Sensitivity of Magnetic Resonance Imaging and Computed Axiography in the Diagnosis of Temporomandibular Joint Disorders in a Selected Patient Population

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Purpose: The aim of this study was to compare sensitivity differences and interpretative agreement for magnetic resonance imaging (MRI) and computed axiography (CA) tracings in a patient population group with temporomandibular disorder (TMD). ***Materials and Methods:*** A convenience sample of 173 patients (53 men, 120 women; mean age: 33.2 ± 2.6 years) diagnosed with TMD was selected for this study. Each patient underwent an evaluation as per the European Academy of Craniomandibular Disorders clinical form as well as MRI and CA. ***Results:*** Use of the MRI results as the gold standard for the planned comparison led to the following observations: a CA sensitivity of 68% for joints without morphologic changes (so-called normal temporomandibular joints [TMJs]), sensitivity of 27% for those with disc displacement, and sensitivity of 8% for those with osteoarthritis. The kappa index, or agreement between the two examination methods, was weak for normal TMJs (0.16), acceptable for anterior disc displacement with reduction (0.28), little for anterior disc displacement without reduction (0.10), and very little for morphologic alterations (0.01). ***Conclusion:*** The sensitivity and agreement of the two examination methods was generally low. It was even worse when pathologic changes in the TMJ were more severe. MRI and CA are different examinations that could both be considered for severe TMD diagnosis. *Int J Prosthodont 2012;25:120–126.*

The temporomandibular joint (TMJ) is a bilateral and diarthroidal movable joint characterized by the interposition of a meniscus between the joint surfaces. Although anatomically distinct, the two joints function in unison, and independent movements are not possible. Diagnosis of temporomandibular joint disorder (TMD) is frequently a clinical challenge given the joint's anatomical and functional complexity as well as the diverse etiologic concerns that can impact the joint's continuing health status.[1] A comprehensive clinical examination is the first and most important investigation in the management of TMD, with optimal imaging an essential adjunct. The current gold standard for the latter evaluation is magnetic resonance imaging (MRI) since it is noninvasive and provides excellent visualization of anatomical alterations, thereby facilitating a correct diagnosis.[2–5] It has been reported that MRI has an 85% accuracy for recording disc position and 77% for disc shape.[6] Moreover, an accuracy of 95% has been demonstrated when coronal and sagittal images are combined to evaluate disc position.[7] Studies that sought to correlate MRI structural findings with interpretations of axiographic tracings have resulted in a sense that axiography sensitivity is suspect and false negatives frequently occur.[2,8,9]

The aim of this study was to compare the sensitivity of MRI and computed axiography (CA) in the diagnosis of articular disc displacement and the presence of degenerative joint disease in a selected and clinically diagnosed group of patients with TMD. The null hypothesis tested was that no differences would exist in sensitivity and agreement of the two exams.

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Table 1 Results of the Clinical Evaluation*

	n	%
Group I	103	60
Group Ia	103	100
Group II	66	38
Group IIa	41	61
Group IIc	25	39
Group III	4	2
Group IIIa	4	100

*See text for description of groups.

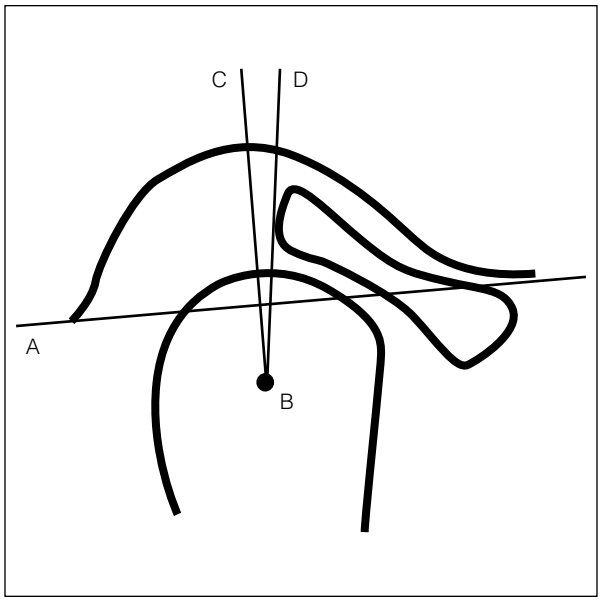


Fig 1 *(right)* Diagram of disc position. A = line between the summits of the postglenoid tubercle and the articular eminence; B = midpoint of the condylar portion of this line. The angle *(CBD)* between the vertical line *(CB)* that was drawn through the midpoint and the line drawn through the posterior margin of the disc *(BD)* was measured on the sagittal MRI for each TMJ.

