EMG STUDY OF MASSETER AND ANTERIOR TEMPORAL MUSCLES IN CLASS II DIV. 1 MALOCCLUSION TREATED WITH ACTIVATOR

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE (ORTHODONTICS)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2006

ISBN 974-04-7003-3

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was submitted to the Faculty of Graduate Studies, Mahidol University
For the degree of Master of Science (Orthodontics)
on
16 March, 2006

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ACKNOWLEDGEMENT

I would like to express my deep appreciation and gratitude to my advisory committee: Assistant Professor Paisal Chaiwat, Assistant Professor Suwannee Luppanapornlarp and Assistant Professor Panupen Sitthisomwong for their guidance, supervision, encouragement, comments, suggestions, understanding and patience.

My special thanks go to Associate Professor Jiraporn Chaiwat, Associate Professor Surachai Dechkunakorn and Associate Professor Isaravadee Visetsiri for providing me the subjects in this study, Dr. Peerapong Santiwong and Dr. Priyada Santilakanawong for EMG information.

I continue to be most thankful to Associate Professor Noppakun Vongsavan for physiologic knowledge, Assistant Professor Panjit Chunhabundit for anatomical knowledge, and Associate Professor Kulaya Narksawat, Associate Professor Dusit Sujirarat, Associate Professor Terdphong Triratana and Mrs. Suwanna K. Suwannawong for the helpful on statistical analyses.

Thank to Mr. Boonlert Ruchikaew and Mrs. Rachaneekorn Patphun for construction of activator appliances.

I deeply thank my colleagues in Orthodontics for all their assistances. I have learned much from them and hope to repay in kind.

Finally, a very special thank to my parents, family and friends who provide me the time and support needed to complete my study.

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ABSTRACT

The purpose of this study was to evaluate the muscle activities in Class II division 1 patients treated with activator during 12 months of observation period and until Class I molar relation achievement, and then compared with the untreated group. The subjects consisted of 25 activator treated and 6 untreated patients. Electromyographic recordings of the masseter and anterior temporal muscles activities were recorded bilaterally in maximum bite of habitual clenching and swallowing.

The results showed that the EMG activities of the masseter and anterior temporal muscles decreased both sides in maximum bite of habitual clenching with significant differences at 12 months of observation period ($p<0.05$). The untreated group presented higher EMG activities than in the treated group with significant difference only in the right side at 12 months of observation period ($p<0.05$). In swallowing, the EMG activities in both groups tended to decrease with no significant differences in both sides and both muscles at 12 months of observation period. Accordingly, no significant differences of the EMG activities were found between both groups in swallowing. When Class I molar relation achievement, the EMG activities of the treated group showed a decrease in both sides and both muscles with significant difference only in the right side of masseter and both sides of anterior temporal muscles in maximum bite of habitual clenching ($p<0.05$). In swallowing, the EMG activities tended to decrease in both sides and both muscles but showed no significant differences.

This study indicated that the EMG activities were influenced by the occlusal instability created during the activator treatment. Accordingly, the complete neuromuscular adaptation has not occurred during 12 months period. However, in the treated patients, the clinical improvement was seen when compared with the untreated group. The results suggest a further study to evaluate the activities of those muscles at the time when all teeth are in proper occlusion to elucidate the definite conclusion and preventing relapse.

KEY WORDS: CLASS II DIVISION 1 / ACTIVATOR / ELECTROMYOGRAPHIC

56 P. ISBN 974-04-7003-3

การศึกษาคลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อแมสซีเตอร์และเทมโพรอลส่วนหน้า ในผู้ที่มีการสบฟันผิดปกติประเภทที่ 2 ชนิดที่ 1 ซึ่งทำการรักษาด้วยเครื่องมือแอคติเวเตอร์ (EMG STUDY OF MASSETER AND ANTERIOR TEMPORAL MUSCLES IN CLASS II DIV. 1 MALOCCLUSION TREATED WITH ACTIVATOR)

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลการทำงานของกล้ามเนื้อแมสซีเตอร์และเทมโพรอลส่วนหน้า ในผู้ป่วยที่มีการสบฟันผิดปกติประเภทที่ 2 ชนิดที่ 1 ที่รักษาด้วยเครื่องมือแอคติเวเตอร์ โดยทำการวัดคลื่นไฟฟ้าและบันทึกผลการทำงานของกล้ามเนื้อทั้งสองด้านขณะกัดฟันและกลืน ในช่วงเวลา 12 เดือน และจนกระทั่งได้ความสัมพันธ์ของฟันกรามแท้เป็นแบบที่ 1 กลุ่มตัวอย่างประกอบด้วยผู้ป่วยที่ได้รับการรักษาด้วยเครื่องมือแอคติเวเตอร์จำนวน 25 ราย และกลุ่มที่ยังไม่ได้รับการรักษา 6 ราย

