

Evaluation of the Effectiveness of Biobehavioral Therapy in the Treatment of Temporomandibular Disorders: A Literature Review

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Temporomandibular disorders (TMDs) involve a heterogeneous group of clinical conditions affecting the stomatognathic system and its related structures. Because the etiology of these disorders is still unclear, a wide range of therapeutic solutions has been proposed in the literature, including occlusal appliances, physical therapies, drugs, and biobehavioral modalities. Biobehavioral therapy could have a beneficial effect in the treatment of TMDs because of the reportedly high prevalence of psychological dysfunction in TMD patients. The authors reviewed the biobehavioral modalities used to achieve pain relief in patients affected by such disorders, with the aim of synthesizing data on the effectiveness these therapeutic approaches. Literature data suggest that the inclusion of biobehavioral interventions in the management of TMDs may be reasonable, even if no conclusions can be drawn about their long-term effectiveness.

Index Terms: biobehavioral therapy, pain management, temporomandibular disorders

The term *biobehavioral* is used to describe treatment modalities derived from the application of behavioral science theories and from methods used to change pain perception, aiming to ameliorate or eliminate affective dimensions and psychological dysfunctions that often accompany pain experience.¹ At present, biobehavioral therapy is considered a safe, reversible, and noninvasive treatment approach that includes a wide range of interventions, such as electromyographic (EMG) biofeedback, cognitive-behavioral therapy (CBT), hypnosis, re-education, and other relaxation tech-

niques.² By implementing these treatments, health care providers aim to provide patients with pain self-management, the modification of cognitive perception, and the maintenance of an acceptable psychosocial function even in the presence of pain.³ Many researchers who have evaluated the efficacy of these treatments in pain management have focused on the most common chronic pain conditions, such as headache and back pain; however, such therapies also have been proposed for the management of temporomandibular disorders (TMDs).⁴

The introduction of biobehavioral therapy as a treatment option for TMD originated from a series of works in which researchers reported a high prevalence of psychological and behavioral disorders in TMD patients.⁵ TMD patients had higher levels of anxiety, depression, and somatization with respect to healthy controls.⁶⁻¹⁰ These findings suggest that factors affecting pain sensitivity, such as mood disorders,

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anxiety, and fatigue, could be important treatment goals in addition to the pain itself, encouraging the involvement of a behavioral component in TMD management. Considering these drawbacks, we reviewed the available literature on the efficacy of biobehavioral therapies in the management of TMDs.

METHODS

We performed an exhaustive *MEDLINE* computer search to identify all studies in the English literature reporting the outcomes of biobehavioral interventions in the management of TMD patients; the primary outcomes of interest included pain, range of mandibular movements, and impairment in oral function. We used the keywords *electromyographic biofeedback*, *cognitive behavioral therapy*, *hypnosis*, and *relaxation training* combined with the term *temporomandibular disorder*. We did not search non-English language publications.

To be eligible for inclusion in the review, studies had to be controlled trials in which researchers compared biobehavioral interventions with no treatment or other well-documented treatment modalities (eg, occlusal appliances). We considered studies in which researchers combined biobehavioral interventions with other treatments if the effect of the biobehavioral therapy could be assessed separately. We reviewed only trials with participants meeting the following criteria: clinical diagnosis of TMD, no previous surgery in the temporomandibular region, and no other serious comorbid conditions (eg, cancer, rheumatic or neurological disease). Furthermore, we considered including studies if the duration of follow-up was reported.

We screened the titles and abstracts obtained from the search according to the inclusion criteria for possible admittance in the review; we then obtained the full text of all studies that appeared to meet the criteria. We also retrieved the full text of articles whose abstracts provided unclear data, to avoid excluding papers of possible relevance.

RESULTS

The search strategy provided a total of 115 abstracts concerning the biobehavioral management of TMD. From these, we obtained 22 full reports; we excluded the remaining 93 articles because they were irrelevant. Of the 22 full papers retrieved, we rejected 3 because they did not meet inclusion criteria: 2 studies^{11,12} because there was no control group for comparison and another¹³ because it did not analyze TMD patients exclusively (eg, included subjects suffering from either chronic back pain or from TMD), so that the effectiveness of biobehavioral interventions in the treatment of TMD could not be assessed separately. The 19

studies that we included in the analysis covered a 26-year period (from 1980 to April 2006) and consisted of prospective follow-up reports.

The selected articles showed heterogeneity in the clinical diagnosis of patients with TMD: Researchers in 5 of the studies evaluated the effectiveness of biobehavioral therapy in the treatment of myogenous TMD, researchers in 1 study investigated the use of biobehavioral therapy in the management of articular TMD, and researchers in the remaining 13 studies evaluated the use of this type of intervention in patients with both articular and myogenous TMD. There were also differences in the criteria to diagnose TMD: Investigators in 10 of the studies adopted the Research diagnostic criteria developed by Dworkin and LeResche,¹⁴ whereas investigators in the remaining studies used different and nonstandardized diagnostic criteria. Researchers in 4 studies examined the use of EMG biofeedback in the management of TMDs, researchers in 2 studies investigated the effectiveness of hypnorelaxation therapy, researchers in 3 studies evaluated the recourse to relaxation training, and researchers in 6 studies analyzed various kinds of cognitive-behavioral intervention. Investigators in 1 study compared the efficacy of relaxation techniques with the use of EMG biofeedback, whereas in the remaining 3 papers, investigators performed a combined treatment approach (ie, EMG biofeedback and CBT). Table 1 shows further details about the studies' settings.

