be linked by a cause and effect relationship. Internal derangement is defined as an abnormal positional and functional relationship between the disk and the mandibular condyle and the articulating surfaces of the temporal bone (Figure 2a–c).[4] Osteoarthritis, a primarily noninflammatory disorder of diarthrodial joints, is characterized by deterioration and abrasion of the articular cartilage and by simultaneous remodeling processes in the underlying bone.[5–7]

A general classification scheme subgroups the various disk positional conditions as (a) superior or 12 o'clock (normal), (b) anterior, (c) anteromedial (Figure 2b), (d) anterolateral, (e) medial (Figure 2c), and (f) lateral. Abnormalities (c) and (d) represent rotational displacements. The functional aspects are (a) coordinated (normal) disk function, (b) disk displacement with reduction, and (c) disk displacement without reduction.

If the disk is displaced anteriorly yet snaps or clicks into normal anatomic position when the jaw opens, the terminology for this condition is disk displacement with reduction. Clinically, this is associated with both opening and closing clicking sounds and is often associated with joint, muscular, and facial pain.

In some patients the disk remains anterior to the condyle regardless of jaw position. This is often associated with painful limitation of jaw opening ("closed lock"). Because condylar translatory mobility is commonly (but not always) hindered on the affected side only, one may observe a deviation of the mandible away from the midline toward the affected side with maximal jaw opening.

A sequela of disk displacement without reduction is a torn, detached or disrupted posterior disk ligament.[1] The bone-on-bone condition that results when the convex bone surface of the condyle articulates directly with the convex bony surface of the temporal bone leads to progressive articular degeneration to arthritis.

In conjunction with functional and anatomic disk derangement, intrinsic alteration of the disk, per se, also develops.[6,8] Included is a change in the configuration or morphology of the disk from a biconcave to a biconvex configuration. Marked deformity and thickening of the disk is an even more striking sequela. Morphologic changes in the disk are also associated with alterations in disk histology leading to metaplastic hyaline cartilage, hyalinization, accumulation of foci of calcium deposits, and abnormal collagen patterns.[9]

CLINICAL PREDICTABILITY OF INTERNAL DERANGEMENTS OF THE TEMPOROMANDIBULAR JOINT

The clinical signs and symptoms of TMJ internal derangement are not consistently reliable to accurately assess the exact extent of the internal derangement. A recent prospective clinical investigation in 188 patients with signs

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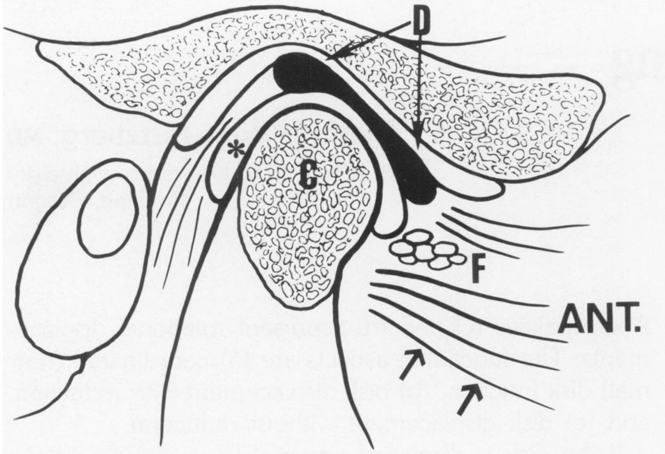

