Original Article

Comparison of Doppler Sonography to Magnetic Resonance Imaging and Clinical Examination for Disc Displacement

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ABSTRACT

Objective: To compare electronic devices advocated as an aid in the diagnosis of disc displacement (DD) of the temporomandibular joint.

Materials and Methods: Ninety-five joints (48 subjects, 36 females and 12 males, mean age = 33.3 years, SD \pm 11.9) were evaluated in this study using magnetic resonance imaging (MRI), clinical examination, and Doppler sonography. All subjects had bilateral MRI scans in the sagittal closed and opened and coronal closed positions.

Results: When the clinical and the Doppler diagnoses for all subjects were compared with the MRI diagnosis, there was a sensitivity of 73% and 90% and a specificity of 70% and 49%, respectively. When the clinical and the Doppler diagnoses for asymptomatic volunteers were compared with the MRI, there was a sensitivity of 0% and 100% and a specificity of 100% and 56%, respectively. For the symptomatic patients, there was a sensitivity of 80% and 89% and a specificity of 48% and 45%, respectively.

Conclusions: The relatively low number of false-negative examinations suggests that Doppler is useful for ruling out DD and may be especially useful in symptomatic patients. Unfortunately, the specificity was low, producing many false-positive examinations.

KEY WORDS: TMJ; Doppler; Sounds; Sonography

INTRODUCTION

Disc displacement (DD) in the temporomandibular joint (TMJ) has been defined as an abnormal relationship of the disc relative to the mandibular condyle, fossa, and the articular eminence.¹ DD has been associated with pain in the TMJ, clicking, crepitation, headaches, and limitation of jaw opening.² Joint sounds are of interest because they are objective signs of DD or degenerative joint disease (DJD), or both. Various electronic devices have been suggested to enhance the ability to listen and analyze these sounds. It should be noted that joint sounds alone are not a reliable diagnostic indicator of the disease status of the TMJ. However, if other clinical findings are taken into consideration, joint sounds may be clinically useful in the diagnosis of DD.³

The clinical significance of joint sounds has been widely explored. Sounds in the TMJ have been reported to be a common sign associated with joint pain and internal derangement.^{4–7} Widmalm et al⁸ evaluated fresh autopsy specimens and found that joint sounds were always correlated with joint abnormality. The absence of joint sounds did not exclude DD or DJD. Absence of joint sounds has been observed in joints with an anterior disc displacement without reduction (DDN) and in joints with extensive remodeling.⁹ Sounds such as crepitus are often associated with DJD.⁵ Gay and Bertolami¹⁰ have suggested that a lack of synovial fluid or the translatory movement of the condyle over retrodiscal tissue produces crepitus. They did not pro-

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FIGURE 1. Doppler sonogram from an asymptomatic volunteer with a normal joint as diagnosed by MR. The clinical and the Doppler examinations were negative. This is an example of a true negative examination. (Recorded at gain 5.)



FIGURE 2. Doppler sonogram from an asymptomatic volunteer with disc displacement with reduction as diagnosed by MR. The clinical examination was negative, and the Doppler examination was positive. This is an example of a false-negative clinical examination and a true positive Doppler examination. (Recorded at gain 5.)



FIGURE 3. Doppler sonogram from a symptomatic patient with a normal joint as diagnosed by MR. The clinical examination was negative, and the Doppler examination was positive. This is an example of a false-negative clinical examination and a false-positive Doppler examination in a symptomatic patient. (Recorded at gain 5.)

vide objective clinical support of this observation. Clicking may be associated with single irregularities in the condylar path,¹¹ or morphologic changes in articular surfaces,¹² or both. Watt¹³ has suggested that fluid cavitation, or sudden movement of ligaments produces sound; however, he did not show any clinical evidence of this hypothesis.

As suggested by epidemiologic studies, TMJ sounds are present in 34% to 65% of the general population.^{5,6,10,14} Tallents et al¹⁵ evaluated 50 asymptomatic volunteers with bilateral vibration transducers with no clinically audible joint sounds. Forty-four percent of all joints had identifiable sounds, but only 16% of all joints and 24% of all patients had disc displacement with reduction (DDR) or DDN, as demonstrated by magnetic resonance imaging (MRI).¹⁵ Roberts et al¹⁶ found joint sounds in 20% of the Symptomatic normal, 82% of the DDR, and 51% of the DDN symptomatic patients on clinical examination. This suggests that

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FIGURE 4. Doppler sonogram from a symptomatic patient with disc displacement without reduction and DJD as diagnosed by MR. The clinical examination was positive, and the Doppler examination was positive. This is an example of a true positive clinical examination and a true positive Doppler examination in a symptomatic patient. (Recorded at gain 5.)

