ORIGINAL ARTICLE

# Muscle response to the Twin-block appliance: An electromyographic study of the masseter and anterior temporal muscles

**Preeti Aggarwal, MDS,[a] O.P. Kharbanda, MDS, FICD, MNAMS,[b] Rashmi Mathur, MBBS, PhD,[c] Ritu Duggal, MDS,[d] and H. Parkash, MDS, FICD, MNAMS, FACD[e]**
*New Delhi, India*

An electromyographic study was performed on 10 young growing girls in the age group of 9 to 12 years with Class II Division 1 malocclusion and retruded mandible, who were under treatment with Twin-block appliances. Bilateral EMG activity of elevator muscles of the mandible (ie, anterior temporalis and masseter) was monitored longitudinally with bipolar surface electrodes to determine changes in postural, swallowing, and maximal voluntary clenching activity during an observation period of 6 months. The changes were noted at the start of treatment (0 month), within 1 month of Twin-block insertion, at the end of 3 months, and at the end of 6 months. The results revealed a significant increase in postural and maximal clenching EMG activity in masseter ($P < .01$) and a numeric increase in anterior temporalis activity during the 6 month period of treatment. The increased electromyographic activity can be attributed to an enhanced stretch (myotatic) reflex of the elevator muscles, contributing to isometric contractions. The main force for Twin-block treatment appears to be provided through increased active tension in the stretched muscles (motor unit stimulation) and from initiation of myotatic reflex activity and not through passive tension (viscoelastic properties) of jaw muscles. The results of this study reaffirm the importance of full-time wear for functional appliances to exert their maximum therapeutic effect by way of neuromuscular adaptation. (Am J Orthod Dentofacial Orthop 1999;116:405-14)

Functional appliances used in the correction of Class II malocclusions are shown to modify the neuromuscular environment of the dentition and associated bones.[1,2] However, the interaction between bone and muscle and the mechanism of neuromuscular adaptation to functional appliance therapy is complex and open to discussion. Several adaptation processes have been proposed,[3] for example, elongation of muscle fibers[3,4] or tendons, migration of muscle attachments along bony surfaces,[3,5] changes in muscle dimensions due to bone displacements and rotations, and muscle hypertrophy.[3] Some of the skeletal alterations have been attributed to morphologic adaptations to an altered muscular tone and to a change in direction of traction exerted by the masticatory muscles.[6]

Ever since Andrésen and Haüpl[7] introduced functional jaw orthopedics (activator) in 1936, diverse views have been presented regarding the neuromuscular responses brought about with activator treatment; most of them are hypothetical.[7,8] Andrésen and Haüpl claimed that myotatic reflexes leading to isometric contractions from the activities of the jaw-closing muscles are produced by the activator, which stimulates the protractor muscles and inhibits the retractor muscles of the mandible. Eschler[8] supported Andrésen and Haüpl but claimed that the retractor muscles are stimulated, not inhibited, by the activator. He attributed the muscle contractions to proprioceptive stretch reflexes and observed the occurrence of both isometric and isotonic contractions with the use of the activator. Selmer-Olsen[9] and Umehara[10] failed to observe active muscle contractions during nocturnal use of the activator and claimed that the viscoelastic properties of the muscles and the stretching of soft tissues are decisive for activator action, besides the muscle contraction. Harvold and Vargervik,[5,11,12] Woodside,[13] and Herren[14] supported Selmer-Olsen's theory and advocated overcompensated construction bites. Between the 2 extremes exemplified by Andrésen and Haüpl versus Selmer-Olsen, a number of authors like Witt[15] supported a combination of isometric muscle contractions and viscoelastic properties being responsible for the forces

From the All India Institute of Medical Sciences.
[a]Former postgraduate student, Division of Orthodontics, Department of Dental Surgery.
[b]Additional Professor, Division of Orthodontics, Department of Dental Surgery.
[c]Additional Professor, Department of Physiology.
[d]Assistant Professor, Division of Orthodontics.
[e]Professor and Head, Department of Dental Surgery.
Reprint requests to: Dr O.P. Kharbanda, Additional Professor, Division of Orthodontics, Department of Dental Surgery, All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110029 India; e-mail, opk@medinst.ernet.in