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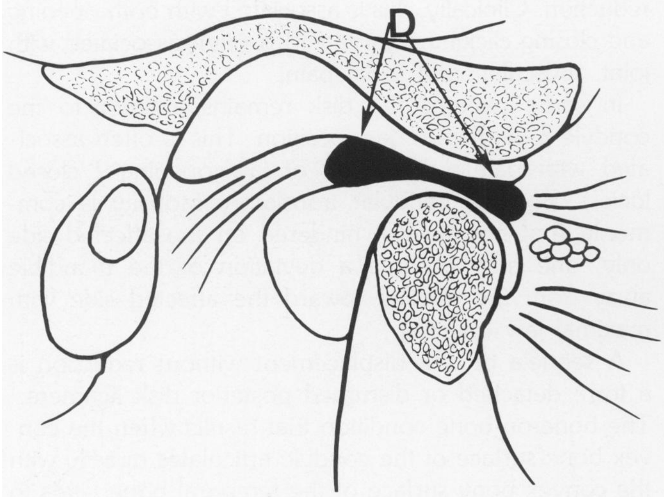

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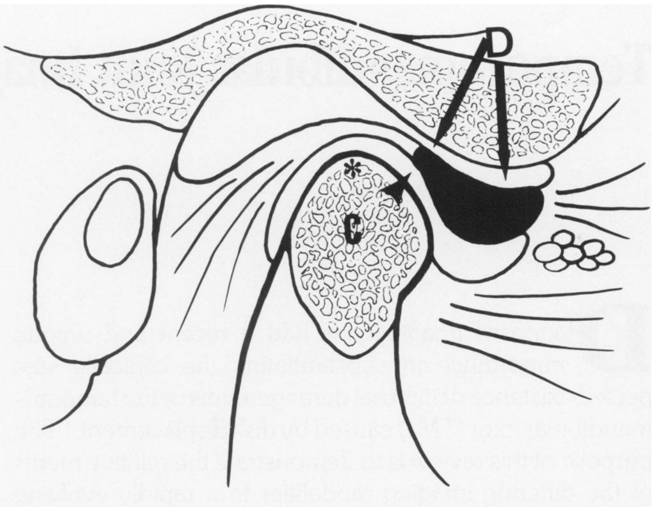
Figure 1. Diagrammatic depiction of a sagittal section through the temporomandibular joint. (a) the normal disk (arrows, D) has a biconcave lens-like configuration and its posterior band is in a superior (12 o'clock) position relative to the condylar head (C). The inferior joint space (*) delineates the undersurface of the disk and is opacified by arthrography. The inferior belly of the lateral pterygoid (arrows) is a muscle of mastication and attaches to the anterior neck of the condyle. A collection of fatty tissue (F) which has been termed the "lateral pterygoid fat pad" separates the upper and lower bellies of the pterygoid muscles and helps to identify the anterior margin of the disk. ANT = anterior. (b) jaw in the open position. When the jaw opens the condyle rotates and translates anteriorly toward the apex of the tubercle, the thin-mid-portion of the disk (arrows, D) remains interposed between the condyle and tubercle.



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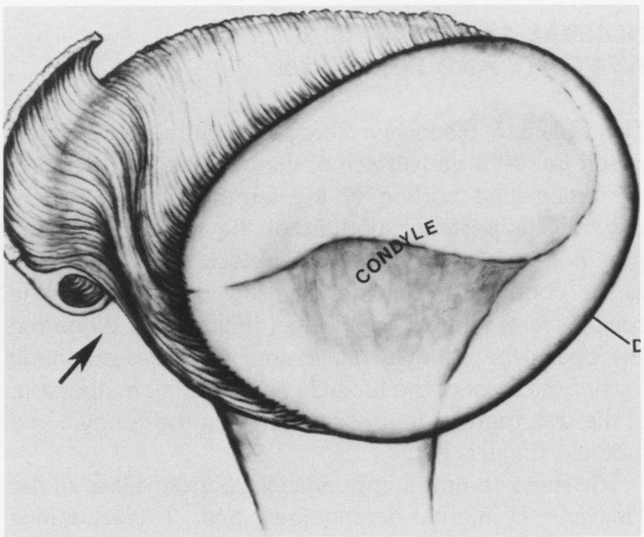

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and symptoms of TMJ pain and dysfunction compared the clinical signs and symptoms with the arthrographic depiction of intracapsular disease.[10] Attempts were made to establish which of those clinical signs and symptoms are the best predictors of the condition of the joint depicted by arthrography. The results revealed that the overall clinical accuracy for the various aspects of internal derangement was in the range of 70%.

