Influence of the activator on electromyographic activity of mandibular elevator muscles

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Integrated electromyographic (IEMG) activity was recorded in 15 children with Class II, Division 1 malocclusion undergoing treatment with an activator. EMG activity was recorded with surface electrodes from anterior temporal and masseter muscles, with and without the activator in the postural mandibular position, during saliva swallowing and maximal voluntary clenching. Similar IEMG activity in the postural mandibular position and during maximal voluntary clenching, with and without activator, was observed. During saliva swallowing, the activity in both muscles was significantly higher with the activator. This supports the rationale for diurnal wear of the activator. Simple linear regression analysis showed a significant negative correlation between the change of masseter muscular activity during saliva swallowing and age of the children ($r = -0.51$), suggesting that treatment with the activator should be started at an early age. (Am J Orthod Dentofac Orthop 1988;94:97-103.)

The most frequent treatment problem in the orthodontic practice is Class II, Division 1 malocclusion.[1] The solution to this problem can involve the use of functional and/or fixed orthodontic appliances.[2,3] One of the most common functional appliances used is the activator.[2]

The activator influence on electromyographic (EMG) activity of mandibular muscles in children with Class II, Division 1 malocclusion has been studied by several investigators. Andresen and Häupl[4] claimed that the protractor muscles of the mandible are stimulated and the retractor muscles inhibited by the use of an activator. On the contrary, Eschler[5] reported a stimulation of the retractor muscles as a result of stretching by the activator. Ahlgren[6] showed that during daytime wear of an activator, an increased postural activity was usually recorded in the masseter and suprahyoid muscles, but not in the temporalis muscles. Furthermore, muscle activity in biting contractions decreased considerably in all tested muscle areas. In addition, Ahlgren[7] produced evidence in support of Andresen's opinion that daytime use of an activator stimulated the protractor muscles and inhibited the retractors during occlusal contact in intercuspal position. Thilander and Filipsson[8] showed an insignificant postural muscular activity with the activator inserted. However, Moss[9] reported an increase in postural activity in patients treated with an activator.

The above-mentioned studies show that, although this treatment method has been used for more than 40 years, there is still much controversy regarding the changes of muscular activity produced by the activator. Therefore, the purpose of this study is to investigate the magnitude of the changes of EMG activity at different functional levels of the stomatognathic system in a group of children with Class II, Division 1 malocclusion undergoing activator treatment. We compare anterior temporal and masseter EMG activity in the postural mandibular position during swallowing of saliva and during maximal voluntary clenching, with and without the activator inserted.

METHODS

The study was carried out on 15 children with skeletal Class II malocclusion, six boys and nine girls, ranging in age from 8 to 15 years (mean, 11.1 years). They were selected according to the following criteria: convex profile, bilateral molar distoclusion with uniform and simultaneous contacts of posterior teeth, and involvement in orthodontic treatment with an activator. Table I shows the more prominent characteristics of the children studied. EMG activity, with and without the activator, was recorded after the period of use stated in the table. The interocclusal distance with the activator

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Table I. Characteristics of children in the study

Subject no.	*Age (yr)*	*Sex*	*Posterior occlusal contacts*		*Activator use period (mo)*	*Interocclusal distance with activator (mm)*	*Overjet (mm)*	*Overbite (mm)*
			Left	*Right*				
1	10	F	3	3	8	3	1	4
2	12	F	3	3	6	3	3.5	2.5
3	11	M	3	3	24	3	3	3
4	11	F	2	2	10	4	5	3.5
5	12	M	4	4	24	6	2	2
6	15	M	3	3	42	5	2	2
7	10	M	3	3	8	3	3	3
8	9	F	2	3	3	4	3	3
9	11	F	2	2	6	5	3	2
10	11	F	3	3	12	4	4	4
11	12	F	3	3	3.5	6	4	4
12	12	F	5	5	18	5	7	2
13	11	M	1	2	13	6	5	3
14	11	M	2	2	8	6	2	2
15	8	F	1	1	8	4	4	3

was measured as the increase in distance between two horizontal lines traced on the central incisors, with and without the activator.

