Predictors of Outcome for Treatment of Temporomandibular Disorders

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Psychosocial factors have been frequently suggested as important risk factors that may delay recovery in patients with temporomandibular disorders. In this study, 94 subjects with chronic temporomandibular disorders were studied using IMPATH:TMJ prior to their entering an interdisciplinary treatment program to determine which factors were most predictive of outcome. Treatment outcome was determined based on significant decreases in the Craniomandibular Index and the Symptom Severity Index from pretreatment to posttreatment. The IMPATH:TMJ items were regressed on treatment outcome for a random sample of half of the subjects (n = 47) to isolate the psychosocial and demographic items most predictive of treatment response. Discriminant analysis was then employed to test the predictive utility of the identified items for these subjects (criterion group), followed by a cross-validation of the items on the remaining 47 subjects (cross-validation group). Low self-esteem, feeling worried, low energy, and sleep activity were identified as useful predictors of treatment outcome in the criterion group. Each are correlates of depression. The discriminant analysis employing these four items accounted for 49% of the variance in treatment response, was statistically significant (P < .0001), and correctly predicted treatment outcome for 41 of 47 subjects (87%) in the criterion group. The predictive utility of the identified items remained statistically significant when applied to the cross-validation group (P < .01). The discriminant function employing the items correctly predicted treatment outcome for 37 of 47 subjects (79%) and explained 28% of the variance in treatment response. Findings of this study suggest that pretreatment psychosocial information is important in predicting treatment outcome for chronic temporomandibular disorders, and that symptoms of depression mediate treatment response for chronic pain patients.
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A major frustration of clinical orofacial pain practice is the failure of some patients to improve with standard treatment protocols because of factors out of the clinician's awareness and control. Knowledge of factors that predict treatment response will allow clinicians not only to develop more appropriate and sensitive treatment plans, but will also contribute to the understanding of factors that perpetuate orofacial pain. The clinician can focus specific attention on addressing these variables or providing appropriate referral to enhance outcome.

The role of psychosocial factors in temporo-mandibular disorders has been researched extensively, and there is general acceptance that there is a relationship between psychosocial factors and chronic temporomandibular disorders.[1-7] Despite this general acceptance, however, the importance of psychosocial factors in temporomandibular disorders and chronic pain is not clear, and these factors may play a role in predisposition, perpetuation, or mediation of treatment outcome.[8]

A recent trend in the psychologic literature has attempted to identify psychosocial factors predictive of patient response to chronic pain treatment.[2,8-14] Since the predictability of treatment outcome for temporomandibular disorders (TMD) has also been found to increase when psychosocial variables are considered,[12] it seems likely that many such unseen factors are psychosocial in origin. Specifically, the purpose of this study was to identify those psychosocial factors (ie, cognitive, demographic, emotional, behavioral, and social) that are predictive of treatment response for subjects with chronic temporomandibular disorders (temporomandibular joint [TMJ] and myofascial pain dysfunction [MPD]).

Materials and Methods

Study Design

Ninety-four patients diagnosed as having chronic temporomandibular pain (TMJ or MPD) were evaluated prior to treatment by a dentist using the Craniomandibular Index (CMI, a measure of the physical impairment of the TMJ and surrounding muscles); each patient completed the Symptom Severity Index (SSI, a measure of the subjective pain experience) and the IMPATH:TMJ (an assessment of psychosocial and demographic factors associated with chronic temporomandibular pain) (Velocity Healthcare Informatics, Minneapolis, MN). Following these pretreatment assessments, each subject participated in a 6-month chronic pain treatment program in which a dentist, a physical therapist, and a psychologist worked conjointly to treat the disorder in an interdisciplinary pain management clinic. Approximately once a year after their initial appointment (6 months after treatment), subjects returned to the clinic for a reassessment on the CMI and the SSI. Treatment outcome (success or failure) was determined based on improvement in both physical condition and subjective pain from preevaluation to postevaluation as measured by the CMI and the SSI. To test

the utility of IMPATH:TMJ items in predicting treatment outcome, subjects were randomly assigned to a criterion (n = 47) or a cross-validation (n = 47) group. Using stepwise multiple regression and discriminate analysis, it was then possible to isolate IMPATH:TMJ items that differentiated between treatment responders and nonresponders and to develop an equation based on these items that best predicted treatment outcome for the determinant group. Finally, the discriminating items were cross-validated on the remaining 47 subjects to test the decrease in predictability that occurs when the equation is applied to a group other than that from which it was developed.

Because all subjects in this study had pain that lasted longer than 6 months' duration, they were considered to be patients with chronic pain. Although there is no well-accepted operational definition of chronic pain,[15] *The Nuprin Pain Report*[16] arbitrarily defined chronic pain as pain sufficiently severe that a person "could not work or engage in routine activities" for more than 30 days in a 1-year period. Rugh and Solberg[4(p21)] assert that chronic pain is the "most threatening and debilitating" symptom of patients with TMD and that chronic TMD is similar to other chronic pain syndromes in that "*the illness of chronic pain itself* may be of as much clinical importance as the disease state or illness with which it is associated [italics added]." Because the majority of patients with chronic pain do not respond to medical or dental treatment in the prescribed manner, they are at risk of suffering iatrogenic disorders following unwarranted surgeries and of developing a narcotic addiction.[8] Therefore, it is hoped that the present study will provide information that is beneficial not only in the treatment of chronic TMD, but also in understanding other chronic pain syndromes.

