RadioGraphics

MR Imaging of Temporomandibular Joint Dysfunction: A Pictorial Review[1]

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LEARNING OBJECTIVES

After reading this article and taking the test, the reader will be able to:

- List the basic principles of MR imaging of the temporomandibular joint.
- Describe the role of MR imaging in the assessment of temporomandibular joint dysfunction, with special emphasis on indirect signs of dysfunction.
- Discuss the correlation between the MR imaging features and clinical symptoms of temporomandibular joint dysfunction.

TEACHING POINTS
See last page

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Temporomandibular joint (TMJ) dysfunction is a common condition that is best evaluated with magnetic resonance (MR) imaging. The first step in MR imaging of the TMJ is to evaluate the articular disk, or meniscus, in terms of its morphologic features and its location relative to the condyle in both closed- and open-mouth positions. Disk location is of prime importance because the presence of a displaced disk is a critical sign of TMJ dysfunction. However, disk displacement is also frequently seen in asymptomatic volunteers, so that other findings may be required to help make the diagnosis. These findings include thickening of an attachment of the lateral pterygoid muscle, rupture of retrodiskal layers, and joint effusion and can serve as indirect early signs of TMJ dysfunction. It is important for the radiologist to detect early MR imaging signs of dysfunction, thereby avoiding the evolution of this condition to its final stage, an advanced and irreversible phase that is characterized by osteoarthritic changes such as condylar flattening or osteophytes. Further studies conducted with the latest MR imaging techniques will allow a better understanding of the sources of TMJ pain and of any discrepancy between imaging findings and patient symptoms.

Abbreviations: LPM = lateral pterygoid muscle, TMJ = temporomandibular joint

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Introduction

The most important anatomic structure of the temporomandibular joint (TMJ) is the articular disk, or meniscus, a biconcave fibrocartilaginous structure that divides this synovial joint into superior and inferior compartments (Figs 1, 2). The interposition of the thinnest part of the disk (the intermediate zone) between the condyle and the temporal bone in both the closed-mouth position and the open-mouth position prevents articular damage. Superior and inferior retrodiskal layers are joined to the posterior band of the disk. These retrodiskal layers and some vasculonervous structures form an anatomic area called retrodiskal tissue, or the bilaminar zone. The LPM has two parts, bellies, or heads: the superior LPM and the inferior LPM. This muscle, together with the digastric muscle and the retrodiskal layers, have an important function in mastication. During jaw opening, two different motions occur at the TMJ. The first motion is rotation around a horizontal axis through the condylar heads. The second motion is translation in which the condyle and meniscus move together anteriorly beneath the articular eminence and the central part of the disk is interposed between the condyle and the articular tubercle. When the mouth is fully open, the condyle may lie beneath the anterior band of the meniscus (Fig 3).

TMJ dysfunction is a common condition that, according to some studies, affects up to 28% of the population, although these studies did not include imaging findings (2,3). The most frequent cause of TMJ dysfunction, or TMJ disorder, is internal derangement, which is defined as an abnormal relationship of the disk to the condyle. In recent years, MR imaging has been confirmed as the imaging technique of choice in the study of TMJ dysfunction. MR imaging technique in this context includes the use of dual surface coils, sagittal oblique and coronal thin sections of 3 mm or less, and proton-density–weighted and T2-weighted sequences in both closed- and open-mouth positions. Furthermore, a dynamic study can be performed during progressive mouth opening with cine MR imaging (4–7). Precise localization of the disk is very important in the diagnosis of TMJ internal derangement and can easily be achieved with MR imaging. An anteriorly displaced disk has been seen in up to 34% of asymptomatic volunteers (8–13), and a normal disk position has been depicted in 16%–23% of symptomatic patients (11,12).

Teaching Point

Teaching Point

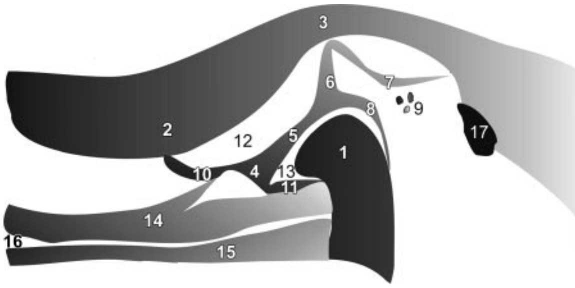


Figure 1. Drawing illustrates the anatomy of the TMJ. *1* = condyle; *2* = temporal bone, articular eminence; *3* = temporal bone, mandibular fossa; *4* = disk, anterior band; *5* = disk, intermediate zone; *6* = disk, posterior band; *7* = superior retrodiskal layer; *8* = inferior retrodiskal layer; *9* = vasculonervous structures; *10* = capsular superior attachment; *11* = capsular inferior attachment; *12* = superior joint space; *13* = inferior joint space; *14* = superior head of the lateral pterygoid muscle (LPM); *15* = inferior head of the LPM; *16* = interpterygoid space; *17* = external auditory canal.

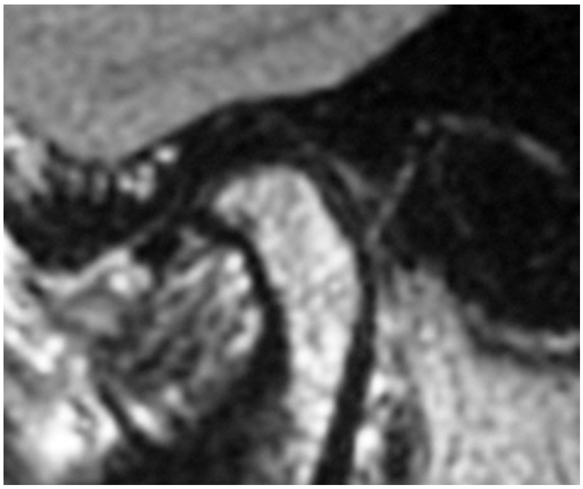


Figure 2. Sagittal oblique spin-echo T1-weighted magnetic resonance (MR) image obtained in the closed-mouth position shows the normal TMJ. (Reprinted, with permission, from reference 1.)

