Original Article

Diagnostic efficacy of quantitative ultrasonography for anterior disc displacement of the temporomandibular joint

Chenyang Li[1], Jinbo Zhou[1], Yuchao Shi[1], Zelin Ye[1], Chunmiao Zhang[1], Ruilai Hou[1], Zhongjie Li[2], Meng You[1]^

[1]State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases & Department of Oral Medical Imaging, West China Hospital of Stomatology, Sichuan University, Chengdu, China; [2]State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases & Department of Temporomandibular Joint, West China Hospital of Stomatology, Sichuan University, Chengdu, China

Contributions: (I) Conception and design: C Li, J Zhou; (II) Administrative support: M You; (III) Provision of study materials or patients: Y Shi, Z Ye, R Hou, Z Li; (IV) Collection and assembly of data: C Li, J Zhou, C Zhang; (V) Data analysis and interpretation: C Li, J Zhou, Y Shi; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Meng You, MD, PhD. Associate Professor and Director, State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases & Department of Oral Medical Imaging, West China Hospital of Stomatology, Sichuan University, 14 Renmin South Road 3rd Section, Chengdu 610041, China. Email: youmeng@scu.edu.cn.

Background: Ultrasonography has been applied as an alternative method in the assessment of temporomandibular joint (TMJ) pathology including anterior disc displacement (ADD). However, a concrete screening or diagnostic method which is feasible in clinical practice has not yet been established. The study aimed to establish a quantitative ultrasonographic method and determine its diagnostic efficacy for ADD of the TMJ.

Methods: A total of 75 joints were allocated to either the normal disc position (NDP) group or the ADD group using magnetic resonance imaging (MRI) as the reference standard. Longitudinal scans of the lateral articular compartment were obtained by a 14-MHz L-shaped linear array transducer. The width of the lateral joint space (LJS), the upper lateral joint space (ULJS), and the lower lateral joint space (LLJS), as well as the position of the lateral articular disc edge (ADE), were investigated by stepwise logistic regression analysis to identify significant indicators of ADD and to build a diagnostic model. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were computed at the optimal cut-off value.

Results: MRI detected 25 joints in the NDP group and 50 joints in the ADD group. Correlation analysis indicated that all 4 variables were associated with ADD. With the best performance of the area under the receiver operating characteristic (ROC) curve (AUC) of 0.939, LJS and ULJS were identified as predictors of ADD and subsequently adopted to build a diagnostic model by stepwise logistic regression. The optimal cut-off value of the 2-variable regression model for diagnosing ADD was 0.800, with a sensitivity of 82%, specificity of 96%, PPV of 97.6%, NPV of 72.7%, and an accuracy of 86.7%.

Conclusions: The quantitative ultrasonographic diagnostic method showed promising diagnostic efficacy. It has the potential to be used for ADD screening in future clinical practice.

Keywords: Temporomandibular joint (TMJ); ultrasonography (US); anterior disc displacement (ADD); diagnostic efficacy; magnetic resonance imaging (MRI)

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^ ORCID: 0000-0001-6189-1845.

Introduction

Disc displacement (DD) of the temporomandibular joint (TMJ) is defined as a malpositioning of the articular disc relative to the condyle and eminence (1). It represents a group of dysfunctional conditions that are highly prevalent in the population, among which anterior disc displacement (ADD) is one of the most common patterns (2).

Medical imaging plays a pivotal role in the diagnosis of ADD, and a proper diagnosis informs the determination of its management (3). A variety of modalities can be used to image the TMJ, including plain radiography, computed tomography (CT), cone beam computed tomography (CBCT), and magnetic resonance imaging (MRI). MRI is considered the "gold standard" in visualizing the disc-condyle relationship and the soft tissue status of the TMJ (4). However, the use of MRI as a screening tool for DD has been limited by its high cost, time-consuming procedure, and low availability, especially in dental institutions.

Ultrasonography (US) has been applied as an alternative method in the assessment of TMJ pathology including DD because it is an easily accessible, non-invasive, low-cost, and dynamic imaging technique without radiation (5,6). Although the results of previous studies have indicated the positive performance of US in diagnosing DD (7,8), a concrete screening or diagnostic method which is feasible in clinical practice has not yet been established (9,10).

In this study, we designed a quantitative measurement method to evaluate the sonograms of TMJ with normal disc position (NDP) or ADD according to MRI images. The diagnostic efficacy of these ultrasonographic measurements in the detection of ADD was explored to determine their possibility as indirect diagnostic indicators for ADD.

Methods

Participants

This study was approved by the Ethics Committee of West China Hospital of Stomatology, Sichuan University (No. WCHSIRB-CT-2022-304) and was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Patients were enrolled from the Department of Temporomandibular Joint (West China Hospital of Stomatology, Sichuan University) from March to August 2022. Informed consent was provided by each participant.

