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Surface electromyography: diagnostic input for atypical swallowing as an aid for choosing therapy

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ABSTRACT

The way in which orthodontic patients swallow poses a major problem during treatment, especially for long-term stability of the end result. If clinical diagnosis of atypical swallowing performed in an empirical manner by the practitioner, aided or not by rehabilitation devices, has been the subject of numerous studies, surface electromyography seems to bring new insight in diagnosing the way patients swallow and in re-training atypical deglutition. After a short refresher about the anatomy and physiology of the mechanisms of swallowing as well as the basic principles of electromyography, a descriptive and comparative study was carried out with 60 patients in order to understand and to prove the reliability and pertinence of this diagnostic tool. The results of the study are based on a collection of graphic and visual data compared to maxillo-facial kinesiographic studies where patients underwent a parallel double blind diagnosis. The objective was to determine if surface electromyography provides reliable, exact and reproducible data based on daily screening. Finally, it may be possible to create a flowchart for clinical decision making by using the results of our study as well as the findings in the literature.

KEY WORDS

Surface electromyography,

Functional rehabilitation using surface EMG,

Atypical deglutition and electromyographic biofeedback,

Orthodontics.

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Surface electromyography is a non-invasive technique that makes it possible to detect neuromuscular pathologies. A clinical examination of patients reveals a close link between maxillo-facial dysmorphism and malfunctions, atypical swallowing being one of the most frequent malfunctions.

If clinical diagnosis of atypical swallowing, done in an empirical manner by the practitioner, with or without the help of re-trainers, has been the subject of numerous research articles[5,7,14,17,21,23,25,35], surface electromyography allows for a new approach for diagnosis and re-training of dysfunctional deglutition[9,12,38,48].

1 – DIAGNOSIS OF ATYPICAL SWALLOWING

1 – 1 – Clinical examination

The initial patient interview is intended to determine different possible etiologies: harmful habits, delayed psychological maturity, short lingual frenum[37].

A clinical examination of swallowing and rest position reveals possible anomalies[1,15,22].

A clinical neurolingual examination of swallowing is based on two criteria[14,33]:

– lingual interposition;
– contraction of the modiolus. (corners of the mouth).

However, for M. Fournier, the contraction of the labial and strap muscles during swallowing is not systematic. The main criterion indicating atypical swallowing is therefore lingual interposition, and contraction of the modiolus is a secondary criterion[14].

1 – 2 – Electromyography

Electromyography is a technique for exploring neuromuscular function[4,13]. It detects and amplifies electrical phenomena that accompany muscular contraction.

An electromyographic examination (EMG) records electrophysiological activities[28,30-32,36,39].

The recorded electrical signals coming from the nerves and muscles are all produced by rapid and transitory changes in the ionic current flow entering and exiting their cells. These currents are controlled by ionic channels encased within the plasma membrane of the cells.

The ionic channels of the neuromuscular fibers are not fundamentally different from those of other cells of the organism. The extensive variety and high density of ionic channels in the sarcolemma (cell membrane surrounding muscle cells) and the axolemma (cell membrane encasing axon fibers) explains the particular nature of the electric properties of myocytes and neurons.

Neuromuscular fibers have both rest potentials and action potentials.

Action potentials are triggered by the presence of voltage-dependent ionic channels in the membrane. These channels remain closed when at rest. When the potential of the membrane is reduced and exceeds a critical value, called the threshold of depolarization, the channel opens.

Classically, in order to record the electric activity of a muscular zone, the practitioner must have three electrodes: two feedback electrodes placed on the electric zone that is being assessed and one ground electrode which is used as a voltage reference point (normally zero) for the amplifiers.

Electromyography makes it possible to detect neuromuscular pathologies (changes in the electromyographic activity, changes in the latency time...)[6,24].

In dentofacial orthopedics, electromyography can help in assessing certain factors which come into play in a particular type of growth. It highlights the repetition of a movement or a function of a muscle or muscle group[4,10,11,13,18,20,26,29,40-47].