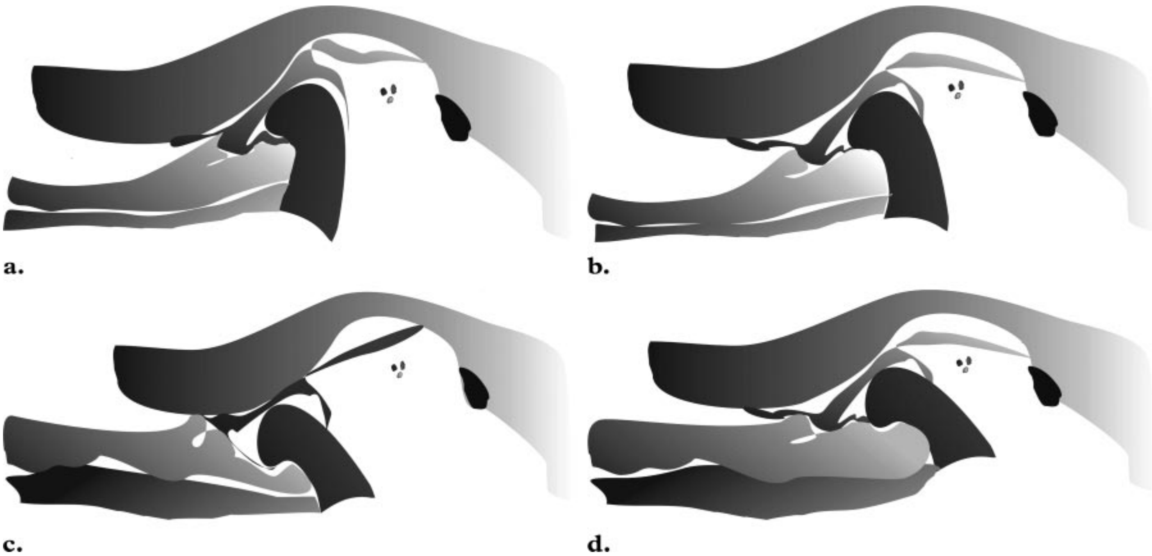
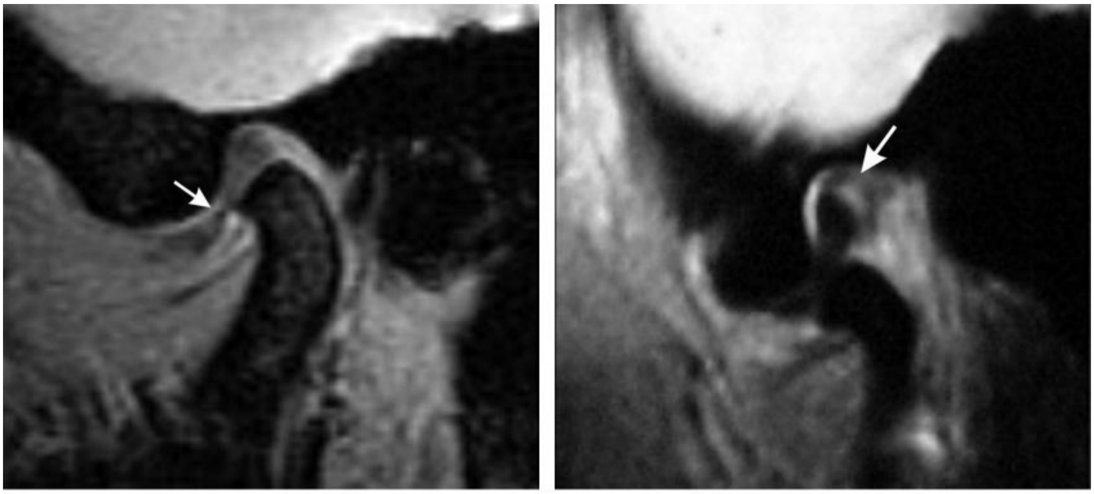


Figure 3. Drawings illustrate TMJ function. **(a)** Initial closed-mouth position. **(b)** At the beginning of the open-mouth position, the digastric muscle forces the condyle downward. The condyle then rotates in the lower joint space, and condylar displacement begins when the jaw is opened beyond 20–25 mm. Retrodiskal ligaments stabilize the disk. **(c)** Condylar protraction (maximum open-mouth position). Involvement of the inferior LPM is basic to this step, and the superior LPM can displace the disk, probably to maintain joint congruence. The superior retrodiskal layer prevents complete abnormal displacement. **(d)** Progression to the maximum clenching position. The inferior LPM is normally very active in this phase as well.

These findings have led investigators to question whether an anteriorly displaced disk is the precursor of clinical internal derangement or merely an anatomic variant (14). Since the advent of MR imaging, there have been substantial improvements in both hardware and software that currently allow better visualization of small structures such as retrodiskal layers or LPM attachments. In this article, we review the role of MR imaging in the assessment of TMJ dysfunction. In so doing, we discuss and illustrate relatively well established MR imaging signs of TMJ dysfunction (eg, abnormal disk morphologic features, disk displacement, joint effusion, osteoarthritis) as well as new indirect MR imaging signs of dysfunction not previously reported (eg, thickening of an LPM attachment, rupture of retrodiskal layers).

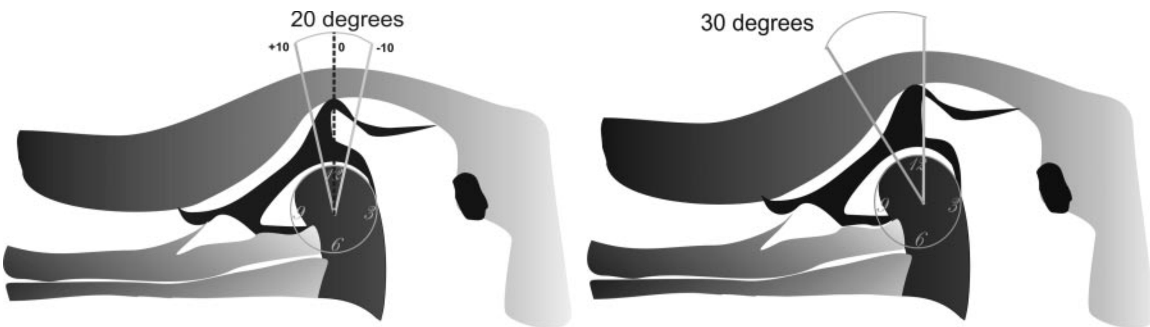
Disk Evaluation

The meniscus of the TMJ is a biconcave fibrocartilaginous structure located between the mandibular condyle and the temporal bone component of the joint. Its function is to accommodate a hinging action as well as the gliding action that occurs between the temporal bone and the mandible. The disk is round to oval, with a thin center (intermediate zone) that separates thicker peripheral portions known as the anterior and posterior bands. At sagittal MR imaging, the meniscus appears as a biconcave structure with homogeneous low signal intensity that is attached posteriorly to the bilaminar zone, which demonstrates intermediate signal intensity. The posterior band and retrodiskal tissue are best depicted in the open-mouth



a. b.

Figure 4. Morphologic features of the normal disk. **(a)** On a sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position), the anterior and posterior bands are thick and the intermediate zone (arrow) is thin, creating a biconcave disk shape. **(b)** Sagittal oblique gradient-echo T2-weighted MR image (open-mouth position) more clearly depicts the posterior band and retrodiskal tissue (arrow). These anatomic entities are best depicted in the open-mouth position.