Clinical evaluation was conducted for each participant according to diagnostic criteria for temporomandibular disorders (DC/TMD) (11). The inclusion criteria were as follows: (I) patients aged over 18 years; (II) patients with at least 1 of the following signs or symptoms: spontaneous or palpated pain in 1 or both TMJs, masticatory muscle soreness, TMJ noise(s), limited mouth opening. The exclusion criteria included the history of previous or in progress TMJ treatment, contraindications to MRI, and patients with any difficulty cooperating with ultrasound examination.

MRI examination

MRI examination was performed as the reference standard to verify the position of articular disc. Accordingly, TMJs were allocated to either the NDP group or ADD group. In detail, an MRI of the TMJ was obtained by a 1.5-T or 3.0-T MRI device with a head-neck coil or TMJ surface coil (12). The images were captured while the patients were in a supine position with mouths closed and open. T1-weighted and T2-weighted images were collected in the sagittal and coronal planes. In the sagittal plane, the NDP was determined if the junction of the posterior band aligned approximately at 12 o'clock relative to the condyle in the closed-mouth position (11). ADD was diagnosed if the posterior band of the disc was located anterior to the 11:30 o'clock position and the intermediate zone was anterior to the condyle head (11). MRI images were evaluated by a TMJ specialist (Li Z) and confirmed by a senior dentomaxillofacial radiologist (You M).

Ultrasonography

High-resolution US (HR-US) examinations were conducted by using a 14-MHz L-shaped linear array transducer (L16-4 HU Ultrasonic Transducer, Resona 5; Mindray, Shenzhen, China). All examinations were performed by the same practitioner (J Zhou), who has over 10 years of clinical experience in US examination. The total image acquisition time was approximately 10 minutes per joint.

During the examination, patients assumed a supine position with their heads tilted away from the side to be examined. They were instructed to keep their mouths closed and maintain maximum intercuspal position. The longitudinal scan of the lateral TMJ was conducted as described by Thirunavukarasu *et al.* (13). In detail, the probe was placed against the patient's skin on the anatomical position of the TMJ, perpendicular to the zygomatic arch and parallel to the mandible ramus (*Figure 1*). The probe was then titled up and down slightly to capture the ideal images of the TMJ for further analysis. To ensure the

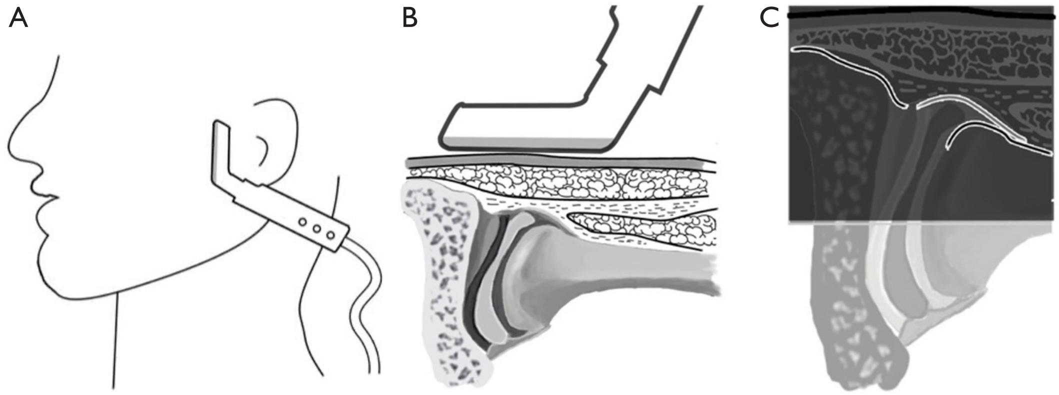

Figure 1 Schematic representation of the ultrasonography examination. (A) The L-shaped ultrasound probe was placed anterior to the tragus and oriented longitudinally. (B,C) The corresponding anatomical schematic and ultrasonographic schematic.

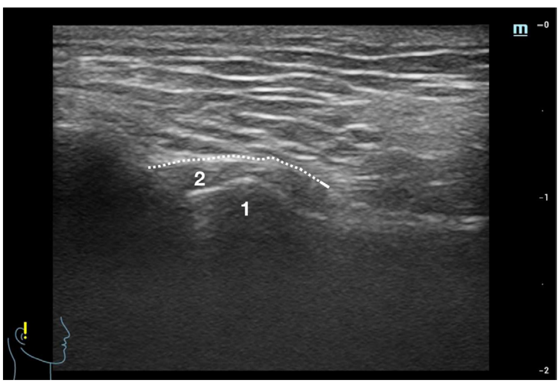

Figure 2 Ultrasound image of a normal TMJ in the closed-mouth position. 1: condyle, the condyle surface appeared as hyperechoic lines; 2: articular disc, it was visualized as a thin homogeneous, hypo-to-isoechoic band; dotted line: joint capsule, it presented as a hyperechoic (white) line. TMJ, temporomandibular joint.

