Influence of the Patient's Clinical Information on the Diagnostic Reproducibility and Accuracy of MRI Scans of Temporomandibular Joint Pathologies

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Purpose: To evaluate the influence of the patient's clinical information on the accuracy as well as interexaminer and intraexaminer reproducibilities of temporomandibular joint (TMJ) magnetic resonance imaging (MRI) scans. ***Materials and Methods:*** Forty MRI scans from 20 TMJs corresponding to 7 TMJ pathologies (ie, degenerative alterations of the condyle, degenerative alterations of the mandibular fossa, alterations in the morphology of the TMJ disc, disc displacement with reduction, disc displacement without reduction, TMJ effusion, and TMJ hypermobility) were assessed by seven uncalibrated specialists in temporomandibular disorders (TMD) at baseline, 30 day-, and 60-day follow-ups for accuracy and reproducibility. No clinical information was provided before the 60-day follow up. ***Results:*** Examiners had a poor to regular accuracy (0.10 to 0.36), kappa index and 5% to 60% correct positive diagnosis) when compared with the radiologist's diagnoses (gold standard). The interexaminer reproducibility ranged from moderate to substantial (kappa = 0.32 to 0.71), and the intraexaminer reproducibility ranged from moderate to perfect (kappa = 0.38 to 1.00). Provision of clinical information improved neither the accuracy nor the reproducibility of the results ($P < .05$), with the exception of the intraexaminer reproducibility of one examiner. ***Conclusions:*** Calibration is needed in assessing TMJ MRI scans, even when trained specialists are provided with clinical information from the patient.
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The magnetic resonance imaging (MRI) examination is the first line of choice for the diagnosis of hard and soft tissue abnormalities of the temporomandibular joint (TMJ).[1] However, the accuracy and reproducibility indices among examiners have varied in different studies and techniques, as well as the image quality, which poses a clinical and research problem.[2–4] One study compared the reproducibility among temporomandibular disorder (TMD) specialists, oral radiologists, and medical radiologists, all with training in reading TMJ MRI scans. They found that the reproducibility values (kappa ranging from 0.18 to 0.41) were lower than acceptable to indicate a substantial agreement (kappa = 0.61).[5] To solve this problem, another study showed that after calibration of three examiners, it was possible for them to obtain reliable and reproducible results in reporting TMJ disc position on MRI scans (kappa increased from 0.52 to 0.80).[6] However, calibration is difficult and time consuming, both in clinical practice and in research.[7] It is important to know the influence of the clinical information on the trained TMD specialist's radiologic diagnosis to determine if that alone could possibly increase both accuracy and reproducibility when assessing TMJ MRI scans.

Therefore, the objective of this study was to assess if the patient's clinical information alone can increase the accuracy and reproducibility of the diagnoses given by TMD specialists based on TMJ MRI scans.

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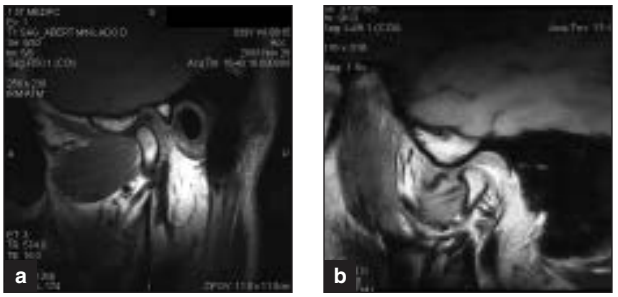

Fig 1 *(left)* Magnetic resonance sagittal image of the temporomandibular joint showing in T1 **(a)** disc displacement with reduction with opened mouth, and **(b)** disc displacement without reduction with opened mouth. All images may also have more than one diagnosis.