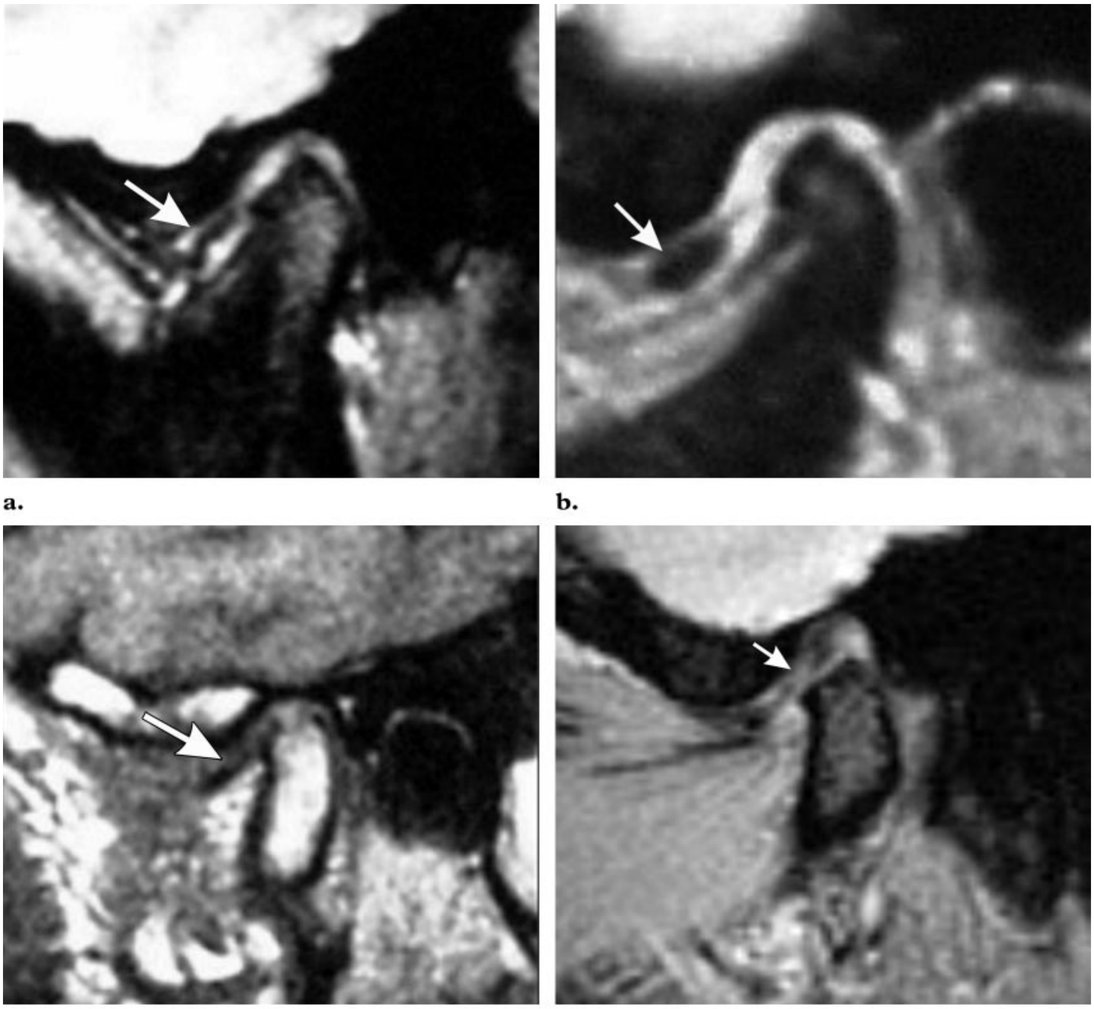


a. b.

Figure 5. Drawings (sagittal oblique views) illustrate disk displacement in the closed-mouth position. **(a)** A pathologic condition is considered to be present if the angle between the posterior band and the vertical orientation of the condyle (twelve o'clock position) exceeds 10°. **(b)** Rammelsberg et al (19) recommended that anterior disk displacement of up to 30° be considered normal to better correlate disk displacement with clinical symptoms of TMJ dysfunction.

position (Fig 4) (15). Typically, the anterior band and the intermediate zone are hypointense and the posterior band is slightly hyperintense, although the posterior band is more frequently hypointense in patients with disk disease (16). The anterior band lies immediately in front of the condyle and the junction of the bilaminar zone, and the disk lies at the superior part of the condyle. The anterior band can be seen as a bulge, which some authors have described as a normal variant of the disk (8,13,17).

When the mandible is in the closed-mouth position, the thick posterior band of the meniscus lies immediately above the condyle near the twelve o'clock position. The junction of the posterior band and the bilaminar zone should fall within 10° of vertical to be within the 95th percentile of normal. A pathologic condition is considered to be present if the angle between the posterior band and the vertical orientation of the condyle (the twelve o'clock line)—the angle of displacement—exceeds 10° (Fig 5a) (9,18,19). However, there is some controversy concerning the usefulness of this sign because other studies have shown that, according to this definition, disk displacement is seen in a large number (33%) of asymptomatic volunteers (11,12). Rammelsberg

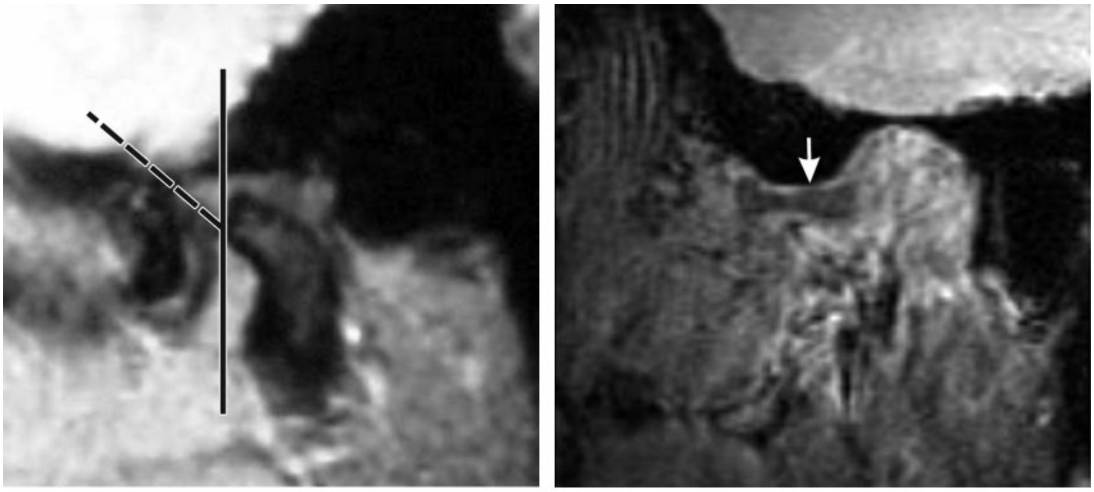


a. b. c. d.

Figure 6. Abnormal morphologic features of the disk. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows a displaced disk (arrow) that has lost its typical biconcavity, having become crumpled and irregular. (Reprinted, with permission, from reference 1.) **(b)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) obtained in a different patient shows a pathologic displaced disk with a rounded shape (arrow). **(c)** Sagittal oblique spin-echo proton-density–weighted MR image (closed-mouth position) obtained in a third patient shows a flattened displaced disk (arrow). **(d)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) obtained in a fourth patient demonstrates perforation of the intermediate zone of the disk (arrow).

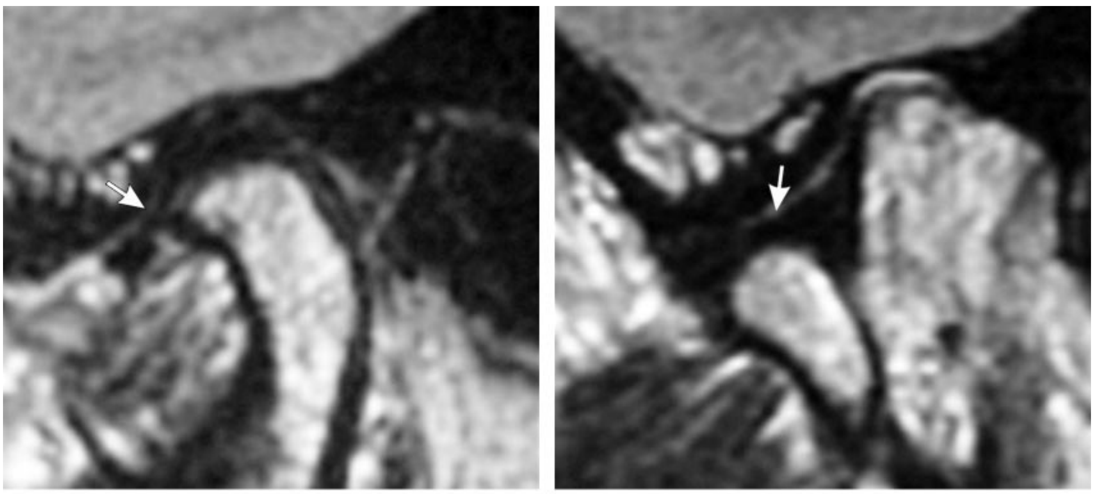
et al (20) have suggested that anterior disk displacement of up to 30° could be considered normal to better correlate disk displacement with clinical symptoms of TMJ dysfunction (Fig 5b). Other authors, such as Helms and Kaplan (21), use the intermediate zone as a point of reference, emphasizing its interposition between the condyle and the temporal bone. This approach does not take into account the angle of displacement of the posterior band.

Disk injuries are the most common cause of TMJ dysfunction. MR imaging is currently the standard imaging technique for diagnosing disk injuries, which can manifest as intrinsic disk lesions (eg, changes in shape and signal intensity) or disk displacement (22). In the early stages of internal derangement, the disk retains its normal shape. Over time, however, the displaced disk is deformed by thickening of the posterior band and reduction in the mass of the anterior band and the central thin area, leading to a biconvex or rounded disk (23). Irregular and rounded morphologic features are universally considered to indicate disease (Fig 6a, 6b) (24–26). In our



a. b.

