Temporomandibular Disorder Diagnostic Groups Affect Outcomes Independently of Treatment in Patients at Risk for Developing Chronicity: A 2-Year Follow-Up Study

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Aims: To evaluate whether a biobehavioral intervention would be more effective than a self-care intervention or no intervention in reducing psychosocial distress, reducing pain, and improving functioning in patients with an acute myofascial temporomandibular disorder (m-TMD). **Methods:** Participants (n = 435) were from community dental clinics in the Dallas-Fort Worth Metroplex who were seeking treatment for their acute TMD symptoms and were recruited between 2008 and 2013. The participants were diagnosed using the Research Diagnostic Criteria for TMD (RDC/TMD) and assigned to a biobehavioral intervention, self-care intervention, or no intervention. Three outcomes were assessed: psychosocial distress, pain, and functioning; and treatment effectiveness was assessed according to TMD diagnosis. Outcome evaluations were conducted immediately postintervention as well as at 1 and 2 years postintervention. Analyses were conducted using two-level hierarchical multilevel linear models (MLMs). **Results:** Contrary to expectations, patients did not respond differently to the intervention based on their TMD diagnosis. Acute m-TMD patients, especially those with other comorbid TMD diagnoses, reported the highest levels of pain and pain-related symptoms and disability. They also exhibited poorer jaw functioning, especially if they were at high risk for chronic TMD. **Conclusion:** This study indicates that acute m-TMD tends to result in more severe symptom presentations, particularly if diagnosed in combination with other TMD comorbidities. Additionally, patients do not appear to respond better to biobehavioral or self-care intervention on the basis of their TMD diagnosis. *J Oral Facial Pain Headache 2016;30:187–202. doi: 10.11607/ofph.1613*

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The temporomandibular joint (TMJ) and associated muscular structures enable horizontal and vertical movements through sliding and bending motions. When a dysfunction or abnormality arises in any of these areas, a temporomandibular disorder (TMD) develops.[1–5] TMD is a common musculoskeletal condition—according to the US National Institute of Dental and Craniofacial Research (NIDCR), about 10 million people in the US (4% of the population) are suspected to have TMD[4,6] and it is estimated that TMD patients spend over $4 billion per year to treat their symptoms.[6,7] These high costs are related to the multifaceted symptom presentation of the disorder. TMD impairs jaw functioning and can cause complications such as stiffening in the jaw, orofacial pain, a restricted range of motion in the TMJ, and abnormal or audible jaw movements (eg, clicking and popping).[4,8–13] Overall, pain is documented as the most common symptom of TMD and it typically dictates treatment-seeking behavior.[1,4,11,14–20] In order to better address this prevalent and costly condition, treatments have become more focused on conservative, reversible approaches instead of more invasive procedures. The Institute of Medicine Report "Relieving Pain in America"[21] emphasized the need to develop cost-effective, early interventions to better manage pain and prevent chronicity. In order to begin this process, in a recent publication[22] various studies were reviewed that focused on acute TMD patients who were at risk for developing chronic and costly TMD problems.[7,13,23–32] Overall, findings revealed that an

early biobehavioral intervention for at-risk acute TMD patients was efficacious in preventing chronicity. The reader is referred to the aforementioned citations for a comprehensive review of these studies. The present study extends the findings of Dougall et al[22] by performing subgroup analyses of the main TMD population exposed to the intervention.

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) diagnostic system[33] has garnered much acceptance and international use in objectively diagnosing and assessing TMD for clinical research purposes.[26,34,35] According to some clinical researchers, TMD should be considered a set of disorders as opposed to only one condition.[17] This perspective is supported by the various subdiagnoses that one can be given.[20] Diagnoses—myofascial TMD (m-TMD), disc displacements, and degenerative joint diseases—are assigned based on physical symptoms, but there are subgroups and often comorbidities for each. It has been found that m-TMD, particularly myofascial pain, is the most prevalent diagnosis.[12,16,36–40] Additionally, past research has shown that psychosocial distress (depressive symptoms, stress, somatization, etc) has a strong relationship with m-TMD.[2,40–42] In a recent review of the literature, Velly et al[43] highlighted the various psychosocial comorbidities (stress, anxiety, depression, catastrophizing, etc) that are common in patients with orofacial pain, especially TMD-related pain. Dahan et al[44] have also recently reported that patients with m-TMD have a greater prevalence of self-reported migraine and chronic fatigue syndrome compared with nonmyogenous TMD patients. Furthermore, according to the RDC/TMD, in order to be diagnosed with m-TMD one must experience pain upon palpation in at least three locations of the extraoral muscles and/or the intraoral muscles[31]; therefore, the experience of pain is inherent in a diagnosis of m-TMD. However, all TMD diagnostic groups (ie, RDC/TMD Axis I) have been linked to poor health outcomes.[45]

Historically, TMD has been known as a chronic pain condition and because over one-third of all costs associated with such a condition are attributed to orofacial pain, some members of the present research team engaged in an investigation to determine how chronic TMD patients differed from nonchronic TMD patients.[28] This led to further research, which helped to develop an algorithm differentiating between those at either a high risk or a low risk for developing chronic TMD.[27] Most recently, it was reported that biobehavioral and self-care interventions can be effectively implemented in a community setting to improve psychosocial symptoms as well as symptoms of pain and functionality among patients at high risk for chronic TMD.[22] Furthermore, the biobehavioral intervention produced a quicker response while the self-care intervention was more likely to lose effectiveness over time.

Based on these various findings, the current study was conducted to assess whether the effectiveness of an early biobehavioral intervention for acute TMD patients would vary by diagnosis (ie, myogenous versus nonmyogenous; multiple diagnoses versus singular diagnosis) in terms of reducing psychosocial distress, reducing pain, and improving functionality compared with patients receiving either a self-care intervention or no intervention; in particular, it was hypothesized that m-TMD patients would exhibit worse symptoms at the outset of the study but report greater improvements following the biobehavioral treatment. Myogenous pain appears to be more debilitating than pain that is evoked from the TMJs,[44] which may be because m-TMD is inherently painful and affects a larger portion of the craniomandibular region as compared with other TMD diagnoses (ie, disc displacements and joint diseases).[46] This discomfort can spread into other aspects of a TMD sufferer's life; therefore, it was believed that a myogenous diagnosis would result in a heightened experience of various TMD-related symptoms. Additionally, oral parafunctional habits (clenching, grinding, etc) are highly related to m-TMD diagnoses[2,41,47] and investigating these symptoms will help determine whether there are differential treatment effects in an acute TMD population according to an individual's RDC/TMD diagnosis. Moreover, because muscle disorders are common among TMD sufferers,[13,16,36–40] it is clinically important to determine if the subset of patients with a myogenous diagnosis benefit more from an early biobehavioral intervention than patients with a different TMD diagnosis. Specifically tailored treatment protocols might then be shown to be more effective for certain patients, in keeping with the current call for precision medicine.[48]

Again, investigations of acute TMD populations are imperative given the pervasiveness,[4,6] high costs,[6–8,25] and debilitating nature of the disorder once it becomes chronic.[1,9,49–51] Such factors can also be magnified when considering the number of co-occurring TMD diagnoses. Unfortunately, some studies have excluded patients with multiple TMD diagnoses[2,52] despite the fact that they are relatively common.[30,31,37,38,40,53,54] The present study, however, included analyses of patients with multiple diagnoses and thus is more generalizable and will significantly add to the TMD literature.