The activator used in the present study (Fig. 1) corresponds to a modification of the original activator in which part of the acrylic structure has been replaced by a metal bar, thus diminishing weight and volume, and increasing the patient's comfort. The bite work for the activator is registered by instructing the patient to bite a wax roll in a forward position of the mandible until it reaches a bite-to-bite position of the incisors and until a 5-mm vertical distance can be measured between the cusps of the molars. Once this occlusal relation is obtained, the register in wax and the work models are mounted in an articulator (fixator). After laboratory work is finished, the trimming of the appliance is made, grinding the acrylic in the occlusal portion of molars and premolars. A vestibular inclination is given to this grinding, which causes an expansive effect at the level of these teeth. It also is given a mesial inclination in the lower molars and a distal inclination in the upper molars to permit the reduction of the occlusal Class II relationship in the posterior teeth. Each time the patient bites on the appliance, the inclined planes carved in the acrylic will guide the posterior teeth to the desired position. The action over the incisors and canines is accomplished by means of wire springs and labial arches.

Surface electrodes* were used for EMG recording. The electrodes were fixed on the left masseter muscle, 1 cm above and below the motor point, on a line running parallel to the ear border (tragus) across the motor point. In the left anterior temporal muscle, one electrode was attached approximately 1 cm above the zygomatic arc and 1.5 cm behind the orbital border; the other was placed 1.5 cm over the lower electrode. A large surface (approximately 9 cm^2) ground electrode was attached to the forehead (Fig. 2).[10,11] EMG activity was filtered (80 Hz to 100 KHz), amplified 1000 times, reamplified 10 to 50 times, integrated (time constant 1800 ms), and finally registered on a polygraph.*

Each child, sitting upright on a dental chair with the head supported and the Frankfurt plane parallel to the floor, inside a Faraday cage, was submitted to three recordings of EMG activity in the postural mandibular position and during swallowing of saliva and maximal voluntary clenching in the intercuspal position, with and without the activator. A typical record is shown in Fig. 3.

The sequence of the recordings with and without the activator was random, recording postural activity first, followed by swallowing of saliva, and finally by maximal voluntary clenching.

Each curve of postural activity lasted approximately 20 seconds and was divided into periods of 4 seconds. Values in the ordinate were obtained by manual measuring; the mean amplitude was then calculated for each curve.

During swallowing of saliva, the peak of integrated EMG (IEMG) activity was measured, allowing a resting

*Grass 5e and 5s, Grass Instrument Co., Quincy, Mass.

*Nihon Kohden RJD-4022, Nihon Kogyo Co., Ltd., Tokyo, Japan.

