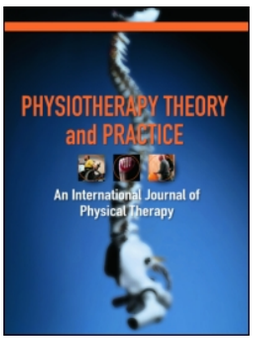

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RESEARCH REPORT

Disc displacement without reduction with limited opening: A clinical diagnostic accuracy study

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ABSTRACT

Purpose: The purpose of this study is to explore the diagnostic accuracy and clinical utility of an examination by a physical therapist using a clinical patient population for diagnosing a specific sub-type of disc displacement (DDWoR wLO) compared to the imaged disc position. **Methods**: Data from 46 patients with a clinical diagnosis of DDWoR wLO (92 clinical examinations and MRI records) were collected. Clinical diagnosis was made based on predefined diagnostic criteria, and the MRI diagnosis was made based on the MRI radiology report obtained from the dental provider. A McNemar test was used to determine whether the outcomes of the clinical and MRI diagnoses differed significantly, and sensitivity, specificity, likelihood ratios, predicative values, 95% confidence intervals, and the overall diagnostic accuracy were computed. **Results**: There was high sensitivity (85%), moderate but unacceptable specificity (73%), and acceptable overall diagnostic accuracy (80%) for using predefined criteria in the diagnosis of DDWoR wLO. The likelihood ratios and predictive values supported the clinical utility of the criteria used for diagnosing DDWoR wLO. **Conclusion**: This is the first study to characterize diagnostic accuracy by a physical therapist of a specific sub-type of TMD in a clinical patient population rather than a research based population. The results suggest that while sensitivity and the overall diagnostic accuracy were acceptable, specificity was lower than acceptable and these findings are discussed in relation to clinical utility of using diagnostic criteria in a clinical setting against a gold standard of MRI.

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Articular disc; disc displacement; physical therapy; sensitivity and specificity; temporomandibular disorders

Introduction

Temporomandibular disorder (TMD) is a musculoskeletal disorder involving the temporomandibular joints (TMJs) and muscles of mastication, and TMD can be a major source of head and orofacial pain (American Academy of Orofacial Pain, 2013). A clear understanding of the TMD problems in the individual patient can assist treatment planning by the professionals involved in their care which can include a variety of healthcare professionals such as dentists, physicians, and physical therapists. An accurate clinical diagnosis is essential not only to researchers who seek to provide sound evidence from which to develop treatments for TMD, but also to clinicians who seek to develop appropriate intervention plans for their patients based on the understanding that different disorders respond differently to treatment (Okeson, 2013).

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), first published in 1992, was an important advancement in providing a diagnostic system to guide research into TMD (Dworkin and LeResche, 1992). In 2014, the criteria were revised to become the Diagnostic Criteria of Temporomandibular Disorders (DC/TMD) with specific diagnostic TMD subsets (Schiffman et al., 2014). Though published diagnostic criteria have been available for over 2 decades, the predoctoral education of practitioners related to identifying specific TMD diagnostic subsets cannot be assumed (Hampton, 2008; Klasser and Greene, 2007; Kraus, 2014) and practicing clinicians may not be experienced in the diagnosis and treatment of TMD (Greene, 2001; McNeill, Falace, and Attanasio, 1992). Since TMD referrals are made from physicians and dentists to other practitioners such as physical therapists with a diagnosis that may not have utilized the current understanding of appropriate TMD classification, establishing an accurate diagnosis on the initial evaluation that can be used to guide treatment is needed (Kraus, 2014). Indeed, in the United States, many states are progressing to direct access to physical therapy without the need for referral, so it is becoming increasingly important that physical therapists become familiar and proficient in the use of diagnostic criteria for all subsets of TMD.

