Electromyographic Correlates of Common Oral Behaviors: Study Extension

A. Specific Aims:

Current theories and management of chronic temporomandibular disorder (TMD) pain continue to circulate around the hypothesis that muscle overuse is a primary factor for either causation or maintenance of the disorder. Yet, there has not been any advancement in the development of a reliable or valid method for initial screening of patients for the presence of overuse behaviors, nor for monitoring progress of change of such behaviors in the context of treatment. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is a comprehensive and validated instrument that contains two Axes for patient assessment (Axis I, physical domain, and Axis II, biobehavioral domain); while Axis II contains a number of constructs for assessing factors that effect, and in turn are affected by, pain, there is a notable absence of any instrument for assessing overuse behaviors. The proposed study is an extension of an ongoing project that has shown data to defend this study’s goals. The purpose of the study extension is to provide more statistically significant data by increasing the sample size, and the study methodology. Data collection to date suffers from inadequate statistical power and generalizability. I propose to resolve that by recruiting additional subjects.

The study objectives are as follows:

1. Characterize the electromyography of common oral behaviors believed to be important in chronic pain.

2. Relate hierarchical patterning of observed electromyography of these behaviors to hierarchical patterning of oral behaviors as self-reported.

3. Explore methods for inducing such behaviors in the laboratory in terms of how motor, emotional, and cognitive factors are differentially related to behavioral control.

4. Evaluate the effect of tongue position on the EMG amplitudes of masticatory muscles in relation to before and after extensive muscle use.
**B. Background and significance:**

Oral parafunction has been described repeatedly in clinical research literature as a significant factor contributing to TMD. While an extensive number of studies have explored nocturnal bruxism, few studies have explored the more complex and subtle types of oral parafunctional behaviors that occur during the waking hours. Prior studies (e.g., 1,2) of diurnal oral parafunctional behavior have focused primarily on intentional clenching and bruxism, providing evidence for believing that such behaviors contribute to TMD pain, but because that type of study has relied upon extreme level of behaviors, they have been limited in furthering our understanding of the behaviors. Little is known about the types of oral parafunctional behaviors people engage in, and how often they may differ in those individuals with vs. without TMD pain. The present study will explore the descriptive electromyography of these behaviors.

Moss and colleagues demonstrated that specific levels of EMG (electromyography) activation are associated with some common jaw behaviors (3). The study measured the EMG values from six muscle groups of the face (i.e., bilateral masseter, temporalis, and orbicularis oris), and found specific EMG values for each of several oral behaviors. This study showed, not surprisingly, that each of these individual behaviors is associated with its own magnitude of EMG activity. Two limitations of that study included failure to compare these behaviors between people with vs. without TMD pain, and the particular behavioral patterns studied were not extensive.

Gallo and colleagues provided excellent evidence for specificity of EMG patterns related to common oral behaviors using waveform templates and expert systems; they demonstrated excellent validity (i.e., high diagnostic utility – sensitivity and specificity) of EMG patterning for particular oral behaviors during sleep (4) and during the waking state (5). With preliminary evidence for EMG specificity regarding diurnal oral parafunctional behaviors and strong evidence for EMG specificity regarding nocturnal oral parafunctional behaviors, we can now look at these diurnal behaviors more in depth in terms of how the patterns compare between TMD patients and non-TMD patients.
While the analytical methodology of Gallo and colleagues would lead to interesting extensions of our present studies, their research is perhaps of greater importance due to its heuristic value: by demonstrating specificity of EMG patterning across the behaviors, they provide strong evidence for differences in how central motor control of the behaviors is organized. In the current study, data have already been obtained from both control and pain subjects, and shown specific EMG patterns for specific oral parafunctional behaviors. Gallo has agreed to collaborate with us in order to apply his analytical technique to the data from our study upon completion.

Results from this study can provide a possible link between specific oral parafunctional behaviors and specific EMG amplitudes. Obtaining data that shows TMD patients produce greater muscle activation than control subjects is a feature that makes this study externally valid. This study has already shown higher EMG amplitudes on almost every behavior when comparing TMD subjects to control subjects; these findings, however, are not statistically significant due to present sample size. Finding what behaviors produce the greatest difference between TMD subjects and control subjects would be useful clinically, by guiding clinicians into what direction to use EMG to help find what behaviors patients are doing to cause TMD pain.