IMAGING

Plain Radiography

The most common radiograph of the TMJ is the transcranial view of both the right and left sides with the jaw closed and opened. These images are acquired as a screening evaluation but are not useful in depicting the soft-tissue elements of the articulation. Positive findings on transcranial radiographs in patients symptomatic for TMJ disease is in the range of 5%–10%.[11] The transcranial radiograph depicts only the lateral third of the condyle, joint space and

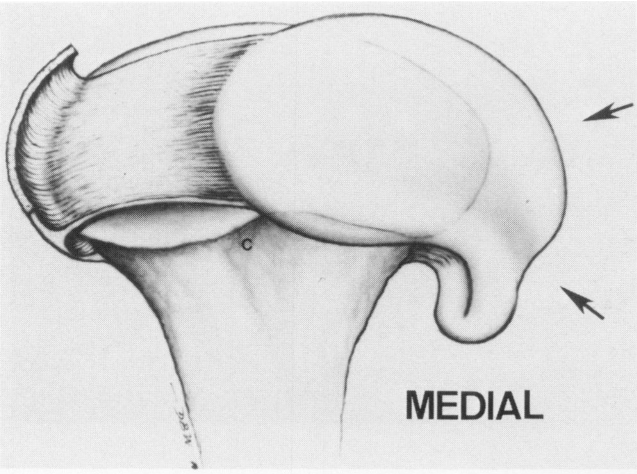

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Figure 2. Diagrams of disk displacement. (a) the displaced disk (D, arrows) has its posterior band (arrowhead) forward of the 12 o'clock position (*) of the condyle (C) as depicted in the sagittal plane. (b) The anteromedial disk displacement represents a rotational abnormality of disk position relative to the condyle and fossa of the temporal bone (now shown). The disk most commonly displaces in an anteromedial direction, and the lateral capsular attachment (arrow) is probably stretched. MED = medial, LAT = lateral. (c) Sideways displacement of the disk. In this representation the disk (arrows) is displaced in the medial direction and without an anterior component to the displacement. The condyle (C) serves as the reference anatomy for determining whether the displacement is anterolateral, anteromedial, medial, or lateral.

temporal bone. Positive findings observed on transcranial radiographs are those of degenerative joint disease.

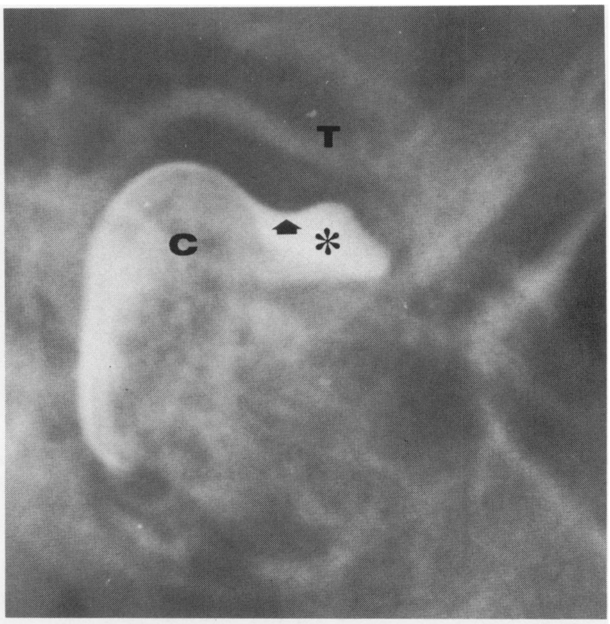
Tomography

The same findings of joint disease as depicted on transcranial radiographs are also visible on sagittal tomograms of the TMJ. However, the sensitivity of multidirectional tomography for changes of degenerative joint disease is greater than that of conventional radiography,[11] because multidirectional tomography can depict multiple regions of the condylar surface and can do so with finer anatomic resolution. The major disadvantage of multidirectional tomography is the high radiation dose.

