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MUSCLE ACTIVITY RELATED TO ACTIVATOR AND INTERMAXILLARY TRACTION IN ANGLE CLASS II, DIVISION 1 MALOCCLUSIONS

AN ELECTROMYOGRAPHIC STUDY OF THE TEMPORAL, MASSETER AND SUPRAHYOID MUSCLES

by

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INTRODUCTION

Diverse views concerning the activity of the masticatory muscles in Class II, div. 1 malocclusion have been reported in a number of electromyographic studies. It has been said that the activity recorded in cases of such malocclusions differs from that in "normal cases" (*Moyers,* 1949; 1950; *Perry,* 1955). This suggests not only a morphologic difference between Angle class II and normal occlusion, but also a physiologic difference, reflected in the distribution of the activity within the musculature. Other workers, however, have found no essential functional differences in the muscle activity when comparing this malocclusion to a series of "normal cases". (*Carlsöö,* 1952; *Liebmann et al.,* 1960; *Grossman et al.,* 1961.)

The activity in the masticatory muscles during and after treatment of Class II malocclusion has also been examined in a number of electromyographic studies. Almost all of them have been concerned with the temporal and masseter muscles, and only a few with the suprahyoid muscles (*Moyers,* 1949; *Ahlgren,* 1960).

As regards the muscle activity in activator therapy it has been stated that the activator "in function" affects the teeth and alveo-

lar process through reflex contraction of the masticatory muscles (*Andresen, Häupl & Petrik*, 1957; *Grude*, 1951; *Eschler*, 1955). On the other hand it has been proposed that the activator "at rest" is active owing to the increased activity in the musles resulting from their stretching (*Ballard*, 1955; *Herren*, 1956; *Ahlgren*, 1960).

The different views on the effect of the activator on the treatment have been based *inter alia* on the muscle activity during sleep, during which the activator is mostly used. *Eschler* (1955) recorded the activity during sleep in the temporal and masseter muscles. By means of a sensitive pressure gauge *Schmuth* (1960) recorded intermittent forces, which he found to be considerably greater in patients with good than with poor results of treatment. *Ahlgren* (1960), on the other hand, found no increase in muscle activity.

The muscle activity accompanying intermaxillary traction therapy has been examined by *Aas* (1960), but in only 3 cases, even these differing with respect to the nature of the malocclusion. The results suggest, however, that the muscular activity on the whole is the same for intermaxillary traction as for the activator at rest.

The purpose of the treatment of cases of class II, div. 1 malocclusion, which is usually performed with an activator or intermaxillary traction, is to recover the normal maxillomandibular jaw relation. The difference in the opinions as to the muscle activity may be due to some extent to the fact that the cases studied may have different causality. The object of the present study was therefore to compare the muscular response when using the two types of apparatus in a homogeneous material of Class II, div. 1 cases. Only the initial stage of the treatment was of interest.

MATERIAL AND METHODS

The series for the study consisted of 14 boys aged 10 years with Angle class II, div. 1 malocclusion. The postnormal relation between the jaws was in all cases one cusp width bilaterally. The overjet was great (ranging from 9 to 14 mm). In addition there was deep overbite, that is, the lower incisors occluded against the gingival thirds of the upper incisors or on the oral aspect of the

gingiva. Cephalometric analysis showed that compared with a selected material with ideal occlusion (*Werner,* 1954) there were large deviations in the inclination of the upper incisors (proclination) and in the angles SNB, SNP and ANB (notation see *Björk,* 1947), indicating a retruded mandible in relation to a normally positioned maxilla.

Four of the boys were drawn at random for activator treatment and 4 for intermaxillary traction. So as to be able to study on the same person the muscle activity due to the activator and intermaxillary traction the other 6 boys were supplied with both types of appliance. In all cases of activator treatment the mandible was displaced forwards by one cusp width. The vertical dimension was then raised so that no stretching of the orbicularis oris muscle was observed. This increase in vertical dimension ranged from 4 to 7 mm.

In intermaxillary traction the rubber ligatures exerted a forward traction on the mandible of about one cusp width. The force in each ligature was 130—150 g. in the postnormal relation.

The distance the mandible was moved forwards with the two types of appliance is seen in Fig. 1, in which tracings of the profile radiographs from the same person show the maxillo-mandibular relation (A) in centric occlusion, (B) with the activator and (C) with intermaxillary ligatures applied.

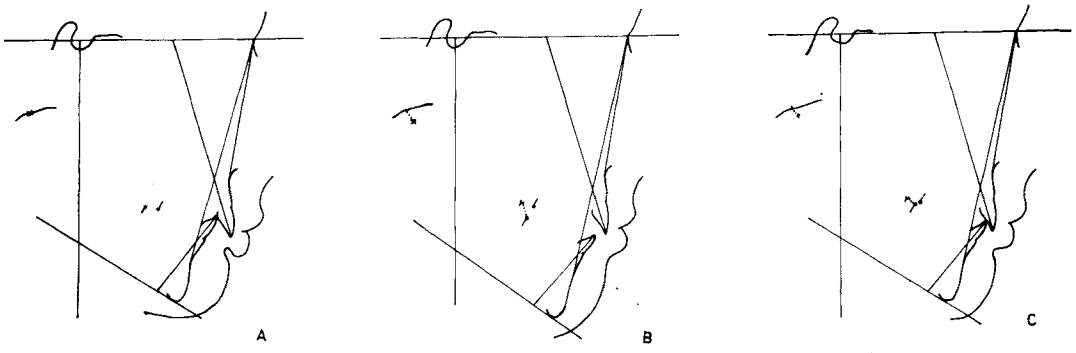


Fig. 1. Tracings from profile radiographs relating to the same subject.