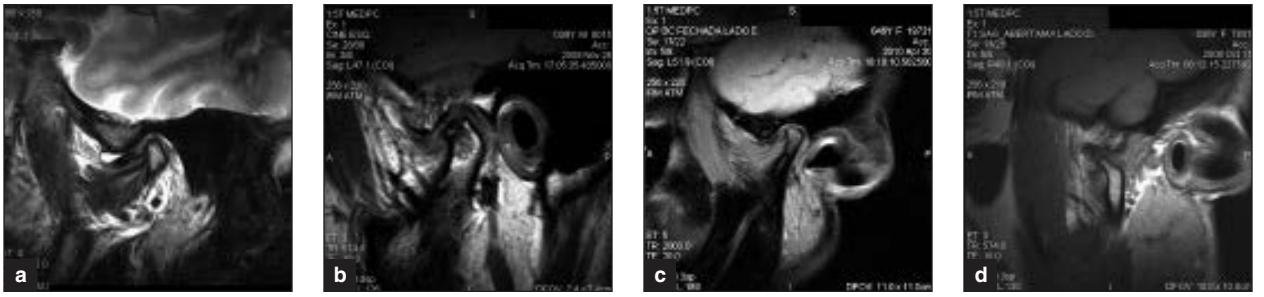

Fig 2 *(below)* Magnetic resonance sagittal image of the temporomandibular joint. **(a)** TMJ effusion (T2), **(b)** degenerative alterations of the mandibular fossa and the condyle (T1), **(c)** alterations in the morphology of the disc (proton density), and **(d)** TMJ hypermobility (T1). All images may have more than one diagnosis.

Materials and Methods

Inclusion and Exclusion Criteria

Forty MRI scans of right and left TMJs with the respective clinical history forms of 20 patients (55% women, mean age = 34.9 years, range = 17 to 51 years) were used for this study. They were collected from a private clinic with written consent obtained from both clinician and patients. This study was approved by the Research Ethics Committee of the São Lucas Hospital (CEP-HSL) of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Protocol 10/05003. Patients of both sexes were selected. The inclusion criteria were based on the presence of the following pathologies of the TMJ: *(1)* degenerative alterations of the condyle, *(2)* degenerative alterations of the mandibular fossa, *(3)* alterations in the morphology of the TMJ disc, *(4)* disc displacement with reduction, *(5)* disc displacement without reduction, *(6)* TMJ effusion, and *(7)* TMJ hypermobility (Figs 1 and 2). The exclusion criteria were *(1)* presence or history of TMJ trauma with fracture of the mandible/condyle, or any other TMJ pathology that was not part of our diagnostic groups, and *(2)* history of collagen vascular diseases or neoplastic conditions with clear contraindications to MRI.[5]

Study Protocol and Image Interpretation

All radiologic exams were performed and interpreted by the same radiology service (SERDIL Radiologia, Brazil) and by the same certified radiologist (operational gold standard). The technical details of the equipment (Magneton 63 SP-Siemens) were: intensity = 1.5 Tesla; repetition time = 574/650 ms (T1), 2,000 ms (proton density), and 5,300 ms (T2); eco time = 16/18 ms (T1), 20/22 ms (proton density), and 90 ms (T2); field of vision = 14.5 cm; matrix = 256 x 256; and slice thickness = 3 mm.[5,7] The pulse sequences and signals were detected using a surface coil.

The TMJs were assessed bilaterally in the sagittal plane (open and closed mouth positions, and perpendicular to the condyle's transverse long axis) and in the coronal plane (closed mouth position, and parallel to the condyle's transverse long axis). The sagittal and coronal images were corrected according to the condyle's long and transverse axes. Both TMJs were imaged in the weighted sequences T1, proton density, and T2.[5,7]

Seven board-certified TMD specialists diagnosed the images for accuracy and reproducibility at three separate time points (baseline, 30-day, and 60-day follow-up). These specialists were oral surgeons with similar educational backgrounds who graduated from the same TMD specialty program with the same training in reading TMJ MRI scans, to standardize the reviewers. Only in the third evaluation (day 60) was the clinical history disclosed. Age, sex, chief complaint, head and neck muscle pain(s), TMJ(s) pain, limitation of maximum mouth opening and lateral excursive movements, joint sounds, and opening pattern (straight, deviation, corrected deviation) were informed. The clinical information followed the Research Diagnostic Criteria for TMD examination guidelines, but the final clinical diagnosis was not provided, to

Table 1 Interexaminer Accuracy

TMJ pathologies in 40 MRI images*	Examiners' diagnoses	Baseline (%)	Kappa B†, NS	Day 30 (%)	Kappa 30†, NS	Day 60 (%)	Kappa 60†, NS
Degenerative alterations of the condyle (n = 18)	Negative Uncertain Positive	50 0 50	0.45	77.5 0 22.5	0.48	45 0 55	0.15
Degenerative alterations of the mandibular fossa (n = 13)	Negative Uncertain Positive	95 0 5	0.39	42.5 0 57.5	0.18	95 0 5	0.39
Alterations in the morphology of the TMJ disc (n = 28)	Negative Uncertain Positive	40 0 60	0.38	90 0 10	0.07	45 0 55	0.39
Disc displacement with reduction (n = 22)	Negative Uncertain Positive	57.5 0 42.5	0.25	42.5 0 57.5	0.05	62.5 0 37.5	0.15
Disc displacement without reduction (n = 13)	Negative Uncertain Positive	77.5 0 22.5	0.34	60 0 40	0.34	80 0 20	0.31
TMJ effusion (n = 14)	Negative Uncertain Positive	62.5 0 37.5	0.18	80 0 20	0.02	52.5 5 42.5	NC
TMJ hypermobility (n = 4)	Negative Uncertain Positive	92.5 0 7.5	0.21	62.5 0 37.5	0.25	70 0 30	0.09

