RESEARCH

The value of magnetic resonance arthrography of the temporomandibular joint in imaging disc adhesions and perforations

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Objectives: This study attempted to validate MR arthrography (MRAr) of the temporomandibular joint (TMJ) in detecting the position, integrity and relations of the articular disc and retrodiscal tissue.

Methods: A total of 20 TMJs from 10 patients with severe TMJ dysfunction underwent MRI and MRAr. A paramagnetic contrast medium was injected into the upper joint compartment to observe possible adhesions and/or leakage into the lower compartment. 15 TMJs were surgically or arthroscopically explored and restored.

Results: MRAr was approximately in the same diagnostic value as MRI when locating position, but superior in detecting disc perforations (eight TMJs) and adhesions (seven TMJs) appearing together in four cases. Surgery confirmed radiological findings in all but one case, where arthroscopy and surgery failed to confirm a disc perforation indicated by MRAr.

Conclusions: TMJ MRAr may simultaneously reveal adhesions and perforations. Sensitivity and the probability of false-positive results require further study.

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Keywords: temporomandibular joint; disorder; magnetic resonance; arthrography

Introduction

Temporomandibular joint dysfunction (TMD) is a common disorder affecting more than 5% of the general population.¹ Many patients show only mild signs and symptoms and only a fraction of the above percentage come to the physician's attention. A variety of causative and exacerbating factors are involved and interact in the pathogenesis and clinical course of TMD.² It is generally accepted that TMD appears as myofascial dysfunction, internal derangement or osteoarthritis. However, it is not always a progressive disease;³ degeneration may not occur sequentially and stages do not occur consecutively for all patients. The first stage is epidemiologically the most prevalent and is managed by conservative treatment.¹ Interventional treatment is indicated for cases in the second and third

stage where the disc may be permanently dislocated and/or perforated. Severe deformation of the articular surfaces caused by interference from osteophytes is also an indication for surgical treatment.³

Several clinical classifications, and almost all of the imaging modalities, have been used to define the exact stage of each case and to develop a concise decision-making algorithm for the appropriate treatment plan. Of the different existing imaging modalities, arthrography provides direct information about the integrity of the articular disc and, since it can show the real-time movement of the joint, gives indirect information about the disc position. The way arthrography is employed in standard practice is not usually informative for disc position in all three dimensions.⁴ CT scanning delineates bone surfaces, but it is of no use for studying the disc.^{5,6} MRI is considered to be the gold standard for disc localization, but it is less informative on integrity, adhesions to temporal fossa or the condition of bone surface.^{5,7,8}

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This article attempts to evaluate magnetic resonance arthrography (MRAr) of the temporomandibular joint (TMJ) for detection of the position, integrity and relations of the articular disc and retrodiscal tissue.

Materials and methods

10 consecutive cases from the outpatient TMJ clinic (4 male and 6 female with a mean age of 54 years) were initially assessed as in need of surgical or interventional

treatment for TMD. This assessment was based on the criteria of pain and dysfunction resistant to conservative treatment and a clinical diagnosis of internal derangement established by two examiners (GV and KT). The clinicians worked independently using their own experience, but a common staging was agreed by both; this was based on the RDC/TMD (research diagnostic criteria for tempromandibular disorders) diagnostic system.^{3,9} The clinical diagnoses are shown in Table 1.

MRI of both TMJs of each patient was performed using a 1.5 T imager (Magnetom Mastro Plus, Siemens,

Table 1 Clinical and radiologic diagnoses in combination with surgical/arthroscopic findings

