Temporomandibular Joint Inflammation: Comparison of MR Fast Scanning with T1- and T2-Weighted Imaging Techniques

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Temporomandibular Joint Inflammation: Comparison of MR Fast Scanning with T1- and T2-Weighted Imaging Techniques

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One hundred painful temporomandibular joints in 100 patients were studied with high-field, surface-coil MR imaging. Partial flip angle or GRASS (gradient-recalled acquisition in steady state) and either T1-weighted or spin-echo long TR/short-long TE imaging techniques were used to assess the relative sensitivity and accuracy of these techniques in detecting joint fluid. Intraarticular fluid, interpreted to represent joint effusion, was observed in 88 of the 100 painful joints scanned. GRASS scans were obtained with the mouth closed, partially opened, and fully opened; T1-weighted and spin-echo images were obtained only with the mouth closed. Long TR/long TE spin-echo images were the most sensitive to fluid detection within the joint spaces. GRASS images were highly sensitive to intraarticular fluid, although the thicker scan section and local artifacts associated with these techniques resulted in lower accuracy compared with the spin-echo long TR/long TE images. Joint fluid was directly observed in many of the 28 joints operated on from the series, and two of two joints were successfully aspirated. Osteochondritis dissecans and avascular necrosis are best demonstrated and staged with a combination of short TR/short TE and long TR/long TE weighted images, although a spin-echo long TR/short and long TE pulse sequence is more practical for this purpose.

We recommend long TR/short and long TE spin-echo closed-mouth sagittal images combined with GRASS closed- and open-mouth views whenever inflammatory temporomandibular joint disease is suspected.

Internal derangement of the temporomandibular joint (TMJ) is a common malady, which, in most circumstances, is easily studied with surface-coil MR imaging [1–10]. Synovitis and joint effusion frequently accompany internal derangement of the TMJ meniscus [1, 3, 6, 8–10]. We investigated the MR findings in painful TMJs exhibiting meniscus and/or osseous derangement and joint effusion by using high-field surface-coil MR imaging.

Materials and Methods

One hundred painful TMJs in 100 patients (84 females and 16 males, 13–67 years old) were studied with a 1.5-T GE superconducting magnet and either a single, 8.9-cm round, receive-only surface coil or, most recently, a dual 8.9-cm round, bilateral, receive-only surface-coil apparatus, employing coupled coils designed to prevent radiofrequency feedback. In patients with bilateral joint pain, only the more painful joint was included in the study. Clinical indications for MR imaging, either individually or in various combinations, included unexplained headache; ear, TMJ, and/or ipsilateral facial pain; TMJ crepitus; clicking and/or locking; recent TMJ; facial or mandibular injury; and either acquired or changing malocclusion within 12 months of clinical evaluation. Details of single-coil technical parameters have been previously described [4–8].

Dual-coil studies were obtained by employing a preliminary axial, 300–600/20/1 (TR range/TE/excitations) sequence with three to eight 5-mm-thick images to provide details of condyle morphology, intrinsic condylar marrow signal, condyle localization, and orientation to the skull base. Seven to nine nonorthogonal 3-mm-thick images with a 1-mm interspace, 700–2500/20–25, 80–100/1, 2 (TR range/TE first-echo range, second-echo range/excitations), 256 ×

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192–256 matrix, and a 12–14-cm field of view were then obtained through the full width of each condyle, scanning perpendicular to the long condylar axis (Fig. 1). A routine multiecho spin-echo (SE) sequence was adopted by using parameters of 2200/25, 80/1, with a 13-cm field of view and a 256 × 192 matrix. This sequence required 7 min, 52 sec. T1-weighted, 3-mm-thick, coronal images were obtained in selected cases by using parameters of 700–900/25/2 and a 12-cm field of view. Sagittal GRASS images were obtained routinely through each joint, simultaneously scanning the joints in closed, partially open, and fully open positions perpendicular to the condylar axis, utilizing a single, 5-mm-thick, mid-condylar, nonorthogonal image, 30/13/2, with a 30° flip angle and a 16-cm field of view.