0889-5406/99/$8.00 + 0 **8/1/98384**

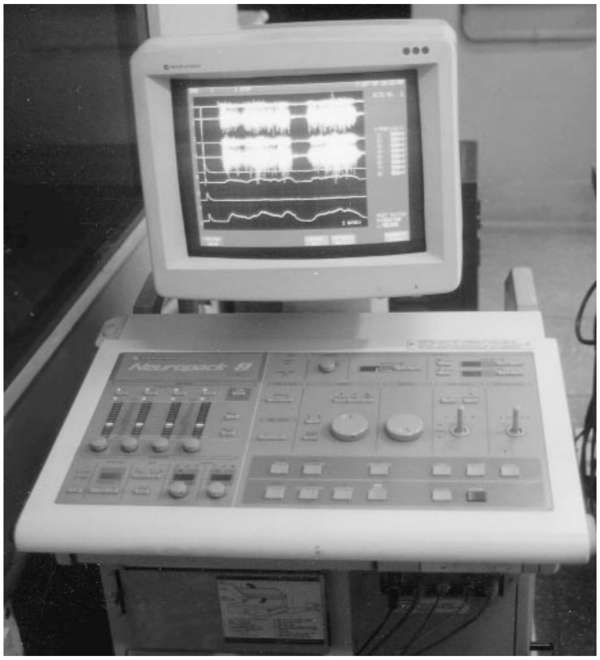

**Fig 1.** Electromyographic equipment used in the study (Nihon Kohden, Japan).

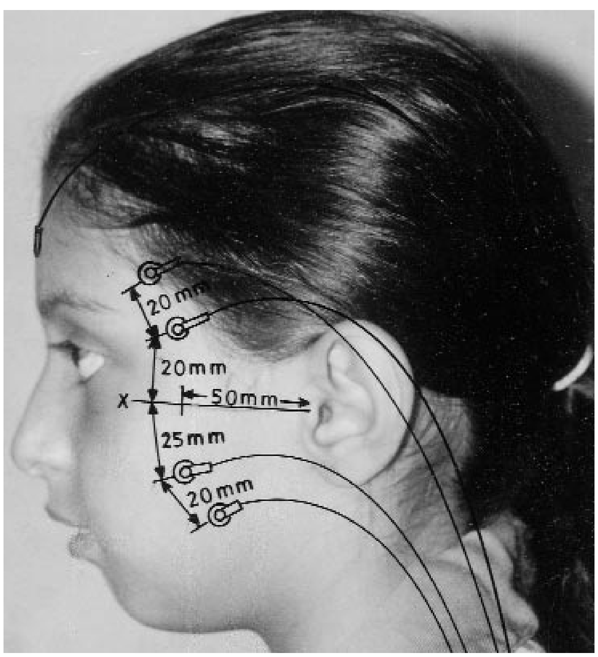


**Fig 2.** Reference lines and landmarks for fixation of surface electrodes on the subject's face.

delivered by the activator and used intermediate construction bite heights.

Concepts of Herren[14] (increased tonus), Schwarz (long-lasting isometric biting),[16] and Ahlgren[16] (pas-

**Fig 3.** Subject with electrodes affixed.

sive elastic muscle tension) became important on testing the original hypothesis of Andrésen-Haüpl.[7] The hallmark of all these previous EMG studies[16-23] was that they were based on a removable appliance meant for intermittent wear, ie, only during night time. Further, the activator and its modifications acted as a splint rather than a device for mandibular hyperpropulsion unlike the one used by McNamara and Carlson[3,24,25] in their primate experiments. This can explain the differing results achieved regarding changes in muscle activity in these studies. In view of these considerations, functional appliances that are worn full-time like Herbst, Jasper Jumper, and Twin-block can be expected to elicit a greater and more rapid neuromuscular response than those worn only part-time, eg, activator. With the full-time wear of an appliance like Twin-block[26,27] that provides greater freedom of movement in anterior and lateral excursions and less interference with normal function, we can expect that the morphologic adaptations that occur in the musculature may be somewhat different in nature and magnitude than those produced with other functional appliances.

The present electromyographic (EMG) study was undertaken to investigate the muscle response of anterior temporalis and masseter muscles to the Twin-block functional appliance treatment and to analyze, quantitatively, the various changes with treatment.

## MATERIAL AND METHODS

The study was conducted on 10 young growing girls in the age group of 9 to 12 years with Class II Division 1 malocclusion and retruded mandible. They all had skele-

