



Behavioral therapy for temporomandibular disorders

Richard Ohrbach¹, Sonia Sharma^{1,2}

¹Department of Oral Diagnostic Sciences, University at Buffalo School of Dental Medicine, Buffalo, NY, USA; ²Department of Orofacial Pain and Jaw Function, Faculty of Odontology, Malmö University, Malmö, Sweden

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Correspondence to: Richard Ohrbach, Department of Oral Diagnostic Sciences, 355 Squire, University at Buffalo School of Dental Medicine, Buffalo, NY 14214, USA. Email: ohrbach@buffalo.edu.

Abstract: Behavior—what a person does to attain a goal—relevant to temporomandibular disorders (TMDs) can be classified into three types: organ system-level functional behaviors, organ system-level non-functional behaviors, and person-level behaviors. Despite decades of productive research regarding the importance of behavior, taken broadly, as encompassing multiple risk factors for another prevalent musculoskeletal pain disorder (low back pain), behavioral research related to TMDs remains in the early stages. Clinically, behavioral factors are complex with regard to adequate assessment, and they require specific conceptual and management skills. Consequently, providing due diligence to their importance is challenging in many medical arenas. The sparse data that exist supporting the role of behavior in TMD onset and persistence indicate that excessive extent of masticatory system non-functional and possibly functional behaviors contributes to painful TMD onset and appear to contribute to chronicity. In addition, TMD-relevant behaviors can be amplified by chronic pain, among other stressors, suggesting a complex reciprocal relationship. Both the reciprocal relationship between TMD pain and functional and non-functional behaviors and the person-level behaviors create multiple interactive feedback loops which then serve as barriers to behavioral change. These barriers need to be addressed in a step-like manner with treatment, such that motor control and sensory perception undergo re-learning. At present, the evidence regarding treatments or their efficacy is minimal and mostly indirect. The field needs to develop better theories regarding how behavior fits within the available evidence pertaining to TMD etiology and persistence. With better theories and transfer of knowledge from other pain fields, better treatment research can be implemented for TMDs.

Keywords: Temporomandibular disorders (TMDs); behavior; pain; assessment; management

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Overview

Behavior can be a deceptively complex concept. At its simplest, behavior—the final result of a coordinated set of motor unit activations in the muscles necessary for the particular movement—is what organisms do in order to achieve a goal. For present purposes, behaviors can be separated into three types: organ system-level functional behaviors, organ system-level non-functional behaviors, and person-level behaviors. If the instrumental purpose is

to communicate, show dismay, or meet nutritional needs, then the simple masticatory system functional behaviors might be to speak, frown, or chew, respectively. But “simple” can be elusive: all 3 behaviors are far more complex than they appear. For example, speech and facial expression are highly nuanced in their goal of maintaining social standing simultaneous with obtaining needs from others. Similarly, chewing is influenced by the need to maintain social eating etiquettes, but chewing requires a complex motor pattern in terms of coordinating eight primary muscles

of mastication and multiple accessory muscles; adjusting trajectories, force, and timing; and integrating constantly changing sensory feedback—all the while avoiding biting on the tongue in lieu of the food bolus (1). While each of the above behaviors has a specific and essential purpose, the complexity underlying their performance also means that they are also influenced by multiple determinants (for example, emotional states) which can lead to variation in performance; those variations can become clinically relevant. Non-functional behaviors involving the masticatory system, usually termed parafunctional or overuse behaviors, reflect coping responses or habit patterns without instrumental purpose. Behavior also encompasses more patterns at the person-level, which are oriented towards addressing higher-level needs. Clinical problems, such as temporomandibular disorders (TMDs)—a group of musculoskeletal disorders affecting the masticatory system, involve all three types of behaviors.