Sample Selection

Potential subjects for this study included patients diagnosed with chronic TMD at the TMJ and Craniofacial Pain Clinic, University of Minnesota Health Sciences Center. Patients referred to this clinic have some combination of headache, jaw pain, neck and shoulder pain, ear pain, and/or facial pain that lasted longer than 6 months' duration and that has not responded to previous treatment. During a 1-year time period, 138 patients referred to this clinic were diagnosed with chronic temporomandibular pain (TMJ or MPD), and each participated in the clinic's treatment program. Furthermore, all 138 patients were evaluated at pretreatment with the following three assessment

Table 1 Pain History of Total Sample at Pretreatment

	Mean	Range	SD
No. of professionals consulted for the problem	3.5	0.0 to 13.0	2.4
No. of different treatments for the problem	1.9	0.0 to 11.0	2.0
No. of years with the problem	8.5	0.0 to 45.0	11.4
No. of physical activities prevented because of pain	6.2	0.0 to 25.0	5.0
Symptom Severity Index (0 to 1)	0.58	0.16 to 0.96	0.17
Craniomandibular Index (0 to 1)	0.41	0.09 to 0.76	0.14

instruments: the CMI, the SSI, and the IMPATH:TMJ. Subjects for this study included those patients who agreed, following a telephone call or letter, to return to the clinic approximately 1 year after their initial visit for a reassessment of their pain condition. Of the 138 potential subjects, the experimenter was able to contact 124 (94%) by telephone or mail to solicit their participation in the study. The remaining 10% could not be located because they had relocated to a different part of the country, their telephone had been disconnected with no forwarding information, or their whereabouts were otherwise unknown. Of the 124 former patients contacted, 111 (90%) returned to the clinic for a reevaluation with the pretreatment instruments, and of these, 94 (76%) completed all posttreatment instruments and were the subjects for the present study. Myofascial pain was the primary diagnosis for 47 (50%) of the subjects, and TMJ disc displacement was the primary diagnosis for 47 (50%).

Of the subjects included in the sample, 84 (89%) were female and 10 (11%) were male. Ages ranged from 16 to 61 years, with a standard deviation (SD) of 11.7 and a mean of 36.6 years. Marital status included 28 (30%) who were single, 52 (55%) who were married, one (1%) who was widowed, six (6%) who were divorced, and seven (7%) who chose not to respond to this questionnaire item. Two years of college was the mean educational level for sample subjects. Table 1 shows a summary of the pretreatment pain history. A mean of 3.5 clinicians had been consulted for the problem, with a mean of 1.9 previous treatments. Symptoms most often reported included headaches (77%), facial or jaw pain (68%), neck

and shoulder pain (60%), and TMJ pain (51%). Subjects most often reported that the condition developed over months (61%), and they usually did not associate the onset of pain with any particular event or stressor. When they did relate the pain onset to a particular event, a stressful situation (13%), medical treatment (11%), and auto and home accidents (11%) were most often mentioned. Finally, subjects reported having the problem for a mean of 8.5 years, and the problem was reported to prevent them from participating in a mean of 6.2 physical activities.

Treatment

The TMJ and Craniofacial Pain Clinic uses an interdisciplinary team approach to chronic orofacial pain management based on the assumption that chronic pain is multidimensional and thus best treated by a multifaceted approach.[4,17] The clinic is an outpatient pain program integrating the expertise of dentists, psychologists, and physical therapists in the treatment of chronic temporomandibular pain. The conceptual basis for the clinic is the biopsychosocial medical model, the general systems theory, and cybernetics.[18,19] This model places equal importance on physical and psychosocial factors in the development and perpetuation of chronic pain; therefore, the services and expertise of each of the team members are considered equally important. Chronic pain is conceptualized as having many components, including physical, cognitive, social, behavioral, emotional, and environmental. Each problem component recursively affects the others and, thus, the whole system. The goal of this team approach is to simultaneously treat all components or levels of an illness. The efficacy of this interdisciplinary clinic in treating patients with temporomandibular pain has been documented elsewhere.[19]

The treatment program had three general goals that were applicable to all subjects: (1) improvement in symptoms, (2) improvement in daily functioning, and (3) reduction in dependency on the health care system.[19] The responsibilities for each of the three team members has been discussed in detail in other publications[19,20] and is only summarized here. The dentist was responsible for establishing the physical diagnosis, placing and adjusting a complete stabilization splint if this was considered appropriate, and monitoring medication. The psychologist was responsible for diagnosing psychologic disturbances and providing appropriate management/referral for these problems, educating subjects as to the nature of the

psychosocial influences on their pain, and offering a cognitive-behavioral program designed to change maladaptive behaviors, such as clenching, bruxing, sleep, and dietary contributing factors. The cognitive-behavioral approach involves teaching subjects to monitor and control dysfunctional oral behaviors using several behavioral approaches, such as self-monitoring, overcorrection, and habit reversal.[21] The physical therapist was responsible for providing an exercise program designed to improve jaw and cervical range of motion, function, and posture. Physical therapy exercises were sometimes augmented with ultrasound, heat/cold therapy, and other modalities when appropriate. Each team member was responsible for providing care in his or her area of expertise. Furthermore, each team member was also responsible for establishing a supportive and trusting relationship with the subject while emphasizing the self-care philosophy of the clinic. Each subject met with the dentist for approximately six 0.5-hour sessions; with the physical therapist one per month for 6 months; and with the psychologist for four 1-hour sessions during the 6-month treatment period.