many patients may not have joint sounds in the presence of DD, implying a high prevalence of false-negative clinical examinations. A recent review suggests that the validity of clinical examination and electronic devices as an aid in the diagnosis of temporomandibular joint disorder (TMD) should be questioned.¹⁷

Doppler auscultation has been suggested to be a noninvasive and a cost-effective instrument used in the diagnosis of DD of the TMJ. Doppler sonography has been used in medicine for the diagnosis of cardiovascular and cerebrovascular disorders.¹⁸ In obstetrics it has been used for monitoring the fetal heart beat and blood flow.¹⁹ The Doppler does this by transforming the ultrasound echoes generated by the turbulence of blood flow to audible and visible sound waves.

Doppler uses sound amplification in the auscultation of TMJ sounds.²⁰ Blood flow in the superficial temporal artery and vein as well as the frictional movements of the condyle-disc-fossa complex can be heard clearly as a result of the sound amplification.²¹ Doppler sonography has been suggested to be able to predict the presence of anterior, medial, and lateral DDs; posterior ligament hyperemia; and adhesions. Doppler is suggested to be useful in patients as a follow-up evaluation to note progression or regression of joint sounds.²² However, there are no studies to substantiate these observations.^{21,22} Currently, there are no controlled studies supporting the use of Doppler analysis for differential diagnosis or even the ability to differentiate between the various types of internal derangement (ie, DDR, DDN, and DD without reduction with DJD [DDN/DJD]).3,23 There is also some question as to the ability of the clinician to predict the presence or absence of DD from clinical findings alone.24

The purpose of this study is to evaluate the accuracy of Doppler sonography to detect joint sounds and compare these findings to MRI and clinical findings.

MATERIALS AND METHODS

Eleven asymptomatic volunteers and 37 TMD patients were included in this study. Asymptomatic volunteers were accepted into the study after completing a subjective questionnaire, which documented the absence of jaw pain, joint noise, locking, or history of TMD treatment. Volunteers had a vertical opening of at least 40 mm.

Symptomatic patients were selected from consecutive patients presenting to the TMD clinic with localized jaw joint pain. The patients had a history of jaw joint pain and one or more of the following symptoms: history of jaw locking decreased mandibular opening or joint noise (click or crepitation). Symptomatic patients and volunteers were collected into two-by-two tables on the basis of the presence or absence of DD. Pain was recorded on a visual analog scale from 0 to 10.²⁵ All subjects signed an informed consent before participation in the study. The subjects were clinically examined by one investigator.

All subjects had MRI of both TMJ in the sagittal closed and open and coronal closed positions. Joints were classified as normal, DDR, or DDN and DDN/ DJD. 26,27

The Doppler examination was performed using the guidelines in the Doppler operation manual. Five patients were recorded five times and correlation coefficients were calculated for within-session variability for Doppler (r = 0.90) and clinical examination (r = 0.92).

Before gathering data, the patient was trained to take 1 second to open and 1 second to close the mouth. The patient was then instructed how to perform lateral movements. A 2- to 3-mm-thick layer of sound transmission gel was applied to the area anterior to the external auditory meatus. The patient was placed in a slightly reclined position in the dental chair, and the transducer was positioned perpendicular to the estimated position of the condyle with very light pressure.

 Table 1.
 MRI Diagnosis of all Joints in Asymptomatic Volunteers and Symptomatic Patients^a

Group	Normal	DDR	DDR/ DJD	DDN	DDN/ DJD	No. of Joints
Asymptomatic	18	4	0	0	0	22
Symptomatic	29	22	1	12	9	73

^a DDR indicates disc displacement with reduction; DJD, degenerative joint disease; and DDN, disc displacement without reduction.

The transducer was manipulated anterior, posterior, superior, and inferior, until the strongest sound of the superficial temporal artery is generated.

After each open and close movements, the calibration button is depressed, indicating one complete cycle. Five open-close cycles and five right and left lateral movements were performed for each joint. This procedure was then repeated on the contralateral side. Clicking and levels of crepitation Figures 3-4 (mild, moderate, and coarse) were graded.²² Open-close and right-left lateral movements were performed for both joints, and a Doppler diagnosis was made as to the presence or absence of DD. If the patient was positive for anything other than mild crepitation, he or she was classified as having a DD by Doppler diagnosis. Mild crepitation was present in 10 of 22 joints (46%) in the asymptomatic volunteers (45%) and in 19 of 73 joints (26%) in the symptomatic patients. This was done to reduce the number of false-positive examinations.