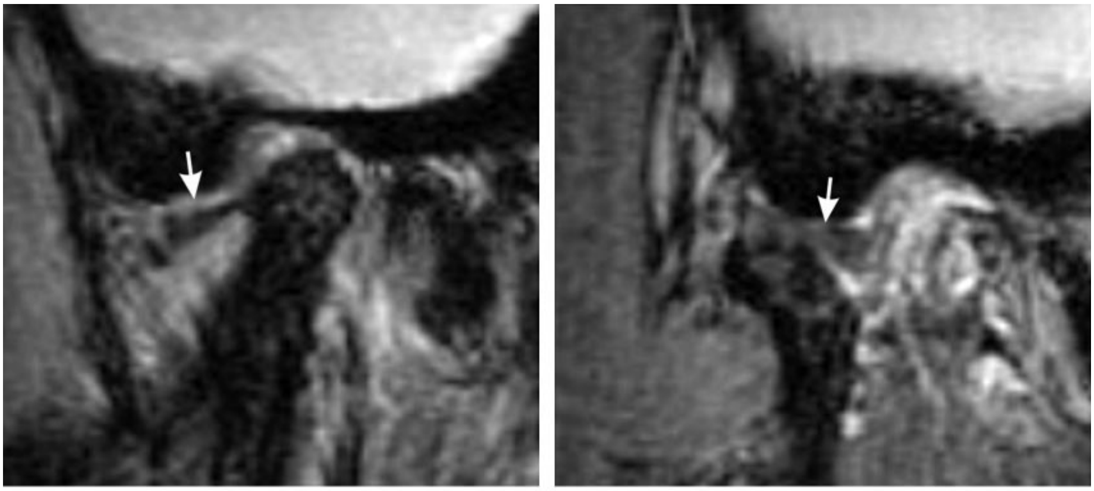
Figure 7. Abnormal disk displacement in TMJ dysfunction. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows significant disk displacement. The intermediate zone is clearly beyond the condyle, and the angle between the posterior band (dashed line) and vertical (solid line) is close to 50°. **(b)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) obtained in a different patient clearly depicts anteromedial disk displacement. The disk (arrow) appears to be "floating" by itself, and the condyle is no longer visualized.



a. b.

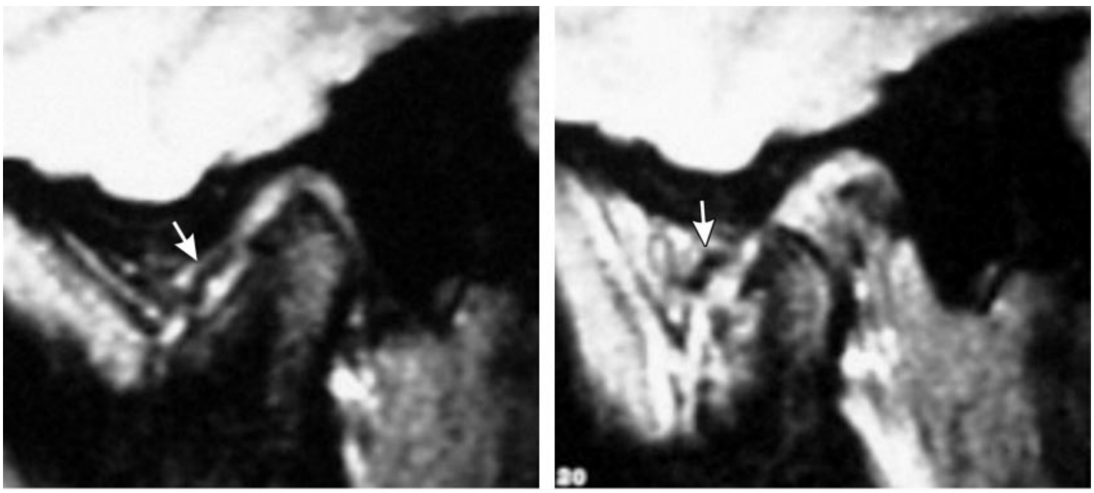
Figure 8. Normal disk mobility. **(a)** Sagittal oblique spin-echo proton-density–weighted MR image (closed-mouth position) shows a disk (arrow) in its normal position between the condyle and temporal bone and centered in the intermediate zone. (Reprinted, with permission, from reference 1.) **(b)** Sagittal oblique spin-echo proton-density–weighted MR image (open-mouth position) shows that the disk (arrow) has maintained its normal position during condylar movement. This interposition of the disk prevents abnormal contact between osseous joint surfaces.

experience, disk flattening also represents a pathologic finding (Fig 6c) (27). Furthermore, the normally intermediate to high signal intensity of the disk at MR imaging diminishes (15). In the chronic stages of disk displacement, a tear or perforation of the meniscus may occur (Fig 6d). Categories of abnormal disk displacement include anterior, anterolateral, anteromedial, lateral, medial, and posterior displacement (28). The use of sagittal and coronal MR imaging has been suggested to diagnose all these types of disk displacements. Other authors have described midlateral disk displacement only on sagittal views (29). The most common cause of interference with the smooth action of the joint is anterior displacement of the posterior band of the meniscus in front of the condyle (Fig 7). Whereas the menis-



a. b.

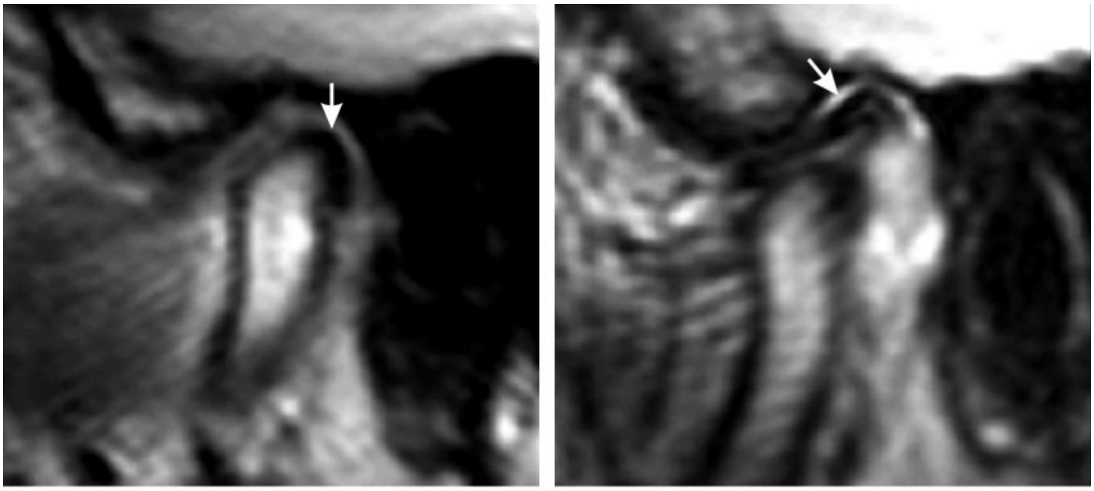
Figure 9. Anterior disk displacement with reduction. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows an anteriorly displaced disk (arrow). **(b)** Sagittal oblique gradient-echo T2-weighted MR image (open-mouth position) shows that the disk (arrow) has returned to its normal position between the condyle and the temporal bone. This return movement generally produces a clicking or popping noise.



a. b.