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An effective clinical examination should be able to identify the specific sub-type of TMD, so that appropriate treatment can be implemented. Pain and functional limitations can be associated in varying degrees with different diagnostic subsets of TMD. For example, forming a diagnosis of disc displacement without reduction with limited opening (DDWoR wLO) relies on a robust subjective history of functional limitations as well as objective limited mouth opening findings. This makes DDWoR wLO a useful diagnosis with which to examine clinical diagnostic accuracy. Several attempts have been made to validate clinical diagnoses of disc displacement (Barclay, Hollender, Maravilla, and Truelove, 1999; Emshoff, Brandlmaier, Bertram, and Rudisch, 2002; Emshoff et al., 2002; Manfredini and Guarda-Nardini, 2008; Orsini et al., 1999; Yatani et al., 1998a; Yatani et al., 1998b) with the majority of studies utilizing magnetic resonance imaging (MRI) as the gold standard for assessment of TMJ disc position (Liedberg, 1996; Petersson, 2010; Tasaki and Westesson, 1993). However, with regard to the disc position, MRI can only determine if a disc is displaced partially or completely with mouth closed and if the disc partially or completely reduces on opening, not whether this causes pain or limited opening. This will affect the validation of a clinical diagnosis when it is compared against an MRI gold standard.

Validation of the original TMD diagnostic criteria involved comparing diagnoses derived by trained dental hygienists using the diagnostic algorithms against a diagnostic reference standard from two TMD experts using all available clinical and imaging data at three study sites (Schiffman et al., 2010a; Schiffman et al., 2010b). However, this type of validation is not available in the clinical setting. A clearer understanding of how diagnostic criteria applied in a non-research setting affects diagnostic accuracy when the gold standard is the imaged disc position is needed (Steenks and de Wijer, 2009). The purpose of this study is to explore the diagnostic accuracy and clinical utility of an examination by a physical therapist using a clinical patient population for diagnosing a specific sub-type of disc displacement, DDWoR wLO, compared to the imaged disc position. This study will provide novel information concerning the clinical utility of a physical therapist using diagnostic criteria to make a clinical diagnosis, and will provide a comparison against research based validation studies.

Methods

The institutional review board at Physiotherapy Associates approved this retrospective study, and all patients provided written informed consent at the time of their first physical therapy appointment. New patients were evaluated from patients referred by dental professionals to one out-patient physical therapy clinic run by the primary author who has over 38 years of clinical experience examining and treating individuals with TMD. The initial referral of patients for PT did not routinely include a diagnosis to the level of the sub-type of TMD. In the majority of cases, the referral from the dentist was for evaluation and treatment of facial and/or jaw pain. The pain level was established in the initial physical therapy visit by self-report using an 11-point numeric pain rating scale, ranging from 0 ("no pain") to 10 ("worst pain imaginable"). Data from this study was collected from patients referred for physical therapy from November 15, 2007 through June 9, 2010. The primary author had been incorporating elements of the RDC/TMD examination since it was first published in 1992 including recommended revisions to the RDC/TMD. All patients were evaluated, treated, and ultimately discharged by the primary author. All patients completed a medical history questionnaire, symptom questionnaire, and a symptom location diagram.

Inclusion criteria

During the time of data collection, a total of 97 patients were clinically diagnosed with DDWoR wLO among all patients referred. The initial inclusion criteria for this study were: 1) patients had to be referred to the physical therapy practice by a dentist; 2) patients could not have symptoms arising from active pathology of the head, face, jaw, and/or dentition; and 3) patients had to be able to complete a medical history questionnaire, symptom questionnaire, a symptom location diagram questionnaire, and had to respond to verbal questions during the examination without assistance. Patients had to be diagnosed with a clinical diagnosis of DDWoR wLO by the physical therapist and have had a magnetic resonance imaging (MRI) scan of their TMJ performed with a written report within 1 year as part of their plan of care.

Clinical diagnosis

The clinical diagnosis of DDWoR wLO was made by the primary author. The left and right TMJs were treated as separate cases such that each patient had the potential to be diagnosed as positive or negative for left DDWoR wLO, right DDWoR wLO or bilateral DDWoR wLO.

