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Determinants of Pain Treatment Response and Non-Response: Identification of TMD Patient Subgroups

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Abstract

The purpose of the present study was to determine if we could identify a specific subtype of temporomandibular disorder (TMD) pain patients that does not respond to treatment. Patients were 101 men and women with chronic TMD pain recruited from the community and randomly assigned to one of two treatment conditions: a standard conservative care (STD) condition or a standard care plus cognitive-behavioral treatment condition (STD+CBT) in which patients received all elements of STD, but also received cognitive-behavioral coping skills training. Growth mixture modeling, incorporating a series of treatment-related predictors, was used to distinguish several distinct classes of responders or non-responders to treatment based on reported pain over a one-year follow-up period. Results indicated that treatment non-responders accounted for 16% of the sample, and did not differ from treatment responders on demographics or temporomandibular joint pathology, but that they reported more psychiatric symptoms, poorer coping, and higher levels of catastrophizing. Treatment-related predictors of membership in treatment responder groups versus the non-responder group included the addition of CBT to standard treatment, treatment attendance, and decreasing catastrophization. It was concluded that CBT may be made more efficacious for TMD patients by placing further emphasis on decreasing catastrophization and on individualizing care.

Temporomandibular disorders (TMD) are a heterogeneous collection of clinical problems characterized by dysfunction of the masticatory musculature, the temporomandibular joint and/or the associated structures. They are often associated with orofacial pain, masticatory dysfunction, or a combination of both. TMDs affect between 10 to 36 million adults in the United States, the majority of them women.^{18, 47} TMDs are among the most frequently occurring musculoskeletal conditions resulting in pain and disability (second only to chronic low back pain), and the most frequent cause of facial pain.³⁷ It is estimated that TM pain disorders cost the US about \$4 billion annually.¹⁷ As such, TMD-related orofacial pain constitutes a chronic pain condition of alarming prevalence and cost.

Despite the disruptiveness of the problem, TMD-related pain, especially that which is primarily muscular in origin (which accounts for majority of cases^{16, 19}), is usually manageable with conservative, non-invasive treatment. Conservative treatment often

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includes pharmacologic pain control using non-steroidal anti-inflammatory drugs, supportive patient education, diet modification, and use of an intraoral splint and/or occlusal therapy^{4, 9, 38} (despite the relative lack of evidence supporting the use of splints or occlusal adjustment^{2, 23}). This standard approach produces modest to large improvements in pain in a significant number of cases.³⁹

Not all patients benefit from this approach, however, and a number of behavioral and psychological treatments have also been used to treat TMD pain. Among these have been psychotherapy,⁴¹ biofeedback,^{6, 60} relaxation,⁵² hypnosis,⁵⁴ and particularly cognitive-behavioral therapy (CBT) approaches.^{13, 26, 64} Research has concluded that CBT benefits TMD patients in an equal or higher measure than other approaches, including standard conservative dental therapies.^{14, 39} Dworkin & Massoth¹² reported that improvement in symptomatology is reported in 85% of cases receiving a psychosocial intervention, including CBT.

In reviews of the efficacy of CBT with heterogeneous pain samples, CBT produced significantly greater changes in the domains of pain experience, and reduced behavioral expression of pain, than waiting list control conditions or alternative treatments.^{29, 33} Similar findings have been reported for homogeneous subgroups of patients with back pain,⁶⁵ fibromyalgia,⁴⁴ and arthritis.²⁰ Despite these good results, some patients still fail to respond to treatment. In their review and meta-analysis Morley, Eccleston and Williams³³ concluded that cognitive-behavioral treatments were often associated with significant improvement in a variety of symptoms. CBT did not, however, yield improvements in several domains that are typically targeted, including mood/affect, cognitive coping, and negative appraisals such as catastrophization, and did not improve pain scores for all individuals.

The reasons for the success of behavioral or cognitive-behavioral programs are not always clear. Turner and colleagues⁶¹ noted that nonspecific effects of treatment, plus disease natural history and regression to the mean, can result in high rates of good outcomes in pain treatments, “which may be misattributed to specific treatment effects” (p. 1609). A number of variables have been identified as predictors of poor response to psychosocial treatment in TMD, including CBT. Among these predictors are depressive symptoms, somatization, catastrophization, low readiness for treatment, poor coping ability, and low self-efficacy.^{26, 63}

In a concerted effort to evaluate specific process variables that mediate the effects of CBT for chronic pain patients, Turner, Holtzman and Mancini⁶³ measured pain beliefs, catastrophizing, and self-efficacy for managing pain in a randomized controlled trial of brief CBT v. an attention control condition for chronic TMD pain. The authors reported that the CBT condition yielded significantly greater improvements at one year in pain, activity interference and jaw use limitations than did the attention control condition. The authors further reported that, in tests of mediation, baseline to 6-month changes in almost all prospective mediators, particularly control beliefs and self-efficacy, mediated the effects of CBT on outcomes at one year. Litt, Shafer, Ibanez and Kreutzer²⁴ further determined that momentary coping and catastrophizing during stressful episodes were strongly associated with posttreatment pain.

Although specific cognitive processes appear associated with improved outcomes, the determinants of *treatment non-response* have not been explored. The question of non-response was raised by a study of TMD treatment that has already been reported.^{24, 26} In this study patients received either a standard conservative treatment (STD) or a treatment that combined standard treatment with CBT (STD+CBT). The main findings of the study²⁶

indicated that patients in both treatment conditions reported drops in pain over the 52 weeks, but that mean improvements in pain over time were greater in the STD+CBT condition, and that pain reports in the STD condition had started to rise again at 24 weeks. Depressive symptom scores and lifestyle interference scores decreased in severity from pre- to posttreatment in both treatment conditions. These improvements were maintained out to 52 weeks.

