The Effects of Tongue Position on Mandibular Muscle Activity

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The purpose of this study was to determine the relationship between tongue position and mandibular muscle activity. Thirty-three subjects (28 women) between the ages of 18 and 34 years (mean = 22.1 years) with no prior injury to or pain in the jaw, mouth, or tongue participated in the study. Subjects were asked to rest quietly while baseline electromyographic recordings were made from the temporalis, masseter, and suprahyoid muscle regions. Afterwards, subjects were randomly assigned to conditions requiring them to position the tongue either "against the anterior palate" or "on the floor of the mouth, making sure the tip does not press against any part of the mouth." The results indicated that right temporalis activity was higher when the tongue was positioned against the roof of the mouth than when it was either at baseline or resting on the floor of the mouth ($P < .03$). A similar pattern of results was observed for the suprahyoid muscle group ($P < .01$). There were no significant differences in masseter muscle activity as a function of tongue position (Ps > .20). These findings suggest caution in labeling the "rest" position of the tongue and indicate that further study of the relationship between tongue position and orofacial pains is needed.

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Over the past 10 years, experimental data in the field of temporomandibular disorders (TMD) are forcing health practitioners to revise their understanding of the etiology and maintenance of these phenomena. Issues such as the relationship between occlusion and TMD pain, the so-called vicious cycle of muscle tension and pain, and the effectiveness of occlusal splint therapy have been examined under more stringently controlled scientific conditions.[1,2] With the efforts of many clinical researchers, well-designed research studies have begun to establish a foundation of knowledge upon which to develop treatment options. It is from within that tradition that the current study was conceived.

It is common for dental and physical therapy practitioners to instruct patients on the correct "rest" position for the tongue.[3–5] Rocabado's 6×6 program[6] for treatment of craniocervical and craniomandibular system disorders emphasizes that the dentist must teach the patient the correct "rest" position of the tongue. Specifically, he recommends that the tip of the tongue should be maintained against the palate with slight pressure. Rocabado further states that in this position, masticatory muscle activity is at a

minimum. No scientific data in the literature, either in the form of electromyography (EMG) or self-report findings, were found to substantiate this claim. Therefore, this recommendation concerning the "rest" position of the tongue currently may be based more on clinical lore than on data derived from careful scientific study.

Both the degree of muscle activity associated with tongue positioning and the association between tongue position and the development or maintenance of TMD are unclear at this point. However, there are some reasons for concern with labeling the tongue placement on the roof of the mouth as a "rest position." First, maintaining pressure against the palate would require recruitment of some muscle fibers, and such muscle activity would be inconsistent with the term "rest." Second, if the person were upright, muscle activity and energy would need to be expended to overcome the force of gravity. Goodheart[7] describes the difference between what a dentist might call a "physiologic rest position of the mandible" and what a physiologist might term the "postural position of the mandible." He states that the term "physiologic rest" is inappropriate because the postural position of the mandible requires the muscles innervated by the fifth nerve to contract just enough to hold the mandible in a balanced state of equilibrium against gravity. It is difficult to know where this balance lies for the tongue and its supporting muscles. Third, the constant maintenance of the tongue in this position, if it is not the "normal" position, has the potential to produce muscle fatigue and discomfort because of the effort required to maintain a "relaxed" position.[8] In summary, "resting" the tongue against the roof of the oral cavity with slight pressure very likely involves the use of muscle activity. Without controlled laboratory experiments, however, this proposition cannot be evaluated.

In some cases, there may be a reasonable clinical rationale for placing the tongue on the roof of the mouth. For example, some patients have excessive translation of the mandible during rotational movements. With such persons, it is conceivable that correct jaw alignment may be obtained by placing the tip of the tongue on the roof of the mouth during mandibular rotation.[9] Further, to restore appropriate mobility and to strengthen the masticatory muscles after soft tissue injury or surgery, opening and closing the mouth with the tip of the tongue on the palate enables the patient to exercise the muscles within a controlled range while retraining them in proper rotational movement.[6] However, such instructions are distinctly different from instructions that the usual and customary rest position of the tongue is on the roof of the mouth.

The present investigation was conducted to measure the activity in masticatory muscle groups when the tongue is placed either on the palate or on the floor of the mouth. It was predicted that positions of the tongue requiring even slight pressure or overcoming gravitational forces (ie, tongue on the palate) would involve greater muscle activity in the orofacial region than would positioning the tongue without pressure and resting it on the bottom of the mouth. Intuitively, this resting position would not involve muscle activity or energy expenditure to oppose the force of gravity, unless the weight of the mandible and tongue would require an increase in elevator muscle activity to maintain the position. Scientific studies of temporomandibular functioning are important in identifying those factors contributing to the development and maintenance of dysfunction from those that anecdotally appear to play a role.