On the basis of these findings, the goal of the present study was to evaluate whether a biobehavioral intervention would be more effective than a self-care intervention or no intervention in reducing psychosocial distress, reducing pain, and improving

Table 1 Demographic Characteristics (n = 435)

	HR/BB, n = 168		HR/SC, n = 131		LR/NI, n = 136				
Variable	M/n	(SD)/(%)	n/M	(%)/(SD)	n/M	(%)/(SD)	χ^2/F	*df*	*P*
Education[a,b] (M[SD])	15.33	(2.17)	15.09	(2.29)	15.27	(2.25)	.46	2,425	.63
Age[a,b] (M[SD])	44.14	(14.99)	42.95	(14.41)	44.61	(17.95)	.39	2,430	.68
Race (n[%])							4.41	8	.82
Caucasian	119	(70.8)	92	(70.2)	93	(68.4)	–	–	–
Latino/a	21	(12.5)	13	(9.9)	18	(13.2)	–	–	–
African American	17	(10.1)	17	(13)	17	(12.5)	–	–	–
Asian	5	(3)	6	(4.6)	2	(1.5)	–	–	–
Other	6	(3.6)	3	(2.3)	6	(4.4)	–	–	–
Gender (n[%])							2.07	2	.36
Male	30	(17.9)	25	(19.1)	33	(24.3)	–	–	–
Female	138	(82.1)	106	(80.9)	103	(75.7)	–	–	–
Marital status (n[%])							14.94	8	.06
Single	52	(31)	37	(28.2)	49	(36)	–	–	–
Married	92	(54.8)	70	(53.4)	65	(47.8)	–	–	–
Divorced or Separated	20	(11.9)	21	(16)	14	(10.3)	–	–	–
Widowed	4	(2.4)	3	(2.3)	3	(2.2)	–	–	–
Not Reported	–	–	–	–	5	(3.7)	–	–	–
Combined household income[b] (n[%])							2.96	8	.94
$0–14,999	16	(9.5)	16	(12.2)	14	(10.3)	–	–	–
$15,000–24,999	12	(7.1)	12	(9.2)	10	(7.4)	–	–	–
$25,000–34,999	14	(8.3)	10	(7.6)	15	(11)	–	–	–
$35,000–49,999	17	(10.1)	10	(7.6)	10	(7.4)	–	–	–
$50,000 or more	106	(63.1)	78	(59.5)	80	(58.8)	–	–	–

[a]Indicates variable is measured in terms of years; [b]indicates variable has system missing values. M = mean; SD = standard deviation.

functioning in patients with acute m-TMD. Additionally, it was hypothesized that patients with m-TMD would present with worse symptoms but respond more favorably to the biobehavioral intervention than patients with other TMD diagnoses.

Materials and Methods

A total of 435 patients with acute TMD were studied. They were administered the RDC/TMD as well as an algorithm for determination of their risk status, high risk or low risk, for developing chronicity.[27] This proprietary algorithm consisted of combining two components of the RDC/TMD: self-reported characteristic pain intensity scores and certain diagnostic indices of myofascial pain. The high-risk patients were then randomly assigned to an early biobehavioral intervention (HR/BB group) or an early self-care intervention (HR/SC group). The LR patients were not assigned to either intervention (LR/NI group), but were not prevented from seeking any treatment on their own.

Participants

The inclusion criteria were as follows: *(1)* be 18 years of age or older; *(2)* have experienced jaw pain no more than 6 months prior to entering the study; *(3)* have no prior history of chronic jaw or face pain; and *(4)* have no comorbid, pain-exacerbating condition[34] (eg, fibromyalgia, low back pain, etc).[3] Participants were recruited from community dental clinics in the Dallas-Fort Worth Metroplex for their TMD symptoms between 2008 and 2013 in the following ways: referrals from community dental clinics, flyers that described the study, word of mouth, internet advertisements, and advertisements disseminated to a mailing list of potential participants. All participants signed an informed consent form. The study and the consent form were approved by the Institutional Review Boards of the University of Texas at Arlington and Texas A&M University Baylor College of Dentistry.

Overall, the sample was middle-aged and consisted mainly of individuals who were college-educated, Caucasian, female, married, and who had a combined household income of at least $50,000 (Table 1). There were no significant demographic differences between the three intervention groups. It should also be noted that the majority of patients had an Axis I RDC/TMD diagnosis: m-TMD only (n = 95); disc displacement only (n = 20); degenerative joint disease only (n = 43); multiple diagnoses including m-TMD (n = 187); multiple diagnoses excluding m-TMD (n = 10); and no diagnosis (n = 80).

Measures

As previously delineated by Dougall et al,[30] trained clinicians administered the RDC/TMD, including the components of the at-risk screening algorithm.[27] The RDC/TMD is comprised of two axes. Axis I involves a physical evaluation, which allows for the physical

TMD diagnosis. Axis II consists of self-report measures assessing psychosocial factors commonly seen in TMD patients. The RDC/TMD evaluators were trained on the RDC/TMD administration by an experienced oral surgeon. Interrater reliability for correct completion of the TMD examination was initially conducted on nonsubject volunteers prior to the start of the study. Quality control of the evaluations was maintained by reevaluating randomly selected cases throughout the project (all cases were recorded) as well as recalibrating evaluators when needed. The initial guidelines delineated by Dworkin et al[55] were followed. This produced close to 100% reliability among evaluators because of routine recalibration sessions. However, as in many large-scale investigations such as the present, there were sometimes inadvertent errors made in entering values in the administration forms during the assessment process. However, these errors were minimal.

Characteristic Pain Inventory. The Characteristic Pain Inventory (CPI) consists of three items that ask participants to rate the severity of the pain they have been experiencing from 0 ("no pain") to 10 ("pain as bad as could be") in reference to three items: *(1)* current pain; *(2)* worst pain during the previous 6 months; and *(3)* average pain during the previous 6 months. The responses to these three items were averaged and then multiplied by 10 to get a pain rating from 0 to 100 with higher numbers corresponding to more pain. In the present sample, the CPI showed high reliability (α = .88).

Graded Chronic Pain Scale. The Graded Chronic Pain Scale (GCPS) is a validated scale that uses a combination of two different measures: the CPI and pain-related disability items.[41,56,57] In addition to three CPI items used for the GCPS, there are four pain-related disability items, three of which assess the degree to which pain has interfered with daily activities rated from 0 ("no interference") to 10 ("unable to carry on any activities"). The fourth pain-related disability item asks participants to indicate the number of days they have not been able to perform their usual activities within the last 6 months. The responses to all seven items were then used to determine five grades of disability, from 0 ("no disability") to 4 ("high disability-severely limiting").

Somatization. Both of the somatization measures were derivatives of the Symptom Checklist-90. The painful somatization scale consists of 12 items that gauge painful somatization tendencies (headaches, nausea, muscle soreness, etc), which are measured on a 5-point scale from 0 ("not at all") to 4 ("extremely"). The responses to the items are averaged to provide an overall score. In the present sample, the painful somatization scale showed high reliability (α = .85). The nonpainful somatization scale consists of seven items that gauge nonpainful somatization tendencies (eg, numbness, dizziness, feeling weak, etc) that are assessed on the same 5-point scale as the painful somatization measure and the responses to the items are averaged to provide an overall score. Higher scores on each somatization scale indicate greater somatization tendencies. In the present sample, the nonpainful somatization scale showed high reliability (α = .79).

Perceived Stress Scale. The Perceived Stress Scale (PSS)[58] measures how one interprets the stressfulness of events that have occurred in the month prior to completing the scale and consists of 10 items. Participants indicated the frequency with which they experienced stressful emotions on a 5-point scale that ranged from 0 ("never") to 4 ("very often"). All 10 items were summed, producing a score that could range from 0 to 40. A higher score was indicative of a relatively higher level of stress. In the present sample, the PSS demonstrated high reliability (α = .91).

Beck Depression Inventory-II. The Beck Depression Inventory-II (BDI-II)[59] was used to assess depressive symptomatology. It consists of 21 items and responses to each item range from 0 to 3. The responses to each item were totaled with a possible maximum score of 63. Higher scores indicated more severe levels of depressive symptoms. In the present sample, the BDI-II showed high reliability (α = .92).

Short-Form 36. The Short-Form 36 (SF-36)[60] is a health survey of 36 items that evaluate individuals' quality of life (QoL) as a result of their current health. It consists of eight scales that measure different facets of health related to both physical and mental wellness. Scores range from 0 to 100 with higher scores indicating a greater improvement in wellbeing. In the present sample, this measure showed high reliability (α = .94).