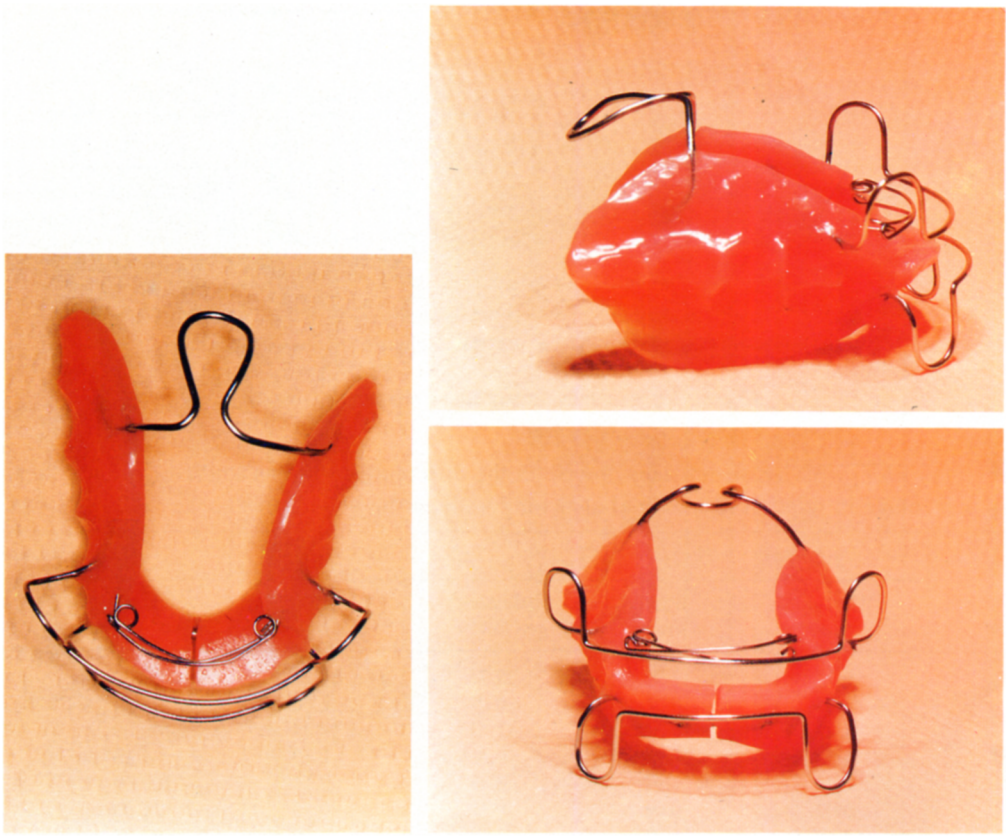

Fig. 1. Three views of activator used in the present study.

period of 30 seconds between each swallowing. During maximal voluntary clenching, the peak of IEMG activity was also measured. A resting period of 30 seconds between clenching was allowed to avoid muscular fatigue.

Subsequently, for each child a mean value based on the three curves in each condition and for each muscle was used because standard error values were negligible.

The mean value of IEMG activity obtained for each muscle during maximal voluntary clenching without the activator was assigned as 100%. The remaining mean values of the other conditions were referred to these values.

The paired comparison of IEMG activity with and without the activator in the postural mandibular position during swallowing of saliva and maximal clenching was performed through the Wilcoxon rank test.

The relationships between the change of IEMG activity with the activator and age, time of use of the activator, overjet, and overbite, and the increase of the vertical dimension produced by the activator were studied by means of a simple linear regression analysis.

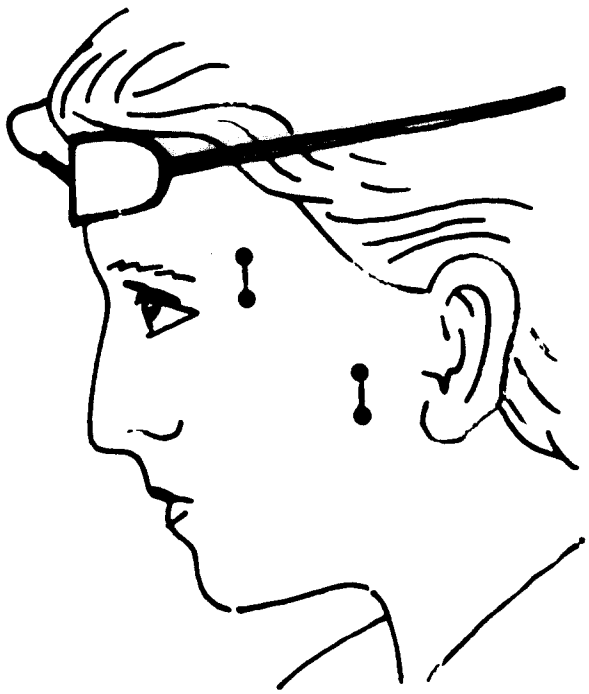

Fig. 2. Drawing demonstrating electrode placement on the masseter and anterior temporal muscles.