(A) Centric occlusion
(B) Activator applied
(C) Intermaxillary ligatures applied

The dotted lines in B and C denote the extent of the displacement of the mandible at the first permanent molars and the temporomandibular joint.

Electromyographic registrations were performed in all cases before and after application of the respective appliances. These registrations were performed with an electromyograph (*Disa*) with an integrator. The action potentials in the first 8 cases were picked up with concentric needle electrodes and in the remaining 6 cases with surface electrodes, two electrodes being placed one centimetre apart over the respective muscle. This close placing of the electrodes reduces to a minimum the EEG-activity that would otherwise inevitably be obtained from the temporal muscle.

The muscle activity was picked up from the right side from the temporal muscle (posterior portion) and the masseter and the suprahyoid muscles. The needle electrodes were placed in the anterior belly of the digastric muscle, and the surface electrodes were applied in the anterior part of the submental region. The action potentials were recorded on continuous film.

In the 6 cases in which both types of apparatus were tested this was done at the same session, and the surface electrodes affixed with collodium were left undisturbed through the two series of tests. The subjects were unaware of when the photographic recordings were made.

The patients were placed in a dental chair with the head resting on the neck support, and the Frankfort plane approximately horizontal. After practice and without the appliance, the patient was required to perform the movements of the mandible, under supervision, according to the following pattern: physiologic rest position — forward movement without cuspal guidance into normal occlusion and into the edge-to-edge relation — physiologic rest position. Electromyographic recordings were made throughout this pattern of movements. The respective appliances were then inserted and the mandible was thereby forced forwards as far as the activator or the intermaxillary ligatures permitted, that is one cusp width (Fig. 1). In this protruded position the appliances were considered to be "at rest", since no closing or other movements were performed. The electromyographic registrations were repeated 5 times in the order specified.

The activator or the intermaxillary ligatures applied were "at rest" in the protruded position only for a while. When the activator was used swallowing movements and during intermaxillary

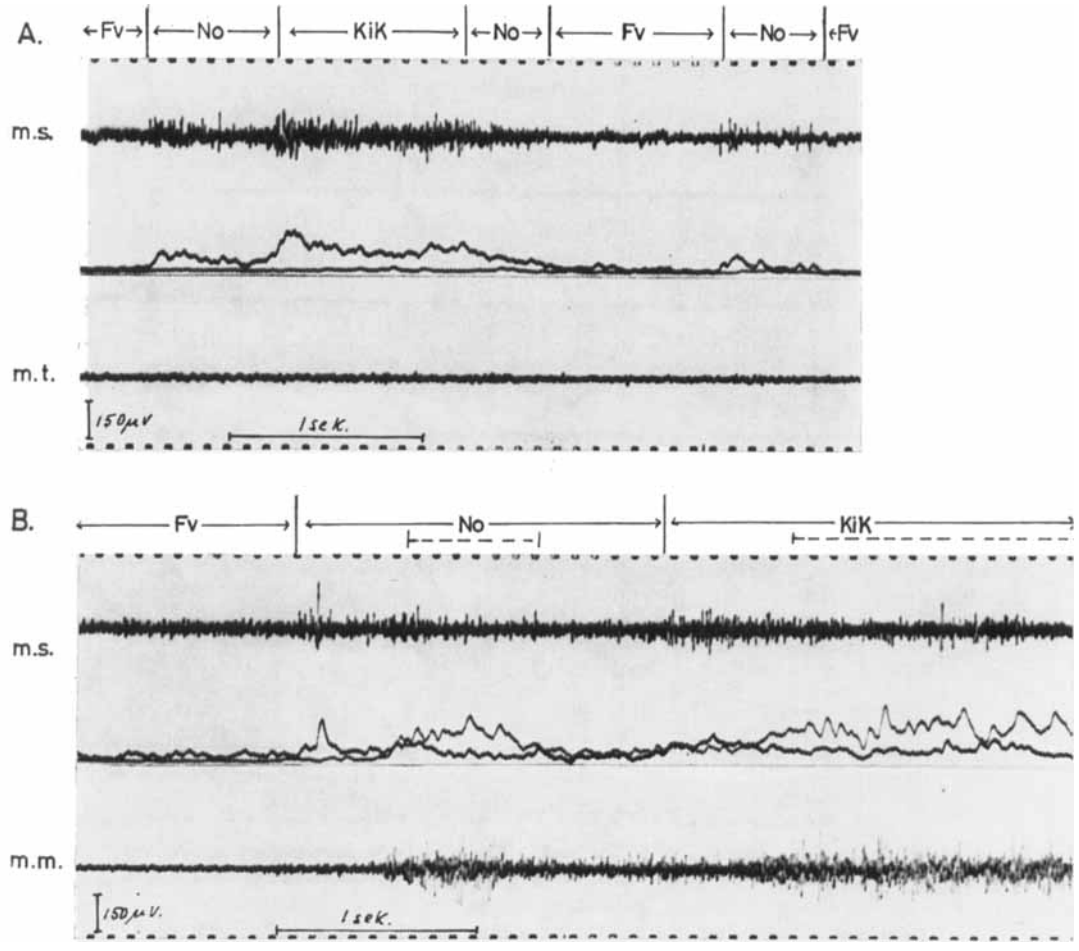


Fig. 2. Forward displacement of the mandible without appliance.