“Behavioral therapy for TMDs” (our title) accurately conveys the eventual goal of this paper yet the first term requires in all instances careful description. Our purpose here is to explore the current status of behavior and its clinical implications regarding pain in general and TMDs in particular. Given the integrated character of behavior (e.g., motor unit activation coupled with role of joint afferents in regulating the motor unit activation), behavior therapy need not distinguish extra-articular TMDs from intra-articular TMDs. Rather, the focus should be on the problematic behaviors that inherently involve both joint and muscle. Finally, because the role of behavior in TMDs is an area that is currently in great flux, strong evidence is sparse. An effective systematic review is precluded at this time. Consequently, we turn to an integrated perspective based on how the TMD field has developed with regard to behavioral concerns, the dynamics and complexity of behavior (so that clinical assessment can be enriched), and assessment and management perspectives relevant to all 3 types of behaviors.

Background, or why we know so little about behavior and TMDs

The potential importance of behavior to the management of TMDs has been recognized since the 1950s (2,3). While some of these early views were very insightful and current in today’s term, most primarily focused on only masticatory system parafunctional behaviors and not behavior more broadly. Moreover, the primary parafunctional behaviors

of interest were restricted to clenching or grinding of the teeth (collectively regarded as bruxism). While the early views sometimes distinguished behaviors that occurred during waking *vs.* sleeping states, more often the distinction was ignored. Subsequent knowledge strongly suggests that these two states should be distinguished for assessment, classification, and management, and clenching and grinding represent only two behaviors among many waking parafunctional behaviors of the masticatory system (4-6). Moreover, distinguishing clenching from grinding during sleep is probably less important than their temporal association with pain (7,8). Consequently, from the 1950s through the 1980s, the considerable clinical interest and investigation into these behaviors and their relation to TMDs was highly limited: the focus was primarily on sleep bruxism, not waking behaviors; operational definitions for either bruxism or TMD were seldom rigorous, if employed at all; and a causal relationship of sleep bruxism to TMD pain was largely accepted as self-evident based on cross-sectional observational data. A belief, however, persisted among many clinicians and investigators that waking behaviors were an important contributor to TMDs, and investigators were increasingly expressing doubt regarding the causal role of sleep bruxism for TMDs. The absence of a conceptual or taxonomic framework for these waking behaviors and for their measurement resulted in a wide range of perspectives, and knowledge development was not systematic. Back-pain research during this same period, in contrast, incorporated behavioral concepts extensively (9-12). Much of what we might describe in this paper as “new” for TMDs was previously identified for back pain.

In recognition that a formal descriptive taxonomic system was needed for TMDs in order to foster far better research, the Research Diagnostic Criteria for TMDs (RDC/TMD) were developed based on core design principles (13,14) leading to physical diagnoses (Axis I) that captured the most prevalent TMDs and to assessment of the person with pain (Axis II) that captured the most common comorbid characteristics known at that time. The developers of the RDC/TMD acknowledged that overuse behavior such as bruxism was probably important for TMDs, based on the existing data, yet assessment and classification of bruxism was not included in the RDC/TMD because evidence for reliable assessment did not exist. Consequently, neither bruxism nor any other type of oral parafunctional behavior was formally assessed within the RDC/TMD except for two questions in the Patient History Questionnaire: “*Have you been told, or do you notice that you grind your teeth or clench*

your jaw while sleeping at night?” and *“During the day, do you grind your teeth or clench your jaw?”* During this period, research regarding sleep bruxism and its relationship to pain increased greatly (15-17), whereas research regarding waking behaviors associated with the masticatory system continued to lag, with some notable exceptions (18,19).

Approximately 10 years following publication of the RDC/TMD, the reliability and validity of the physical diagnoses within the RDC/TMD was formally tested in a large multi-site study (20). The project investigators were further tasked with potential expansion of the Axis II assessment protocol, which included better assessment of behavior associated with the TMDs (21). By the early 2000s, chronic pain research, including behavioral aspects of chronic back pain, had led to convincing evidence that behavior can both contribute to, and be exacerbated by, chronic pain (22-30). Yet, parallel knowledge regarding waking behavior and TMDs was notably absent despite, if anything, an increased sensitivity by clinicians that such behaviors were important; management to that date in practice settings was primarily implemented via principles initially advocated in the 1950s (for example, the single directive to the patient: “lips together, teeth apart”) (2), while management in university settings often incorporated some form of electromyographic (EMG) biofeedback as a direct intervention into waking parafunctional behavior (31-34). There was little integration between these approaches.