2 – EQUIPMENT AND METHOD

Sixty students in their second year of Orthodontic training at the University of Paris 7 were randomly chosen among all the students at the Dental School.

The research was divided into two distinct phases:

- diagnosis by two maxillofacial physical therapists;
- diagnosis by electromyography.

The data base manager program Inner Smile created by Loma Linda University, in collaboration with C. Gugino, will be our reference point for this research.

The electromyographic examination (Fig. 1 and Fig. 2) is performed according to a very precise protocol:

1. cleansing the skin of the patient with firm circular movements in order to remove all impurities by using a compress;
2. use of alcohol in order to clean and dry the skin and then a (3M) abrasive strip to reduce impedance;
3. secure the respiration belt around the abdomen of the patient who is seated comfortably, with straight back and head up[16,34];
4. electrodes are placed firmly on the skin with light pressure (without pushing on the middle of the electrode;
5. the examiner must be relaxed in order for the patient to relax;
6. an atmosphere of calmness must permeate the therapy room.

3 – RESULTS

The clinical diagnosis performed by the kinesiologists revealed 52 cases of atypical swallowing out of the 57 subjects who were examined (3 patients were absent).

The diagnosis showed 22 contractions of the orbicularis oris during swallowing. Out of the 22 contractions, only one was not correlated to a tongue thrust.

Electromyography indicated a prevalence of infantile deglutition in 91.2% of the subjects in this group. This diagnostic tool revealed a