The primary criteria for diagnosis of DDWoR wLO used across all patients were History (positive for both of the following): 1) a prior history of clicking with or without intermittent locking; and 2) a current report of limited jaw opening sufficient enough to limit mouth opening to interfere with chewing, yawning and brushing of teeth; and a positive exam demonstrating an

active inter-incisal mouth opening of ≤ 30 mm without correction of vertical incisal overlap.

MRI diagnosis

Only patients with MRI's that had been taken as part of the referring dentist's plan of care within one year of the clinical diagnosis were included in this study. As such, not all clinically diagnosed patients had imaging studies performed. At the time of the clinical examination, MRI reports were not available for review by the primary author who was thus blinded to the MRI diagnosis when making the clinical diagnosis. All available MRI reports were later obtained by the primary author from the office of the referring dentist. Diagnoses from the written radiology reports were used to generate the MRI diagnoses. A diagnosis consistent with a non-reducing disc displacement was considered a positive MRI diagnosis. Diagnoses related to a partially displaced or partially reducing disc, a reducing disc, joint effusion, and condylar or disc degeneration were considered negative MRI diagnosis of DDWoR wLO as was an MRI report of normal findings. Fifty-one of the 97 patients reported having an MRI done, but written radiology reports were only available for 47 of the individuals diagnosed with DDWoR wLO. Of those 47 individuals, 1 patient was excluded because the time between the MRI and clinical diagnoses was more than a year. Of the remaining 46 patients, all had bilateral MRIs available as well as bilateral clinical examinations. Therefore, the final sample used for analysis was 92 MRI records and 92 clinical examinations.

Statistical analysis

To analyze the data, a 2 × 2 table was constructed comparing the clinical diagnosis to the diagnosis from the MRI report. Here, diagnostic accuracy is used to refer to the amount of agreement between information from the clinical diagnosis and information from the MRI diagnosis using multiple measures: McNemar test, sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively), positive and negative likelihood ratios (LR+ and LR−, respectively) with 95% confidence intervals (CI_{95}), as well as an overall measure of diagnostic accuracy (Bossuyt and Reitsma, 2003; Fritz and Wainner, 2001). Using IBM SPSS Statistics 22 (Statistical Package for the Social Sciences, Chicago, IL, USA), the McNemar test was used to determine whether the outcomes of the clinical and MRI diagnoses differed significantly. This test helps to determine whether a person's diagnosis is the same, regardless of whether the clinical or MRI diagnosis was used. Other measures of diagnostic accuracy were calculated from the 2 × 2 table. Sensitivity is the proportion of subjects with DDWoR wLO who have a positive clinical diagnosis and specificity is the proportion of subjects without DDWoR wLO who have a negative clinical diagnosis. Acceptable sensitivity and specificity for a definitive diagnosis were considered as sensitivity ≥ 70% and specificity ≥ 95% (Schiffman et al., 2014). Positive and negative predictive values describe the ability of a diagnostic test to correctly determine the proportion of patients with (PPV) or without (NPV) the disease from all patients with a positive or negative test result, respectively. Acceptable PPV and NPV values for diagnostic accuracy were defined as ≥ 75%. Likelihood ratios were calculated to indicate how much the clinical diagnosis raised or lowered the probability of having DDWoR wLO: the larger the positive likelihood ratio (LR+), the greater the likelihood of disease; the smaller the negative likelihood ratio (LR–), the lesser the likelihood of disease (Jaeschke, Guyatt, and Sackett, 1994). A LR+ of between 2 to 4 with a LR– of 0.2 to 0.5 was defined as generating a small but sometimes important shift in probability, while a LR+ of between 5 to10 with a LR– of 0.1 to 0.2 was defined as generating a moderate shift in probability. Overall accuracy was calculated to provide a summary measure of diagnostic accuracy and it is the probability that an individual will be correctly classified by the clinical diagnostic criteria. It is calculated as the sum of true positives plus the sum of true negatives divided by the number of observations (Portney and Watkins, 2008). Acceptable overall diagnostic accuracy was defined as overall accuracy ≥ 75%.