Arthrography

Transcranial or tomographic radiographs suffice for simple delineation of the osseous structures of the TMJ. 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.

The arthrographic procedure for depiction of the joint



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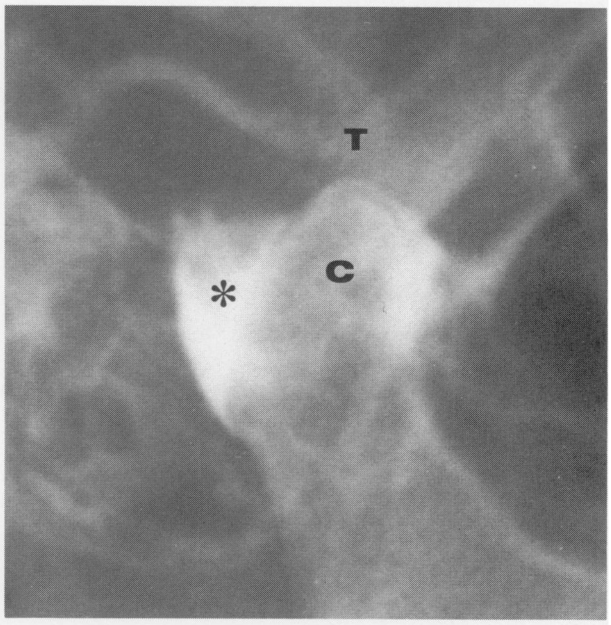

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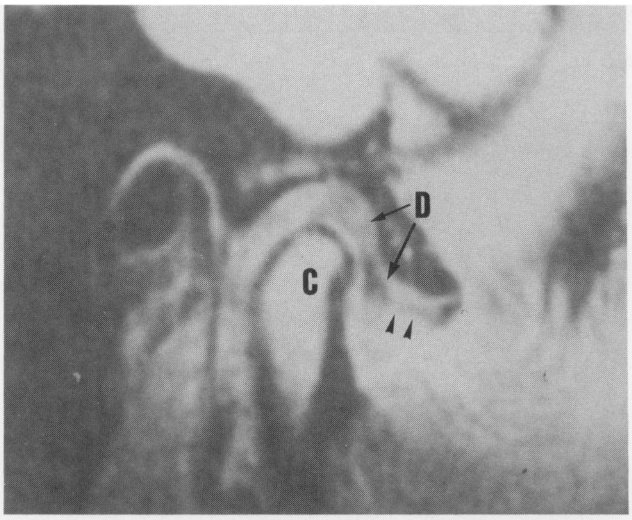
Figure 3. Lower joint space, single-contrast arthrogram depicting disk displacement with reduction. (a) Contrast is in the lower joint space (*) and this demonstrates that the posterior band of the disk is anterior to the 12 o'clock position of the condyle (C) and creates a concave impression (arrow) on the anterior recess of the joint space. T = tubercle. (b) Reduction of the displacement of the disk. The jaw is now maximally opened and the condyle (C) is just beyond the margin of the apex of the tubercle (T). The disk has now reduced and the contrast material has cleared from the anterior recess of the joint space and has flowed into the posterior recess of the joint space (*).

Figure 4. Placement of 6 cm surface coils (arrows) for bilateral TMJ imaging and with the jaw opened using a syringe wrapped in saline-soaked gauze as a bite-block.