(A) From the physiologic rest position (Fv) to normal occlusion (No) and edge-to-edge relation (KiK).

(B) As above. The broken line refers to biting.

In this and the following figures the following abbreviations are used:

m. s. suprahyoid muscles
m. t. temporal muscle (posterior portion)
m. m. masseter muscle

In this and the following figures the activity was integrated from the base line. The heavier line corresponds to the upper and the thinner line to the lower registration.

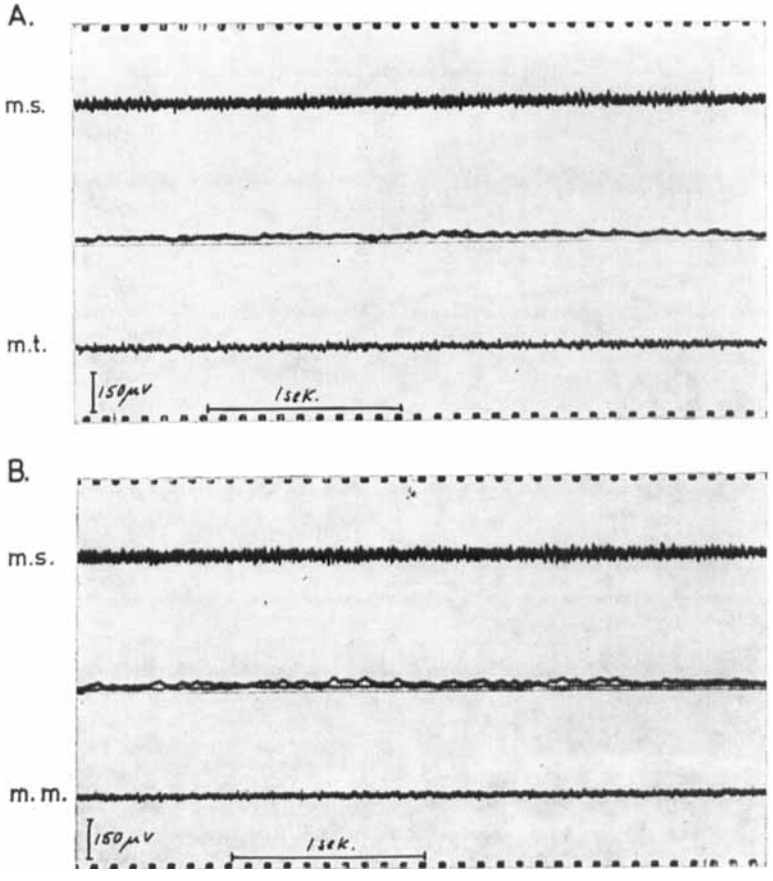


Fig. 3 (a—b). The acivator "at rest". The mandible forced forward as far as the activator permitted. No closing or other movements were performed.

traction movements of the mandible, chiefly forwards-and-backwards, were observed. Because of these the muscle activity for the respective appliances "in function" was therefore recorded over a period of about half an hour.

RESULTS

Muscle activity without appliance

In all cases the muscle coordination before the application of each appliance was in full agreement with *Carlsöö*'s findings for "normal" subjects. Thus, activity was recorded in the masseter muscle and the suprahyoid muscles in a forward displacement of