ผลการศึกษาพบว่า กลุ่มที่ได้รับการรักษาและกลุ่มควบคุมมีการทำงานของกล้ามเนื้อแมสซีเตอร์และเทมโพรอลส่วนหน้าทั้งสองด้านในขณะกัดฟันลดลงอย่างมีนัยสำคัญในช่วง 12 เดือนของการรักษา ($p<0.05$) เมื่อเปรียบเทียบกลุ่มทั้งสอง พบว่ากลุ่มควบคุมมีการทำงานของกล้ามเนื้อทั้งสองมัดสูงกว่าแต่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติเฉพาะด้านขวา ($p<0.05$) นอกจากนี้พบว่าทั้งสองกลุ่มมีแนวโน้มของการทำงานของกล้ามเนื้อทั้งสองมัดทั้งซ้ายและขวาในขณะกลืนลดลงอย่างไม่มีนัยสำคัญทางสถิติ และไม่พบความแตกต่างระหว่างกลุ่ม ส่วนกลุ่มที่ได้รับการรักษาจนกระทั่งได้ความสัมพันธ์ของฟันกรามแท้เป็นชนิดที่ 1 พบว่าในขณะกัดฟันมีการลดลงของการทำงานของกล้ามเนื้อทั้งสองมัด แต่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของการลดลงเฉพาะด้านขวาของกล้ามเนื้อแมสซีเตอร์และกล้ามเนื้อเทมโพรอลส่วนหน้าทั้งซ้ายและขวา ($p<0.05$) ส่วนในขณะกลืนมีแนวโน้มลดลงของการทำงานของกล้ามเนื้อทั้งสองมัดทั้งสองด้านแต่ไม่มีนัยสำคัญ

การศึกษานี้แสดงให้เห็นว่า การเปลี่ยนแปลงของการสบฟันในช่วง 12 เดือน ของการรักษาด้วยเครื่องมือแอคติเวเตอร์ส่งผลต่อการเปลี่ยนแปลงการทำงานของกล้ามเนื้อบดเคี้ยว นอกจากนี้การสบฟันที่ยังไม่ครบเต็มที่จะมีอิทธิพลต่อการทำงานของกล้ามเนื้อบดเคี้ยวเช่นกันอันเนื่องจากการปรับตัวของระบบประสาทกล้ามเนื้อที่อาจยังไม่สมบูรณ์ อย่างไรก็ตามพบว่าผู้ป่วยที่ได้รับการรักษาด้วยเครื่องมือนี้มีการเปลี่ยนแปลงทางคลินิกที่ดีขึ้นเมื่อเทียบกับกลุ่มควบคุม การวิจัยนี้เสนอแนะว่าควรมีการศึกษาต่อถึงผลของกล้ามเนื้อบดเคี้ยวต่อการรักษาในผู้ป่วยที่มีการสบฟันผิดปกติประเภทที่ 2 ชนิดที่ 1 ด้วยเครื่องมือแอคติเวเตอร์จนได้ลักษณะของการสบฟันที่ดีเพื่อให้เกิดการปรับตัวอย่างสมบูรณ์ของระบบประสาทกล้ามเนื้อ และอาจจะลดการคืนกลับสู่สภาพก่อนการรักษาได้ภายหลังเสร็จสิ้นการรักษา

56 หน้า ISBN 974-04-7003-3

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CHAPTER I
INTRODUCTION

In the last 30 years, functional appliance therapy has become a generally accepted method to treat discrepancies of sagittal jaw relations in children. Until now, this method shows its greatest application and success in Class II malocclusions. A variety of different functional appliances are available. The appliance selection for the treatment can be adapted to the type of anomaly and to the growth pattern. The growth direction, the growth amount, and the timing are relevant to the ultimate success of treatment. Functional appliances are shown to modify the neuromuscular environment of the dentition and associated bones. However, the interaction between bone and the mechanism of neuromuscular adaptation to functional appliance therapy is very complex. One of the most common functional appliances used is the activator. The influence of the activator on electromyographic activity of mandibular muscles in children with Class II division 1 malocclusion has been studied by several investigators (1-5). Due to the diversity of samples, different recording techniques, types of electrodes, timing of treatment, varying in designed appliances and individual variation, it is difficult to conclude the effectiveness of the activator. Although there were studies about the effect of the activator on muscle activities, the long term effect is not clear.

Thus the present study would be undertaken to provide further evaluation of the masseter and anterior temporal muscle activities in maximum bite of habitual clenching and swallowing during activator treatment without the appliance in the mouth in long term treatment between treated and untreated patients.

CHAPTER II
OBJECTIVES

The Purposes of this Study are as Follows:

1. To evaluate the muscle activities in Class II division 1 patients treated with activators in masseter and anterior temporal muscles in maximum bite of habitual clenching and swallowing during 12 months of treatment and until Class I molar relation.

2. To evaluate the muscle activities in Class II division 1 patients untreated with activators in masseter and anterior temporal muscles in maximum bite of habitual clenching and swallowing during 12 months of observation period.

3. To compare the muscle activities in Class II division 1 patient treated and untreated with activators during 12 months of observation period.