Materials and Methods

A convenience sample of 173 consecutive patients (53 men, 120 women; mean age: 33.2 ± 2.6 years) with signs and symptoms of TMD and who met the study's inclusion and exclusion criteria were selected for this study. The patients were selected from those referred to the Department of Orthodontics and Gnathology at the University of Turin, Turin, Italy. They were selected between June 2000 and December 2007 and met the following inclusion criteria: Each patient possessed an intact, restorative intervention–free, natural dentition and met the Dworkin and LeResche[10] research diagnostic criteria for TMD. Informed consent was obtained from all patients.

The study was carried out in a single-blind fashion. All subjects underwent clinical evaluation (European Academy of Craniomandibular Disorders [EACD] form),[11,12] radiographic evaluation (panoramic radiograph, lateral head radiograph), stone casts, intra- and extraoral photographs, MRI, and CA. The EACD clinical form was assessed by the same operator. CA and MRI were recorded separately by two different operators. MRI results were interpreted by the same radiologist skilled in TMJ imaging; the CA tracings were diagnosed by the same skilled dentist.

The clinical evaluation led to the diagnoses summarized in Table 1 and showed that 60% (103 patients) had pain of muscular origin, and the diagnosis was group I (muscle disorders), with a subdiagnosis of group Ia (myofascial pain); 38% (66 patients) had clicks, and the diagnosis was group II (anterior disc displacement), with 61% (41 patients) receiving a subdiagnosis of group IIa (anterior disc displacement with reduction) and 39% (25 patients) receiving a subdiagnosis of group IIc (anterior disc displacement without reduction); and 2% (4 patients) had arthritis or arthrosis, and the diagnosis was group III (arthralgia, arthritis, arthrosis), with a subdiagnosis of group IIIa (arthralgia).

MRI

Examinations were performed using a 1.5T device (Signa, GE Medical Systems) in maximum closing and maximum mouth opening positions.

The temporomandibular images were obtained using a surface coil (127 mm) that was able to evaluate both TMJs and to employ a small field of view (12 to 14 cm) with consequent higher spatial resolution.

The study was carried out with fast spin echo T1-weighted sequences (time to repeat: 600 to 800 ms, time of echo: 14 ms, slice thickness: 3 mm, gap: 0.1 mm, and matrix: 256 × 224 points) in a condylar greater axis perpendicular to the sagittal plane. Three slices (lateral, middle, and medial) were recorded for each joint. The middle one was usually evaluated; when the disc position was not clear, the lateral and medial slices were considered.

To evaluate the disc position,[13] a line was drawn between the summit of the postglenoid tubercle and the articular eminence, marking the midpoint of the condylar portion of this line. The angle between this line and the vertical line (through the midpoint and posterior margin of the disc) was measured on the sagittal MRI images for each TMJ (Fig 1).

The degree of anterior disc displacement was evaluated during maximum closing as follows: 0 to 10 degrees = normal value and > 11 degrees = anterior disc displacement. Anterior disc displacement was classified as either with reduction when the disc was in the normal position at maximum mouth opening or without reduction when the disc was still anteriorly displaced in the maximum mouth opening position. Furthermore, the following morphologic alterations were evaluated using MRI: *(1)* osteophyte formation and head condyle flattening and *(2)* signs of osteosclerosis with a hypointense signal. The diagnosis was based on the presence of both morphologic alterations 1 (osteophyte formation and/or head condyle flattening) and 2 (hypointense signal T1-weighted sequences).[14–16]

The bony abnormalities of the TMJ are less clearly visualized on MRI compared to computed tomography.[16,17] However, MRI is able to visualize the surface alterations of the condylar head in the degenerative and posttraumatic joint.[18,19]

Disc deformities were evaluated as either no deformation when the morphology was biconcave or deformed when the morphology was different from biconcave (thickening of posterior band, lengthened, biconvex, folded, and rounded).[13]

As a limitation of the method to evaluate the disc position, it must be said that in some cases of disc displacement, disc deformation, and fibrotic metaplasia of the bilaminar ligament, it is not possible to clearly determine where the posterior band ends. For this reason, the intraobserver agreement has been evaluated.