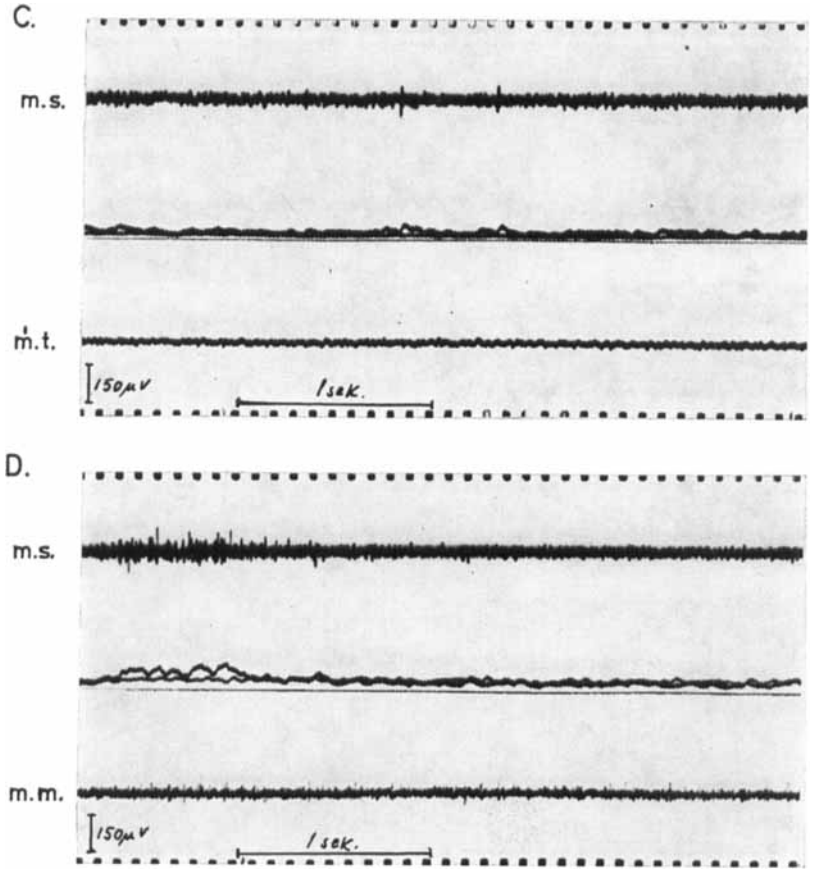


Fig. 3 (c—d). Intermaxillary traction "at rest". The mandible forced forward as far as the intermaxillary ligatures permitted. No closing or other movements were performed.

the mandible and this was more marked with greater forward displacement. Biting in edge-to-edge position further increased the activity in the masseter muscle, whereas in the suprahyoid muscles it diminished. No activity was noted in the temporal muscle (posterior portion) in forward movement (Fig. 2).

Muscle activity with the appliances "at rest"

When the activator or intermaxillary ligatures were applied a forward displacement was in all cases accompanied by slight activity in the suprahyoid muscles but not in the posterior portion

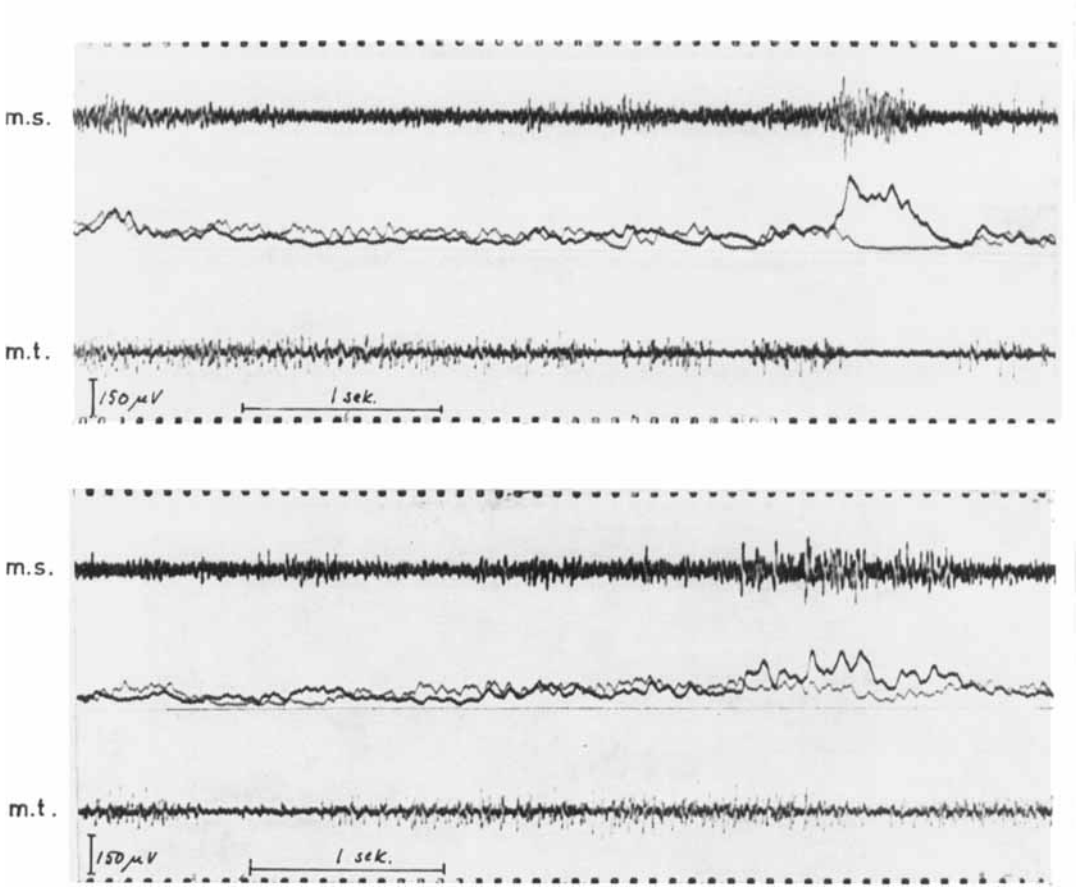


Fig. 4 a. Activator "in function". Swallowing movements were performed spontaneously.

of the temporal muscle. In the masseter the activity was negligible. Since small differences in the position of the electrodes can result in large differences in the amplitude of the potentials, a comparison of the muscle activity for the two types of appliance was performed only in the 6 cases in which the electrodes remained in the same position throughout the recording period for the two appliances.

