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Two-Compartment Arthrography and MR

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The reliability and accuracy of two-compartment temporomandibular joint (TMJ) arthrography was compared with MR imaging on the basis of an analysis of surgical findings obtained from joints that had been studied preoperatively with arthrography or MR or, in some cases, both procedures. Seven hundred forty-three consecutive TMJ arthrograms were successfully obtained in a total of 443 patients by using a single 27-gauge needle and a two-compartment technique in each joint. There was a 100% correlation with surgical findings in 218 radiologically abnormal joints operated on within 90 days of arthrography with respect to the presence or degree of meniscus displacement and normal or abnormal disk morphology and function. In 604 patients 1052 TMJs were studied with high-field-strength surface-coil MR. Surgical findings were available for correlation in 170 of the joints studied. Forty-three joints were studied with both two-compartment arthrography and MR. Eight operated joints had been imaged successfully with both two-compartment arthrography and MR. Both methods of evaluation provided highly reliable and accurate information regarding meniscus position and shape. Arthrography was superior to MR in detecting capsular adhesions and the presence or absence of perforation of the disk or meniscus attachments. Simple meniscectomy (with or without insertion of a temporary Silastic TMJ implant) was the most frequently performed surgical procedure in the series, followed by meniscus repositioning procedures. Joint effusions, failed TMJ implants, and avascular necrosis were demonstrated best with MR. Soft-tissue lesions, including intrinsic degeneration of the meniscus, anomalous muscle development, muscle atrophy, tendinitis, and injuries such as contusions and hematomas, were demonstrated only with MR. Partial-flip-angle GRASS (gradient-recalled acquisition in the steady state) techniques permit both fast scanning and study of functional joint dynamics. Joint fluid may appear as high signal intensity on GRASS images because of T2*-weighting.

We recommend MR as the procedure of choice for diagnosis of uncomplicated internal derangements of the TMJ. Two-compartment arthrography with videofluoroscopy is an important ancillary procedure that should be performed whenever capsular adhesions or perforations are suspected and not demonstrated with MR and whenever MR is inconclusive.

Temporomandibular joint (TMJ) arthrography and surface-coil MR are reliable and accurate imaging procedures for the diagnosis of internal derangement of the TMJ [1–27]. MR is now established as the procedure of choice over arthrography in most circumstances requiring meniscus imaging because of its lack of ionizing radiation, noninvasive characteristics, and superior soft-tissue contrast resolution compared with conventional techniques [18–27]. Arthrography with videofluoroscopy is superior to MR for the diagnosis of early perforations and joint adhesions. We have endeavored to compare the reliability and accuracy of two-compartment arthrography with MR and to define the respective roles of these procedures in TMJ diagnosis. Recommendations for specific applications of two-compartment arthrography and MR are offered.

Materials and Methods

Most arthrography patients were screened with submentovertex and jaw-protruded posteroanterior (Towne) views of the skull base and mandible followed by cephalometrically corrected and tightly collimated lateral closed- and open-mouth TMJ tomograms. Three closed- and one open-mouth views were typically obtained at 3-mm intervals. Arthrography was performed by one investigator between September 1986 and November 1987 by using a single 27-gauge needle to opacify the upper and lower compartments of each joint. The needle was first advanced into the lower joint compartment from below with the mouth partially open; palpation of the joint from above with the opposite index finger was alternated with intermittent fluoroscopy. After confirmation of proper needle tip position with a small test injection, 0.4–0.6 ml of contrast material (iothalamate meglumine, 43%, or iohexol, 180 mg/ml) without epinephrine was injected under fluoroscopic vision with the bevel opposed to the condylar surface (Fig. 1). After satisfactory opacification of the intact lower joint compartment, the patient was instructed to partially close his mouth and the needle was advanced through the posterior attachment without fluoroscopy into the posterior aspect of the superior joint compartment, after which another 0.4–0.6 ml of contrast material was injected under fluoroscopy guidance. Local anesthesia was not used; however, 2% Xylocaine was mixed with the contrast material, 20% by volume, before injection. Most joints were injected in less than 60 sec, beginning with initial skin puncture and ending with needle removal, after opacification of both joint compartments. The two-compartment technique was attempted in all joints; however, in some joints, only one compartment could be opacified. Magnified (×2) videofluoroscopy with tight collimation was routinely performed after needle removal, and local pressure was applied to the puncture site for about 10–20 sec. Then, tightly collimated, lateral, magnified fluoroscopic spot films were obtained routinely perpendicular to the condylar axis with the mouth closed, partially open, and fully open. Lateral arthrotomograms were obtained after spot filming in most normal or intermediate-stage (no perforation) cases by using tight collimation and a four-on-one exposure format per film (three closed-mouth views at 2- to 3-mm intervals and one mid-condyle open-mouth view). Arthrotomograms were omitted whenever obvious perforations were encountered or when spot films and videofluoroscopy clearly defined disk morphology and position.