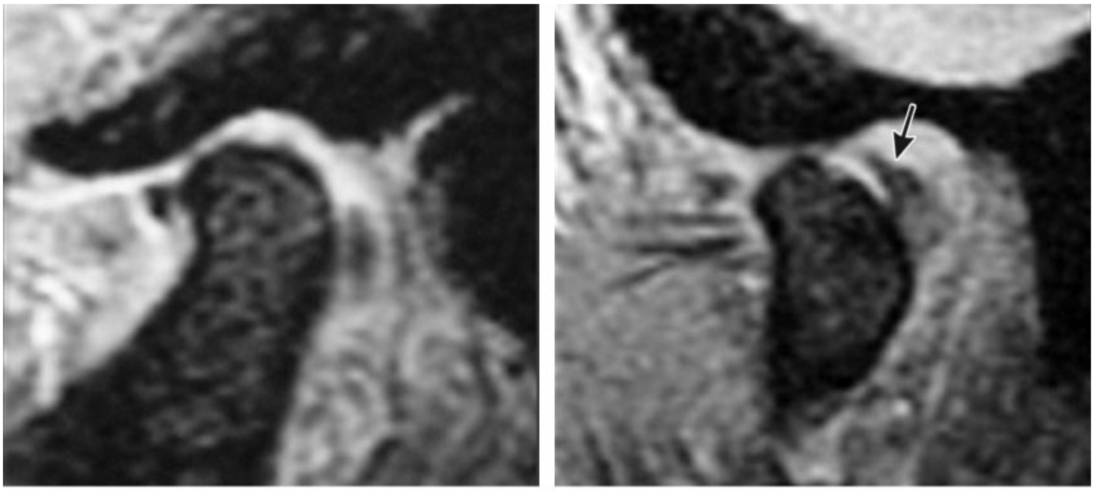
Figure 10. Anterior disk displacement without reduction. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows a disk (arrow) displaced from its normal location. **(b)** On a sagittal oblique gradient-echo T2-weighted MR image obtained in the open-mouth position, the disk (arrow) remains displaced from its normal location. (Fig 10 reprinted, with permission, from reference 1.)

cus translates anteriorly, the posterior band remains in front of the condyle and the bilaminar zone becomes abnormally stretched. Anterior displacement with reduction can frequently exist when the displaced posterior band returns to its normal position with condylar motion (Figs 8, 9). When a displaced meniscus returns to its normal position, it commonly produces a noise. In some patients, the meniscus remains anteriorly displaced at maximum mouth opening. This condition is known as anterior displacement without reduction (Fig 10) and is usually not associated with noise in the early stages (23). Another pathologic condition is the so-called "stuck disk." In this condition, the disk remains in a fixed position relative to the glenoid fossa and the articular eminence in both closed- and open-mouth positions, probably due to the formation of adhesions. It is



a. b.

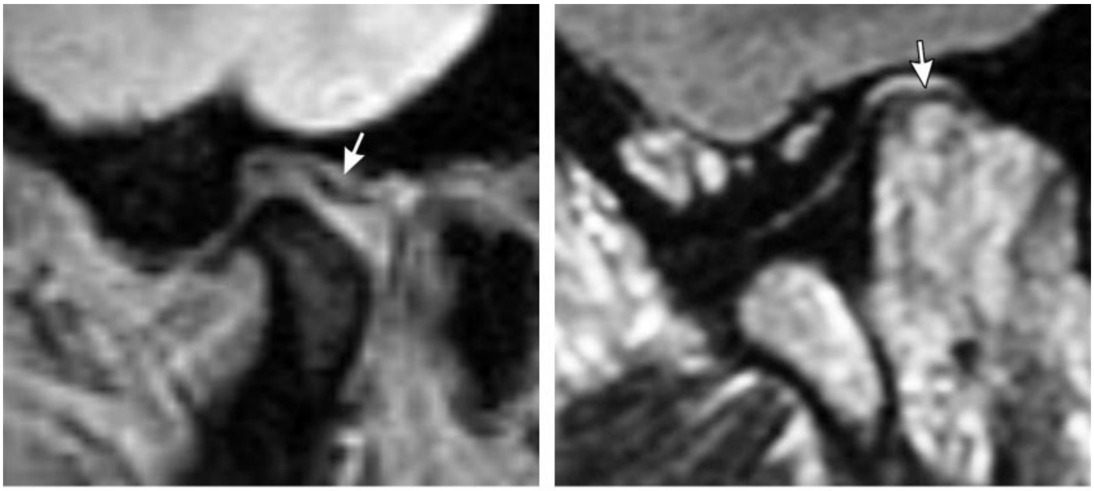
Figure 11. Stuck disk. On sagittal oblique spin-echo proton-density–weighted MR images obtained in the closed-mouth **(a)** and open-mouth **(b)** positions, the posterior band (arrow) remains close to the mandibular fossa. Opening of the jaw in this case was seriously limited.



a. b.

Figure 12. Posterior disk displacement. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows a posterior band displaced posteriorly. **(b)** On a sagittal oblique gradient-echo T2-weighted MR image obtained in the open-mouth position, the posterior band (arrow) remains displaced. The jaw was nearly locked in this case.

Figure 13. Joint effusion. On a sagittal oblique gradient-echo T2-weighted MR image obtained in the closed-mouth position, joint fluid (arrow) clearly delineates the shape of the disk between the upper and lower joint spaces. This phenomenon is best seen on T2-weighted images.



a. b.

Figure 14. Normal retrodiskal tissue. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) clearly depicts the retrodiskal layers (arrow). These structures play an important role in normal disk movement and can easily be visualized at MR imaging. **(b)** Sagittal oblique spin-echo proton-density–weighted MR image (open-mouth position) shows the superior retrodiskal layer (arrow) between the posterior band and the mandibular fossa. (Reprinted, with permission, from reference 1.)

critical that this condition be ruled out by performing MR imaging in both the closed- and open-mouth positions (Fig 11). A stuck disk causes limitation of condylar translation and may be associated with pain and joint dysfunction (28,30). Posterior disk displacement is another rare pathologic entity, accounting for 0.01%–0.001% of all TMJ disorders (31,32). The main clinical sign is sudden molar open bite (ie, jaw locked in the open position). MR imaging allows the diagnosis, showing a posterior band displaced beyond the one o'clock position (Fig 12).

Additional MR Imaging Signs of TMJ Dysfunction

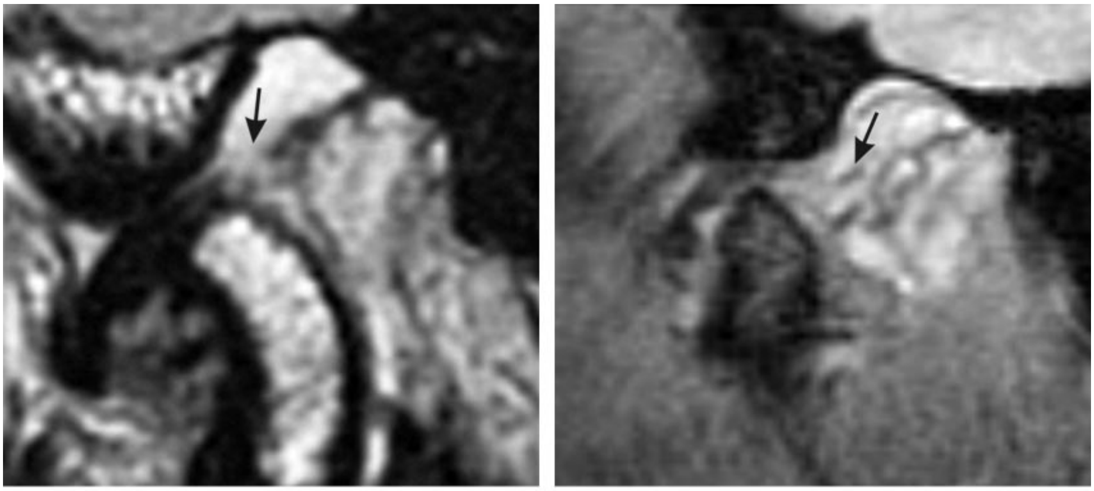
Joint Effusion

Joint effusion is usually defined as a large amount of articular fluid. The presence of joint effusion is an unusual sign in asymptomatic individuals (9), and only small amounts of fluid are seen in these cases (27,33). The presence of large amounts of joint effusion has been associated with TMJ pain and disk displacement (34) and represents an early change that can precede osteoarthritic changes (22). At MR imaging, joint effusion is best depicted with T2-weighted sequences, manifesting as areas of hyperintensity. Joint effusion is generally seen surrounding the anterior band (27). If a large accumulation of fluid exists, a so-called "arthrographic effect" can be seen, wherein the fluid highlights the shape of the disk in the upper and lower joint spaces (Fig 13). MR imaging can also help differentiate between joint effusion and synovial proliferation. Some authors have found that gadolinium-enhanced MR imaging of the TMJ may allow clear differentiation between the proliferating synovium, which enhances, and joint effusion, which does not. This technique can be useful if rheumatic inflammatory joint disease associated with joint effusion is suspected (35).