Chewing-related Pain. In order to obtain a measure of functional pain, participants were asked to chew five tablets of an artificial test food material (CutterSil). After chewing the fifth tablet, participants were asked to indicate which side of their mouth felt most uncomfortable during chewing and to rate their level of chewing pain from 0 ("no pain") to 10 ("pain as bad as could be") for both sides. Because the TMD literature does not suggest one side of the mouth being more prone to pain than the other side, the pain rating was taken from the least comfortable side of the mouth. In the event that a participant indicated that both sides were equally uncomfortable, an average of the two pain ratings was used.

Masticatory Performance. As explained above, participants were given five tablets of CutterSil to chew in order to ascertain each participant's level of masticatory performance. CutterSil is a standardized, artificial test food material that consists of condensed silicone with negligible flavor, scent, or absorptive

properties; these characteristics make CutterSil a superb material for evaluating functionality in terms of mastication.[61] Evaluation is done using median particle size (MPS) and broadness of distribution (BD) of the CutterSil. MPS is measured in millimeters and gives an indication of masticatory performance with a small level being indicative of adequate breakdown of the test food material, which can give some indication of better nutritive absorption later on in the digestive process.[7] Similarly, the BD measure serves as an indication of the variance of the sample and a small level, which is associated with a wider distribution, is indicative of a superior masticatory performance.[62] For more details on the development and assessment of CutterSil, the reader is directed elsewhere.[62]

Procedure

After the participants formally consented and were deemed eligible for the study, the baseline evaluation, which included the aforementioned assessments, was completed. After the baseline evaluation, each participant's at-risk status was determined by using the algorithm developed by the authors.[27] Participants were then categorized as at low risk or at high risk for chronic TMD. This method has produced 91% correct classification rates among chronic TMD patients.[27] If participants were determined to be at low risk for developing chronic TMD, they were assigned to the low-risk, no intervention (LR/NI) group. If participants were determined to be at high risk for developing chronic TMD, they were randomized into one of two intervention groups: the high-risk, biobehavioral intervention (HR/BB) group or the high-risk, self-care intervention (HR/SC) group. During the intervention phase, the HR/BB group received a biobehavioral intervention that included cognitive behavioral treatment techniques as well as biofeedback. The HR/SC group received a self-care intervention that included educational materials on the management of TMD (Fig 1). The intervention phase consisted of six sessions that lasted for about 3 weeks depending on the participant's schedule and afterwards a series of postintervention follow-up evaluations were administered to all participants. These postintervention evaluations occurred immediately after the intervention, 1 year after the intervention, and 2 years after the intervention (Fig 2).

Data Analyses

The outcome measures (psychosocial, pain, and functioning) were assessed across the four major time points: preintervention, immediate postintervention, 1-year follow-up, and 2-year follow-up. The participants were grouped based on both the RDC/TMD Axis I diagnosis determined at preintervention and their treatment group: LR/NI, HR/BB, or HR/SC.

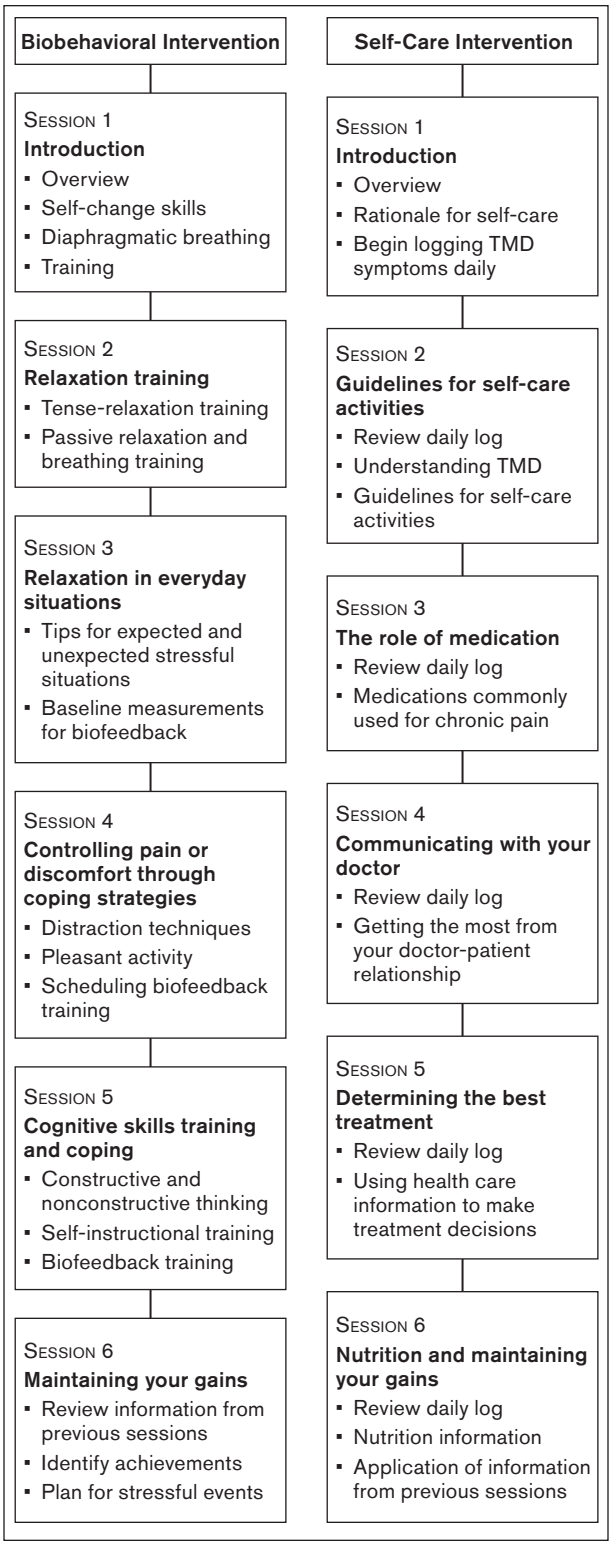

Fig 1 Comparison of HR/BB and HR/SC interventions.

Analyses were conducted using two-level hierarchical multilevel models (MLMs). These models were chosen over traditional ANOVA models because they handle missing and unbalanced repeated-measures data and model between- and within-subjects effects.

