Surface intraoral genioglossus EMG recording technique for kinesiologic studies

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Electromyographic (EMG) recordings from intraoral genioglossus surface electrodes were compared to fine-wire recordings of the left genioglossus muscle during selected activities that involved (1) rest, (2) tongue protrusion without resistance, (3) isometric tongue protrusion, (4) jaw opening without resistance, (5) isometric jaw opening, and (6) swallowing. Right and left lateral protrusions of the tongue were evaluated also. Recordings from both surface and fine-wire configurations showed similar onset times, relative amplitude changes, and cessation times of EMG activity during unresisted tongue protrusion and isometric tongue protrusion. Swallowing EMG activity occurred somewhat earlier and was longer in duration in the surface electrode recordings than the fine-wire recordings; however, maximum amplitudes occurred at similar times. Neither type of electrode recorded significant EMG activity during jaw opening or isometric jaw opening. These findings support the validity of recording EMG activity of the genioglossus muscle by surface recording electrodes supported by an acrylic appliance. The development of such an appliance may be an important biofeedback tool to control genioglossus activity during such activities as tongue thrusting. (Am J Orthod Dentofac Orthop 1989;94:240–4.)

Electromyographic (EMG) analysis of the genioglossus muscle has until recently been limited to intramuscular electrode recordings. A new intraoral surface recording electrode has been developed by Dobie and associates, which allows monitoring of genioglossus EMG activity during respiration. In that study comparison between recordings of intraoral surface electrodes and concurrent intramuscular fine-wire electrodes (controls) were reported to be similar during tongue protrusion, retraction, and side-to-side movement.

We attempted to use the newly developed surface electrode for studying genioglossus activity during swallowing, but found the electrode carrier was bulky and hindered natural tongue movements. The purpose of the present article is to report a substantial modification of Dobie and associates' electrode carrier that allows comfortable swallowing and retains specific recording properties for the genioglossus muscle.

METHODS
Simultaneous recordings in six adult subjects with Angle Class I malocclusions were obtained from the left genioglossus muscle by means of bipolar, fine-wire electrodes, and from both right and left genioglossus muscles using a custom-fitted bipolar surface recording electrode carrier. The ground electrode was located on the dorsal surface of the right hand and recordings were obtained in a shielded room to eliminate noise of 60 c/s. Electromyographic recordings were amplified and filtered with a bandwidth of 20 to 1000 Hz, and recorded on FM tape (bandwidth of 0 to 2500 Hz) for off-line display and analysis.

The custom-fitted surface recording electrode carrier was fabricated on a dental cast of the mandibular arch similar to a technique reported by Dobie and associates, but without the bulkiness of their mouthpiece. The impression of the mandibular arch was made while the subject protruded the tongue to determine the level of attachment at the floor of the mouth and to record the lingual frenum. Two Teflon-coated stainless steel wires (0.01 mm in diameter), bared 5 mm at their ends, were positioned lingual and slightly medial to the mandibular lateral incisors. The tips of the bared wires were placed at the junction of the attached gingiva and mucosa of the floor of the mouth on either side of the lingual frenum to overlie the insertion of the genioglossus muscles. Acrylic was molded around the wires.

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and continued linguually to the mandibular second molars on both sides to form a rigid carrier that would not interfere with occlusion of the teeth. The Teflon-coated wires, which extended from the electrode carrier, were protected from possible biting forces by 1.0 mm of clear plastic tubing that covered the free wires (Fig. 1).

Bipolar fine-wire electrodes of Karma alloy (25 µm) were used to record the EMG activity of the left genioglossus muscle. The method of placement of the fine wires intramuscularly was similar to that of Bole. Topical anesthetic was placed on the mucosa of the floor of the mouth overlying the left genioglossus and fine wires were inserted with a 27-gauge needle. The point of insertion was 3 to 4 mm lateral to the lingual frenum and 5 to 7 mm posterior to the lingual muco-gingival junction.

Reliability of the fine-wire placement into the left genioglossus muscle was confirmed by two criteria. The first criterion was to observe increased EMG activity with protrusion of the tongue and minimal EMG activity with jaw opening against resistance. The second criterion was to observe protrusion of the tongue with electrical stimulation at an intensity that just exceeded muscle fiber depolarization. This criterion was applied to two subjects; it was consistent with the action of the genioglossus muscle and differentiated the genioglossus from the mylohyoid muscle, which lies in close proximity.
Fig. 2. A, Raw EMG data of two isometric bursts of tongue protrusion against the lingual maxillary incisors. The upper trace is a fine-wire recording of the left genioglossus muscle and the lower trace is a surface recording from both genioglossus muscles. Total gain for the EMG is 1000. Peak and resting activity occur at similar times in both surface and fine-wire recordings. B, Raw EMG data recorded during a swallow. The upper trace is the fine-wire recording and the lower trace is the surface recording. Note that small amplitude potentials in the surface EMG recordings precede and follow activity from fine-wire electrodes. However, greatest peak-to-peak activity is similar between electrodes.