While the chronic pain literature was replete with evidence supporting both system-specific behavioral problems (such as guarding behaviors to protect against pain—in the case of low back pain) as well as more general illness-associated behaviors (such as avoidance of responsibilities, excessive rest, and pain-related disability), this aspect of behavior was typically not integrated into the realm of TMDs. Instead, TMDs were regarded as uniquely a function of structural aberrations and different in kind from all other chronic musculoskeletal pains. A specific clinical focus on behaviors that putatively affected the masticatory system was largely excluded, and as pain research revealed increasing links between chronic muscle pain and the biopsychosocial model, a belief emerged in TMD treatment settings that intra-articular disorders were “different” and that the biopsychosocial model was therefore not applicable to such disorders. Certainly, consistent evidence has demonstrated that individuals with only intra-articular TMJ problems have less psychological distress compared to those with only myofascial pain disorders (35,36). Yet, absence of distress does not mean

that behavioral factors affecting the physical condition are absent. The field of medicine had clearly recognized that a disorder as structural as knee osteoarthritis exhibited pain more responsive to mood states than to degree of disease-related tissue damage, and behavior was a primary factor in determining both disease and function outcomes (37,38).

In summary, the field of TMDs has been largely isolated from chronic musculoskeletal disorders in general, resulting in notable differences within the TMD field: an increased emphasis on identifying structural changes as risk factors, a primary treatment focus on structural factors (whether deemed a risk factor or not), and neglect of behavioral factors and central dysregulation now known to be associated with chronic pain disorders (14). Developments in waking behavior and its clinical implications regarding pain generally and TMDs in particular will be further explored. We will not explore the role of sleep bruxism, a behavior of a different type occurring in a different state of consciousness and perhaps best classified as a movement disorder; for that, the reader is directed to other sources (39-41).

A pathogenetic view of behavior and TMD

Functional behaviors often become automatic after sufficient learning such that when performed in a customary context by a healthy individual, the behavior becomes easy to perform and occurs without conscious planning for how the behavior should unfold. In such circumstances, we forget about behavior as an important concept because it is seemingly an invisible bridge from one state (e.g., I am hungry) to the next state (e.g., I am satisfied). In this circumstance, the end goal of the behavior is to maximize the probability of experiencing the perception associated with the desired goal. In response to various circumstances, the goal of a behavior may shift, however, from maximizing a desired enjoyable (hedonic) perception to avoiding an aversive perception. Rather than appetitive, behavior becomes protective and, consequently, becomes much more complex in both its execution (with respect to how the behavior is implemented by the motor cortex) and its intention. Negative reinforcement replaces positive reinforcement.

Clinical problems such as TMDs can result from more of a behavior, characterized as increased frequency, duration, or magnitude of the behavior. Both functional and non-functional behaviors are important. Functional behaviors considered part of normal jaw use, such as chewing or speaking, can be taken to excess but whether they, in excess,

are primary causes of clinical problems or whether they are aggravating factors once a disorder is present is not yet known. In contrast, sudden excessive use of chewing gum can easily lead to localized muscle spasm that can readily resolve by immediately terminating the excessive gum chewing. Other functional but perhaps non-normative behaviors involve bracing the jaw such as playing violin or holding a telephone handset between shoulders and mandible and these behaviors, if done to excess, are believed to be capable of causing musculoskeletal problems (42).

Multiple types of non-functional (overuse) behaviors are possible such as clenching, tooth tapping, tooth pressing, tongue pushing, tongue sucking, lip biting, jaw bracing, and jaw tension. Increases in the behavior(s) are thought to be particularly important risk factors for TMDs (43-49). The mechanism underlying how non-functional behaviors might lead to the development or aggravation of pain or dysfunction remains poorly understood. Associations demonstrated in cross-sectional studies (50-52) have been the most frequent type of study from which interpretations of causation have been inappropriately made. A small number of well-performed studies, primarily through ecological monitoring of behavior and time-locked symptom changes, provide more convincing evidence (43,53).