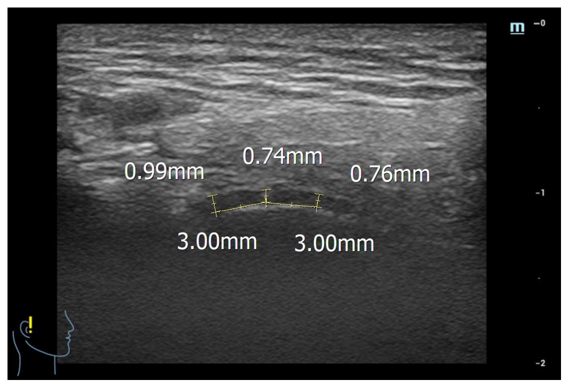

Figure 3 Schematic diagram of the measurement method. Widths of LJS, ULJS, and LLJS measured in an ultrasound image of a normal TMJ. The LJS was measured from the reference point of the most lateral cortical profile to the corresponding joint capsule. ULJS and LLJS are measured as the distance between the 3 mm above and below the most lateral point and its corresponding joint capsule, respectively. In this sonogram, LJS =0.74 mm, ULJS =0.99 mm, LLJS =0.76 mm. LJS, lateral joint space; ULJS, upper lateral joint space; LLJS, lower lateral joint space; TMJ, temporomandibular joint.

accuracy of quantitative analyses, no pressure was applied to the TMJ during the examination.

The following 4 quantitative variables representing the structure of the lateral TMJ were defined: the width of lateral joint space (LJS), upper lateral joint space (ULJS), lower lateral joint space (LLJS), as well as the position of lateral articular disc edge (ADE). On the sonograms, the condyle surface appeared as hyperechoic lines, and the articular disc was visualized as a homogeneous, hypo-to-isoechoic band. The joint capsule presented as a hyperechoic (white) line (*Figure 2*). As shown in *Figure 3*, the LJS was measured as the distance between the most lateral cortical profile point of the condyle head and its corresponding joint capsule; ULJS and LLJS were measured as the distance between 3 mm above and below the most lateral condylar point and their corresponding joint capsule, respectively. The ADE position was the lateral edge of articular disc attaching the condyle, which was determined based on the clock face (*Figure 4*). The 3 distance variables were measured by 2 investigators (Li C and Zhou J) independently, whereas ADE positions were judged by both investigators, who finally made a consensus decision.

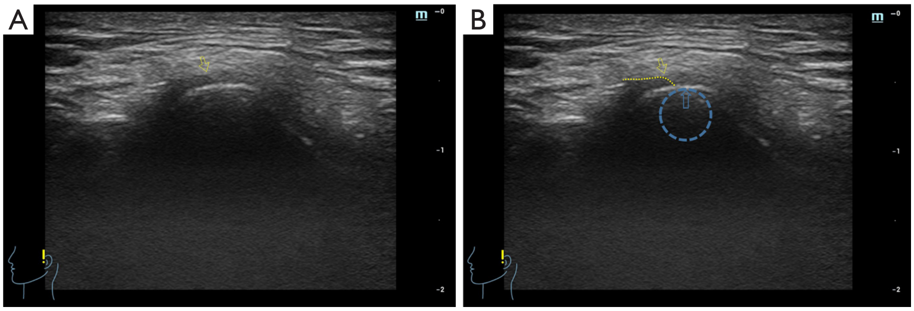

Figure 4 Schematic diagram for evaluation of the lateral ADE position. (A) Ultrasound appearance of the normal articular disc (yellow arrow) was seen as a thin, homogeneous, hypo-to-isoechoic band in the longitudinal plane. (B) Referring to the lateral-most aspect of the condyle which was defined as 12 o'clock (blue arrow), the ADE (yellow dotted line) is in 9–12 o'clock in this sonogram. Blue circle: analog clock; blue arrow points to 12 o'clock. ADE, articular disc edge.

Statistical analysis

According to a general rule for calculating the sample size which recommends 10 positive events per variable (EPV) for regression analyses (14), more than 40 joints with ADD were needed to obtain an accurate estimation for the current statistical model with 4 variables.

Each TMJ was considered a statistical unit. Continuous variables including the width of LJS, LLJS, and ULJS were expressed as means, standard deviations (SDs), minimum, and maximum, whereas frequency (%) was calculated for the categorical variable ADE. Inter-examiner reliability was measured by the interclass correlation coefficients (ICCs) for distance variables.

The width of LJS, ULJS, LLJS and the position of lateral ADE were compared between NDP and ADD groups using the Mann-Whitney *U* test. Multicollinearity was assessed according to the variance inflation factor (VIF) for each variable, with a VIF value >5 indicating multicollinearity. Receiver operating characteristic (ROC) curves were drawn to appraise the diagnostic efficacy of these variables in predicting ADD. The optimal cut-off values of LJS, ULJS, and LLJS for detecting ADD were obtained based on the Youden index.