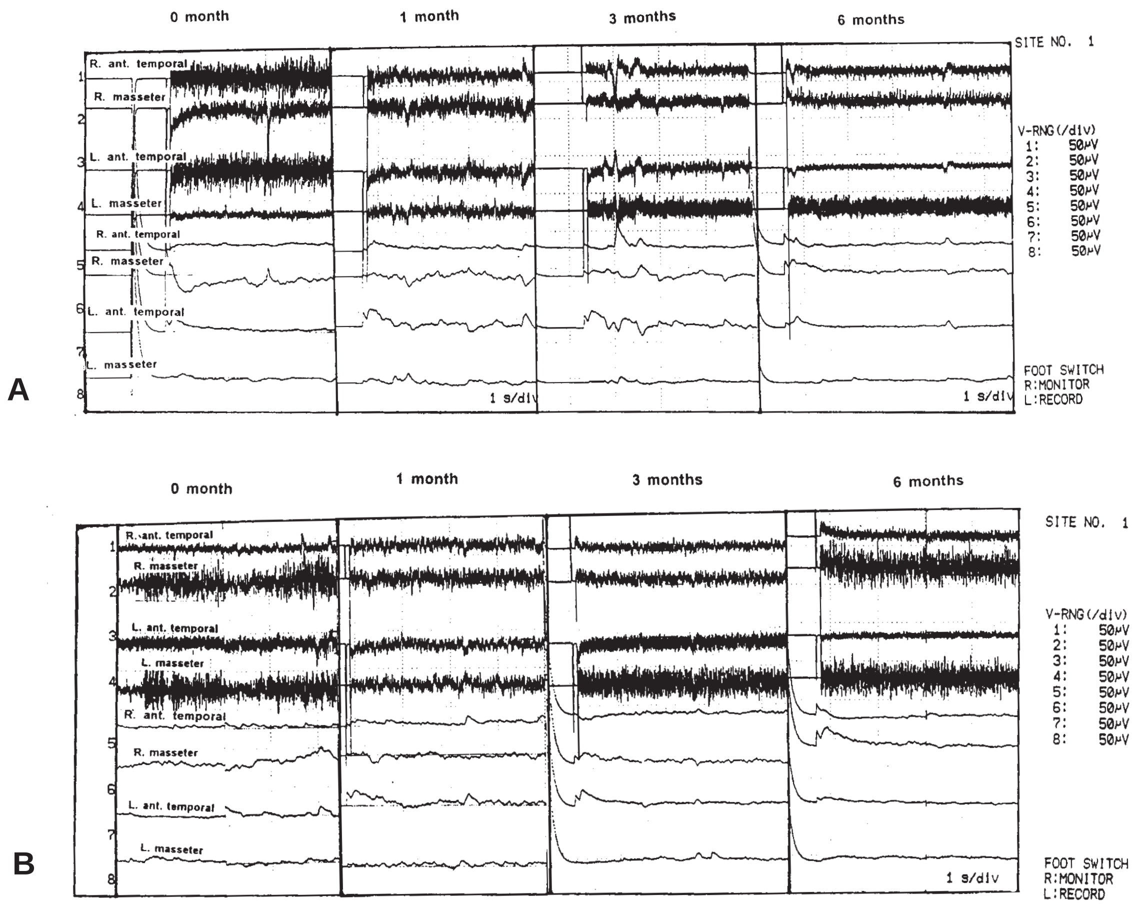


**Fig 4. A**, Representative sections of EMG during postural position of the mandible without Twin-block. **B**, Representative sections of EMG during postural position of the mandible with Twin-block. (**A** and **B**, *Tracings 1, 2, 3,* and *4* represent raw EMGs, and *5, 6, 7*, and *8* are integrated EMGs.)

tal Class II pattern with ANB angle > 4.5°, normal dentition for the age and were free of subjective neuromuscular, auditory, or mandibular dysfunction symptoms. None of the subjects had undergone any orthodontic treatment before their inclusion in the study. These patients underwent treatment with Twin-block appliance for the correction of retrognathic mandible.

Bilateral EMG signals for each patient were recorded from the anterior temporal and masseter muscles. An 8-channel EMG, Neuropack-8, MEB-4200 (Fig 1) series and bipolar surface disk electrodes with a 2-pin plug (Nihon-Kohden, Japan) were used. Before each recording session, the procedure was explained in detail to the patient and her parents to allay anxiety. The subjects were asked to wash their face with soap and water. The skin over the muscles was cleaned with alcohol and dried thoroughly. The subject was comfortably seated in a shielded room to eliminate outside electrical interferences.

Electrode placement was standardized according to the method advocated by Yuen et al[28] (Figs 2 and 3). Electrode alignments were assisted by palpation during voluntary clenching and relaxation in the intercuspal position. The EMG recordings were performed using all 8 channels on the EMG. Four channels recorded the direct (raw) EMG activity from the anterior temporalis and masseter muscles. The remaining 4 channels recorded the integrated EMG waveforms. Sensitivity was set at 50 μV/cm for muscle activity during postural mandibular position, 200 μV/cm for swallowing of saliva and 500 μV/cm or 1 μV/cm for maximal voluntary clenching in the intercuspal position, because of the greater amplitude of the waveform.

Each patient underwent 4 EMG registration sessions both with and without the Twin-block appliance in the mouth. The recordings were performed before and immediately after fitting the Twin-block, at the time of appliance delivery to the patient, within 1