MR studies of 1052 TMJs were performed in 604 patients by using a 1.5-T superconducting magnet* and a single, commercially available 8.9-cm surface coil with the patients supine and externally rotated to the surface coil. All studies were performed between February and November 1987. Each study was interpreted by one of three radiologists, and most studies were reviewed by the senior author. Most cases had been screened with mandible-skull views and lateral TMJ tomograms. External rotation to the coil (cephalometric correction) was used because of time considerations and software restrictions that frequently reduced the number of T1-weighted images that could be obtained with nonorthogonal, oblique scans perpendicular to the condylar axis. A number of different imaging parameters were used. The parameters used for the first approximately 350 joints have been described [25]. The last approximately 700 joints were studied in the closed-mouth position with 1-mm interspaced 3-mm-thick T1-weighted sagittal images, 600/20/2 (TR/TE/excitations), 12-cm field of view (FOV), and 256 × 256 matrix. This sequence required 5 min 8 sec. A GRASS (gradient-recalled acquisition in the steady state) axial localizing sequence, 21/9, was used with a flip angle of 30°, 24-cm FOV, 128 × 256 matrix, and three 10-mm images requiring 9 sec. Partially and fully open-mouth views were obtained by using GRASS images, 25/13, with a 256 × 256 matrix, 10–30° flip angle, 16-cm FOV, and single 5-mm-thick sagittal image with one (6 sec) to four (26 sec) excitations. After initial experimentation with the software, a standardized GRASS sequence with a flip angle of 30°, one mid-condyle 5-mm-thick image, and two excitations (13 sec) was adopted. We experimented with 3-mm-thick images, but abandoned them because a larger FOV (24 cm) and longer TR, and hence a longer imaging time, were required. GRASS scans of 3 mm had higher noise and were often less accurate than 5-mm images. All patients in the
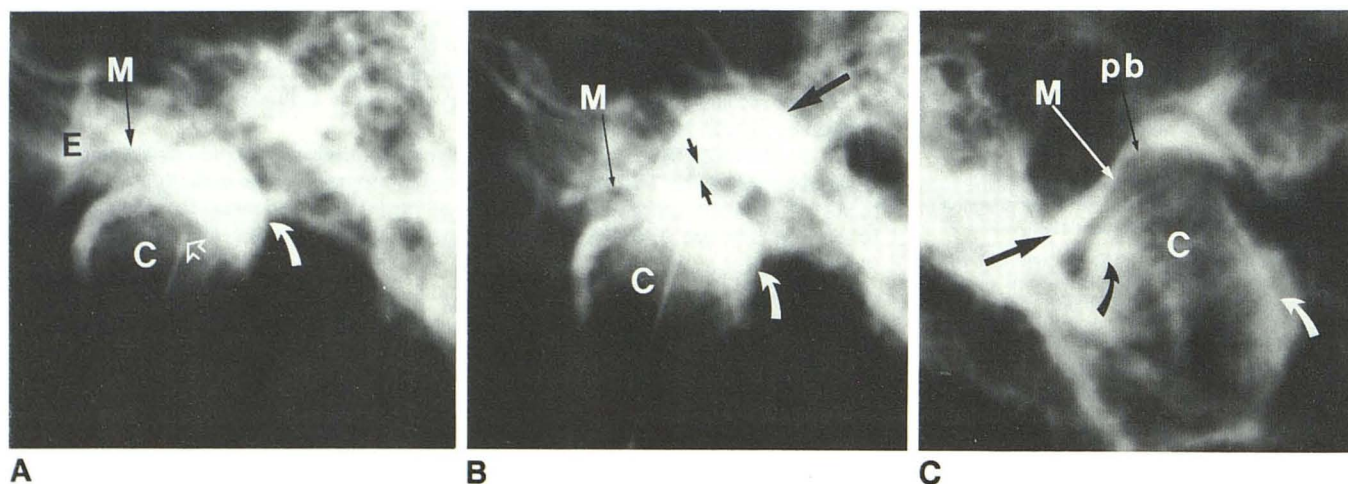

Fig. 1.—Sequential stages in thin-needle two-compartment temporomandibular joint arthrography.

A, Magnified lateral fluoroscopic spot film with mouth partially open after inferior compartment (*curved arrow*) injection. Needle tip (*open arrow*) and bevel lie apposed to posterolateral articular surface of mandibular condyle (C). Meniscus (M) lies beneath articular eminence (E) of temporal bone.

B, After lower compartment (*curved arrow*) opacification. Needle is advanced upward from lateral pole of condyle (C) and through (*small black arrows*) posterolateral meniscus attachment into upper compartment (*large black arrow*), which is then injected. Meniscus (M) is sharply demarcated.

C, Optimal compartment opacification. Lateral fluoroscopic spot film after needle removal, with mouth closed and injected joint nearest X-ray tube. Lower (*white arrow*) and upper (*straight black arrow*) joint compartments are each ideally filled with approximately 0.5 ml of contrast material. Posterior band (pb) of meniscus is slightly displaced anteriorly relative to condyle.

second and third groups were studied with GRASS scans in the open-mouth position. Selected patients were studied with GRASS scans only. Selected patients in the last group were also studied with surface-coil 1-mm interspaced T1- or T2-weighted coronal images with TR = 600–2500 to assess the side-to-side meniscus position, bony changes, and muscular disease. Patients with suspected disease involving the muscles of mastication were studied with surface-coil TMJ techniques and either T1-weighted or spin-echo 3- or 5-mm-thick coronal scans with the head coil to assess side-to-side symmetry. Four normal volunteer joints were also studied with closed-and open-mouth GRASS scans (Fig. 2). Selected joints were studied with a series of 12 sequential GRASS images during incremental degrees of either mouth opening or closure to permit viewing of muscle contraction and meniscus function during jaw movement. Several joints were imaged in the closed position with both GRASS and spin-echo sagittal and/or coronal images, 2500/20, 80, for the purpose of comparison when inflammatory disease or joint fluid was suspected.