CA

CA is based on the following principles according to Gsellmann et al.[20] A conventional double facebow system (mandibular and maxillary facebow) is attached to the patient. The mandibular bow is used for transmitting hinge axis movements of the mandible to the maxillary facebow. The maxillary facebow carries sagittally mounted flags, which serve to register hinge axis movements. Registration takes place electronically. This permits axis translation to be recorded within all mandibular kinetics in two dimensions.

Border condylar movements were measured with the Cadiax Diagnostic axiograph and Gamma Dental Software (Gamma Dental). The Cadiax Diagnostic axiograph is connected to a condylograph facebow and interfaced with a computer for data storage and subsequent analysis.[21] All measurements were recorded using the protocol according to Piehslinger et al.[22] In all subjects, the axiography recorded the movement of both joints simultaneously, but according to the literature,[23] the statistical analysis was performed considering single joints. The parameters in axiography evaluated during protrusion, mediotrusion, and opening movements on the sagittal plane were[23]: length of tracings for structural and muscular evaluation, deviation of tracings of 3 mm or more for clicking detection, time curves and speed of joint movements for clicking evaluation, morphology (concave, convex, straight) of tracings for structural evaluation, lack of superimposition (lack of repeatability) for muscular evaluation, and asymmetry of length of the left and right tracings (> 3 mm) for structural evaluation.

The information provided by the tracings was presumed to be compatible with the following diagnostic interpretations as per the following findings[24–26]: *(1)* normal function and morphology: concave morphology, normal length of the tracings according to Slavicek values,[21] symmetry of the left and right tracings, superimposition (repeatability of the considered movements), lack of deflections or deviations, return to centric relation, absence of sudden accelerations and decelerations, and sagittal condylar inclination of 45 to 60 degrees and Bennet angle of 8 to 12 degrees; *(2)* anterior disc displacement with reduction: crossover of the tracings, presence of sudden accelerations and decelerations, deflections or deviations on frontal and horizontal planes; *(3)* anterior disc displacement without reduction: abnormal morphology (straight or convex), increased sagittal condylar inclination, decreased length of opening movement, absence of sudden accelerations and decelerations; and *(4)* morphologic alterations: serious morphologic alterations of tracing (convex, unstable, and changeable).

Statistical Analysis

Agreement between MRI and CA was assessed using the kappa evaluation. Sensitivity and its 95% confidence interval were calculated to determine how CA classifies each diagnostic category in comparison to MRI. The intraobserver agreement in MRI was evaluated by two skilled radiologists for 10% of cases (36 TMJs). STATA/SE version 9.0 for Windows (StataCorp) was used for data management and statistical analysis.