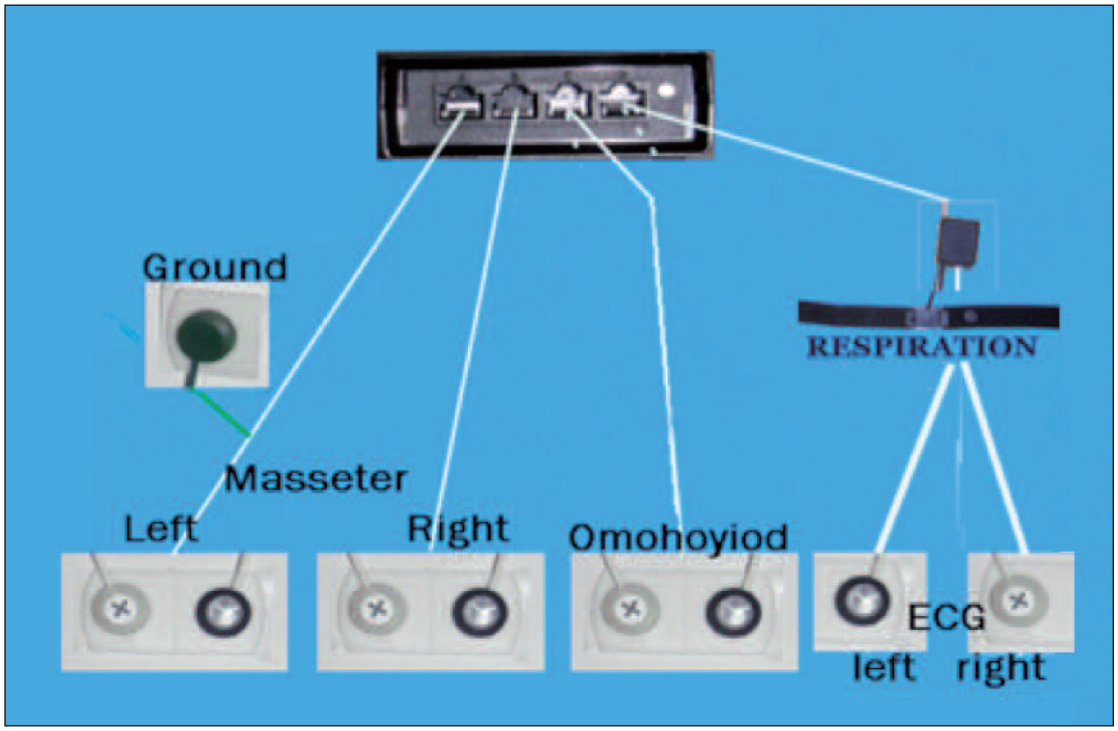
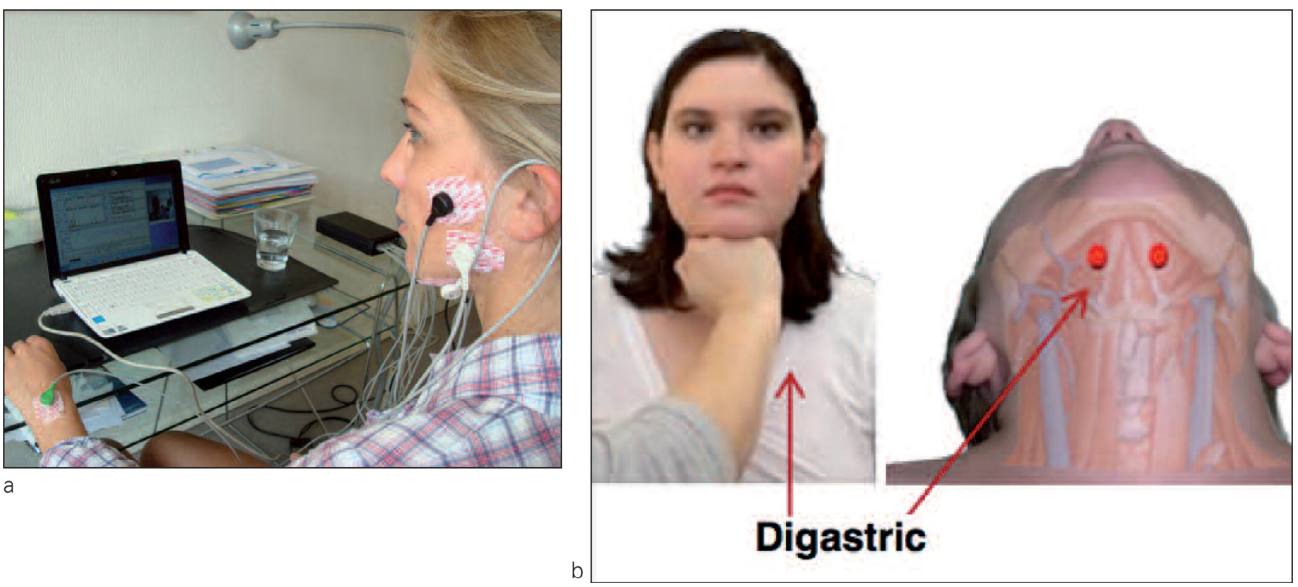


Figure 1
Connections to the electromyograph.



a

b

Figures 2a and 2b
Patient preparation and electrode positioning.

contraction of the orbicularis oris in 100% of deglutitions, with different degrees of contraction.

From a graphical perspective, electromyography makes it possible to highlight different muscular activities encountered during swallowing (Figs. 3 to 7):

- 49 cases of asymmetry in the thickness of the masseter muscle *vs* 11 cases of symmetry of the thickness of the masseter muscle;
- 8 EMG activities of masseter muscles with tongue at rest position;
- 3 dominant tongues;

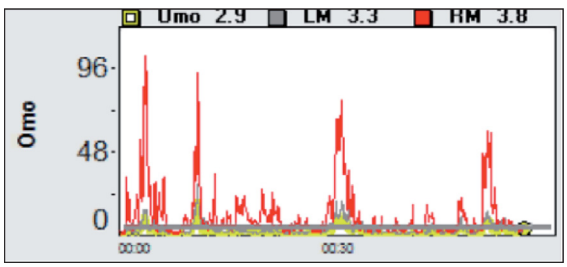


Figure 3
Tongue activity at full rest.