COMMENT

EMG Biofeedback

EMG biofeedback is a muscular relaxation technique in which a signal constantly provides patients feedback about their masticatory muscles' activity level.⁴ By using this biofeedback technique, health care providers aim to give patients the opportunity to evaluate a specific physiological parameter (eg, blood pressure, skin temperature, muscular tension); in myofascial pain patients, health care providers monitored muscular tension through EMG activity as it was proposed in the case of other chronic pain disorders, such as tension-type headache.¹⁵ In regard to TMD management, most EMG trials included only patients with masticatory muscles disorders because researchers have hypothesized that myofascial pain patients have an increased stress-induced muscle activity.¹⁶

Dahlstrom, Carlsson, and Carlsson¹⁷ analyzed the efficacy of EMG biofeedback and muscular relaxation therapies in comparison with occlusal splint therapy. Patients undergoing splint therapy are trained to wear an occlusal splint during the night for 6 weeks. After a month, both groups reported a significant reduction of pain symptoms,

but only the members of the biofeedback group showed a significant increase in the range of mandibular movements. Because of the characteristics of the study sample and the adopted treatments, the authors suggested that such intervention seems to be effective in patients with usual daytime parafunctions, whereas the nighttime use of a bite splint was more effective in patients with nighttime parafunctional habits. This assumption is in agreement with the results reported by Pierce and Gale,¹⁸ who suggested that biofeedback is ineffective in nighttime *bruxers* (those who habitually and involuntarily grind or clench their teeth). The authors treated these patients with EMG biofeedback and other relaxation techniques, and at the end of the 6-month observation period, the patients' EMG activity returned to pretreatment levels. Also, on the basis of their findings, Hijzen et al¹⁹ claimed that biofeedback is more effective for patients with daytime parafunctional habits than it is for patients with nighttime parafunctional habits.

Dahlstrom, Carlsson, and Carlsson¹⁷ did not describe how they blinded patients' identities or the diagnostic process. They also did not describe data-collection methods and participants' baseline conditions sufficiently and neglected to acknowledge the presence of some confounding variables (eg, sex, age, prior treatments received) that might have affected the attempt to relate an exposure to an outcome. Dalen et al²⁰ compared the effects of EMG biofeedback on frontalis and masseter muscle activity with control conditions in 2 groups of patients diagnosed with myofascial pain dysfunction syndrome. The treatment protocol provided for 8 biofeedback sessions, given twice a week for 4 weeks. Treatment did not include any relaxation training, and feedback was presented only on a 36-cm color monitor. EMG levels in frontalis and masseter muscles decreased significantly in the experimental group during training sessions; follow-up data showed that frontalis EMG levels after 3 and 6 months were reduced significantly in the experimental group but not in the control group. Both groups improved subjectively, as judged by reports on pain intensity and duration, but this improvement was significantly more pronounced in the experimental group. The authors concluded that biofeedback training facilitates muscular relaxation and self-regulation and that visual EMG feedback, consisting of a patterning of muscle activity, can be integrated as part of myofascial pain treatment. Unfortunately, these authors omitted a number of details, thus limiting generalization of results. For example, they did not adequately describe the data-collection method, intra- and interobserver reliability of observable outcome measures were not satisfactory, and they did not describe the blinding procedure between patients and evaluators.

Erlandson and Poppen²¹ compared the effectiveness of EMG biofeedback and a prosthetic guide with EMG biofeedback only or the last treatment provided with additional instructions to place the jaw in the rest position. The results of this report indicated that the supplementary procedures that placed the jaw in a relaxed posture led to a reduction of masticatory muscle activity and an increased range of motion, whereas biofeedback by itself showed minimal effects. However, in that study, the researchers administered 2 training sessions of EMG biofeedback, and we believe that patients would have achieved greater benefits with a more prolonged training, as suggested by study results indicating that a minimum of 6 sessions are needed for EMG biofeedback effects to be manifested.²² The study by Erlandson and Poppen also lacked details about baseline conditions, randomization strategies, and patients' recruitment.

Turk, Zaki, and Rudy²³ compared the efficacy of relaxation techniques (eg, biofeedback and stress management) with occlusal splint therapy. The authors divided patients randomly into 3 groups; they assigned patients from the first and second groups to 1 of the 2 treatment protocols, whereas patients from the third group were put on a waiting list (passive control group). Later, the researchers added a fourth group whose members were put under treatment matching (eg, relaxation techniques and occlusal devices). After 6 weeks, pain intensity was significantly reduced in all 3 treatment groups, but occlusal therapy seemed to be more effective; at the end of the sixth month, patients treated with occlusal appliances reported the recurrence of symptoms, whereas those under relaxation therapy experienced a further reduction of pain levels. The combined treatment approach was more effective than either of the single treatments alone, particularly in pain reduction, at the 6-month follow-up. Such findings suggested that the combined use of treatments offered additive effects, at both earlier and later treatment stages, because of the immediate benefits of occlusal appliances and the long-lasting effectiveness of biobehavioral therapy. Given these premises, we believe that combining conventional conservative treatments with psychologically suited interventions may be the most effective approach to TMD treatment, especially for the long-term support of immediate outcomes.

Experts in the field consider the study by Turk, Zaki, and Rudy²³ to be well-designed, although the authors did not fully describe the methods used to generate the random allocation sequence (eg, a computer algorithm, a table of random numbers). The description of the method adopted to generate the randomization sequence is important because an allocation strategy that is suitable to prevent selection bias must be generated and concealed from investigators enrolling patients.²⁴

TABLE 1. Characteristics of the Studies Included in the Analysis

Reference	Study population		Intervention and control/comparison groups	Frequency and course of intervention
	<i>N</i>	<i>M</i> age (y)		
<i>EMG BF</i>				
Dahlstrom et al ¹²	30	28.6	BF or occlusal devices	6 weeks duration; the splint was used at night for 6 weeks; BF received 6 training sessions lasting 30 min each
Dalen et al ²⁰	19	27.75	EMG BF and passive controls	8 BF training sessions given twice a week for 4 weeks; each session consisted of a baseline resting period, 2 training periods, and a subsequent resting period, each lasting 3 min and 20 s
Erlandson et al ²¹	24	—	BF only, BF + INSTR, BF + PROS	2 treatment sessions given once a week; BF received 15 consecutive 1-min trials. In addition, INSTR instructed to hold jaw in an open rest position, whereas PROS were asked to hold a metal bar between their incisors
Turk et al ²³				
Study 1	80	34.1	IA treatment, BF/SM treatment, WL controls	
Study 2	30	33.6	IA + BF/SM	
Overall				BF/SM were seen for 6 weekly 1-hr sessions; IA were instructed to wear the occlusal device at all times for 6 weeks; patients in study 2 received a treatment protocol that combined the IA and BF/SM treatments used in first study