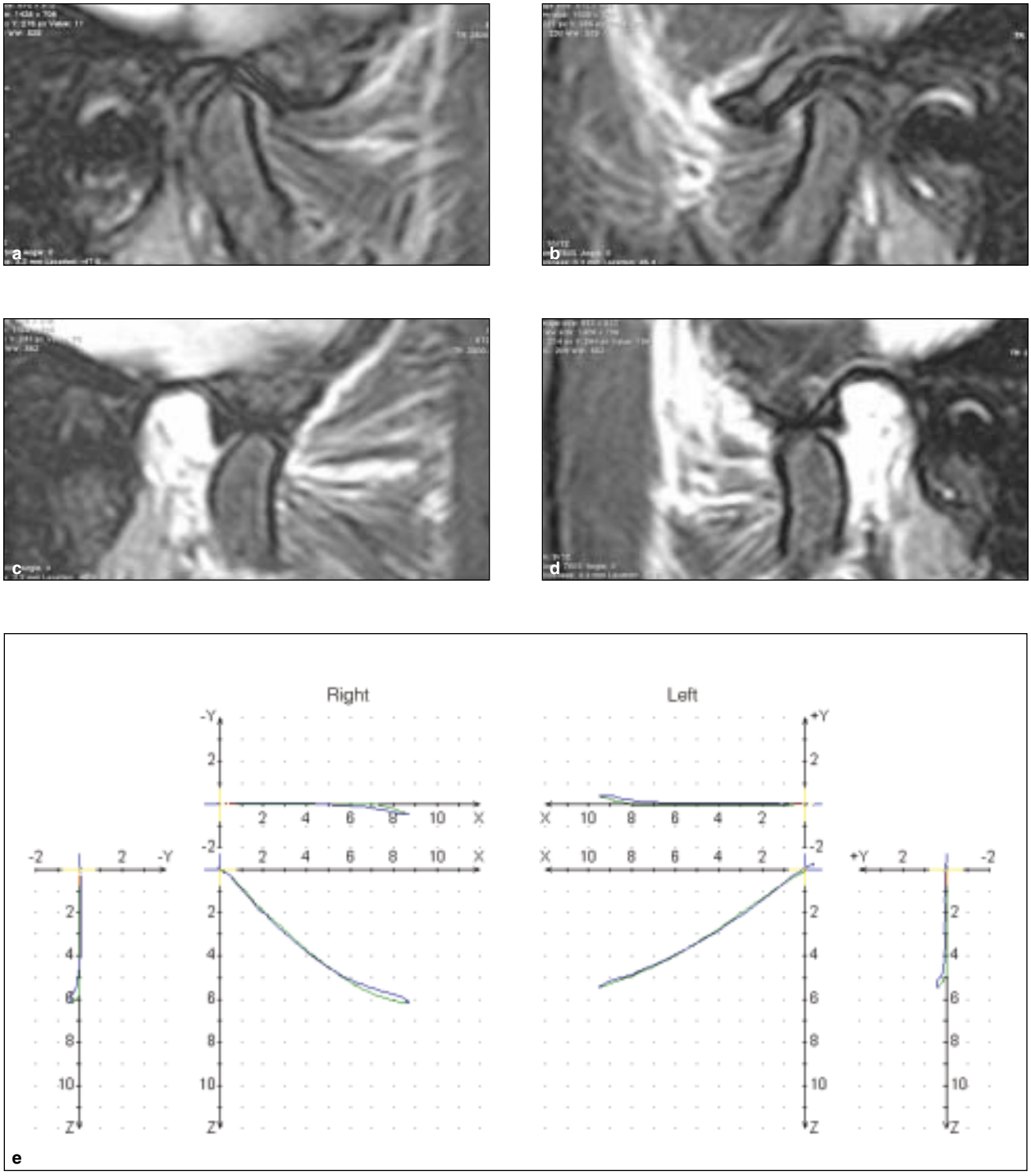
Results

The intraobserver agreement for MRI was 95.6% ($P < .0001$, kappa evaluation with 95% confidence interval). The results for MRI and CA are summarized in Table 2.

