The accuracy of dynamic Magnetic Resonance Imaging in evaluation of internal derangement of the temporomandibular joint; comparison with arthroscopic findings

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Abstract  Purpose: To determine the correlation between dynamic Magnetic Resonance Imaging (MRI) and arthroscopy findings in internal derangement of the temporomandibular joint (TMJ).

Material and methods: This study was conducted on 25 patients (of 28 TMJs), 18 females and 7 males their age ranging from 20 to 42 years (mean 31 years). All patients were submitted to MRI examination of the TMJ. All of these patients underwent arthroscopy for diagnosis and treatment and results were compared with dynamic MRI findings.

Results: Concerning disc position, MR examination revealed 24 TMJs out of 28 (85.7%) with anteriorly displaced discs, while 4 TMJs (15.3%) showed normal disc position. When type of displacement was considered, MRI revealed 8 TMJs (28.7%) with anterior disc displacement with reduction (ADDWR), while 16 TMJs (57.1%) with anterior disc displacement without reduction (ADDWOR). While arthroscopy revealed 6 TMJs out of 28 (21.4%) with ADDWR, 14 TMJs (50%) showed ADDWOR and 8 TMJs (28.6%) with normal disc position.

MRI assessment of disc mobility revealed 12 out of 28 TMJs (42.8%) with limited asynchronous...
1. Introduction

Internal derangement (ID) of the temporo-mandibular joint (TMJ) refers to the abnormal relationship or position of the disc to the mandibular condyle and articular eminence (1). It is considered one of the major causes of pain and dysfunction of the TMJ (2). ID by definition is a disruption within the internal aspects of the TMJ, in which there is a displacement of the disc from its normal functional relationship with the mandibular condyle and the articular portion of the temporal bone (3). The American Association of Oral and Maxillofacial Surgeons (AAOMS) defined ID as alterations in the normal dynamic motion of the intra-capsular elements leading to joint dysfunction.

Nowadays there are various methods used for its diagnosis. However, Magnetic Resonance Imaging (MRI) and arthroscopy represent the most effective and reliable modalities among the contemporary techniques. Moreover, they are characterized by being generally safe when compared to old techniques (4,5). Nevertheless, there is no enough data to correlate the findings of both. Therefore it should be of interest to investigate prospectively, how well dynamic MRI findings correlate with intra-articular pathology as seen by arthroscopy.

The aim of this study is to evaluate the correlation between dynamic MRI and arthroscopy findings in internal derangement of the temporo-mandibular joint.

2. Patients and methods

The current prospective study was conducted on 25 patients (of 28 TMJs), 18 females and 7 males their age ranging from 20 to 42 years (mean 31 years). IRB approval was obtained and patients’ consent as well. Patients were selected from referred population to the TMJ clinic in the department of Oral and Maxillofacial surgery at the dental hospital at teaching institute, which is a primary referral center for TMD for both conservative and surgical treatments. Patients were examined bilaterally, 3 patients had bilateral TMD and 22 had unilateral TMD, 15 for right TMD and 7 for left TMD. Informed consents were obtained from all patients after explaining the purposes of MRI and arthroscopy.

2.1. Patients selection

Patients were selected on the basis of clinical diagnosis of ID of the TMJ using RDC/TMD system. RDC/TMD offers a standardized system for the clinical diagnostic process (6,7).

Patients involved in this study were classified in the following groups:

1. Axis I group II.a: A condition of disc displacement with reduction
2. Axis I group II.b: A condition of disc displacement without reduction and with limited opening
3. Axis I group II.c: A condition of disc displacement without reduction and without limited opening
4. Axis II: Classification of graded chronic pain, grades I and II.

2.1.1. Inclusion criteria

Patients included in either of the above groups, unresponsive signs and symptoms to splint and conservative non surgical therapy for at least 4–6 months, successful clear dynamic MR image, successful diagnostic arthroscopy procedures and techniques, and age ranged from 15 to 50 years.

2.1.2. Exclusion criteria

Patients with previous TMJ surgery, systemic inflammatory joint disease, facial growth disturbances, direct trauma, or fracture of facial bones, cardiac pacemakers or cerebral aneurysm clips, were excluded from the study. Pregnant and lactating females were also excluded from the study.