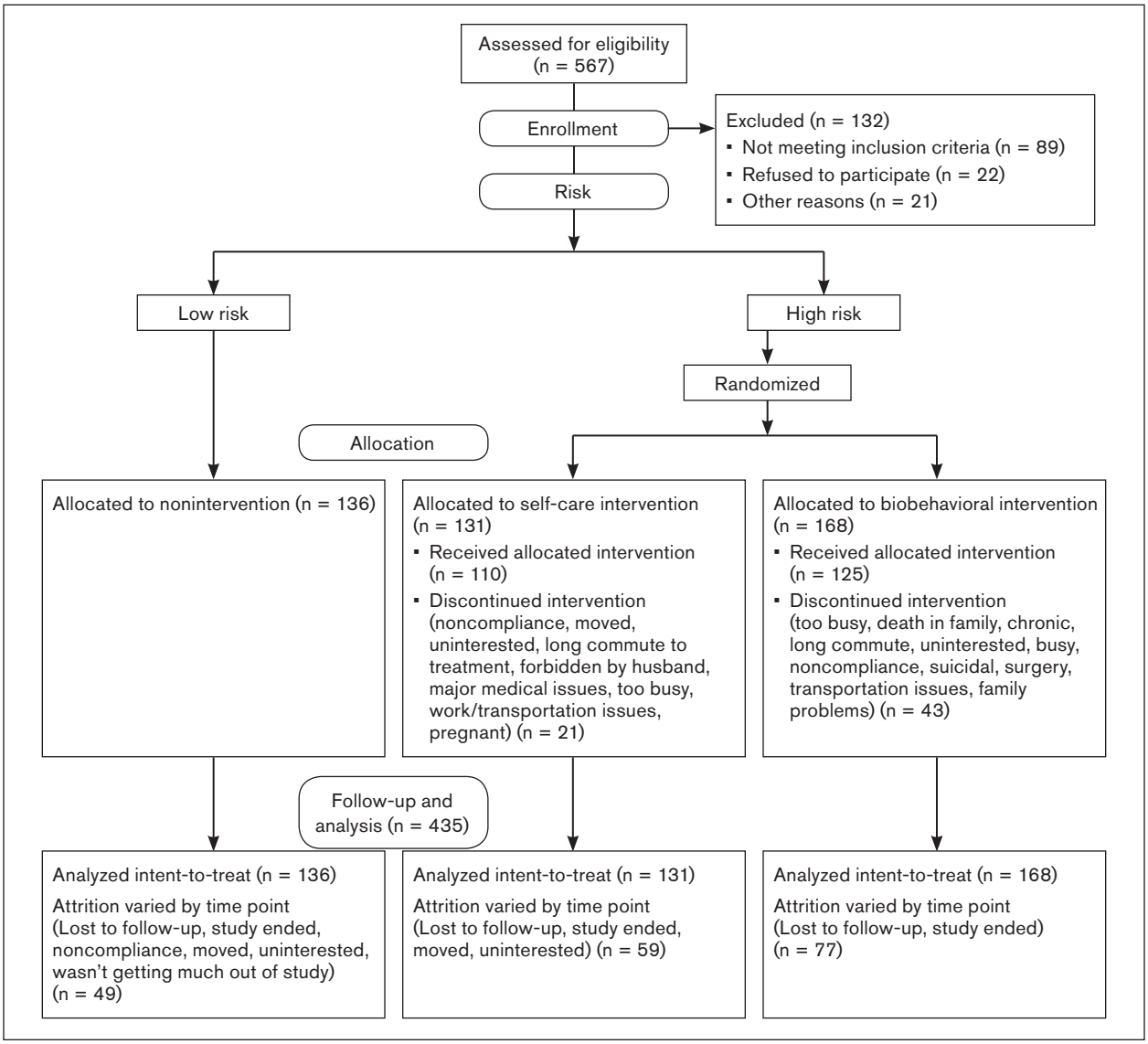

Fig 2 Participant flowchart.

Calculation of intraclass correlation coefficients for the models that included only a random intercept confirmed that a substantial amount of variance (21% to 67%) in each outcome was attributable to the second-level factors, confirming that MLM was an appropriate statistical strategy (Table 2). As in a traditional ANOVA, the interest was in comparing categorical group differences based on mean symptom reports. Therefore, only the fixed effects of the independent variables were examined; specifically, the between-subjects effects of diagnosis group and treatment group, the within-subjects effect of time, and the resulting two-way and three-way interactions. To better fit the data, the models included random intercepts and used a heterogenous autoregressive covariance matrix to model the effect of time. The full MLM equation was:

$$Y_{ij} = \gamma_{00} + \gamma_{10}\text{Time} + \gamma_{01}\text{Group} + \gamma_{02}\text{Diagnosis} + \gamma_{03}\text{Group}\times\text{Diagnosis} + \gamma_{11}\text{Time}\times\text{Group} + \gamma_{12}\text{Time}\times\text{Diagnosis} + \gamma_{13}\text{Time}\times\text{Group}\times\text{Diagnosis} + u_{0j} + e_{ij}$$

The following models were examined: intercepts only; main effects of time, diagnosis group, and treatment group (all fixed effects); all possible two-way interactions; and a fourth model that added the three-way interaction among diagnosis group, treatment group, and time. This fourth model tested the hypothesis that the effects of treatment would vary over time according to diagnostic group. However, none of the models, including this three-way interaction, fit the data and so were not reported. There was still interest in examining the direct effects of diagnosis, as well as whether diagnostic group moderated the effects of time or the effects of the treatment

Table 2 Model Fit and Improvement for the Psychosocial, Pain, and Functional Outcome Variables

Outcome	Parameters	−2 Log likelihood	χ^2 Difference test or ICC
Psychosocial outcomes			
Perceived stress (n = 435; observations = 1,184)			
Intercept only	3	7,598.47	ICC = .65
Main effects	17	7,518.09	$\chi^2(14) = 80.383$, $P < .001$
Two-way interactions	48	7,463.46	$\chi^2(31) = 54.63$, $P = .005$
Three-way interaction	77	7,447.73	$\chi^2(29) = 15.732$, $P = .98$
Depressive symptoms (n = 434; observations = 1,159)			
Intercept only	3	7,503.43	ICC = .67
Main effects	17	7,369.08	$\chi^2(14) = 134.35$, $P < .001$
Two-way interactions	48	7,311.67	$\chi^2(31) = 57.40$, $P = .003$
Three-way interaction	77	7,278.28	$\chi^2(29) = 33.40$, $P = .26$
Mental health quality of life (n = 434; observations = 1,186)			
Intercept only	3	8,684.74	ICC = .51
Main effects	17	8,590.50	$\chi^2(14) = 94.24$, $P < .001$
Two-way interactions	48	8,560.03	$\chi^2(31) = 30.47$, $P = .49$
Three-way interaction	77	8,538.21	$\chi^2(29) = 21.82$, $P = .83$
Nonpainful somatization (n = 435; observations = 1,186)			
Intercept only	3	1,551.74	ICC = .61
Main effects	17	1,458.45	$\chi^2(14) = 93.29$, $P < .001$
Two-way interactions	48	1,412.52	$\chi^2(31) = 45.93$, $P = .04$
Three-way interaction	77	1,382.64	$\chi^2(29) = 29.88$, $P = .42$
Pain outcomes			
Self-reported pain (n = 435; observations = 1,188)			
Intercept only	3	11,129.66	ICC = .21
Main effects	17	10,214.46	$\chi^2(14) = 915.20$, $P < .001$
Two-way interactions	48	10,076.79	$\chi^2(31) = 137.68$, P < .001
Three-way interaction	77	10,055.58	$\chi^2(29) = 21.21$, P = .85
Chewing pain (n = 424; observations = 1,126)			
Intercept only	3	5,153.80	ICC = .46
Main effects	17	4,797.82	$\chi^2(14) = 355.98$, $P < .001$
Two-way interactions	48	4,711.23	$\chi^2(31) = 86.60$, $P < .001$
Three-way interaction	77	4,673.46	$\chi^2(29) = 37.77$, $P = .13$
Painful somatization (n = 435; observations = 1,186)			
Intercept only	3	1,590.05	ICC = .65
Main effects	17	1,481.43	$\chi^2(14) = 108.62$, $P < .001$
Two-way interactions	48	1,432.24	$\chi^2(31) = 49.20$, $P = .02$
Three-way interaction	77	1,408.15	$\chi^2(29) = 24.08$, $P = .73$
Pain-related disability (n = 435; observations = 1,187)			
Intercept only	3	3,208.29	ICC = .25
Main effects	17	2,591.98	$\chi^2(14) = 616.31$, $P < .001$
Two-way interactions	48	2,455.28	$\chi^2(31) = 136.70$, $P < .001$
Three-way interaction	77	2,433.33	$\chi^2(29) = 21.95$, $P = .82$
Functional outcomes			
PQoL (n = 434; observations = 1,186)			
Intercept only	3	8,151.78	ICC = .61
Main effects	17	8,082.40	$\chi^2(14) = 69.38$, $P < .001$
Two-way interactions	48	8,029.58	$\chi^2(31) = 52.82$, $P = .01$
Three-way interaction	77	7,995.35	$\chi^2(29) = 34.23$, $P = .23$
MPS (n = 425; observations = 1,078)			
Intercept only	3	3,202.41	ICC = .64
Main effects	17	3,084.07	$\chi^2(14) = 118.34$, $P < .001$
Two-way interactions	48	3,029.11	$\chi^2(31) = 54.96$, $P = .005$
Three-way interaction	77	3,003.94	$\chi^2(29) = 25.17$, $P = .67$
BD (n = 425; observations = 1,078)			
Intercept only	3	8,465.01	ICC = .59
Main effects	17	8,306.95	$\chi^2(14) = 158.06$, P < .001
Two-way interactions	48	8,274.97	$\chi^2(31) = 31.98$, P = .42
Three-way interaction	77	8,243.88	$\chi^2(28) = 31.09$, P = .31

ICC = intraclass correlation coefficient; MHQoL = mental health quality of life; PQoL = physical quality of life; MPS = median particle size; BD = broadness of distribution.