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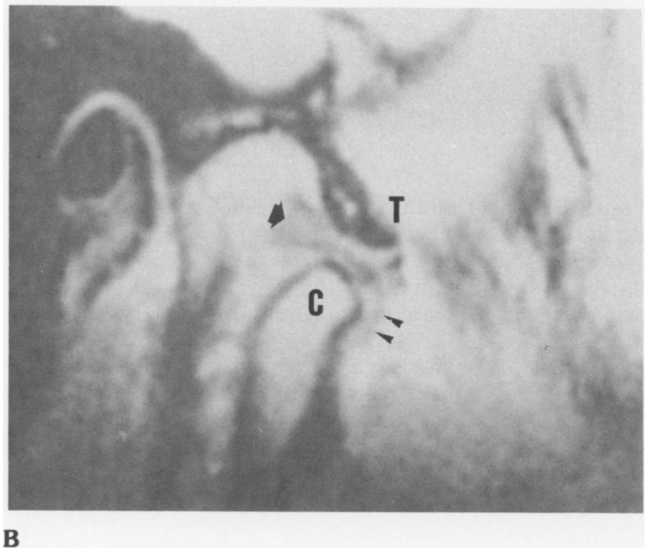

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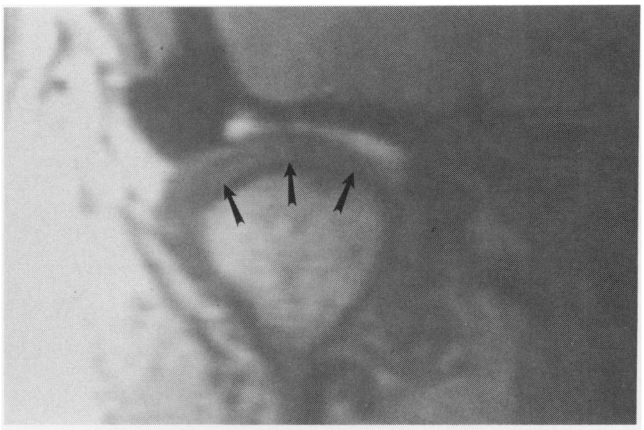

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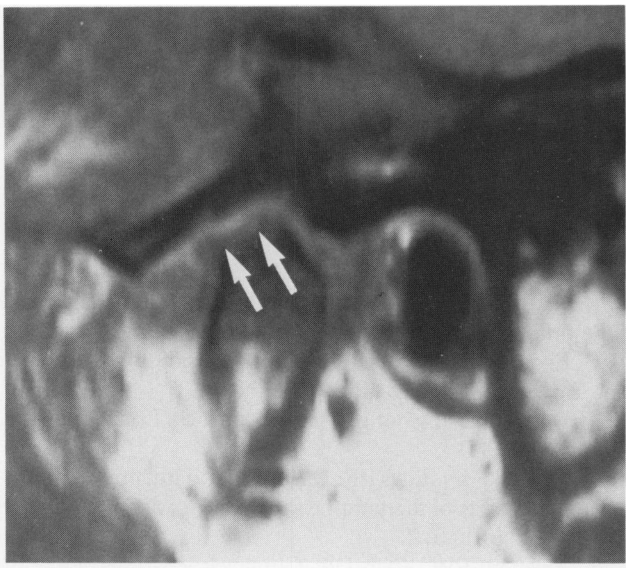
Figure 5. MR images of the normal TMJ with jaw in closed and opened positions. (a) Jaw in the closed position sagittal image. The image demonstrates the normal biconcave lens-like configuration of the disk (arrows, D) and with the posterior band in the superior (12 o'clock) position. The image also demonstrates the attachment of the superior belly of lateral pterygoid muscle to the anterior band of the disk (arrows). C = condyle. (b) Jaw in the open position sagittal image. The disk is interposed between the condyle (C) and tubercle (T). Relatively high signal (arrow) is often noted in the posterior band of the disk. The disk is attached to the neck of the condyle via firm capsular (Arrows) attachment. (c) Coronal plane of imaging with the jaw closed demonstrates the normal position of the arc-shaped disk (arrows). (d) diagrammatic depiction of the MR image shown in (c) and depicting the normal arc-shaped configuration and position of the disk (arrows).

space entails the injection of a water-soluble contrast material into the lower alone or lower and upper joint compartments under fluoroscopic guidance and using a 23-gauge scalp vein needle.[12] Approximately 0.4–0.5 mL of contrast medium is injected into the lower compartment under fluoroscopic observation. We use approximately 0.03 mL of 1:1000 epinephrine mixed into 3 mL of contrast material to allow intraarticular containment of contrast medium for subsequent imaging.