2.1.3. Standardization and blinding technique

The study was carried out in a single blind fashion to eliminate bias, every patient underwent dynamic MRI examination. Dynamic MRI examination was performed by the same protocol for all patients to assure technique standardization. All MR images were evaluated by the same experienced radiologist (8 years experience) who was blinded to results of clinical diagnosis. The MRI and arthroscopic examination were conducted within not more than two weeks interval, and the patients received no treatment during this period to avoid any changes in the joint status. The arthroscopic procedures were done by the same surgeon and assistant using standard technique (8). Both of them were blinded to clinical and MRI results. Arthroscopic findings were recorded on DVDs and were recorded as a written report immediately after the procedure, the results of MRI and arthroscopy were compared.

2.1.4. MRI examination

MRI examination were conducted on a MR machine, Intera 1.0 Tesla superconductive unit, Philips medical systems, Netherlands), using bilateral TMJ surface coil.

movements, while 3 TMJs (10.7%) with stuck disc, and 13 TMJs (46.4%) with normal mobility. While arthroscopy revealed 11 out of 28 TMJs (39.2%) with limited disc mobility, 1 TMJs (3.5%) with stuck disc, and 16 TMJs (57.1%) with normal mobility.

The results of this study showed no significant statistical difference between arthroscopy and MRI in diagnosing disc position and disc mobility.

Conclusions: Both arthroscopy and dynamic MRI are statistically correlated with each other in detecting TMJ internal derangement. Nevertheless, reviewing the results highlighted the advantages of MRI augmented by dynamic protocol over arthroscopy in diagnosing disc position and mobility and hence, we recommend using MRI as a first line diagnostic modality when internal derangement is suspected.
2.1.5. Static protocol

1. Static sagittal T1WI in fully closed and maximum open mouth positions (TR = 525, TE = 15, FOV = 110/2.1, slice thickness = 3 mm).
2. Static sagittal T2WI in fully closed and maximum open mouth positions (TR = 2500, TE = 120, FOV = 150/3.1, slice thickness = 3 mm).

2.1.6. Dynamic protocol

Dynamic proton density sagittal images were obtained during incremental movements of the examined joint from closed to the maximum assisted mouth opening as recorded by RDC/TMJ examination then sequentially reversing back to the closed mouth position. The parameters of dynamic proton density sagittal images were (TR = 1500 ms, TE = 30 ms, FOV = 200/2.8, slice thickness = 3 mm and slice gap = 0.3 mm, flip angle = 90°). To start with a 5-mm axial localizing image section was obtained through the mandibular condyle level to indicate the sagittal image orientation of the TMJ parallel to the mandibular ramus. Following accurate condyle localization a series of proton density sagittal images of each TMJ were obtained. Patients were examined in supine position. Various mouth opening positions were investigated using gradually added tongue blades of standard thickness of 2 mm each. Started at closed mouth position then adding only one blade at the premolar area to prevent early protrusion, then gradual opening of the mouth is achieved by adding two overlying plates each time till reaching the maximum assisted opening followed by a gradual decrease till closed mouth position again. Plates were precisely added over each other to avoid any unwanted sliding or sudden protrusion during the whole cycle. Selected representative slices were loaded into a standard program that allowed fast serial observation of the series in a CINE mode or a pseudo-dynamic film.

2.2. MRI interpretation

Images acquired in the static and dynamic modes were used to assess the following parameters: articular disc (position, morphology, and mobility), morphology of the condyle, articular eminence, glenoid fossa, joint effusion and edema of the medullary bone.

Normal disc position was defined by location of the posterior band of the disc at the superior or 12 o’clock position relative to the condyle in closed mouth position, while in open mouth position normal disc was identified by interposition of the intermediate zone between condylar head and articular eminence (9).

While disc displacement was defined as the posterior band of the disc being in an anterior to 12 o’clock position relative to the superior part of the condyle in closed mouth position. A disc was considered reduced when the disc returned to a superior position on jaw opening. If there is no reduction and the disc remained anterior, this was considered as disc displacement without reduction (10). Disc was considered not visible when, neither signal intensity nor outlines could delineate it (11). Scoring system of various disc positions: 0: Normal disc position, 1: anterior disc displacement with reduction, 2: Anterior disc position without reduction and N: not visible.