The Expected Benefits of this Study

1. The investigation will elucidate the muscle activities treated with activators in Class II division 1 patients.

2. The results from this study will be a guideline for diagnosis and treatment planning in orthodontic treatment.

CHAPTER III
LITERATURE REVIEW

Functional Appliances

According to Bishara and Ziaja (6), the term “functional appliance” refers to a variety of removable appliances designed to alter the arrangement of various muscle groups that influence the function and position of the mandible in order to transmit forces to the dentition and the basal bone. Typically altering the mandibular position sagittally and vertically, resulting in orthodontic and orthopedic changes, generated these muscular forces. Many types of functional appliance use the activity of the masticatory, facial, lip and tongue musculature to transmit force through the teeth onto the periosteum and bone. These forces induce the dentoalveolar adaptations and effect on growth of maxilla and mandible; for example, Activator, Twin block, Bionator, Oral screen etc. Many types of functional appliances are designed to prevent or eliminate force of the masticatory facial, lip and tongue musculature namely Frankel appliance. It is tissue-born appliance while it facilitates active muscular training. The buccal and labial shields relieve the muscle pressure on the teeth causing the crowns to tip buccally. The buccal shields are positioned to maximal depth of the vestibule thus producing an outward pull on the periosteal tissue. This force is transmitted through the muscle fibers and connective tissue onto the alveolar bone, where it induces lateral movement of the alveolus. Although it is in fact a fixed bite-jumping appliance, the Herbst appliance is discussed with functional appliances because its biologic mode of action includes effects on the masticatory musculature.

A functional appliance is considered to stimulate mandibular growth in growing patients with retrognathia. One of the most common functional appliances used is the activator. Andresen and Haupl (7) in 1936 believed that the repetition of the new mandibular closure pattern induced musculoskeletal adaptation and resulted in the reduction of the orafacial musculature. The muscular force generated by the forward mandible positioning was transferred to maxillary and mandibular teeth through the acrylic body and labial bow. These forces produced the effect on growth of maxilla and mandible and causing dentoalveolar adaptation. The construction bite determines the sagittal and vertical displacements of the mandible, the degree and direction of appliance activation. Varying in construction bite depends on the objective of treatment. Many types of activators has been constructed and named after the constructor. With its large forward bite registration, the Herren activator is claimed to act as a splint (8). During mouth closure the mandible is guided anteriorly, when the appliance is in place, the masticatory muscles are in the forced lengthened or shortened condition compared to their rest length. The resulting tonus alteration of the musculature would cause the mandible to turn back to its original position during rest, but this is restricted by the activator's forced guidance. The Harvold-Woodside activator is designed to affect the recruitment of certain masticatory and facial muscles and to control the eruption of teeth (9). In contrast to the Andresen activator, it is constructed to interfere with the postural position of the mandible and with the vertical distance between the jaws. The activator should serve to stretch certain selected muscle groups using the elastic properties of the muscles and the isometric contractions elicited by the appliance. This activator keeps the mandible extended beyond the rest position and the elasticity of the muscles moves the mandible toward the rest position. The forces can be transmitted to the teeth in order to correct malpositions even though the patients are relaxed and asleep. The isometric constructions, which result from the stretching, exercise the muscles, thus changing the muscle matrix. All the muscles that are selectively stretched are affected in this fashion. By keeping the mandible at a level extending beyond the rest position, the activator strengthens the facial muscles, particularly the buccinators and the lips. According to Harvold, the activator does not elicit responses in the mechanisms controlling the growth of the jawbones, but merely induces changes in the musculature supporting the mandible relative to the maxilla and finally are arrangement of the muscle attachments. Table 1. demonstrates the numerous differences in construction bite design (6).

Table 1. Variation in the construction bite of activators.

Method of action	Vertical construction bite	Anteroposterior construction bite
Dentoalveolar		
Bjork 1951	5 mm. increase	Class I molar
Wieslander and Lagerstrom 1979	5 mm. increase	Class I molar
Primarily dentoalveolar with orthopedic effect		
Harvold and Vangervik 1971	5-6 mm. increase beyond rest position	End to end incisor
Pancherz 1984	5-7 mm. increase beyond rest position	Class I molar / greater
Vargervik and Harvold 1985	7-8 mm. increase beyond rest position	-
Condylar		
Birkebaek, Melsen and Terp 1984	Greater than 2 mm. beyond rest position	End to end incisor
Other		
Luder 1982	3-5 mm. increase beyond rest position	3-4 mm.
Williams and Melsen 1982	2-3 mm. increase beyond rest position	End to end incisor

Source: Bishara and Ziaja, 1989 (6)

Muscles of Mastication

The musculature has been cited as an influence factor in development of malocclusion and in relapse after orthodontic therapy. Diverse views concern the activity of masticatory muscles in type of malocclusion. This suggests not only a morphologic different between Angle's classification, and also a physiologic different reflected in the distribution of activity within the musculature. Many authors suggested that the activity recorded in cases of such malocclusions differ from that in normal cases (10-16). The relationship between the masticatory muscle activities has been studied electromyographically (EMG) by various researchers. Most studies were concerned with the activity in temporal and masseter muscles. Because of these muscles lie superficially and EMG can be recorded with satisfactory results.