Case			Clinical diagnosis		Radiologic diagnosis		Surgical/arthroscopic findings
No.	Age/sex	R/L	1st examiner	2nd examiner	MRI	MRAr	
1	70 m	R	Hypermobility, DWR	Hypermobility, DWR	1. DWR, hypermobility 2. DWR, subluxation	1. DWR, subluxation, adhesions 2. DWR, subluxation	Incipient DWR
		L	Hypermobility DWR	Hypermobility DWR	1. DWR, hypermobility 2. DWR, subluxation	1. DWR, subluxation, perforation, adhesions 2. DWR, subluxation, perforation, adhesions	DWR, perforation
2	42 f	R	DWoR	DWR	1. DWR 2. DWR	1. DWR, disc integral 2. Incipient DWR	No intervention
		L	DWoR	DWoR, osteoarthritis	1. DWoR, disc disruption, osteoarthritis 2. DWoR, osteoarthritis	1. DWoR, adhesions, osteoarthritis 2. DWoR, osteoarthritis	DWoR, adhesions, disc integral
3	56 m	R	Osteoarthritis DWoR	DWoR	1. DWoR, disc disruption 2. DWoR, disc disruption	1. DWoR, integral disc 2. DWoR, adhesions	DWoR, integral disc
		L	Osteoarthritis	Osteoarthritis	1. Disc disruption, osteoarthritis 2. DWoR, condyle irregularity	1. Wide communication between spaces, osteoarthritis 2. Perforation, adhesions, osteoarthritis	Disc destruction
4	21 f	R	DWoR	DWoR	1. DWR 2. DWR	1. DWR 2. DWR adhesions,	Arthroscopy: DWR
		L	Arthralgia, osteoarthritis	Arthralgia	1. DWR 2. Normal	1. Adhesions 2. Adhesions	Arthroscopy: adhesions
5	28 m	R	DWoR	DWoR, osteoarthritis	1. DWoR, disruption 2. DWoR	1. DWoR perforation, osteoarthritis, 2. DWoR perforation	DWoR perforation, osteophyte
		L	Normal	DWR	1. Incipient DWR 2. Normal	1. Normal 2. Normal	No intervention
6	32 f	R	Normal	DWR	1. DWR 2. Incipient DWR	1. DWR 2. Normal	Arthroscopy: normal
		L	DWoR	DWoR	1. DWoR, disc disruption 2. DWoR	1. DWoR, adhesions, perforation 2. DWoR, adhesions, perforation	Arthroscopy/surgery: DWoR adhesions, disc integral
7	58 f	R	Osteoarthritis-DWoR	DWoR Osteoarthritis	1. DWoR 2. DWoR, disc disruption,	1. DWoR, perforation, adhesions, osteoarthritis 2. perforation, adhesions, osteoarthritis	DWoR, perforations, adhesions
		L	Normal	Normal	1. DWR 2. Incipient DWR	1. Incipient DWR 2. DWR, adhesions	No intervention
8	63 m	R	DWR	Normal	1. DWR 2. DWR	1. DWR, adhesions 2. DWR	No intervention
		L	Osteoarthritis	Osteoarthritis	1. DWoR, disc destruction 2. DWoR, disc disruption	1. Perforations, adhesions, DWoR 2. DWoR, perforations, adhesions	Adhesions, disc destruction
9	66 f	R	Osteoarthritis	Osteoarthritis	1. DWoR, disc disruption 2. DWoR	1. DWoR 2. DWoR, perforation, osteoarthritis	No intervention
		L	Osteoarthritis	Osteoarthritis	1. DWoR, disc disruption 2. DWoR. Osteoarthritis,	1. DWoR perforation, adhesions, osteoarthritis 2. DWoR, perforation, osteoarthritis	Disc perforations, degeneration
10	50 f	R	DWR	DWR	1. DWR 2. Incipient DWR	1. Incipient DWR, adhesions 2. Normal,	Arthroscopy: adhesions
		L	DWoR	Osteoarthritis DWoR	1. DWoR, disc disruption 2. DWoR, disc destruction	1. DWoR, perforation 2. DWoR, perforation, adhesions	DWoR, perforations

m, male; f, female; DWR, disc displacement with reduction; DWoR, displacement without reduction; R, right; L, left. In radiologic diagnoses numbers 1 and 2 correspond to examiners 1 and 2

Erzlangen, Germany) with a double-loop array coil. The correct sagittal plane was determined using the long axis of each condyle (*i.e.* the axis joining the medial to the lateral pole). The coronal section was determined to be perpendicular to the sagittal plane. A T_1 weighted spin-echo sequence (repetition time (TR) 420 ms; echo time (TE) 15 ms; 256×256 acquisition matrix and 160-mm field of view) in the sagittal plane in both the closed and open mouth positions were scanned. The same sequences were obtained in the coronal plane. Image thickness was determined at 3 mm. The radiological findings were recorded for each patient by one radiologist and kept for comparison with findings from the MRAr performed by another radiologist (AP and MP, respectively).