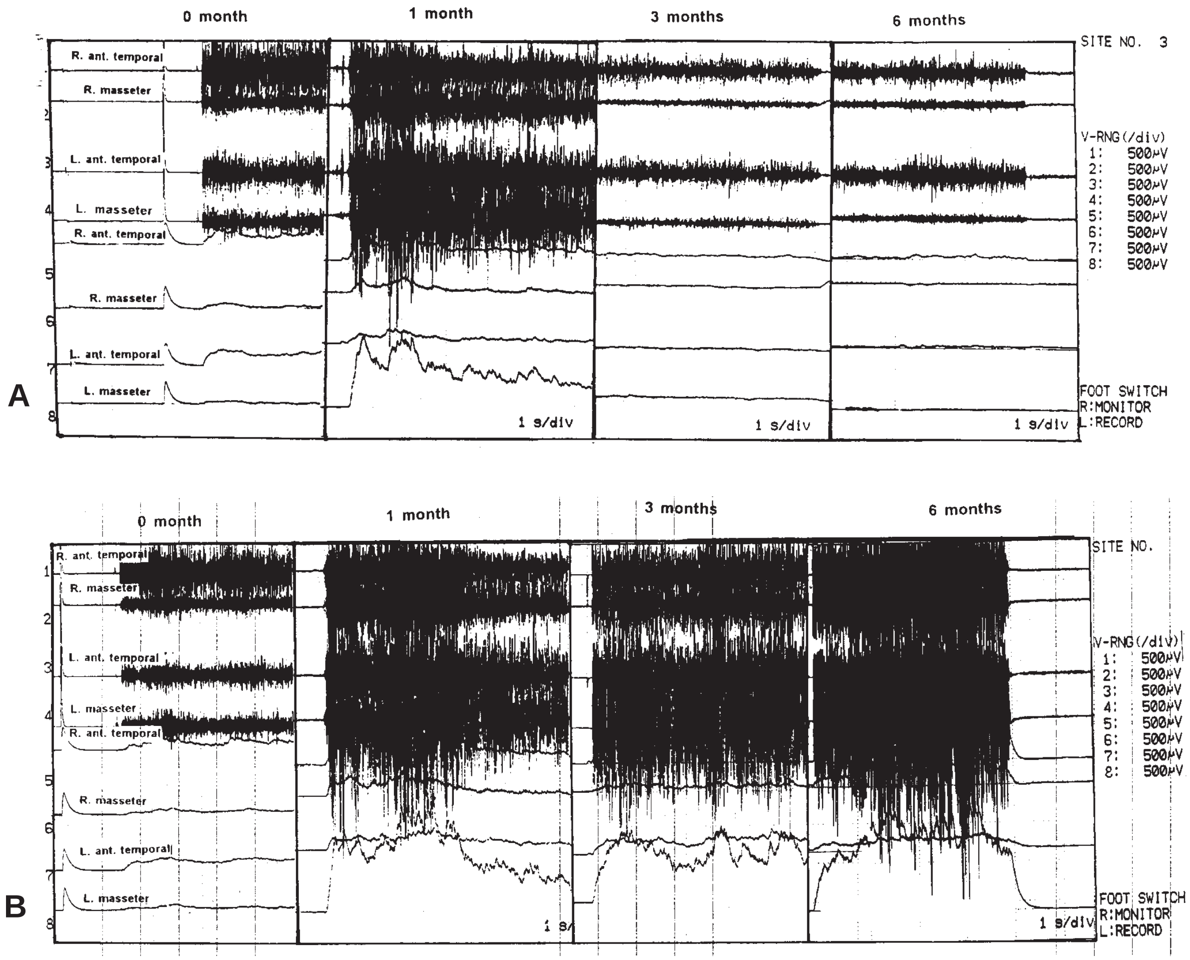


**Fig 5. A**, Representative sections of EMG during maximal voluntary clenching without Twin-block. **B**, Representative sections of EMG during maximal voluntary clenching with Twin-block. (**A** and **B**, *Tracings 1, 2, 3*, and *4* represent raw EMGs, and *5, 6, 7*, and *8* are integrated EMGs.)

month after fitting the Twin-block, at the end of 3 months, and at the end of 6 months. Each of the recordings were done during postural mandibular position, swallowing of saliva, and maximum voluntary clenching in the intercuspal position (Figs 4 and 5).

EMG was recorded on heat sensitive paper and the electromyograms obtained were analyzed. For the muscle activity during postural mandibular position, the method used by Moller[29] and Stavridi and Ahlgren[30,31] was used. A section of the recording of the direct EMG signals where the activity in all channels was steady and minimal over a 5-second period was taken. Two parallel lines were drawn through the majority of the peaks representing the average peak-to-peak amplitude. The distance between them was measured with a digital caliper (Mitutoyo, Japan) on 3 different locations, and the mean of these measurements was computed. For saliva swallowing and maximal clenching, the measurements of the EMG amplitude were made on the integrated signal called the maximal integrated EMG activity. The integrated EMG value was obtained by measuring the maximum height (epoque) of the signal from the baseline in millimeters and then multiplying by the calibration factor to obtain the absolute value in microvolts. The mean of all epoque values measured in each interference pattern for each swallow and clench was obtained.

All measurements were made to the nearest 0.01 mm with the digital caliper. The measurements and their conversion to microvolts according to the sensitivities used for the various functional activities recorded were carried out manually. The same operator made all recordings. Friedman two-way nonparametric analysis of variance was used to evaluate the change in

**Table I.** Mean and SD (in μV) values of the muscle activity in the postural position of the mandible without the Twin-block appliance (n = 10)

| | *EMG recordings* | | | | |
|---|---|---|---|---|---|
| *Muscle* | *(1) 0 month* | *(2) 1 month* | *(3) months* | *(4) 6 months* | *Difference P* |
| Anterior temporalis | 10.27 ± 5.49 | 12.31 ± 9.34 | 13.67 ± 8.17 | 16.06 ± 8.06 | NS |
| Masseter | 9.55 ± 4.89 | 12.75 ± 9.54 | 12.53 ± 6.59 | 13.37 ± 6.20 | NS |

NS, Not significant.

**Table II.** Mean and SD (in μV) values of the muscle activity in the postural position of the mandible with the Twin-block appliance (n = 10)

| | *EMG recordings* | | | | |
|---|---|---|---|---|---|
| *Muscle* | *(1) 0 month* | *(2) 1 month* | *(3) months* | *(4) 6 months* | *Difference P* |
| Anterior temporalis | 8.52 ± 3.20 | 12.03 ± 9.18 | 10.81 ± 5.59 | 12.98 ± 5.67 | NS |
| Masseter | 8.71 ± 3.38 | 11.24 ± 5.62 | 11.69 ± 3.50 | 13.88 ± 6.21 | 1 vs 2*<br>1 vs 3*<br>1 vs 4* |

NS, Not significant.
*$P < .05$.

**Table III.** Mean and SD (in μV) values of the muscle activity during saliva swallowing without the Twin-block appliance (n = 10)

| | *EMG recordings* | | | | |
|---|---|---|---|---|---|
| *Muscle* | *(1) 0 month* | *(2) 1 month* | *(3) months* | *(4) 6 months* | *Difference P* |
| Anterior temporalis | 59.05 ± 38.50 | 55.00 ± 10.18 | 77.31 ± 43.28 | 67.93 ± 26.25 | NS |
| Masseter | 67.02 ± 39.87 | 44.61 ± 17.10 | 80.28 ± 46.43 | 72.82 ± 41.68 | NS |

NS, Not significant.

EMG activity over the 6-month observation period. Multiple range tests were used to determine the change in EMG activity at different time intervals. Paired *t* tests were done to compare EMG activity without and with the Twin-block appliance in the mouth at each recording.