It is clear from the electromyograms so obtained that the activity in the suprahyoid muscles was of the same magnitude for the activator as for the intermaxillary traction, and this is consistent with the increase in activity that can be recorded in the same subject during voluntary protrusion of the mandible to

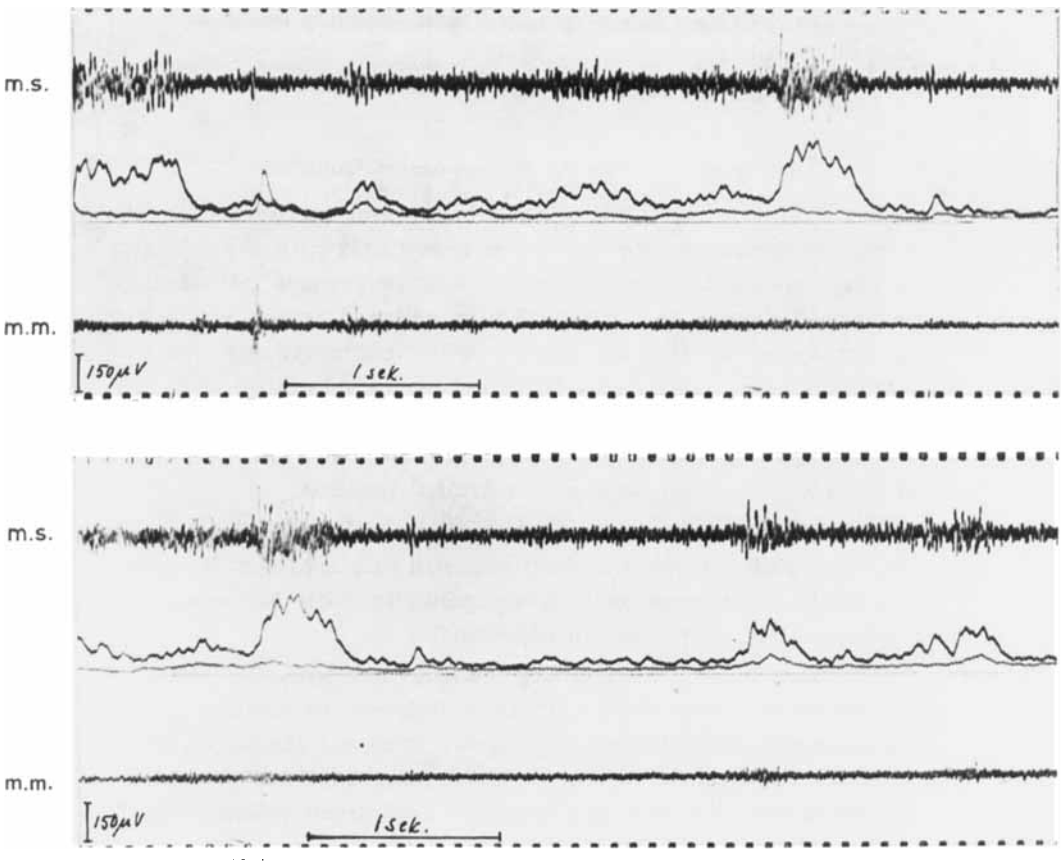


Fig. 4 b. See text Fig. 4 a.

the same extent. (Fig. 3.) This activity is small, since the displacement amounts to only one cusp-width.

In spite of the fact that the forward movement of the mandible in each individual was approximately the same for the activator and intermaxillary traction, the activity recorded from the masseter muscle, was not of the same magnitude for the two types of appliance; it being less with the activator "at rest" than with intermaxillary traction, which itself was of the same magnitude as for an equal, volontary displacement of the mandible. These differences are in all probability due to the fact that the activator at the same time forces an opening movement. As *Carlsöö* (1956) has shown, the activity in the masseter muscle is reduced gradu-

ally to the opening movement performed ventrally of the habitual path of opening.

Muscle activity with the two appliances "functioning"

On observing the patient over fairly long periods with the respective apparatus applied it was found that with the activator in place swallowing movements were performed periodically, presumably owing to the increase in salivary secretion through the presence of the appliance; with intermaxillary traction applied, definite periodic movements of the mandible were performed, chiefly forwards and backwards, so that the force exerted by the ligatures varied from maximum in postnormal occlusion (130—150 g.) to zero in some protruded position.

These observations were made in the same experiment series, and thus with the surface electrodes still in place, and the action potentials were recorded photographically with the respective appliances "at rest" and "in function".

It is seen from the electromyograms that with the activator "in function" there was a marked increase in activity in the suprahyoidal muscles at fairly regular intervals (though varying from one subject to another) which corresponded to the frequency of the swallowing movements. A relatively intense activity was recorded in the posterior portion of the temporal muscle, and only for short irregular periods does this portion seem to have been at rest. The activity was least for the masseter muscle, and only occasionally was there any tendency for it to increase, and then only for short periods (Fig. 4).