Muscles of mastication consist of the masseter, the temporal, the medial pterygoid and the lateral pterygoid muscles (17) showed in Figure 1. All muscles that are attached to mandible have an influence on its movements and positions. Muscles move parts only by pulling them. Hence, the musculoskeletal apparatus is designed in opposing systems. Agonists act to pull in a given direction while antagonists pull in the opposite direction to bring parts back to the original position. A muscle is organized in functional units. The unit consists of a number of muscle fibers innervated by the same motoneuron. These motor units vary in sizes. Muscles controlling fine, swift, subtle movements and adjustments are made up of the smallest number of muscle fibers per motoneuron (muscles of ear ossicles, larynx, and pharynx have less than 10 fibers per motoneuron). Muscles involved in grosser performance have the largest number of muscle fibers per motoneuron. Jaw muscles seem to range between these extremes (about 600 to 900). Activating an increasing number of motor units while, at the same time, reducing the action of antagonists, makes movements. The masseter and the medial pterygoid are associated as a sling, and for the most they pull in an upward and forward direction. The most massive portion of the temporal lies anteriorly, and it pulls upward in a practically vertical direction. The pull of lateral pterygoid is forward in a practically horizontal direction. The resultant of the vertical component of the temporal and the horizontal component of the lateral pterogoid is upward and forward, which is in coordination with the masseter-pterygoid sling.

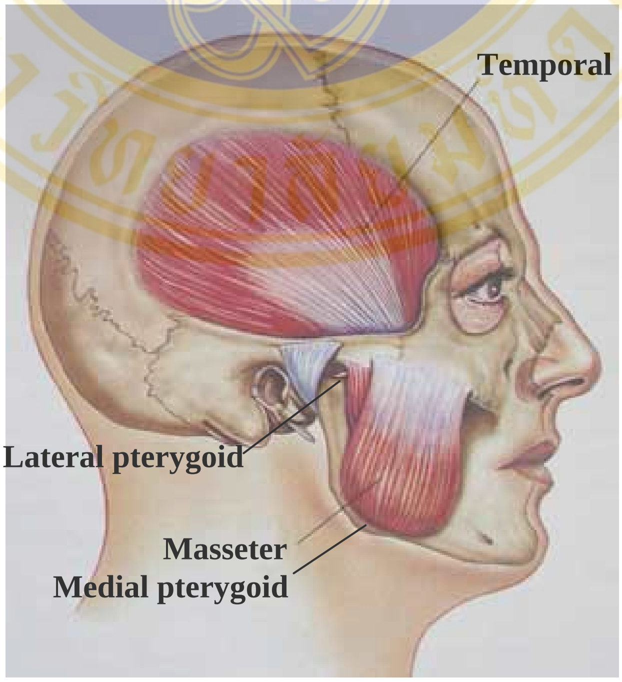

Figure 1. The muscles of mastication.

Source: Sicher, 1980 (17)

Masseter muscle: the most superficial of the masticatory muscles, stretches as a rectangular plate from the zygomatic arch to the outer surface of the mandibular ramus. The origin consists of two heads; the superficial head arises from superficial aspect of anterior 2/3 of lower border of zygomatic arch, the deep head arises from posterior 1/3 of lower border and through medial surface of zygomatic arch. The insertion attaches at lateral surface of mandibular ramus, coronoid process of mandible and angle of mandible. The masseteric nerve, the branch of anterior trunk of V_3, supplies the muscle; it reaches and enters the muscle from its deep surface after passing through the semilunar notch of the mandible. The action of the muscle is that of a powerful elevator of lower jaw closing the jaw and exerting pressure on the teeth, especially in the molar region.

Temporal muscle: the fan-shaped, the anterior fibers are vertical; the fibers in the middle part of the muscle are increasingly oblique. The most posterior fibers run horizontally forward to bend sharply downward in front of the articular eminence to reach the mandible. The origin extends from the floor of temporal fossa and deep surface of temporal fascia. The insertion fibers pass through deep zygomatic arch and fuse to thick tendon and attach to anterior and posterior borders, apex and medial surface of coronoid process of mandible. Further more the tendinous extensions have two tendons; the superficial (outer) tendon is attached to the anterior border of coronoid process and mandibular ramus, the deep (inner) tendon is inserted to the temporal crest of mandible. The deep tendon is stronger and longer than the superficial tendon, it just medially and reaches downward into the region of the lower wisdom tooth. The retromolar fossa of the mandible between the superficial and deep tendon is free from the insertion of the temporal muscle fibers. The innervation is provided by the anterior and posterior deep temporal branches of anterior trunk of V_3. The action of the muscle, built more for movement than for power, is mainly an elevator of the mandible. Its middle fibers have a retracing component because of their oblique direction downward and forward. It's most posterior fibers act as retrusion of mandible because of their horizontal direction.

Medial pterygoid muscle: situate on the medial side of the mandibular ramus, is anatomically and functionally a counterpart of the masseter muscle. It is a rectangular, powerful muscle, although it is not as strong as the masseter muscle. The origin consists of two heads; the superficial head is attached to the lateral surface of the pyramidal process of palatine bone and the tuberosity of maxilla, the larger deep head is attached to the medial surface of the lateral pterygoid plate and the grooved surface of the pyramidal process of palatine bone. The fibers of the medial pterygoid muscle run downward, backward and outward direction. The field of insertion is at the medial surface of the mandibular angle. The innervation is provided by the medial pterygoid muscle which the branch of undivided trunk of V_3. The muscle is a synergist of the masseter and temporal muscles, especially of its superficial part; therefore, the action is an elevator of the mandible.