TMJ = temporomandibular joint; NS = nonsignificant; NC = noncomputed.
*Each image may have more than one diagnosis.
†Kappa index was compared using the mode (most frequent diagnosis) of the examiners for each of the seven pathology diagnoses vs the operational gold standard.

prevent information biases.[3] Image shuffling at each evaluation was used to assure blinding and to prevent memory biases.

For accuracy, the examiners' diagnoses were compared with the radiologist's diagnoses at the three time points. For reproducibility, the examiners' diagnoses at days 30 and 60 were compared with their first diagnoses at baseline.

Statistical Analyses

Positive/negative percent agreement and Kappa index were used for measuring accuracy. In addition, the Kappa index mode (most frequent diagnosis) of the examiners for each of the seven pathologies diagnosed was calculated and compared with the radiologist's diagnosis, the operational gold standard. Analysis of variance (ANOVA) with Tukey-b test was used to compare the changes in the kappa index among the three time points. Kappa index was used additionally for percent agreement to compensate for the chance observer agreement, which is particularly important considering that the different TMJ pathologies analyzed had different numbers of images.[5] Student *t* test was used for inter- and intraexaminer reproducibilities. SPSS program version 17.0 for Windows (IBM) was used for analysis.

Results

The interexaminer accuracy results using the positive/negative percent diagnoses and the kappa index can be assessed in Table 1. The examiner diagnoses at baseline, 30-day, and 60-day follow-up versus the gold standard ranged from 5% to 60% for correct positive diagnoses. The mean kappa index at the three time points versus baseline ranged from poor to regular (0.10 to 0.36). The kappa index could not be calculated for TMJ effusion (day 60) due to uncertain diagnosis in 5% of images after a clinical information of previous trauma was given. The TMJ pathologies that had the most accurate mean diagnoses when compared to the gold standard at baseline in decreasing order were degenerative alterations of the condyle, disc displacement without reduction, degenerative alterations of the mandibular fossa, alterations in the morphology of the TMJ disc, TMJ hypermobility, disc displacement with reduction, and TMJ effusion. The clinical information did not change any of the results (ANOVA, $P < .05$).

Table 2 shows the individual and mean interexaminer and intraexaminer reproducibilities using the kappa index when comparing the 30-day and 60-day follow-up versus baseline. In the overall mean interexaminer reproducibility, the results were substantially

Table 2 Intraexaminer and Interexaminer Reproducibilities

TMJ pathologies in 40 MRI images*	Day	Examiner 1	2	3	4	5	6	7	Interexaminer reproducibility (mean kappa)
Degenerative alterations of the condyle (n = 18)	30	0.53	0.41	0.58	0.59	0.53	0.14	1.0	0.53
	60	0.28	0.48	0.32	0.84	0.53	0.55	NC	0.50
Degenerative alterations of the mandibular fossa (n = 13)	30	0.52	0.07	0.21	0.65	0.36	0.20	1.0†	0.43
	60	0.12	0.13	0.48	NC	0.03	0.31	NC	0.21
Alterations in the morphology of the TMJ disk (n = 28)	30	0.52	0.48	0.25	0.78	0.60	0.37	1.0	0.57
	60	0.49	0.39	0.37	0.81	NC	0.37	1.0	0.61
Disk displacement with reduction (n = 22)	30	0.42	0.35	0.42	0.82	0.44	0.39	1.0	0.54
	60	0.33	NC	0.35	0.83	NC	0.01	1.0	0.50
Disk displacement without reduction (n = 13)	30	0.65	0.80	0.65	0.67	0.62	0.60	1.0	0.71
	60	0.82	NC	NC	0.86	0.62	0.31	1.0	0.72
TMJ effusion (n = 14)	30	0.65	0.65	0.30	0.56	0.07	0.70	1.0	0.56
	60	NC	0.47	0.22	NC	0.07	0.44	1.0	0.44
TMJ hypermobility (n = 4)	30	0.47	0.36	0.65	0.47	0.54	0.61	1.0	0.58
	60	NC	0.09	NC	0.65	NC	0.44	1.0	0.54
Intraexaminer reproducibility (mean kappa)	30	0.53	0.44	0.43	0.64	0.45	0.43	1.0	NS
	60	0.40	0.31	0.34	0.79†	0.31	0.34	1.0	(Inter- and intraexaminer)