Materials and Methods

Subjects

Thirty-three subjects (28 women) ranging in age from 18 to 34 years were recruited from a university community to participate in this study. Subjects were screened prior to participation and were excluded if they had any current or prior injury to or pain in the jaw, mouth, or tongue. All subjects gave informed consent after the procedures and the voluntary nature of the experiment had been explained. While gender representation is obviously imbalanced, this proportion (85% female) is representative of the patients seen for treatment of facial pain complaints.[12] Twenty-nine (93.5%) subjects described themselves as Caucasian, two (6.5%) described themselves as African American, and two declined to answer. The average height for participants was 5 ft 6 in (SD = 29 in). Average weight was 137 lb (SD = 29 lb), and average age was 22.1 years (SD = 3.4 years). This research was approved by the Institutional Review Board for the Protection of Human Subjects at the University of Kentucky.

Experimental Setting

All procedures were conducted in a sound-attenuated room at the Orofacial Pain Center of the University of Kentucky. Participants were seated upright in a cushioned chair with head support.

Electromyograph Recordings

Physiologic measures were recorded using a J&J I-330 computerized physiograph (J&J Enterprises, Poulsbo, WA), which integrated data over 1-second intervals during the data collection trials. Electromyograph sites were monitored using 0.5 cm^2 silver/silver chloride surface electrodes. The surface of the skin was cleaned and abraded with an alcohol swab, and electrolyte paste was applied to the EMG electrodes before they were attached to the skin surface with adhesive collars. The EMG electrodes were then placed bilaterally on the masseter muscles and on the right temporalis muscle according to procedures described by Carlson et al.[10,11] Electromyograph electrodes were also placed on the suprahyoid muscle region as described by Lemke and Van Sickels.[12] The monitoring was restricted to these four sites because a maximum of four EMG channels could be monitored with the available equipment.

Procedures

All subjects were screened for health history and inclusion criteria. Once these criteria were met and informed consent was obtained, EMG electrodes were attached and checked for comfort, and the EMG signals were observed to ensure that no artifact or electrical interference was present in the signal. After an adaptation period, wherein the EMG signals stabilized, all subjects rested quietly during a 5-minute baseline period while physiologic recordings were made. During this and all recording periods, subjects were asked to sit as quietly and comfortably as possible and to refrain from unnecessary movements. After the baseline period, all subjects were told that they would be instructed to alternate the position of their tongue so that the tip of the tongue would be placed on the roof or floor of the mouth. They were also told that each trial of tongue position would last for 1 minute. Subjects were then instructed either to place the anterior third of the tongue on the roof of the mouth according to modified guidelines explained by Rocabado,[6] or to rest the tongue on the floor of the mouth. The interested reader is encouraged to refer to the original instructions by Rocabado, which also include instructions to breathe through the nose and to use the diaphragm muscle, in addition to "maintain[ing] the anterior third of the tongue against the palate with slight pressure."[6p589] Subjects were given instructions that were as close to this as possible except for the specifications regarding tongue positions. The order of tongue placement was randomly assigned. Seventeen subjects began with instructions to place the tongue on the roof of the mouth.

During all trial periods, subjects were asked to keep their lips and teeth slightly apart to control for facial positioning and to minimize extraneous movements. While this is also a modification of Rocabado's original instructions, this position has been identified by Rugh and Drago[13] as the position of the mandible at which activity of the masticatory muscles is minimal. These instructions were also included in order to reduce the error variance associated with the multiple positions of the mandible that subjects might assume. Complete instruction sets are given in Appendix 1. For each position of the tongue, the full instructions were given at the beginning of the first two trials and then abbreviated for the last trial, either as, "up on the roof of your mouth" or as "down on the floor of your mouth." All subjects alternated positions until three trials were recorded in both positions. Upon completion of the evaluation session, electrodes were removed and subjects were debriefed and thanked for their participation.

Data Analyses

All analyses were performed using the SAS statistical software program.[14] Baseline EMG activity was calculated by averaging readings for the five 1-minute periods of rest. Mean physiologic activity level during trials was calculated by averaging EMG readings for the three time periods when subjects placed their tongues on the roof of the mouth and on the floor of the mouth.