Normal disc morphology was defined as biconcave in appearance in sagittal planes in closed mouth position and bow tie in open mouth position with a definable anterior band, intermediate zone and posterior band, while morphological changes of the disc include atrophy, thickening of the posterior band and shortening of the entire antero-posterior length, disc morphology was scored as: 0: normal disc morphology and 1: abnormal disc morphology.

Evaluation of disc mobility was determined on dynamic images. Normal disc mobility was defined as synchronous condylar and disc movements, abnormal disc mobility was graded as (A) if disc has limited mobility and if it was stuck, i.e.: the position of the anterior band shows no changes between open and closed mouth it was graded as (B), (12) disc mobility was scored as: 0: normal disc mobility, 1A: limited disc mobility and 1B: Stuck disc.

2.3. Arthroscopy technique and examination

Diagnostic arthroscopy was done for all joints through standard fossa portal of entry by MCcain (13,14). Supplementary subcutaneous infiltration anesthesia in the periauricular area was administered when needed. A standard single puncture technique described by MCCain et al. was established (6).

The puncture site was located by drawing Holmlund–Hellsing line (15) between lateral canthus of the eye and the tip of the tragus then bisecting it in the midportion of external tragal cartilage of the ear, the upper joint space was distended with 2–3 ml of Ringer’s lactate solution using 21 G needle, the patient is instructed to open mouth widely, a sharp trocar protected by an outer cannula was advanced till contacting the bone of the lateral crest of the fossa, till puncturing of the capsule by trocar which is confirmed by fluid in the cannula, then placing a blunt obturator followed by irrigation.

The quality of image is checked and diagnostic sweep from posterior synovial pouch to anterior synovial pouch was done. The arthroscopic images were recorded and saved on DVDs and MPEG4 format using a digital video recorder and player.

2.4. Statistical analysis

Qualitative data were presented as frequencies and percentages. McNemar’s test was used to study the association between MRI and arthroscopy regarding disc position and mobility. Quantitative data were presented as mean and standard deviation (SD) values.

The significance level was set at $p \leq 0.05$. Statistical analysis was performed using SPSS, version 16 for Windows (Chicago, IL, USA).

3. Results

This prospective study included 25 patients of 28 TMJs. Eighteen females and 7 males. Their age ranged from 20 to 42 years (Table 1).

MRI was used to assess disc position, disc morphology, disc mobility, bone marrow edema, condylar translation and joint effusion. The frequencies and percentages of different MRI findings are summarized in (Table 2).

Arthroscopic examination was used to examine retrodiscal tissues, glenoid fossa, articular disc, articular eminence and
anterodiscal tissues. The frequencies and percentages of different arthroscopic findings are summarized in Table 2.

Association between findings of MRI and arthroscopy was calculated for disc position and disc mobility (Table 3). The results of this study showed no significant statistical difference between arthroscopy and MRI in diagnosing disc position and disc mobility (Table 3).

3.1. MRI findings

The frequencies and percentages of different MRI findings are summarized in (Table 1).

Concerning disc position, MR examination revealed 24 TMJs out of 28 (85.7%) with anteriorly displaced discs, while 4 TMJs (15.3%) showed normal disc position. When type of displacement was considered, MRI revealed 16 TMJs (57.1%) with ADDWOR (Figs. 1 and 2), while 8 TMJs (28.7%) with ADDWR (Figs. 3 and 4).

MRI assessment of disc mobility revealed 12 out of 28 TMJs (42.8%) with limited asynchronous movements, while 3 TMJs (10.7%) with stuck disc, and 13 TMJs (46.4%) with normal mobility.

3.2. Arthroscopic findings

Arthroscopic examination was used to examine retrodiscal tissues, glenoid fossa, articular disc, articular eminence and anterodiscal tissues. The frequencies of different arthroscopic findings are summarized in Table 2. Concerning disc position, the arthroscopic examination revealed 6 TMJs out of 28 (21.4%) with ADDWR, while 14 TMJs (50%) showed ADDWOR and 8 TMJs (28.6%) with normal disc position.

Arthroscopic examination of disc mobility revealed 11 out of 28 TMJs (39.2%) with limited disc mobility, while 1 TMJ (3.5%) with stuck disc, and 16 TMJs (57.1%) with normal mobility.