Results

Intraarticular fluid collections were detected with SE long TR/long TE images in 88 joints and in 86 of 94 joints in which meniscus displacement, with or without meniscus deformity and/or intrinsic signal changes, was observed. Joint fluid was confidently detected with GRASS images in only 75 joints, indicating that this technique is less sensitive than the 3-mm-thick SE images. Sixteen joints exhibited alterations in mandibular condyle morphology and/or marrow signal characteristics, which were compatible with either osteochondritis dissecans (OCD) or avascular necrosis (AVN), or, in two cases, with both. Synovial thickening, joint fluid, and condylar AVN with active rheumatoid arthritis were observed in one joint. Fluid collections were detected within two joints in which the meniscus was judged to be normal in position, morphology, and intrinsic signal characteristics. Intraarticular fluid was commonly observed within the lateral aspect of the anterior recess of the upper-joint compartment with the mouth closed, possibly relating to mechanical factors, such as the upper compartment being larger than the lower-joint space, which is also compressed with the mouth closed. Lower-compartment fluid was less frequently observed than upper-compartment fluid, most often lying anterior to the condyle on closed-mouth images. Fluid was most often isointense relative to gray matter on T1-weighted images and of either intermediate or high intensity on proton-density (long TR, short TE) images (Figs. 2–8 and Table 1). Fluid was typically signal intense on GRASS and SE long TR/long TE images (Figs. 2–5, 7, 8, and Table 1). Joint hematomas exhibited a variable appearance, ranging from intermediate (most common) to high T1 and GRASS signal intensity (Figs. 6 and 7). Hematomas and bloody effusions were invariably signal intense on SE long TR/long TE images.

To date, 28 joints (28 patients) have undergone joint exploration and meniscectomy, including routine histologic evaluation of surgically removed material. Joint fluid was directly observed in many of the 28 joints operated on for progressive mechanical symptoms and pain. Most patients were treated with aspirin and/or other antiinflammatory agents plus soft diet during the time between imaging and surgery, resulting in decreased pain and possibly decreased joint fluid. The presence or absence of joint fluid was not specifically addressed at surgery in some of the operated cases. Percutaneous joint-fluid aspiration was performed in two cases; aspirated fluid was submitted for routine laboratory analysis. Bloody effusion was confirmed surgically and/or by aspiration in four joints. Synovitis with thick, proteinaceous synovial fluid was encountered in two joints in which synovial biopsies were performed. Morphologic and surface structural changes in the mandibular condyle compatible with either AVN or OCD were confirmed in six joints that also exhibited internal derangement of the TMJ meniscus with joint effusion (Figs. 8 and 9). All of the patients who underwent meniscectomy experienced significant postoperative improvement in joint function and relief of pain.

Discussion

Pain, inflammation, and joint effusion are commonly observed with derangement of the TMJ meniscus and/or os-