Electromyographic activity at baseline was compared with activity when the tongue was at the roof and on the floor of the mouth using repeated measures analysis of variance (ANOVA). Paired comparison *t* tests were used to evaluate a priori hypotheses. The advantage of a repeated measure design with EMG recordings is that each subject serves as her/his own control.[15] This is important because EMG activity can be influenced by such factors as skin preparation, site placement, age, and subject morphology.[1]

Results

Thirty-three subjects completed the study. To verify random assignment, analyses were conducted to ensure that the group which started with the

Table 1 Electromyograph Activity

Site	Baseline (μv)	Roof (μv)	Floor (μv)	Post baseline (μv)	*P*
Right masseter	2.38 (3.24)	2.42 (1.31)	2.33 (1.30)	2.01 (1.02)	.83
Left masseter	2.67 (1.15)	2.48 (1.13)	2.30 (.80)	2.27 (1.03)	.20
Right temporalis	3.07 (1.78)	3.50 (1.79)	3.06 (1.75)	3.22 (1.99)	.03
Suprahyoid	3.02 (0.82)	4.23 (2.33)	3.85 (2.07)	3.33 (1.60)	.01

Standard deviation is denoted within parentheses.

instructions to place the tongue on the roof of the mouth did not differ on any demographic variable from the group which started by allowing the tongue to rest on the floor of the mouth (*P*s > .05).

There were no significant differences for EMG activity in the right ($F [2,30] = 0.19$, $P < .83$) or left masseter muscles ($F [2,24] = 1.72$, $P < .20$), regardless of tongue position. The repeated measures ANOVA for the right temporalis ($F [2,29] = 3.96$, $P < .03$) and for the suprahyoid region ($F [2,28] = 5.46$, $P < .01$) reached significance. A priori contrasts revealed that EMG activity in the right temporalis was significantly higher ($t [1,32] = 2.83$, $P < .01$) when the tongue was on the roof rather than on the floor of the mouth. Contrasts for the suprahyoid muscle region revealed that EMG activity was lower at baseline than when the tongue was either on the roof ($t [30] = 3.35$, $P < .01$) or on the floor ($t [31] = 2.43$, $P < .05$) of the mouth. Further, EMG activity in the suprahyoid region was significantly higher ($t [1,32] = 1.87$, $P < .05$) when the tongue was on the roof of the mouth rather than on the floor of the mouth. These results are presented in Table 1.

Discussion

The principal finding of this study was that muscle activity was increased in the suprahyoid and temporalis regions when the tongue was positioned on the anterior palate and maintained in that position with slight pressure as compared to positioning the tongue on the floor of the mouth. This study also found that muscle activity in the masseter region was not altered as a consequence of tongue placement. Although the range of the EMG differences was small, it does support the premise that it is inaccurate to instruct patients to place the tip of the tongue on the roof of the mouth as a means of relaxing the masticatory muscles.

The use of EMG records to determine the resting position of the mandible has been criticized by Lund and Widmer.[1] They were especially critical of the use of EMG in the establishment of proper rest and occlusal positioning. Since some degree of muscle activity is necessary at all times, and since differences between subjects in age, sex, and facial morphology influence EMG readings, they suggested that "there is no evidence that the clinical rest position can be determined on the basis of some standard level of postural activity . . . because of differences between muscles and between subjects."[1p126] We agree with this view. It is important to note, however, that the present study used a within-subjects design, where each subject served as his or her own control to adjust for the influence of the age, sex, and facial morphology variables. Further, our data are reported in terms of relative differences in EMG activity rather than absolute values representing rest or activity. Therefore, it is reasonable to conclude that relative changes in muscle activity would be comparable within subjects as they altered positions. Based on the present data, positioning the tongue on the floor of the mouth with specific instructions minimizes muscle activity in comparison to placing the tongue on the roof of the mouth with instructions.

Despite the current discussions concerning the lack of a relationship between muscle activity and pain reports in controlled experiments,[1,2] finding a position of relaxation for the tongue and facial muscles is often identified as an important step in the clinical management of orofacial pain. Previous publications in the fields of physical therapy and dentistry suggested that a key component of the rehabilitation of biomechanical dysfunction of the temporomandibular joint (TMJ) requires the patient to learn new postural relationships in order to maintain the orthostatic equilibrium of the upper body.[6] Often these programs include instructions for

positioning the tongue during rest. Positioning the tongue so that the anterior third of the tongue pushes against the palate with slight pressure is assumed to be the rest position because it is viewed as basic to normal swallowing. There is reason to believe that this tongue position may help to prevent excessive translation of the jaw during normal rotation, but the scientific evidence that the tongue's physiologic rest position is generally on the roof of the mouth is lacking. Our data suggest that temporalis and suprahyoid region muscle activity is higher when the tongue is placed on the roof of the mouth than when the tongue is on the floor of the mouth. Based on these data, it would be imprudent to state that the "rest" position of the tongue is on the roof of the mouth. We acknowledge, however, that the degree of muscle activity has yet to be determined when the instructions to place the tongue on the roof of the mouth are accompanied by instructions "to breathe through the nose and to use the diaphragm muscles for respiration."[6p589]

Clinical therapies are often based on logic that precedes accurate biologic explanations for the symptoms. Tongue motor function is controlled by the hypoglossal nerve and responds readily to cortical control.[16] If the upper brain is involved in tongue activity, stressors may activate learned parafunctions, such as placing the tongue on the palate. Our data show that tongue position maintained on the roof of the mouth by slight pressure involves masticatory and cervical muscles. It is possible that such learned tongue positioning could result in perceived muscle fatigue or pain for some individuals.