Instruments

Craniomandibular Index. The CMI is designed to provide a standardized measure of problems in mandibular movement, TMJ noise, and muscle and joint tenderness for use in epidemiologic and clinical outcome studies. The CMI is divided into items assessing jaw dysfunction, termed the *Dysfunction index* (D_i), and items measuring muscle tenderness, termed the *Muscle index* (M_i). The D_i specifically measures the range of motion of the TMJ, pain in range of motion, TMJ tenderness, and TMJ noise. The M_i measures tenderness following palpation of intraoral muscles, extraoral jaw muscle sites, and neck muscles. Reliability and validity studies of the CMI have been demonstrated elsewhere.[22,23]

Symptom Severity Index. The SSI measures the self-report severity of pain and employs five items that measure the multidimensional aspects of pain severity using category-based visual analog scales (VAS). These six components include sensory intensity, affective intensity, tolerability, frequency, duration, and scope of symptoms, using checklists assessing pain symptoms commonly associated with temporomandibular disorders. Previous studies suggest that SSI items are a valid assessment of changes in temporomandibular pain following treatment.

IMPATH:TMJ. The IMPATH:TMJ is a psychometric survey instrument designed to provide an evaluation of the behavioral, psychosocial, and demographic factors that influence the development and perpetuation of TMD. Questionnaire items were derived from extensive surveys of medical, psychologic, and dental literature, and items with a demonstrated relationship to chronic pain were included in the instrument.[24] The questionnaire includes an assessment of historic and demographic information, verbal pain descriptors, and symptoms checklists.[25–29] The evaluation of pretreatment psychosocial factors (ie, behavioral, emotional, cognitive, and social) is accomplished by use of 100-mm VAS, which have been reported as valid and reliable measures in pain assessment studies.[29] Validity of the IMPATH items was examined in a recent study that reported that pain patients scored significantly different on questionnaire items than did a control group.[30] In the same study, the reliability, stability, and internal consistency for the instrument was found to be acceptable.

Procedures

Following referral to the TMJ and Craniofacial Pain Clinic, each patient met with a member of the treatment team for a screening interview to determine the appropriateness of the clinic's program for addressing their particular concerns. Following the interview, each potential subject completed the IMPATH:TMJ and the SSI and was evaluated on the CMI by one of the dentists calibrated in its use. The three dentists were the same dentists who participated in the reliability study of the CMI, and their interrater reliability on the instrument was .95. The dentist diagnosed each potential subject as having chronic TMJ or MPD according to specific diagnostic criteria.[31]

In addition to the evaluation with the dentist, each potential subject met for 1 hour with the staff psychologist and for 1 hour with the staff physical therapist prior to treatment. Following pretreatment testing and evaluation, all subjects participated in a 6-month individualized management program designed by the evaluation team and based on the contributing factors and treatment goals as described above. Of the original 138 subjects who were evaluated on all pretreatment measures, 109 (79%) completed the 6-month treatment program, and 29 (21%) participated in but did not complete the 6-month treatment protocol. Fricton et al[19] reported that the results of patients who do not complete the treatment program are retrospectively found to differ from those of

patients completing the program at pretreatment on several psychosocial and clinical variables. However, since the purpose of the study was to *predict* treatment outcome based on pretreatment demographic and psychosocial data, no comparisons were made between completers and noncompleters of the program. In fact, it was expected that a percentage of subjects would fail to complete the treatment program, and it was an aim of the study to determine if pretreatment information would be useful in identifying noncompleters, and if noncompleters were less successful in reducing temporomandibular pain and impairment.

Approximately 1 year following the initial appointment date (or 6 months following the completion of the treatment program), the examiner telephoned each of the 138 potential subjects to elicit participation in the study. Potential subjects had completed all pretreatment measures and evaluations (CMI, SSI, and IMPATH:TMJ). Upon contacting a former patient, the examiner asked if he or she would be willing to come back for a free follow-up physical examination of the condition and fill out a questionnaire assessing the current severity of the temporomandibular problems. Subjects who could not be reached by phone were mailed a letter to the address given on their pretreatment IMPATH:TMJ and asked to participate in the study. Of the original 138 potential subjects, 124 (90%) were contacted either by telephone or mail, and 111 (90%) of these subjects agreed to fill out the SSI and come in for the follow-up exam on the CMI. Of the 111 subjects who consented for follow-up evaluations, 92 completed the treatment program and 19 failed to complete the treatment program. Thus, the sample for this study included 84% of the original sample of program completers (92 of 109) and 66% of the program noncompleters (19 of 29). However, when considering the 124 patients who the experimenter was able to contact, 92 of 106 completers (87%) and 17 of 25 noncompleters (68%) agreed to come for follow-up examinations and testing. It is important to note that nearly all subjects (both completers and noncompleters) agreed to fill out the follow-up SSI but that only those subjects who could come back to the clinic for an examination on the CMI were included in the study. Since several former patients moved to a different part of the country, it was impossible for them to return for a follow-up examination.