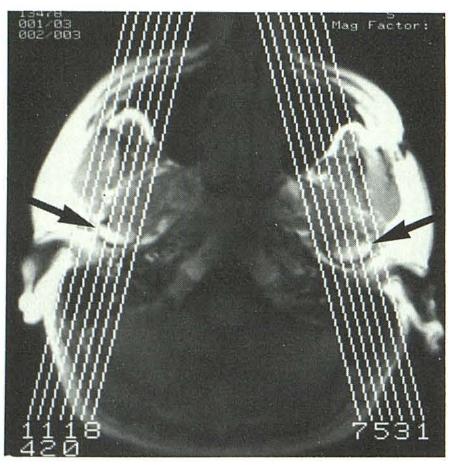
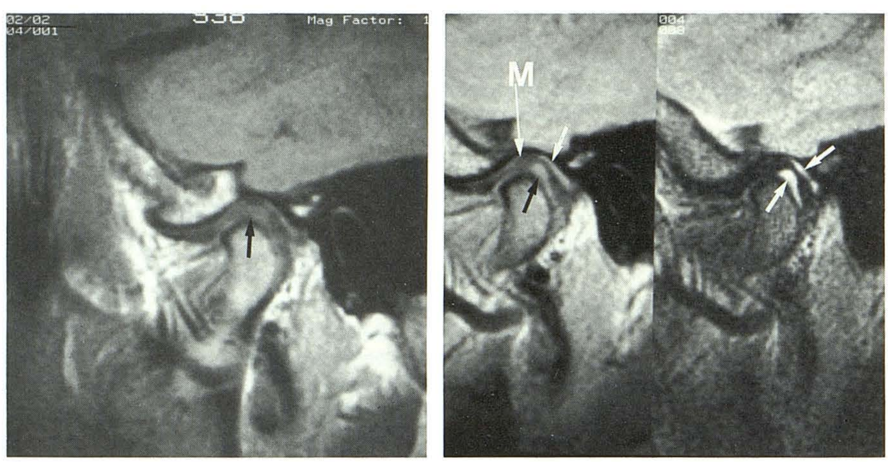


Fig. 1.—Axial, 300/20, 5-mm-thick localizing image shows condyles (*arrows*) and axes of sagittal scans (*lines*).

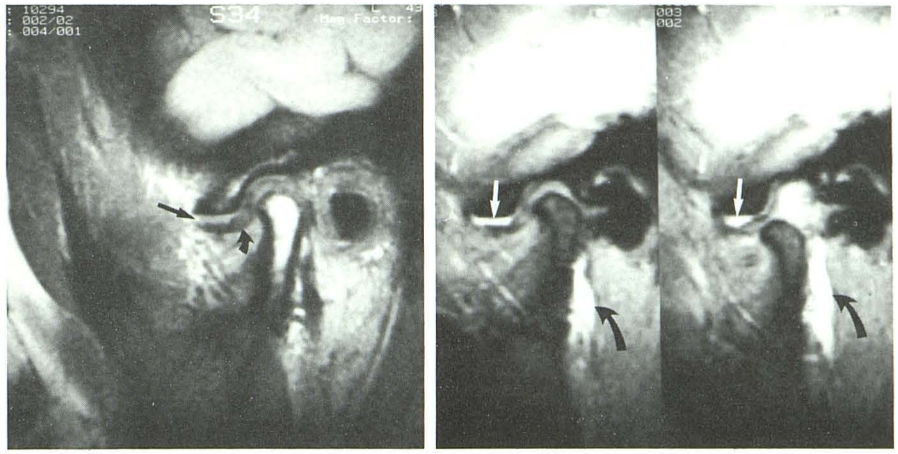


A B

Fig. 2.—Acute inflammatory TMJ arthropathy causing joint pain, headache, and fluctuating malocclusion in a 24-year-old woman.

A, Closed-mouth, sagittal, 600/20, image shows indistinct posterior band of normally positioned meniscus (*arrow*).

B, Sagittal, multiecho, 2500/20 (*left*), 80 (*right*), images show normal meniscus (M) position with fluid (*arrows*) in both upper- and lower-joint compartments. Symptoms improved with antiinflammatory medications.