Table 3 Significance Tests for the Fixed Effects in the Final Multilevel Models by Psychosocial Outcomes

Outcome/effect from final model	Significance test
Perceived stress	
Diagnosis group	$F(5,439.91) = 2.76$, $P = .02$
Treatment group	$F(2,433.46) = 0.02$, $P = .98$
Time	$F(3,267.45) = 7.52$, $P < .001$
Diagnosis group × treatment group	$F(10,422.20) = 531.00$, $P = .87$
Diagnosis group × time	$F(15,270.83) = 2.18$, $P = .01$
Treatment group × time	$F(6,270.56) = 1.81$, $P = .10$
Depressive symptoms	
Diagnosis group	$F(5,411.54) = 2.18$, $P = .06$
Treatment group	$F(2,413.40) = 0.07$, $P = .93$
Time	$F(3,263.32) = 11.26$, $P < .001$
Diagnosis group × treatment group	$F(10,407.99) = 0.93$, $P = .51$
Diagnosis group × time	$F(15,280.39) = 1.53$, $P = .10$
Treatment group × time	$F(6,259.75) = 3.01$, $P = .01$
MHQoL	
Diagnosis group	$F(5,393.23) = 3.27$, $P = .01$
Treatment group	$F(2,407.47) = 0.10$, $P = .91$
Time	$F(3,286.25) = 16.16$, $P < .001$
Nonpainful somatization	
Diagnosis group	$F(5,389.06) = 4.60$, $P < .001$
Treatment group	$F(2,402.14) = 0.79$, $P = .45$
Time	$F(3,288.77) = 1.81$, $P = .15$
Diagnosis group × treatment group	$F(10,391.47) = 0.92$, $P = .51$
Diagnosis group × time	$F(15,292.65) = 0.74$, $P = .75$
Treatment group × time	$F(6,288.92) = 2.90$, $P = .01$

MHQoL = mental health quality of life.

group regardless of time. Therefore, only the effects involving diagnostic group are reported, although all analyses did include treatment group and treatment group over time to control for their effects. Readers are referred to a previous report for the findings related to treatment group over time.[22] For simplicity, only the models at the highest level are reported. Post hoc analyses using a Bonferroni correction for multiple comparisons were conducted to determine which levels of the variables were different from one another. As was expected, there were no significant differences between the demographic variables across the conditions of the study (Table 1).

Results

Contrary to expectations, the main hypothesis was not supported: the biobehavioral intervention was not more effective for patients with m-TMD. However, other effects involving TMD diagnostic group were of interest and are reported below, controlled for the effects of time and treatment group over time, which were reported previously.[22]

Psychosocial Distress

In order to assess the effects of the different interventions on psychosocial distress (perceived stress, depressive symptoms, mental health quality of life [MHQoL], and nonpainful somatization) in terms of TMD diagnoses, a series of MLMs were conducted to determine the best fit for the data (Tables 2, 3, and 4). Reports of perceived stress changed over time as a function of diagnosis (diagnosis group × time). As expected, simple-effects analyses revealed that at preintervention m-TMD patients reported significantly more perceived stress than patients diagnosed with degenerative joint disease, multiple diagnoses excluding m-TMD, or no diagnosis; patients with multiple diagnoses including m-TMD also reported significantly more perceived stress at preintervention than patients with no diagnosis. However, there were no significant differences between the diagnostic groups at any other time point. Additionally, analysis of simple effects of time revealed that reports of perceived stress significantly decreased from preintervention to all later assessments for patients diagnosed with m-TMD and multiple diagnoses including m-TMD, as well as for patients diagnosed with disc displacement. Furthermore, when averaging across the four time points, it was revealed that diagnosis affected MHQoL and nonpainful somatization. As expected, patients diagnosed with m-TMD and with multiple diagnoses including m-TMD reported significantly poorer MHQoL than patients with multiple diagnoses excluding m-TMD. Additionally, patients diagnosed with m-TMD reported significantly more nonpainful somatization than patients with degenerative joint disease or no diagnosis. In contrast, there were no significant differences in reports of depressive symptoms by diagnosis group.

Pain

MLMs were conducted in order to assess the differential treatment effects on pain according to TMD diagnosis (Table 2). There were significant effects of diagnosis group on all measures of pain (averaging across time and treatment group): self-reported pain, chewing-related pain, painful somatization, and pain-related disability (Tables 5 and 6). In general, patients diagnosed with m-TMD or with multiple diagnoses including m-TMD tended to report more of all types of pain than patients with nonmyogenous TMD diagnoses. Participants with multiple diagnoses including m-TMD reported higher levels of all types of pain than participants with other diagnoses. These patients also reported significantly more pain during chewing than those with degenerative joint disease, m-TMD alone, or no diagnosis; and reported significantly more pain-related disability than patients with degenerative joint disease or no diagnosis.

Table 4 Means and Standard Errors by Diagnosis and Time for the Psychosocial Outcomes

	No RDC/TMD Axis I diagnosis		m-TMD		Disc displacement		Degenerative joint disease		Multiple diagnoses including m-TMD		Multiple diagnoses excluding m-TMD	
Outcome	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
Perceived stress												
Preintervention	12.88[a,d]	0.81	17.33[a,b,c,1,2,3]	0.76	18.13[1,2,3]	1.60	13.33[b]	1.08	16.68[d,1,2,3]	0.56	9.82[c]	2.36
Postintervention	13.60	0.88	15.11[1]	0.81	12.91[1]	1.75	12.55	1.11	14.41[1]	0.62	9.65	2.43
1 y	13.45	0.98	14.32[2]	0.88	11.33[2]	2.09	11.41	1.26	13.66[2]	0.70	9.08	2.68
2 y	14.05	1.10	15.24[3]	0.88	12.18[3]	2.15	11.20	1.37	14.14[3]	0.70	11.19	2.74
Total	13.49	0.76	15.50	0.70	13.64	1.52	12.12	0.98	14.73	0.53	9.94	2.18
Depressive symptoms												
Preintervention	5.72	0.87	9.78	0.81	8.17	1.73	6.74	1.16	9.98	0.60	4.30	2.51
Postintervention	5.22	0.89	7.06	0.81	4.53	1.76	5.80	1.12	6.76	0.62	3.07	2.45
1 y	5.25	0.98	6.18	0.89	2.97	2.04	4.13	1.25	6.15	0.68	2.65	2.72
2 y	5.22	1.06	6.67	0.86	1.63	2.03	4.34	1.30	5.67	0.68	3.06	2.65
Total	5.35	0.78	7.43	0.71	4.33	1.53	5.26	1.00	7.14	0.53	3.27	2.22
MHQoL												
Preintervention	48.23	1.22	44.08	1.14	45.70	2.44	49.61	1.66	45.49	0.85	55.95	3.56
Postintervention	50.18	1.31	48.22	1.20	50.61	2.60	51.28	1.61	49.00	0.91	57.59	3.51
1 y	49.73	1.43	49.56	1.29	51.75	3.08	52.79	1.82	49.98	1.01	58.47	3.73
2 y	47.92	1.53	46.88	1.19	54.63	2.97	52.54	1.88	49.87	0.95	55.78	3.78
Total	49.01	1.03	47.18[a]	0.93	50.67	2.05	51.55	1.30	48.58[b]	0.71	56.95[a,b]	2.93
Nonpainful somatization												
Preintervention	0.30	0.06	0.60	0.06	0.21	0.12	0.32	0.08	0.60	0.04	0.19	0.18
Postintervention	0.25	0.07	0.52	0.06	0.27	0.13	0.26	0.08	0.46	0.05	0.13	0.18
1 y	0.30	0.07	0.51	0.06	0.32	0.15	0.22	0.09	0.39	0.05	0.11	0.19
2 y	0.20	0.08	0.43	0.06	0.21	0.15	0.25	0.10	0.36	0.05	0.09	0.20
Total	0.26[a]	0.05	0.52[a,b]	0.05	0.25	0.11	0.26[b]	0.07	0.45	0.04	0.13	0.15

Means with the same superscript are different at $P < .05$. Letters indicate differences within rows and numbers indicate differences within columns.
M = mean; SE = standard error; MHQoL = mental health quality of life.