Following the injection of contrast material into the articulation, fluoroscopic-dynamic videotape images are recorded during opening and closing of the jaw (Figure 3a, b). In those patients having disk displacement without reduction or in those articulations that are normal or indeterminate, multidirectional tomography (arthrotomography) is performed following the fluoroscopic component of the examination.

The advantages of arthrography are: a) it accurately depicts the anatomic relationship of the disk to the condyle and temporal bone; b) it enables a dynamic functional assessment of normal and abnormal physiology; c) it is easy to perform in experienced hands; d) it has limited requirements for specialized imaging technology; and e) it is relatively inexpensive compared with computed tomography (CT) and magnetic resonance (MR) imaging.



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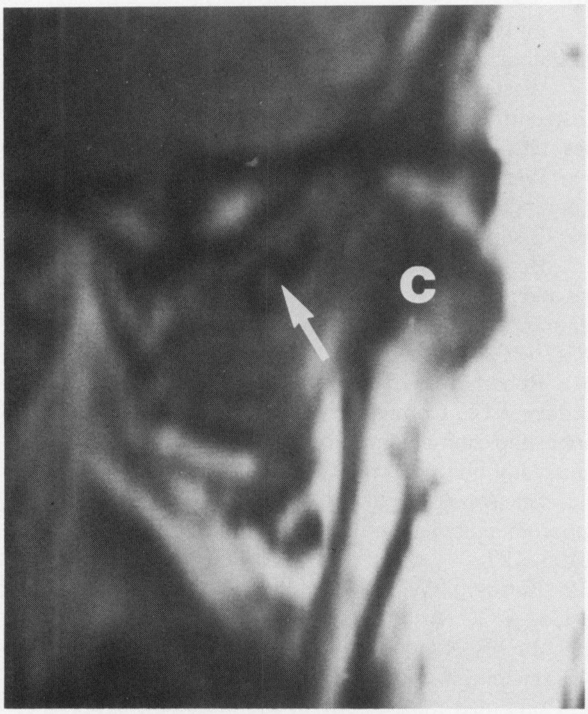

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The disadvantages of arthrography are: a) it involves a substantial radiation dose in a predominantly young, female population; b) it is an invasive procedure; c) its successful performance requires training and experience; d) it cannot accurately depict bony pathology; e) it is probably less precise in demonstrating anatomic, positional abnormalities than MR; and f) it cannot directly depict the soft-tissue components of the articulation.

Significant complications from TMJ arthrography in ex-

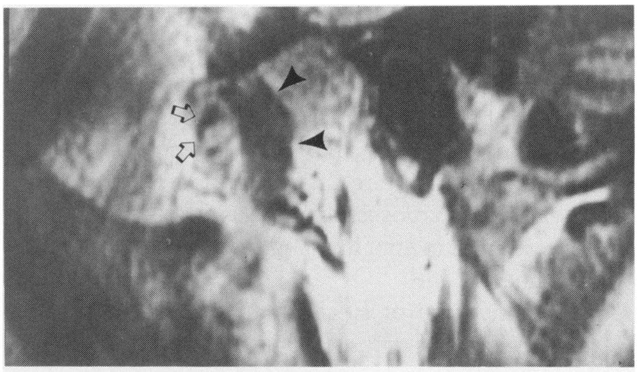

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Figure 6. MR depiction of chronic, anteromedial disk displacement without reduction associated with condylar degeneration. (a) In the closed jaw position, sagittal plane of imaging, the condyle is noted to be flattened and irregular (arrows). The disk cannot be visualized in the sagittal imaging plane. (b) Coronal plane of imaging with the jaw closed shows the medial disk (arrow) displacement. The disk is of signal intensity and is far medial to the condyle (C). (c) Sagittal image with the jaw maximally opened shows the deformed, completely displaced disk (open arrows), representing disk displacement without reduction. Note the low signal of the entire condyle (arrowheads) representing degeneration (TR/TE = 1000/25 ms).