Clinical problems can also result from alterations in how the behavior is executed. Perhaps the best known example is musicians who overuse certain fine muscles of the hands leading to fatigue and unconscious compensatory development of new motor unit recruitment patterns that allow the individual to continue to play, which then increases the risk for development of tendon injuries that can completely stop all performance (42). The muscles of mastication are equally susceptible to such problems. For example, the presence of odontogenic pain will alter chewing pattern, typically one that is asymmetrical, in order to avoid loading of the involved tooth; unilateral chewing increases risk for developing a TMD (54). In this instance a functional behavior becomes abnormal in its execution, which is both unconscious (e.g., pain is a stunningly effective behavioral change agent) and conscious (e.g., avoidance of pain is also a stunningly effective behavioral change agent).

A unidirectional path—from excessive behavior to pain onset, aggravation, or both—appears to be an incomplete description of behavior and its relationship to clinical musculoskeletal disorders. The available evidence indicates that clinical problems such as TMDs can also result in increased frequency, duration, and magnitude of a behavior

as well as result in alteration of behavior execution as attempts to adapt to any pain or limitation in movement (55). We previously reported a very large magnitude of association (OR =16.8, 95% CI: 8.6–32.9) between a global index of oral overuse behaviors and chronic painful TMD, in contrast to the magnitude of association with other factors associated with painful TMD—for example, TMJ sounds on palpation during movement (OR =2.6, 95% CI: 1.9–3.7) or female sex (OR =4.0, 95% CI: 2.6–6.0) (50,56). This very large association between parafunctional behaviors and chronic painful TMD in a cross-sectional study design was interpreted as likely reflecting a reciprocal process: effects of the behaviors on TMD chronicity as well as the behaviors being respondent to pain, other mechanical jaw problems, or other more general factors such as stress.

Behavior also refers to more global patterns of action by the individual, such as operant behavior—a specific behavioral pattern by the individual to control how one's needs are met by another person; illness behavior—the act of being ill, seeking care, taking medication; or fear-avoidance behavior—localized guarding coupled with withdrawal from normal use of the affected body region—itsself a behavior characterized by, paradoxically, inaction. These types of patterns can (and probably most often do) exist in addition to local patterns, described above. Consequently, the entire performance of chewing that also includes congruent facial expressions could be used as a means to control another through chewing-related pain behaviors; or chewing could be slow in a way in which an individual demonstrates to others that illness is present; or chewing could become highly limited due to fear-avoidance beliefs resulting eventually in progressive atrophy of the masticatory muscles. In each of these three instances, the behavior can be quantified in terms of frequency, duration, and force; and in each instance, the intention behind the behavior can be identified. In addition, each of these three instances could occur in the same individual within a short period of time. Understanding the local behavior—chewing—requires understanding the individual; the neurophysiology alone underlying the different ways in which chewing might manifest as a behavior would be insufficient for understanding how a behavior, such as chewing, might be a problem.

Behavior is the final output of motor activation, and yet that same behavior is also a source of input to the nervous system: the execution of a given behavior serves as the starting point of a new cycle of central nervous system activity wherein the outcome of that behavior, measured

as both sensory experience of the behavior as well as the instrumental goal of the behavior, becomes the input for a new cycle of activity. While a given behavior can be readily classified by the observer based on its beginning and ending, behavior for the individual is a continuous stream, that is, behavior is inherently dynamic and represents simultaneously the outcome of controlled motor activation as well as the sensory and motivational state of the organism as it exists at that moment. For patients whose clinical condition is linked to behavior, both levels are important. Both levels, in turn, contribute to the reciprocal process identified above.

Behavior, in relation to a disorder such as TMDs, can therefore be considered from two levels: the behavior as a discrete form of activity, and behavior as the sum total of all action by the individual on the world around them—what may be termed organismic behavior. Discrete behavior performed in an excessive manner (to be defined)—that is, beyond normal functional requirements—is generally assumed to be pathogenic towards local tissue. Organismic behavior, in contrast, acts on the individual as a whole: withdrawal behavior leads to depression, for example. A given behavior can exist at both levels simultaneously: protecting the back from excessive movement, called guarding behavior, entails hyperactivity of the associated muscles in one part of the back (and is typically asymmetrical), and hyperactivity can lead to fatigue, incoordination, muscle contracture, and pain; guarding behavior also limits activity engagement and thereby decreases pleasure and social support and contributes to depression. Depression leads to further inactivity and guarding. Clearly, behavioral problems must be identified and physical treatments for TMDs must be aligned with restoration of adaptive behavior (57).