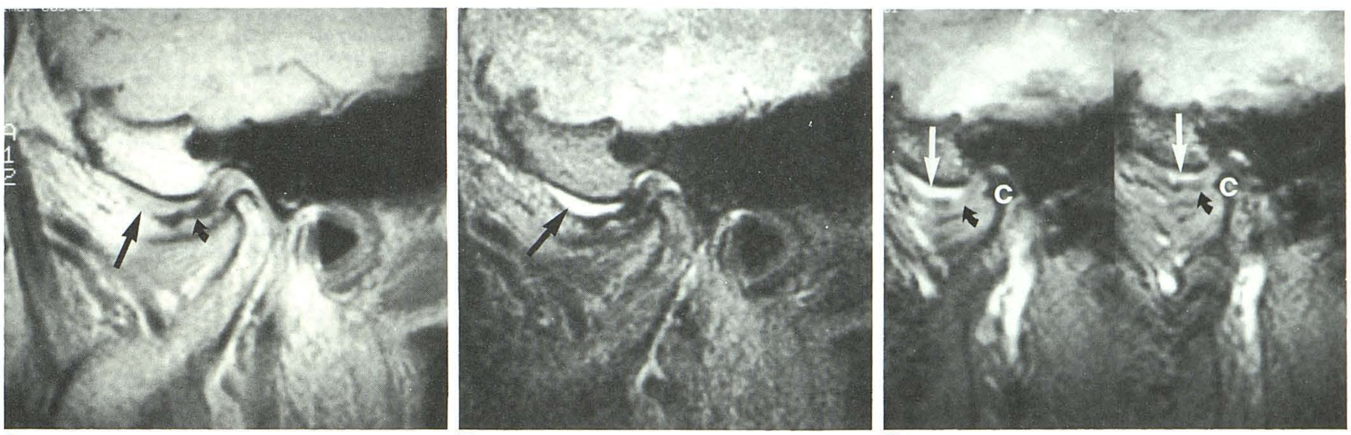


A B

Fig. 3.—Headache, facial pain, fluctuating ipsilateral open bite, and joint locking caused by surgically confirmed inflammatory, nonreducing meniscus derangement.

A, Sagittal, 600/20, image shows anterior displacement and surgically confirmed myxomatous degeneration of meniscus (*curved arrow*). Upper-compartment effusion (*straight arrow*) is isointense with gray matter.

B, Sagittal GRASS, 21/12.5/30° flip angle, closed- (*left*) and open-mouth (*right*) images show signal-intense fluid (*straight arrows*) above displaced meniscus. Note bright signal from retromandibular vessel (*curved arrows*).

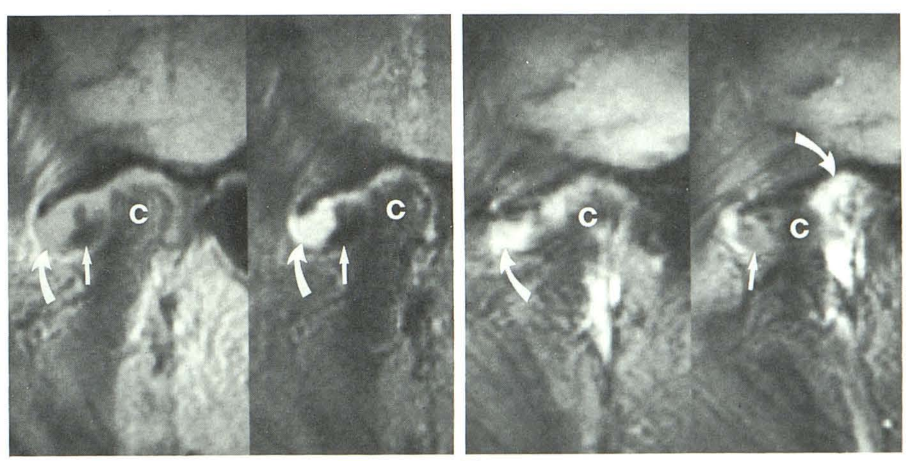


A B C

Fig. 4.—Earache, altered hearing, open bite, and TMJ locking caused by surgically proved inflammatory, nonreducing meniscus derangement.

A and *B*, Spin-echo 2200/20 (*A*), 100 (*B*), images show displaced meniscus (*curved arrow* in *A*) with large joint effusion (*straight arrows*). Note normal marrow signal within condyle.

C, Closed- (*left*) and open-mouth (*right*) GRASS images delineate effusion (*straight arrows*) above displaced meniscus (*curved arrows*) and condyle (*C*).