## RESULTS

### Muscle Activity During Postural Position of Mandible

The mean anterior temporalis EMG activity increased numerically from 0 to 6 months both without and with Twin-block, however, this increase was statistically not significant (Tables I and II). There was also no statistically significant difference between the EMG activity of masseter muscles without or with the Twin-block in the mouth in all the recordings. The mean masseter activity, both without and with a Twin-block showed a steady rise ($P < .05$), from the start up to the 6 month recording session.

### Muscle Activity During Saliva Swallowing

No significant difference in muscle activity was found with or without Twin-block at any of the 4 registrations in both anterior temporal and masseter muscles (Tables III and IV). The temporalis activity between the 4 registrations followed no definite pattern of increase or decrease without Twin-block. The activity with Twin-block, although increased progressively from the start up to 6 months, was statistically not significant. The mean masseter activity with Twin-block increased numerically on progressing from the start to the end of 6 months, but the difference in values between the recordings was statistically not significant.

### Muscle Activity During Maximal Voluntary Clenching

The mean EMG values of anterior temporalis muscle with Twin-block in the mouth during clenching showed a variable pattern from the start of the treatment until the end of the 6 month observation period. However, the masseter muscle showed a definite

**Table IV.** Mean and SD (in μV) values of the muscle activity during saliva swallowing with the Twin-block appliance (n = 10)

| | EMG recordings | | | | |
|---|---|---|---|---|---|
| *Muscle* | *(1) 0 month* | *(2) 1 month* | *(3) months* | *(4) 6 months* | *Difference P* |
| Anterior temporalis | 37.58 ± 16.92 | 65.32 ± 61.13 | 66.53 ± 42.96 | 82.17 ± 66.62 | NS |
| Masseter | 63.01 ± 51.00 | 76.38 ± 92.05 | 82.86 ± 82.05 | 121.14 ± 117.21 | NS |

NS, Not significant.

**Table V.** Mean and SD (in μV) values of the muscle activity during maximal voluntary clenching without the Twin-block appliance (n = 10)

| | EMG recordings | | | | |
|---|---|---|---|---|---|
| *Muscle* | *(1) 0 month* | *(2) 1 month* | *(3) months* | *(4) 6 months* | *Difference P* |
| Anterior temporalis | 322.91 ± 200.59 | 233.04 ± 113.56 | 280.82 ± 141.30 | 320.45 ± 298.03 | NS |
| Masseter | 358.92 ± 412.82 | 303.41 ± 349.28 | 240.74 ± 245.58 | 343.44 ± 283.66 | NS |

NS, Not significant.

**Table VI.** Mean and SD (in μV) values of the muscle activity during maximal voluntary clenching with the Twin-block appliance (n = 10)

| | EMG recordings | | | | |
|---|---|---|---|---|---|
| *Muscle* | *(1) 0 month* | *(2) 1 month* | *(3) months* | *(4) 6 months* | *Difference P* |
| Anterior temporalis | 226.83 ± 161.02 | 292.95 ± 224.18 | 412.75 ± 259.68 | 395.49 ± 198.44 | NS |
| Masseter | 246.22 ± 284.83 | 413.28 ± 489.14 | 549.71 ± 431.17 | 633.33 ± 448.68 | 1 vs 3*<br>1 vs 4**<br>2 vs 3*<br>2 vs 4** |

NS, Not significant.
*$P < .05$.
**$P < .01$.

response of a progressive increase in the activity at each recording session. The differences were significant statistically ($P < .01$) (Tables V and VI).

## DISCUSSION

The mode of action of functional appliance therapy has been linked to neuromuscular and skeletal adaptations to altered function in the orofacial region.[3,24] McNamara and Carlson's[3,24] investigations indicated that modification of functional position of the mandible results in an immediate alteration of the neuromuscular activity of the orofacial muscles, particularly noticeable in the lateral pterygoid muscles. It was concluded that as skeletal adaptations occur, the need for compensatory muscle function is reduced. Several investigations have been carried out to correlate the timing of the appearance and disappearance of altered functional patterns to the rate and extent of skeletal and dental adaptations.[16,18,20,22,23,32]

The present study was conducted on active protrusion achieved with a Twin-block appliance, which allows for full-time wear. In this study, we chose to record the EMG activity after 1, 3, and 6 months of treatment. One month was chosen because neuromuscular changes might occur earlier than the morphologic changes; 3 months was selected because a positional response of the mandible is often noted at this time with functional appliance treatment; and 6 months because some children have a late response. The findings over the 6 month observation period are being discussed in the light of changes seen during different functional activities both with and without the appliance in the mouth.

Insertion of the Twin-block appliance in the mouth caused a change in the EMG pattern of both the anterior temporalis and masseter muscles during the 6 months observation period. Both the muscles were stimulated; however, the masseter showed a more definite pattern of change. Although the temporalis did show a trend toward increase in activity, this was not statistically significant. The masseter activity increased during postural rest position and clenching, whereas during the act of swallowing there was no change in EMG activity.

There was no change in the postural activity of anterior temporalis immediately on insertion of the appliance, which is in agreement with Ahlgren[16] whereby the "rest" activity of temporalis with the activator inserted was the same as that without. During the 6 month period, the values at each recording were higher with the appliance than without, presumably the result of the reciprocal innervation of the retractor muscles in protruded mandibular movements. These findings are in agreement with Moyers,[33] Carlsöö,[34] Latif,[35] and Ralston and Libet.[36] The mean masseter activity with Twin-block increased gradually, progressing through the 4 recording sessions both with and without appliance. However, the values with the Twin-block in the mouth showed a statistically significant increase. During the recording of postural activity with Twin-block, the child was asked to close the mouth according to the bite registration position of the inclines. The increased postural activity of the masseter is explained as a balancing contraction as a result of the protrusion of the mandible imposed by the Twin-block. These findings are in confirmation with the anatomic functions of the masseter, which plays a dominant role in elevation when the mandible is protracted. These results partly confirm Andrésen's original hypothesis that in Class II treatment with an activator, the protractor muscles are stimulated, but disagree with the opinion that the retracting muscles are inhibited. Our findings also agree with Eschler's[8] report of increased muscle activity in both the anterior temporalis and the masseter muscles as a response to Twin-block treatment. Though the anterior temporalis activity did not change significantly, a definite trend toward increase in numeric values was observed between 1 recording session and the next.