The issue of normal tongue position and proper development of the oral cavity has been of significant interest to dentistry. For instance, Subtelny and Sakuda[17] have used cineradiographs to evaluate tongue position and to link the positioning of the tongue to oral cavity development. Proper oral cavity development reportedly requires pressure from the tongue on the roof of the mouth. This research and related studies evaluating tongue position by using pressure transducers placed in the oral cavity[18] have not, however, generally included direct measurement of muscle activity via EMG. Moreover, this line of investigation has not provided a definitive answer to the question of what position of the tongue would result in the lowest level of muscle activity or what the parameters (time, intensity of force, and so forth) of tongue positioning are that affect growth outcomes in the oral cavity. Consequently, there is need for additional research to establish the relationships between tongue position, muscle activity, and developmental outcomes.

The logic of the argument for the tongue's resting position on the palate is hard to follow when instructions to "maintain the position with slight pressure" are given to patients. It seems reasonable to infer from our data that this slight pressure comes at the cost of increased suprahyoid and temporalis region activity. Maintaining this elevated position of the tongue when a person is sitting or standing is likely to require force to overcome gravity unless it is done by supporting internal structures. Given our findings, we suggest that instructing patients to rest their facial muscles by placing the tongue on the roof of the mouth with slight pressure against the palate is a practice that needs to be modified.

There may be circumstances during which patients gain therapeutic benefits from placing the tip of the tongue against the roof of the mouth,[6] but our data would suggest that this is not a relaxed position for muscles of mastication. Because the range of the EMG differences is relatively small, it may be tempting to dismiss these findings as clinically insignificant. Presently, however, we do not have data addressing the magnitude of differences in EMG activity that correspond to the presentation of clinical symptoms, and this question remains open for further scrutiny. In the view of Lund and Widmer,[1] however, EMG activity as it is currently measured in the laboratory and clinic has not generally been shown to be a factor in the genesis and maintenance of orofacial pains. Ultimately, the actual position of the tongue and the muscle activity involved may prove to be inconsequential so long as people minimize the use of pressure or force against other structures of the masticatory system.

Seventeen of the 33 subjects in the present study reported that their tongue usually is on the roof of their mouth. When they were asked to let the tongue rest on the floor of the mouth, they reported feelings of awkwardness. We are presently conducting a follow-up study to determine whether or not the "normal" position of the tongue will influence EMG activity of the facial muscles. It is possible that adaptation of muscles to routine positions may have obscured our current findings; therefore, we are re-examining this question in a study that accounts for subjects' reports of the "normal resting position" of the tongue. It is also possible that subjects may need several hours or days to practice the experimental instructions so as to minimize the potential problems associated with a natural position and the requirements of the experimental session.

The widespread use of "resting instructions" in dental and physical therapy environments highlights our lack of knowledge concerning the etiology of TMD. Moreover, it is noteworthy that this tongue position is often perceived as therapeutic and may even be associated with symptom relief among patients, even though it is possible that this position could also be associated with an increase in symptoms. Many logical arguments presented by well-meaning health professionals assist in relieving presenting complaints of TMD. In an environment where many therapies for TMD are successful, and we often do not have a good understanding of why they work when they do work, caution and prudence are necessary in order to prevent the perpetuation of misinformation within clinical practice. Actually, the symptom relief in TMD may be associated with biologic events independent from many aspects of our therapies.

We recognize several limitations in the present study, including: *(1)* no formal evaluation of the subjects' normal rest positions, *(2)* no means of knowing whether those positions would change spontaneously if subjects were given general instructions to relax but were not given specific body movements for accomplishing that task, and *(3)* no independent analysis of the tongue position in subjects to ensure their compliance with the position requested. As indicated earlier, we are taking steps to address these problems in a follow-up study. It would also be useful to collect EMG data from the pterygoid muscle groups. While this would be likely to involve invasive needle EMG recordings, it could be done on a subsample of subjects to determine whether or not such muscle groups would be influenced by tongue position. It would also be valuable to collect information regarding a subject's perceptions of muscle activity in the various positions to determine whether or not they correspond with EMG data. Finally, data from persons reporting TM pain should also be obtained because the presence of pain is known to influence the activity of masticatory muscles.[19] Even though these are important areas for improvement, this study provides useful information regarding the role of muscle activity and tongue position that challenges common assumptions within the field.