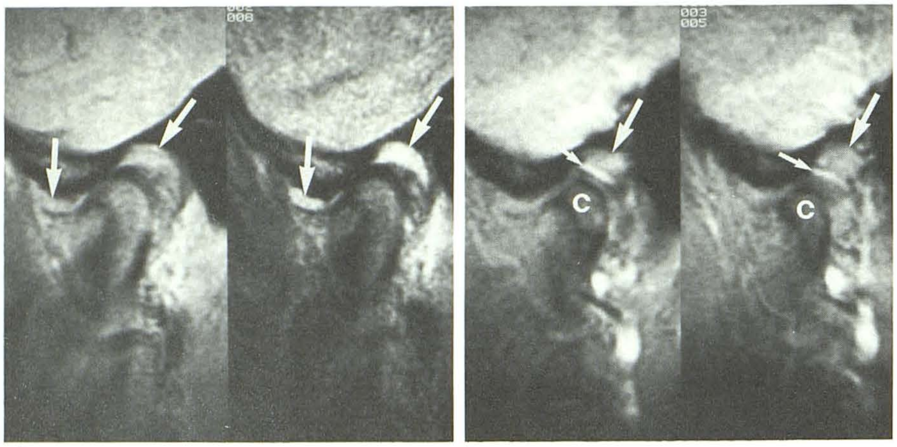


A B

Fig. 5.—Severe crossbite, joint pain, and swelling caused by rheumatoid arthritis in a 40-year-old woman.

A, Spin-echo, 2200/25 (*left*), 80 (*right*), images show fluid (*curved arrows*) with degenerated meniscus (*straight arrows*). Old avascular necrosis of condyle (*C*) is manifested by loss of marrow signal and articular surface collapse.

B, Closed- (*left*) and open-mouth (*right*) GRASS images show mobile joint fluid (*curved arrows*) with mouth opening. Meniscus (*straight arrow* on *right*) remains in front of deformed condyle (C). Patient was treated with analgesics, antiinflammatory medications, and soft diet.

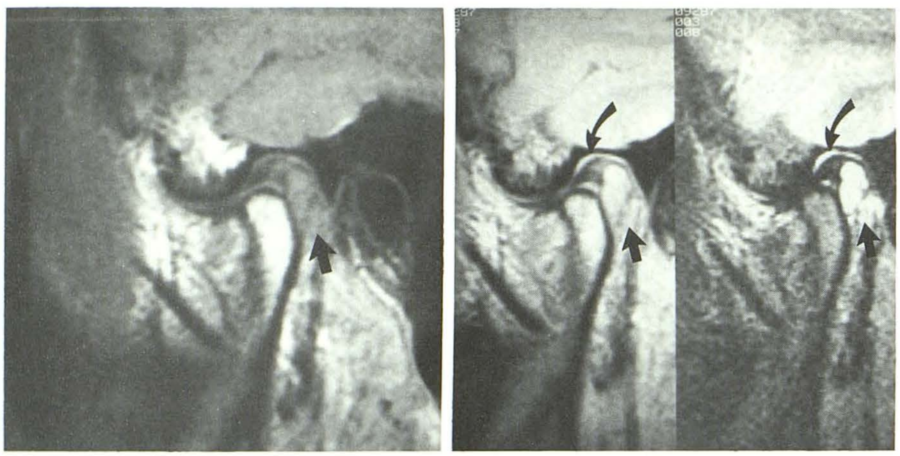


A B

Fig. 6.—Painful posterior open bite and ear pain associated with acute posttraumatic hemarthrosis, proved by nontraumatic, fluoroscopically guided joint aspiration.

_A_, Spin-echo, 2200/25 (_left_), 80 (_right_), images reveal large upper-compartment fluid collection (_arrows_), causing downward condylar displacement.