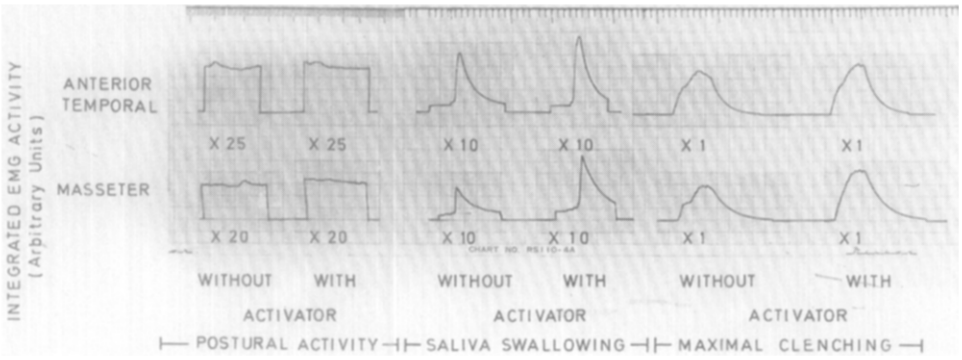

Fig. 3. Representative integrated EMG activity record.

Table II. Integrated EMG activity of masseter muscle in the different conditions studied (mean values are expressed as percentage in relation to maximal clenching without the activator)

	Postural activity		*Saliva swallowing*		*Maximal clenching*	
Subject no.	*Without activator*	*With activator*	*Without activator*	*With activator*	*Without activator*	*With activator*
1*	6.13	7.25	5.75	64.25	100.00	122.88
+	0.09	0.20	0.09	2.00	—	2.40
2*	8.23	8.35	11.81	14.44	100.00	131.26
+	0.09	0.30	0.60	1.10	5.10	2.10
3*	2.74	2.59	8.48	9.11	100.00	50.85
+	0.02	0.04	0.60	0.50	1.90	2.10
4*	12.12	11.02	44.63	79.06	100.00	342.15
+	0.20	0.07	1.20	5.30	6.00	31.60
5*	2.50	2.55	3.80	5.15	100.00	42.50
+	0.02	0.02	0.20	0.40	3.70	1.20
6*	3.47	6.07	7.16	8.89	100.00	147.00
+	0.05	0.20	0.10	0.90	2.90	1.90
7*	3.89	3.79	6.92	16.87	100.00	112.70
+	0.02	—	0.10	1.20	1.20	0.40
8*	3.30	3.48	4.96	53.57	100.00	146.35
+	0.02	0.04	0.20	0.10	2.90	2.30
9*	3.35	3.43	6.08	13.72	100.00	135.07
+	0.04	0.04	0.30	0.90	3.20	1.10
10*	11.51	12.23	14.63	15.59	100.00	47.96
+	0.49	0.60	0.30	0.20	1.70	2.50
11*	3.22	3.73	5.28	10.04	100.00	85.81
+	0.03	0.06	0.30	0.40	1.40	0.90
12*	3.92	4.30	19.00	24.95	100.00	74.31
+	0.01	0.01	2.10	0.90	3.90	2.00
13*	5.19	5.47	8.70	11.36	100.00	91.16
+	0.03	0.03	0.10	0.10	4.90	—
14*	25.00	22.50	46.50	76.50	100.00	325.00
+	0.00	0.01	1.60	—	5.20	29.50
15*	5.55	6.15	11.54	29.39	100.00	147.38
+	0.03	—	0.20	0.60	4.40	4.40

* = Mean value.
\+ = Standard error.

RESULTS

Tables II and III show the mean values of IEMG activity for each child in the masseter and anterior temporal muscles, respectively, and in the postural mandibular position during swallowing of saliva and during maximal voluntary clenching, with and without the activator.