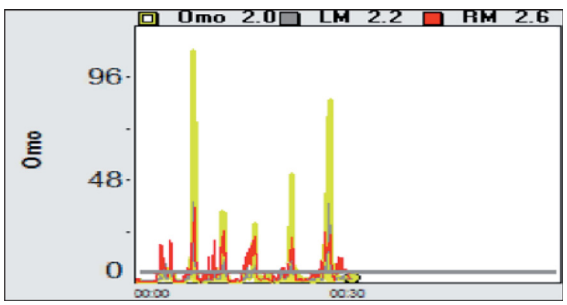


Figure 4
Dominant tongue.

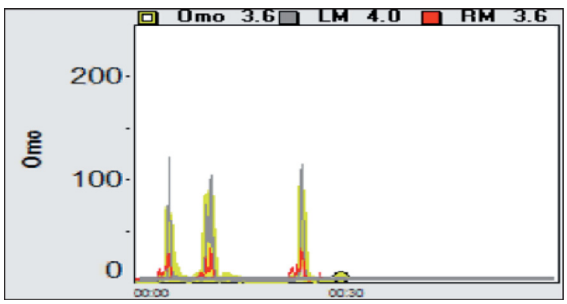
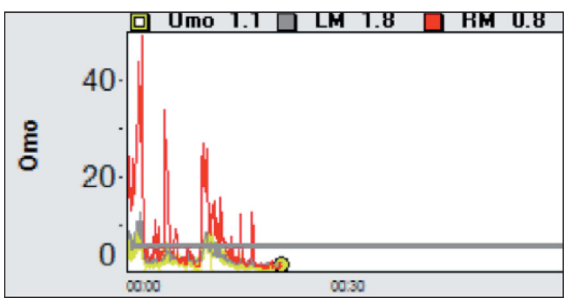


Figure 5
Asychronism of contraction.



Figures 6
Incomplete swallowing.

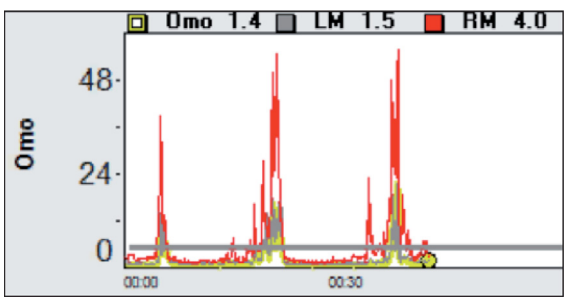


Figure 7
Asymmetry of the masseters.

- 9 so-called cases of incomplete swallowing with progressive muscular atrophy.

- 6 deglutitions presenting a problem of synchronization of muscular contractions.

For a better approach and understanding of the electromyographic data, it has been calibrated. This recording is based on the different deglutitions and tongue positions of a volunteer subject (an orthodontist, who knew what we were doing and was in good health).

The graphics of the main types of deglutition encountered can be seen on the following graphs (red curve: right masseter: gray curve: left masseter; yellow curve: supra-hyoids or orbicularis) (Figs. 3 to 7).

3 – 1 – Functional deglutition – Occlusion – Tongue on palate

During this type of deglutition, the tongue is placed on the palate, the teeth are in occlusion, stabilizing the mandible. The lingual activity is contained within that of the masseters.

In this example, the activity of the masseters is synchronized, symmetric, with raised intensity (approximately 20 µV) (Fig. 8).

3 – 2 – Functional deglutition – Disclusion – Tongue on palate

Asynchronism of the intensity and asymmetry of the activity of the masseters are seen. The intensity of contraction of the masseter muscles is weak intensity (approximately 100 µV) (Fig. 9).