On returning to the clinic, subjects were reexamined on the CMI by a dentist, and each subject was again asked to complete the SSI. The dentist was blind as to the subject's original CMI scores or whether they had completed the program. Complete data were lacking for 17 patients (follow-up CMI exam or SSI was absent), and these subjects were thus excluded from the study. This left a total of 94 patients with chronic TMD who were evaluated at pretreatment on the CMI, the SSI, and the IMPATH:TMJ and who were evaluated approximately 1 year later on the CMI and the SSI.

Evaluating Treatment Outcome. In determining treatment outcome, it was considered important to assess changes in both functional impairment (as measured by the CMI) and subjective pain severity (as measured by the SSI). Subjects were classified as "successful" at posttreatment if both of the following two changes occurred:

1. There was a decrease of one SD (0.14) or greater on the CMI from pretesting to posttesting, or the posttreatment CMI was less than 0.15.

2. There was at least a 30% decrease (equivalent to one SD) on the SSI from pretesting to posttesting.

It was not considered appropriate to evaluate physical improvement based only on percentage of change on the CMI, since it was possible for less severely impaired subjects to realize significant improvement without being classified as successfully treated. Therefore, 0.15 was chosen as a marker to indicate treatment success, since this value is equivalent to one SD greater than what a control group scored on this instrument. Thus, posttreatment scores less than 0.15 indicated that the functional impairment of the TMJ and surrounding structures was in a normal range. A 30% decrease in SSI ratings was considered as an acceptable level of change in subjective pain severity, since this percentage is equivalent to one standard deviation when employing pretreatment SSI values.

Statistical Analysis

Discriminant analysis was employed to determine which pretreatment IMPATH:TMJ items were predictive of treatment outcome for patients with chronic TMD. This statistical procedure isolates questionnaire items that discriminate between treatment responders (successful) and nonresponders (not successful). Each of the 94 subjects was randomly assigned to a criterion or a cross-validation group, either group consisting of 47 subjects. The discriminant equation was developed using subjects from the criterion group only. Stepwise multiple regression was utilized to isolate a subset of IMPATH:TMJ items that provided the best

prediction of the dependent variable (response to treatment) with as few items as possible. With stepwise multiple regression, a questionnaire item is considered if, in conjunction with previously selected items, it contributes significantly to the prediction of the dependent variable (according to the change in R^2). Stepwise multiple regression analysis was first performed on five clusters of IMPATH:TMJ items (demographic, emotional, cognitive, behavioral, and emotional) to select the best response predictors from each item cluster. A second stepwise multiple regression analysis was then performed on the identified items to determine which category of IMPATH:TMJ items best predicted treatment response. Discriminant analysis was then employed to test the predictive utility of the identified items, and a discriminate function was developed based on these items to predict treatment outcome for each of the 47 subjects in the criterion group. By means of the discriminant function, it was possible to compare the predicted treatment results with the actual treatment results based on pretreatment to posttreatment changes in the CMI and SSI, and to note the percentage of patients correctly classified at pretreatment by the discriminant function. Finally, the identified items were cross-validated on the remaining 47 subjects (cross-validation group) to calculate the extent to which the predictive power of the discriminant function shrinks when applied to subjects other than those from which the equation was derived.

Results

Table 2 shows the percentage of patients in either group who were classified as successful or not in treatment. Twenty-nine of 47 subjects (61.7%) in the criterion group and 27 of the 47 subjects (57.4%) in the cross-validation group were classified as successfully treated at posttreatment. Although this is considerably less than the 70% to 90% success rate that is typically reported for TMD patients,[1,2,32] it should be noted that the present study employed stringent criteria for determining treatment success, and all subjects had had chronic temporomandibular pain during a duration of at least 6 months.

Stepwise multiple regression was the statistical procedure used to isolate IMPATH:TMJ items predictive of treatment outcome. Each cluster of IMPATH:TMJ items (ie, demographics, emotions, behaviors, cognitions, and social) was separately regressed on treatment outcome (success or failure) to identify items most predictive of treatment

Table 2 Treatment Outcomes for Subjects in the Criterion Group and Subjects in the Cross-Validation Group*

	n	Within-group frequency (%)	Total population frequency (%)
Criterion group	47		
Failure	18	38.3	19.1
Success	29	61.7	30.9
Cross-validation group	47		
Failure	20	42.6	21.3
Success	27	57.4	28.7
Total sample			
Failure	38	40.4	
Success	56	59.6	
Total	94	100.0	100.0

*Success is defined as a 30% or greater decrease in SSI ratings from pretesting to posttesting and a posttest CMI rating below 0.15 or at least 0.14 less than the pretreatment CMI rating. A total of 94 cases were valid, and none was missing.

response from each of the psychosocial components theorized to contribute to the experience of chronic pain.