A multivariable model examining contributing factors to pain onset and pain chronicity highlights both unique pathways as well as likely recursive pathways between risk factors and the transition to chronicity and maintenance of chronicity (58). Based on the mixture of biopsychosocial variables contributing to pain progression, behavior encompasses many of those processes. However, we have little direct evidence regarding this proposed reciprocal pathway or, by extension, the proposed dynamic process whereby both primary and reciprocal patterns augment each other in terms of possible behavioral persistence and symptom aggravation. An attempt to depict this complexity for clinicians is notable for its description of how the clinician must understand and actively manage

the multiple feedback processes inherent in these patterns; the therapeutic task is clearly one of reteaching normal movement and posture to the patient (59). The very frequent incomplete response to simple behavioral therapies for non-functional behaviors (e.g., “just stop doing the parafunctional behavior”) (60–62) may point to the potential importance of more complex mechanistic pathways such as this proposed reciprocal one as well as the necessity to integrate, in one’s treatment approach, problems in functional behaviors (e.g., altered chewing) as well as problems in person-level behaviors (e.g., fear-avoidance). Consequently, we suggest that possible bi-directional and multi-level causal links could be present in individuals with chronic TMDs. The therapeutic challenge extends well beyond the available evidence from clinical trials.

Masticatory system functional behaviors

Assessment

Behaviors considered to represent instrumental jaw use include chewing, opening the mouth, verbal and non-verbal expression, and others such as musical instrument playing. Determining normal *vs.* abnormal extent of these behaviors is very difficult due to the extreme extent each of these can occur within individuals who are (and remain) completely asymptomatic. Consequently, the useful clinical markers for abnormality appear to be alteration in how the behavior is executed and frequency.

Alterations in behavioral execution occur with chewing (such as unilateral chewing in response to a symptomatic tooth), mandibular movement (such as deflected opening in response to disc clicking or unilaterally shortened muscle), speech (such as continuing to speak when masticatory muscles are fatigued), and musical instrument performance (such as with small string, wind, or brass instruments). For wind and brass instruments, alterations are typically evident in strained embouchure which is best determined by the individual’s music teacher and managed accordingly. Alterations in execution can also occur as a result of very hurried chewing, for example, and pushing the central pattern generator for mastication beyond coordinated movement. High frequency of usage typically occurs with speech, bracing the mandible for musical instrument positioning, and rotating the head and mandible to hold a phone (or any object) between mandible and shoulder. Alterations in execution as well as high frequency beyond interoceptive signals indicative of strain are assumed to

include recruitment of less-optimal motor units in order to continue to function, which can lead to dysfunctional recruitment and further fatigue.

In all instances, the patient history will indicate a change in the behavior, comparing pre-symptom state to the present symptom state. The clinician appraisal is therefore based on relative changes in execution, as inferred from the history, and relative changes in frequency of the putatively problematic behaviors, coupled with examination findings of alterations in movement. For example, chewing could have always been bilaterally symmetrical prior to the breakage of a tooth, after which unilateral chewing began to avoid the tooth; notably, after the tooth was repaired the unilateral chewing persisted—simply because new learning led to implementation of a new automatic (habitual) pattern.

Management

Restoration of normal behavioral pattern and expectations is the therapeutic goal for problematic functional behaviors (63). Little evidence exists for the below principles in specifically managing the masticatory system in relation to a TMD; instead we rely upon general principles established elsewhere (64–67). Reinstating bilateral chewing is accomplished via conscious retraining by the patient; a 2-week period could be used during which softer foods are consumed in order to facilitate the change from unilateral to bilateral chewing, and then gradually returning to normal textured foods. Bilateral chewing includes alternating side of the bolus, splitting the bolus to chew both sides simultaneously, or any combination. The training period in using soft diet should be time-limited; excessive use of soft diet contributes to further problems, while rapid return to normal textured food diet facilitates symptoms improvement (68).