Despite these overall results it was apparent that not all patients benefited from treatment, and that the progress of the sample as a whole was not represented adequately by sample means over time. Indeed, it is a widely observed clinical phenomenon that there always seems to be some subset of patients who do not respond as most patients do, that is, who are not like other patients. The purpose of the present study was to determine if we could identify a specific subtype of TMD patients who do not respond to treatment, and to further determine what treatment-related processes might influence these individuals.

Patients were 101 men and women with chronic TMD-related pain recruited from the community and randomly assigned to one of two treatment conditions: a Standard conservative care (STD) condition or a Standard care plus CBT condition (STD+CBT) in which patients received all elements of STD, but also received cognitive-behavioral coping skills training. Each treatment was 6 weeks long. Patients were administered a number of instruments designed to measure potential mediating variables, and were assessed for pain, pain-related interference, and depressive symptoms every three months for one year. Growth mixture modeling (GMM), incorporating a series of treatment-related predictors, was used to distinguish several distinct classes of responders or non-responders to treatment based on reported pain, lifestyle interference, and depressive symptoms over a one-year follow-up period. It was hypothesized that certain treatment-related processes, including lower retention in treatment, and less adaptive change in coping, self-efficacy and catastrophizing, would be predictive of treatment non-response.

Materials and Methods

All procedures were approved by the Institutional Review Board of the University of Connecticut Health Center.

Participants

Participants were 85 women and 16 men seeking treatment for a complaint of either bilateral or unilateral pain in the general area of the temporomandibular joint, including areas near the masseter, lateral pterygoid and temporalis muscles, that had persisted and was noticeable on a daily basis for a period of at least 3 months. The proportion of women to men in this sample is comparable to that of other clinical samples.²⁸ This number of participants was sufficient to, at a minimum, detect significant between-group differences at posttreatment on each of the major dependent variables, with a power of .8 and alpha set at .05.

Patients were recruited between October 2003 and July 2007 from the dental clinics in our university-based school of dental medicine (10%), from other dental referrers (< 5%), and from the greater Hartford metropolitan area via newspaper and web-based advertisements offering free short-term treatment. None were referred from specialized facial pain clinics. To be eligible patients needed to have a positive Axis I diagnosis on the Research Diagnostic Criteria for temporomandibular disorders (RDC/TMD)¹¹ (positive on at least one Group), and could have no contraindications to TMD treatment (as determined by the consulting oral surgeon; e.g., oral cancer that would require immediate treatment). Patients were excluded for any of the following: lack of fluency in English (as determined by inability to read and understand a statement of informed consent); previous surgery for

treatment of TMD pain; history of rheumatoid disease; extensive anatomical destruction or deterioration of the TM joint; diagnosed as having pain of neuropathic or odontogenic origin; carrying a diagnosis of psychosis; current use of antidepressants or anxiolytics; taking narcotic pain medication; or pregnancy (due to prescription of non-steroidal antiinflammatory drugs).

Of 196 persons screened, 121 were deemed eligible for the study, and 101 were assigned to treatment. The mean age of the sample was 39.4 years ($SD = 12.1$). The majority of participants were white (79%), with 9% black and 9% of Hispanic origin. Forty-one percent were married or cohabiting. The average years of education was 14.7 ($SD = 2.5$). The participants reported having chronic TMD pain for 6.7 years on average ($SD = 6.6$), with a mean pain intensity rating of 3.5 on a scale to 6 ($SD = 1.3$). Thirty-nine percent of patients were diagnosed by an oral surgeon (as per RDC procedures) with some disk displacement with or without reduction. At posttreatment 88% of patients provided data, and 73% provided data at 52 weeks. The final follow-ups were conducted in June of 2008.

Measures and Instruments

Outcome variable: Pain—Ratings of pain experience at each of the assessment points were collected using the Multidimensional Pain Inventory (MPI).²² A composite pain variable based on Von Korff's "characteristic pain intensity" was calculated on a scale from 0 – 6 by averaging MPI ratings of current pain, average pain, and worst pain in the past week.⁶⁶ Reliabilities of the index exceeded $\alpha = .80$.

Demographics—A number of demographic characteristics were available to help characterize trajectory-based groups. These included sex of patient, age, race, education, employment status, marital status, and income.

Pain and TMJ Pathology—Pain and temporomandibular joint pathology variables were derived from the Patient History Questionnaire portion of the Research Diagnostic Criteria examination for TMD (RDC/TMD).¹¹ The RDC/TMD consists of 31 items assessing orofacial pain complaints along two axes: a physical disorders axis (Axis-I) to detect muscle disorders, disk displacements, and other joint conditions, and a psychosocial axis (Axis-II) to assess perceived pain intensity, pain-related disability, functional limitations, depression and non-specific symptoms suggestive of somatization. The RDC/TMD has demonstrated reliability,⁴⁰ including physical examination by the oral surgeon. Patients were examined by one of two participating oral surgeons, each trained to criterion reliability ($ICC = .90$). Variables of interest in this study included Years of Pain, Pain Grade (a score based on pain and disability)⁶⁷, and reports of bruxism. Clicking in the joint and joint locking were diagnosed on clinical examination.