Lateral pterygoid muscle: arises from two heads; the smaller superior head originates from the infratemporal surface and the crest of greater wing of sphenoid bone, the larger head originates from the lateral surface of the lateral pterygoid plate. The insertion fibers is attached to the anteromedial surface of the articular capsule and thus indirectly to the anterior border of the articular disc. The majority of the fibers are inserted to the anterior surface of the mandibular neck. The nerve to the lateral pterygoid muscle branches off the masseteric or the buccal nerves, the branch of anterior trunk of V_3. The action of the muscle is the chief protractor of lower jaw; protect backward displacement of the articular disc and the head of mandible while opening the mouth. Lateral pterygoid muscle coordinate with the digastric muscle while opening mouth.

Electromyographic Activity

According to Scott (18) and De Luca (19), The term “ Electromyographic activity (EMG) ” refers to the small electrical currents are generated by muscle fibers prior to the production of muscle force. These currents are generated by the exchange of ions across muscle fiber membranes, a part of signaling process for the muscle fiber to contract. EMG can be measured by applying conductive elements or electrodes to the skin surface, or invasively within the muscle. The electrode can classify into two categories; the surface electrode (measurement of muscle bundle) and the needle electrode (measurement of motor unit, muscle fiber).

Surface EMG is more common method of measurement, since it is non-invasive, can be conducted by personal and has minimal risk to subjects. Measurement of surface EMG is dependent on a number of factors. The amplitude of the surface EMG signal (sEMG) varies from the μV to the low mV range. The amplitude, time and frequency domain properties of sEMG signal are dependent on factors such as the timing and intensity of muscle contraction, the distance of electrode form the active muscle area, the properties of overlying tissue (thickness of overlying skin and adipose tissue), the electrode and amplifier properties and the quality of contact between the electrode and the skin. In most cases, information on the time and intensity of muscle contraction is desired. There are methods to reduce the impact on the sEMG signal by using the same electrodes and amplifier, ensuring consistency in the quality of contact between the electrodes and the skin. Within subjects, the variability of the sEMG signal can also be reduced in consecutive recording sessions by placing the electrodes over the same skin location. The most important of the method is the reduction of the ambient noise (the noise is generated by electromagnetic devices), the transducer noise (the noise is generated at the electrode-skin junction) and cross-talk (the signal from neighboring muscle). These factors can be avoided by using the appropriate size of the electrodes, the conductive gel, the bipolar Ag-AgCl electrodes, the inter-electrode distance of 20 mm. The inter-electrode distance should not exceed ¼ of muscle fiber length. The position of electrode is in the middle of muscle between the origin and insertion. The reference electrode should be placed as far away as possible and on electrical neutral tissue (over bony prominence). EMG signal can determine the activation timing of the muscle, estimate the force produced by the muscle and obtain an index of the rate at which a muscle fatigue through the analysis of frequency spectrum of the signal.

The Muscular Activities in Different Types of Occlusion

The review literatures in an eletromyographic investigation were shown in Table 2 to compare the differences in sample, type of electrodes, type of muscles and type of masticatory function. Most researches (10-15) studied in the growing children. In growing children, many researchers found no significant differences in the masseter and anterior temporal muscular activities in rest position between Class II division 1 and normal occlusion (11, 15). In maximum clenching, the EMG activities of the masseter and anterior temporal muscles in Class II division 1 were lower than in normal occlusion (15). In chewing the EMG activities of the masseter and anterior temporal muscles in Class II division 1 were lower than in normal occlusion (11), however, the EMG activities of temporal muscles were found no significant difference (13). In maximum bite in the intercuspal position, there were differences in results because of the occlusal instability and different sides of the placement of the electrode (13, 15). Pancherz (13) found that the EMG activities of the masseter and temporal muscles in Class II division 1 were lower than in normal occlusion, whereas Lowe and Takada (15) found no significant differences. In swallowing, the children with Class II division 1 exhibited less EMG activities in the masseter and anterior temporal muscles than the children with normal occlusion (11), however, Lowe and Takada (15) found no significant differences.

Miralles et al. (16) found that the postural activities for the masseter and anterior temporal muscles were higher in Class III than in Class I and Class II, whereas in Class I and Class II subjects' activities were similar. During swallowing, the masseter muscle activities in Class III were higher than in Class I and Class II, whereas the anterior temporal muscle activities were higher in Class III than in Class II, no significant differences between Class III and Class I, Class II and Class I. During maximum voluntary clenching, the activities were not different among classes.

In normal occlusion, the postural EMG of the posterior temporal muscles was found to be greater than in the anterior temporal muscles (12). During chewing and maximal bite, the EMG activities in the masseter and temporal muscles were large in cases with a tendency to parallelism between the jaws bases and between the mandibular lines (rectangular shape of the face in profile and small lower face high).