3 – 3 – Atypical deglutition – Anterior tongue passing between upper and lower incisors

We are dealing with the same graph that we referenced for functional deglutition in disclusion (Fig. 10).

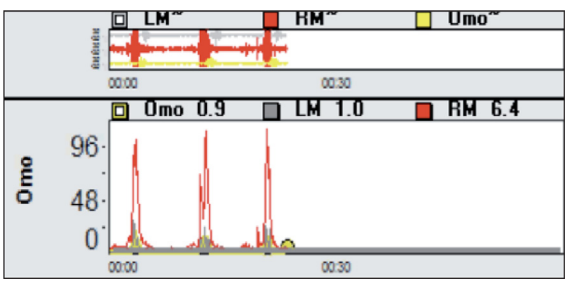


Figure 9

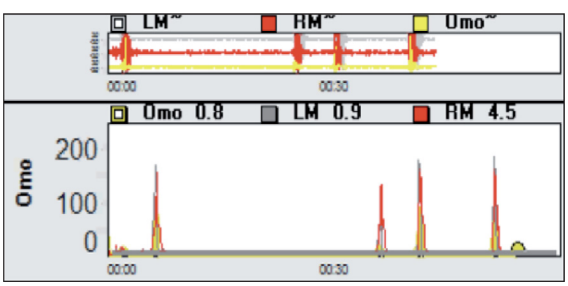


Figure 8

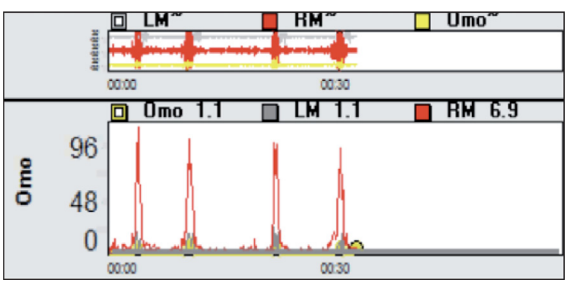


Figure 10

3 – 4 – Atypical deglutition – Tongue against the lingual face of lower incisors – Uncontrolled tongue at rest

The graph is the same as the one for functional deglutition in disclusion (Fig. 11).

Tongue activity at rest is shown here by permanent activity of the masseters but with weak amplitude.

3 – 5 – Contracted orbicularis – Functional deglutition – Disclusion

The intensity of masseter contractions is weak (approx. 30 μV) due to disclusion, similar to that of the orbicularis (Fig. 12).

3 – 6 – Uncontracted orbicularis – Functional deglutition – Disclusion

The intensity of orbicular contraction is the same as the one we just saw above, but here the masseters are very intensely contracted (200 μV) (Fig. 13).

3 – 7 – Atypical deglutition – Tongue on palate and contracted orbicularis during swallowing

This is the same graph as the preceding one, but here the intensity of the orbicularis is higher (approx. 100 μV) (Fig. 14).