With the intermaxillary traction in function a marked increase in activity was recorded in the suprahyoid muscles over varying periods, corresponding to the forward movement of the mandible. Activity was also recorded in the posterior portion of the temporal muscle. This, however, was not as continuous as that due to the activator, the periods of activity alternating with periods of rest, corresponding to the backward and forward movement of the mandible. In the case of the intermaxillary traction, as for the activator, the minimum activity was recorded for the masseter muscle. Occasionally, however, there was a pronounced increase

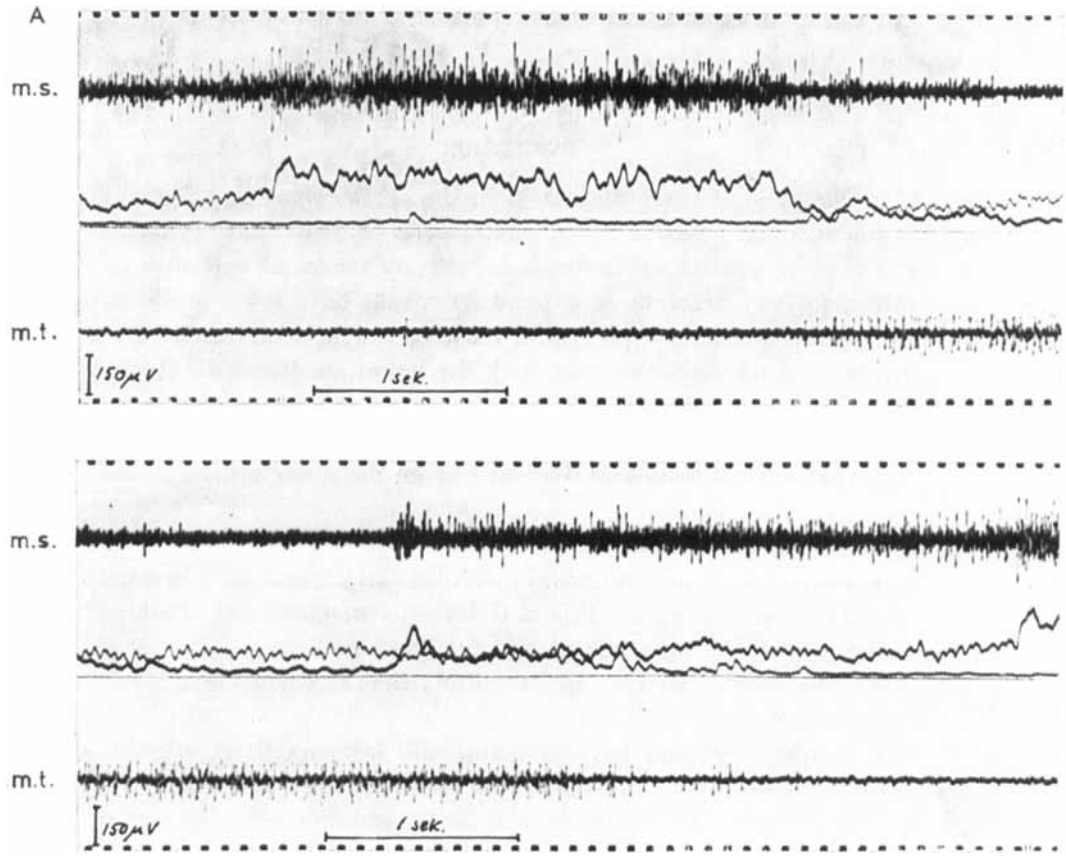
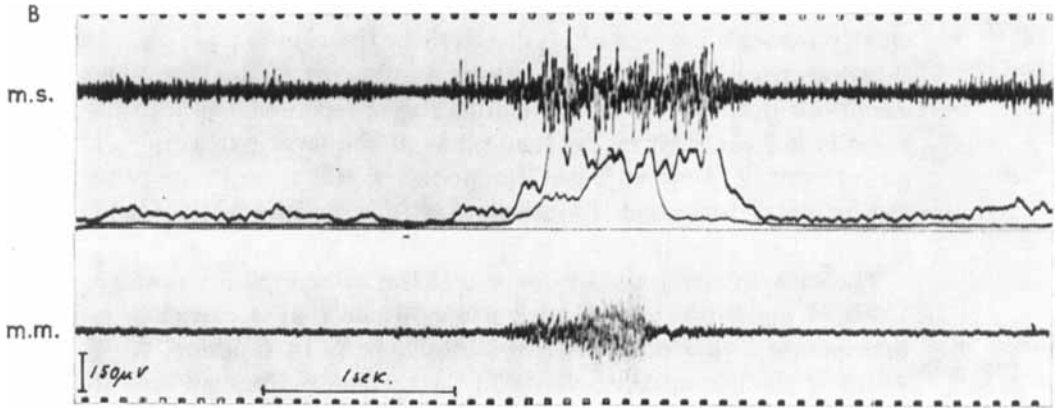


Fig. 5 (a—b). Intermaxillary traction "in function". Movements of the mandible, chiefly forwards and backwards, were performed spontaneously.



in activity in connection with a marked protrusion of the mandible (Fig. 5).

DISCUSSION

In the present investigation as in the earlier ones on the same problem, only some of the muscles were studied, that might be expected to exhibit an increase in activity when an activator or intermaxillary traction is applied. It would have been desirable to examine the lateral pterygoid muscle, which is of course, also involved in forward movements of the mandible (*Carlsöö,* 1952), but this presents some difficulty in children, for this muscle can be reached only with needle electrodes. It is unlikely, however, that this muscle behaves differently from the other muscles with the apparatus applied.