Results

Demographics of the sample are shown in Table 1. Thirty-four of the 46 patients were referred by 5 dentists and 12 patients were referred by 4 oral surgeons. Thirty patients had MRI images taken prior to referral and 16 patients had MRI images taken after referral. The average time between the MRI and the clinical diagnosis was 38 days (range 0–273 days). Thirty of the 46 patients had an MRI within 30 days of the clinical exam, 8 had an MRI between 31 and 60 days of the clinical exam, 5 had an MRI between 61 and 90 days of the clinical exam, and 3 of the 46 patients had an MRI between 91 to 273 days of the clinical exam. MRI reports were obtained from 30 radiologists in 9 radiology centers. There were no adverse events to report from performing either the clinical or the imaging tests.

The McNemar test showed no significant difference between the clinical and MRI diagnoses (Chi-Square = 32.04, p = .81) indicating that there was no statistically significant difference between a person's clinical diagnosis and their MRI diagnosis. Sensitivity was 85% and specificity

Table 1. Demographic, clinical, and MRI characteristics of the patient sample[1].

Patient Age (mean, range)	39 years (13-74)
Physical Therapy Positive Clinical Diagnosis (number of patients)	
Bilateral	10
Right	21
Left	15
MRI Positive Diagnosis (number of patients)	
Bilateral	15
Right	14
Left	11
MRI Negative Diagnosis (number of patients)	6
Duration of symptoms[2] (mean, range)	3.7 months (10 days - 24 months)
Pain score[3] on initial visit (mean, range)	4 (0-8)
Maximum interincisal opening at initial visit (mean ± SD)	26.5 mm (3.8)

[1]Data were derived from the clinical examination of both temporomandibular joints of 46 patients who also had MRI reports which provided a final sample of 92.
[2]Average duration between the time the patient reported jaw locking to the time of clinical diagnosis.
[3]Numeric Pain Rating Scale score on a 0–10 scale, 0 = "no pain", 10 = "worst pain imaginable".

Table 2. Clinical diagnosis results associated with the MRI diagnosis results.

		MRI Diagnosis								
		+ve	−ve	Sensitivity (CI_{95})	Specificity (CI_{95})	PPV (CI_{95})	NPV (CI_{95})	LR+ (CI_{95})	LR- (CI_{95})	Overall Accuracy
Clinical Diagnosis	+ve	47	10	85%	73%	82%	77%	3.2	0.2	80%
	−ve	8	27	(72–93%)	(56–86%)	(70–91%)	(60–90%)	(1.8–5.4)	(0.1–0.4)	

Abbreviations: MRI, magnetic resonance imaging; +ve, positive; −ve, negative; CI_{95}, 95% confidence interval; LR+, positive likelihood ratios; LR−, negative likelihood ratio; PPV, positive predictive value; NPV, negative predictive value.

was 73% (Table 2) indicating acceptable sensitivity but less than acceptable specificity. The PPV and NPV showed acceptable clinical utility of the clinical diagnostic criteria to correctly determine the proportion of patients with (PPV) or without (NPV) the disease from all patients with a positive or negative test result (Table 2). Both the PPV (82%) and NPV (77%) were greater than the threshold value of 75% established a priori. The LR+ indicated that the likelihood of a patient having a DDWoR wLO is increased by approximately three-fold given a positive clinical diagnosis result. The LR– of 0.2 is consistent with a moderate decrease in the probability that an individual with a negative clinical diagnosis will have DDWoR wLO. In order to generate a small but possibly important shift in the probability of having the condition, both LR+ and LR- values should be evaluated. The overall diagnostic accuracy, reported as 80%, was acceptable (Table 2).