Retrodiskal Layer Rupture

As mentioned earlier, retrodiskal layers (superior and inferior) and vasculonervous structures constitute an anatomic area called retrodiskal tissue, or the bilaminar zone. The inferior retrodiskal layer is made up of collagen fibers, and the superior retrodiskal layer consists of elastic fibers (Fig 14). These retrodiskal layers play an important role in normal disk displacement. Improvements in MR imaging currently allow detailed depiction of these structures and related pathologic changes. Rupture of superior retrodiskal layer fibers may produce significant disk instability. This sign, which to our knowledge has not been previously described, is seen in two different patients with severe nonreduced disk displacement in Figure 15. The significance (if any) of this finding is unknown and awaits histologic confirmation.

Teaching Point



a. b.

Figure 15. Abnormal retrodiskal tissue. **(a)** Sagittal oblique spin-echo proton-density–weighted MR image (open-mouth position) obtained in a patient with internal derangement without reduction shows rupture of the fibers of the superior retrodiskal layer (arrow), resulting in loss of union with the posterior band. (Reprinted, with permission, from reference 1.) **(b)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) obtained in a different patient again depicts rupture of the fibers of the superior retrodiskal layer (arrow).

In 1992, Manzione et al (36) identified the "pseudomeniscus sign," or thickening of the posterior meniscal attachment that occurs in some patients with an anteriorly displaced meniscus. The authors suggested that this sign could represent a type of TMJ protective reaction, and that affected patients may be less symptomatic than those who do not develop this thickening.

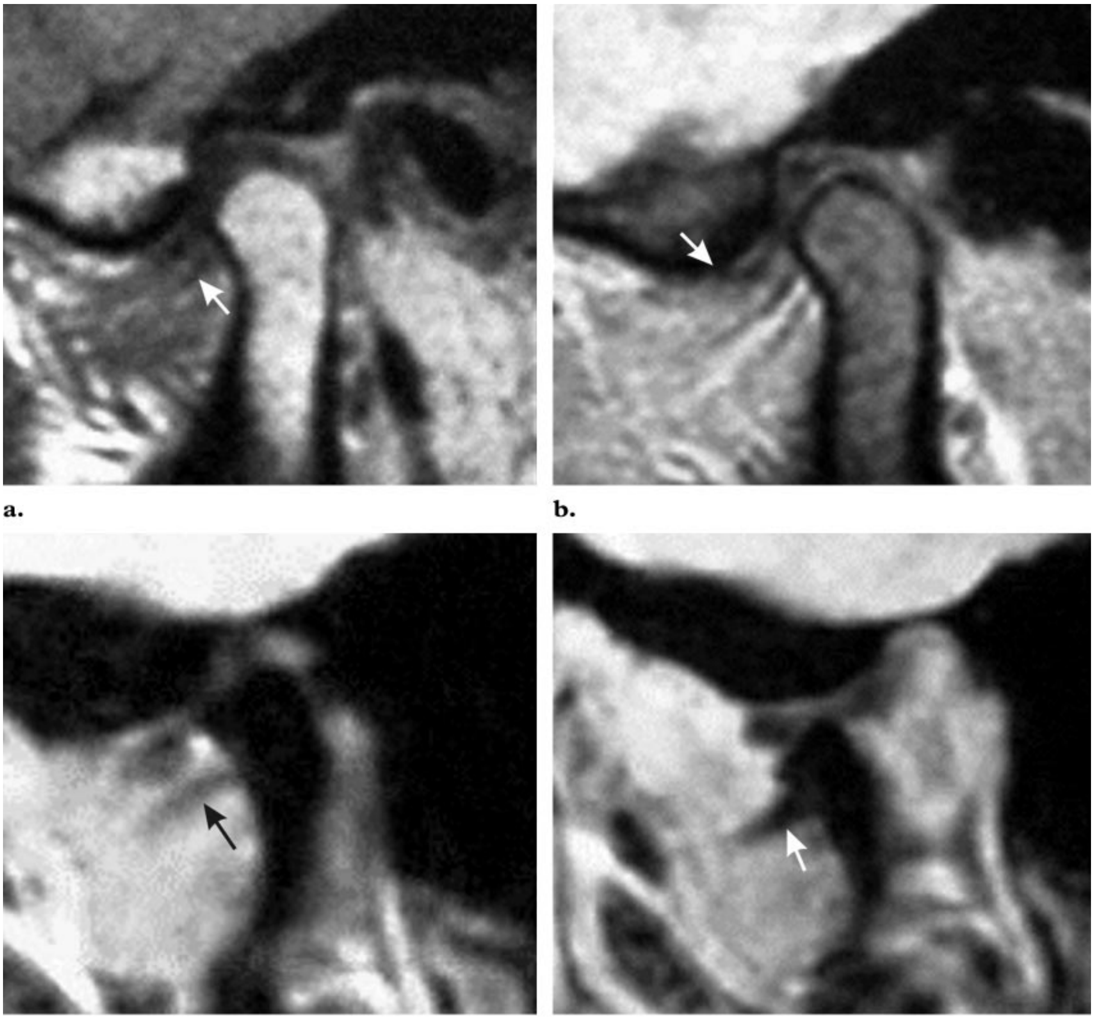
The other components of retrodiskal tissue are vasculonervous structures. A higher T2 signal intensity, due to a higher degree of vascular supply, has been found in the retrodiskal tissue of painful joints compared with that of nonpainful joints (25,37). On the other hand, a decreased signal intensity may be associated with fibrous changes observed in a chronic displaced disk (38).

Thickening of an LPM Attachment

Some authors, such as Aziz et al (39), believe that the two parts of the LPM—the superior LPM and the inferior LPM—are really two separate and distinct muscles. LPM attachment shows a high degree of variability among individuals. Insertion of the muscle onto the condyle alone has been described, as have insertions divided between the condyle, the capsule, and the disk (40–43).

The role of the LPM in normal TMJ function is still controversial. According to the classically defined functions of the two parts of the LPM muscle, the superior LPM is active in closing, retrusion, and ipsilateral jaw movements, whereas the inferior LPM is active in opening, protrusion, and contralateral jaw movements. However, recent data indicate that these conceptions are too simplistic. An important role for the LPM in the generation of side-to-side and protrusive jaw forces has been suggested. The LPM is, therefore, likely to play an important role in parafunctional excursive jaw movements and possibly in influencing jaw position in patients in whom the relationship between the maxilla and the mandible changes from one clinical exploration to the next (44). With use of electromyographic studies, Lafreniere et al (45) showed that, in cases of TMJ internal derangement, the inferior LPM may become hyperactive in specific positions to help stabilize and position the condyle and the disk. The temporal and masseter muscles are not hyperactive in TMJ internal derangement.