Psychiatric Symptoms—Depression Symptoms at each assessment point were measured using the 20-item Center for Epidemiological Studies Depression scale (CESD).⁴² The CESD is well suited for use in a population with medical problems such as chronic pain in that it relies less on physical symptoms of depression than do other measures. In the current sample the CESD had an internal reliability of $\alpha = .94$. Anxiety symptoms were measured using the trait anxiety scale of the State-Trait Anxiety Inventory.⁴⁸ Somatization was measured with the 12-item somatization subscale of the Symptom Checklist 90 - Revised (SCL-90-R),¹⁰ and has been validated as a stand-alone measure.³⁰ All of these variables have been implicated in exacerbating or maintaining chronic pain.⁵⁷

Cognitive Constructs—Several cognitive variables associated with pain treatment outcomes were also assessed. Readiness to engage in self-management treatment for chronic

pain was measured using the Pain Stages of Change Questionnaire (PSOCQ).^{21, 37} The PSOCQ assesses readiness using 30 Likert-scaled items scored from 1 (strongly disagree) to 5 (strongly agree), and is comprised of four scales: Precontemplation, Contemplation, Action and Maintenance. In the current study a single “Readiness” variable was calculated (i.e., Contemplation + Action + Maintenance – Precontemplation; $r = .68$).

Pain management self-efficacy was assessed using the Chronic Pain Self-Efficacy Scale (CPSS).³ The CPSS is a 22-item questionnaire designed to measure chronic pain patients’ confidence in their ability to cope with aspects of chronic pain. The CPSS is constructed of three subscales: self-efficacy for pain management, self-efficacy for coping, and self-efficacy for coping with symptoms, as well as a total score, which was the score used in the present study (internal reliability $r = .96$ in this sample). The baseline value of self-efficacy was used to characterize trajectory-based groups.

Both coping and catastrophizing were measured using the 18-item Pain-Related Self-Statements Scale (PRSS).⁸ This scale was chosen because of its demonstrated validity with TMD patients, and because it is relatively short. In the present sample the reliability of the coping subscale was $r = .78$, and the reliability of the catastrophizing subscale was $r = .86$.

Optimism and pessimism have been shown to be related to physical and psychological outcomes, including pain.⁴³ Optimism and pessimism were measured by the 12-item Life Orientation Test-Revised.⁴⁶ Using 5-point Likert scales, participants rated how much they agreed or disagreed with four optimism items, four pessimism items or four filler items.

Treatment-related variables: Adherence and cognitive change—Finally, we were interested in treatment-related changes that might influence trajectory-based groups. That is, we wanted to identify attributes that change with treatment that might affect whether someone was a treatment responder or a non-responder. One of these was treatment retention. A key aspect of psychosocial treatment is the idea that patients will not benefit from treatment if they do not attend treatment or follow treatment recommendations.⁵⁶ Attendance at treatment sessions was our measure of treatment retention.

Patients in both the STD and the STD+CBT conditions completed a Treatment Check Sheet at each visit during the treatment period to monitor adherence to the use of the splint, adherence to a soft diet, and taking of non-steroidal medication as prescribed. Adherence in each category was calculated as a percentage of days in the previous week that criterion adherence was met or partially met. Adherence to use of the splint was considered met if a patient wore the splint either as a night guard (i.e., when sleeping), or at least 6 hours per day during waking hours. If the splint were worn less than 6 hours in a day, the adherence rate would be calculated as a proportion of the 6 hours. As for diet, patients reported what they ate at each meal during the week. Adherence was calculated based on a proportion of 21 meals that were considered soft. Medication adherence was based on patient report of taking the NSAID medication twice a day. Pill count was used to confirm the patient report.

Most significant were the expected changes in cognitive constructs. Pre-post changes in self-efficacy, in coping self-statements and in catastrophizing were calculated using residualized change scores.⁵ Residualized change scores were used to obtain gain scores that were uncorrelated with initial status or pretest scores, and are thus unbiased by pretreatment status.⁸ These scores represented the effects of treatment on these constructs, and were used in analyses as predictors of membership in trajectory-based groups.

Treatment

Treatment in both conditions consisted of six sessions conducted over a six to nine week period. Treatment was delivered by four Master's level therapists with at least 2 years' experience in cognitive-behavioral therapy with medical patients. The same therapists provided both of the study treatments in order to minimize therapist effects. Both treatments were manual-driven. A detailed outline of each session gave the therapists specific guidelines as to what material to cover, what points to emphasize, and the specific kinds of homework to be assigned. The precise content of therapy sessions depended on the individual patient's circumstances and experiences. All treatment sessions in both conditions were audiotaped and reviewed for adherence to the treatment protocol by the first author. Supervision of therapists was conducted biweekly throughout the course of the study. All patients were asked to keep records of their medication use, splint use, and diets each week. Greater detail regarding the treatments appears elsewhere.^{24, 26}

Standard Treatment (STD)—Standard Treatment consisted of splint therapy plus soft diet and oral anti-inflammatory agents.⁴⁹ Subjects in this group were fitted with an acrylic flat plane, non-repositioning occlusal splint during the first treatment visit, one to two weeks after the baseline visit, with instructions to keep it in place continuously (except for eating) for the succeeding 4 weeks, after which a tapering schedule was recommended. However, patients were allowed to retain the splint, and continue its use after the 6-week treatment period, if they preferred (as was the case in about 50% of patients). Additionally, despite instructions to use the splint continuously, patients generally did not use it continuously during the day. About 55% used the splint primarily at night. This pattern of splint use was much like that seen in our non-research patients. A decision was made not to try to enforce continuous use of the splint, and to allow patients to use it as they saw fit, just as in typical clinical practice.