Discussion

Previous investigations in the use of diagnostic criteria for sub-types of TMD have indicated good to excellent diagnostic accuracy (Schiffman et al., 2014). However, it is not clear whether this is also true for diagnosing TMD in a clinical setting where tight research control is not feasible and the gold standard for comparison is an MRI. This is the first study to examine diagnostic accuracy of a clinical diagnosis of DDWoR wLO, a sub-type of disc displacement, when the clinical diagnosis was made by a physical therapist compared to a diagnosis generated from a clinically obtained MRI. Taken together, the results showed acceptable sensitivity, less than acceptable specificity, and acceptable overall diagnostic accuracy for using predefined criteria in the clinical diagnosis of DDWoR wLO. In addition, the clinical utility of the diagnostic criteria was good as evidenced by the likelihood ratios and predictive values for both ruling in and ruling out the presence of DDWoR wLO.

Under clinical conditions, the sensitivity of the clinical diagnosis in the current study was high at 85% suggesting that the clinical criteria used can recognize DDWoR wLO when it is present. High sensitivity for a diagnosis also indicates that, when the clinical diagnosis is negative, there is increased confidence for excluding or ruling out the presence of that diagnosis. Specificity on the other hand did not meet the threshold for acceptance of the clinical diagnosis at 73% which was below the acceptable specificity threshold of ≥ 95% (Schiffman et al., 2014). One variable to consider however when comparing the results is that the gold standard to establish diagnostic accuracy in the DC/TMD standard diagnosis was consensus between two TMD and orofacial pain experts using a comprehensive history, physical examination, and all available imaging studies (panoramic radiograph, TMJ MRIs, and computed tomography). Therefore, it is unlikely that a specificity threshold of ≥ 95% could have been achieved

in the present study when the gold standard for comparison was just MRI. Despite that, the overall diagnostic accuracy was acceptable.

Prior studies examining the sensitivity and specificity of clinically diagnosing DDWoR wLO have shown either good to excellent sensitivity (80%) and specificity (97%) using the DC/TMD (Schiffman et al., 2010a) or poor sensitivity (22%) and excellent specificity (99%) using the original RDC/TMD (Truelove et al., 2010). The overall accuracy of the clinical diagnosis in the current study was 80% and this is consistent with previous studies of accuracy found in the diagnosis of disc displacement without reduction (Yatani et al., 1998b). While sensitivity and specificity provide important information about true positive and negative rates, clinicians are more concerned with the predictive value of diagnostic criteria and how findings can help to inform clinical decisions rather than just the sensitivity or specificity of a test. Tests of clinical utility such as likelihood ratios and predictive values are now expected in evidence-based practice (Fritz and Wainner, 2001; Jaeschke, Guyatt and Sackett, 1994). Predictive values give an indication of how likely a patient with a positive or negative diagnosis is to actually have or not have a condition of interest, while likelihood ratios give an indication of how much a clinician should shift their suspicion for the presence or absence of a condition of interest given a particular test result. In addition to sensitivity and specificity, the current study provides both predictive values and likelihood ratios to support the clinical utility of using predefined diagnostic criteria to identify one clinical subtype of disc displacement. The results of this study should provide increased confidence to dental and medical professions about the abilities of a physical therapist to utilize diagnostic criteria to identify clinically significant TMD disc displacement. While the clinician in this study was highly experienced, the straightforward diagnostic criteria used here should enable any physical therapist with appropriate training in obtaining inter-incisal mouth opening measurements to expect similar results. The experience of the clinician however becomes significantly more important in the absence of clear diagnostic criteria. Additionally, it should be noted for all practitioners that the use of diagnostic algorithms in the classification of TMD does not negate the importance of a comprehensive clinical examination to exclude other pathology (Steenks, 2004).