According to Lowe et al. (14), in Class II division 1, high anterior temporal activities were correlated with flat palatal planes and large ramus heights. High masseter activities were correlated with upright maxillary incisors in rest position.

Table 2. The muscular activities in different types of occlusion.

Author	Sample	Electrode	Muscle	Function
Ahlgren et al. 1973 (11)	1.Normal: 15 cases Age 9-11 y. 2.Cl.II div.1: 15 cases Age 9-13 y.	1.Bipolar surface in masseter + orbicularis 2.Hook in Ant. + Post.temporal	Left of 1.Ant.temporal 2.Post.temporal 3.Masseter 4.Superior orbicularis	1.Rest position 2.Chewing 3.Swallowing
Pancherz 1980 (13)	1.Cl.I: 23 cases Age 11.6 y. 2.Cl.II div.1: 23 cases Age 11.9 y.	Bipolar hook	Bilateral of 1.Temporal 2.Masseter	1.Maximum bite in intercuspal position 2.Chewing
Lowe and Takada 1984 (15)	1.Cl.I: 18 case 2.Cl.II div. 1: 25 cases 3.Cl.II div. 2: 12 cases Age 11.9 y.	Bipolar surface	Left of 1.Ant.temporal 2.Masseter 3.Orbicularis	1.Rest 2.Maximum bite 3.Maximum clenching 4.Jaw opening 5.Swallow
Miralles et al. 1991 (16)	Young adult: 33 cases (Cl. I, Cl. II, Cl. III) Age 16-30 y.	Bipolar surface	Left of 1.Ant.temporal 2.Masseter	1.Postural 2.Maximum clenching 3.Swallowing
Ingervall and Thilander. 1974 (12)	Normal F : 27 cases M : 25 cases Age 9-11 y.	1.Bipolar surface in masseter + orbicularis 2.Hook in Ant. + Post.temporal	Bilateral of 1.Temporal (Ant.+Post.) 2.Masseter 3.Orbicularis	1.Postural 2.Chewing 3.Swallowing 4.Maximum bite
Lowe et al. 1983 (14)	Cl.II div. 1: 20 cases Age 11.6 y.	Bipolar surface	Left of 1.Ant.temporal 2.Masseter 3.Orbicularis	1.Rest 2.Maximum bite in intercuspal position 3.Maximum clenching 4.Jaw opening

The Muscular Activities in Activator Treatment

The review of literatures in an eletromyographic activity in activator treatment was shown in Table 3 to compare the differences in sample, method of treatment, type of electrodes, type of muscles and type of masticatory function.

Since Andresen and Haupl introduced functional jaw orthopedics (activator) in 1936, diverse views have been presented including the neuromuscular responses brought about with activator treatment. They claimed that the activities of the jaw closing muscles are produced by the activator, which stimulates the protractor muscles and inhibit the retractor muscles of the mandible. Eschler supported Andresen and Haupl but claimed that the retractor muscles are stimulated, not inhibited, by activators.

According to Ahlgren (1), during daytime use of activators, the protractor muscles of the mandible (masseter muscles) were stimulated, while the retractors (temporal muscles) were inhibited. This investigation studied the EMG pattern in Class II division 1 children with activator and without activator in the mouth, compared before and 2 years after treatment.

In 1986, Ingervall and Bitsanis (2) found that the muscle activities in rest position were low and the same with or without the activator in the mouth. There were significant differences decreased only in the activities of the posterior portion of temporal muscle in rest position during 6 months of treatment. The activities of the masseter, anterior temporal and posterior temporal muscles during maximum bite and chewing were influenced by the occlusal instability created during the course of initial treatment.

In 1991, Ingervall and Thuer (4) studied the effect on muscle activities in Class II division 1 children for 1 year of activator treatment. The effect on muscle activities was compared with that in a similar group of children being treated with a headgear (in Class II division 1) and multiband groups (in Class I malocclusion). The activities of both anterior and posterior temporal muscles in the rest position were constant during 1 year period of observation in all three groups. During maximum bite the activities of both muscles tended to decrease after the start of treatment. However, this effect was decreased significantly for the posterior temporal muscle in the headgear group, in the multiband group and in the activator treatment group with a large protrusion.

Miralles et al. (3) compared the activities of the anterior temporal and masseter muscles in Class II division 1 malocclusion with and without the activator in the mouth after activator treatment. The children were treated with activators with different periods of activator wear (3 months to 42 months). This research found that similar integrated EMG activities in the postural mandibular position and during maximal voluntary clenching, with and without activator. However, during saliva swallowing, the activities in both muscles were significantly higher with activator.

Noro et al. (5) studied the effects of construction bite, they found that higher construction bite changed the direction of forces from vertical to posterior and form vertical to anterior in Class II and Class III, respectively. The magnitude of forces increased significantly with varying construction bite heights from 2 to 8 mm.