Patients were also given a 5-week course of non-steroidal anti-inflammatory medication (NSAIDs; naproxen sodium 550 mg PO BID). (Extra strength acetaminophen was substituted for naproxen for those patients who reported having difficulty with NSAIDs or who had gastric ulcer disease. This was the case for 8 patients.) A soft diet was also prescribed, with special attention paid to avoiding foods that require extreme jaw opening (e.g., large sandwiches) or foods that had caused pain in the past (e.g., steak). Patients were asked to continue the NSAIDs and the soft diet until the end of the 6-week treatment period, after which they were informed that they could alter the treatment as they saw fit, but with a recommendation that the soft diet be continued. All patients were seen once a week during treatment, and provided the therapist with weekly "progress checks" which served to control for the time and attention received by participants in the STD+CBT condition.

Standard Treatment + Cognitive-Behavioral Treatment (STD+CBT)—The STD +CBT condition included all aspects of the STD treatment described above. In addition, patients received a brief cognitive-behavioral program that focused on relaxation training, stress management, and cognitive restructuring. Treatment was intended to promote self-efficacy, reduce catastrophization, and increase the use of adaptive coping responses and habit modification. The program addressed the three most significant cognitive factors in TMD pain identified by Turner;⁶² beliefs and appraisals, coping and catastrophizing, and a significant behavioral factor, orofacial relaxation.⁷ The cognitive behavioral program was intended to teach skills to keep the patient from returning to old habits, and to reduce clenching, bruxing, and catastrophizing cognitions that contribute to TMD pain and distress. Sessions included an introduction and rationale for treatment, relaxation training and self-efficacy enhancement, masseter EMG biofeedback-assisted relaxation with an emphasis on relaxing the masseter muscles, habit modification (especially clenching and bruxing),

combating negative thoughts and catastrophization, and stress management. Homework each week took the form of practicing skills discussed in the treatment sessions. Relaxation practice was assigned as homework every week.

Adherence to treatment—Overall, 87% of patients attended six treatment sessions, with no significant differences in attendance by treatment condition. Mean rates of adherence were as follows: Soft diet = 92%; Medication = 86%; Splint use = 73%. Patients averaged 7 hours of splint use per day, using it most often as a night guard. There were no between-treatment differences in these measures.

Procedure

Intake session—Persons meeting initial eligibility criteria were seen for an intake assessment session in the Dental Clinical Research Center (DCRC) of the University of Connecticut Health Center. Potential subjects were examined by an oral surgeon to rule out neuropathic or odontogenic pain and to classify the person according to the RDC for TMD. Individuals meeting all inclusion/exclusion criteria at this point were told of all procedures involved and administered a consent form. Baseline measures of the major dependent variables were then administered, and impressions were taken for the flat-plane splint. Patients were given \$40.00 for completion of the baseline measures. Those who agreed to participate were randomized to either the Standard Treatment group (STD; n=49) or to the Standard Treatment + Cognitive-Behavioral Treatment group (STD+CBT; n=52) using a computerized urn randomization procedure⁵⁰. The two conditions were balanced on sex, age, ethnic background, pain level recorded at baseline, and RDC axis I diagnoses. The first treatment appointment was then scheduled for one to two weeks later, coinciding with the delivery of the splint.

Follow-up and data collection procedures—A trained M.A.-level research associate, who was not blinded to treatment condition, conducted the pretreatment and follow-up research assessments. Follow-up interviews were conducted in person and were scheduled at 6 weeks (posttreatment), and at weeks 12, 24, 36 and 52. Participants were compensated \$25 for each in-person follow-up assessment. Eighty-three percent of patients provided complete data at the 52-week follow-up.

Data analysis—Given the varied response to treatment found in our initial analyses, we decided to determine whether we could detect a subset of “very successful” or “very unsuccessful” patients, and explore the predictors of membership in those subsets using Growth Mixture Modeling (GMM). GMM was designed for the purpose of grouping individuals with similar patterns of change over time on a given variable, that is, have similar trajectories. To do this, GMM estimates continuous latent growth factors (i.e., intercept, slope, and nonlinear slope) as indicators of a categorical latent variable (a class or grouping variable), that defines the multiple latent “classes.” These classes are often thought of as homogeneous subsamples of the larger sample, each with its own estimates of slopes and intercepts that represent the mean intercept and slope for all the individuals grouped into that class.³⁴ In GMM differs individual differences in both the slope and intercept are estimated using random coefficients and are free to vary across groups.

In the present study GMM analyses were conducted using MPlus version 7.1³⁵ MPlus uses maximum likelihood estimation with robust standard errors to estimate parameters, using the variances and covariances of the observed data. In this way the procedure uses all available data, and provides a widely accepted method for dealing with missing data.²⁷ For these models Time was measured in months. MPI-based characteristic pain at each of the six data collection points were used as the observed indicators in the models. Initial tests of the

models included only the six pain indicators and estimated three latent growth factors: intercept, slope (linear change over time), and quadratic slope (nonlinear change over time), describing the trajectories of pain over time. Models comprising from 1 to 5 trajectory classes were evaluated. However, variances of the linear slope and the quadratic slope were both fixed at zero to allow the models to converge.