Demographics

Of the 28 demographic IMPATH:TMJ items assessed, only the number of previous treatments was identified as a potential predictor of treatment outcome. This item accounted for 17% of the variance in treatment response ($P < .05$). There was a negative correlation ($r = -.41$) between the number of previous treatments and treatment outcome, meaning that the likelihood of being successfully treated decreased as the number of previous treatments increased.

Emotions

Of the 16 emotional items evaluated, three (low self-esteem, low energy, feeling worried) were identified as potential predictors of treatment outcome. These three items accounted for a combined total of 41% of the variance in outcome scores ($P < .001$). As subjects reported experiencing low self-esteem and low energy less often, the likelihood of their succeeding in the program increased ($r = .49$ and $r = .45$, respectively). Stated another way, low self-esteem and low energy were predictive of treatment failure. There was a negligible relationship ($r = -.02$) between reports of feeling worried and treatment success.

Table 3 Discriminant Analysis of IMPATH:TMJ Items for Treatment Outcome for the Criterion Group (n = 47) and the Cross-Validation Group (n = 47)

	Criterion group coefficient	Cross-validation group coefficient
Low self-esteem	0.94	1.10
Sleep level	−0.53	−0.41
Low energy	0.62	0.28
Feeling worried	−0.66	−0.09
Eigenvalue	0.95	0.38
Canonical correlation	0.70	0.53
Canonical correlation squared	0.49	0.26
Chi square (df = 4)	25.32*	13.32*

*Statistically significant (P < .01).

Behavior

Of the 11 behavioral items assessed, sexual activity level, sleep habits, and eating habits were identified as potential predictors of treatment outcome by the stepwise regression procedure. The combination of these three items accounted for 31% of the variance in the dependent variable ($P < .01$). The relationship between sexual activities and treatment outcome was positive ($r = .39$), meaning that higher ratings of sexual satisfaction were correlated with treatment success. Sleep and eating habits were found to be negatively correlated with treatment success ($r = −.22$ and $r = −.21$, respectively). Thus, as pretreatment ratings of sleep and eating habits became more problematic, the likelihood of the person succeeding in the program diminished.

Cognitions

Two of the fourteen cognitive items were identified as potential predictors of treatment outcome. First, as subjects reported feeling "confused" less often at pretreatment, they were more likely to be successful in the program ($r = .43$). Second, how long subjects thought it would take to reduce the problem was slightly negatively correlated with treatment outcome ($r = −.11$). As the amount of time that subjects thought would be necessary to treat the condition increased, so did the possibility of their being successful in the program. In other words, subjects who unrealistically believed at pretreatment that their problem would be reduced "immediately" were more likely to fail in the pro-

gram. The combination of the two cognitive items accounted for 27% of the variance in the dependent variable ($P < .05$).

Social Items

Finally, of the nine social items assessed, only how often the subjects thought the problem was an excuse not to do some things was identified by stepwise multiple regression as a potential predictor of treatment outcome. This single factor accounted for 11% of the variance in treatment outcome ($P < .05$) and was positively correlated with treatment response ($r = .34$). In other words, as subjects reported that the problem was an excuse to not do some things, the probability of their failing in the program increased.

Stepwise multiple regression of the five IMPATH:TMJ clusters (demographics, emotions, behaviors, cognitions, and social items) yielded a total of 10 potential predictors of poor treatment response for subjects with chronic TMD. These items included poor attitude about success of treatment, low self-esteem, low energy, feeling worried, low level of sexual activity, poor eating habits, poor sleep, feeling confused, unrealistic expectations on reducing the problem, and frequent use of the problem as an excuse to avoid activities.

Identification of Items for the Discriminant Analysis

The next operation in developing the discriminant function was to enter the 10 items previously identified as potential predictors in a second stepwise multiple regression analysis. The purpose of this analysis was to identify items to be included in the discriminant function. Of the 10 items included in the analysis, four (low self-esteem, level of sleep, low energy, and feeling worried) were identified as the best predictors of treatment response (Table 3). The combination of these four items accounted for 49% of the variance in treatment outcome ($P < .005$). There was a positive correlation between scores for low self-esteem and low energy with treatment outcome ($r = .49$ and $r = .45$, respectively). This can be interpreted to mean that as subjects rated themselves as experiencing low self-esteem and low energy more often at pretreatment, the probability of their succeeding in the program decreased. As the pretreatment ratings for sleeping behavior approached a desirable level (eg, slept soundly all night), the likelihood of the person succeeding in the program improved.

Discriminant Analysis

Following the identification of the four salient predictor items, discriminant analysis was performed to determine the utility of these items in predicting treatment outcome. The four items are listed in Table 3 in descending order of importance according to their standardized discriminant function coefficient value. The canonical coefficient represents the relative contribution of each item to the discriminant function for treatment outcome, with the sign merely denoting the direction of the contribution. The predictive utility of the discriminant function is summarized by several statistics presented. The eigenvalue (.95) is a measure of the total variance in the predictive items. The canonical correlation measures the degree of relationship or association between the combination of predictive items and treatment outcome. This statistic is similar to Pearson's (product-moment) correlation coefficient in that it can be squared and interpreted as the proportion of variance in treatment outcome explained by the identified items. As previously noted, the combination of the four variables was successful in explaining 49% of the variance in treatment response for the determinant group. Finally, chi square was computed as a test of statistical significance, and the discriminant function was found to be significant at $P < .0001$.