Relevant outcome measures	Results	Authors' conclusions
<i>EMG BF</i>		
Subjective rating of symptoms according to a 5-point scale, the Clinical Dysfunction index (Helkimo Index), and maximal mouth opening	Differences between groups were not significant; severity of symptoms and clinical signs of dysfunction were significantly reduced. The maximal mouth opening increased in both groups, but improvement was significant only in BF.	Effects of 2 treatments during a short follow-up period were similar.
EMG levels, pain duration, pain intensity (subjectively evaluated on a 10-point scale)	Significant reduction of EMG levels in the masseter muscle during treatment period and a return to pretreatment levels after the end of treatment; frontalis EMG levels showed a significant effect during treatment and a lasting difference at follow-up. Pain duration decreased significantly over time, but no difference between-group effect was found; a similar result was found for the pain intensity variable.	EMG BF training yielded long-lasting subjective improvements.
EMG levels, ROM, MPI, and self-report of pain (4-point scale)	Decreases of EMG scores and improvements of ROM measures were significantly greater in INSTR and PROS than in BF; pre- and posttreatment difference scores on MPI were not significantly different. Self-report of pain ratings showed no significant differences among groups.	Two procedures that directly placed the jaw in a relaxed posture decreased masticatory muscle activity and improved range of motion to a significantly greater degree than did BF training alone.
PSS, muscle PPI, CES-D, POMS	At posttreatment, IA and BF/SM had significant reduction of pain; BF/SM had significantly lower pain scores than IA. At 6-month follow-up, pain levels between groups were not statistically different; analysis of depression measures revealed a significant group by time interaction, but IA and BF/SM depression scores were not statistically different at posttreatment. At 6-month follow-up, IA depression scores increased significantly; significant group by time interaction for the combined group; IA pain scores were significantly lower than for BF/SM, whereas depression scores were not statistically different.	BF/SM and IA treatments produced significant short-term effects on pain and depressed mood; IA treatment appeared to have a greater initial effect than BF/SM. However, at 6-month follow-up, IA-treated patients displayed significant relapses whereas BF/SM appeared to maintain their initial gains. Comprehensive treatment produced greater long-term maintenance of therapeutic benefits for pain.

Table continues

TABLE 1. (Continued)

<i>Hypnosis</i>				
Stam et al ³²	61	25.7	Hypnosis, relaxation, WL	Hypnosis and relaxation groups received 4 weekly sessions of treatment
Winocur et al ³⁹	40	30.25	Hypnosis, occlusal appliances, minimal treatment (recommendations concerning parafunctional activities, diet, etc)	5 sessions during a period of 49 days; hypnorelaxation group requested to perform self-hypnosis 3 times a day; occlusal appliance group instructed to wear oral device during sleep
<i>Relaxation techniques</i>				
Okeson et al ²³	24	29.9	Splint therapy or relaxation therapy (a 20-min cassette tape of a relaxation procedure)	6 weeks of treatment; splint therapy group asked to wear bite guard continuously except during eating and oral hygiene procedures; relaxation group asked to listen to tape at least once a day
Carlson et al ²⁹	44	34.6	SDC program, including a flat-plane oral appliance and self-care instructions; PSR training addressing multiple components (eg, proprioceptive training, progressive relaxation, diaphragmatic breathing training)	26-week duration; patients instructed to wear splint at night; PSR protocol was provided during two 50-minute sessions separated by a 3-week interval
Wahlund ³⁰	122	15.3	BI + RT, BI + OA, BI	3-month duration; BI + OA and BI + RT received treatment in 4 sessions conducted at 2-week intervals, whereas BI received information in 1 session lasting about 30 minutes. BI + OA were instructed to wear device every night

Hypnosis

Pain intensity, frequency of sounds in TMJ, extent of limitation in mouth opening (140-mm VAS)

Treatment groups showed significant degree of association with posttreatment pain and limitation of mouth opening; differences between 2 treatment groups were not significant. Overall relationship between treatment group and rated sounds was not significant.

Two treatment groups did not differ on pain, limitation, and sounds; both differed from the WL group on posttreatment pain and limitation; the success of psychological therapies over more traditional conservative therapies is consistent with the hypothesis that stress-induced muscular hyperactivity is related to TMD.

Pain severity on a 100-mm VAS, sensitivity to manual palpation of superficial masticatory muscles and range of mouth opening, measured in AMO and PMO

Active treatment was more effective than minimal treatment with regard to masseter sensitivity and muscle sensitivity to palpation; significance of hypnorelaxation was greater than occlusal appliances in this respect; no significant differences were found between groups in regard to temporalis sensitivity to palpation and range of mouth opening.

The reduced muscle sensitivity to palpation was due to treatment, with hypnorelaxation exhibiting an even more pronounced effect than occlusal appliance; the hypnorelaxation protocol might have caused a reduction in patients' general anxiety and decreased their subjective perception of pain.

Relaxation techniques

Observable pain score (tenderness and pain during palpation), maximum comfortable interincisal distance, and maximum interincisal distance

Significant reduction in observable pain scores and significant increase in maximum opening even in presence of pain for occlusal splint group; no statistically significant decrease in muscle pain; no significant improvement of maximum comfortable opening nor maximum opening for relaxation therapy group.

The relaxation technique is not effective in reducing the symptoms associated with TMDs.