The Doppler findings were compared with MRI of the joints and clinical diagnosis. Two-by-two tables were constructed listing true positives (TP), false positives (FP), true negatives (TN), and false negatives (FN). Sensitivity (TP/TP + FN) and specificity (TN/TN + FP) were then calculated. The data were evaluated as a total group as well as within subgroups for symptomatic TMD patients and asymptomatic volunteers.

RESULTS

Forty-eight subjects (11 asymptomatic volunteers and 37 symptomatic TMD patients) were included in this study. Ninety-five joints were evaluated clinically, with Doppler sonography and MRI (Table 1). One joint was unreadable on MRI and eliminated from calculations.

The mean age of the 48 subjects was 33.3 years (SD = 11.9) and range was 15–57 years. There were 36 females and 12 males. The 11 asymptomatic volunteers had a mean age of 39.5 years (SD = 7.2) with the range being 30–52 years. There were four females and seven males. The 37 symptomatic TMD patients had a mean age of 31.4 years (SD = 12.5) and the range was 15–57 years. There were 32 females and five males.

When clinical diagnosis for all subjects was com-

Table 2. Comparison of Clinical Diagnosis with MRI Findings for Asymptomatic and Symptomatic Subjects (Sensitivity = 73%; Specificity = 68%)^a

		MRI Diagnosis	
		+	_
Clinical	+	TP 35	FP 15
Diagnosis	_	FN 13	TN 32

^a MRI indicates magnetic resonance imaging; TP, true positives; FP, false positives; FN, false negatives; and TN, true negatives.

Table 3. Comparison of Doppler Diagnosis with MRI Findings for Asymptomatic and Symptomatic Subjects (Sensitivity = 90% and Specificity = 49%)^a

		MRI Diagnosis	
		+	_
Doppler	+	43	24
Diagnosis	_	5	23

^a MRI indicates magnetic resonance imaging.

Table 4. Comparison of Clinical Diagnosis with MRI for the Asymptomatic Volunteers (Sensitivity = 0% and Specificity = 100%)^a

		MRI Diagnosis	
		+	_
Clinical	+	0	0
Diagnosis	-	4	18

^a MRI indicates magnetic resonance imaging.

Table 5. Comparison of Doppler Diagnosis with MRI for the Asymptomatic Volunteers (Sensitivity = 100% and Specificity = 56%)

		MRI Diagnosis	
		+	_
Doppler	+	4	8
Diagnosis	_	0	10

pared with MRI, there were 35 TP, 15 FP, 32 TN, and 13 FN (Table 2). The sensitivity of clinical diagnosis was 73% (35/35 + 13) and the specificity was 70% (32/32 + 15).

When Doppler diagnosis for all subjects was compared to MRI, there were 43 TP, 24 FP, 23 TN, and 5 FN (Table 3). The sensitivity was 90% (43/43 + 5) and specificity of Doppler diagnosis was 49% (23/23 + 24).

When clinical diagnosis was compared to MRI for asymptomatic volunteers there were 0 TP, 0 FP, 18 TN, and 4 FN. (Table 4). The sensitivity was 0% (0/0 + 4) and specificity of clinical diagnosis was 100% (18/18 + 0).

When Doppler diagnosis was compared with MRI for asymptomatic volunteers there were 4 TP, 8 FP, 10 TN, and 0 FN (Table 5). The sensitivity was 100%

Table 6. Comparison of Clinical Diagnosis with MRI for the Symptomatic Patients (Sensitivity = 80% and Specificity = 48%)^a

		MRI Diagnosis	
		+	_
Clinical	+	35	15
Diagnosis	-	9	14

^a MRI indicates magnetic resonance imaging.

Table 7. Comparison of Doppler Diagnosis with MRI for the Symptomatic Patients (Sensitivity = 89% and Specificity = 45%)^a

		MRI Diagnosis	
		+	_
Doppler	+	39	16
Diagnosis	—	5	13

^a MRI indicates magnetic resonance imaging.

(4/4 + 0) and specificity of Doppler was 56% (10/10 + 8).

When clinical diagnosis of the subjects was compared with MRI for symptomatic TMD patients there were 35 TP, 15 FP, 14 TN, and 9 FN (Table 6). The sensitivity was 80% (35/35 + 9) and specificity was 48% (14/14 + 15).

When Doppler diagnosis was compared to MRI in the symptomatic TMD subjects there were 39 TP, 16 FP, 13 TN, and 5 FN (Table 7). The sensitivity was 89% (39/39 + 5) and specificity was 45% (13/13 + 16).

DISCUSSION

Doppler sonography has been suggested as useful in the diagnosis and documentation of DD. No studies have been performed on the efficacy of this device for this application. This study evaluated the accuracy of Doppler sonography in determining the presence or absence of TMJ DD.