In the present study it was found that muscle activity was recorded for both activator and intermaxillary traction. When the appliance was "at rest" this activity was insignificant, that is, when no closing or other movement were performed, but large when the appliance was "in function", that is when such movements were performed.

It would seem that both activator and intermaxillary traction provoke spontaneous movements of the mandible, which give rise to this increase in the muscle activity and hence to muscular forces of a constantly varying magnitude; which are transmitted via the respective appliances, to the teeth and alveolar process. It is generally considered that the force exerted by the intermaxillary ligatures is continuous and results in normal occlusion chiefly through movement of the teeth in the alveolar processes. However, because of the spontaneous movements of the mandible variations in the stress in the ligatures were recorded, so that this force is not constant in the true sense of the term but rather of an intermittent nature. Thus similarities would seem to apply to the activator for which the displacing force is intermittent and generated by activation chiefly by the masticatory muscles.

The muscle activity is, in theory, of the same type for the two kinds of appliance and of such a magnitude that it can exert a therapeutic action only when the appliance is in function. As a result of the increase in activity in the retractors the direction of

the force, especially in the upper anterior segment, would be such as to promote remodelling processes in the alveolar process in a favourable direction.

The spontaneous pattern of movement contributes to a forward traction of the mandible, and this might elicite a condylar response, with remodelling processes and possibly stimulation of growth. That such a condylar response can be obtained in orthodontic treatment has been shown in animal experiments (*Breitner,* 1940; *Häupl et al.,* 1939, 1954; *Baume et al.,* 1961). Histologic findings on man (*Baume et al.,* 1959) and cephalometric studies (*Gresham,* 1952; *Ricketts,* 1952, 1955) would seem to support this supposition.

That this condylar response and the remodelling processes in the alveolar process are due to the muscular activity is the basis for the concepts of *Andresen* and *Häupl* on functional jaw orthopaedics. Insofar as this intermittent interaction of forces is of significance for these remodelling processes it is of principally the same type for the two types of appliance. The small differences in the pattern of movement that were observed in this study are probably of no significance. The muscle activity is, however, of broadly the same type for the two appliances "in function".

The activator effect has been analysed in the waken state, and this is not necessarily the same as during sleep. Some reservation as to the general validity must therefore be made with respect to the time in the day the appliance is used. It is often recommended to use the activator as much as possible during the day to improve its effect; this provides further support for the view that the activator, in common with intermaxillary traction, exerts its greatest effect "in function".

The muscle activity was studied only in the initial stage of the treatment. The possibility of adaptation effects later on is of course an important factor. The muscle response to the two appliances was examined on the same subject to eliminate such sources of error as the positioning of the electrodes and individual variations. It is obviously impossible to study the adaptation effects under the same conditions since comparison between the two appliances cannot be made on the same person after treatment with only one of them.

SUMMARY

An electromyographic study of the activity in the masseter, posterior portion of the temporal and suprahyoid muscles has been performed on 14 boys (10 years of age), with Angle Class II, div. 1 malocclusions with retruded mandible. This activity was studied on applying activator or intermaxillary traction, and was recorded with the appliance "at rest" and "in function", that is, without and with spontaneous movements of the mandible.

The muscle activity was fairly low with the respective appliances "at rest", but "in function" it was intense with both appliances.

With small differences in the movement pattern it would seem that the muscular activity and hence the stimulus to remodelling are in principle the same for the two types of appliance.

RÉSUMÉ

ACTIVITÉ MUSCULAIRE DUE À L'EMPLOI D'UN ACTIVATEUR OU DE LA TRACTION INTERMAXILLAIRE DANS LE MALOCCLUSION CLASSE II, DIVISION 1 D'ANGLE.

ETUDE ÉLECTROMYGRAPHIQUE DES MUSCLES TEMPORAL, MASSÉTER ET SUS-HYOIDIENS

Une étude électromyographique de l'activité du masséter, de la partie postérieure du muscle temporal et des muscles sus-hyoïdiens a été faite sur 14 jeunes garçons (âgés de 10 ans), présentant des malocclusions classe II, division 1 d'Angle, avec rétrognathie mandibulaire. Cette activité a été étudiée en plaçant un activateur ou une traction intermaxillaire, et a été enregistrée avec l'appareil "en action" ou "au repos", c'est-à-dire avec ou sans mouvements spontanés de la mandibule.

L'activité musculaire était assez basse avec les deux types d'appareils "au repos", mais, "en action" elle était intense avec les deux appareils.

Avec quelques petites différences dans le mouvement décrit, il semblerait que l'activité musculaire, et, par conséquent, le stimulus provoquant le remodelage, sont en principe les mêmes pour les deux types d'appareils.

ZUSAMMENFASSUNG

DIE MUSKELAKTIVITÄT BEI BEHANDLUNG MIT AKTIVATOR UND INTERMAXILLÄREN ZÜGEN BEI FÄLLEN VON ANGLE-KLASSE II:1.