Many investigation in activator treatment concerned about the EMG activities of the masseter and anterior temporal muscles with and without the activator in the mouth (1-3). However, there were no significant differences in EMG activities in rest position in both two muscles (2, 4). In maximum bite in the intercuspal position (2, 4), chewing (2) and swallowing (2, 3), the EMG activities were different in results during the period of treatment; these effects were influenced by occlusal instability. But the clinical improvement was rapid as evident from decrease in overjet and in ANB as well as a change in molar relation.

The effects of Herbst appliance (20) showed an increase in the masseter and temporal muscular activities in Class II division 1 malocclusion for 6 months after treatment, and the muscular imbalance between the masseter and temporal muscles were reduced during 6 months after treatment. According to Hagg et al. (21-22), they reported an increase in EMG activities of the masseter but no changes in anterior temporal muscles after 6 months of treatment with Herbst appliances. And the muscular imbalances in the masseter and anterior temporal between the right and left sides were reduced after 6 months of treatment. The children were treated with oral shield, showed a decrease in orofacial muscles (23). Aggarwal et al. (24) reported a significant increase in postural and maximal clenching in the masseter and anterior temporal muscular activities during the 6-month period of treatment with Twin-block.

In animal studies, McNamara (25) found that the postural activities of the posterior temporal muscles decreased but the activities of the lateral pterygoid muscles increased with cemented splints. However, Sessle et al. (26) reported a decrease in postural EMG activities of the superior and inferior heads of the lateral pterygoid, superficial masseter and anterior digastric muscles with Herbst appliance and functional protrusive appliance. In the same, Yamin et al. (27) reported a decrease in postural EMG activities of the lateral pterygoid, masseter and digastric with Herbst, Frankel and Twin-block.

Table 3. The muscular activities in activator treatment.

Author	Sample	Treatment	Electrode	Muscle	Function
Ahlgren. 1978 (1)	Cl.II div.1: 20 cases Age 8-16 y.	Activator full time	Bipolar intra-cutaneous	Bilateral of Temporal Masseter	With and without activator in the mouth in early and late treatment.
Ingervall and Bitsanis 1986 (2)	Cl.II div.1: 15 cases Age 8.3-13.5y	Activator 6 month at night	Hook	Bilateral of Ant.+Post. temporal Masseter Digastric	1.Rest position with and without 2.Chewing 3.Swallowing 4.Maximum bite with and without activator
Miralles et al. 1988 (3)	Cl.II div.1: 15 cases Age 8-15 y.	Activator daytime	Bipolar surface	Left of Ant.temporal Masseter	With and without activator in 1.Postural position. 2.Swallowing 3.Maximum voluntary clenching
Ingervall and Thuer 1991 (4)	1.Cl.II div.1: 24 cases 2.Cl.II div.1: 15 cases 3.Cl.I: 16 cases Age 9.2-12.7y	Activator 1y Headgear Multiband	Bipolar hook	Bilateral of Ant.temporal Post.temporal	1.In rest position 2.Maximum bite in intercuspal position

CHAPTER IV
MATERIALS AND METHODS

Collection and Selection of Sample

This study was designed as a clinical study. Thirty-one patients from the Orthodontic Department of the Faculty of Dentistry at Mahidol University, Thailand, were included in this study. They were divided into two groups: activator treated and untreated group as a control. The first group consisted of 25 orthodontic patients (13 boys and 12 girls, ages 8 years 1 month to 13 years 7 months) who were planned to treat with an activator to correct to Class I molar relation. The second group included 6 patients (2 boys and 4 girls, ages 7 years 10 month to 11 years 3 months) who were not treated with an activator but waited for full fixed orthodontic appliances.

The protocols were reviewed and approved by the committee on human rights related to human experimentation Mahidol University to study in the human (see Appendix). All patients were explained in the details of this study and signed the informed consent if they agreed to participate. Table 4-5 shows the characteristics of the sample in this study.

The Criteria for Selection of the Sample

1. Hand-wrist radiographs showed that their developmental stage ranged from before to just past the peak of pubertal growth spurt.

2. No clinical signs of temporomanibular joint disorders.

3. No history of prior orthodontic treatment.

4. Skeletal type II with retrognathic mandible, Angle’s Class II division 1 malocclusion, well align or mild crowding, proclination or spacing of anterior teeth, large overjet and deep overbite.

4.1 The ANB angle was $\geq$ 4.58 degrees.

The sample had to have the ANB angle which was at least one standard deviation more than the mean of ANB of Thai norm. According to Sawaengkit et al.

(28) the norm of the ANB angle was 2.93 ± 1.65; therefore, the selected sample had to have the ANB angle, which was more than 2.93 + 1.65 = 4.58 degrees.

4.2 The Wits appraisal was ≥ -1.02 mm.

The sample had to have the Wits appraisal, which was at least one standard deviation more than the mean of the Wits appraisal of Thai norm. According to Sawaengkit et al. (28), the mean of the Wits appraisal was –2.94 ± 1.92; therefore, the selected sample had to have the Wits appraisal, which was more than –2.94 + 1.92 = -1.02 mm.