Results

Arthrography

All but two arthrograms in the series were diagnostic with respect to normal or abnormal meniscus shape and front-to-back position and the presence or absence of disk reduction after mouth opening. Perforations were firmly diagnosed in at least 155 joints when filling of the upper compartment was observed and either spot-filmed or videotaped during lower compartment injection, and the needle tip was clearly within the lower compartment with the bevel contacting the condyle (Fig. 3). The meniscus was displaced anteriorly in over 620 joints (Fig. 4). Abnormal meniscus function without demonstrable anterior, medial, or lateral displacement was observed and recorded with videofluoroscopy in 16 joints (Fig. 5). There was one posteriorly displaced meniscus with a ruptured anterior attachment; over 100 joints were normal. Anterior, lateral, or medial meniscus displacement was confirmed in all of the 218 operated joints. Six joints studied early in the arthrography series and described as showing mild anterior displacement and incomplete reduction proved to be substantially displaced either anteromedially (two joints) or anterolaterally (four joints) at surgery. Perforation was surgically confirmed in 85 joints. Two unexpected perforations were found at surgery in patients whose clinical symptoms had not changed within 90 days of arthrography. No large perforations were found that had not been diagnosed preoperatively. Two arthrographic false-positive perforations were found at sur-
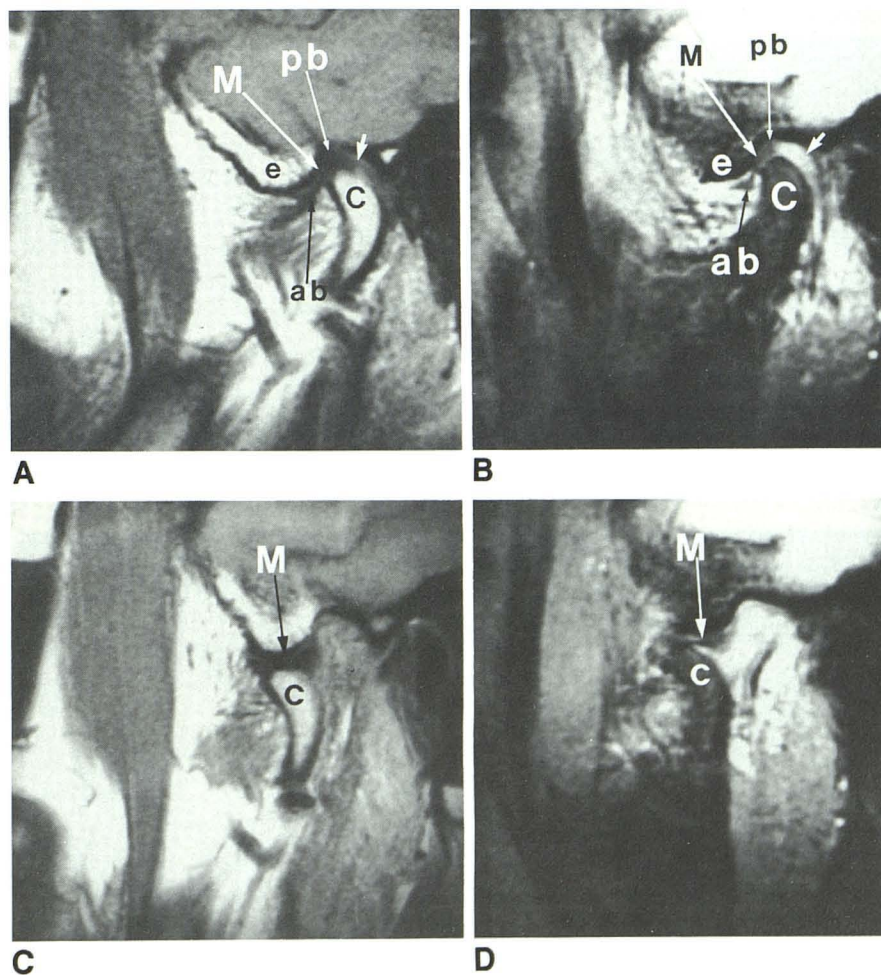

Fig. 2.—Normal temporomandibular joint.

A and B, Closed-mouth sagittal T1-weighted (A) and GRASS (B) images show normally positioned meniscus (M) relative to condyle (C) and articular eminence. Meniscus is biconcave and exhibits a uniform low signal intensity. Anterior (ab) and posterior (pb) bands of disk and normal posterior attachment or bilaminar zone (arrow) are sharply defined. Note hypointense marrow signal from condyle and eminence in B compared with T1-weighted images.

C and D, After translation. Meniscus remains interposed between eminence and condyle.
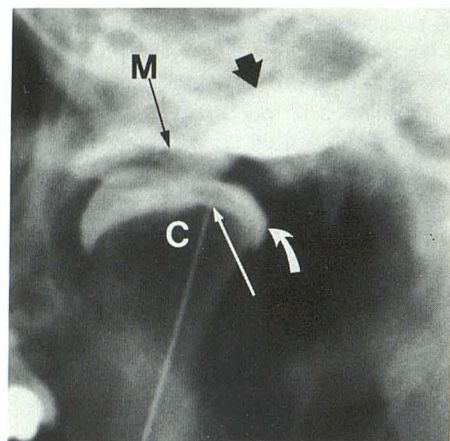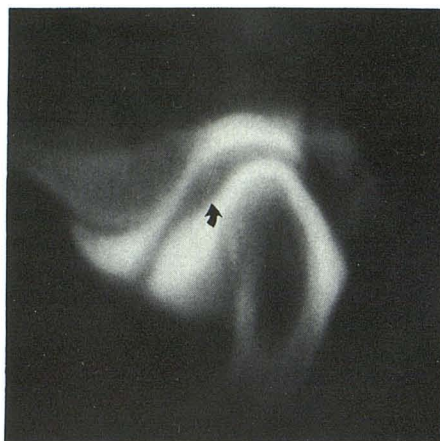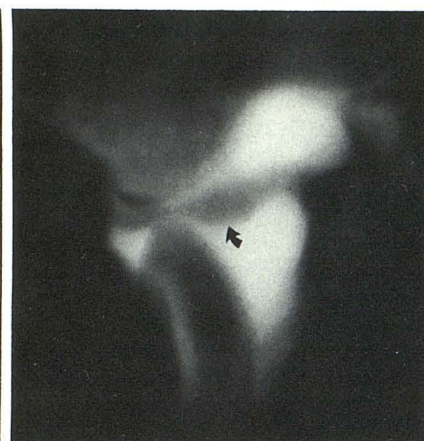
Fig. 3.—Perforation (surgically proved). Magnified lateral fluoroscopic spot film during inferior compartment (*curved arrow*) injection. Needle point and bevel (*straight white arrow*) lie apposed to articular cortex of condyle (C). Meniscus (M) is demarcated by pathologic filling of upper (*black arrow*) compartment due to perforation (not seen).
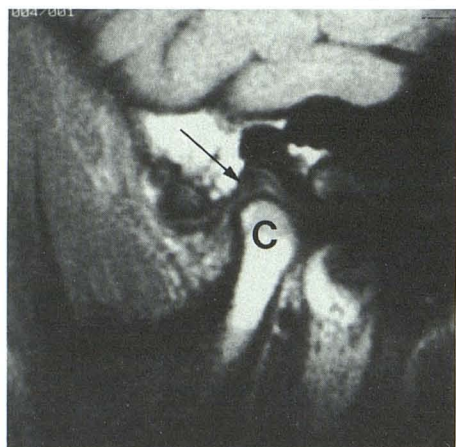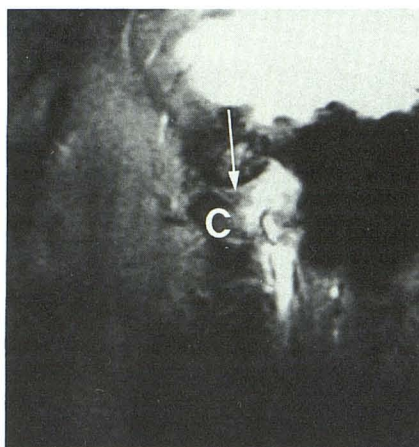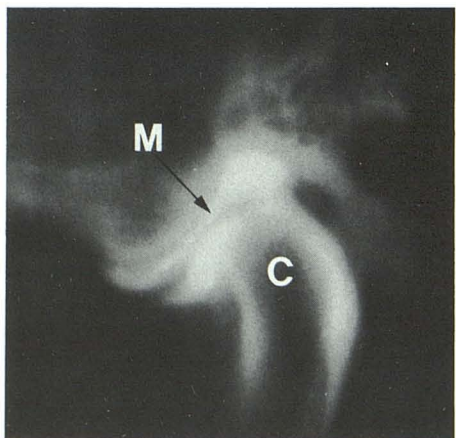
Fig. 4.—Reducing internal derangement of temporomandibular joint.
A, Lateral closed-mouth arthrotomogram. Posterior band of disk (*arrow*) is displaced anteriorly.
B, Lateral open-mouth arthrotomogram. After translation and clinical "click," posterior band of disk (*arrow*) lies in normal position, behind condyle.
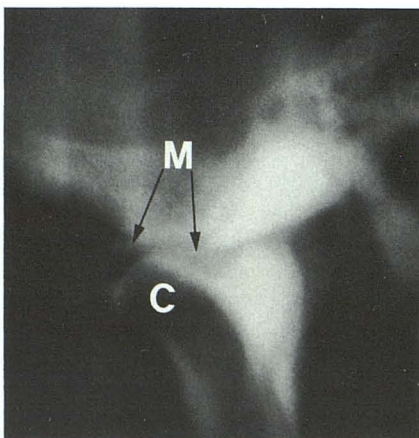
Fig. 5.—Normal MR images and arthrotomograms in 37-year-old man with painful, audible temporomandibular joint "snapping" 1 year after jaw trauma.
A and *B*, T1-weighted closed-(*A*) and GRASS open-(*B*) mouth images are normal. Meniscus (*arrow*) lies in normal position atop condyle (C).
C and *D*, Meniscus (M) appears normal in shape and position relative to condyle. At videofluoroscopy, there was pathologic adherence of meniscus to lateral aspect of articular cortex. Sudden disk reduction was observed dynamically, resulting in an audible "snap" as condyle passed beneath articular eminence. Postarthrography coronal MR images were also normal. Joint exploration was advised; the patient refused surgery.

