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 1988;94:240-4.)

Electromyographic (EMG) analysis of the genioglossus muscle has until recently been limited to intramuscular electrode recordings.[1-4] A new intraoral surface recording electrode has been developed by Doble and associates,[5] 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 Doble and associates' electrode carrier[5] that allows comfortable swallowing and retains specific recording properties for the genioglossus muscle.

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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 Doble and associates,[15] 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

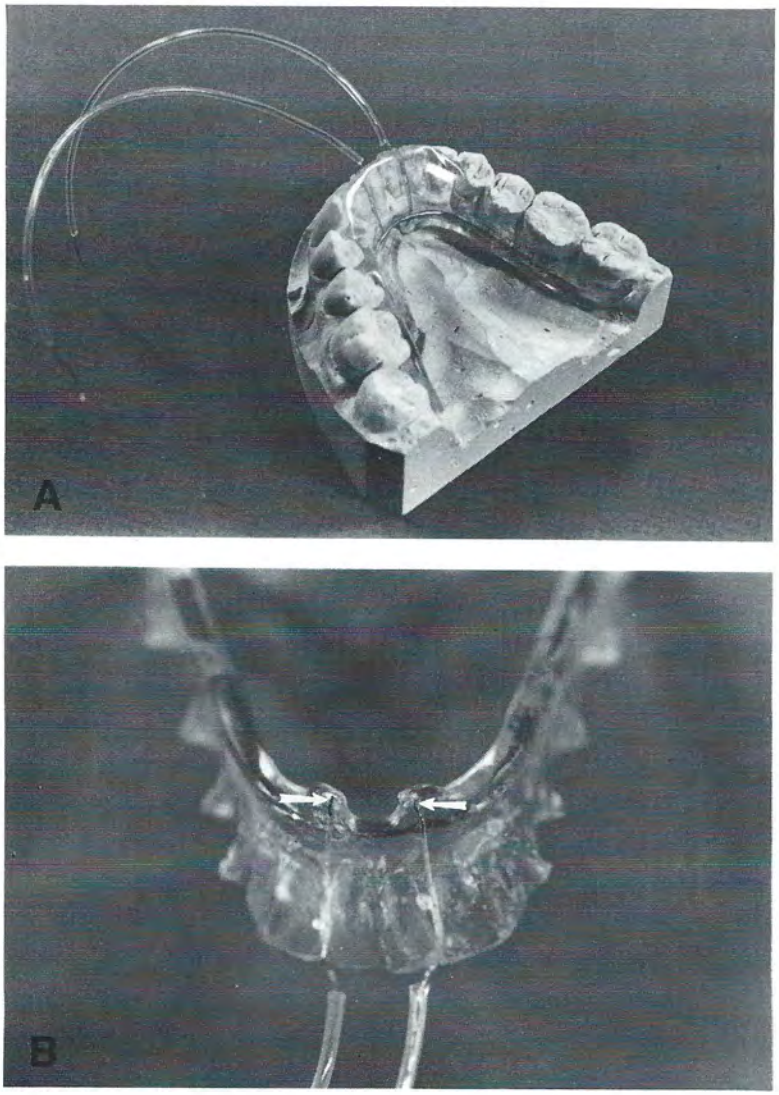

Fig. 1. A, Intraoral genioglossus surface EMG electrode incorporated into an acrylic appliance is shown positioned on cast that was used for fabrication. **B,** Electrode has been removed from cast and rotated 180° to show clearly exposed bared wires *(arrows)* that overlie the mucosa.

and continued lingually 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)[6] 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.[4] 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 mucogingival 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.