Before the MRAr was performed, informed consent, approved by the local ethics committee and the hospital medical service, was obtained from all patients. A paramagnetic contrast medium (dimegulumine gadopentate, Magnevist, Bayer-Schering AG, Berlin, Germany) was used diluted 1:100 in normal saline. The same operator (GV) injected the solution into the upper articular compartment in both TMJs of all patients to obtain MRAr images comparable with those of MRI. The upper compartment was selected because it is easily accessible to operators familiar with lavage and arthroscopy of the TMJ; a leak of the contrast medium from the upper into the lower compartment through a disc perforation is not detectable when injecting it into both spaces; and the risk of penetrating the disc and injecting the contrast medium into the other compartment is significantly lower than it would be if the lower compartment were to be targeted. The same is true for the risk of an extra-articular injection by targeting the lower compartment. After disinfection of the pre-auricular skin, local anaesthesia was administered by infiltrating 0.90 ml of mepivacaine HCl until the needle "felt" the articular eminence. A syringe with the paramagnetic medium was then attached to each needle and 0.5–0.8 ml of the solution was injected. The patient was asked to make movements with his or her mandible to facilitate the diffusion of the liquid throughout the whole compartment and to clench the teeth tightly in the habitual occlusion. The latter increases the intra-articular pressure and thus permits leakage from the upper to the lower compartment if a small perforation is present. Another indication of successful injection into the articular compartment is if the patients report they "cannot exercise enough power" with their posterior teeth. The radiologist who performed MRAr used the same axes and planes and interpreted the images independently from the results of the MRI. MRAr slice thickness was the same as MRI slice thickness. Radiological diagnoses from MRI compared with those from MRAr are presented in Table 1, as well as clinical diagnoses and surgical and arthroscopic findings.

Of the 20 TMJs, 15 were surgically or arthroscopically explored and restored. Four of them only received arthroscopic exploration and lavage under general anaesthesia. One patient (Case 6, female) received both

arthroscopy and open surgery on her left TMJ. The decision of whether to operate or not was based on the two major clinical findings of pain resistant to conservative treatment on the one hand, and limited ability to open the mouth on the other. MRAr and arthroscopy findings were also taken into account. Of the 20 TMJs, 5 received no intervention at all either because they were clinically and radiologically quite normal or because of asymptomatic osteoarthritis that yielded priority to the other TMJ. After MRAr, transient facial nerve palsy was observed and was attributed to local anaesthesia. Arthroscopy resulted in minor complications, such as pain and TMJ disability, that lasted 3–4 days post-operatively. Open surgery resulted in palsy of the frontal branch of the facial nerve, which in one patient lasted up to 2 months post-operatively.

2 months after the first radiological examination, the MR records were given back to radiologists along with the initial referring clinical diagnoses. The radiologist who performed the MRI now received the MRAr for diagnosis, and *vice versa*. By doing so the possibility of examiner-dependent bias on interpretation of radiological findings was dramatically reduced. Table 1 contains a concise presentation of all ten cases. The term "disc disruption" in radiological diagnoses means disorganization of the disc, which was still radiologically recognizable. The term "disc destruction" means that the fibrocartilaginous disc had become almost unrecognizable. Questionable radiological diagnoses were indicated with a query, but in elaboration of the results they consider as certain, they were able to check for false positive results whilst excepting that a questionable diagnosis "turns" data towards false negative results. Only those findings from surgery or arthroscopy that pertain to disc position, adhesions and perforations observed through imaging are listed without any detailed description of the kind of operation.