MPI, a 100-mm VAS, a muscle pain index, maximum interincisal opening with and without pain, the SCL-90-R and the Pittsburgh Sleep Quality Index

At posttreatment, both experimental groups showed significant reduction in pain severity (VAS self-rating and MPI); at 26-week follow-up, PSR reported significantly less pain than SDC; at follow-up, PSR had greater maximum opening with and without pain than SDC; sleep dysfunction and somatization significantly decreased in both groups, whereas anxiety and obsessive-compulsive symptoms did not; no differences in measured psychological variables between groups.

PSR is an effective management approach for chronic muscle pain that is as effective as standard dental therapy in the short-term therapy but provides improved pain reduction and ROM over a 6-month period.

Pain intensity (100-mm VAS), pain frequency (5-point scale)

Adolescents treated with BI + OA were significantly more improved than BI but not significantly different from those in BI + RT (VAS); frequency of pain was significantly reduced only for BI + OA.

Occlusal appliance was superior to both relaxation therapy and brief information regarding pain reduction and is recommended when treating adolescents with TMD pain.

Table continues

TABLE 1. (Continued)

<i>CBT</i>				
Oakley et al ⁴⁸	56	35	CBT (pain-class group), WL	6-week duration; CBT consisted of five 1.5-hr weekly sessions
Dworkin et al ⁴³	185	37	CB intervention and UT (occlusal splints, jaw exercises, medications, etc) or UT alone	CB groups met for two 2-hr sessions spaced 1 week apart before the onset of UT
Dworkin ⁵⁰	124	37.7	SC intervention or UT, with the latter including physiotherapy, patient education, medications, and intraoral appliances	3-session intervention (SC): the first session lasted 75 min, followed by a second session 2 weeks later, lasting 50–60 min; the third session of 50–60 min occurred 1 month after the second session
Dworkin ⁵¹	117	38.8	CC and UT or UT only, with the latter including physiotherapy, patient education, medications, and intraoral appliances	4-month duration; 6 session interventions (CC)
Turner et al ⁵³	126	37.35	PMT or SCM	4 sessions over 8 weeks
Turner et al ⁵²	148	37.3	PMT or SCM	4 sessions over 8 weeks

<i>CBT</i>		
STAI, BDI, MPQ, pain ratings on a 100-mm VAS, ratings of jaw function problems (11-point scale), pain-free mouth opening	There was a significant pretreatment/posttreatment difference on the STAI and BDI scores in pain-class condition; in previously WL patients, reduction in depression was not significant, but anxiety significantly fell.	CBT is effective for TMD pain. This is particularly noteworthy, as patients were those who reported less than 50% improvement from a dental/physical medicine treatment protocol.
Mandibular ROM (assisted and unassisted), pain intensity (VAS), pain interference (10-point scale), SCL-90-R, GCPS	CB's pain continued to decrease at significantly greater rate than UT (VAS); CB intervention did not enhance the effect of UT on physical and psychological parameters.	A brief group CB intervention, placed before conventional clinical treatment for TMD began, is useful in ameliorating report of TMD pain; the effects seem long-lasting, albeit modest in size.
Vertical ROM (jaw), number of muscles painful to palpation, SCL-90-R, GCPS	No statistically significant differences observed in regard to vertical ROM (jaw); significant improvement over time for SC in regard to number of muscles painful to palpation; SC's psychological distress tended to decrease over the course of the study compared with UT. Difference in trends between groups was marginally significant.	Use of RDC/TMD psychological assessment criteria can contribute to successful clinical decision making for TMD management.
CPI, GCPS, vertical ROM (jaw), number of sites painful to palpation	At posttreatment, CC CPI levels fell significantly below UT's, but at 1-year follow-up, difference was not statistically significant. CC pain-related interference lower than UT; this difference approached statistical significance, but at 1-year follow-up the difference was not statistically significant. Vertical ROM (jaw) and number of sites painful to palpation did not show statistically significant change through 1-year follow-up.	Post-intervention, CC was significantly more efficacious than UT for TMD; however, when the CBT component ended after 6 sessions, CC group did not sustain its initial marked rate of improvement.
TMD pain intensity, pain-related activity interference, jaw use limitation (10-point scales)	No statistically significant difference between the study groups in rate of within-subject change over time on the daily outcome measures, but consistently greater within-subject improvement in the PMT group on the daily process measures. Significantly greater proportions of PMT than SCM showed clinically important improvement in daily activity interference and jaw use limitation.	The treatment had the intended effect of altering patients' daily pain appraisals.
GCPS, MFIQ, BDI, SOPA, SES, CSQ Catastrophizing scale, CPCI	PMT had significantly better outcomes than did SCM on all outcome measures (pain-related activity interference, characteristic pain intensity, depression, etc) across the 3 follow-up assessments; PMT showed significantly greater overall improvement at each follow-up assessment on each belief and catastrophizing measure.	Among patients receiving UT in a specialty clinic for chronic TMD pain, a brief CBT intervention, compared with a self-care education/attention control condition, produced statistically and clinically significant improvement in activity interference, pain, depression, and jaw function over the following year.