Muscle activity during maximal voluntary clenching immediately on insertion of the Twin-block appliance in the mouth was lower in both anterior temporalis and masseter than without the appliance. This can be accounted for by the fact that when the muscle is lengthened and isometrically contracted, the EMG activity falls, although the tension is greater. This is in accordance with the active muscle activity in the isometric length-tension curve.[37] This can also be interpreted as an effect of reciprocal innervation,[34] the temporalis muscle being an antagonistic muscle to a protrusive movement of the mandible. This agrees with the results of Ahlgren[16] who reported a decrease in electrical activity during biting contractions in the anterior temporalis muscles in 82% of the cases and a decrease in masseter in 59% of the cases immediately after insertion of activator. Alternatively, it can be accounted for because of the relative inexperience with the wear of the Twin-block appliance and apprehension of soft tissue damage and breakage.

In our study, the anterior temporalis activity without Twin-block showed a decrease from the initial recording to the second recording within 1 month and thereafter a steady increase at the 3 month and 6 month recordings. This temporary drop from 0 month to 1 month can be attributed to the children's tension and anxiety at their first confrontation with the recording procedure. Hence, our baseline for subsequent comparison may be too high. The possibility of a neuromuscular adaptation in a short span of less than a month seems to be unlikely. When the subjects had become used to the appliance after 3 and 6 months, greater activity was exerted during maximal bite. A mild increase that was not significant can be attributed to the slowly adapting receptors in the tendon organs that are not stimulated enough to cause inhibition to the generation of further tension during maximal clenching. Our findings are similar to the results of Ingervall and Bitsanis[38] whereby an increase in clenching activity without appliance occurred from 1 month onward until the end of 6 months.

The mean EMG activity of the anterior temporalis and masseter was higher with the Twin-block appliance than without at the 3 month recording. This difference was prominently seen in both right and left sides. At the end of 6 months, masseter activity without Twin-block increased approximately to pretreatment values, though remaining significantly lower than values with the Twin-block in the mouth. These observations corroborate the previous findings of Pancherz and Anehus-Pancherz[39] and Ingervall and Bitsanis,[38] who reported decreased masseter activity during maximal voluntary clenching after 3 months of treatment and attributed it to occlusal instability and/or lack of occlusal contacts of teeth in the posterior segments, occurring during bite jumping with Herbst appliance and activator, respectively.

The 3 month registration appears crucial for analyzing the neuromuscular changes occurring with functional appliance treatment, indicating a strong possibility that sagittal repositioning of a retruded mandible in Class II Division 1 cases takes place approximately within 3 months of initiating functional appliance treatment. The occlusal instability caused by changed tooth position and intermaxillary relations brought about by treatment is reflected in a reduced EMG activity of masseter muscle during maximal clenching. A stable occlusion has been shown to be a prerequisite for maximal muscle activity during biting. Muscle activity during clenching decreases with lessening numbers of posterior teeth in contact and drops dramatically when only the incisors are in contact. When clenching in the intercuspal position is directed anteriorly (as with clenching with the Twin-block), the superficial masseter muscles attain maximal activity.[40] It has been found that during biting in the maximal occlusion a vast number of mechanoreceptors, located in the periodontal ligaments of the posterior teeth are activated.[41] This number is probably decreased in the incisor edge-to-edge position, whereby antagonistic tooth contacts are restricted to a few anteriorly located teeth with Twin-block treatment.

In our study, the subjects were in the active phase of Twin-block therapy at the end of 3 months, and an improvement in sagittal discrepancy was apparently observed through a change in molar relation from Class II to at least half cusp Class II in all of the patients, leaving the posterior teeth out of occlusion. Thus, the decrease in masseter activity during clenching without twin block can be attributed to a lack of, or diminished number of occlusal contacts, at the end of 3 months. With the Twin-block inserted in the mouth, masseter activity was observed to be quite high, possibly because the Twin-block provided the necessary interocclusal contacts and provided better stabilization of the mandible. By the end of 6 months, with progress of treatment, a better mandible stabilization and an increase of occlusal contact area occurred; this distributed the occlusal load of clenching over a larger periodontal area, and a significant increase in clenching activity occurred.

In this study, mean masseter activity during maximal clenching with Twin-block showed a progressive increase from the initial recording to the 1 month, 3 month, and 6 month recording sessions. The increase was highly significant statistically. Our findings are in accordance with the results obtained by Pancherz and Anehus-Pancherz[39] with respect to increase in masseter EMG activity exceeding pretreatment values, after 6 months of Herbst treatment. The findings of this study do not support the results reported by Miralles et al[32] who found no statistically significant difference in EMG activity during maximal voluntary contractions with or without an activator. Ingervall and Bitsanis[38] found a slight decrease in masseter activity with the activator in the mouth, as Ahlgren[16] did in 59% of the cases. The results of this study also contrast with those of Stavridi and Ahlgren[30] who reported no significant difference in masseter activity during clenching with or without the oral screen activator in the mouth.