The decision regarding the number of classes to be retained for each outcome was based in part on the Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC); Lo-Mendell-Rubin test (LMR), the Bootstrapped Likelihood Ratio Test (BLRT), and on the entropy score. Both AIC and BIC assess relative model fit based on a function of the log-likelihood value that better fits the observed data, but also exacts a penalty for having more parameters in the model. Smaller AIC and BIC values correspond to a better model with a higher log-likelihood value and fewer parameters.³⁴ The LMR and BLRT test the extent to which adding one more class would improve model fit. A significant chi-square value on either of these tests indicates that the specified model fits the observed data better than a model with one fewer class. The entropy statistic is an overall estimate of each individual's class membership probability. Entropy values can range from 0.0 to 1.0, with higher values indicating better classification. Taken together, the best fitting model would generate a lower BIC, a significant LMR or BLRT p value, and higher entropy. The solution chosen in the present study was also based in part on interpretability of the trajectories.³⁶ Although a greater number of trajectories might yield a lower BIC or greater entropy, a solution was rejected if two or more of the trajectories were redundant, or if one or more classes contained fewer than 10% of the sample.

Trajectory-based groups were first characterized by baseline characteristics using analysis of variance (for continuous variables) or chi-square, following a procedure like that used by Miaskowski³¹ to characterize classes of postoperative pain patients. Groups were evaluated by demographics, pain and TMJ pathology variables, psychiatric indicators, and scores on cognitive constructs. The baseline variables were evaluated by variable families in order to account for the multiple correlated tests involved.⁵⁵ Critical p values for each variable family were thus set as follows: demographics, $p < .0007$; pain and TMJ pathology, $p < .0125$; psychiatric variables, $p < .0170$; and cognitive constructs, $p < .0008$.

Finally, treatment-related variables were examined as predictors of trajectory-based group membership. This was done to determine if certain processes related to treatment per se might predict membership in one or another trajectory-based group, and thus highlight practices or processes that might improve long-term outcomes.

Results

Trajectory-Based Groups based on MPI-Based Characteristic Pain

The relative model fit indices for models with one to five classes are shown in Table 1. Although a five-class model had better fit statistics than the four-class model, two of the classes of the five-class model contained fewer than 10 individuals, and the trajectories showed a great deal of overlap. Therefore a four-class solution was adopted.

The initial unconstrained four-class model for MPI-based characteristic pain over time is shown in Figure 1. Group 1 was referred to as “Moderate Pain – Treatment Responders” and comprised about 27% of the treatment sample. These were individuals who at baseline reported moderate pain (about 3 on the scale to 6), and who responded well to treatment, with pain levels maintained below a score of 1 over the course of the next year. Group 2 patients, about 16% of the treatment sample, were referred to as “Treatment Non-Responders.” These patients reported high pain at baseline, but responded only minimally to

treatment (i.e., continued to report pain near 4 or greater throughout the study). The third group was labeled “High Pain - Treatment Responders.” This group, making up about 17% of the sample, reported high pain at baseline but responded well to treatment, such that by the end of the follow-up period at 52 weeks this group was reporting almost no pain. The fourth group was labeled “Moderate Pain – Moderate Responders.” Patients in this group reported moderate pain at baseline, and showed relatively modest improvement in pain scores (about 30% improvement) over the course of the study.

Characteristics of Trajectory-Based Groups

Individual patients were assigned to trajectory-based groups based on predicted group membership. Probabilities of membership in assigned groups were estimated at greater than 90%, while probabilities of being in any other group were less than 12%. Patients in the trajectory-based groups were examined for their standing on a number of baseline characteristics. Table 2 shows the results of analyses of baseline characteristics by trajectory-based groups. Examination of the table suggests that Treatment Non-Responders tended to be similar to the other patients in terms of demographics, but were more likely than the other groups to report high disability on the Graded Pain scale. Treatment Non-Responders were also more likely to have higher baseline scores on the CESD depression scale and on somatization, to have lower self-efficacy scores than those in other groups, and to have higher scores on pessimism and catastrophization.

Treatment-Related Predictors of Trajectory-Based Group Memberships

The GMM method allows the regression of growth factors and class membership onto predictor variables. The resulting parameter estimates are multinomial logistic regression coefficients. In order to test effects of treatment and potential treatment mechanisms, four risk models were evaluated: 1) Effect of Treatment; 2) Effects of treatment adherence (i.e., session attendance, and adherence to splint, to medication, and to diet instructions); 3) Effects of cognitive and behavioral change (i.e., pre-post changes in pain management self-efficacy, catastrophization and coping skills); and 4) a combined model of all significant variables to detect possible mediation. Effects of cognitive change were limited to pre-posttreatment changes because it appears that the levels of the cognitive change variables remained stable after the posttreatment time period.

The results of the analyses of all four-class models based on MPI pain scores are summarized in Table 3. For each model analyzed Class 2 (Treatment Non-responders) was used as the reference class. This was done to allow a clear comparison of those who responded with those who did not respond to treatment. As seen in the Table, results for Model 1 shows that Treatment condition was a significant predictor of membership in both Class 1 and Class 3 relative to the reference Class (Class 2). The relative distributions of trajectories based on treatment condition are shown in Figure 2. As seen in the Figure, relative to those in the STD condition, patients in the STD+CBT condition were less likely to be members of Class 2 (Treatment Non-Responders) than were patients treated in the STD condition. On the other hand patients treated in the STD+CBT condition were more likely to be members of Class 1 (moderate pain – treatment responders) and Class 3 (Treatment Responders), than were those assigned to STD. Additionally, the Class 3 patients treated in the STD condition appear to have taken a bit longer than the STD+CBT patients to reach low pain levels: at 36 weeks the STD patients in Class 3 were still reporting moderate to high pain.