We applied correlation analysis (i.e., Spearman correlation and point biserial correlation analyses) to find the possible association between the 4 variables and ADD. Variables that significantly associated with ADD in correlation analysis were included in stepwise logistic regression to select factors with maximum prediction performance. The logistic regression model is defined by the following formula:

$$\text{Logit}(P) = \ln\left[P/(1-P)\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \qquad [1]$$

where βs are the coefficients and Xs are candidate predictors. Calibration of the model was assessed with the Hosmer-Lemeshow goodness-of-fit test. Using the Youden index method, the optimal threshold for the linear predictor values was calculated to identify the presence of ADD. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy at the threshold were calculated.

The level of significance adopted for the tests and models was set at 5%. All analyses were carried out using SPSS 26.0 (IBM Corp., Armonk, NY, USA), or Python 3 (for point-biserial correlation; Python Software Foundation, Wilmington, DE, USA). The clinical findings and MRI results were concealed from the US technicians and data analysts, until all data had been processed.

Results

Participants

A flow chart illustrating the participant inclusion process is displayed in *Figure 5*. A total of 48 patients with 75 TMJs were included in this prospective study with a female-to-male ratio of 43:5. Their ages ranged from 18 to 55 years, with a mean age of 26.5 years. Totally, MRI examination detected 25 (33.3%) normal joints belonging to the NDP group, and 50 (66.7%) joints belonging to the ADD group. The sample size met the standard of 10 EPV, which was sufficient and reliable for the following predictive analysis.

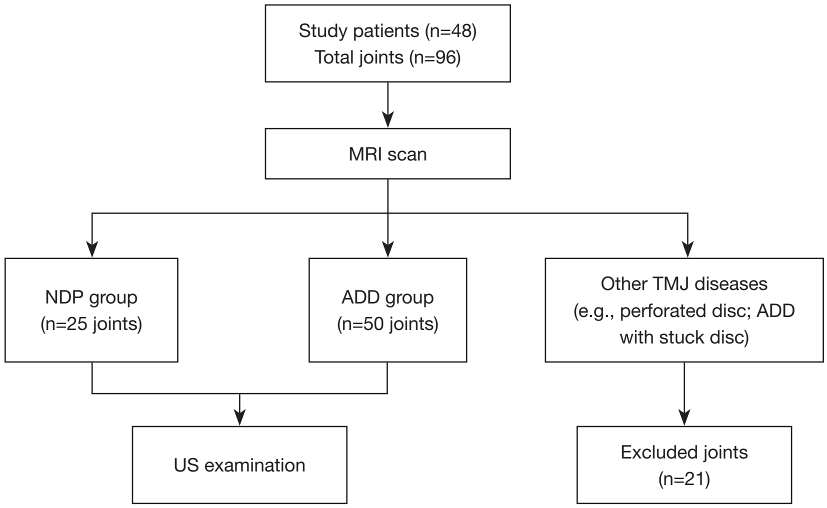

Figure 5 Flow chart of the study joints inclusion process. MRI, magnetic resonance imaging; NDP, normal disc position; ADD, anterior disc displacement; TMJ, temporomandibular joint; US, ultrasonography.

Table 1 Statistic descriptive of measurements in the NDP and ADD groups

Variables	NDP group (n=25)				ADD group (n=50)				P value
	Mean	Min	Max	SD	Mean	Min	Max	SD	
LJS (mm)	0.745	0.380	1.110	0.205	1.433	0.490	2.780	0.551	<0.001
ULJS (mm)	1.184	0.520	2.230	0.433	2.276	0.970	5.040	0.860	<0.001
LLJS (mm)	0.874	0.540	1.840	0.311	1.461	0.470	2.660	0.438	<0.001

NDP, normal disc position; ADD, anterior disc displacement; Min, minimum value; Max, maximum value; SD, standard deviation; LJS, lateral joint space; ULJS, upper lateral joint space; LLJS, lower lateral joint space.

Table 2 Statistic descriptive of articular disc edge position in the NDP and ADD groups

ADE position	NDP group (n=25)			ADD group (n=50)			P value
	Frequency	Percent	Valid percent	Frequency	Percent	Valid percent	
12 o'clock and before	22	88	88	21	42	42	–
After 12 o'clock	2	8	8	25	50	50	–
N/A	1	4	4	4	8	8	–
Total	25	100	100	50	100	100	0.003

N/A: the border of disc edge was not available in ultrasonographic imaging. NDP, normal disc position; ADD, anterior disc displacement; ADE, articular disc edge.

US measurements

Descriptive statistics of the 4 variables are shown in *Tables 1,2*. The mean values of LJS, ULJS, and LLJS in the ADD group were all significantly greater than those in the NDP group (all P<0.001). The ICCs for inter-examiner reliability resulted in 0.930 [95% confidence interval (CI): 0.891–0.955] for LJS, 0.906 (95% CI: 0.856–0.940) for ULJS, and 0.856 (95% CI: 0.781–0.906) for LLJS.

With the lateral-most aspect of the condyle defined as 12 o'clock, the ADE position of 22 (88.0%) TMJs in the NDP group and 21 (42.0%) TMJs in the ADD group were located throughout 9–12 o'clock, respectively. In the NDP group, 2 (8.0%) TMJs were situated over 12 o'clock, whereas the number was 25 (50.0%) in the ADD group. The ADE position of 5 TMJs (1 in NDP, 4 in ADD) could not be clarified due to their poorly demarcated disc borders on sonograms.