Table continues

TABLE 1. (Continued)

<i>Combined biobehavioral interventions</i>				
Funch et al ⁵⁵	57	39.3	BF therapy or relaxation techniques (tape-recorded relaxation)	Therapy on a weekly basis for an average of 12 weeks; BF received ten 1-min trials with a 15-s intertrial interval; second group listened to 20-min tape-recorded relaxation once a week
Mishra et al ⁵⁷	94	35.76	CBST, BF, CBST/BF, no treatment	12 sessions of 1.5 hr each (except for the combined treatment group that lasted 2 hr), held twice a week for the first 4 weeks and once a week for the last 4 weeks
Gardea et al ⁵⁸	108	36	CBST, BF, CBST/BF, no treatment	12 sessions of 1–2 hr each, held twice a week for the first 4 weeks and once a week for the last 4 weeks
Gatchel et al ⁵⁹	101	37.76	EI including CBT and BF or NI	Six 1-hr sessions

Note. BF = biofeedback; EMG = electromyographic; INSTR = group given jaw-posture instructions; PROS = prosthetic guide; ROM = range of motion; MPI = muscle pain index; IA = interocclusal appliance; BF/SM = biofeedback/stress management; WL = waiting list; PSS = pain severity scale; PPI = Palpation Pain Index; CES-D = Center of Epidemiologic Studies–Depression Scale; POMS = profile of mood states; VAS = visual analog scale; AMO = active (voluntary) maximal mouth opening; PMO = passive (assisted) maximal mouth opening; SDC = standard dental care; PSR = physical self-regulation; MPI = Multidimensional Pain Inventory; SCL-90-R = Revised Symptom Checklist; BI = brief information; RT = relaxation training; OA = occlusal appliances; STAI = State-Trait Anxiety Inventory; BDI = Beck Depression Inventory; MPQ = McGill Pain Questionnaire; CB = cognitive-behavioral; UT = usual treatment; GCPS = graded chronic pain score; SC = self-care intervention; RDC = research diagnostic criteria; CC = comprehensive care and UT; CPI = characteristic pain intensity; CBT = cognitive-behavioral treatment; PMT = cognitive-behavioral pain management training; SCM = self-care management; MFIQ = Mandibular Function Impairment Questionnaire; SOPA = Survey of Pain Attitudes; SES = Self-Efficacy Scale; CPI = Chronic Pain Coping Inventory; CBST = cognitive-behavioral skills training; EI = early intervention; NI = nonintervention; WOC = ways of coping; SCID-I = structured clinical interview for the *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed (*DSM-IV*) axis I disorders; SCID-II = structured clinical interview for *DSM-IV* axis II disorders.

Relaxation Techniques

Relaxation techniques, such as progressive muscular relaxation, yoga, and meditation, evoke the neurophysiologic response known as *relaxation response*.²⁵ This reaction consists of a tone reduction in the sympathetic nervous system that results in muscle relaxation and a depression of neuroendocrine response to unfavorable external condi-

tions, thus providing patients a sense of well-being and reduced anxiety.

Experts have hypothesized that TMD patients seem to overrespond to environmental stimuli with an increased sympathetic activation, which results in an altered breathing rate and in an augmentation of cardiovascular activity.²⁶ Thus, relaxation techniques may represent a suitable tool to

Combined biobehavioral interventions

Pain ratings based on a 6-point scale (to assess short-term therapy effects) and a 7-point scale based on both palpation and interview (2-year follow-up)	Relaxation group tended to have greater average percentage of pain reduction than BF group, although the difference was not significant; long-term outcomes (2-year follow-up) were similar for both groups.	Knowledge of pretherapy factors, particularly clinical, may allow for more optimal assignment to therapy condition.
CPI, GCPS, POMS	Significant decreases in CPI scores from pretreatment to posttreatment among all treatment conditions; a significant difference between BF and no-treatment groups; no significant difference in GCPS score among the 4 groups; significant improvements on all POMS variables.	BF was the most effective at reducing pain and pain-related disability. However, CBST and combined treatment were also effective relative to the no-treatment condition. All treatment conditions produced significant improvement in POMS
CPI, GCPS and 12-item checklist (to assess the degree of functional limitations related to jaw problem)	Significant differences between combined and BF groups compared with no-treatment group (CPI score); significant difference between combined and no-treatment groups (GCPS); significant differences between combined and no-treatment groups and between CBST and no-treatment groups.	Decreases in subjective pain, pain-related disability, and interference with facial activities clearly demonstrate all 3 biobehavioral interventions are more effective than no treatment in treating TMD. The combined group appeared to be best suited to treat patients in the most comprehensive manner.
CPI, WOC, SCID-I and SCID-II	Both groups' CPI scores improved significantly at 1-year follow-up: EI had significantly lower CPI scores; NI showed little change in coping abilities, whereas EI made significant improvements (WOC); NI had significantly more disorders than EI (SCID-I and SCID-II); groups were similar at intake.	At 1-year follow-up, EI fared far better in terms of pain and overall emotional functioning than did NI.

control such hyperreactions. Carrington et al²⁷ reported that these treatments emphasize long-term self-management of stress because most patients continued practicing relaxation techniques even after the initial phase of treatment.

Okeson et al²⁸ found that the use of occlusal devices led to a significant decrease in muscle tenderness, whereas there were no statistically significant improvements in the group

of patients recruited for relaxation therapy. However, they obtained the results only by means of objective measurements and used subjective assessments of the patient to evaluate the overall effectiveness of the administered therapy.

Carlson et al²⁹ compared the long-term efficacy of flat-plane intraoral appliances with a brief training program that included postural relaxation, training in breathing, and

proprioceptive re-education for the management of masticatory muscle pain disorders. Posttreatment evaluation at 6 weeks showed a decreased pain severity, decreased life interference, and increased mouth opening without pain in both groups. At the 26-week follow-up, members of the group under behavioral management reported less pain and greater mouth opening, both with and without pain, than did the standard dental care group. A methodological flaw of this study is that some participants in both groups were taking medications during the study period. The authors stated that the stability of the symptoms was achieved prior to random allocation to minimize the potential influence of medications on outcomes measures, but this could represent a source of performance bias that could have affected the internal validity of the research. Wahlund, List, and Larsson³⁰ reported different results in their randomized clinical trial involving adolescents with TMD pain, in which they compared the effects of occlusal appliances and relaxation therapy, each combined with brief information, with brief information only. Patients treated with occlusal devices experienced a significantly higher reduction of pain frequency and intensity, even though the researchers found no significant differences between the treatment groups in jaw opening or muscle and TMJ tenderness scores. Occlusal appliance therapy was superior to both relaxation therapy and brief information regarding pain reduction. Wahlund, List, and Larsson designed their study well, although it lacked details about the method of blinding and randomization.