Results

A total of 20 TMJs were diagnosed by 2 clinicians (Table 1). The clinical diagnosis was the same in 85% of cases (different diagnoses were given for Cases 5 (left), 6 (right) and 8 (right)). The MRI radiological diagnoses by two radiologists was the same in a higher percentage of cases (bordering on 90% — all except Case 5 (left) and Case 6 (right) TMJ). Clinical diagnosis of disc displacement was confirmed by MRI in almost all cases — only two clinical diagnoses did not match MRI findings. One of these was a false-negative (Case 7, left) and one was misdiagnosed as displacement without reduction, probably owing to muscular restriction of mouth opening (Case 4, right).

MRAr did not yield as clear a picture for locating the position of the disc as that obtained through MRI, especially in cases of incipient disc displacement. In three cases (Case 2 (right), and Cases 7 and 9 (left)) a previously diagnosed disc displacement with reduction

(DWR) in MRI was questionable in MRAr. Three more cases of incipient DWR in MRI were diagnosed as normal in MRAr (Cases 6 and 10 (right), and 5 (left)). Generally the presence of the contrast medium was responsible for yielding a more confused picture of the transition zone and disc composition. Thus, the diagnosis of “disc disruption” established by the first radiologist on MRI could not be made by the second radiologist on MRAr. However, MRAr specified the “disruption” in adhesions and perforations.

Adhesions were diagnosed on MRAr by both radiologists in 7 TMJs (35%), although individually lesions were observed or suspected more frequently. In 4 cases (20%) (Cases 1, 6 and 8 (left), and Case 7 (right)) both examiners observed perforations and adhesions on MRAr simultaneously (Figure 1a,b,c). Adhesions were mainly confirmed by arthroscopy, whereas open surgery could not reveal such tiny lesions because of disc dissection. However, adhesion remnants were sporadically observed in surgery. Owing to this difficulty only half of the above cases of synchronous appearance of perforations and adhesions were confirmed surgically. In three more cases each radiologist diagnosed perforations and adhesions simultaneously (Cases 3 (left), 10 (left) and 9 (right)).

Perforations were observed by both examiners in 8 out of 20 TMJs (40%). All of them were confirmed by arthroscopy or open surgery except one (Case 6, left). In that case MRAr revealed adhesions that were visible with arthroscopy and suggested a perforation which arthroscopy failed to confirm (Figure 2a,b,c). In the same TMJ a dislocation of the disc without reduction was ascertained and open surgery was decided upon, which confirmed the integrity of the disc. In Case 5, functional loading of the joint, as described previously by means of jaw movements, revealed leakage of the medium from one compartment into the other in the open-mouth position, although in the closed-mouth position the medium remained restricted to the superior

compartment (Figure 3). In cases where MRAr gave no evidence of perforation, surgery confirmed the MRAr obtained findings even when there was a high clinical suspicion of the presence of perforations, as in osteoarthritic cases (Figure 4).

The radiological confirmation of the osteoarthrosis clinical diagnosis through MRI was inconclusive. The term “osteoarthrosis” was included in only 3 out of the 20 MRIs (Cases 2, 3 and 9) and only in 1 of them by both radiologists (5%; Case 2, left). However, MRAr was able to establish the diagnosis in 4 cases by both radiologists (20%; Cases 2, 3, 7 and 9). In all of these cases a leak of the contrast medium into the lower compartment facilitated the depiction of bone irregularities. In two additional cases (Cases 5 and 9, right) one of the radiologists identified osteoarthritic lesions. These cases also had perforations in MRAr, and were confirmed in surgery. A cumulative presentation of the above diagnoses can be seen in Table 2.

In all operated cases with dislocated, but integral discs, repositioning and anchorage was performed with a Mitek mini anchor (DePuy Mitek, Inc, Raynham, MA). Three of the perforated discs underwent discoplasty and five were discectomized and replaced with cartilage from the ear, or left without replacement.