We found a significant correlation between the position of ADE and ADD (P=0.03) by Spearman correlation analysis. The point biserial correlation analysis suggested a moderate correlation of 3 capsular width measurements (LJS, ULJS, and LLJS) with ADD (r_1=0.576, r_2=0.572, r_3=0.573, respectively; P<0.05).

Predictive model construction

The VIF confirmed no multicollinearity among the independent variables, with all VIFs less than 5. Upon stepwise logistic regression, both forward selection and backward elimination, LJS (P=0.003) and ULJS (P=0.012) were consistently selected. The 2-variable model consisting of LJS and ULJS had the strongest predictive value (86.7%) for ADD. Although LLJS and ADE also correlated with the diagnosis of ADD, adding them into the model did not improve the predictive value.

The formula of the best diagnostic model for ADD consisting of LJS and ULJS was as follows:

$$\begin{aligned}\text{Logit}(P_{ADD}) &= \ln\left[P_{ADD}/(1-P_{ADD})\right] \\ &= -7.617 + 5.021 \times LJS + 2.222 \times ULJS\end{aligned} \quad [2]$$

and the predicted probability value was established as follows:

$$P_{ADD} = 1/\left[1+e^{-(-7.617+5.021\times LJS+2.222\times ULJS)}\right] \quad [3]$$

The model calibration was characterized by a good fit (χ^2=1.869, P=0.967) in the Hosmer-Lemeshow test.

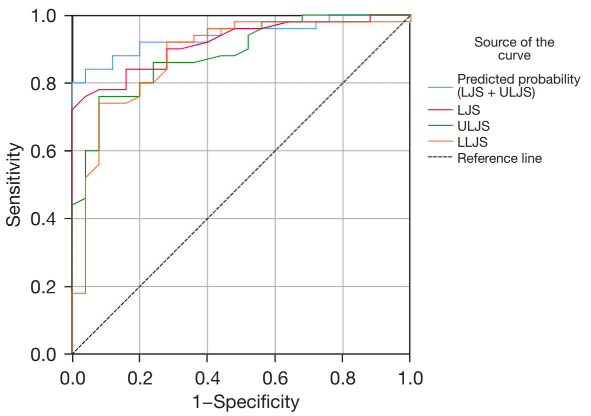

Figure 6 ROC curves of LJS, ULJS, LLJS, and predicted probability of the combination of LJS and ULJS. AUCs were 0.917, 0.884, 0.880, and 0.939 respectively. Diagonal segments are produced by ties. ROC, receiver operating characteristic; AUC, area under the ROC curve; LJS, lateral joint space; ULJS, upper lateral joint space; LLJS, lower lateral joint space.

Diagnostic performance of variables in predicting ADD

The areas under the ROC curves (AUCs) of LJS, ULJS, LLJS, and predicted probability of the 2-variable regression model were 0.917, 0.884, 0.880, and 0.939, respectively (P<0.05). As shown in *Figure 6*, the regression model combining LJS and ULJS got the highest accuracy.

Using the Youden index method, we ascertained that the optimal cut-off value for LJS was 1.095 mm with a sensitivity of 76% and specificity of 96%. The sensitivity and specificity of the optimal threshold for ULJS were 76% and 92% (cut-off value: 1.670 mm), and 92% and 72% for LLJS (cut-off value: 1.010 mm), respectively (*Table 3*).

Besides, we determined that the optimal cut-off point for the 2-variable regression model was 0.800. Of those TMJ with a normal disc-condyle relationship, 0.4% (1/25) were classified as false positive by this diagnostic cut-off point, whereas 18% (9/50) of ADD patients were sorted

Table 3 Optimal cut-off values for individual variables and the predictive probability combining LJS and ULJS, for diagnosing ADD

Variables	AUC (95% CI)	Cut-off value	Sensitivity	Specificity
LJS	0.917 (0.857–0.977)	1.095 mm	0.76	0.96
ULJS	0.884 (0.810–0.959)	1.670 mm	0.76	0.92
LLJS	0.880 (0.794–0.967)	1.010 mm	0.92	0.72
Predicted probability (LJS and ULJS)	0.939 (0.888–0.991)	0.800	0.82	0.96

LJS, lateral joint space; ULJS, upper lateral joint space; ADD, anterior disc displacement; AUC, area under the ROC curve; ROC, receiver operating characteristic; CI, confidence interval; LLJS, lower lateral joint space.

Table 4 The diagnostic performance of the US quantitative method based on the two-variable regression model for the participants

US	MRI		Total
	ADD	NDP	
ADD (P_{ADD} >0.800)	41	1	42
NDP	9	24	33
Total	50	25	75

US, ultrasonography; MRI, magnetic resonance imaging; ADD, anterior disc displacement; NDP, normal disc position.

into the false negative (*Table 4*). At this P_{ADD} cut-off point, the sensitivity for predicting ADD was 82%, specificity was 96%, PPV was 97.6%, NPV was 72.7%, +LR was 20.5, −LR was 0.1875, accuracy was 86.7%, and diagnostic odds ratio (DOR) was 109.3.