### Muscle Activity During Saliva Swallowing

No significant increase or decrease in EMG activity during saliva swallowing was found, without or with Twin-block throughout the 6-month observation period, in either anterior temporal or masseter muscles. The mean masseter activity during swallowing increased numerically from the start to the end of the 6 months, but the difference in values between the recordings was not significant statistically.

Great individual variation of the muscle activity was seen during swallowing both with and without Twin-block in the mouth. Ahlgren,[16] Findlay and Kilpatrick[42] reported similar findings. Miralles et al,[32] on the other hand, found higher swallowing activity with the activator especially in the masseter and proposed that it could be a result of better mandible stabilization and the increase of occlusal contact area, thereby causing the muscular force to be distributed over a higher periodontal area and diminishing jaw elevator muscle inhibition by periodontal mechanoreceptors. Swallowing saliva on command is a very commonly used experimental procedure to evaluate muscle function often referred to as “empty swallowing.” During the course of our study, it was frequently the most difficult recording to achieve. A limitation of the procedure is that it depends largely on how much effort is exerted during the exercise. During natural “reflex” swallowing, the effort is less. Miralles et al[32] and Ahlgren[16] and Stavridi and Ahlgren[30] found considerable increase in swallowing EMG activity with an activator in the mouth; they explained it as being the result of a greater flow of saliva caused by the introduction of an insoluble material in the mouth. The results of this study do not agree with the previous findings.

In our study, the construction bite height of the Twin-block was within the limits of the patients’ freeway space. The proponents of this method believe that such an appliance increases the frequency of reflex contractions in the masticatory muscle.[3,8,43] Moreover, the appliances were fabricated with heat-cured acrylic resin to help obtain force levels required to be generated in isometric contractions. Because the inclined planes of the Twin-block keep the mandible in a protrusive posture constantly, the appliance does not permit shortening of the elevators and the muscle fibers develop a higher tension during posture and clenching. This uninterrupted stretch on the muscle spindles leads to a repeated stimulation of the stretch receptors. We gained excellent cooperation in terms of full-time appliance wear. Thus, we can attribute the increased

EMG activity to active muscle contractions and not purely because of passive stretching. We can presume that the clenching exercises with the Twin-block and the lengthening of the masseter stimulated the muscle spindles, leading to enhanced reflex contractions and increased EMG activity.

Clark[27] observed the clinical response after fitting the Twin-block appliance during the active phase closely analogous to changes observed and reported in animal experiments with fixed inclined planes. Within a few days of fitting the appliances, the position of muscle balance is altered so that it becomes painful for the patient to retract the mandible. This has been described as the "pterygoid response" by McNamara[27] or the formation of a "tension zone" distal to the condyle by Harvold.[5] It is rare for such a response to be observed with functional appliances that are not worn full time. The muscle response findings with Twin-block, which is a 24-hour wear appliance, are not in agreement with the EMG research of several authors,[16,18,30,32,38] whereby no significant change in muscle activity, with or without appliances, was found with splint-like activator or its modifications, meant for intermittent wear.

From the significant increase in EMG activity of masseter and numeric increase in activity of anterior temporal muscles in our study, we deduce that active contraction of muscles plays a more important role in treatment with Twin-block than passive tension associated with viscoelastic properties of soft tissues unlike the activator. This increase in postural EMG activity may reflect an adaptation to a new mandibular position during the active phase of treatment with Twin-block.

The muscle activity in this study was examined only in the initial stage of the treatment with Twin-block. All subjects were in the active phase of sagittal correction by the end of 6 months wherein there were unbalanced and reduced number of occlusal contacts in the posterior dental arch segments. The Twin-block appliance had presumably imposed alterations in the neuromuscular region in the treated subjects, and a complete neuromuscular adaptation had not occurred as seen through the difference in EMG values without and with the Twin-block appliance in mouth, even at the end of 6 months. A 6 month observation period may not be lengthy enough to draw definite conclusions. The possibility of adaptation effects later with Twin-block treatment is an important factor.

## CONCLUSIONS

A definite muscle response of anterior temporalis and masseter muscles to the Twin-block functional appliance treatment was observed. The mean masseter activity during postural position increased significantly, progressing from the start to the first, third, and sixth months of treatment, indicating neuromuscular adaptations to the altered posture of the mandible. The most significant change occurred in the EMG activity of the masseter muscle during maximal voluntary clenching, which increased from the start to the end of 6 months. Significant changes in EMG activity were observed at the end of 3 months of the treatment, which was concomitant with a clinical improvement seen in sagittal jaw relationship.

The increased EMG activity during posture and maximal voluntary clenching supports active reflex contractions (motor unit stimulation) to play a dominant role in the neuromuscular changes with Twin-block treatment and not passive tension due to viscoelasticity of muscles.

We thank Dr Sanjay Sood, Department of Physiology, for his help in taking the EMG records.