To further test the predictive utility of the identified IMPATH:TMJ items, the discriminant function based on these items was used to predict treatment outcome, and the classification of subjects based on the discriminant function was then compared with actual treatment outcome based on changes in CMI and SSI scores. The total percentage of subjects classified correctly by the discriminant function was 87%, meaning that the treatment response was accurately predicted for 41 of the 47 subjects by use of pretreatment information on the four IMPATH:TMJ items. Furthermore, the discriminant function accurately identified 93% of the subjects who were actually successful in the treatment program, meaning that it correctly identified 26 of 28 subjects actually successful in the treatment program.

Cross-Validation Results

As has been previously discussed, the identified IMPATH:TMJ items are only useful as predictors if they are able to accurately predict treatment outcome for a group of subjects independent from those on which the discriminant function was developed. To assess the utility of the four identi-

Table 4 Accuracy of Discriminant Function for Predicting Treatment Outcome for the Criterion Group (n = 47) and the Cross-Validation Group (n = 47)

	Predicted group membership	
Actual outcome	Successful	Unsuccessful
Criterion group*		
28 successful	26 (93%)	2 (7%)
19 unsuccessful	4 (21%)	15 (79%)
Cross-validation group*		
27 successful	23 (85%)	4 (15%)
20 unsuccessful	6 (30%)	14 (70%)

*Total cases correctly classified for the criterion group was 41 of 47 (87%). Total cases correctly classified for the cross-validation group was 37 of 47 (79%).

fied factors (low self-esteem, feeling worried, low energy, and sleep level), each was employed in a discriminant analysis of treatment outcome for the 47 subjects in the cross-validation group. The results of the cross-validation are a better estimate of the true relationship between the identified items and treatment outcome, since chance factors maximizing the original correlations will not operate in the cross-validation sample. Although approximately 60% of the subjects in the criterion group were successfully treated, this percentage dropped to approximately 57% for the cross-validation group.

Results of this discriminant analysis for the cross-validation group are presented in Tables 2 to 4. Although the standardized discriminant function coefficient values were less for three of the items (sleep level, low energy, and feeling worried), the coefficient for low self-esteem actually increased in predictive power when applied to the cross-validation group. Since this item was the most useful predictor for both groups, one may have increased confidence in its overall utility in predicting treatment outcome. Conversely, the feeling worried item added little to the predictive utility of the equation. A review of the summary statistics shows that the predictive power of the discriminant function decreased when applied to the cross-validation sample. The total variance of the predictive items (eigenvalue) for the cross-validation sample is .38 compared to .95 for the criterion group. Likewise, the canonical correlation coefficient is reduced from .70 to .53, and the variance in treatment outcome explained by the discriminant function (canonical correlation squared) dropped from .49

to .26. Finally, although the chi square value remained statistically significant ($P < .01$), it also dropped in value from 25.32 to 13.32. However, because the chi square value remained statistically significant ($P < .01$), the hypothesis that there is a relationship between pretreatment psychosocial factors and treatment outcome for temporomandibular patients is confirmed.

Certainly, the most important test of the utility of the discriminant function in predicting treatment response is the percentage of subjects correctly classified for the cross-validation group. The discriminant function accurately predicted treatment response for 79% (37 of 47) of the subjects in the cross-validation group and 85% (23 of 27) of those who were actually successful in the program (see Table 4).

Discussion

The multiple stepwise regression identified the following 10 IMPATH:TMJ items as predictive of treatment outcome: (1) success of previous treatments; (2) low self-esteem; (3) low energy; (4) feeling worried; (5) level of sexual activity; (6) level of eating habits; (7) level of sleep; (8) feeling confused; (9) how long the subject thinks it will take to reduce the problem; and (10) how often the problem is an excuse for not doing something. When these 10 factors were entered into a second stepwise regression on treatment outcome, the following four factors (listed in descending order of their predictive power) emerged: low self-esteem, feeling worried, low energy, and sleep activity. The discriminant analysis employing these four factors accounted for 49% of the variance in treatment response, yielded a finding that was statistically significant at $P < .0001$, and correctly classified treatment outcome for 41 of 47 subjects in the criterion group (87%). When applied to the cross-validation group, the predictive power of the identified items decreased, as expected. However, the discriminant function still was able to explain 26% of the variance in treatment outcome, remained statistically significant ($P < .01$), and accurately predicted treatment response for approximately 80% of cross-validation subjects. Thus, the hypothesis that there is a relationship between pretreatment psychosocial factors and treatment outcome for subjects with TMD was supported. Furthermore, the standardized discriminant function coefficient for one item, low self-esteem, actually increased for the cross-validation group, and this item was the best predictor of treatment response.