gery; both were in large patients in whom the joint spaces had been punctured with difficulty by using a direct (straight down) approach as opposed to the usual needle placement from below. Filling of both compartments was attributed to needle passage through the lateral recess of the upper compartment en route to the lower compartment, establishing communication along the needle tract.

MR Imaging

About 30 of over 630 attempted examinations could be neither performed nor completed because of claustrophobia. At least 38 joint studies were inconclusive owing to patient motion, magnetic field interference from dental braces, or unusual joint anatomy, all resulting in inadequate delineation of the meniscus. Nineteen joints in 17 patients who had undergone either failed or inconclusive MR were later successfully studied with two-compartment arthrography (Figs. 6 and 7). MR was performed after successful arthrography in 12 joints (seven patients) for the purpose of comparison. Fourteen joints that had been successfully imaged with MR were subsequently studied with arthrography to confirm or rule out perforation, scar tissue, and in one case a loose joint body. Perforation of the meniscus attachments or disk was surgically encountered in 20 joints in which the diagnosis had not been established before surgery. Perforation was not found in seven joints in which it had been suggested on preoperative scans. Meniscus displacement was confirmed in all 142 joints in which surgery was performed for bothersome stable or progressive mechanical symptoms with or without joint pain. In 28 joints, surgery was performed for removal of permanent implants or repair of previous failed arthroplasty. Preoperatively diagnosed perforation was confirmed in 64 joints. Pathologic joint effusion was diagnosed in 22 joints and was confirmed surgically in all eight of the 22 joints operated on to date (Figs. 8–10). Simple meniscectomy, with or without interposition of a temporary, percutaneously removable Silastic TMJ implant for 3–4 weeks after meniscectomy, was performed in most of the surgical cases. Meniscus repositioning (plication) procedures were performed in se-

lected cases. All removed disks were submitted for pathologic evaluation. Periodic acid-Schiff stain was applied to selected specimens for demonstration of myxomatous or myxoid degeneration of meniscus collagen.

Discussion

Arthrography

Thin-needle two-compartment TMJ arthrography is a highly reliable and accurate diagnostic procedure. Previously described single- and two-compartment arthrographic techniques all provide accurate anatomic detail of meniscus position and morphology [2–17]. We believe that diagnostic accuracy is enhanced with the combination of dual-compartment opacification and videofluoroscopy. Injection of the superior joint compartment is accomplished by merely repositioning the needle after lower compartment opacification; it requires only an additional 15–30 sec in most cases. Filling of the anterior recess of the upper compartment allows concise distinction between a thickened anterior band of the disk and simple nonreduction of the posterior band (Fig. 7). Capsular adhesions may be diagnosed during injection of the joint compartments and observed during videofluoroscopy. Adhesions and scar tissue are commonly observed after failed TMJ arthroplasty, inflammation, or joint trauma, particularly if there has been hemorrhage into the joint [16, 25]. Superior joint-space adhesions and small loose bodies cannot be identified without filling of the upper compartment. The diagnosis of medial or lateral meniscus displacement is facilitated by two-compartment opacification and frontal videofluoroscopy.

Arthrography is superior to MR for the diagnosis of joint capsule adhesions and detection of small perforations [26]. The diagnosis of perforations involving either the meniscus attachments or the disk itself is important for surgical planning. Joint locking, caused by nonreduction of the disk during mouth opening, commonly progresses to perforation of the posterior meniscus attachment [2, 3, 9, 25, 28, 29]. Once perforation has occurred, the direct contact between the articular surfaces of the condyle and the temporal bone may

Fig. 6.—Old, posttraumatic deformity with intact meniscus, seen arthrographically after inconclusive MR.

A, T1-weighted sagittal image shows seemingly empty articular space (open arrow), suggesting large perforation. Meniscus (solid arrow) appears to lie entirely in front of condyle. (Adjacent images also suggested a large perforation.)