Discussion

In the present study, we included a relatively large number of ADD joints to examine the change of capsular widths and their diagnostic efficacy using NDP joints as a control. All 3 measurements presented significantly greater mean values in the ADD group than the NDP group, which implied the lateral capsular distention caused by DD. Correlation analysis indicated that all 4 variables including measuring widths and ADE were associated with ADD. However, only LJS and ULJS were identified as predictors of ADD by stepwise logistic regression; adding ADE position or/and LLJS failed to improve the performance of the regression model. The predictive model, established by combining LJS and ULJS, achieved high accuracy in terms of ROC area, which had better diagnostic performance in identifying ADD compared to LJS or ULJS alone. At the optimal cut-off point of the 2-variable regression model, the diagnostic score defined at 0.800 yielded excellent sensitivity/specificity, and these performance data are comparable to the previous best-performed ultrasound diagnostic tests of DD (15,16).

In previous studies of ultrasound evaluation of TMJ disorders, most data about diagnostic efficacy were from the assessment of DD (17-19). Although 70% of these studies presented excellent or acceptable diagnostic test accuracy, a very wide range of sensitivity and specificity was reported (5). The possible reasons included the adoption of different ultrasound techniques and the variation of diagnostic criteria for DD in ultrasound images.

As for the ultrasound techniques, a standardized protocol is required for better reproducibility and clinical feasibility. Previous studies had indicated that HR-US with a frequency higher than 12 MHz could differentiate the tissues in more detail and therefore achieve better diagnostic performance (20,21). The transducer was normally placed anterior to the tragus and oriented horizontally or longitudinally (7,8,13). The horizontal scan can image the transversal slices of the anterosuperior articular compartment, and therefore is commonly adopted to evaluate the disc position relative to the condyle and articular eminence. On the contrary, the longitudinal scan can obtain the sonogram of the lateral superior and inferior joint, in which the lateral intra-articular space, composed of the lateral pole of the condylar process, the disc, and the articular capsule, can be well viewed (22). Although most DDs are anterior and medial, we hypothesize that the form of the lateral intra-articular space would also be affected by the displaced disc.

The diagnostic criteria for DD in most studies depended on the practitioner's subjective judgement of the disc position compared to the condyle. In a static closed-mouth position, NDP was diagnosed when the disc was simply located above the condylar head (23), or its posterior border was located at or distal to the posterosuperior aspect of the condyle (24), or its intermediate zone located between the anterosuperior aspect of the condyle and the posteroinferior aspect of the articular eminence (15,17,25-27). The variety and subjectivity of the descriptive diagnostic criteria limited its reliability and applicability in the routine clinical screening of DD, especially for dentists or junior radiologists unfamiliar with TMJ sonograms. Moreover, the contour of the disc cannot always be clearly observed in sonograms, which further hindered its application in DD diagnosis (28). In the current study, although we found that a significantly higher proportion of joints in the ADD group had the ADE located beyond 12 o'clock, others were located at an area similar to that of normal joints or failed to be identified in sonograms. This indicated that the diagnostic efficacy of the lateral disc edge position alone was insufficient.

The objective methods based on the measurement of representative anatomical landmarks were proposed to detect intra-articular abnormalities indirectly (29). The measurement methods were applied to obtain the reference values of normal joints (13,30), as well as to evaluate their association with joint effusion (31-34), joint pain (35), juvenile idiopathic arthritis (JIA) (36,37), and DD (29,38). The lateral capsular width was the most frequently used variable to investigate structural abnormalities in these studies.

In order to obtain reliable sonograms for measurements of lateral intra-articular space, a standard scanning protocol was adopted in the current study. In addition to the most lateral capsular width (the value of LJS), the upper and the lower lateral capsular widths (the values of ULJS and LLJS) were also measured to better evaluate the anatomical variation and minimize the observational error. The inter-examiner ICC for these 3 measurements showed excellent reliability for LJS and ULJS, and good reliability for LLJS, which indicated that the current scanning and measuring protocol was reliable. LLJS had mean values similar to those of LJS, whereas the ULJS had larger mean values compared to LJS, in both NDP and ADD groups. It could be explained by the larger disc thickness at the laterosuperior articular space. The capsular distension had previously been reported to be associated with intra-articular disorders or joint pain, which was detected indirectly as increased capsular width (31,32,34,35). Although some studies have implied that the capsular width tends to increase in patients with DD (29,34), its diagnostic value has remained controversial due to limited published data and variation of study design.

The main strength of this study is providing an objective diagnostic protocol from standard scanning and measurement methods to the diagnostic model and cut-off value which facilitates the feasibility and reproducibility of ultrasound examination in diagnostic investigation of ADD.