Pioneering research (69) regarding altered mandibular opening movement pattern in the frontal plane as well as acceleration and deceleration during the open-close movements in response to disc displacement with reduction has led to the assumption that such patterns are an intrinsic consequence of the mechanics of an internal derangement. An alternative interpretation, such as from the fear-avoidance model (27,70,71), suggests that altered opening patterns emerge due to unconsciously avoiding the difficulty endangered by an internal derangement, and that over time the compensatory pattern becomes the dominant (habitual) one and, by extension, becomes the new normal within which joint function (and joint proprioception) accommodates. Such patterns also occur in response to

musculoskeletal pain (72). Correcting deviations in the frontal plane as well as changes in speed of movement are best addressed with visual feedback: a mirror for the patient to observe the movement, directions from the clinician regarding what is normal, and gradual retraining of the movement in order to return to a more normal pattern. Such strategies represent emerging understanding of altered body representation and movement patterns as treatment targets for musculoskeletal disorders (73–76).

Highly frequent speech, such as by teachers or individuals in the service industry, can become an aggravating factor for overuse; teaching use of intermittent relaxation during non-speech moments can allow for recovery rather than the recurrent strain that persistent overuse of speech can lead to, given the presence of a musculoskeletal disorder.

Masticatory system non-functional behaviors

Assessment

Traditionally, waking parafunctional behaviors have been assessed by interview or self-reported questionnaire regarding presence or absence of clenching or grinding behaviors associated with the teeth. The behaviors were considered to be dichotomous—absent (normal) or present (abnormal)—with regard to a potential contribution to a TMD. An early landmark publication of individuals from 15–65 years of age provided a life-course perspective regarding a more complex occurrence of these behaviors: tooth clenching was reported by 42% of individuals during 35–44 years of age, and as low as 15% during other ages; soft tissue biting was reported by 19% during 15–24 years of age, and then decreasing to 10% for the remaining ages; object biting was reported by 23% during 15–24 years of age, and thereafter only a few percent for the remaining age groups; and tongue pressing was reported by 10% across all age groups (77). The results of that investigation indicated that multiple types of parafunctional behaviors exist, that positive response rates were increased when various behaviors were queried rather than only clench or grind, and that some behaviors have a lifetime pattern whereas other behaviors are life stage-specific. Similar findings of multiple behaviors have been observed, for example, in nursing students (78); at least daily, 39% reported touching or holding teeth together, 15% holding jaw rigid, and 24% biting objects.

An important implication of those findings is that since waking parafunctional behaviors are more often

unconsciously rather than consciously performed, a single question of “clench or grind?” does not sufficiently probe memory, and without a sufficient probe, false negatives are probable. A series of questions prompts respondents to more carefully consider each behavior, often augmented by testing the behavior and directly probing memory of proprioceptive experience. Ecological momentary assessment data provide consistent estimates. When prompted in the field by a pager to self-monitor (79), non-TMD controls reported their teeth were in contact 45% of the time, while individuals with either disk displacement or myofascial pain reported 56% of the time, and individuals with both myofascial pain and TMJ arthralgia reported 73% of the time. When similarly prompted in the field by pocket computer (4), a mixture of individuals (TMD-free, or any type of TMD) reported varying proportions (range, 2–26%) of 11 different behaviors per prompt, and reported any of 6 behaviors such as clench or press 76% of the time. Overall, under-assessment has been likely in both clinical settings and in published research, leading to under-estimation of associations with TMDs.