Of the measures of adherence tested in Model 2, attendance in treatment was a very strong predictor of membership in Class 3 (treatment responders) relative to Class 2 (non-responders). None of the other adherence measures were significant predictors of Class

membership. Cognitive change variables were tested as predictors of Class membership as shown in the results for model 3. Of these, decreased catastrophizing was a significant predictor of membership in Class 3 relative to Class 2.

The combined model, model 4 in Table 3, shows that treatment condition (i.e., the addition of CBT to standard treatment), and decreases in catastrophizing, remained as important predictors of Class membership in most treatment-responsive class relative to the non-responders of Class 2.

Discussion

As discussed above, TMD-related pain is often amenable to relatively conservative, non-invasive treatment, with or without the addition of psychosocial treatment. Additionally, the literature on predictors of treatment success tends to focus on average outcomes for patient samples, rather than the study of heterogeneous patient subsamples.^{26, 63} The results presented here suggest, however, that there exists a subgroup of patients for whom treatment is not effective, i.e., a discrete set of treatment non-responders who are not really like other patients. In the current study this subgroup accounted for about 16% of the total sample. This proportion of non-responders is comparable to rates found in other studies.¹⁵

The variables measured in this study that characterized the non-responder group were consistent with expectations based on earlier research. Non-responders were likely to score higher on depression, had lower self-efficacy and coping scores, and scored higher on pessimism and catastrophizing than their more adaptive peers. It is surprising that these patients did not exhibit more joint pathology than the patients who did well in treatment. This result is counter to studies of other conservative treatment samples, which found that those with more severe joint pathology, especially disk displacement, were more likely to fail treatment.⁶⁸ Despite the lack of joint pathology, however, these patients were more likely to report being disabled by their TMD pain.

The trajectory-based groups found in this study resemble to some extent the two of the three-groups of pain patients described by Turk and Rudy.^{58, 59} In their taxonomy based on cluster analysis, chronic pain patients were classified into three homogeneous groups on the basis of their scores on the Multidimensional Pain Inventory. Patients were scored as either dysfunctional (scoring poorly on measures of depression and coping ability), interpersonally distressed (scoring at normal levels on all measures except for showing an absence of social support), or adaptive copers, who remain active despite continuing pain, with little psychological distress or life interference (although the reasons for this are not known). The treatment non-responders in the present study resemble Turk & Rudy's dysfunctional patients, whereas the moderate pain and treatment responders in the present study are more like adaptive copers. Turk and Rudy found, however, that all patients improved on physical, psychosocial and behavioral measures with treatment. Furthermore, those patients classed as dysfunctional demonstrated significantly greater improvements on pain intensity, impact of symptoms, depression, and negative thoughts, than did the other types of patients.⁴⁵ In the present study our "dysfunctional" patients tended not to improve with treatment. Our treatment responders and our moderate pain patients however, were very much alike, and like Turks and Rudy's adaptive copers, in that all of these groups responded to treatment.

The most significant results were those involving the processes related to treatment that were predictive of trajectory group membership. As seen in Table 3, treatment condition, (i.e., the addition of CBT procedures to standard treatment), treatment attendance, and decreases in catastrophizing were all individually predictive of membership in one of the treatment-responsive groups. In the combined analysis attendance dropped out as a unique

predictor, suggesting that the effects of the addition of CBT to standard treatment were accounted for by more than simply exposure to the therapist. On the other hand, the significant effect of decrease in catastrophizing seen in the combined model, with the treatment condition effect present, suggests that the decreases in catastrophizing were not entirely the effect of treatment per se, but probably occurred as a function of some other aspects of being in treatment. It is even possible that drops in catastrophizing were the result of early drops in pain, rather than the cause. Our current data do not permit us to parse the cause-effect relationship between catastrophizing and pain response over time.

The specific measure of catastrophization used, the PRSS, was apparently sensitive to changes that occurred during treatment. The nine items that assess catastrophizing (e.g., “No matter what I do I cannot change the pain”) reflect cognitions (self-statements) that are often the specific targets of cognitive-behavioral treatments and of decreasing pain. Although subcategories of catastrophizing were never identified by the authors of the PRSS, other research employing the instrument suggest that the items tap both helplessness and the tendency to magnify the pain.⁶⁹ Other measures, however, might have performed as well (or better) than the PRSS, which did not reflect differential treatment effects in the present study. The Pain Catastrophizing Scale⁵² (PCS), for example, is a widely-used 13-item scale that assesses catastrophizing self-statements similar to those of the PRSS, reflecting anxiety about continuing pain, helplessness in the face of pain, and rumination or preoccupation with the pain problem. Different patients may show more or less of these different aspects of catastrophizing, and CBT treatments for chronic pain have been specifically developed to address these, with changes in catastrophizing reflected in PCS scores.⁵⁴ Thus the PCS might have been a better measure in the present study.