One of the limitations of the current study is that only the static longitudinal images were obtained for assessment. Unlike previous disc position evaluation studies mostly based on the transversal plane (5), the ADE position in the current study reflects only the lateral attachment of the disc, rather than the intuitive judgement of the anteroposterior position of the disc relative to the condyle and eminence. Moreover, joint effusion which was considered associated with capsular distention was not excluded from our participants. Although none of the assessed variables showed a significant difference between ADD alone and ADD with joint effusion (data not shown), differential diagnosis of joint effusion should be considered when using the current diagnostic protocol. Besides, the availability of qualified US images could be affected by the experience of the ultrasound technician and the variation of joint anatomy, which may preclude the application of this method in some cases.

Conclusions

This study established an objective US protocol for screening ADD of TMJ. The diagnostic cut-off value of the regression formula defined as 0.800 obtained a promising diagnostic efficacy.

Further studies should be conducted to validate the proposed new diagnostic model through large external independent cohorts, evaluation of the potential dynamic ultrasound features for ADD detection, automatic capture of standard sonogram, and automatic measurement by intelligence techniques.

Acknowledgments

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-401/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of the West China Hospital of Stomatology, Sichuan University (No. WCHSIRB-CT-2022-304). All participants signed informed consent.

References

1. de Leeuw R. Internal derangements of the temporomandibular joint. Oral Maxillofac Surg Clin North Am 2008;20:159-68, v.

2. Bag AK, Gaddikeri S, Singhal A, Hardin S, Tran BD, Medina JA, Curé JK. Imaging of the temporomandibular joint: An update. World J Radiol 2014;6:567-82.
3. Katzberg RW. Is ultrasonography of the temporomandibular joint ready for prime time? Is there a "window" of opportunity? J Oral Maxillofac Surg 2012;70:1310-4.
4. Ferreira LA, Grossmann E, Januzzi E, de Paula MV, Carvalho AC. Diagnosis of temporomandibular joint disorders: indication of imaging exams. Braz J Otorhinolaryngol 2016;82:341-52.
5. Almeida FT, Pacheco-Pereira C, Flores-Mir C, Le LH, Jaremko JL, Major PW. Diagnostic ultrasound assessment of temporomandibular joints: a systematic review and meta-analysis. Dentomaxillofac Radiol 2019;48:20180144.
6. Talmaceanu D, Lenghel LM, Bolog N, Buduru S, Leucuta D, Rotar H. High-resolution ultrasound imaging compared to magnetic resonance imaging for temporomandibular joint disorders: An in vivo study. Eur J Radiol 2020;132:109291.
7. Talmaceanu D, Lenghel LM, Bolog N, Popa Stanila R, Buduru S, Leucuta DC, Rotar H, Baciut M, Baciut G. High-resolution ultrasonography in assessing temporomandibular joint disc position. Med Ultrason 2018;1:64-70.
8. Azlağ Pekince K, Çağlayan F, Pekince A. The efficacy and limitations of USI for diagnosing TMJ internal derangements. Oral Radiol 2020;36:32-9.
9. Kundu H, Basavaraj P, Kote S, Singla A, Singh S. Assessment of TMJ Disorders Using Ultrasonography as a Diagnostic Tool: A Review. J Clin Diagn Res 2013;7:3116-20.
10. Maranini B, Ciancio G, Mandrioli S, Galiè M, Govoni M. The Role of Ultrasound in Temporomandibular Joint Disorders: An Update and Future Perspectives. Front Med (Lausanne) 2022;9:926573.
11. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group†. J Oral Facial Pain Headache 2014;28:6-27.
12. Xiong X, Ye Z, Tang H, Wei Y, Nie L, Wei X, Liu Y, Song B. MRI of Temporomandibular Joint Disorders: Recent Advances and Future Directions. J Magn Reson Imaging 2021;54:1039-52.
13. Thirunavukarasu AJ, Ferro A, Sardesai A, Biyani G, Dubb SS, Brassett C, Hamilton DL. Temporomandibular joint anatomy: Ultrasonographic appearances and sexual dimorphism. Clin Anat 2021;34:1043-9.
14. Pavlou M, Ambler G, Seaman S, De Iorio M, Omar RZ. Review and evaluation of penalised regression methods for risk prediction in low-dimensional data with few events. Stat Med 2016;35:1159-77.
15. Emshoff R, Brandlmaier I, Bodner G, Rudisch A. Condylar erosion and disc displacement: detection with high-resolution ultrasonography. J Oral Maxillofac Surg 2003;61:877-81.
16. Jank S, Emshoff R, Norer B, Missmann M, Nicasi A, Strobl H, Gassner R, Rudisch A, Bodner G. Diagnostic quality of dynamic high-resolution ultrasonography of the TMJ--a pilot study. Int J Oral Maxillofac Surg 2005;34:132-7.
17. Friedman SN, Grushka M, Beituni HK, Rehman M, Bressler HB, Friedman L. Advanced Ultrasound Screening for Temporomandibular Joint (TMJ) Internal Derangement. Radiol Res Pract 2020;2020:1809690.
18. Su N, van Wijk AJ, Visscher CM, Lobbezoo F, van der Heijden GJMG. Diagnostic value of ultrasonography for the detection of disc displacements in the temporomandibular joint: a systematic review and meta-analysis. Clin Oral Investig 2018;22:2599-614.
19. Razek AA, Al Mahdy Al Belasy F, Ahmed WM, Haggag MA. Assessment of articular disc displacement of temporomandibular joint with ultrasound. J Ultrasound 2015;18:159-63.
20. Dimova-Gabrovska M, Dimitrova D, Yordanov B, Apostolov N, Peev T. Ultrasound Diagnosis of Temporomandibular Joint in Patients with Craniomandibular Dysfunctions. Journal of IMAB 2019;25:2563-9.
21. L K SK, Zachariah GP, Chandran S. Ultrasonography: A step forward in temporomandibular joint imaging. A preliminary descriptive study. Clin Pract 2019;9:1134.
22. Dupuy-Bonafé I, Picot MC, Maldonado IL, Lachiche V, Granier I, Bonafé A. Internal derangement of the temporomandibular joint: is there still a place for ultrasound? Oral Surg Oral Med Oral Pathol Oral Radiol 2012;113:832-40.
23. Tognini F, Manfredini D, Melchiorre D, Bosco M. Comparison of ultrasonography and magnetic resonance imaging in the evaluation of temporomandibular joint disc displacement. J Oral Rehabil 2005;32:248-53.
24. Emshoff R, Bertram S, Rudisch A, Gassner R. The diagnostic value of ultrasonography to determine the