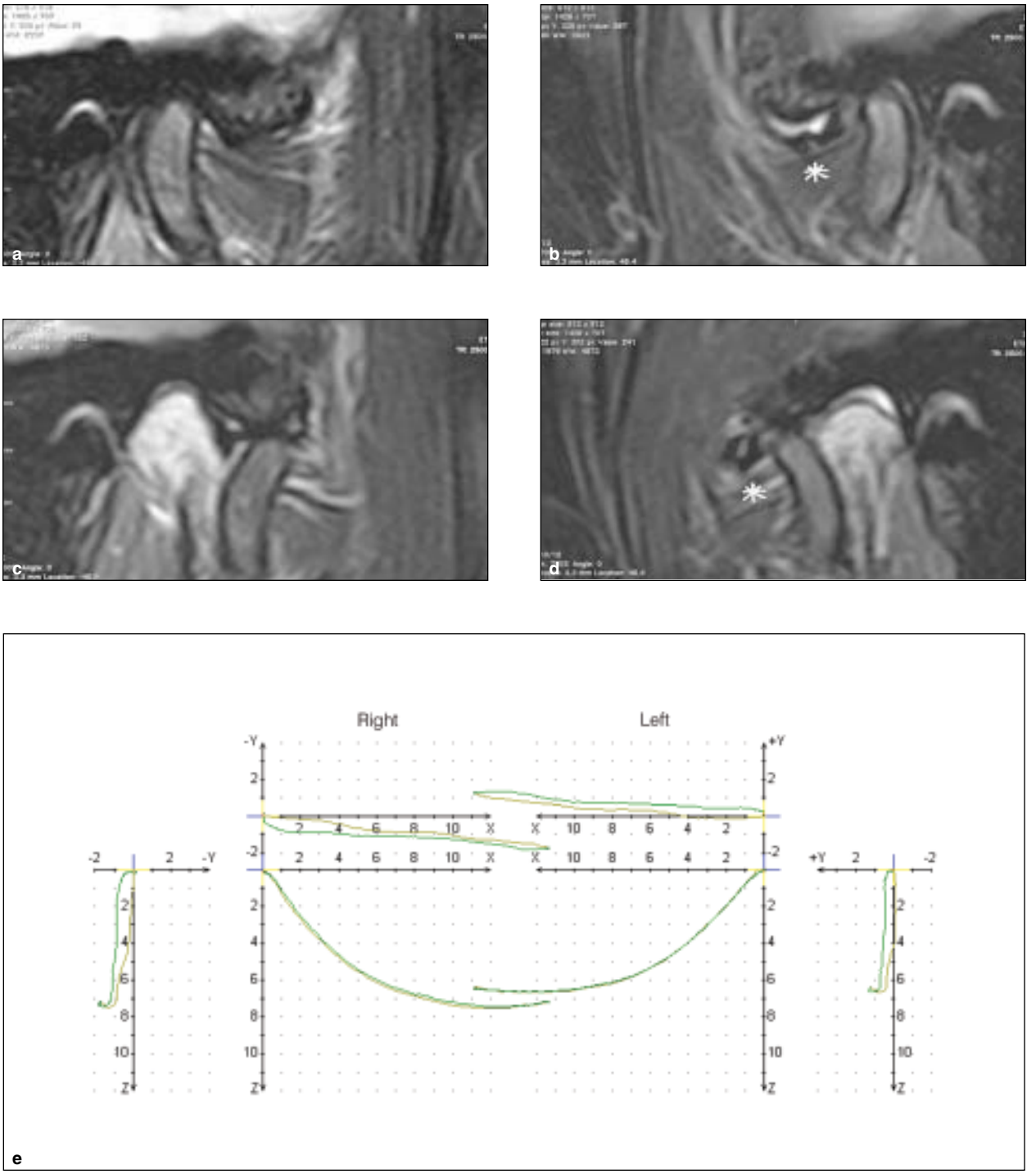
MRIs of 346 TMJs (173 patients) were compared with CA diagnoses (Figs 2 and 3). The results

Table 2 Comparison of Diagnostic Results for MRI and CA

	MRI (%)	CA (%)
Normal TMJ	164 (47.4)	205 (59.2)
Anterior disc displacement with reduction	102 (29.5)	72 (20.8)
Anterior disc displacement without reduction	68 (19.6)	34 (9.8)
Morphologic alterations	12 (3.5)	35 (10.2)



Figs 2a to 2e **(a to d)** MRI of normal right and left TMJs and **(e)** normal CA sagittal tracings during maximum opening.



Figs 3a to 3e **(a to d)** MRI of left anterior disc displacement without reduction *(asterisk).* **(e)** The sagittal CA tracings during maximum opening of the same patient are normal on both sides.

showed that the diagnostic sensitivity of CA vis-a-vis the MRI gold standard was as follows (Fig 4): 67.7% (confidence interval [CI]: 60.0% to 74.8%) for normal TMJ, 27.5% (CI: 19.1% to 37.2%) for anterior disc displacement with reduction, 27.9% (CI: 17.7% to 40.2%) for anterior disc displacement without reduction, and 8.3% (CI: 0.2% to 38.5%) for morphologic alterations.