The sensitivity of the clinical diagnosis was 73%. Widmalm et al⁸ found that absence of joint sounds in cadaver specimens does not exclude DD or DJD. They also suggested that when noise was present all specimens had DD. Eriksson et al⁹ found an absence of sounds in joints with anterior DDN and in joints with extensive remodeling.

The false-positive findings with clinical diagnosis produced a specificity of 68% (Table 2). This is similar to the findings of Tallents et al¹⁵ in asymptomatic volunteers, where 16% of all joints had DD but 44% of all joints had identifiable joint sounds when evaluated with an electronic device.¹⁵ Roberts et al also suggested that 20% of symptomatic normal joints, arthrographically evaluated, had clicking or crepitation sounds.¹⁶

Fifty-one percent of the joints were found to have DD when evaluated with MRI. Five of the 48 (10%) were false negative on Doppler diagnosis. The Doppler diagnosis had a sensitivity of 90% when compared

with MRI (Table 3). Sixty-seven joints (43 + 24) were found to be positive for DD when evaluated with Doppler sonography (71%) (Table 3). Twenty-four (36%) had a false-positive Doppler diagnosis (no DD). There were nine more false-positive findings using Doppler diagnosis compared with clinical diagnosis. This suggests that Doppler sonography increases the risk of false-positive diagnosis, as noted in the specificity of 49% when compared with MRI. Doppler was more effective at ruling out DD than clinical diagnosis (higher sensitivity). If the Doppler is negative, then you are likely to be negative relative to clinical diagnosis alone. However, there were more false-positive findings when compared with clinical diagnosis (lower specificity). An electronic device should have a higher specificity to prevent overdiagnosis.

When the asymptomatic volunteers were evaluated by Doppler, 12 of 22 joints (55%) were positive for DD (Table 5). Eight (67%) were false positive, producing a specificity of 56%. Four of 22 joints (18%) had sounds recorded with Doppler, had DD on MRI producing a sensitivity of 100%. Doppler was effective at predicting DD (sensitivity of 100%) but had many false-positive examinations (specificity of 56%). The Doppler picked up four occult derangements but also suggested that eight volunteers had DD who were normal by MR criteria.

In the symptomatic TMD patients, 50 of 73 joints (68%) were found to be clinically positive for DD (Table 6). Fifteen (30%) were false-positive clinical diagnosis (no DD) when compared with MRI (specificity of 48%). Forty-four of 73 joints (60%) were found to have DD. Nine of the 44 (20%) had no sound (false negative) when examined clinically (sensitivity of 80%).

In the symptomatic TMD patients, 55 of 73 joints (75%) were found to be positive for DD with Doppler sonography (Table 7). Sixteen (29%) were false-positive Doppler diagnoses (specificity of 45%). Forty-four of 73 joints (60%) were found to have DD on MRI, but 5 of the 44 (11%) had false-negative findings with Doppler sonography. Sensitivity was 89% when compared with MRI.

Tables 2 through 7 demonstrate that Doppler diagnosis was more effective at predicting DD than clinical diagnosis (higher sensitivity), but there was an increase in false-positive diagnosis (lower specificity).

The diagnosis of DDN/DJD was eliminated in the clinical diagnosis aspect of this study because different levels of crepitation were difficult to grade by clinical diagnosis. Eriksson et al⁹ has suggested that crep-

itation was an unreliable sign of arthrosis and should be used with caution as a diagnostic aid. This, however, did not change the results because this study compared normal vs DD. DDN and DDN/DJD fell into the DD category when data were collapsed.

When we examine a patient clinically it is important to know whether the patient has DD. Roberts et al¹⁶ suggested that the ability to predict the presence or absence of DD was 67% and in this study it was 71% (35 + 32/95) (Table 2). If the symptomatic patients are evaluated alone (35 + 14/73) it is 67%, which is similar to previous studies.²⁵ We might have a strong clinical opinion that the patient does or does not have DD, but we are wrong 29% to 33% of the time. The ability to predict the presence or absence of DD with Doppler has a predictability of 69% (43 + 23/95) (Table 3). The accuracy of MRI to assess disc position is 73%, and when coronal views are obtained it is 95%^{26,27} and is a more appropriate study to assess disc position when necessary. This may be more important when surgical treatment is considered. Probably the most important reality is that in the initial examination of a patient, the presence or absence of joint sounds should not influence the initiation of conservative (nonsurgical) care. Treatment should be as reversible as possible, especially in patients who have had no previous treatment.

CONCLUSIONS

- The sensitivity of Doppler diagnosis for DD diagnosis was acceptable, because there were few FN.
- Unfortunately the specificity was low, producing many false-positive examinations.

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