B, Closed-mouth lateral arthrotomogram reveals thin, but intact, meniscus (M) lying in normal position, atop rounded condyle (C). Posterior band of disk (open arrows) is thinned and identical in thickness to adjacent posterior attachment (arrowheads). There is thickening of anterior band (solid arrow) of disk. On the basis of these findings, physical therapy was advised to improve restricted joint motion.
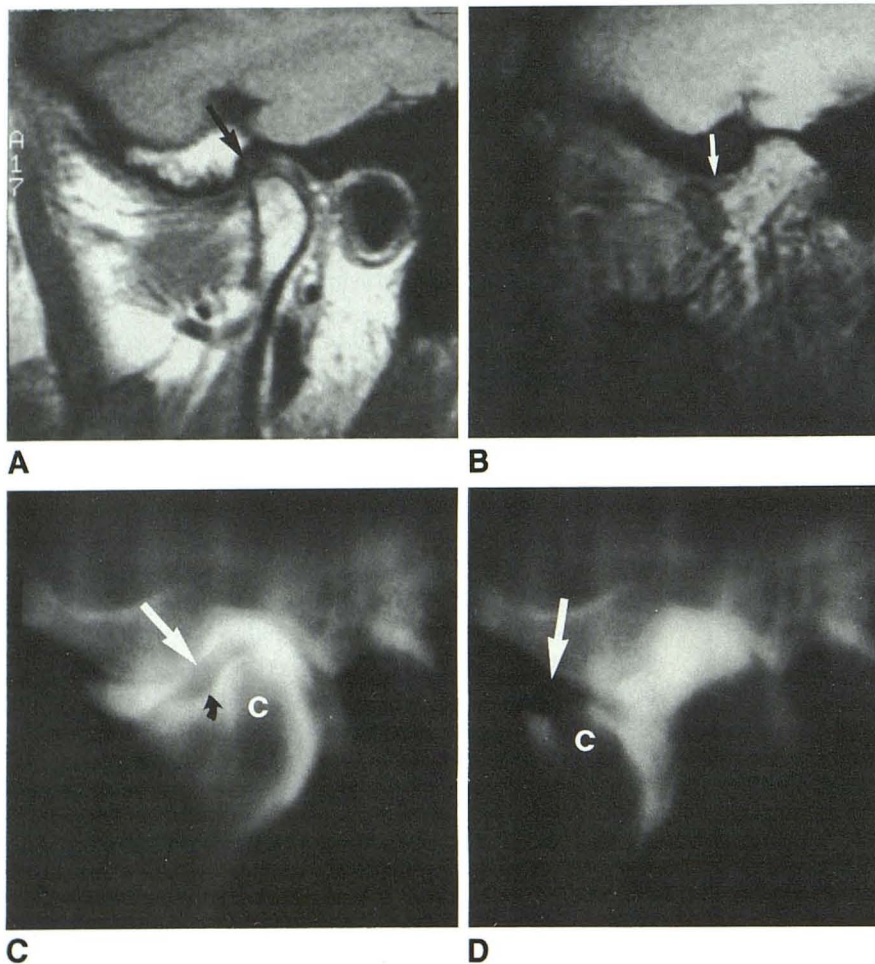
A   B

A

B
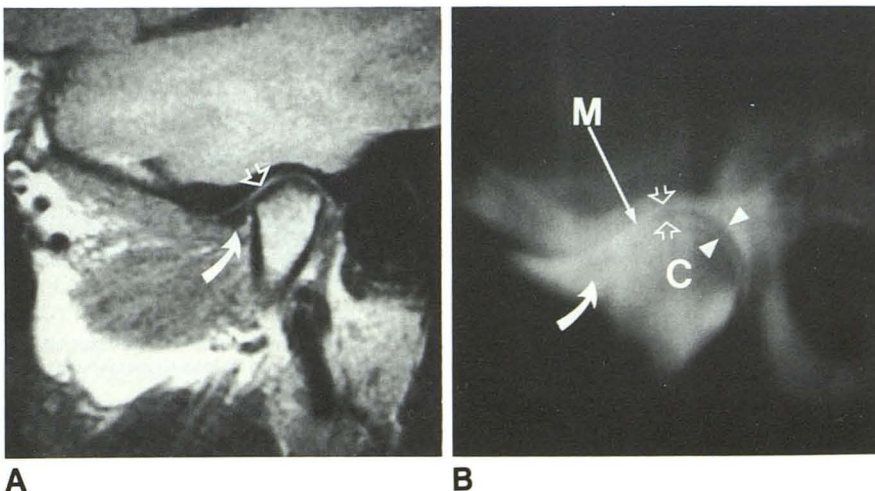
Fig. 7.—Clinically progressive internal derangement seen with MR and follow-up arthrography 9 weeks later. Patient progressed from clicking to locking during interval between imaging procedures.

A and *B*, T1-weighted closed- (*A*) and GRASS open- (*B*) mouth scans reveal normal meniscus (arrows) position with slightly inhomogeneous signal.

C and *D*, Closed- (*C*) and open- (*D*) mouth arthrotomograms reveal nonreducing internal derangement. *C* shows thickening of anterior band (*black arrow*) of disk, which is anteriorly displaced (*white arrow*) (compare with *A*). In *D* meniscus (*arrow*) fails to reduce and buckles in front of condyle (c).