4. Discussion

Temporo-mandibular 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 disc, or meniscus, in terms of its morphologic features and its location relative to the condyle in both closed- and open-mouth positions. Disc location is of prime importance because the presence of a displaced disc is a critical sign of TMJ dysfunction. However, disc displacement is also frequently seen in asymptomatic volunteers, so that other findings may be required to help make the diagnosis (16).

The diagnostic accuracy of MRI and arthroscopy had been extensively evaluated in the literature. Both techniques had proven high sensitivity and reliability in diagnosing several TMJ conditions. Each technique had been extensively tested for accuracy and compared to other modalities such as; clinical, radiographic, histologic, and even open surgery to evaluate their diagnostic efficacy in different TMJ arthropathies (17,18,10,19–23). The outcomes of these studies proved that both techniques are the gold standard in diagnosing the aforementioned conditions (5,24,25–27).

It is also expected that comparing the findings of both techniques will provide the clinicians with valuable data required to thoroughly investigate the joint dynamics in both radiographic and real image in order to improve our understanding and recognition of different TMJ conditions. Unfortunately very few studies attempted to directly compare both techniques to each other and to correlate their results (17,28,29).

Therefore, this study reviewed the literature to select the most appropriate and unique findings that can be distinguished in MRI and/or arthroscopy regarding ID. We attempted to define each finding accurately on the basis of the most appropriate and solid description present in TMJ studies. Then we compared and correlated the equivalent findings in each technique to its counterpart in the other technique in order to determine which of them is more reliable in diagnosing ID.
In this study, determination of the method of patients’ selection in TMD is an important point in building of this study, compared to other studies (7,30,17,12,27,31–33).

Arthroscopy and MRI had been compared to each other in previous studies. Rao et al. (17) in 1990 were leading in directly comparing the two techniques with arthrography and open surgery. They evaluated 36 joints for disc position and morphology, and disc perforation. In their study the agreement between MR imaging and arthroscopy regarding disc position was noted in 28 out of 36 joints (78%) and in our result was 85.7% the difference may be due to the gold standard technique used they used open surgery while we used arthroscopy as a gold standard technique also the difference in the number of patients may be a factor.

Moses et al. (29) also compared arthroscopy and MRI findings to determine the reliability of arthroscopic diagnosis. They reviewed retrospectively the charts of 30 patients who underwent bilateral arthroscopy. The parameters examined were the position of the articular disc, disc deformity, mobility of the articular disc and condylar mobility. In detecting anterior disc displacement, without determination of the type of displacement, MRI and arthroscopy showed agreement of 78%. Our results are consistent with Moses et al. They concluded that diagnostic arthroscopy proved to be as useful to the Maxillofacial surgeon dealing with the TMJ as the diagnostic value of the knee arthroscopy used by orthopedic surgeons.

The arthroscopists in both studies were not blinded to results of MRI findings at the time of surgery, so their arthroscopic

<table>
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<th>Patients group n = 28 TMJs</th>
<th>MRI findings</th>
<th>Arthroscopic findings</th>
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Agreement between MRI and arthroscopy in disc position is 85.7%.

![Fig. 1](image1.png) Thirty-one year old female, DDWOR and limited mobility. Sagittal PDWI of the right temporo-mandibular joint in closed mouth a, and open mouth, b shows disc displacement anteriorly in closed mouth and the disc remains anterior without reduction in open mouth.

![Fig. 2](image2.png) Twenty-four year old female, DDWOR and limited mobility. Sagittal PDWI of the left temporo-mandibular joint in closed mouth a, and open mouth, b shows disc displacement anteriorly in closed mouth and the disc remains anterior without reduction in open mouth (black arrow), with stuck disc as disc is fixed in position with abnormal shape and configuration.
results may be biased. However, at early nineties TMJ arthroscopy was still a new born technique that required more confidence and experience to be incorporated in blinded studies. Furthermore, the complication rate following diagnostic arthroscopy had diminished dramatically and the technique is considered now as a safe minimally invasive technique. Thus our study was conducted as a single blind study in which arthroscopic findings were obtained while arthroscopists were blinded to results of MRI in order to overcome the above mentioned drawbacks and to help us in achieving evidence based results.