TMJ = temporomandibular joint; NS = nonsignificant; N = noncomputed.
*Each image may have more than one diagnosis.
†Student *t* test (30 d vs 60 d), $P < .05$.

higher than the accuracy results, ranging from moderate to substantial (kappa = 0.32 to 0.71). The TMJ pathologies that had the most reproducible diagnoses in decreasing order were: disc displacement without reduction, alterations in the morphology of the TMJ disc, TMJ hypermobility, disc displacement with reduction, degenerative alterations of the condyle, TMJ effusion, and degenerative alterations of the mandibular fossa. Similar to accuracy, the clinical information did not change any of the reproducibility results from 30-day to 60-day follow-up (Student *t* test, $P < .05$).

In the overall mean intraexaminer reproducibility, the results were also substantially higher than accuracy and slightly higher than the mean interexaminer reproducibility, ranging from moderate to perfect (kappa = 0.38 to 1.00). Similar to interexaminer reproducibility, the clinical information did not improve the mean intraexaminer reproducibility from 30-day to 60-day follow-up, with the exception of examiner no. 4 (Student *t* test, $P < .05$).

Discussion

Despite the fact that the clinical information provided at day 60 did not improve the kappa values in either accuracy or reproducibility in diagnosing the TMJ MRI images, it must be emphasized that only the need for calibration for a radiologic assessment was being tested before and after clinical information was provided. It is important to stress that the clinical information is always an essential part of the final diagnosis.[1,3,4,7] The values reported here for both accuracy and reproducibility must be interpreted with care due to the wide kappa variation among the examiners' image interpretations, considering that they might have interfered during the mean scoring. The results of Tables 1 and 2 agree with previous studies that uncalibrated examiners, even if experienced, are not trained to examine TMJ MRI scans for both accuracy and reproducibility.[2–5] However, they disagree with some studies that found high intra- and interexaminer agreement for TMJ MRI scans, but the examiners were calibrated.[6]

Conclusions

Poor to regular kappa values were found for accuracy, and moderate to substantial kappa values were found for both intra- and interexaminer reproducibilities in uncalibrated examiners, even if experienced in diagnosing TMJ pathologies using MRI scans. The clinical information introduced at the last examination had no impact on any of the results. Calibration in reading TMJ MRI scans is required to reduce the wide variation found among examiners, even if they are trained specialists.

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Literature Abstract

Trends in death associated with pediatric dental sedation and general anesthesia

The authors attempted to quantify pediatric mortality in relation to dental anesthesia by reviewing media reports gathered from the Lexis-Nexis Academic database and a private foundation website. Deaths of US-based children (≤ 21 years of age) who died after receiving anesthesia for a dental procedure in a dental office, ambulatory surgery center, or hospital from 1980 to 2011 were reviewed. Providers of anesthesia were classified as general/pediatric dentist, oral surgeon, or anesthesiologist. The results showed that 47% (n = 21) of the deaths reviewed occurred in children 2 to 5 years of age; 70.5% (n = 31) of deaths occurred in an office setting; and 56.8% (n = 25) of deaths occurred with a general/pediatric dentist. Most deaths, 68% (n = 17), were associated with sedation anesthesia in comparison to local anesthesia or general anesthesia. An external body reviewed 11 cases to determine whether a deviation from standard practice contributed to the cause of death; adverse rulings were made in 9 cases. Due to the limitation of the study scope, the authors commented that the findings might not be representative of all pediatric dental deaths. However, they opined that some of the pediatric deaths could have been prevented by reducing the need for dental procedures through aggressive preventive care, or through better observance of standards of care when rendering treatment to patients who require general anesthesia.

Lee HH, Milgrom P, Starks H, Burke W. *Pediatr Anesth* 2013;23:741–746. **References:** 11. **Reprints:** Dr Helen H. Lee, Department of Anesthesiology and Pain Medicine, University of Washington, 4800 Sand Point Way NE, M/S W-9824 PO Box 5371, Seattle, WA 98105, USA. Email: Hlee4nd@Hotmail.com—*John Chai, Evanston, Illinois, USA*.