Collectively, these findings point to a spectrum of types of behaviors and number of different behaviors one individual might do, varied intensity and varied frequency of different behaviors across individuals, and a trait-like aspect for certain behaviors that are life-long. In addition, some individuals are far more prone to such behaviors. Being considered within a spectrum also suggests that “parafunction” as a classification may miss another important perspective: these behaviors lie within a continuum that is dependent on extent (frequency, duration, and force magnitude) of each reported behavior, summed across all of the reported behaviors). A critical threshold likely exists in that continuum separating “normal” from clinically abnormal and potentially pathogenic. Just as everyone exhibits at least a small extent of sleep bruxism some of the time (80,81), nearly everyone engages in some type of waking parafunctional or overuse oral behavior, at least some of the time. The variability in types of behaviors as well as their frequency is probably influenced by multiple mechanisms: the behaviors can occur both unconsciously as an autonomous habit, unconsciously as reactive to other events such as back pain or physical strain (e.g., weight training), unconsciously as adaptive behaviors, and consciously (or unconsciously) as a coping mechanism to other events such as stress or anger.

Among possible approaches for simple routine assessment of these behaviors, the self-reported Oral

Behaviors Checklist (5,6) has perhaps the best evidence for reliability and validity and was consequently adopted as a standard instrument within Axis II of the DC/TMD (82). The 21 items probe sleep bruxism and posture (2 items), non-functional behaviors such as clenching or jaw bracing (11 items), and functional behaviors such as playing a musical instrument, unilateral chewing, and sustained talking (8 items). The instrument uses a 5-point rating scale from none of the time to all of the time. Semantically, the terms are well-understood (5), similar behaviors such as “clench” *vs.* “press” have distinct EMG signatures (83), and self-report assessment via a paper instrument accords very well with field monitoring of the behaviors (4). Whether all of these items, as indicators of different types of behavior, are equally important contributors to TMD onset or aggravation has not yet been determined. Consequently, the major scoring to date has utilized a sum score from all 21 items (46,50) and best practice for clinical usage is to further interview the patient regarding positive responses in order to confirm frequency, explore context (i.e., behavioral antecedents, setting), and identify consequences. Patients may have very informed responses to each of these 3 interview questions, or these questions may point to as-yet unknown aspects of the person’s behavior and suggest an action plan for daily monitoring and then reassess. Associations between OBC high scores and TMDs have been reported from many settings (6,47,50); clearly, the extent of parafunctional behaviors exists along a continuum, and a low extent should be considered “normal” and not pathogenic.

Ultimately, a questionnaire such as the OBC is only the beginning of assessment; the patient must recognize the behaviors, their frequency, their context, and their consequences (e.g., pain episodes, increased temporomandibular joint clicking), but a full recognition can take months of engagement through treatment, so expectation of understanding by both patient and clinician at the early stages should be realistic. An appraisal based on the initial information (such as responses to the OBC and related interview) is required to determine if change in the behaviors should be a goal for treatment. The initial assessment must also lead to patient engagement; without that, behavioral management cannot succeed.

Management

When extent of non-functional behaviors is high, then treatment should focus on attainment of a neutral position of the mandible which is incompatible with any

parafunctional or overuse behavior (with the important and paradoxical exception of muscle strain sometimes emerging in the goal to attain that neutral position). The goal is to retrain habitual and respondent parafunctional behaviors, replacing what is customary with a new habitual neutral position of the mandible. Defining neutral, however, is challenging; for some, “neutral” is the location of the mandible where EMG measure of the masticatory muscle activity is minimal (84), whereas for others “neutral” is defined interoceptively as absence of “tension”. The former is typically achieved with tongue tip held in the floor of the mouth, while the latter is achieved with tongue tip placed at anterior palate (the so-called “n-position”), at least at the beginning (84,85). Both approaches are useful, but lead to different positions of the mandible as measured in the vertical plane—with the mandible positioned more inferior in order to attain minimal EMG. The minimal EMG approach *vs.* a “relaxed, non-tense position” has been extensively researched with other muscles (86,87), and while minimal EMG is certainly associated with the least perception of any tension, it is also perhaps unnecessary from what might be described as clinically “normal”, correlates poorly with symptom reduction, and represents a therapeutic goal that may be more difficult relative to ecologically useful training.

There is little systematic evidence for efficacy of tongue posture training alone (88,89), yet some form of relaxation is used frequently and with good efficacy for TMD symptoms (90). Similarly, EMG biofeedback has been used to train individuals for relaxation of the masticatory elevator muscles. While EMG biofeedback is an effective procedure for targeted muscle relaxation, its efficacy is improved when combined with other behavioral treatments (32). Behavioral management requires more than simply learning how to decrease motor cortex activation of a specific muscle (91,92). Overall, general relaxation skills or mindfulness training tend to be superior for any chronic pain (93-95) and augment local treatment of behaviors well.