## REFERENCES


1. Graber TM, Rakosi T, Petrovic AG. Dentofacial orthopedics with functional appliances. St Louis: CV Mosby; 1985.
2. Graber TM. Physiologic principles of functional appliances. St Louis: CV Mosby; 1985.
3. McNamara Jr JA. Neuromuscular and skeletal adaptations to altered function in the orofacial region. Am J Orthod 1973;64:578-606.
4. Woodside DG, Altuna G, Harvold E, Herbert M, Metaxas A. Primate experiments in malocclusion and bone induction. Am J Orthod 1983;83:460-8.
5. Harvold EP. The activator in interceptive orthodontics. St Louis: CV Mosby Co; 1974.
6. Ahlgren J, Bendeus M. Changes in length and torque of the masticatory muscles produced by the activator appliance. Swed Dent J 1982;15:15-35.
7. Andrésen V, Häupl K. Funktions—kieferorthopädie; Die Grundlagen des Norwegischen System. Leipzig: JA Barth; 1936.
8. Eschler J. Die funktionelle Orthopadie des Kausystems, Munchen: C. Hauser; 1952.
9. Selmer-Olsen R. En Kritisk betraktning over "Det norske system." Nor Tannlaegefor Tid 1937;47:85-91,134-42, and 176-93.
10. Umehara Y. An experimental study on the functional jaw orthopedics. J Stomatol Soc 1941;15:482.
11. Harvold EP, Vargervik K. Morphogenetic response to activator treatment. Am J Orthod 1971;60:478-90.
12. Vargervik K, Harvold EP. Response to activator treatment in Class II malocclusions. Am J Orthod 1985;88:242-51.
13. Woodside DG. Studies of functional appliance therapy. In: Graber TM, ed. Physiologic principles of functional appliances. St Louis: CV Mosby Company.
14. Herren P. The activator's mode of action. Am J Orthod 1959;45:512-27.
15. Witt E. Investigations into orthodontic forces of different appliances. Trans Eur Orthod Soc 1966;391-406.
16. Ahlgren J. An electromyographic analysis of the response to activator (Andrésen-Haüpl) therapy. Odontol Revy 1960;11:125.
17. Grosfeld O. Changes of muscle activity patterns as a result of orthodontic treatment. Trans Eur Orthod Soc 1965;41:203-14.
18. Thilander B, Filipsson R. 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. Acta Odontol Scand 1966;24:241-57.
19. Ahlgren J. The neurophysiologic principles of the Andrésen method of functional jaw orthopedics: a critical analysis and new hypothesis. Swed Dent J 1970;63:1.
20. Moss JP. Function: fact or fiction? Am J Orthod 1975;67:625-46.
21. Pancherz H, Anehus M. Masticatory function after activator treatment: an analysis of masticatory efficiency, occlusal contact conditions, and EMG activity. Acta Odontol Scand 1978;36:309-16.
22. Pancherz H. Long-term effects of activator (Andrésen appliance) treatment. Odontol Revy 1976;27:11-42.
23. Ahlgren J. Early and late electromyographic response to treatment with activators. Am J Orthod 1978;74:88-93.
24. McNamara JA, Carlson DS. Quantitative analysis of temporomandibular joint adaptation to protrusive functions. Am J Orthod 1979;76:593-611.

25. McNamara JA. Functional determinants of craniofacial size and shape. Eur J Orthod 1980;2:131-59.
26. Clark WJ. The Twin-block traction technique. Eur J Orthod 1982;4:129-38.
27. Clark WJ. The Twin-block technique. Am J Orthod Dentofacial Orthop 1988;93:1-18.
28. Yuen SWH, Hwang JCC, Poon PWF. Changes in power spectrums of electromyograms of masseter and anterior temporal muscles during functional appliance therapy in children. Am J Orthod Dentofacial Orthop 1990;97:301-7.
29. Moller E. The chewing apparatus: an EMG study of the action of the muscles of mastication and its correlation to facial morphology. Acta Physiol Scand 1966;69Supple280:1.
30. Stavridi R, Ahlgren J. Muscle response to the oral-screen activator: an EMG study of the masseter, buccinator, and mentalis muscles. Eur J Orthod 1992;14:339-49.
31. Ahlgren J. An electromyographic analysis of temporalis function in normal occlusion. Am J Orthod 1985;87:230-9.
32. Miralles R, Berger B, Bull R, Manns A, Carjaval R. Influence of the activator on electromyographic activity of mandibular elevator muscles. Am J Orthod Dentofacial Orthop 1988;94:97-103.
33. Moyers RE. An electromyographic analysis of certain muscles involved in temporomandibular movements. Am J Orthod 1950;36:481.
34. Carlsöö S. An electromyographic 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 the mandible. Acta Anat 1956;26:81-93.
35. Latif A. An electromyographic study of the temporalis muscle in normal persons during selected positions and movements of the mandible. Am J Orthod 1957;43:577-91.
36. Ralston HJ, Libet B. The question of tonus in skeletal muscle. Am J Phys Med 1953;32:85-92.
37. Fulton JF. A textbook of physiology, 17th ed. Philadelphia and London, WB Saunders Company; 1956.
38. Ingervall B, Bitsanis E. Function of masticatory muscles during the initial phase of activator treatment. Eur J Orthod 1986;8:172-84.
39. Pancherz H, Anehus-Pancherz M. Muscle activity in Class II Division 1 malocclusions treated by bite jumping with the Herbst appliance: an electromyographic study. Am J Orthod 1980;78:321-9.
40. Wood WW. A review of masticatory function. J Prosthet Dent 1987;57:222.
41. Goldberg LJ. Masseter muscle excitation induced by stimulation of periodontal and gingival receptors in man. Brain Res 1971;32:369-81.
42. Findlay IA, Kilpatrick SJ. An analysis of myographic records of swallowing in normal and abnormal subjects. J Dent Res 1960;39:629-37.
43. Noro T, Tanne K, Sakuda M. Orthodontic forces exerted by activators with varying construction bite heights. Am J Orthod Dentofacial Orthop 1994;105:169-79.