Perhaps the most significant result of this study concerns the effect of adding CBT procedures to standard conservative treatment for TMD pain. As noted in the discussion above (and seen in Figure 2), the addition of CBT procedures appears to have had a significant effect on the subsequent pain trajectories of the patients. Relative to standard treatment CBT appears to have limited the number of non-responsive patients. It is likely, however, that treatment could be improved further if additional efforts could be found to alter catastrophizing in a more systematic way. Although a treatment effect on catastrophizing was not discoverable in the present analyses, diary studies of these same patients indicate that momentary catastrophizing did decrease from pre-to-posttreatment with the addition of cognitive-behavioral procedures.²⁵ This effect on episodic catastrophizing has also been seen in studies of other chronic pain samples.⁷⁰

This study highlights the importance of recognizing the heterogeneous nature of clinical pain samples. Treatment of patients as a homogeneous group is likely to produce suboptimal treatment for many patients.³⁹ As discussed above, no treatment is successful for everyone. Of particular interest here, however, are those characteristics that may make a patient less suited to, or less accepting of, psychosocial treatments.

Most CBT programs for pain, for example, require a significant degree of commitment to the process. This includes the willingness to think about one's problem differently, adhere to homework assignments, and commit to working to change one's thoughts, feelings and behaviors about one's pain problem. Catastrophizing, or the tendency to exaggerate a negative mental set, interferes with all of those tasks, and is considered one of the most important cognitive contributors to chronic pain experience.⁵¹ In TMD patients catastrophizing measured as a trait has been linked to greater levels of depression, activity interference, and perceived jaw interference⁶², and is associated with symptom severity and failure in treatment.⁵³ In the current study those high in catastrophizing constituted the non-responders.

The current study has some notable limitations. The first, and most problematic, is the relatively small sample size, which necessitated imposing some constraints on the growth models to insure solutions. Although this approach is common and even necessary,³⁴ the resulting models are not exact fits to the data, and the resulting classes were small. Additionally, the somewhat selective nature of the sample may make it somewhat unrepresentative of the population that is currently seeking treatment for orofacial pain; high percentages of our own clinic patients present with prescriptions for antidepressants and/or narcotic pain medication and would have been excluded from the current study. Thus our sample may have been somewhat more adaptive, and less severely affected than other clinical samples.

The lack of enforcement of some procedures for patients, particularly in the Standard portion of treatment, may have introduced variance into the results that could have obscured some findings. This was particularly the case with patients' use of the splint, which varied considerably. The decision not to enforce specific procedures for splint use was made so that the Standard treatment would be comparable to that patients would receive in community practice. We believe this was achieved; the patients in this study reported splint, diet and medication use that was quite comparable to that of our non-research patients. As such, we believe that this was a good test-bed to evaluate the added contribution of cognitive-behavioral procedures.

The argument has been made that almost every TMJ problem responds to simple conservative dental treatment, and that the addition of CBT is not necessary.³² A number of studies have demonstrated, however, that CBT, alone or in combination with other modalities, can improve outcomes for patients with TMD pain.¹ Few well-controlled studies have compared standard treatment to a standard treatment with added CBT. As the current study demonstrates, the addition of CBT procedures to treatment result in added treatment efficacy and improved outcome over time. In order to treat effectively the most recalcitrant types of patients, however, more varied, creative, and individualized approaches will be necessary. It is expected that cognitive-behavioral tactics, or other types of treatment, that specifically address catastrophizing will be needed to treat some subsets of patients. In particular treatment approaches will need to determine specifically what can work or not work for each individual patient. Treatment approaches that emphasize flexibility and meeting the individual needs of patients, we believe, represent the new direction in treatment research for TMD-related chronic pain.

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Perspective

This article provides evidence that the TMD chronic pain population is heterogeneous, and that a subsample of patients will be unresponsive to standard or psychosocial approaches. The addition of CBT to treatment may be helpful for this group, but new individualized approaches will be needed to treat all patients effectively.

Figure 1.

Initial trajectory-based model of MPI Pain over time. Dark lines show the mean pain scores for each trajectory for each time period. Gray lines show the estimated trajectories based on the Growth Mixture Model (GMM) parameter estimates.

Figure 2.

MPI Pain trajectory-based classes plotted separately by treatment condition. The percentages shown refer to the percentage of patients treated in each condition (STD or STD+CBT) who had membership in each of the 4 classes. The percentages for each Treatment Condition add up to 100%.

Table 1
Fit indices for GMM Class Solutions for Ratings of Characteristic TMD Pain Over Time.

GMM Solution	Log Likelihood	AIC	BIC	Entropy	LMR adjusted	BLRT
1-Class	-1065.22	2154.43	2147.91	N/A	N/A	N/A
2-Class	-1053.70	2139.39	2130.70	.87	21.86 ^{ns}	23.04 [*]
3-Class	-1052.63	2145.26	2134.39	.89	2.02 ^{ns}	2.13 ^{ns}
4-Class	-1035.44	2118.89	2105.85	.86	17.07 ^{ns}	18.00 [*]
5-Class	-1023.60	2103.20	2087.99	.94	22.47 ^{ns}	23.69 [*]

Note: ns=non-significant
AIC= Akaike Information Criteria; BIC= Bayesian Information Criteria; LMR=Lo-Mendell-Rubin test; BLRT=Bootstrapped Likelihood Ratio Test
All solutions inadmissible until quadratic slope variances fixed to 0.
^{*} p< .001

Table 2

Baseline Characteristics of Patients by Pain Trajectory Class (N=101)