Despite our understanding of the role of psychosocial factors in the etiology of temporomandibular pain and pain in general, little is yet known about the factors contributing to the perpetuation of chronic pain. Previous research has not emphasized the importance of psychosocial factors in predicting outcome for patients with chronic pain.[13] The present study clearly demonstrated that psychosocial factors influence the perpetuation of chronic pain and its resiliency to treatment. Use of the discriminant function derived from the study resulted in the accurate classification of approximately 80% of the temporomandibular subjects. Furthermore, the equation accurately classified 85% of those subjects who were actually successful in the program. The predictive utility of the discriminant function derived in this study compares favorably with the results reported in similar studies. Although the study by Lipton and Marbach[13] reported that the eight factors included in their discriminant function allowed them to correctly classify 80% of temporomandibular subjects, the authors failed to cross-validate the equation on an independent sample, and thus, confidence in their findings is diminished.

In addition to evaluating the utility of IMPATH:TMJ items in predicting treatment outcome, a goal of the present study was to increase the understanding of which particular psychosocial factors are most important in influencing treatment outcome and why. A careful evaluation of the 10 items identified as potential predictors reveals that most are involved in characteristics of depression. As with the studies by Gerschman et al[8] and Lipton and Marbach,[13] the number of previous treatments was correlated negatively with treatment success. According to Gerschman et al,[8] this finding suggests that "previous behavior is the best predictor of future behavior" and may support the notion that previous contact with medical and dental professionals may play some role in maintaining the pain, either through reinforcement of pain behaviors or "learned helplessness" as patients with chronic pain become discouraged after repeated treatment failure. This failure is correlated to depression in the patients who did not respond to treatment. In the present study, six (level of eating habits, level of sleep, level of sexual activity, low energy, low self-esteem, feeling confused) of the 10 predictors are correlates of depression. Although the feeling depressed item of the IMPATH:TMJ was not identified as a predictor of treatment response, this item was highly correlated with low self-esteem ($r = .57$); it may be that sub-

jects are more likely to acknowledge low self-esteem, low energy, and feelings of confusion than depressed feelings. This hypothesis is further supported by the Gerschman et al[8] study, which grouped patients with TMD into two categories—those with chronic facial pain as their main complaint and those with altered facial sensation as their primary complaint. Gerschman et al[8(p48)] reported the following: "Psychiatric evaluation disclosed that many of these patients suffered from a chronic psychiatric illness of moderate severity (52 and 72% respectively). The most common diagnosis was some variety of depression (55 and 47% respectively). The predominance of depressive symptoms was borne out by the Hamilton Depression scores according to which 77 and 62%, respectively, were moderate to severely depressed."

These findings are congruent with other studies of chronic pain treatment clinics in which extensive psychiatric evaluations revealed that a high number of patients suffered from an affective disorder.[6,33,34] In addition, anxiety disorders were present in 66% of the women and 59% of the men in one of the studies.[34] Since subjects in this study also had chronic pain, the likelihood that depression-mediated treatment response seems even more likely. Furthermore, depression is often associated with symptoms of stress and anxiety,[15] and stress-related oral behaviors are the presumed cause of temporomandibular disorders. The implications of these findings for the treatment of temporomandibular pain and chronic pain in general is that symptoms of depression must be addressed if treatment is to be successful. Interventions focused entirely on the pain or on physical symptoms may be misdirected.

Although the results have important implications in clinical management of orofacial pain, there are some limitations regarding the study. An attempt was made in the study to measure both physical and subjective pain reliably and validly, yet numerous sources of error and inconsistency are inherent in pain evaluation. Pain is a subjective experience, and the attributes or properties of pain are only hypothetical constructs derived from a theory or model.[15] Although using the CMI is an attempt to measure the physical impairment presented by temporomandibular disorders, it too relies on subjective evaluations that may be inconsistent. For example, several items on the Dysfunction index and the entire Palpation index are scored by asking the patient, "Does this hurt?" As has been discussed elsewhere in this study, "hurt" may have different meanings according to

one's culture and the context of the situation, and the concept may even vary in meaning on different days.[22] Furthermore, since the CMI relies on palpation of specific muscle bands or ligaments, error is introduced when there is variability in the amount of pressure applied, the palpation technique, the size of the distal phalanx, and the area actually palpated. An additional limitation of this study was the exclusion of pretreatment physiologic factors as predictors of treatment outcome. It was hypothesized that psychosocial factors interact systemically with physical or sensory factors to produce chronic pain; yet, the study did not empirically examine the question of whether certain physical conditions or impairments were predictive of treatment outcome. Physiologic variables could not be used in this study because they were used as outcome measures of successful treatment.

However, it would still be useful to know if the discriminant equation predicted equally well for subjects with myofascial pain as it did for subjects with TMD. Thus, the relationship between the degree of physical impairment and likelihood of treatment success is still not known. Perhaps the degree of physical impairment accounts both for the depression and the failure of the subject to benefit from treatment.

Finally, it cannot be assumed that the specific IMPATH:TMJ items identified in this study as useful predictors would also be predictive for other chronic pain populations. Although it may be argued[4] that patients with chronic TMD are psychologically similar to other patients with chronic pain, the fact that the majority of the subjects were women (89%), all were white, and all resided in the upper Midwestern section of the United States limits the extent to which the findings can be generalized to other chronic pain populations. Furthermore, results are limited to the method of treatment utilized in the study. It is still not known whether similar results would be obtained for patients with craniofacial pain subjected to a treatment program other than that employed in this study.