EINE ELEKTROMYOGRAFISCHE UNTERSUCHUNG DES M. TEMPORALIS, M. MASSETER UND DER SUPRAHYOIDALEN MUSKULATUR

Eine elektromyografische Untersuchung der Aktivität im dorsalen Anteil des M. temporalis, des M. masseter sowie der suprahyoidalen Muskulatur wurde bei 14 Jungen im Alter von 10 Jahren mit der Diagnose Angle-Klasse II: 1 bei Rücklage des Unterkiefers durchgeführt. Diese Aktivität wurde bei Behandlung mit sowohl Aktivator wie intermaxillären Zügen untersucht und mit entsprechendem Gerät "in Funktion" und "in Ruhe" registriert, d.h. mit und ohne Bewegungen des Unterkiefers.

Die Ergebnisse zeigen, dass die Muskelaktivität bei beiden Geräten "in Ruhelage" relativ unbedeutend ist. "In Funktion" dagegen wird bei beiden Geräten eine kräftige Muskelaktivität registriert.

Aufgrund der Ergebnisse wird schliesslich der Effekt mit beiden Apparaturen diskutiert, wobei angenommen wird, dass beide das gleiche Endergebnis zeigen, d.h. Zahnstellungsveränderungen in den Alveolarfortsätzen sowie ev. Umbauvorgänge im Bereich des Kiefergelenks.

REFERENCES

Aas, B. M., 1960: En elektromygrafisk undersøkelse av m. temporalis og m. masseter ved forskjellige ortodontiske behandlingsmetoder. Norske Tannlaegefor. Tid. *70:* 85.

Ahlgren, J.., 1960: An electromyographic analysis of the response to activator (Andrésen-Häupl) therapy. Odont. Revy *11:* 125.

Andresen—Häupl—Petrik, 1957: Funktionskieferorthopädie, J. A. Barth, München.

Ballard, C. F., 1955: A consideration of the physiologic background of manbular posture and movement. Dent. Pract. *6:* 80.

Baume, L. J., K. Häupl, & R. Stellmach, 1959: Growth and transformation of the temporo-mandibular joint in orthopedically treated cases of Pierre Robin's syndrome. Am. J. Orthodont. *45:* 901.

Baume, L. J. & H. Derichsweiler, 1961: Is the condylar growth center responsive to orthodontic therapy? Oral Surg., Oral Med. & Oral Pathol. *14:* 347.

Björk, A., 1947: The face in profile. Svensk tandläk.-T.: *40*, no. 5 B.

Breitner, C., 1940: Bone changes resulting from experimental orthodontic treatment. Am. J. Orthodont. *26:* 521.

Carlsöö, S., 1952: Nervous coordination and mechanical function of the mandibular elevators. Acta odont. scand. *10:* suppl. 11.

—»— 1956: An electromyografic study of the activity of certain suprahyoid muscles (mainly the anterior belly of digastric muscle) and of the reciprocal innervation of the elevator and depressor musculature of of the mandible. Acta anatomica *26:* 81.

Eschler, J., 1955: Elektrophysiologische und pathologische Untersuchungen des Kausystems. Dtsch. Zahnärztl. Z. *10:* 1421.

Gresham, H., 1952: Mandibular changes in Andresen treatment of Angle class II malocclusion. New Zealand Dent. J. *48:* 10.

Grossman, W. I., B. E. Greenfield & D. I. Timms, 1961: Electromyography as an aid in diagnosis and treatment analysis. Am. J. Orthodont. *47:* 481.

Grude, R., 1951: Myo-functional therapy. Trans. Europ. Orth. Soc.

Herren, P., 1956: Über die Reizqualitäten Kieferorthopädischer Apparate. Schweiz. Mschr. Zahnheilk. *66:* 13.

Häupl, K. & Psansky, R., 1939: Experimentelle Untersuchungen über Gelenktransformation bei Verwendung der Methoden der Funktionskieferorthopädie. Deutsche Zahn-, Mund- u. Kieferheilk. *6:* 439.

Häupl, K., 1954: Die kieferorthopädische Gewebeumbau bei Behandlung des dysgnathen Frontzahnüberbisses mit dem Aktivator. Deutsch. Zahnärtzl. Z. *9:* 1158.

Liebmann, F. M. & F. Cosenza, 1960: An evaluation of electromyography in the study of the etiology of malocclusion. J. Prosth. Dent. *10:* 1065.

Moyers, R., 1949: Temporomandibular muscle contraction patterns in Angle Class II, division 1, malocclusions: An electromyographic analysis. Am. J. Orthodont. *35:* 837.

—»— 1950: An electromyographic analysis of certain muscles involved in temporomandibular movement. Am. J. Orthodont. *36:* 481.

Perry, H. T., 1955: Functional electromyography of the temporal and masseter muscles in Class II, division 1 malocclusion and excellent occlusion. Angle orthod. *25:* 49.

Ricketts, R. M., 1952: A study of changes in temporomandibular relations associated with the treatment of class II malocclusion. Am. J. Orthodont. *38:* 918.

—»— 1955: Facial and dental changes during orthodontic treatment as analyzed from the temporomandibular joint. Am. J. Orthodont. *41:* 163.

Schmuth, G., 1960: Muskeltätigkeit und Muskelwirkung im Rahmen der Funktionskieferorthopädie. Deutsch. Zahn-, Mund- und Kieferheilk. *32:* 4.

Werner, H., 1954: Bestämning av överkäkens och underkäkens cefalometriska orientering. Svensk tandläk.-T.: *47:* 419.

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