A few MR imaging studies have demonstrated morphologic and pathologic changes in the LPM (46,47). In Finland, Yang et al (48) reported some morphologic changes in both bellies of the LPM, such as hypertrophy, atrophy, or contracture in patients with anterior disk displacement without reduction of the TMJ. These changes had a significant association with clinical symptoms such as pain or restricted jaw opening. However, in advanced stages of TMJ dysfunction



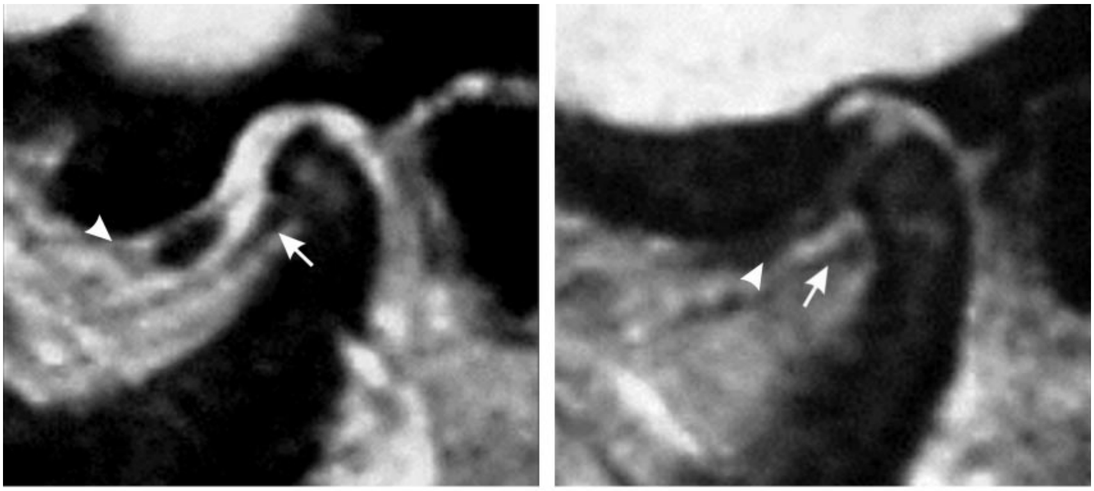
a. b. c. d.

Figure 16. Normal LPM. **(a)** Sagittal oblique spin-echo proton-density–weighted MR image (closed-mouth position) shows a thin attachment of the inferior LPM (arrow) just below the disk. **(b)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows a thin attachment of the superior LPM (arrow) just in front of the disk. **(c)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) shows the thin insertional area of the inferior LPM (arrow). **(d)** On a sagittal oblique gradient-echo T2-weighted MR image obtained in the open-mouth position, the insertional area of the inferior LPM (arrow) has increased due to contraction of the muscle during this phase.

(when condylar limitation is due to osteoarthritis), the pathologic changes in the LPM at MR imaging were reduced (48). In 2005, Taskaya-Yilmaz et al (49) used MR imaging to evaluate the relationship between internal derangement of the TMJ and type of LPM attachment. They found that if the superior LPM attaches to the disk but not to the condyle, the disk may displace anteriorly very easily. Thus, this anatomic situation reduces the functionality of the superior LPM and may cause muscle atrophy. Furthermore, spasm of the LPM causes disk displacement and atrophy, leading to degeneration of the LPM.

In 1999, we performed a quantitative MR imaging study comparing 80 patients with TMJ dysfunction with 12 healthy volunteers (27). We found that the mean diameters of the superior and inferior LPM attachments in the closed-mouth position were significantly higher in affected patients than in the control group. Only findings on images obtained in the closed-mouth position were analyzed; in the open-mouth position, the diameters of these attachments were physiologically greater than in the closed-mouth position (Figs 16, 17). Furthermore, the diameter of the inferior LPM increased proportionately

Teaching Point



a. b.

Figure 17. Abnormal LPM. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) of a symptomatic TMJ shows complete disk displacement. **(b)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) of the contralateral asymptomatic TMJ shows subtle disk displacement. The insertional areas of the superior (arrowhead) and inferior (arrow) LPMs are markedly thinner than those in the symptomatic TMJ (cf **a**).

with increases in the degree of disk displacement (Fig 18) (1,27). These findings are similar to those in the electromyographic studies by Lafreniere et al (45), which showed that the inferior LPM may become hyperactive in cases of TMJ internal derangement. Some of these MR imaging findings (eg, thickening of the inferior and superior LPM attachments) have been previously described in isolated cases by Katzberg et al (4); to our knowledge, however, these findings have not been systematically analyzed. Furthermore, it is important to be familiar with these changes to avoid confusing a thickened inferior LPM with the disk ("double disk sign") (Fig 19).

Osteoarthritis

Osteoarthritis of the TMJ is more common in older persons, but gender and dentition are not major factors in the development of TMJ disease in these patients (51,52). If osteoarthritic changes do appear, even in young individuals, a long-standing internal disk derangement without reduction should be ruled out. Osteoarthritic changes tend to appear as advanced-stage TMJ dysfunction and may be interpreted as signs of disease progression (15,53). Yang et al (48) reported that osteoarthritis correlated with condylar limitation. On the other hand, the presence of TMJ pain or joint effusion is not relevant in this advanced stage of disease. In fact, symptoms related to TMJ dysfunction decrease with age and are often remitting and self limiting (54–57). According to Westesson (52), the diagnosis of osteoarthritis can be made when the condyle demonstrates one or more of the following imaging findings: flattening, osteophytes, erosions, and sclerosis. MR imaging is a valuable diagnostic tool for evaluating local TMJ-related signs of os-

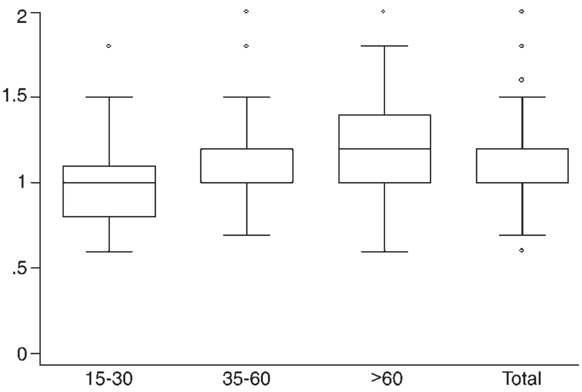
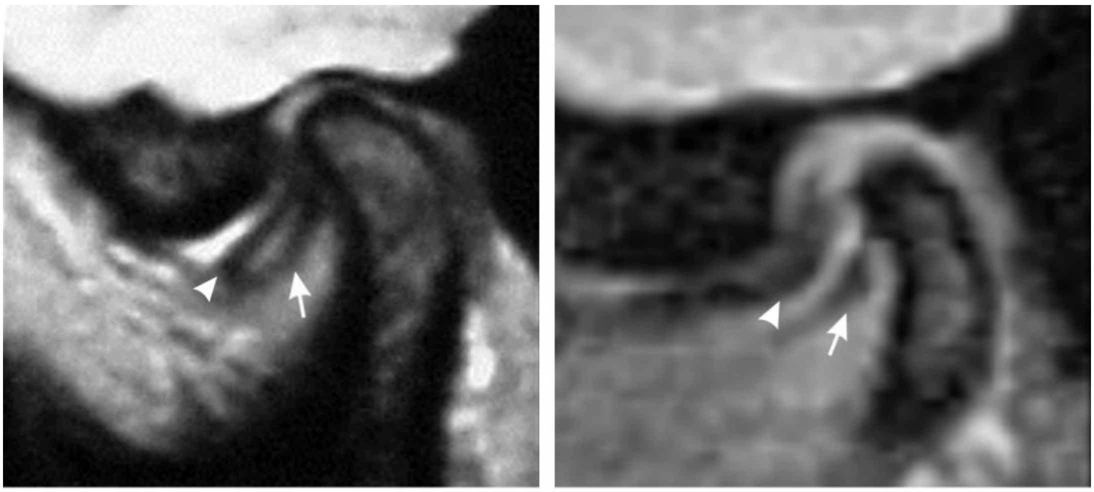