Given the wide spread use of the RDC/TMD and now the DC/TMD, it is prudent to explore how the criteria used in the current study differed from the criteria in other classification systems. At the time of this study, the RDC/TMD used ≤ 35mm of maximum unassisted inter-incisal opening which included correction of vertical incisal overlap. The DC/TMD now utilizes maximum assisted opening (passive stretch) movement including vertical incisal overlap of < 40 mm. The current study used ≤ 30 mm maximum unassisted inter-incisal opening without adding a correction of vertical incisal overlap, which is typically expected to account for 3–5 mm (Okeson, 2013). The rationale for not including vertical incisal overlap is that the relationship between the central incisors is constant and does not change during the time that a patient is receiving treatment. Measuring inter-incisal opening is a useful clinical measurement since it is the variable that is expected to change in response to intervention. The criteria used in the current study did not include the use of passive stretch during opening. The primary author considered this test in the examination but was not reliant on it to make the diagnosis which is consistent with the current DC/TMD. The rationale for this is that clinically, patients with a DDWoR wLO often have concurrent diagnostic subsets of arthralgia and myalgia (Kraus, 2014) and may be fearful of having their jaw passively stretched which would affect the validity of this aspect of the test.

Identifying the value of inter-incisal opening that signifies an abnormal range of motion is made difficult by the large normal range of opening that has been shown in healthy subjects that can vary based on age and gender (Gallagher, Gallagher, Whelton, and Cronin, 2004; Landtwing, 1978; Lewis, Buschang, and Throckmorton, 2001). For maximal mouth opening in healthy subjects, the minimal clinically detectable difference has been suggested to be 5 mm (Kropmans et al., 1999) and therefore ≤ 35 mm of maximum unassisted opening may now be an acceptable point below which to designate limitation. By choosing ≤ 30 mm of inter-incisal opening in the current study, we may have increased the chance of true positive findings. However, from a clinical perspective this also decreased the chance of providing unnecessary treatment for a patient that had an opening in the upper 30 mm range who was satisfied with their functional opening. A diagnosis of DDWoR wLO depends on an unambiguous current history of limited opening and clearly would identify those patients that have limited mouth opening and therefore a clinically significant disc displacement requiring intervention.

Study limitations

This study had several limitations. It lacked a true healthy control group which may have increased the risk of a higher false positive rate. In addition, there was a limitation in having an imperfect reference standard against which to compare clinical diagnostic accuracy. The MRIs were performed at different centers which may have used different criteria for diagnosing limited condylar translation associated with a disc displacement without reduction. In

addition, while imaging can identify disc position and whether the disc can partially or completely reduce, imaging cannot account for whether a non-reducing disc is associated with pain or limited functional opening to discriminate between symptomatic and asymptomatic individuals (Petersson, 2010). Considering that MRI has been shown to identify nearly one-third of asymptomatic volunteers with TMJ disc displacement (Haiter-Neto, Hollender, Barclay, and Maravilla, 2002; Katzberg, Westesson, Tallents, and Drake, 1996; Tasaki et al., 1996), relying on MRI findings alone does not identify a disc displacement that needs treatment from a disc displacement that does not need treatment. Therefore, when comparing against an MRI diagnosis to assess accuracy of a clinical diagnosis as was done in this study, it is unlikely that 100% sensitivity or specificity could be gained. If the MRI diagnosis generated more false positives than truly existed this might explain the lower specificity in the current study. Finally, the extensive experience of the clinician in treating patients with TMD cannot be ignored as potentially increasing the sensitivity and overall diagnostic accuracy of the findings. However, the clinical diagnostic criteria used here could easily be implemented by an entry level physical therapist with some basic training to ensure reliability of obtaining inter-incisal mouth opening measurements.

Conclusions

In conclusion, comparing clinical diagnostic accuracy against an MRI diagnosis demonstrates comparable sensitivity but lower sensitivity than previous comparisons of the use of diagnostic criteria against a clinical gold standard which utilized both expert and imaging findings. However, the use of diagnostic criteria in a clinical population can provide useful input to inform evidence based practice of physical therapists as evidenced by the likelihood ratios and predictive values for both ruling in and ruling out the presence of a specific type of disc displacement.

Acknowledgments

The institutional review board at Physiotherapy Associates approved this retrospective study, and all patients provided written informed consent at the time of their first physical therapy appointment.

Declaration of interest

The authors declare no conflict of interests.

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