Regardless of which strategy is taken to teach a neutral position of the mandible, the same requirements must be met: patient adherence, clinician persistence with biweekly or monthly follow-up and problem-solving, retraining in the targeted skill towards mastery, and exploring antecedents and barriers. With a goal to transform, for example, overuse behaviors that occur during much of the day to overuse behaviors that seldom occur during the day, the time required for this type of behavioral change varies across individuals: some individuals will describe a nearly

100% resolution within a period as short as 2 weeks, while others will require up to a year. Patience and persistence on the part of both patient and clinician is required, but continued investigation into antecedents and co-factors is also required. For example, poorly managed back pain (leading to flareups) or ongoing family stressors, either of which can trigger bouts of masticatory overuse behavior, will hinder or even prevent progress for patients in making desired behavioral changes. Overall body tension or fear-avoidance beliefs will similarly impact negatively on the potential for progress. At present, there is no empirical evidence describing this type of tailored care for TMDs. Such approaches have become the standard for back pain and are recommended for TMDs, pending outcomes of necessary clinical trials (96).

Person-level behaviors

Person-level behavioral factors will contribute to masticatory system non-functional behaviors as well as interfere with local treatments oriented at changing the behaviors. These factors include the following, along with sample effects on behavioral change:

- ❖ Depression, which affects motivation;
- ❖ Anxiety, which increases general muscle tonus, serves as a proximal trigger for reactive behaviors, and is associated with worry and ruminative thoughts that increase trait-like tendencies for these behaviors;
- ❖ Post-traumatic stress disorder, which has effects similar to those of anxiety;
- ❖ Other comorbid pain disorders, which act as recurrent triggers for reactive behavior;
- ❖ General body tension, which may be regional (neck and masticatory system) or general (whole body), and which increases the difficulty in learning to control masticatory muscle activity;
- ❖ Operant behaviors, which reflect secondary gains and can interfere with local behavioral therapies;
- ❖ General stress, which increases overall body tonus and general reactivity;
- ❖ Poor time-management or assertiveness skills, which contribute to inability to make behavioral change a priority and which increase general stress;
- ❖ Absence of relaxation skills, which creates a substantial barrier in learning the local skill of masticatory muscle control;
- ❖ Fear-avoidance, which fosters continued muscle response as a guarding behavior;

- ❖ Illness behavior, which affects motivation to change and confidence in one's ability to create that change;
- ❖ And pain-related disability, which increases probability of poor adherence to behavioral change.

The above list is of course not exhaustive but does represent prevalent problems that trigger non-functional behaviors or act as barriers to local behavioral treatment for those behaviors. In addition to these factors affecting oral masticatory behaviors, these factors can also affect each other, highlighting the complexity of behavior: a jaw clench event could just be a habitual behavior, or it could be tied into one or many of the person-related behavioral factors stated here. Each of these factors should be actively considered by the clinician at outset of evaluation with regard to magnitude and probable relevance to the TMDs, non-functional behaviors, and pain. This assessment should then be incorporated into the treatment as necessary, depending on overall patient response to initial therapies. In addition, identified patterns of antecedents leading to non-functional behaviors or to pain amplification should be noted. Each of these factors has its own specific treatment needs and approaches, and a detailed and critical description is beyond the scope of this review.

Conclusions

Behavior associated with mandibular function transcends physical diagnoses, and behavior relevant to TMDs includes functional, non-functional, and person-level types. Non-functional behaviors contribute to TMD onset and persistence, but mechanism(s) for how the behaviors contribute to pain in particular remain unknown. Person-level behaviors contribute to chronic pain in general but TMD-specific evidence is limited. Assessment and management of these behaviors requires that the clinician utilize principles of behavioral change, address complex patterns due to interaction of multiple behaviors, and continually problem-solve with the patient. Finally, successful behavioral change by patients depends on substantial care and time by the clinician.

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