**C. Preliminary studies:**

The use of imagery as described in last year's proposal to elicit an unconscious response from the subjects has been discarded due to the failure to obtain any significant EMG amplitudes when asking the subjects to perform behavioral tasks. After running 3 pilot subjects and speaking with researchers who have worked with imagery in this context before, it was obvious that eliciting an EMG response while imagining an overt oral behavior would not be very reliable in this lab.

The proposed protocol, using overt behaviors, was conducted in this lab. Some of the findings have been accepted for presentation at the IADR 2004 (7, 8). As a summary of our findings to date we contrasted cases vs controls in terms of resting performance, the
Electromyographic Correlates of Common Oral Behaviors: Study Extension

Michael Markiewicz

semantics and physiological equivalents of one common behavior (tooth clenching) and comparison of oral behaviors to non-oral behaviors for generalizability, based on 11 TMD and 11 controls. The data for 2 subjects were discarded due to artifact as extreme responses. Per protocol, baselines prior to each oral behavior were collected across 18 baseline trials. The problem with the baseline readings was the data were highly positively skewed with outliers. Methods for dealing with the outliers, in terms of obtaining a reliable estimate of baseline activity included dropping, recoding, or selecting lowest value (i.e., best performance). Using the latter approach, TMD patients had higher baselines than the controls for all muscles studied, though the difference was not significant using a 2-tailed t-test. In selecting an average baseline using all the data, both groups were equal.

Cases and controls each exhibited similar types of patterning (linear vs non-linear) in lifting weights with their arm (, p =0.86) and biceps baseline values between trials exhibited high variability in both groups.

Both groups exhibited very high variability in masticatory muscle baselines, with TMD slightly greater than controls averaged over 17 separate baseline trials (non-significant); best baseline values demonstrated that TMD exhibited marginally higher resting EMG vs controls (t-test, avg p=0.062). The difference in baseline EMG amplitudes was not significantly different between groups for a few possible reasons. The first one being that there were extreme baseline values for a few subjects from both groups, and this data had to be discarded in the procedure talked about earlier, and the second and most important reason being that the statistical power was not enough with this small of a sample size to overcome the values from outliers. The EMG of 4 similar behaviors (clench, touch, press, hold) was different (ANOVA, p = 0.013) but the groups did not differ within behavior. For other behaviors, such as reading, yawning, talking on a telephone, the TMD group exhibited a non-significantly higher EMG amplitudes compared to the control group. Correlation between trial 1 and trial 2 of task trials were performed, and compared for TMD vs control with regard to reliability. There was no consistent pattern: for any tasks, one group might exhibit much higher reliability than the
others, these inconsistent results are attributed to the relatively small sample size. These data demonstrate within-subject and between-group differences regarding the organization of motor control for simple tasks. TMD subjects appear to generate higher levels of resting EMG amplitudes. Similar oral behaviors have distinctive and widely understood electrophysiology associated with the semantics of those behaviors.

There were 3 males and 10 females in the pain group, and there were 7 males and 5 females in the control group. The average age of the pain group was 42 while the average age of the pain group was only 26. This difference in the age between the two groups in the first wave of subjects is be corrected using recruiting procedures highlighted in the methods section.

Sample size determinations, using alpha of 0.05 and statistical power of 0.8, were computed. For the best baseline values, the number of subjects to reach statistical significance is 28 (for the suprhyoid muscles) or 44 (for the masseter muscles). In reference to on-going tonic behavior, the best baselines are actually one of the more theoretically affluent variables in this study. For the reason that relaxed baseline control requires all muscle groups, a multivariate analysis is appropriate, and this could potentially reduce the number of subjects due to moderate (r=0.4) covariation among the variables. For the performed tasks, the number of subjects to reach significance ranges from about 40 upwards. This of course, is based on the particular task. Other data describing the impact of persistent pain on performance suggests that TMD subjects may in fact be capable of less force than controls, for a given task such as clenching or chewing. Consequently, expected outcome of the observed data is not predictable at present. Correlations among the first and second task trials were also performed, by subject group; the values are sometimes consistent across related tasks, within a group, and sometimes not. We suspect that the variability in correlations may perhaps be due to a relatively small sample size. In sum, we propose to collect data for at least 17 more subjects within each group, for a total of 34 more subjects.
When considering this data, and given the time limitations if the study to work in, the goal of this lab would be to recruit about 10 subjects per week, at about 2 hours per subject.