Fig. 4 gives the group mean of IEMG activity for

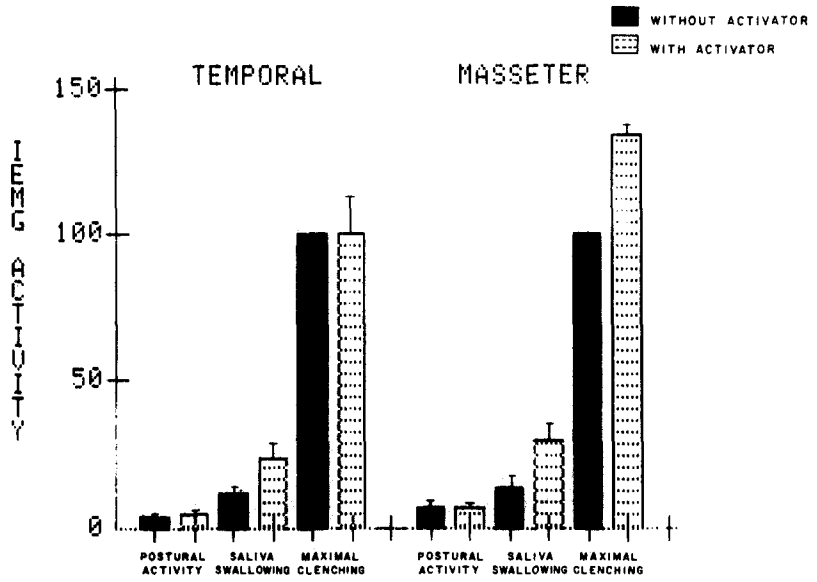

Fig. 4. Group mean of integrated electromyographic (IEMG) activity of the anterior temporal and masseter muscles with and without the activator during different conditions studied.

each condition recorded. It is possible to observe similar postural activity for both muscles, whereas during swallowing of saliva, the activity is higher with than without the activator. During maximal clenching, similar activity is noted in the anterior temporal muscle and higher activity in the masseter muscle with the activator.

IEMG activity of both muscles with and without the activator is compared in Table IV. During swallowing of saliva, the change in activity was significant for both muscles, whereas in the postural mandibular position and during maximal voluntary clenching, changes were not significant.

The only significant correlation demonstrated by simple linear regression analysis was that between the change of masseter IEMG activity during saliva swallowing, with and without the activator, and age of the children ($r = -0.51$).

DISCUSSION

The results of the present study show similar tonic IEMG activity with and without the activator. This is in accordance with Thilander and Filipsson,[8] but in opposition to Ahlgren[6] with respect to the masseter muscle and to Moss[9] with respect to the anterior temporal and masseter muscles—both showed an increase in tonic activity with the use of the activator.

The absence of variation of tonic IEMG activity with the activator inserted can be explained by a compensation between a mechanic advantage and vertical dimension on the one hand, and by gravitational force vectors on the other. The anterior repositioning of the jaw determines an increase of the mechanic advantage, thus decreasing IEMG activity. Furthermore, beyond the freeway space, the increase of vertical dimension produced by the activator (mean = 4.49 mm of interocclusal distance) determines a decrease of tonic activity as has been demonstrated in previous works.[12-14] Contrary to this, the gravitational component increases with jaw repositioning, causing a higher stimulation of neuromuscular spindles of jaw elevator muscles and thus reflexly increasing EMG activity.

In relation to saliva swallowing, results showed significantly higher IEMG activity for both muscles with the activator inserted, particularly noticeable in the masseter muscle. It has been demonstrated that EMG activity from the anterior temporal and masseter muscles is lower in Class II, Division 1 malocclusion than in normal occlusion.[15,16] Furthermore, Ahlgren, Ingervall, and Thilander[17] showed higher EMG activity of anterior temporal and masseter muscles in normal occlusion than in postnormal occlusion, probably caused by better stabilization of the mandible in the intercuspal position in normal occlusion.

During saliva swallowing, the higher activity with the activator is probably a result of better mandible stabilization and the increase of occlusal contact area, indicating that muscular force is distributed over a higher periodontal area. This means a lower pressure over the periodontal ligament, indicating lower inhibition of the jaw elevator muscles mediated by periodontal mechanoreceptors. In addition, the activator leaves the anterior teeth, which present a lower mechanoreceptor threshold, in disclusion, thus diminishing further jaw elevator muscle inhibition.