In addition, patients diagnosed with m-TMD reported significantly more painful somatization than patients with degenerative joint disease or no diagnosis.

Functionality

In order to assess the effects of treatment on functionality in terms of TMD diagnosis, MLMs were conducted by examining physical quality of life (PQoL) and masticatory performance (measured by the MPS and BD measures of the CutterSil) (Tables 2, 7, and 8). Patients diagnosed with m-TMD had generally worse masticatory performance in both the MPS and BD measures (ie, larger values for both) than other diagnostic groups (a main effect of diagnosis averaged across time and treatment group). Moreover, m-TMD patients had significantly worse BD outcomes when compared with patients with multiple diagnoses including m-TMD. There were also differences between the diagnostic groups within each of the treatment groups (diagnosis group × treatment group). Specifically, within the HR/BB treatment group, patients with multiple diagnoses excluding m-TMD had poorer performance as assessed by the MPS (mean [M] = 5.31, standard error [SE] = 0.65) than those with disc displacement (M = 2.91, SE = 0.43). However, within the HR/SC group, patients diagnosed with either m-TMD or multiple diagnoses including m-TMD had poorer performance as assessed by the MPS (M = 4.46, SE = 0.25; M = 3.91, SE = 0.15, respectively), than the participants with no diagnosis (M = 2.86, SE = 0.23). There were no differences between the diagnosis groups within the LR/NI group. Additionally, there were no differences in PQoL between the diagnostic groups.

Discussion

As noted above, the present study was part of a first large-scale investigation that aimed to evaluate whether a biobehavioral intervention for acute TMD, found to be efficacious in academic clinical settings, could be effectively implemented in community-based clinics. Previously, the authors had reported that both biobehavioral and self-care interventions were effective in patients at high risk for developing chronic TMD and that both interventions improved outcomes related to psychosocial issues, pain, and functionality.[22] The current investigation specifically assessed whether a biobehavioral intervention would be more effective for patients with m-TMD than for patients with other TMD diagnoses. Overall, the present study found that the effects of the biobehavioral and self-care interventions did not differ based on the patients' diagnoses, suggesting that these interventions can be applied to all types of TMD patients.

Table 5 Significance Tests for the Fixed Effects in the Final Multilevel Models by Pain Outcomes

Outcome/Effect from final model	Significance test
Self-reported pain	
Diagnosis group	F(5,440.75) =4.09, *P* = .001
Treatment group	F(2,538.88) = 28.17, *P* < .001
Time	F(3,336.28) = 116.07, *P* < .001
Diagnosis group × treatment group	F(10,443.98) = 1.71, *P* = .08
Diagnosis group × time	F(15,340.91) = 1.50, *P* = .10
Treatment group × time	F(6,337.54) = 17.44, *P* < .001
Chewing pain	
Diagnosis group	F(5,404.65) = 8.44, *P* < .001
Treatment group	F(2,404.23) = 2.57, *P* = .08
Time	F(3,259.71) = 31.86, *P* < .001
Diagnosis group × treatment group	F(10,380.53) = 1.68, *P* = .08
Diagnosis group × time	F(15,270.91) = 2.14, *P* = .01
Treatment group × time	F(6,254.11) = 5.08, *P* < .001
Painful somatization	
Diagnosis group	F(5,411.05) = 5.76, *P* < .001
Treatment group	F(2,414.56) = 0.75, *P* = .47
Time	F(3,262.15) = 3.91, *P* = .01
Diagnosis group × treatment group	F(10,407.11) = 0.97, *P* = .47
Diagnosis group × time	F(15,265.25) = 0.86, *P* = .61
Treatment group × time	F(6,262.29) = 3.06, *P* = .01
Pain-related disability	
Diagnosis group	F(5,429.32) = 5.10, *P* < .001
Treatment group	F(2,458.77) = 13.66, *P* < .001
Time	F(3,345.17) = 94.86, *P* < .001
Diagnosis group × treatment group	F(10,417.84) = 1.28, *P* = .24
Diagnosis group × time	F(15,351.65) = 1.49, *P* = .11
Treatment group × time	F(6,347.08) = 17.31, *P* < .001

Much like the current study, Mora et al[39] compared two different treatment groups, one including both cognitive-behavioral treatment and biofeedback and the other involving the application of splints, in TMD patients. It was found that patients in both groups reported improvement in psychosocial distress over time, yet group differences were not found. In two separate studies, Dworkin et al[1,20] found that TMD patients who were and were not treated for their symptoms did not differ in terms of depressive symptoms and somatization, which they suspected may have been due to the lack of specificity in the cognitive-behavioral therapy approach used to address these issues as well as to the fact that the same study personnel assessed both groups. Furthermore, Dworkin et al[1] posited that psychosocial dysfunctions may need more rigorous cognitive-behavioral treatment approaches in order to produce noticeable improvements when comparisons are made with patients not receiving treatment. Nonetheless, it should be kept in mind that many of these studies did not evaluate high-risk patients and such patients were assessed in the present investigation. Therefore, a word of caution should be raised in attempting to compare results across studies.

The one important new finding of the present investigation was that there were important differences between the diagnostic groups pertaining to the psychosocial, pain, and functioning outcomes, and this finding may be used to better tailor future interventions to specific patient needs. In particular, patients with either m-TMD only or in combination with other TMD diagnoses tended to report worse outcomes than the other diagnostic groups. Given the high levels of pain and dysfunction that m-TMD sufferers report,[2,37,54,63,64] it was expected that the reports of the m-TMD study population would be indicative of higher levels of psychosocial distress. Indeed, it was found that patients with m-TMD only or in combination with other TMD diagnoses reported greater perceived stress before the intervention, although they quickly remitted to lower levels during the follow-up assessments. Patients with disc displacement followed a similar pattern. Patients with m-TMD also reported poorer MHQoL than patients with multiple diagnoses excluding m-TMD. Patients with m-TMD also reported greater somatization than other patients with other TMD diagnoses.

Contrary to past research findings that suggested that a biobehavioral intervention is beneficial for patients with TMD in relieving psychosocial distress,[45] the current study did not find that the biobehavioral intervention was as effective in reducing stress, depressive symptoms, and somatization or in improving mental wellness in m-TMD patients compared with the other m-TMD patients evaluated (HR/SC and LR). It was also not found that m-TMD patients in the HR/BB group improved in psychosocial distress when compared with patients with multiple diagnoses including m-TMD. This was not surprising in light of the report by Velly et al[43] that patients with orofacial pain report many psychosocial comorbidities including anxiety, depression, and somatization. Also, findings by Dahan et al[44] revealed more comorbid migraine and chronic fatigue syndrome disorders in m-TMD patients. Thus, these comorbidities may be especially more prevalent in m-TMD patients, requiring an even more comprehensive treatment plan for those patients above and beyond the biobehavioral intervention provided in the present investigation.

It is also noteworthy that a preliminary study found that there were no differences in pain and masticatory functioning between depressed and nondepressed TMD participants.[7] It was suggested that depressed TMD patients have quite possibly become desensitized to their TMD-related symptoms.[7] Also, in another preliminary study, Lorduy et al[31] found no differences between groups in depressive symptoms or mental wellbeing (as measured by the SF-36). Unfortunately, in these studies, a breakdown by diagnosis (especially for m-TMD) was not evaluated.