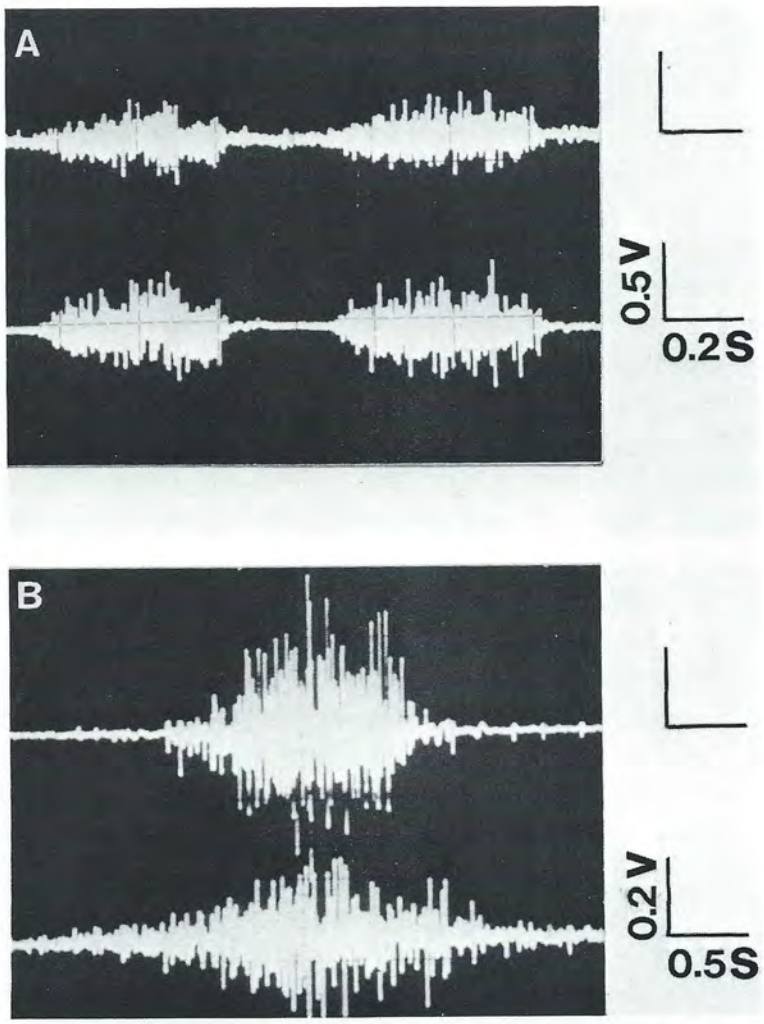

Fig. 2. A, Raw EMG data of two isometric bursts of tongue protrusion against the lingual maxillary incisors. The upper trace is a fine-wire recording of the left genioglossus muscle and the lower trace is a surface recording from both genioglossus muscles. Total gain for the EMG is 1000. Peak and resting 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 unresisted tongue protrusion and isometric 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 (occurred longer), but peak EMG activity was identified as similar (Fig. 2, *B*). Notice that differences during swallowing are 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 unresisted 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 electrode primarily recorded the EMG signal from the genioglossus muscles. Activation of the lateral pterygoid 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 activity, however, showed earlier onset of the surface recording activity and longer duration when compared with the fine-wire recordings. Timing of maximum activity during swallowing was not found to be different between the two electrode recordings; this finding suggests that the genioglossus activity was superimposed on background EMG activity of other muscles involved in the swallowing action, such as suprahyoid muscles or extrinsic tongue muscles.

Another difference, although not unexpected, was found between the EMG recorded from the surface and intramuscular electrodes, which demonstrated that the surface electrode recordings did not differentiate between the EMG activity of the right and left genioglossus 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 electrode 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 explained by the fact that the surface electrode recorded from both genioglossus muscle and the fine wires recorded 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 technique in children should be essentially the same. Control of genioglossus hyperactivity in children would be an ideal therapeutic intervention since it has been hypothesized that postural tongue forces of long duration have a significant impact on the development of an anterior open bite malocclusion;[7] it also would affect the stability of the occlusion after orthodontic intervention. 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 positioning of the surface electrodes, so that a comparison of multiple recording sessions can be obtained.

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