Table III. Integrated EMG activity of anterior temporal muscle in the different conditions studied (mean values are expressed as percentage in relation to maximal clenching without the activator)

	Postural activity		*Saliva swallowing*		*Maximal clenching*	
Subject no.	*Without activator*	*With activator*	*Without activator*	*With activator*	*Without activator*	*With activator*
1*	6.58	6.41	10.44	60.00	100.00	131.58
+	0.10	0.10	0.30	7.10	2.20	3.60
2*	5.67	7.94	5.88	7.10	100.00	117.21
+	0.04	0.10	0.20	0.40	1.40	2.30
3*	1.97	2.38	11.01	4.90	100.00	24.19
+	0.04	0.01	0.70	0.30	3.50	1.40
4*	2.13	2.36	13.05	30.06	100.00	101.30
+	0.01	0.04	1.40	2.80	3.20	5.60
5*	2.67	2.41	6.70	3.15	100.00	72.85
+	0.05	0.02	0.90	0.20	2.00	1.50
6*	3.19	5.11	16.66	23.28	100.00	123.84
+	0.10	0.30	0.50	1.40	2.70	1.30
7*	1.57	1.60	6.60	9.40	100.00	83.33
+	0.01	0.00	1.00	0.40	1.70	3.00
8*	1.57	2.04	6.26	56.25	100.00	138.97
+	0.03	0.09	0.60	0.80	2.70	1.80
9*	7.43	7.57	10.00	55.71	100.00	204.71
+	0.03	0.03	0.30	4.00	1.80	2.60
10*	1.95	1.89	2.88	3.60	100.00	26.58
+	0.03	0.05	0.30	0.20	0.50	2.20
11*	1.77	1.49	2.21	3.58	100.00	58.59
+	0.20	0.01	0.20	0.20	4.40	1.50
12*	2.38	3.30	25.92	21.23	100.00	70.00
+	0.10	0.04	3.40	1.40	1.50	3.60
13*	8.23	8.19	7.73	8.91	100.00	59.66
+	0.01	0.02	0.02	0.80	5.40	0.70
14*	7.10	5.75	24.23	42.00	100.00	152.11
+	0.02	0.01	0.50	2.50	4.90	5.70
15*	3.05	2.89	15.05	19.50	100.00	133.90
+	0.01	0.02	0.40	1.30	2.10	2.70

* = Mean value.
+ = Standard error.

Table IV. Comparison of integrated EMG activity with and without activator during the different conditions studied (Wilcoxon rank test)

	Muscle	
Condition	*Masseter*	*Anterior temporal*
Postural activity	NS	NS
Saliva swallowing	**	*
Maximal clenching	NS	NS

*$P < 0.05$; **$P < 0.01$; NS = nonsignificant.

Group mean IEMG activity during maximal voluntary clenching did not differ with or without the activator. According to Ahlgren,[6] the activity for both muscles diminishes with the activator in some children (subjects 3, 5, 10, 11, 12, and 13); in others it significantly increases (subjects 1, 2, 6, 8, 9, 14, and 15) (Tables II and III). An increase of IEMG activity may be expected with the activator because of a lower inhibition of jaw elevator muscles mediated by periodontal mechanoreceptors. Nevertheless, in some children apprehension for soft-tissue damage and/or activator breakage could induce the lower activity registered with the activator during maximal voluntary clenching.

It is important to consider that in the present study the comparison with and without the activator was performed in children with different periods of activator wear (minimum of 3 months, maximum of 42 months). Although this could explain the disparity in the modification of tonic and maximal clenching activity with those reported in previous investigations,[6,9] no significant correlation was found between use period and IEMG activity change. The significant negative correlation between masseter muscular activity change dur-

ing saliva swallowing and age of the children demonstrates that the change in activity is greater for younger children and suggests that treatment with the activator should be started at an early age.

In summary, we find a significant increase of IEMG activity only with the activator inserted during saliva swallowing. This supports the recommendation for diurnal wear of the activator because it has been demonstrated that the frequency of saliva swallowing during sleep is very low.[18] The higher activity during saliva swallowing with the activator is particularly important because it is a functional activity repeated between 600 and 2400 times each day.[18-22] Furthermore, it has been demonstrated that subjects with Class II, Division 1 malocclusion swallow more frequently[2,6] and there is evidence that the activator determines a reflex increase of saliva secretion, which could also increase swallowing frequency.[6,8]

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