C

D

A

B

C
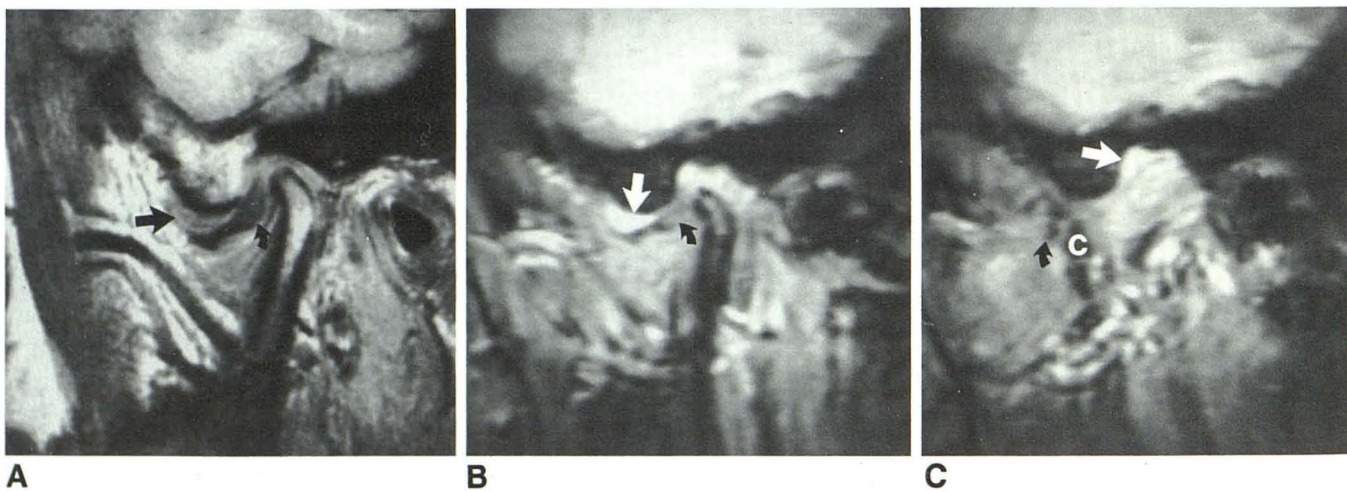
Fig. 8.—Nonreducing internal derangement with superior compartment effusion and intact bilaminar zone (surgically proved).

A, T1-weighted image shows anterior displacement of thickened and deformed meniscus (*curved arrow*), which also exhibits increased signal. Fluid (*straight arrow*) is seen above disk.

B, Early open-mouth GRASS image shows increased signal within deformed meniscus (*curved arrow*). Fluid (*straight arrow*) is signal-intense.

C, Maximal open-mouth GRASS image shows nonreduction of disk (*curved arrow*), which remains in front of condyle. Fluid (*straight arrow*) now lies posterior to condyle, above intact posterior attachment. Simple meniscectomy was performed with insertion of temporary Silastic implant for 3 weeks to prevent adhesions.

Fig. 9.—Nonreducing internal derangement with perforation (surgically proved).

A, Meniscus (curved arrow) is displaced and deformed and exhibits increased signal compared with anterior attachment (straight solid arrow). Fluid (open arrow) is seen in anterior recess of superior compartment. Superior joint space (arrowhead) is narrowed at point of focal perforation.

B, Open-mouth GRASS scan shows signal-intense fluid (open arrow) above displaced meniscus (curved arrow) owing to T2* effect. Focal perforation was encountered at junction of disk and posterior attachment (arrowhead). Simple meniscectomy was performed to relieve painful joint locking of 4 months duration.
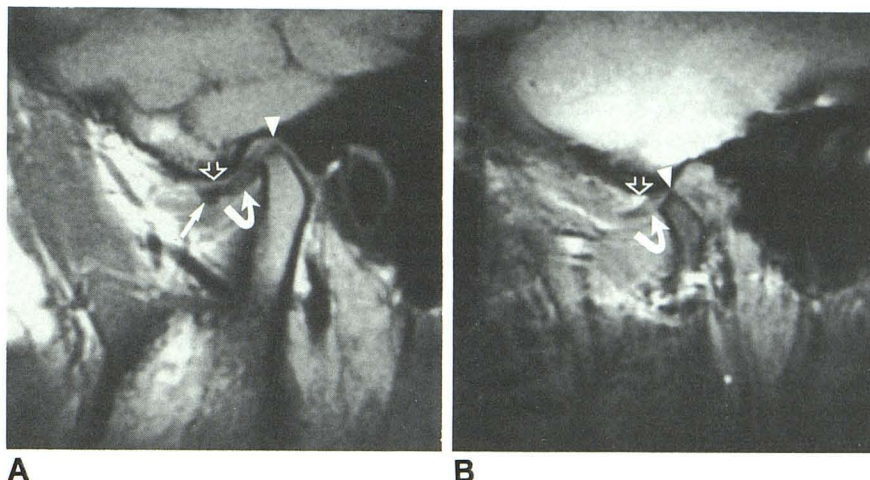

A   B

Fig. 10.—T1-weighted coronal scan shows lateral displacement of meniscus (curved arrow) with large joint effusion (straight solid arrows) and perforation of disk attachment above lateral pole (open arrow) of condyle (c) (surgically proved).
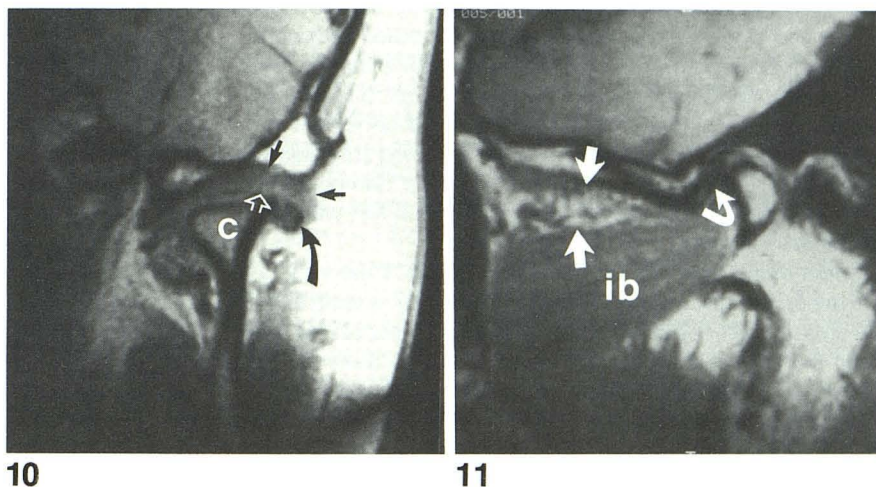
Fig. 11.—Muscle atrophy and fatty replacement with chronic anterior meniscus displacement in 24-year-old man. There is atrophy and fatty replacement of superior belly (straight arrows) of lateral pterygoid, which attaches to displaced meniscus (curved arrow). Normal inferior belly (ib) of lateral pterygoid. Simple meniscectomy resulted in complete cessation of mechanical temporomandibular joint symptoms.