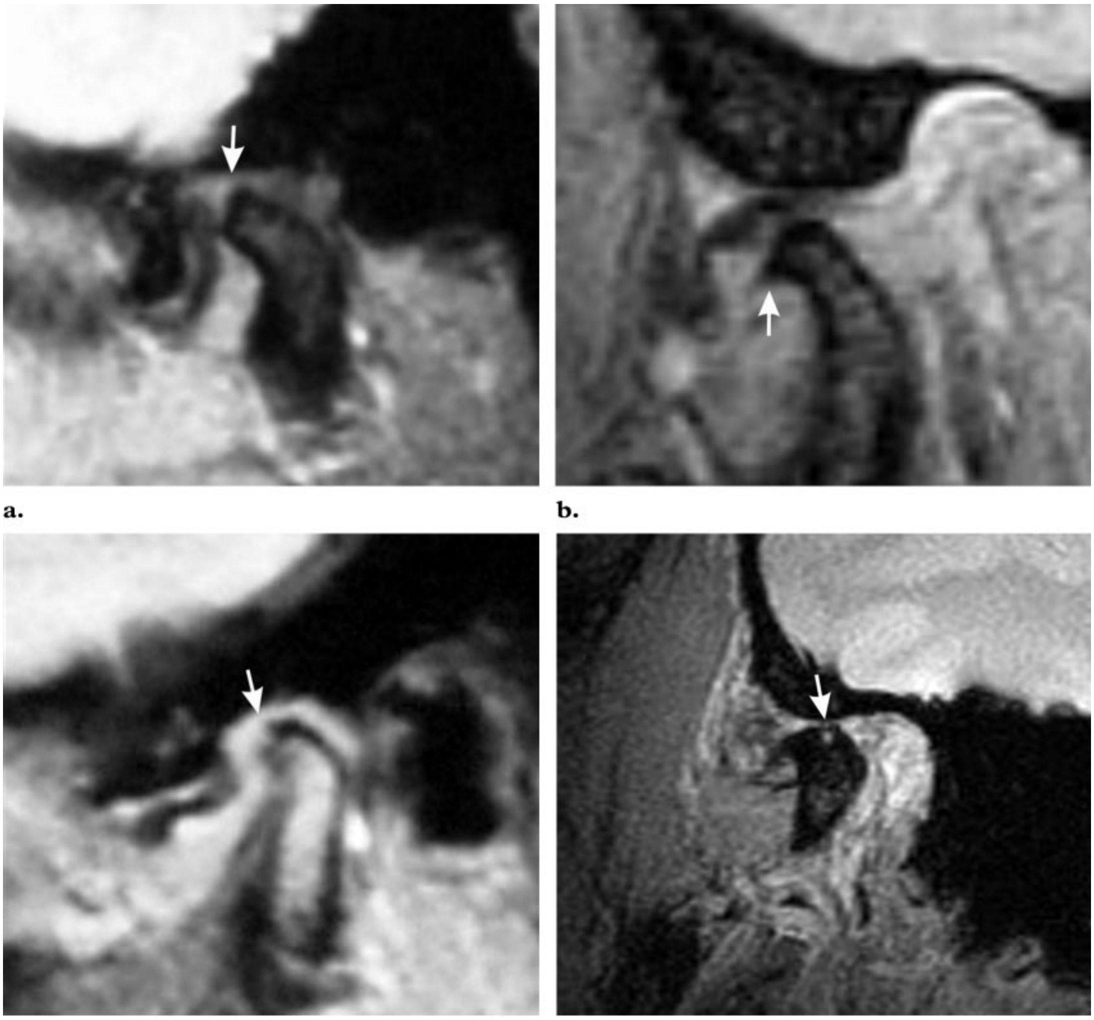
Figure 18. Diagram illustrates the relationship between the angle of disk displacement in degrees (x-axis) and the diameter of the inferior LPM attachment in millimeters (y-axis) in the closed-mouth position. The diagram shows a significant relationship between the two variables: As the angle of disk displacement increases, the diameter of the muscle attachment also increases. The statistical Altman test was performed.



a. **b.**

Figure 19. Double disk sign. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) of a symptomatic TMJ shows complete disk displacement. The thick insertional area of the inferior LPM (arrow) is parallel to the disk (arrowhead), creating the double disk sign. (Reprinted, with permission, from reference 1.) **(b)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) of a symptomatic TMJ in a different patient demonstrates severe internal derangement (arrowhead). A thick inferior LPM attachment (arrow) is again seen. The double disk sign must be recognized to distinguish between disk and muscle attachment.

teoarthritis (57,58). In 1999, in the same group of individuals previously described, we studied MR imaging signs of osteoarthritis (Fig 20) (27). Osteophytes and condylar flattening were seen in 27% of cases, erosions in 13%, and sclerosis in 9%. Osteophytes were seen in only one individual in the control group. Our results confirmed that the prevalence of osteophytes and flattening was significantly higher in patients with TMJ dysfunction than in the control group (27).



a. b. c. d.

Figure 20. Osteoarthritic changes in four different patients. **(a)** Sagittal oblique gradient-echo T2-weighted MR image (closed-mouth position) obtained in a patient with internal derangement shows condylar flattening (arrow). **(b)** Sagittal oblique gradient-echo T2-weighted MR image (open-mouth position) obtained in a patient with internal derangement without reduction clearly depicts an osteophyte (arrow). **(c)** Sagittal oblique spin-echo T2-weighted MR image (closed-mouth position) obtained in a patient with internal derangement shows condylar erosion (arrow). **(d)** Sagittal oblique gradient-echo T2-weighted MR image (open-mouth position) obtained in a patient with internal derangement without reduction demonstrates a condylar osteophyte, flattening, sclerosis, and erosion (arrow), all of which are signs of osteoarthritic changes (cf **a–c**).

Conclusions

In this article, we have described MR imaging findings in TMJ dysfunction. The first step is to evaluate the disk, its morphologic features, and its location in both closed- and open-mouth positions relative to the condyle. Other MR imaging signs that can suggest a diagnosis of TMJ dysfunction include thickening of an LPM attachment, rupture of retrodiskal layers, or joint effusion (Table 1). The last stage of dysfunction

Teaching Point

Table 1
Direct and Indirect MR Imaging Signs of TMJ Dysfunction

Direct signs
Abnormal disk morphologic features
Crumpled
Rounded
Flat
Perforated
Abnormal disk displacement in closed-mouth position
Anterior displacement
More frequently observed
Posterior band exceeds 10° (9,18,19) or 30° (20) from vertical
Posterior displacement
Rare
Posterior band exceeds −10° (9,18,19) or −30° (20) from vertical
Lateral or medial displacement
Abnormal disk movement in open-mouth position
Anterior disk displacement with reduction
Anterior disk displacement without reduction
Stuck disk (disk remains fixed)
Osteoarthritic changes of the condyle
Flattening
Osteophytes
Erosion
Sclerosis
Indirect signs
Large amount of joint fluid (joint effusion)
Increased thickness of LPM attachments
Rupture of retrodiskal layers

Note.—Numbers in parentheses indicate reference numbers.

Table 2
Progression of TMJ Dysfunction as Seen at MR Imaging

Increase in thickness of LPM attachments
Disk displacement in closed-mouth position, disk displacement with reduction in open-mouth position
Joint effusion
Rupture of retrodiskal layers
Disk displacement in closed-mouth position, disk displacement without reduction in open-mouth position
Osteoarthritic changes

manifests as osteoarthritic changes such as condylar flattening or osteophytes. It is important for the radiologist to detect early MR imaging signs of TMJ dysfunction, thereby avoiding its evolution to this advanced and irreversible phase characterized by osteoarthritic changes (Table 2).

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MR Imaging of Temporomandibular Joint Dysfunction: A Pictorial Review

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Page 766
The most frequent cause of TMJ dysfunction, or TMJ disorder, is internal derangement, which is defined as an abnormal relationship of the disk to the condyle.

Page 766
Precise localization of the disk is very important in the diagnosis of TMJ internal derangement and can easily be achieved with MR imaging. An anteriorly displaced disk has been seen in up to 34% of asymptomatic volunteers (8–13), and a normal disk position has been depicted in 16%–23% of symptomatic patients (11,12).

Page 773
Improvements in MR imaging currently allow detailed depiction of these structures and related pathologic changes. Rupture of superior retrodiskal layer fibers may produce significant disk instability.

Page 775
The mean diameters of the superior and inferior LPM attachments in the closed-mouth position were significantly higher in affected patients than in the control group.

Page 779

Table 1
Direct and Indirect MR Imaging Signs of TMJ Dysfunction

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Abnormal disk morphologic features
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Rounded
Flat
Perforated
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Posterior displacement
Rare
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Stuck disk (disk remains fixed)
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Flattening
Osteophytes
Erosion
Sclerosis
Indirect signs
Large amount of joint fluid (joint effusion)
Increased thickness of LPM attachments
Rupture of retrodiskal layers