_B_, Closed- (_left_) and open-mouth (_right_) GRASS images show low- (_large arrows_) and high-intensity (_small arrows_) fluid. There was immediate resolution of open bite and ear pain after 1.4 ml of clotted blood, fibrin, and serum were aspirated from upper-joint compartment with 18-gauge needle.



A B

Fig. 7.—Posterior open bite, severe pain, and trismus associated with traumatic contusion and rupture of posterior meniscus attachment in 32-year-old man with preauricular swelling and developing echymosis.

_A_, Sagittal, 600/20, image shows isointense swelling of posterior meniscus attachment insertion (_arrow_) displacing the condyle anteriorly.

_B_, Spin-echo, 2500/20 (_left_), 80 (_right_), images show signal-intense upper-compartment fluid (_curved arrows_) with intermediate- (_left_) and high-intensity (_right_) edema and contusion within thickened posterior attachment (_straight arrows_). Patient was treated with analgesics and soft diet. Pain and swelling resolved within 12 days.

seous structures (Figs. 2–9). The combination of joint inflammation and advanced derangement of the TMJ meniscus with or without posterior attachment perforation appears to play a causal role in the pathogenesis of both OCD and AVN involving the mandibular condyle [10]. Considering that meniscus derangement and joint inflammation may progress to OCD/AVN and ultimately to degenerative osteoarthritis and joint disability, it is important to detect these soft-tissue lesions on initial imaging studies. We have not seen demonstrable fluid collections in any of eight normal joints (six bilaterally normal volunteers with completely negative histories) studied with high-resolution SE images (Fig. 10). Of curious note is the fact that we frequently observe fluid within an otherwise normal-appearing and painless joint opposite a deranged joint in patients undergoing bilateral study.

Frequently observed symptoms of TMJ inflammation include pain localized to the face, TMJ, preauricular region, and ipsilateral ear. Subjective complaints such as earache, fluid in the ear, tinnitus, and difficulty hearing are all commonly observed in patients with inflammatory arthropathy of the TMJ. We have confirmed transitory decrease in conductive and sensorineural hearing in association with ipsilateral TMJ inflammation. This relationship is fairly common and merits further investigation (Fig. 4). Fluctuating changes in occlusion are frequently encountered in conjunction with inflammatory arthropathy of the TMJ (Figs. 2–8) [10, 11]. This finding is explained by inflammatory thickening of the meniscus and/or ligaments combined with joint effusion, exerting downward force on the mandibular condyle and resulting in either ipsilateral posterior open bite or a sensation of joint fullness and inability to close the posterior molars adjacent to the inflamed joint. With AVN, articular surface collapse or subsidence occurs, leading to rapid loss of vertical dimension in the mandibular condyle and condylar neck (proximal mandibular segment) and exceeding the capacity of the ipsilateral teeth to intrude and/or realign. This leads to contralateral anterior open bite as the medial pterygoid, temporalis, and masseter contract against the shortened mandible (Fig. 5) [9, 10]. Ipsilateral facial pain and headache, generally confined to the region of the muscles of mastication, are frequently encountered with inflammatory arthropathy and may be the presenting clinical symptoms. We have observed generalized cephalalgia and cervical pain with TMJ inflammation, particularly when joint disease is bilateral and/or associated with acquired malocclusion [11].

We observed isointense signal relative to gray matter within typical serous effusions by employing short TR/short TE images (Figs. 2, 3, and Table 1). Serous and proteinaceous