Table 6 Means and Standard Errors by Diagnosis and Time for the Pain Outcomes

	No RDC/TMD Axis I diagnosis		m-TMD		Disc displacement		Degenerative joint disease		Multiple diagnoses including m-TMD		Multiple diagnoses excluding m-TMD	
Outcome	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
Self-reported pain												
Preintervention	52.45	1.57	56.04	1.46	51.90	3.09	52.45	2.08	58.33	1.08	51.98	4.57
Postintervention	35.09	2.73	35.78	2.50	28.93	5.54	37.33	3.41	44.53	1.91	41.21	7.22
1 y	10.04	3.01	21.31	2.72	18.00	6.73	17.52	3.86	24.28	2.15	25.44	7.99
2 y	13.45	3.76	21.50	2.80	36.16	7.39	17.74	4.65	23.08	2.32	15.14	8.71
Total	27.76[a]	1.85	33.66	1.62	33.75	3.78	31.26	2.33	37.55[a]	1.25	33.44	5.03
Chewing pain												
Preintervention	2.22[a,b,c,1]	0.27	3.68[a,d,1,2,3]	0.26	2.60[e]	0.57	3.75[b,1,2,3]	0.37	4.68[c,d,e,1,2,3]	0.19	4.04[1]	0.80
Postintervention	1.82[a,2]	0.29	2.16[b,1]	0.27	1.64	0.61	2.32[1,4,5]	0.35	3.23[a,b,1,4,5]	0.20	2.33	0.80
1 y	0.99[a,1,2]	0.27	1.70[2]	0.25	1.49	0.62	0.91[b,2,4]	0.36	2.18[a,b,2,4]	0.20	1.91	0.72
2 y	1.33	0.38	1.60[3]	0.30	2.24	0.78	0.32[a,3,5]	0.45	2.39[a,3,5]	0.24	1.41[1]	0.89
Total	1.59[a]	0.22	2.28[b]	0.20	1.99	0.45	1.83[c]	0.28	3.12[a,b,c]	0.15	2.42	0.61
Painful somatization												
Preintervention	0.48	0.07	0.85	0.06	0.39	0.13	0.51	0.09	0.83	0.05	0.38	0.19
Postintervention	0.43	0.07	0.72	0.06	0.47	0.13	0.39	0.08	0.65	0.05	0.21	0.18
1 y	0.44	0.07	0.69	0.07	0.40	0.15	0.37	0.09	0.59	0.05	0.30	0.20
2 y	0.42	0.08	0.63	0.07	0.24	0.16	0.41	0.10	0.56	0.05	0.23	0.20
Total	0.44[a,c]	0.06	0.72[a,b]	0.05	0.38	0.11	0.42[b]	0.07	0.66[c]	0.04	0.28	0.16
Pain-related disability												
Preintervention	1.70	0.07	1.88	0.07	1.61	0.14	1.73	0.09	2.03	0.05	1.81	0.21
Postintervention	1.22	0.11	1.21	0.10	0.98	0.22	1.21	0.14	1.63	0.08	1.33	0.29
1 y	0.51	0.11	0.83	0.10	0.54	0.23	0.60	0.13	0.90	0.08	0.79	0.28
2 y	0.48	0.14	0.92	0.10	1.34	0.27	0.60	0.17	0.89	0.09	0.38	0.32
Total	0.98[a]	0.07	1.21	0.06	1.12	0.14	1.03[b]	0.09	1.36[a,b]	0.05	1.08	0.20

Means with the same superscript are different at $P < .05$. Letters indicate differences within rows and numbers indicate differences within columns.
M = mean; SE = standard error.

Because TMD is typically regarded as a chronic pain condition, it was natural to expect that an early intervention program would be effective in reducing pain, particularly for patients with m-TMD because these patients tend to suffer inordinately from pain.[37,54,64] Indeed, patients with multiple diagnoses including m-TMD reported greater pain in all four pain measures than patients with other TMD diagnoses. While m-TMD patients reported improvements in chewing-related pain from baseline to all of the follow-up assessments, they continued to report higher levels of chewing pain than nonmyogenous TMD patients at all four assessments. Notably, patients with multiple diagnoses including m-TMD reported more chewing pain than patients who were diagnosed with m-TMD only, a finding that supports the idea that combination diagnoses, especially those that involve a muscle disorder, produce more severe symptom presentations.

Unfortunately, a reduction was not found in facial pain, painful somatization, or pain-related disability for m-TMD patients receiving the biobehavioral intervention compared with the other patients. This outcome is similar to earlier laboratory findings. For instance, Mishra et al[29] found that there were no differences in treated versus nontreated TMD patients with regard to pain-related disability. It was speculated that the emphasis on psychosocial techniques in the biobehavioral intervention may have conflicted with the patients' physiologic view of their disorder, thereby hindering the intervention's efficacy. Bernstein and Gatchel[28] found no difference between treatment groups in orofacial pain, and they suggested that the measure used to gauge facial pain (the CPI measure) might have been lacking in sensitivity. Likewise, Lorduy et al[31] found no differences between groups in orofacial pain or pain-related disability. This discrepancy in the findings among the different pain measures may also have been due to the fact that chewing-related pain was tied to a function for which patients had an immediate reference (ie, the report of chewing-related pain was given directly after the chewing task), whereas the reports of facial pain, painful somatization, and pain-related disability were likely not as immediately experiential. More importantly, however, was the fact that of the different TMD categories above, only m-TMD appears to require more intensive intervention. This was not provided in these earlier studies.

Other studies have found null results for nonfunctional pain. In one investigation, Michelotti et al[52] found that patients with m-TMD who received physical therapy in addition to education were not different from control patients in terms of pain intensity or pain

Table 7 Significance Tests for the Fixed Effects in the Final Multilevel Models by Functional Outcomes

Outcome/effect from final model	Significance test
PQoL	
Diagnosis group	F(5,420.27) = 1.92, *P* = .09
Treatment group	F(2,417.25) = 3.37, *P* = .04
Time	F(3,269.22) = 3.26, *P* = .02
Diagnosis group × treatment group	F(10,408.85) = 0.50, *P* = .89
Diagnosis group × time	F(15,273.88) = 0.86, *P* = .61
Treatment group × time	F(6,271.50) = 5.29, *P* < .001
MPS	
Diagnosis group	F(5,448.02) = 3.14, *P* = .01
Treatment group	F(2,466.20) = 1.32, *P* = .27
Time	F(3,258.72) = 6.69, *P* < .001
Diagnosis group × treatment group	F(10,421.02) = 2.70, *P* = .003
Diagnosis group × time	F(15,266.16) = 1.20, *P* = .27
Treatment group × time	F(6,247.46) = 1.34, *P* = .24
BD	
Diagnosis group	F(5,429.82) = 4.05, *P* = .001
Treatment group	F(2,457.23) = 2.69, *P* = .07
Time	F(3,274.58) = 10.30, *P* < .001
Diagnosis group × treatment group	F(10,428.12) = 1.64, *P* = .09
Diagnosis group × time	F(15,267.82) = 0.56, *P* = .90
Treatment group × time	F(6,261.52) = 0.92, *P* = .48

PQoL = physical quality of life; MPS = median particle size; BD = broadness of distribution.

pressure thresholds. In addition, Crider et al[10] discussed various findings[65,66] relating to biofeedback training to reduce pain over time, and noted there were no differences between patients receiving biofeedback and those not receiving it, which the authors suggested may have been due to some methodologic issues. Furthermore, Dworkin et al[1,20] also compared groups of TMD patients who were either in a treatment group or in a control group and Mora et al[39] compared two different treatment groups of TMD patients. Both studies found that although there was a reduction in pain over time, the groups did not differ in pain or pain-related disability, which, once again, was ascribed to a lack of specificity of the cognitive-behavioral treatment. In the present study, even though a standard cognitive-behavioral treatment protocol was used, it was further specifically tailored to the needs of particular patients. Again, however, as noted earlier, it should be kept in mind that the present study evaluated high-risk patients. Other studies have not, making comparisons between them difficult.