perienced hands are uncommon. One of the most frequent complications is contrast medium extravasation into the capsule and soft tissues around the joint, which causes pain. Nonionic contrast media will be the agents of choice to minimize this discomfort. Vagal reactions are not infrequent and if a severe hypotensive response with bradycardia should occur, one must be prepared to administer 0.6 mg of atropine intravenously. Transient facial nerve palsies may result from too vigorous infiltration of lidocaine.

Computed Tomographic (CT) Imaging

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.[13] CT scanning has, however, decreased dramatically in the assessment of TMJ internal derangements since the advent of MR imaging with surface coils, because the soft-tissue contrast and anatomic detail on MR images is markedly superior to that obtained with CT.

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 Resonance (MR) Imaging

MR imaging with surface coils (Figure 4) is a proven method for the assessment of internal derangements of the TMJ and is rapidly surpassing arthrography and CT as the imaging method of choice.[1,14,15] The major advantages of MR in comparison with arthrography and CT are: a) it is noninvasive, b) it requires no ionizing radiation for image acquisition, c) it permits a direct visualization of the disk and joint structures, and d) multiplanar imaging is readily obtained and more easily interpretable. Comparative studies using cryosectional cadaver material in conjunction with multiplanar imaging have demonstrated the high accuracy of MR.

At the University of Rochester Magnetic Resonance Center, MR imaging of the TMJ is the second most commonly performed study. (Head MR imaging is the first, and cervical spine and lumbar spine MR studies are third and fourth, respectively.)

The normal TMJ demonstrated by MR images in the sagittal closed, sagittal open, and coronal closed jaw positions is depicted in Figure 5. In the sagittal plane the disk has a biconcave-lens-like configuration with the posterior band lying at the 12 o'clock position relative to the condylar head (Figure 5a). The low signal intensity of the fibrous disk is clearly depicted because of the relatively bright signal intensity emanating from the surrounding soft tissues and lateral pterygoid fat pad. The cortex of the condylar head has an absence of signal but is well depicted because of the relatively bright signal intensity of the contiguous cartilagenous and synovial tissues, superiorly, and the bright signal of the fatty marrow in its cancellous portion, inferiorly. The disk has a "bow-tie" configuration with maximal jaw opening and maintains its position interposed between the convexity of the condyle inferiorly and the convexity of the tubercle superiorly (Figure 5b). The posterior disk attachment has a bright signal relative to the posterior band of the disk due to the rich network of fatty tissue contrasted with the low signal intensity of the fibrous disk. In the coronal plane the disk has an arc-shaped configuration with the medial margin of the disk attaching to the medial pole of the condyle and with the lateral margin attaching to the lateral pole of the condyle (Figure 5c).

An example of a chronically displaced disk is shown in Figure 6a–c. The disk has an abnormal configuration, is completely displaced anterior to the condylar head and does not reduce with attempted maximal jaw opening. Abnormalities in the condylar head are also clearly depicted. The coronal plane of imaging shows a medial displacement in conjunction with the anterior displacement, the condition thus representing a rotational anteromedial displacement.

The disadvantages of magnetic resonance imaging are the inability to depict perforations of the posterior ligament, the limitation to static images and the high cost. The application of gradient-recalled acquisition in the steady state (GRASS) shows some promise in depicting sequential positions of the disk; however, the dynamics of the clicking event cannot be depicted due to the relatively long imaging times.

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