Summary

This study clearly demonstrated that the assessment of psychosocial factors, particularly correlates of depression, are useful in predicting treatment response (success or failure) for these patients with chronic TMD, since treatment outcome was accurately classified for approximately 80% of the sample subjects. As more factors pre-

dictive of treatment failure for patients with chronic pain are identified and addressed, both our understanding of the nature of chronic pain and the likelihood of treatment success will increase.

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Resumen

Factores de Predicción en el Resultado del Tratamiento de los Desórdenes Temporomandibulares

Se ha indicado muy frecuentemente que los factores psicosociales son factores de riesgo importantes que pueden demorar la recuperación en pacientes con desórdenes temporomandibulares (DTM). En esta investigación, se estudiaron a 94 personas con DTM crónicos utilizando el programa para computadora denominado IMPATH:TMJ, antes de involucrar al paciente con un programa de tratamiento interdisciplinario para determinar cúales eran los factores que mejor predecían su resultado. El resultado del tratamiento fue determinado basándose en disminuciones significativas de los Indices Craneomandibular y de Severidad Sintomática desde antes hasta después del tratamiento. Los detalles concernientes al programa IMPATH:TMJ fueron sometidos a un examen de regresión relacionado al resultado del tratamiento de una muestra escogida al azar que comprendía la mitad de los sujetos (n = 47), para aislar los detalles psicosociales y demográficos que podían predecir mejor la respuesta al tratamiento. Se utilizó un análisis discriminante para evaluar el poder de predicción de las características identificables en estos sujetos (grupo de criterio), seguido por una validación cruzada de las características de los 47 sujetos remanentes (grupo de validación cruzada). Se identificaron factores útiles para predecir el resultado del tratamiento en el grupo de criterio; tales fueron el amor propio debilitado, ansiedad, y la falta de energía y sueño. Estos factores son correlativos con la depresión. Este análisis discriminante que tuvo en consideración estas cuatro características y explicó el 49% del cambio en la respuesta al tratamiento, fue estadísticamente significativo (P < 0,0001), y pronosticó correctamente el resultado del tratamiento en 41 de los 47 sujetos (87%) en el grupo de criterio. La utilidad predictiva de las características identificadas continuó siendo estadísticamente significativa cuando se aplicó al grupo de validación cruzada (P < 0,01). La función discriminante que empleaba las características predijo correctamente el resultado del tratamiento en 37 de los 47 sujetos (79%) y explicó el 28% del cambio en la respuesta al tratamiento. Los hallazgos de este estudio indican que la información psicosocial antes del tratamiento es importante en la predicción del resultado del tratamiento en los DTM crónicos, y que los síntomas de depresión intervienen en el resultado del tratamiento en pacientes con dolor crónico.

Zusammenfassung

Voraussagbarkeit des Behandlungsresultats bei Myoarthropathien

Psychosoziale Faktoren sind oft als wichtige Risikofaktoren angesehen worden, welche die Heilung bei Myoarthropathien verzögern können. In dieser Studie wurden 94 Patienten mit chronischen Myoarthropathien unter Verwendung von IMPATH:TMJ zur Bestimmung der Faktoren mit der grössten Voraussagekraft für das Behandlungsresultat untersucht, bevor sie in ein interdisziplinäres Behandlungsprogramm eintraten. Das Behandlungsresultat wurde aufgrund des Vergleichs von prä- und posttherapeutischem Craniomandibular Index und Symptom Severity Index bestimmt. Die Punkte des IMPATH:TMJ wurden hinsichtlich des Behandlungsresultats für eine randomisierte Probe der Hälfte der Probanden (n = 47) untersucht, um die psychosozialen und demographischen Punkte mit der grössten Voraussagekraft für das Ansprechen auf die Behandlung herauszufinden. Anschliessend wurde für diese Patientengruppe (Kriteriengruppe) eine Diskriminanzanalyse zur Bestimmung der Voraussagewertes dieser Punkte durchgeführt, gefolgt von einer Kreuzprobe dieser Punkte auf die verbleibenden 47 Patienten. Niedere Selbstachtung, Sorgen, Niedergeschlagenheit und Schlafaktivität wurden als nützliche Faktoren für die Voraussage des Behandlungsresultats der Kriteriengruppe identifiziert. Diese vier Punkte, welche 49% des unterschiedlichen Ansprechens auf eine Behandlung begründen, erwiesen sich in der Diskriminanzanalyse als statistisch signifikant (P < .001) und sagten das Behandlungsresultat für 41 der 47 Patienten (87%) der Kriteriengruppe korrekt voraus. Der Voraussagewert dieser Punkte blieb statistisch signifikant, wenn man sie auf die Kreuzprobe anwandte (P < .01). Die Diskriminanzfunktion sagte das Behandlungsresultat bei 37 von 47 Patienten (79%) korrekt voraus und erklärte 28% der Varianz im Ansprechen auf die Behandlung. Die Resultate dieser Studie legen nahe, dass psychosoziale Informationen vor der Behandlung wichtig sind, um das Behandlungsresultat bei chronischen Myoarthropathien vorauszusagen und dass Depressionssymptome das Ansprechen auf die Behandlung variieren können.