Hypnosis

At a 1995 National Institutes of Health conference,¹ experts suggested that hypnosis was an effective treatment for a wide range of chronic pain conditions; it is also considered a possible tool to manage bruxism and TMDs.¹ In the dental literature, researchers in several case reports^{31–33} and clinical studies^{34–36} considered its use in the treatment of myofascial pain patients.

Nevertheless, these investigators did not consider the fluctuating nature of TMD symptoms and the high rate of spontaneous remissions that characterizes these pain syndromes.³⁷ Furthermore, researchers in only a few of these studies compared the therapeutic effectiveness of hypnosis with other traditional evidence-based therapies.

Stam, McGrath, and Brooke³⁸ assessed whether the presence of a hypnotic induction procedure would increase treatment outcomes by comparing a group of patients receiving hypnosis and suggested cognitive strategies with a group receiving relaxation training and suggested cognitive strategies. Findings from that study showed an improvement in both treatment groups, with no differences between

the 2. The most significant limitations of this study were the lack of a follow-up evaluations and the high rate of dropouts; the exclusion of patients from data analysis after they have been allocated to treatment groups may introduce attrition bias.²⁴

Winocur et al³⁹ carried out a randomized, controlled clinical trial to evaluate the efficacy of hypnosis with respect to occlusal appliance therapy in a study population of 40 women with a history of at least 6 months of facial pain. The researchers assigned participants to 1 of 3 possible treatment groups: hypnorelaxation, occlusal appliances, and minimal treatment (ie, counseling). At the end of the observation period, all patients reported a marked reduction of pain pressure threshold, but changes were significant only for the hypnorelaxation group members. Such results may be explained by the high rate of psychosocially impaired patients in the study population, which is in line with published literature.⁴⁰ The investigators gave only those patients who received behavioral therapy in the form of hypnorelaxation a therapeutic tool that could reduce anxiety levels and, as a consequence, subjective perception of pain. The number of participants in the study, however, was relatively small, thus preventing generalization of the findings.

CBT

CBT involves a number of therapeutic methods believed to modify the emotional approach of patients to their clinical conditions and reduce negative thinking and perceived impact of TMD symptoms, thus enhancing their personal strategies for coping with pain.^{41–43} This approach has been applied mostly in the psychiatric setting, but its efficacy is also confirmed in other clinical fields, including those specializing in chronic pain conditions, such as TMDs. Teaching systems created on the basis of this type of approach are numerous and have different characteristics, but all share common targets, such as teaching patients to recognize elements that affect pain perception, encouraging patients to reimage their pain experience, learning new methods of pain response, teaching pain control, and encouraging constant improvement in exercise and activity levels.^{44,45}

The efficacy of CBT in TMD treatment never has been explored in such a wide manner as for other chronic pain conditions. Rudy et al⁴⁶ demonstrated that patients affected by orofacial TMD-related pain would benefit in some way from CBT in a differential manner, which takes into account the presence and type of psychosocial impairment. Some reviewers^{43,47} have noted that patients who improved with these protocols seemed to experience continued improvement of their symptoms at long-term follow-ups. Therefore, the use of cognitive-behavioral modalities, in addition to other kinds

of medical methods, has been viewed as a possible alternative to enhance the success rate in the management of TMD.

Oakley et al⁴⁸ studied the effects of CBT in a patient population for whom prior treatment had failed by comparing active treatment with a waiting-list control condition. The 5-week CBT included relaxation training, self-monitoring of stressors, and cognitive coping strategies. Patients were predominantly women and had been referred to the study after having poor responses to dental/physical medicine care. The researchers evaluated patients' conditions using self-report measures of pain, distress, and jaw function problems; a practitioner assessed pain-free opening, muscle palpation pain, and tenderness of the temporomandibular joints. The authors concluded that the cognitive-behavioral intervention had its greatest effect on improving dysphoric mood, especially anxiety, but also proved effective in reducing pain in a group previously insensitive to available biomedical treatment for TMD. These findings seem to provide evidence for the effectiveness of CBT for TMD; however, the results indicate that this type of intervention had its greatest influence on mood. Although there were some improvements in pain ratings, the reduction did not appear related to the treatment but rather associated with the passage of time. Overall, the results from this report suggest that CBT can produce improvements in patients' perception of pain and quality of life. A limitation of this study was that patients selected for treatment were those who reported less than 50% improvement from a usual conservative treatment protocols; this choice may have affected the external validity of the report. Furthermore, the authors noted the difficulty in randomly assigning participants to the study groups because recruitment lasted several months. Randomization is the key for a proper trial design because it removes the potential for bias in the allocation of patients to different interventions, it tends to ensure that study groups are comparable with respect to both known and unknown prognostic factors, and it guarantees the validity of statistical tests of significance used to interpret the results.⁴⁹

In a similar study by Dworkin et al,⁴³ patients received either CBT before usual treatment or usual treatment alone, with the aim to determine whether a minimal cognitive-behavioral intervention followed by usual TMD treatment could enhance the effects of conventional treatments. The cognitive-behavioral protocol consisted of 2 sessions focused on self-management and self-monitoring of TMD symptoms; education on psychophysiologic aspects of stress and basic pain physiology; usual dental treatment consisting of fabrication of a flat-plain occlusal splint; nonsteroidal anti-inflammatory drugs; and exercises to improve mandibular range of motion. At the end of the experimental period, all

patients showed significant improvements with respect to time, but only patients from the first group reported further improvements at 1-year follow-up. Patients who participated at the cognitive-behavioral intervention followed by usual treatment showed greater long-term decreases in reported pain level and pain interference in daily activities than did patients who received usual treatment alone. The benefits of cognitive-behavioral intervention were not seen when groups were compared at 3-month follow-up; during the 3- to 12-month follow-up interval, however, the usual treatment group maintained essentially the same level of improvement, whereas the cognitive-behavioral group continued to improve. The authors noted that their results must be taken with caution because the effectiveness of cognitive-behavioral intervention compared with usual treatment, although assessed after a reasonable follow-up period, is modest in size: For pain interference, they did not find a clear statistical significance. Another limitation was the absence of a standardized set of diagnostic criteria and examination procedures, which were not yet available to TMD clinicians when the study was performed.