D. Methods and Materials:

Subjects: Subjects will be comprised of two groups: a TMD pain group and an asymptomatic control group. The TMD pain group (n=12) will be recruited from a university-based private practice in pain management. These subjects will be selected based on having been given a TMD diagnosis based on RDC/TMD criteria. Since older control subjects are needed in this wave of recruiting due the need for balance between the mean Control subjects will be recruited within the age range of 41 and 72 years of age. This age range was taken from adding the difference between the TMD and control subjects mean ages in the first wave of subjects to the TMD groups mean, and then using the standard deviation of the pain subjects ages as a reference for the age range by adding and subtracting the standard deviation to and from the mean age of the TMD patients. Subjects with current painful locking of either TMJ, based on history will be excluded, as the study procedures may possibly exacerbate that particular type of pain.

Control subjects are defined as individuals who have a lifetime absence of the diagnostic symptoms and signs of TMD based on RDC/TMD criteria.

Increasing the subject size 2-fold from the prior study should resolve the issue of power and generalizability of the data obtained from the subjects, and should provide sufficient evidence when comparing baseline and behavioral tasks amplitudes between pain and control subjects. Subjects will be paid $25 for their participation in the study.

Design: This is a single session experiment, which will require no more than approximately 1.5 hours for participation. Data will be collected using a repeated measures design.

Measures: Data will be comprised of self-report measures regarding oral parafunctional behavior status and pain levels, examination data for diagnostic confirmation, and EMG for assessment of behaviors during the study. A self-report questionnaire, the Oral Behaviors Checklist (OBC), provides frequency data for the targeted behaviors in this study.
A standardized clinical examination, as defined by the RDC/TMD, will be performed by a calibrated examiner in order to confirm diagnostic status.

For electromyography (EMG) measurements, surface electrodes will be attached to the skin overlying each of the bilateral masseter, anterior temporalis muscles, and the suprathyroid muscles for the facial region and, to the biceps of the dominant arm for control procedures. Standard procedures that include skin preparation with a mild abrasive gel and electrode collars to affix the electrodes to the skin will be followed (9). Custom software written in Testpoint controls data acquisition and off-line analysis.

**Procedures:**

**Phase 1:** Subjects meeting the above criteria will be recruited used for the study. A calibration procedure for the overall protocol will be performed by asking the subject to lift with the dominant arm, in sequential order, hand weights (1, 3, 5, 10 and 15 lbs); the sequence will then be repeated a second time.

**Phase 2:** Subjects will be asked to perform two jaw posture procedures. These involve (1) placing the tongue on the roof of the mouth, and (2) placing the tongue on the floor of the mouth. Two trials will be performed. Each trial will be 1 minute long.

**Phase 3:** The subject will then be asked to perform several key oral behaviors. These behaviors include; clenching the teeth, touching the teeth together, pressing the teeth together, holding the teeth together, tensing the muscles of the face, pressing the tongue forcible against the teeth, various excursive movements, and holding the jaw in a rigid position.

**Phase 4:** The last set of behaviors includes common parafunctional behaviors that might elicit a different EMG response in both groups. These behaviors include holding the telephone while sitting still, and then while talking, reading out loud, yawning, and chewing gum.

**Phase 5:** The last phase of the study will have subjects again do the same jaw posture procedures as they did before. These are repeated to record the subjects after exhausting the jaw muscles.
Statistical management of Data:

Repeated measures ANOVA using task [actual performance, imagined performance] and trial [trial 1 vs. 2] will be used for the data analysis for the primary hypotheses.
E. References


F. Resource Information. Facilities and Research Project Equipment

Experiments will be performed in the Psychophysiology Laboratory of the Center for Orofacial Pain Research of Dr. Richard Ohrbach, located in Squire Hall. The laboratory is equipped with oscilloscope, multi-channel computer-based data acquisition, and multiple software programs for data acquisition, analysis, and statistics. Research personnel within the Center provide assistance with IRB matters, subject recruitment for the Center databases, and compensation to subjects.

G. Other Support for Applicant and Sponsor

Sponsor (RO) has individual grants from NIH which supports subject compensation and any material costs.

H. Human subjects: IRB approval has been obtained. There were no untoward events in the collection of data from the first wave of subjects.

I. Vertebrate Animals

Not applicable.

J. Recombinant DNA, Recombinant DNA Molecules

Not applicable.