	Class 1 Moderate Pain – Treatment Responder (n=27)		Class 2 High Pain – Non- Responder (n=16)		Class 3 High Pain – Treatment Responder (n=17)		Class 4 Moderate Pain – Moderate Responder (n=41)		F or χ^2
	M or %	SD	M or %	SD	M or %	SD	M or %	SD	
Demographics									
Sex: % Women	81.50		87.50		94.10		80.50		1.96
Age (years)	36.29	12.78	40.36	12.42	40.23	11.51	40.77	11.87	0.82
Race: % White	81.50		50.00		82.40		79.20		29.48
Education (Years)	14.56	2.44	13.25	1.57	14.12	3.62	15.68	1.75	4.90*
Employed: % Full or Part Time	74.10		50.00		58.80		82.90		7.65
Marital: % Married/ Cohabiting	25.90		31.20		35.30		58.50		8.56
Income: % > \$50,000	25.90		31.20		47.10		53.70		19.31
Pain and TMJ Pathology									
Years Pain	8.93	9.31	5.82	5.00	7.00	6.55	5.47	4.73	1.62
Pain Grade: % High Disability	18.50		50.00		41.20		9.80		27.86*
Bruxism: % Positive	88.90		81.20		76.50		80.50		1.30
Clicking: % Positive	88.90		93.80		94.10		80.50		3.05
Locking: % Positive	74.10		68.80		64.70		46.30		6.10
Psychiatric Symptoms									
CESD Depressive Symptoms Score	11.63	8.16	23.75	15.57	13.35	8.04	9.90	8.54	8.00*
Trait Anxiety Score	40.74	9.91	43.00	12.28	41.47	10.15	38.07	8.43	1.20
SCL Somatization	9.11	6.45	13.81	9.75	10.00	6.12	8.44	6.59	2.31
Cognitive Constructs									
Readiness for Treatment	6.52	1.51	5.53	1.49	5.81	3.10	7.03	2.02	2.72
Pain Coping Self-Efficacy	77.23	11.45	62.14	21.64	73.53	23.83	78.29	11.65	6.50*
Optimism	14.11	3.39	12.44	3.43	14.31	3.09	15.12	2.93	2.80
Pessimism	9.44	4.69	14.75	3.77	9.81	2.76	8.37	3.28	11.50*
PRSS Coping Score	2.69	0.60	1.95	0.64	2.33	0.83	2.71	0.74	5.27*

	Class 1 Moderate Pain – Treatment Responder (n=27)		Class 2 High Pain – Non- Responder (n=16)		Class 3 High Pain – Treatment Responder (n=17)		Class 4 Moderate Pain – Moderate Responder (n=41)		
	<i>M</i> or %	<i>SD</i>	<i>M</i> or %	<i>SD</i>	<i>M</i> or %	<i>SD</i>	<i>M</i> or %	<i>SD</i>	<i>F</i> or <i>z</i>
PRSS Catastrophizing Score	1.49	0.74	2.47	1.09	1.89	0.82	1.52	0.86	5.62 [*]
% of Class in STD+CBT Condition	51.0		37.4		71.9		48.8		12.00 [*]

* *P* significant at family-wise error rate adjusted value

Table 3

Summary of Growth Mixture Model Analyses of Characteristic Pain Based on Four Trajectory-Based Groups. Estimates (Bs) are Multinomial Logistic Regression Coefficients, Quantifying the Effect of the Predictor on Membership in Each Latent Class, With Group 2 (Treatment Non-Responders) as the Reference Class. N=101.

Model	Predictors	Group 1 (Moderate Pain – Treatment Responder)					Group 3 (High Pain – Treatment Responder)					Group 4 (Moderate Pain – Moderate Responder)				
		B	se	t	OR	95% CI	B	se	t	OR	95% CI	B	se	t	OR	95% CI
1	Treatment Condition ^a	1.39	0.71	1.96*	4.01	0.01	2.78	1.61	0.73	2.21*	5.00	0.18	3.04	0.88	0.34	0.74
2	Attendance in Treatment	0.02	0.26	0.08	1.02	-0.49	0.53	2.01	0.78	2.59**	7.46	0.48	3.54	0.29	0.79	1.27
	Adherence to Medication	-0.04	0.03	1.12	0.96	-0.10	0.02	-0.01	0.04	-0.02	0.99	-0.09	0.07	0.03	-0.88	0.97
	Adherence to Splint	-0.01	0.02	-0.36	0.99	-0.05	0.03	-0.01	0.02	-0.35	0.99	-0.05	0.03	0.02	0.84	0.98
	Adherence to Diet	-0.06	0.05	-1.16	0.94	-0.16	0.04	-0.01	0.05	0.17	0.99	-0.11	0.09	0.05	0.98	1.05
3	Catastrophizing Change	-0.46	0.70	-0.66	0.63	-1.85	0.93	-1.37	0.55	-2.49**	0.25	-2.45	-0.29	0.27	0.51	1.31
	Coping Change	0.02	0.08	0.25	1.02	-0.14	0.18	0.18	0.11	1.64	1.19	-0.04	0.40	0.14	1.27	1.15
	Self-Efficacy Change	0.01	0.02	0.50	1.01	-0.03	0.05	0.01	0.02	0.51	1.01	-0.03	0.05	-0.01	0.03	0.99
4	Treatment Condition	1.61	0.96	1.68	5.00	-0.30	3.51	1.82	0.88	2.06*	6.17	0.10	3.54	0.19	-0.26	0.95
	Attendance in Treatment	-0.32	0.25	-1.29	0.73	-0.82	0.18	0.01	0.25	0.04	1.01	-0.48	0.50	0.18	0.60	1.19
	Catastrophizing Change	-1.00	0.54	-1.83	0.37	-2.07	0.07	-1.03	0.47	-2.21*	0.35	-1.95	-0.11	-0.03	0.25	0.97

^aSTD=0; STD+CBT=1

* p < .05

** p < .01