Past research has also shown that the presence of m-TMD disrupts one's ability to function properly.[29,42,54,63,67] This was supported by the finding in the present study that patients with m-TMD reported significantly poorer masticatory performance than patients with either multiple diagnoses including m-TMD or participants with no diagnoses and it was revealed that MPS and BD tended to be worse for participants with a diagnosis of m-TMD only. Additionally, m-TMD patients in the HR/SC group had larger MPS, indicating a poorer masticatory performance, when compared with participants with m-TMD who were in the LR/NI group. This deficiency in functionality was hypothesized to extend beyond mastication and it was also hypothesized that a biobehavioral intervention could provide relief.

Other studies have found similar results. For instance, Wright et al[13] have found that there were no differences in chewing performance at the end of treatment between high-risk and low-risk patients with acute TMD. Sanders[68] also found that there were no differences in masticatory performance between the high-risk groups who were receiving treatment. Furthermore, Dougall et al[30] found that high-risk, acute TMD patients as well as patients with multiple RDC/TMD Axis I diagnoses did not differ from low-risk, acute TMD patients and patients without multiple diagnoses, respectively, with regard to masticatory performance. In the present study, the high-risk patients receiving either of the interventions began functioning as well as the less low-risk patients following treatment. Considering these findings, in addition to the fact that the two interventions did not yield differences in masticatory performance, it can be speculated that CutterSil may not have been able to detect such differences. In particular, CutterSil helps identify treatment differences related to occlusion and therefore dictates the chewing pattern.[69] The CutterSil assessments used in the present study may not have produced significant effects because the treatments provided were either therapeutic or educational for TMD pain in general, as opposed to involving a method that could affect occlusion more directly (eg, manual therapy).

One other minor limitation of the current study was that the diagnostic criteria for TMD were revised while the study was still in progress. Therefore, care must be taken in interpreting the diagnostic information gathered from the RDC/TMD. The RDC/TMD criteria are not meant to be used as an exhaustive, singular diagnostic tool for every type of TMD, orofacial pain, or psychiatric condition.[70] Instead, the criteria are intended to provide the first step of a replicable, standardized method of identifying and classifying subgroups of TMD by using a biopsychosocial perspective.[71] Consequently, now that this first step has been established, a newer version of the RDC/TMD has been created, the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD), which has great promise for surpassing the success of its predecessor. Indeed, following the release of the original RDC/TMD, great strides were made in pain

Table 8 Means and Standard Errors by Diagnosis and Time for the Functional Outcomes

	No RDC/TMD Axis I diagnosis		m-TMD		Disc displacement		Degenerative joint disease		Multiple diagnoses including m-TMD		Multiple diagnoses excluding m-TMD	
Outcome	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
PQoL												
Preintervention	50.02	1.04	46.86	0.97	51.57	2.07	49.69	1.40	47.09	0.72	44.48	3.03
Postintervention	49.73	1.06	48.85	0.98	49.21	2.11	50.88	1.33	48.67	0.74	46.80	2.91
1 y	51.59	1.20	48.25	1.09	53.26	2.56	52.09	1.54	48.32	0.85	48.33	3.18
2 y	51.18	1.29	49.60	1.03	51.67	2.50	50.92	1.59	49.14	0.81	49.09	3.21
Total	50.63	0.92	48.39	0.84	51.43	1.82	50.90	1.17	48.31	0.63	47.18	2.60
MPS												
Preintervention	3.59	0.14	4.06	0.13	3.81	0.28	3.93	0.18	3.99	0.10	4.55	0.40
Postintervention	3.49	0.16	4.16	0.15	3.40	0.33	3.98	0.21	3.84	0.11	4.89	0.45
1 y	3.12	0.17	3.97	0.16	3.42	0.39	3.59	0.23	3.70	0.12	3.95	0.55
2 y	3.08	0.23	3.72	0.18	3.69	0.45	3.02	0.28	3.25	0.14	3.95	0.53
Total	3.32[a]	0.14	3.98[a]	0.13	3.58	0.29	3.63	0.18	3.70	0.09	4.33	0.39
BD												
Preintervention	12.12	1.59	20.07	1.51	18.08	3.33	15.77	2.17	16.48	1.11	26.95	4.73
Postintervention	13.27	1.86	20.34	1.72	14.76	3.82	16.17	2.40	15.16	1.30	30.35	5.31
1 y	10.44	1.79	16.29	1.63	13.01	4.06	10.82	2.31	11.34	1.26	19.49	5.78
2 y	8.45	2.13	14.72	1.70	12.30	4.19	8.28	2.61	8.11	1.29	18.29	5.23
Total	11.07[a]	1.44	17.86[a,b]	1.31	14.54	2.98	12.76	1.86	12.77[b]	0.98	23.77	4.24

Means with the same superscript are different at $P < .05$. Letters indicate differences within rows and numbers indicate differences within columns. M = mean; SE = standard error; PHQoL = physical quality of life; MPS = median particle size; BD = broadness of distribution.

research and as a result new assessments and constructs were created.[71] These advances then led to a quest for improving how the RDC/TMD could better assess TMD.[71] In 2001, a group of researchers engaged in a 7-year validation project that consisted of a series of six studies.[35,47,72–75] After the culmination of these studies, the RDC/TMD were revised, and the name was changed to the DC/TMD.[71] The new diagnostic criteria were released on February 3rd, 2014, and are intended to assess TMD to a greater extent than did the RDC/TMD, to clarify the interpretation of the diagnostic information, and to be used in both research and clinical settings.[71] In fact, the original creators of the RDC/TMD did forewarn that the assessment tool would need further revisions to increase accuracy and validity,[71] and these revisions have culminated in the DC/TMD, which are vastly different from the RDC/TMD. Most notably, the somatization measures have been removed, and the items that measured orofacial pain and pain-related disability have changed their time references from the past 6 months to the past 30 days. Such changes would have likely altered the results of the current study, especially considering the fact that the outcome measures that were either altered or removed were the very ones that rendered null findings.

Although many findings of the present investigation did not reveal significant differences between the two intervention groups, there may be an overarching reason to explain this. For instance, some researchers have found that patients who have good rapport with health care professionals and who are able to receive professional guidance and have their concerns listened to and addressed tend to produce favorable outcomes in terms of a reduction in TMD symptoms.[1] This may have been a significant therapeutic component for the self-care intervention group. Another potential limitation is the possibility of regression towards the mean. The hypothesis posited that the most improvement would occur in subgroups of patients that were expected to have the worst outcomes. It should be emphasized that all of the necessary precautions were taken to combat this potential confounder: the groups were randomly assigned, repetitive assessments were administered, and a large dataset was used.[76] Interestingly, in a long-term study, Ohrbach and Dworkin[77] found that about half of the TMD patients in their study remitted (ie, reported an absence of pain) at a 5-year follow-up, which suggests that TMD pain may be cyclical in nature and resolve on its own.[64,78] However, additional research on this issue is still needed.

Conclusions

The overall purpose of the present study was to build on past research conducted in academic clinical settings that showed that early interventions, particularly those that are biobehavioral, were efficacious for high-risk, acute-TMD patients. It was also the first large-scale translational investigation undertaken to examine the effectiveness of these interventions when implemented in community-based clinics. The

use of subgroup analyses to assess treatment effects according to the diagnoses given to patients prior to their respective interventions supports the success of this translational study. Overall, the current study was able to show the following: early interventions are effective in high-risk, acute-TMD populations; m-TMD tends to result in more severe symptom presentations, particularly if diagnosed in combination with other TMD diagnoses; and TMD-related symptoms tend to decrease over time. Other important contributions of studies such as this have been further highlighted by Dougall et al.[22] Such contributions reinforce Sessle's recent conclusion that: "…along with advances in ensuring better knowledge transfer to and application by clinicians, significant improvements in the diagnostic and management approaches will be made that will alleviate the pain and suffering of many patients with or at risk for a chronic orofacial pain condition."[79]

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