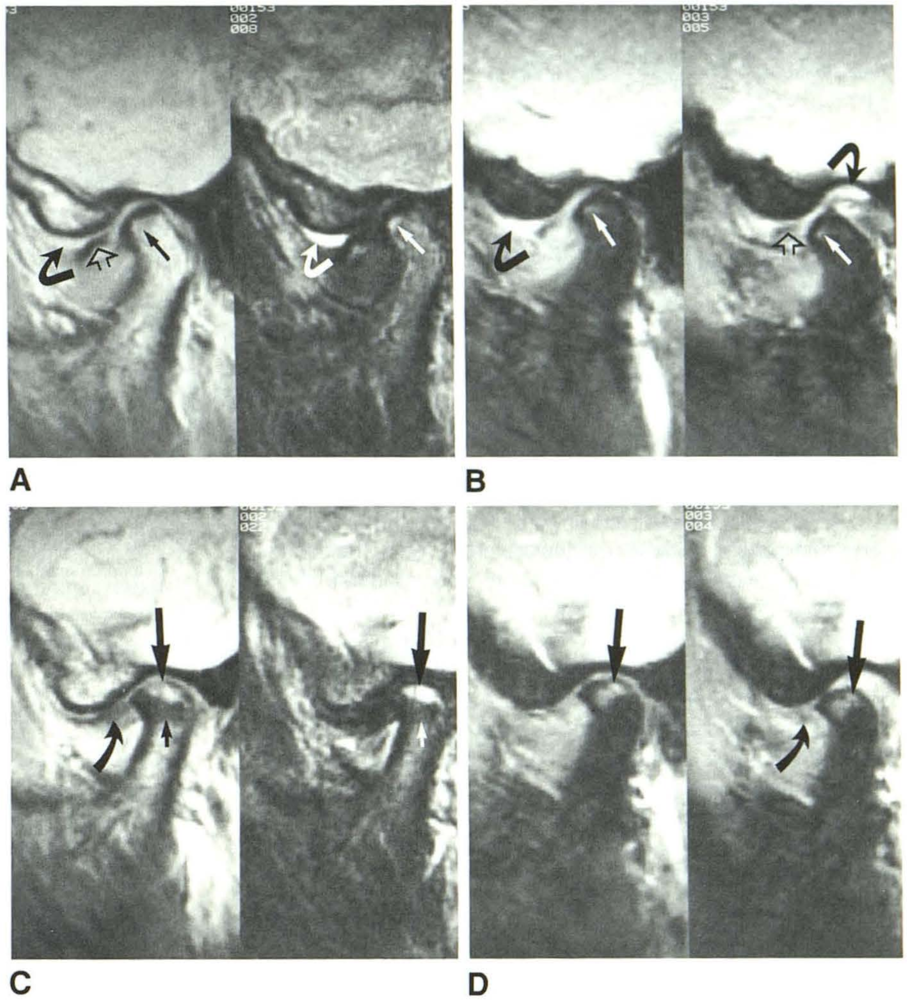


Fig. 8.—Fluctuating occlusal disturbance with TMJ pain and locking due to ipsilateral inflammatory arthropathy with marrow edema and contralateral subacute AVN of condyle (46-year-old woman).

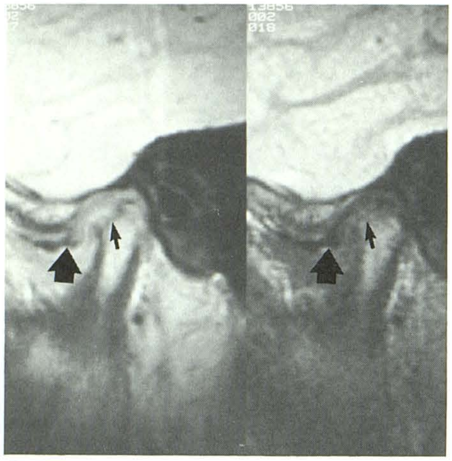
***A* and *B*, Sagittal spin-echo (*A*), 2200/25 (*left*), 80 (*right*), and GRASS (*B*) closed- (*left*) and open-mouth (*right*) images of painful joint show fluid (*curved arrows*) above displaced meniscus (*open arrows*). Altered marrow signal (*straight arrows*) seen beneath intact articular cortex of condyle, suggesting marrow edema. At surgery, effusion and perforation of posterior meniscus attachment were observed.**