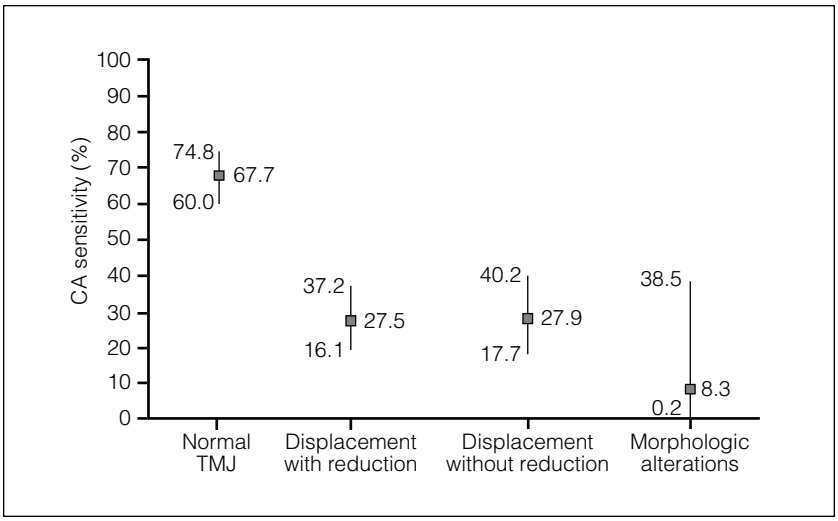


Fig 4 CA sensitivity of a normal TMJ is clearly higher (67.7%) than that of a pathologic TMJ (27.5% to 27.9%).

The agreement between the two examinations resulted in the following kappa index values: weak for normal TMJs (0.16), acceptable for anterior disc displacement with reduction (0.28), little for anterior disc displacement without reduction (0.10), and very little for morphologic alterations (0.01).

Discussion

Previous reports in the literature have demonstrated that MRI and CA often show different outcome information and suggest that the latter's efficacy as a basis for TMD diagnosis may be limited.[2,27] This study suggests that agreement of the two examinations is almost acceptable for normal TMJs but worsens when the pathology is more serious. Consequently, the null hypothesis was rejected, and there are indeed substantial differences between the two proposed diagnostic techniques as used for the purposes of this study.

MRI and CA record different characteristics of the joint with different modalities: MRI shows structural pathologies in static conditions while CA reflects condylar kinematics in dynamic conditions.

The low agreement between the two examinations does not necessarily mean that one is not reliable or that one is more reliable than the other. It means that they show the TMJ from different points of view. In fact, the results showed that a great number of cases diagnosed as anterior disc displacement without reduction by MRI (68 TMJs) do not show the same diagnosis in CA (34 TMJs) (27.9%). This means that even if the disc is anteriorly displaced without reduction (frequently considered a serious TMJ pathologic outcome), the mandibular border movements might be almost normal. This clinical observation reflected a functional, dynamic compensation to the anatomical pathology and is an important diagnostic consideration. It should be emphasized that CA requires additional skills for both data recording and the diagnosis of tracings; however, it provides an objective demonstration of functional movements of the TMJ.

It is clear that TMJ pathology and clinical implications are complex and that TMD diagnostic methods continue to evolve.[2] However, the starting point for understanding the latter is based on an informed acceptance of normative values, be they morphologic, functional, or patient-mediated ones, and that these values are reconcilable with the diversity of changes that occur in the context of progressive disease processes, patients' adaptive responses, and their time-dependent continuum of clinical evaluation. It should therefore be recognized that to date, rigorous and robust information regarding patient adaptation as well as patient-mediated concerns to such disease conditions remain unclear. However, an open-minded approach to advances in diagnostic protocols underscores the need for developing additional adjunctive evaluation techniques.

Conclusion

The sensitivity and agreement of the two examination methods used for this specifically selected patient population group was generally low. It appeared to become worse when pathologic changes in the TMJ were more severe. MRI and CA are different examinations and should both be considered for severe TMD diagnosis.

Acknowledgment

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