10   11

result in focal erosion of the articular-bearing-surface fibro-cartilage and progress to degenerative osteoarthritis [28, 29]. Inflammatory complications of osteoarthritis such as synovial hyperplasia and joint hyperemia may develop and result in pain, soft-tissue swelling, joint effusion, crepitus, and disability. Because of the potential for the development of degenerative osteoarthritis after perforation, the presence or absence of perforation is an important diagnostic finding that should be determined in symptomatic patients, particularly if disease progression is suspected or demonstrated clinically. Progressive symptoms and demonstrated perforation may warrant prompt surgical intervention. Meniscectomy, if performed before the development of osteoarthritis, may increase the articular-bearing-surface contact area between the temporal bone and condyle, thereby decreasing focal stress loading on the bearing-surface cartilage and decreasing the likelihood of osteoarthritis development [25, 30]. Injection of the lower compartment with a thin needle directed into the joint space from below with the mouth open while under direct fluoroscopic vision with simultaneous videotaping provides the most accurate determination of the presence or absence

of perforation in most circumstances (fig. 3) [5, 10, 13, 17]. A cephalad needle approach to the lower joint space is important to avoid passage through a low-lying lateral recess of the upper compartment, resulting in creation of a needle-tract communication and upper compartment filling during initial lower-joint-space injection. Most perforations are posterior to the disk; therefore, an open-mouth position during lower-space injection allows free passage of contrast material into the upper compartment through defects in the meniscus attachments. The open-mouth position during injection also facilitates upper compartment filling, as the posterior half of the upper space is best seen with the condyle forward (Fig. 1 and 3–5). Large perforations are seen with spot films and arthrotomograms; however, small perforations are inferred by pathologic upper compartment filling (Fig. 3).

Videofluoroscopy provides valuable dynamic information regarding meniscus function [7, 9, 13, 17]. Small irregularities in either the articular surface of the condyle or along the undersurface of the meniscus may result in pathologic meniscus function during condylar movement (Fig. 5). Joint bodies may be detected during videofluoroscopy [31]. Videofluoros-

copy facilitates the diagnosis of external restriction to joint motion when muscle contracture or bony changes such as coronoid process hyperplasia or anomalous facial development exist [32]. Previously reported double-compartment techniques do not include routine videofluoroscopy, as the procedure generally requires separate injections into each compartment, usually with larger needles or catheter sheaths, which are left in the joint spaces during filming [2, 9, 11, 17]. Cadaver studies comparing single- and double-compartment arthrography have found the two-compartment technique to be more accurate for demonstrating anatomy, but recommend single-compartment techniques for the evaluation of joint function [17]. The thin-needle, two-compartment technique reported here incorporates routine videofluoroscopy into the procedure and in many cases eliminates the previously described dependence of this technique on tomography.

Pain has been commonly associated with TMJ arthrography, dissuading many clinicians from using this procedure for evaluating symptomatic patients [12, 33]. The use of a thin needle and single skin puncture permits a skilled arthrographer to opacify both joint compartments with a minimum of patient discomfort and soft-tissue trauma. Insult to the meniscus or disk attachments relating to needle advancement into the superior joint compartment is rarely detected surgically or pathologically. In our series, there were no demonstrable hematomas or contusions in joints studied with MR within 24 hr after arthrography.

Proper filling of the joint compartments is important, as joint dynamics may be substantially altered by overfilling either one or both joint compartments. The simple presence of fluid within the joint may create a hydrostatic barrier between the condyle and meniscus, permitting reduction of a previously locked joint. If both compartments are opacified with minimal and equivalent amounts of contrast material, functional relationships will be maintained and changes in meniscus-condylar positioning can be avoided (Fig. 1).

MR Imaging

Abnormalities of meniscus position and morphology usually are clearly demonstrated with surface-coil MR [18–25] (Figs.

8–13). MR is superior to arthrography for the demonstration of medial vs lateral meniscus displacement (Fig. 10). Soft-tissue structures are sharply defined with the high contrast resolution provided by MR. MR is superior to arthrography for detecting intrinsic degeneration of meniscus collagen (Figs. 7–10) [25]. Partial-flip-angle or GRASS techniques permit fast scanning of the joint, often adding significant physiologic information over standard T1-weighted images [25, 34–40]. In many cases, GRASS scans alone are sufficient for demonstrating disease. Sequential GRASS images obtained during incremental degrees of mouth opening may be obtained to provide dynamic tapes for viewing meniscus-condylar function during jaw movement, although, in our experience, these tapes generally do not affect diagnostic accuracy [25, 40]. The combination of high-resolution, T1-weighted closed-mouth sagittal images and one or two open-mouth GRASS scans enhance the diagnostic information available with T1-weighted images alone (Figs. 8 and 9). High-resolution T1-weighted images are important for most closed-mouth studies, particularly if GRASS images appear normal, as it is essential to define meniscus signal characteristics (Figs. 2, 5, and 7–13). High-resolution (256 × 256 matrix) GRASS images are usually adequate for demonstrating meniscus position on closed-mouth views; however, spatial resolution is decreased by the necessity of using a larger FOV (16 cm) and 5-mm-thick sagittal images, compared with the smaller FOV (12 cm) used with T1-weighted scanning techniques. GRASS scans of 3 mm require a larger FOV (24 cm), which necessitates image magnification, and longer TR intervals (and acquisition times) are required, further negating the advantages of the 3-mm sections compared with the 6- to 13-sec 5-mm-thick scans. Rapid, sequential open-mouth GRASS images replace videofluoroscopy in many circumstances; however, these tapes have diminished spatial resolution compared with magnification videofluoroscopy and usually are unnecessary. Small fluid collections within the joint compartments may be detected with T1- and T2-weighted and short GRASS scans (Figs. 8 and 9) [38, 39]. Fluid is most often seen in the anteromedial and lateral recesses of the joint compartments with the mouth closed. Lengthening the TR interval may