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Appendix 1

Instructional Sets

Preliminary Instructions:
"I'm going to ask you to move your tongue to the top of your mouth and then the bottom of your mouth. We'll alternate positions three times. Each time will last for one minute and then I'll tell you to move it."

Tongue on Roof:
"Begin by placing your tongue against the anterior palate (the roof of your mouth, near the top, front teeth) and make a clucking sound. Now, maintain the front third of your tongue against the palate with slight pressure until I tell you to move it so that the tongue stays comfortably on the roof of the mouth. Also, keep your lips and teeth slightly apart so that the mouth stays in a relaxed position" (adapted from Rocabado[9]).

Tongue on Floor:
"Begin by placing your tongue on the floor of your mouth. Make sure you're not pushing against the back of the teeth so that the tongue stays comfortably on the floor of the mouth. Just let the tip of the tongue 'flop' to the floor of the mouth and let it lie there until I tell you to move it. Also, keep your lips and teeth slightly apart so that the mouth is in a relaxed position."

Resumen

Los Efectos de la Posición de la Lengua en Relación a la Actividad de los Músculos Mandibulares

El propósito de este estudio fue el de determinar la relación entre la posición de la lengua y la actividad de los músculos mandibulares. En este estudio participaron 33 personas (28 mujeres) cuyas edades oscilaban entre los 18 y 34 años (media = 22,1 años). Los participantes no habían sufrido lesiones previas ni dolor en la mandíbula, boca o lengua. Se efectuaron registros electromiográficos basales de las regiones musculares: (temporal, masetera y suprahioidea); mientras que las personas descansaban. Luego, los participantes fueron asignados al azar a dos grupos diferentes, dependiendo de la colocación de la lengua. Un grupo colocó la lengua contra el paladar anterior, otro la colocó sobre el piso de la boca, teniendo cuidado de que la lengua no presionara ninguna parte de la boca. Los resultados indicaron que la actividad del temporal derecho era mayor cuando la lengua estaba posicionada contra el paladar, que cuando estaba en la posición basal, o sobre el piso de la boca ($P < 0,03$). Se registraron patrones similares en los resultados observados en el músculo suprahioideo ($P < 0,01$). No se observaron diferencias significativas en la actividad muscular masetérica en relación a la posición de la lengua ($Ps > 0,20$). Estos resultados indican que hay que tener cautela al calificar la posición "de reposo" de la lengua e indican que es necesario efectuar más estudios en cuanto a la relación entre la posición de la lengua y los dolores orofaciales.

Zusammenfassung

Die Auswirkungen der Zungenposition auf die mandibuläre Muskelaktivität

Das Ziel dieser Studie war die Bestimmung der Beziehung zwischen Zungenposition und mandibulärer Muskelaktivität. Dreiunddreissig Personen (28 Frauen) im Alter zwischen 18 und 34 Jahren (Durchschnitt = 22.1 Jahre) ohne frühere Verletzungen oder Schmerzen im Kiefer, im Mund oder in der Zunge nahmen an dieser Studie teil. Die Personen mussten während der basiselektromyographischen Aufzeichnungen, welche von den Regionen der Mm. temporales, masseteri und suprahydoidales gemacht wurden, ruhig bleiben. Anschliessend wurden die Probanden zufällig Bedingungen zugeteilt, welche sie dazu aufforderten, die Zunge entweder "gegen den vorderen Gaumen" oder in den Mundboden, dabei darauf achten, dass die Spitze nicht gegen einen Teil der Mundhöhe drückt" zu positionieren. Die Ergebnisse deuteten darauf hin, dass die Aktivität des rechten M. temporalis höher war, wenn die Zunge am Dach der Mundhöhle lag, als wenn sie entweder in Grundstellung oder im Mundboden bleibe ($P < .03$). Ein ähnliches Muster von Resultaten wurde für die suprahyoidale Muskelgruppe beobachtet ($P < .01$). Es gab keine signifikanten Unterschiede in de Masseteraktivität als Funktion der Zungenlage ($Ps > .20$). Diese Befunde mahnen zur Vorsicht bei der Festlegung der "Ruheposition" der Zunge und deuten darauf hin, dass weitere Studien zur Beziehung zwischen Zungenposition und orofazialen Schmerzen notwendig sind.