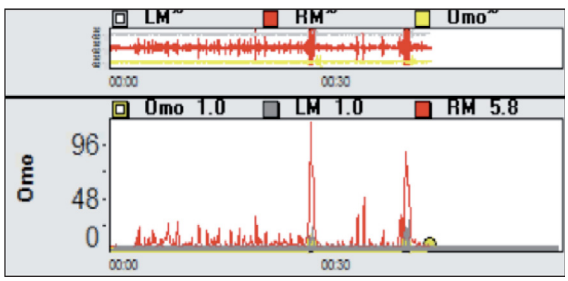


Figure 11

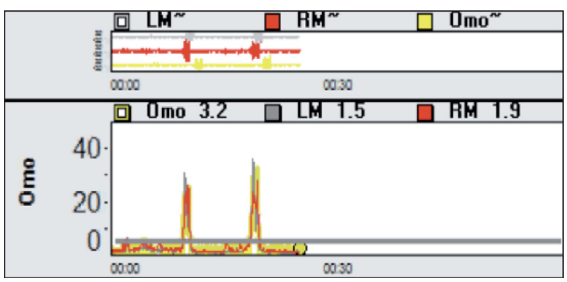


Figure 12

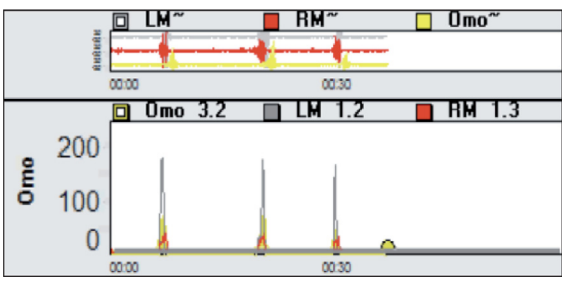


Figure 13

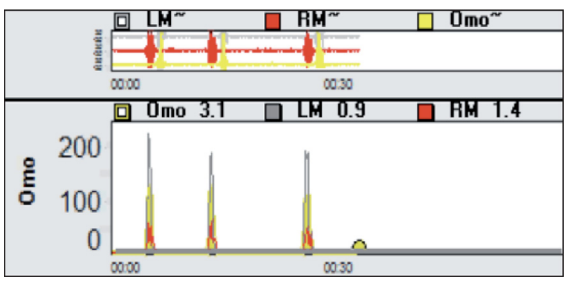


Figure 14

4 – DISCUSSION

After reading the results of the research and calibration, electromyography alone does not make it possible to make a precise diagnosis of atypical deglutition[19].

An electromyographic recording is useful in arriving at an accurate clinical diagnosis, since it objectifies certain criteria that are non-specific to atypical deglutition and are inperceptible when they occur:

- asymmetry of the masseters;
- dominant tongue;
- incomplete swallowing;
- lingual activity when at rest;
- poor muscular synchronization.

Each of these criteria is independent of the others.

Drawing a parallel between electromyography and a clinical examination is not feasible. They are complementary and each contributes different data concerning deglutition.

A perusal of the graphs, allows the practitioner to understand the functioning of the masseters and their relation with the power of the suprahyoid muscles (dominance, asymmetry, synchronism).

The real position of the tongue is impossible to objectify during deglutition (Figs. 5 and 6). A dominant tongue only indicates an inverted relation of power between the masseters and the suprahyoid muscles: the tongue rises to the palate, with the teeth apart.

The intensity of the masseters informs the functioning of arch deglutition in occlusion or disclusion (Figs. 3 and 4 ''calibration'').

It would seem necessary to make an individual calibration before an electromyographic examination in order to objectify the intensity of masseter contraction in IOM and during deglutition.

The intensity of contraction of the suprahyoid muscles can also be analyzed because of the calibration: these recordings are made with the tongue pressed against the palate with unclenched teeth. The data concerning breathing and orbicularis contraction draws an accurate clinical picture[8].

5 – CONCLUSION

Electromyography and clinical examination are complementary and each contributes specific data for the diagnosis of atypical deglutition. Without performing a preliminary examination, the use of electromyography for the diagnosis of malfunctioning deglutition will be limited. Benchmarking best practices, intended for obtaining reliable and reproducible results must necessarily require performing a diagnostic clinical examination. This examination will be the basis for follow-up treatment during subsequent patient care.

Surface electromyography makes it possible to determine exact diagnostic criteria that are clinically undetectable.

The use of this diagnostic tool requires implementing a reliable

protocol and an individual ''calibration'' in order to measure the muscular activity during swallowing.

After this diagnostic procedure, the practitioner looks for a common electromyographic pattern. The practitioner then will attempt to draw on all reliable and reproducible diagnostic criteria in order to achieve an optimal result through reeducation. The experience of the practitioner and clinical know-how must inform the electromyographic protocol in order to make a more exact diagnosis of deglutition function so as to ensure a successful re-training. [2,3,27].

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