Recordings were obtained during seven conditions with three trials per condition to verify reproducibility of the activity. The seven conditions were (1) rest, (2) tongue protrusion without resistance, (3) tongue protrusion with resistance against the lingual surface of the maxillary incisors, (4) jaw opening without resistance, (5) jaw opening with resistance against the hand, (6) swallowing, and (7) isometric lateral protrusion to the right and left sides to selectively activate the left or right genioglossus muscle.

Data analysis consisted of comparing the EMG characteristics of onset, relative amplitude, and duration of the surface electrode recordings to the fine-wire recordings, which were used as the standard or control. Surface recordings were graded as similar or dissimilar for the three characteristics for each of the three trials for all subjects.

RESULTS

In all subjects minimal EMG activity was observed in the fine-wire recordings from the left genioglossus muscle, while relaxed activity and no observable EMG activity were found in the surface recordings. In general, the recordings from both electrodes were similar.
Differences between recordings probably arose because
(1) fine-wire electrodes were placed unilaterally and (2)
the surface electrode recorded minimum nonspecific
activity. During resisted tongue protrusion and iso-
metric tongue protrusion, the EMG recordings from the
fine-wire and surface electrodes showed similar onset
of EMG activity, similar amplitude maxima, and similar
duration of EMG activity during each trial for each
subject (Fig. 2, A). Swallowing EMG activity recorded
by the surface electrodes was dissimilar for all subjects
for onset (that is, occurred earlier) and duration (oc-
curred longer), but peak EMG activity was identified
as similar (Fig. 2, B). Notice that differences during
swallowing arc toward the start and finish of activity,
and that these differences reflect only small-amplitude
surface potentials. Minimum activity was observed in
both electrode recording configurations during un-
resisted jaw opening and isometric jaw opening.

Right lateral isometric tongue protrusion produced
high-amplitude EMG activity recorded from both the
fine-wire electrodes and the surface electrodes. Left
lateral tongue protrusion also produced high-amplitude
EMG activity in the surface electrode recordings, but
showed minimal, sporadic activity from the fine-wire
recordings of the left genioglossus muscle.

DISCUSSION

The present study examined the efficacy of a surface
electrode for monitoring genioglossus EMG activity
during various tongue movements. In general, results
of the study show similar onset, amplitude variation,
and cessation of EMG activity during activation of the
genioglossus muscles, and indicate that the surface elec-
trode primarily recorded the EMG signal from the
genioglossus muscles. Activation of the lateral ptery-
goid and anterior digastric muscles during isometric jaw
opening contributed minimally to the surface electrode
recordings, suggesting very little EMG contamination
from the major jaw-opening muscles. Swallowing ac-
tivity, however, showed earlier onset of the surface
recording activity and longer duration when compared
with the fine-wire recordings. Timing of maximum ac-
tivity during swallowing was not found to be different
between the two electrode recordings; this finding sugges-
ts that the genioglossus activity was superimposed
on background EMG activity of other muscles involved
in the swallowing action, such as suprahypoid muscles
or extrinsic tongue muscles.

Another difference, although not unexpected, was
found between the EMG recorded from the surface and
intra muscular electrodes, which demonstrated that the
surface electrode recordings did not differentiate be-
tween the EMG activity of the right and left genio-
glossus muscles. During protrusion of the tongue to
either the left or right, the EMG activity recorded from
the surface electrode was the same. During protrusion
to the right, the EMG activity from the fine-wire elec-
trode was similar to the surface recording electrodes.
During protrusion to the left, however, the fine-wire
recordings were sporadically active and of diminished
amplitude. The differences between surface and fine-
wire recordings during left protrusion probably are ex-
plained by the fact that the surface electrode recorded
from both genioglossus muscle and the fine wires re-
corded only EMG activity from the left genioglossus
muscle. Tongue protrusion to the left or right requires
a selective activation of genioglossus activity, which
would not be differentiated by the bilateral recording
of the surface electrodes.

Although this technique was tested in adults, the
application of the noninvasive surface recording tech-
nique in children should be essentially the same. Con-
trol of genioglossus hyperactivity in children would be
an ideal therapeutic intervention since it has been hy-
pothesized that postural tongue forces of long duration
have a significant impact on the development of an
anterior open bite malocclusion; it also would affect
the stability of the occlusion after orthodontic inter-
tervention. Longitudinal evaluation of the genioglossus
EMG activity in children with a noninvasive recording
technique could provide essential information regarding
the timing and duration of the protrusive component of
tongue activity, and may contribute to the refinement
of hypotheses regarding the cause of anterior open bite
malocclusion. A distinct advantage of this electrode
carrier is its relatively small size, which allows normal
tongue function and the accurate and repeatable posi-
tioning of the surface electrodes, so that a comparison
of multiple recording sessions can be obtained.

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