A   **B**

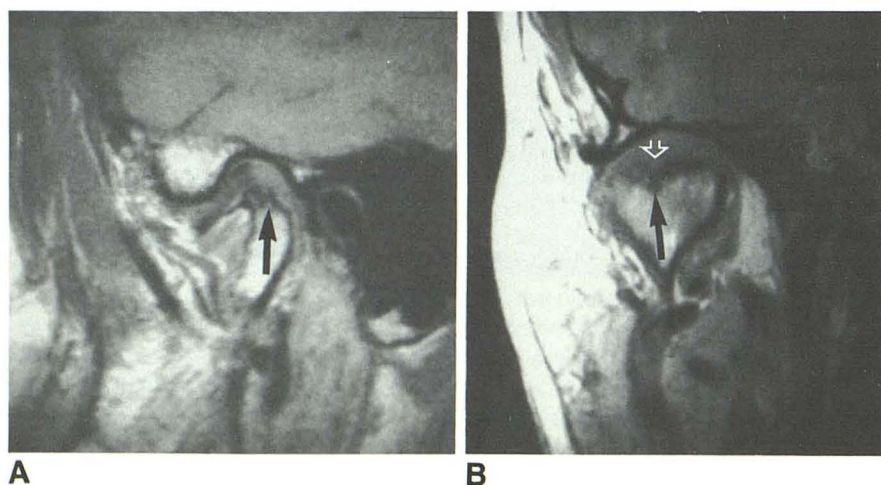Fig. 12.—Avascular necrosis of mandibular condyle in 46-year-old woman with old femoral head avascular necrosis and recent onset of severe temporomandibular joint pain after minor injury (changes bilateral).

A, Decreased marrow signal with deformed articular surface (*arrow*). Disk and posterior attachment intact.

B, Coronal image shows defect (*open arrow*) in articular cortex and marrow hypointensity (*solid arrow*).

Fig. 13.—Condylar defect in 29-year-old man with 2-year history of progressive joint pain and open-jaw locking.

A, Meniscus (*solid arrow*) is normally positioned relative to deformed condyle. "Bird's-nest deformity" (*open arrow*) is seen as an excavation in superior articular surface of condyle.

B, Arthrotomogram 4 weeks after MR study to assess suspected adhesions and possible joint fragment (none seen). Meniscus (*solid arrow*) is sharply defined and appears normal. Condylar (C) defect (*open arrow*) fills with contrast material. Videofluoroscopy revealed transitory open-jaw locking caused by catching of disk on irregular posterior articular surface of condyle (*open arrow*). Patient refused surgery.

A

B
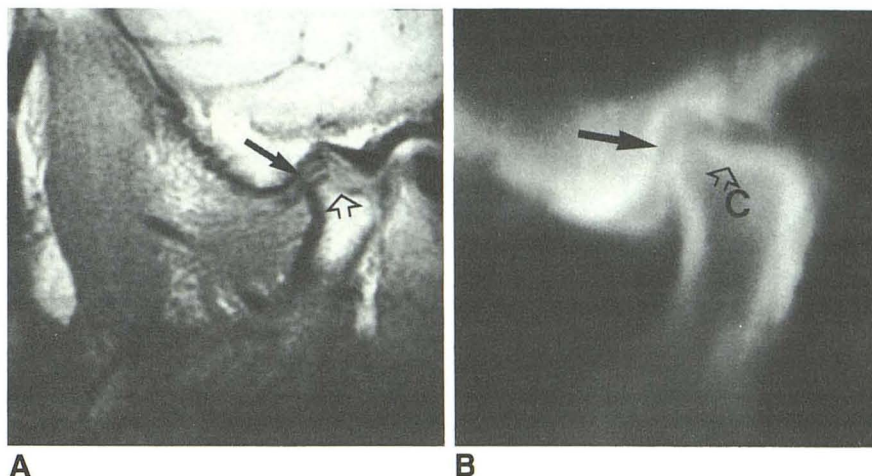
further enhance the ability to detect joint effusions with the GRASS techniques, although the fast (TR = 21–25 msec) scans appear highly sensitive to fluid owing to T2* effects.[†]

Both T1-weighted and fast scans are superior to arthrography-videofluoroscopy for evaluating musculotendinous structures (Fig. 11). One to three short, sequential, open-mouth GRASS scans permit assessment of masticatory muscle contraction. Avascular necrosis and osteochondritis of the mandibular condyle are best defined with MR (Fig. 12) [41, 42]. MR is recommended to study joint implants and associated complications [25, 43]. High-resolution T1- or T2-weighted scans are recommended over short GRASS techniques when studying lesions of the marrow space, as the altered marrow signal may be obscured on the short GRASS images. T1-weighted or combined multiecho T1- and T2-weighted images are recommended for muscle and ligament imaging, especially if atrophy or intrinsic inflammation is suspected.

MR provides valuable information regarding the intrinsic structural integrity of the meniscus collagen, which may exhibit inhomogeneous or increased signal, often heralding myxoid or myxomatous degeneration of the disk (Figs. 8–11) [25]. We advise caution with attempted surgical repair on an intrinsically degenerated and deformed meniscus, as the disk collagen may be structurally weakened by myxoid degeneration. A simple meniscectomy is our surgical procedure of choice when dealing with a deformed meniscus exhibiting high MR signal.

Perforations of the meniscus attachments are often difficult to diagnose confidently with MR in its current state of technology. The meniscus attachments frequently appear attenuated and may lead to a false-positive interpretation of perforation (Fig. 6). If disease progression is suspected and the disk attachments appear attenuated, arthrography should be performed to resolve the question of perforation (Fig. 13).

In approaching the problem of TMJ imaging, we recommend screening submentovertex (base) and open-mouth jaw-

protruded posteroanterior views of the skull base and mandible, combined with tightly collimated closed- and open-mouth lateral TMJ tomograms [22, 25, 33]. These screening radiographic procedures provide valuable information with regard to side-to-side skull base and condylar symmetry, condyle positioning within the glenoid fossa, and the presence or absence of degenerative bony changes. When osteoarthritic changes are observed tomographically, there may be no need for either MR or arthrography. If reconstructive arthroplasty is contemplated, MR is recommended to study soft-tissue structures. Tomograms are a valuable adjunct to MR in deranged joints, as it is often difficult to differentiate joint calcification from scar tissue and identify calcium within tendon attachments with MR alone. MR is the imaging procedure of choice over arthrography in most circumstances. Two-compartment arthrography is an important ancillary imaging procedure that provides information complementary to MR and may serve as an imaging alternative. Arthrography may be required to assess the presence or absence of perforation and joint adhesions. Patients with normal or inconclusive MR results and unusual or progressive clinical symptoms should be studied with two-compartment arthrography. Percutaneous joint dilatation and lavage, for treatment of capsular adhesions, is an interventional application of this procedure that shows considerable promise.

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