Discussion

MRAr is an imaging modality performed by injecting a contrast medium into a joint. The use of such a medium intravenously is not an arthrography but a contrast-enhanced MRI of the joint.¹⁰ MRAr of the TMJ was described in 2000 by Toyama *et al.*¹¹ In this publication the contrast medium, which was the same as the one used in our study, was injected into both articular compartments. It is well known (based on experience derived from conventional arthrography)¹² that this demonstrates the perforations as discontinuities of the disc or

Figure 1 The left temporomandibular joint of Case 1. (a) Sagittal T_1 weighted MRI slice 15, with closed mouth shows anterior dislocation of the disc. The transition zone is indicated by arrowhead. (b) magnetic resonance arthrography in the same position and level (T_1 weighted image slice 15) demonstrates symphysis to the fossa and articular eminence (white arrowheads) and a possible perforation near the transition zone (black arrowhead). (c) Anteriorly displaced disc (D) in surgery. The articular eminence (E) has been removed. R, retrodiscal tissue; Z, zygomatic arch

Figure 2 Case 6: anterior disc displacement without reduction; left temporomandibular joint. (a) Sagittal T_1 weighted magnetic resonance arthrography, slice 13, with closed mouth. Adhesions are shown (white arrows). Between adhesions a possible leak of the contrast medium into the lower compartment suggests disc perforation (black arrow). (b) Arthroscopy reveals adhesions, but a perforation is not observed between them. D, disc; PR, posterior recess; F, fossa. (c) Open surgery for reposition of the displaced disc. D, disc; C, capsule; Z, zygoma. The disc is integral

posterior attachment, and the sensitivity is proportional to the discriminative ability of the tomograph and the dimensions of the perforation. In contrast, injection of the medium into only one compartment outlines a perforation indirectly by means of leakage or overflow.^{12,13} The sensitivity of this technique is proportional to the pressure developed in the medium-flushed compartment. The amount of the paramagnetic medium is an approximate indicator of this pressure although the few relative studies in this field determine this amount at 0.5-1 ml.^{11,12,14} To determine the optimal pressure or amount to be injected for MRAr of the TMJ, further study is needed since depiction of adhesions is a further objective of the technique and excessive pressure may cause lysis of adhesions.

Depiction of adhesions was the objective of a study by Yang *et al*,¹⁴ who performed MRAr of TMJ by injecting dimeglumine gadopentetate into the upper

compartment only. They reported a high accuracy of the technique in diagnosing adhesions of the disc to the fossa and the articular eminence provided the medium was infused gradually and under low pressure. Although slice thickness was only 1 mm, there was no report on the diagnostic accuracy of single-compartment MRAr with regard to disc perforations in the study. To the best of the authors' knowledge the present study is the first on the accuracy of MRAr in detecting disc perforations by injecting a paramagnetic contrast medium into only the upper compartment while adhesions are also visible. As the high intra-articular pressure of the medium is useful in the depiction of perforations, but not of adhesions, the correct increase of pressure can probably be achieved "functionally" by means of active movements of the patient's jaw, and not by an increase in the volume to be injected. 4 TMJs (20% of the total number of cases)

Figure 3 Case 5 (right temporomandibular joint). (a) Sagittal T_1 weighted MRI, slice 4, with closed mouth shows an anteriorly displaced and degenerated disc. The arrow points to a sharp irregularity (osteophyte) of the condylar surface. (b) Sagittal T_1 weighted magnetic resonance arthrography (MRAr), slice 3, with closed mouth. The contrast medium is restricted in the upper compartment whilst the irregularity is apparent (arrow). (c) Sagittal T_1 weighted MRAr, slice 3, with opened mouth. Opening of the mouth reveals leakage of the medium into the lower compartment (arrow heads)

Figure 4 Osteoarthritis of the right temporomandibular joint of Case 3. (a) Sagittal T_1 weighted MRI, slice 4, with closed mouth shows severely osteoarthritic condyle (black arrowhead) and anterior disc displacement (white arrowheads). (b) Sagittal T_1 weighted magnetic resonance arthrography, slice 5, with closed mouth. Despite disorganization of the disc (arrowhead), the contrast medium remains in the upper compartment. (c) Surgery confirms the integrity of the disc (D), which is repositioned and tied down on the condyle with a Mitek anchor. The excessive retrodiscal tissue forms a plica (white arrowhead). The black arrowhead indicates the articular capsule

showed simultaneous adhesions and perforations. This was probably achieved through the technique discussed above.