temporomandibular joint disk position. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;84:688-96.
25. Emshoff R, Jank S, Bertram S, Rudisch A, Bodner G. Disk displacement of the temporomandibular joint: sonography versus MR imaging. AJR Am J Roentgenol 2002;178:1557-62.
26. Kaya K, Dulgeroglu D, Unsal-Delialioglu S, Babadag M, Tacal T, Barlak A, Ozel S. Diagnostic value of ultrasonography in the evaluation of the temporomandibular joint anterior disc displacement. J Craniomaxillofac Surg 2010;38:391-5.
27. Severino M, Caruso S, Rastelli S, Gatto R, Cutilli T, Pittari L, Nota A, Tecco S. Hand-Carried Ultrasonography Instrumentation in the Diagnosis of Temporomandibular Joint Dysfunction. Methods Protoc 2021.
28. Shanthi DM. Progress in the Study of Temporomandibular Joint Disorder by Ultrasound Imaging. Journal of Contemporary Medical Practice (JCMP) 2020;2:61-5.
29. Hayashi T, Ito J, Koyama J, Yamada K. The accuracy of sonography for evaluation of internal derangement of the temporomandibular joint in asymptomatic elementary school children: comparison with MR and CT. AJNR Am J Neuroradiol 2001;22:728-34.
30. Elias FM, Birman EG, Matsuda CK, Oliveira IR, Jorge WA. Ultrasonographic findings in normal temporomandibular joints. Braz Oral Res 2006;20:25-32.
31. Manfredini D, Tognini F, Melchiorre D, Zampa V, Bosco M. Ultrasound assessment of increased capsular width as a predictor of temporomandibular joint effusion. Dentomaxillofac Radiol 2003;32:359-64.
32. Bas B, Yılmaz N, Gökce E, Akan H. Ultrasound assessment of increased capsular width in temporomandibular joint internal derangements: relationship with joint pain and magnetic resonance grading of joint effusion. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:112-7.
33. Johnston K, Bird L, Bright P. Temporomandibular joint effusion and its relationship with perceived disability assessed using musculoskeletal ultrasound and a patient-reported disability index. Ultrasound 2015;23:90-6.
34. Talmaceanu D, Lenghel LM, Csutak C, Bolog N, Leucuta DC, Rotar H, Tig I, Buduru S. Diagnostic Value of High-Resolution Ultrasound for the Evaluation of Capsular Width in Temporomandibular Joint Effusion. Life (Basel) 2022;12:477.
35. Kim JH, Park JH, Kim JW, Kim SJ. Can ultrasonography be used to assess capsular distention in the painful temporomandibular joint? BMC Oral Health 2021;21:497.
36. Assaf AT, Kahl-Nieke B, Feddersen J, Habermann CR. Is high-resolution ultrasonography suitable for the detection of temporomandibular joint involvement in children with juvenile idiopathic arthritis? Dentomaxillofac Radiol 2013;42:20110379.
37. Tonni I, Borghesi A, Tonesi S, Fossati G, Ricci F, Visconti L. An ultrasound protocol for temporomandibular joint in juvenile idiopathic arthritis: a pilot study. Dentomaxillofac Radiol 2021;50:20200399.
38. Díaz DZR, Müller CEE, Gavião MBD. Ultrasonographic study of the temporomandibular joint in individuals with and without temporomandibular disorder. J Oral Sci 2019;61:539-43.

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