***C* and *D*, Spin-echo (*C*) and GRASS (*D*) images of less painful contralateral joint show nonreducing meniscus (*curved arrows*) derangement with altered marrow signal (*large straight arrows*), suggesting subacute avascular necrosis. Note absence of joint fluid and zone of sclerosis (confirmed tomographically) (*small straight arrows*).**

TABLE 1: MR Signal Characteristics of TMJ Effusions (88 Joints)

Type of Fluid	Signal Intensities Relative to Gray Matter			
	T1	Long TR/ Short TE	T2	GRASS
Serous	Isointense	Isointense to hyperintense	Hyperintense	Hyperintense
Proteinaceous	Isointense	Isointense to hyperintense	Hyperintense	Hyperintense
Hemarthrosis	Isointense to hyperintense (highly variable)	Isointense to hyperintense (variable)	Hyperintense	Isointense to hyperintense (variable)

effusions typically exhibited high intrinsic signal with both GRASS and SE long TR/long TE images. Bloody effusions exhibited variable appearance (Figs. 6 and 7) [5, 6, 10]. Long TR, short and long TE SE images provide the most practical, sensitive, and accurate method of detecting joint fluid and evaluating fluid characteristics. SE images are also highly valuable in detecting and staging marrow lesions, such as AVN (Figs. 5, 8, 9) [9, 10, 12–16]. GRASS images are highly sensitive to fluid; however, spatial resolution is decreased by the necessity of using thicker (5-mm) sections. They are less accurate than SE images, and local vascular-flow signals may simulate fluid and/or edema (Fig. 3) [6–8]. Short GRASS scans are the most helpful ancillary images in cases in which motion degrades SE image clarity. Because of their short



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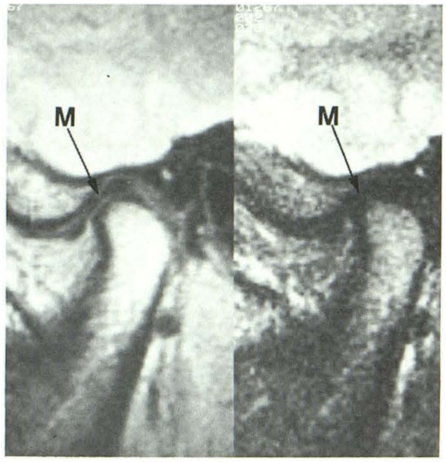

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Fig. 9.— Osteochondritis dissecans or transchondral fracture (*small arrows*) of condyle, displaced meniscus (*large arrows*), and effusion (not seen but present on adjacent images) in 19-year-old woman with ear and TMJ pain, contralateral anterior open bite, and joint locking 5 months after direct blow to mandible. Sagittal, spin-echo, 2200/25 (*left*), 80 (*right*), images.

Fig. 10.—Normal TMJ (no fluid) in 32-year-old clinically normal volunteer. Sagittal, spin-echo, 2200/25 (*left*), 80 (*right*), images show normal meniscus (M).

acquisition times, GRASS images are preferred in the assessment of meniscus-condylar position and function during mouth opening and mastication.

We recommend SE long TR, short and long TE, closed-mouth pulse sequences combined with GRASS closed- and open-mouth images for the evaluation of painful TMJs with or without mechanical symptoms, such as clicking, crepitus, and locking, and in all patients with disturbances of occlusion. T1-weighted images are distinctly less sensitive to fluid detection. The detection of joint fluid and inflammation is of vital importance, in that joint inflammation may result in the development of joint adhesions, progressive meniscus derangement, and either OCD or AVN leading to osteoarthritis, refractory occlusal deficits, and joint disability. The demonstration of active inflammation may influence patient management. In cases of progressive joint symptomatology, where meniscus derangement and joint inflammation are demonstrated with MR imaging, meniscectomy may be beneficial, since we have found that a torn and/or degenerated meniscus may be the primary cause of ongoing joint inflammation. Patients should be advised of the possibility of the development of AVN and osteoarthritis in cases of untreated inflammatory TMJ arthropathy.

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