In our study, the upper compartment was the site of choice for the injection owing to our familiarity with arthroscopy and lavage, which allowed for a successful approach without fluoroscopic guidance. This minimized the possibility of penetrating the disc and yielding a false-positive perforation. However, in one patient (Case 6) the question still exists as to whether the unconfirmed perforation depicted on MRAr was a false-positive result or a hypersensitivity of the method. Another reason for choosing the superior compartment for the injection is for the study of adhesions, which mainly develop in this compartment. Whether single or dual space arthrography is the universally preferred method still remains unanswered in the literature. In a recent paper, Kuribayashi *et al*¹⁵ studied two patient groups retrospectively, one group with disc perforation and one without, as determined by conventional arthrography findings. Although a dual space technique was initially chosen, the procedure was stopped if a leak from the lower compartment (which was the first to receive the contrast medium) into the upper was noticed. This clearly constitutes a case of single compartment arthrography.

The authors also used TMJ arthrography to investigate perforations and MRI to determine disc location and evaluate soft-tissue consistency. The possibility of MRAr becoming the examination of choice for the

overall study of TMD and therefore replacing arthrography, MRI and other modalities is mainly dependent on its ability to prove successful at localizing the exact position of the fibrocartilaginous portion of the disc as the most frequent indication for performing MRI for TMD is to confirm a disc dislocation.¹⁶ There are no data in the literature comparing these two modalities with regard to this specific indication. Literature from the field of orthopaedics points to possible disadvantages of MRAr, especially in some T_2 weighted images where local anaesthetics may appear as a bright signal within tissues.¹⁷ In the TMJ, T_2 weighted images have been reported to depict joint effusion, which is present in cases of disc perforation at a percentage not exceeding 23%.¹⁸ However, joint effusion may appear in both compartments as a bright signal¹⁹ that cannot be distinguished from that of the contrast medium on the single compartment MRAr of the joint. Therefore, T_2 images obtained through MRAr of the upper compartment may result in a false-positive diagnosis of disc perforation. Moreover, the bright signal produced by the contrast medium may confuse the transition zone between the fibrocartilaginous and retrodiscal tissue in T_2 weighted images. Since the objective of the present paper was to study disc perforations and adhesions, and not joint effusions, the above limitations were the main reason for obtaining only T_1 weighted images. In spite of the diagnostic value of T_1 images, the sensitivity of MRAr in localizing disc position in the initial stages of

Table 2 Radiologic diagnoses of perforations, adhesions and osteoarthritic lesions from magnetic resonance arthrography

	Radiologist 1 (%)	Radiologist 2 (%)	Both radiologists (%)
Perforations	40	45	40
Adhesions	50	50	35
Perforations + adhesions	25	25	20
Osteoarthritis	25	25	20

displacement appeared lower than that of MRI in our study. However, comparisons of diagnostic accuracy between MRI and MRAr with regard to disc displacement, as well as the optimal dissolution of the contrast medium that is associated with the distinctive capacity of MRAr, need documented evidence.

Arthroscopy is a promising diagnostic and interventional procedure with regard to TMD. It can detect both disc dislocations and perforations. However, in many papers dealing with arthroscopy of the TMJ, MRI is also included in pre-operative assessment of patients,^{19,20} hence arthroscopy does not preclude

radiology as a possible diagnostic tool. Whether MRAr is more sensitive than arthroscopy at uncovering small disc perforations or whether it may yield a false-positive result owing to penetration of the disc during the procedure has not been discussed in literature, and the present paper contributes very little to the subject.

In conclusion, there is little experience in the use of MRAr in imaging of the TMJ. It appears to be a promising technique in the investigation of both perforations and adhesions and it could prove useful in treatment planning, either interventional, arthroscopic or by open surgery.

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