Dworkin et al⁵⁰ performed a randomized clinical trial to compare usual conservative treatment with a self-care intervention (incorporating cognitive-behavioral methods) fitting to patients who reported minimal levels of psychological dysfunction. The results showed that at 1 year, patients included in the tailored self-care treatment program showed significantly decreased pain and pain-related disability compared with active controls. These participants also reported consistent, but not significant, lower levels of depression and somatization. An ancillary finding was that Research Diagnostic Criteria for TMDs proved to be a reliable, valid tool capable of identifying subtypes of TMD patients potentially sensitive to selected treatments. But the most relevant limitation of the paper concerns the study design, as outlined by the authors. The exclusion of the most psychosocially impaired patients reduces the external validity of the study, even though the authors were forced to that choice, because without this restriction patients experiencing significant levels of psychological distress would be assigned to a minimal treatment intervention with respect to their needs, thus leading unavoidably to a large number of dropouts after randomization.

In another trial involving a more intensive cognitive behavioral intervention, Dworkin et al⁵¹ enrolled patients reporting higher levels of pain and pain-related disabilities. The researchers provided TMD patients with high levels of psychosocial impairment with a tailored 6-session CBT approach in combination with usual conservative treatment. The psychologically based treatment program was more

effective than were standard treatments in decreasing pain and improving patients' capacity to control pain. However, at the end of the cognitive-behavioral program, members of the experimental group did not maintain the initial marked rate of improvement, and the researchers recorded comparable levels of physical and psychological outcome variables for both groups at 1-year follow-up. Because most cognitive-behavioral programs for chronic pain range from 12 to 24 sessions, it is also possible that the 6-session treatment protocol was too short for patients who were selected on the basis of high levels of psychosocial disability.

Turner, Mancl, and Aaron⁵² reported the results of a randomized clinical trial of CBT for chronic TMD pain. They compared the brief cognitive-behavioral intervention with a self-care education/attention control condition, which produced statistically significant improvement in activity interference, pain severity, depression, and jaw function over the following year. A potential limitation of that study is the varied levels of competence of the clinicians who conducted the pain management training and the self-care protocol (ie, a trained psychologist versus a bachelor's-level patient educator). The superiority of the cognitive-behavioral protocol may have been due to not only the different treatments but also to the treatment provider's background. This choice may have represented a confounding variable, acting as a source of performance bias.

The same authors, in a short-term study,⁵³ had reported previously that cognitive-behavioral intervention acted mainly as a pain appraisal's modifier; in other words, patients assigned to a 4-session CBT showed significantly higher improvement in measures of variables, such as pain-related beliefs, catastrophizing, and coping with respect to those assigned to an education/attention control condition. In regard to the outcome measures, the results were less consistent; only one of these variables—jaw use limitation—showed a trend toward greater improvement in the cognitive-behavioral group, and this effect was minimal. However, there was a higher decrease in pain-related interference on daily activities in the cognitive-behavioral group than in the control group during the last 2 treatment weeks. These findings indicated a trend toward greater improvement in activity interference and jaw function in the CBT than in the control group at the end of the treatment (between weeks 6 and 8), suggesting that the treatment effect might have been more evident if the researchers had instated a longer follow-up period. Moreover, according to the authors, the lack of marked differences in the outcome measures immediately after treatment could be proof that the different levels of provider competence did not affect the study results. However, to control for nonspecific effects of the CBT interven-

tion, such as attention and concern from the psychologist, a further experimental condition should be added. In this way, conclusions can be drawn about the relative efficacy of the cognitive-behavioral components of the treatment protocol and that of other external factors.⁵¹

A possible limitation of that study was the use of 3 items to assess each section of a daily electronic diary kept by participants, thus affecting the reliability and validity the interviews. Some study enrollees did not complete an electronic interview; however, the researchers performed the analysis according to the *intention to treat principle* (ie, a principle that requires analysis of a trial according to allocation at randomization and not according to whether patients received or completed treatment; the use of this principle removes the bias that may arise from patients leaving trials because of poor outcomes or side effects), thus avoiding selection bias.⁵⁴ Another challenge might have been reconciling the differences in baseline characteristics between groups. Despite these confounding variables, bias was avoided by the researchers' use of multivariate techniques (ie, mathematical modeling used to examine the potential effect of one variable while simultaneously controlling for the effect of many other factors).

Combined Biobehavioral Interventions

Funch and Gale⁵⁵ compared the efficacy of EMG biofeedback with other relaxation techniques in patients affected by chronic temporomandibular joint disorders. At the end of the study, patients who were treated with EMG biofeedback experienced an average 35% decrease in pain, whereas patients treated with other relaxation techniques reported a 56% reduction. The main limitation of that investigation was the lack of a passive control group: Investigators should assess the efficacy of an intervention with a comparison against a no-treatment group to limit the influence of confoundings, such as time and the regression toward mean effects. Moreover, the study sample comprised chronic TMD patients who had undergone other ineffective treatments previously (91% received medication, 53% received equilibration, and 53% wore mouth splints), thus challenging the generalizability of the findings to broader populations. Furthermore, the sample size was relatively small, and the researchers based the chosen outcome measures on patients' subjective reports, the accuracy of which the researchers did not evaluate. The investigators also failed to detail the blinding method. Blinding patients to the treatment they have received in a controlled trial is particularly important when involving subjective response criteria, such as alleviation of pain.⁵⁶

In a well-designed clinical trial by Mishra, Gatchel, and Gardea,⁵⁷ 2 biobehavioral treatments and a combined inter-

vention were more effective in reducing pain and pain-related disability than was nontreatment. Moreover, although all 3 treatment protocols allowed for significant improvements in mood state and pain scores, patients in the biofeedback group experienced greater reduction in pain perception. According to the authors, the observation that members of the combined treatment group showed fewer improvements than did members of the biofeedback-alone group was due to the first group's training to improve their cognitive-behavioral skills along with biofeedback. This may have influenced patients' perception of the disorder. TMD patients usually view their illness as physically based rather than as a psychosocial disorder, so they might be more receptive to biofeedback training focusing on physiologic aspects, with a combined treatment protocol involving the psychosocial dimension.