In the current study, regarding disc position, MRI and arthroscopy yielded the same diagnosis in 24 joints out of 28 (85.7%), “either normal or displaced” which is comparable to previous studies (8,11). Moreover, out of 24 joints diagnosed by MRI to have displaced discs, arthroscopy proved the same diagnosis in 20 joints (71.4%) while the remaining 4 joints were diagnosed normal. However, regarding the accurate diagnosis of the type of displacement, either with or without reduction, the agreement increased to 20 joints out of 24 joints (83.3%).

Regarding disc position and mobility, one should note that the ability of arthroscopy in detecting normal discs comparable to MRI is excellent as arthroscopy had accurately detected all normal cases. However, in few cases, with abnormal disc position and abnormal mobility, arthroscopy showed false negative results (interpreted as normal discs). Yet, a critical question crops up here; does any disagreement in diagnosing disc position or mobility between preoperative MRI and arthroscopy means misinterpretation of arthroscopy? To be able to answer this question we will focus on one example from our patients. In case No. 3 the MRI dynamic images clarified that the patient suffers from a stuck disc, however, arthroscopy revealed normal disc mobility. However, these inconsistent results do not necessarily mean that arthroscopy was mistaken. This assumption was based on the fact that MRI as a radiographic technique provides us with information about internal joint anatomy and conditions without interfering with the joint dynamics. On the other hand, arthroscopy is an interventional technique, and the arthroscopic diagnosis is established after or during lavaging of the joint which

**Fig. 3** Twenty-two year old female, DDWR and limited mobility. Sagittal PDWI of the left temporo-mandibular joint in closed mouth a, and open mouth, b shows disc displacement anteriorly in closed mouth, recaptured in open mouth with translation of the condyle with abnormal shape of the disc (arrow) in b.

**Fig. 4** Twenty-five year old male, DDWR and very limited mobility. Sagittal PDWI of the left temporo-mandibular joint in closed mouth a, and open mouth, b shows disc displacement anteriorly in closed mouth, with very mild reduction and very limited mobility in b, also note the mild joint effusion on a and b (white arrow).
potentially change both preoperative condition and dynamics of the joint. The role of arthroscopic lysis and lavage in treating different TMJ conditions especially stuck discs is well established in the literature (34,35,12,36,37). Moreover, the disc position and mobility can potentially change due to the insufflation with the irrigation solution and placement of the obturator and the outer cannula into the joint (17). That means that arthroscopy in some patients, like this particular patient, may provide us with information about the joint after treatment which totally differs from preoperative one.

Thus the assessment of arthroscopic accuracy in diagnosing disc position and mobility by comparing its findings with preoperative MRI findings only seems an improper method of assessment. Therefore, we suggest that arthroscopy should be compared to a preoperative and to an immediate postoperative MRI rather than a preoperative MRI only, because postoperative MRI will show nearly the same joint condition during arthroscopic diagnosis. Moreover, comparing all these aforementioned data to clinical findings of the patients both pre and postoperatively will aid greatly to correlate particular symptoms and to define intra-articular findings.

Dynamic MRI examination should be done as a routine examination of TMJ problems because static MRI usually skips detecting both the kinematic changes that affect the disc during function and asynchronous disc condyle movement (38). One limitation of the current dynamic techniques is that they are not truly dynamic. It uses devices or tongue blades to artificially open the mouth; hence the name pseudodynamic is more accurate. The images depicted are, in reality, a set of static jaw position at various degrees of jaw opening and closing (39). Seemann et al. proved that this artificial mouth opening may differ from the natural opening and they proposed a technique to detect motion during MRI scan using optoelectronic tracking. Recently, Wang et al. (40) in 2007 had established a new MRI protocol which allows for a real dynamic way in imaging TMJ. The quality of the produced images is encouraging to replace the old protocols with this new one.

The current study has some limitations, firstly, retrodiscal tissues were not examined on MR images as there are no definite criteria for interpreting retrodiscal tissues on MRI. Secondly, MR images were acquired in 1.0 Tesla magnet which is the only available device in our region.

Finally, the present study concluded that both arthroscopy and dynamic MRI are statistically correlated with each other in detecting TMJ internal derangement. Nevertheless, reviewing the results highlighted the advantages of MRI augmented by dynamic protocol over arthroscopy in diagnosing disc position and mobility and hence, we recommend using MRI as a first line diagnostic modality when internal derangement is suspected.

References