Gardea, Gatchel, and Mishra⁵⁸ reported a prospective outcome evaluation at 1 year following the research by Mishra, Gatchel, and Gardea.⁵⁷ All 3 treatment groups maintained the previously described benefits, and the highest rate of improvement was in the combined group, compared with biofeedback and nonintervention. This might have happened because biofeedback training, which focuses on physical pain complaints, may have provided benefits immediately after intervention, whereas cognitive-behavioral skills training that addressed the psychological dimension may have taken more time to produce positive changes. On the basis of these observations, the authors concluded that a combined intervention was suitable to address all the biopsychosocial aspects of TMD and to give long-term benefits.

Gatchel et al⁵⁹ adopted a single-blind design, thus limiting the internal validity of their study. The medical staff caring for patients or people performing the assessment in a randomized trial should be blinded to treatment allocation to minimize possible bias in patient management and in evaluating disease status.⁵⁶ Furthermore, the researchers included no placebo condition in the study.

Conclusions

Biobehavioral modalities involve a large collection of therapeutic, safe, noninvasive, reversible interventions that may contribute to the improvement of coping skills and self-management abilities in TMD patients.⁴ The common objective of these methods is to attain the ability to change the cognitive attributions or meanings given to pain symptoms.³ In the past, application of these treatment modalities was mostly reserved to back pain and headache patients, and it was recently extended to TMD patients on the basis of their similar pattern of mood disturbances and psychosocial impairment. Among the wide range of biobehavioral

approaches, the most widely used for TMD management were EMG biofeedback, CBT, hypnosis, re-education, and other relaxation techniques.³

An evaluation of literature data on this particular issue is complicated for many reasons, the first of which is the difficulty of comparing past studies in this area, as there was no consensus for the diagnostic criteria that comprise TMD. Researchers may have used invalid, nonstandardized schemas to assess and classify the patients, and, as a consequence, what is thought to be the same population may actually be heterogeneous. The diagnoses also were often expressed with inconsistent terminology. Other factors that contributed to the difficulty of cross-study comparisons were related to the characteristics of the adopted treatment protocols. The number of treatment sessions the participants received varied consistently between studies, and, in some cases, investigators did not specify any characteristics of the treatment protocol. Other frequent methodological weaknesses included the lack of control groups, specification about TMD symptoms' duration and characteristics, and objective outcome measures. Moreover, most studies were case reports, case series, or clinical studies with small sample sizes. Because these methodological shortcomings prevented formal meta-analysis and complicated qualitative pooling of the included studies, we performed a basic literature overview.

Biofeedback is based on the idea that stress-induced hyperactivity may be an important component of muscular TMD.¹⁶ The feedback information assists patients in the self-control and management of their own levels of muscular tension, which may be a contributing factor for the onset, maintenance, or exacerbation of pain.⁶⁰ Crider and Glaros⁶¹ reviewed literature data about treatments incorporating EMG to determine the efficacy of biofeedback-based treatments. They reported that 69% of patients who received EMG biofeedback were rated as symptom-free or significantly improved with treatment, compared with 35% of patients treated with placebo interventions or who received no treatment. Positive outcomes for EMG biofeedback treatments showed no deterioration from posttreatment levels to 24-month follow-up. Despite these encouraging results, there has been a decline in studies about biofeedback-based treatments that involve all the medical literature dealing with chronic pain conditions, among which is TMD.

Researchers have not conducted randomized clinical trials on the use of CBT for TMD patients as extensively as those in which they investigated its usefulness in patients affected by other chronic pain conditions. Nevertheless, TMD patients could differentially benefit from these treat-

ment modalities⁴⁶ on account of their degree of psychosocial distress. However, positive effects of cognitive-behavioral modalities were still observed at 1-year follow-up, suggesting their long-lasting effectiveness.

Hypnorelaxation is not as time-consuming as EMG biofeedback or other relaxation techniques requiring a continuous patient motivation, but further studies are strongly needed to rate its efficacy in comparison with other treatment approaches, also considering the lack of studies involving a follow-up evaluation over long time periods.

Relaxation techniques are designed to improve patients' stress-management skills by providing strategies for the control of emotional factors and autonomic activities associated with chronic pain.^{62,63} The literature suggests that relaxation therapy increases improvement and prevents relapses that may occur with conventional therapy alone and also reveals that relaxation techniques are time consuming and require a strong motivation.

Our literature review suggests the need to further investigate the efficacy of biobehavioral interventions in TMD management. Future researchers should compare biobehavioral treatments and occlusal appliance therapy outcomes, with the latter representing the most popular and documented treatment approach to TMDs, with an efficacy rate of about 70% to 90%.⁶⁴ Investigators must control future studies with randomization, placebo treatments, and, if possible, blinding, also including a passive control group. Researchers must perform follow-up assessments so they can draw conclusions about the efficacy over time of the proposed therapeutic modalities. Nevertheless, the strongest efforts should be directed toward the identification of a standardized treatment protocol or at least a better definition of the available ones, which is necessary to allow cross-center comparisons and replications of studies, thus simplifying the complex interaction between the clinical and research settings.

NOTE

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