4.3 The PP-MP angle

4.3.1 The PP-MP angle was between 15.65 and 26.15 degrees for the normodivergent group.

The normodivergent sample had to have the PP-MP angle which was between one standard deviation of the mean of the PP-MP angle of Suchato and Chaiwat's study (29) According to their study, the PP-MP angle was 20.9 ± 5.25; therefore, the selected normodivergent sample had to have PP-MP angle which was between 15.65 and 26.15 degrees

4.3.2 The PP-MP angle was < 15.65 degree for hypodivergent group.

The hypodivergent sample had to have the PP-MP angle which was at least one standard deviation less than the mean of the PP-MP angle, which was less than 20.9 – 5.25 = 15.65 degree.

4.3.3 The PP-MP angle was > 26.15 degree for hyperdivergent group.

The hyperdivergent sample had to have the PP-MP angle, which was at least one standard deviation more than the mean of the PP-MP angle, which was more than 20.9 + 5.25 = 26.15 degree.

Table 4. The characteristics of the sample in this study.

Group	n	Sex		Skeletal		Age	Hand wrist
		Boys	Girls	Open	Normal		
Activator	25	13	12	12	13	8.08-13.58 Y	PP2 to MP3c
Control	6	2	4	2	4	7.83-11.25 Y	PP2 to MP3c

Table 5. Dentofacial morphology of the sample in this study.

Cephalometric variable	Activator (n=25) Mean ± SD	Control (n=6) Mean ± SD
SNA	82.24 ± 4.69	84.35 ± 2.87
SNB	75.92 ± 4.22	77.23 ± 2.28
ANB	6.33 ± 1.28	7.12 ± 1.03
Wits	1.73 ± 2.27	2.61 ± 1.98
Maxillary length	78.59 ± 3.82	78.59 ± 4.72
Mandibular length	98.48 ± 4.68	96.19 ± 4.80
MP	33.96 ± 5.08	31.85 ± 4.98
PP	7.56 ± 3.11	7.12 ± 3.55
MPPP	26.39 ± 5.38	24.72 ± 5.54
SNPg	76.47± 4.03	77.27 ± 2.09
U1-NA	30.90 ± 6.15	27.08 ± 5.90
L1-NB	30.20 ± 6.84	33.27 ± 4.15
Overjet	7.84 ± 2.27	7.52 ± 1.52
Overbite	5.76 ± 1.56	6.10 ± 1.04

Methods

Design and Construction of Activator

The activator used in this study (Figure 2) corresponds to a modification of the original activator with clasps that fix the appliance to the upper first molars and labial bow with U-loop at upper and lower anterior teeth. The bite work for the activator was registered by instructing the patient to bite a wax roll in a forward position of the mandible until it reached a bite-to-bite position of the incisors or as protrusion as possible and until a 5 mm. vertical distance could be measured between the cusps of the first molars. According to Noro et al. (5) they studied the effects of construction bite, they found that higher construction bite changed the direction and magnitude of forces, thus in this study we fixed construction bite heights 2-3 mm more than freeway space that the activator keeps the mandible extended beyond the rest position and the elasticity of the muscles moves the mandible to forward position. When this occlusal relation was obtained, the registration wax bite and working models were mounted in an articulator. Each time the patient bit on the appliance, the occlusal acrylic in the posterior region was reduced to guide the posterior teeth to the desired position especially in skeletal deep and normal configuration patients, and kept the occlusal acrylic the same level during treatment in patients who presented with skeletal open configuration. Patients were asked to wear the activator at night (6 pm. to 6 am.) and to record the wearing time through the period of treatment.

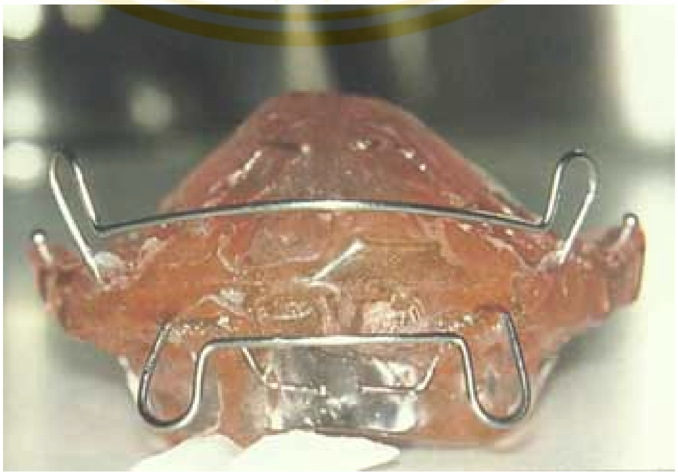

Figure 2. The activator used in this study.

EMG Registration Schedule and Setup

Bilateral EMG signals for each patient were recorded from the masseter and anterior temporal muscles in the rest position, maximum bite of habitual clenching and swallowing of saliva or little water. A 5-channel EMG, Medelect-M2 and bipolar surface electrodes were used (Figure 3). Four channels recorded EMG and one reference EMG channel. The lower-frequency filter was set at 100 Hz. and the upper-frequency one was set at 10 kHz. The amplifier sensitivity was set at 200 μv/division for muscle activities.

Figure 3. Electromyographic device Medelect-M2.

Before each recording secession, the procedure was explained in detail to the patients to allay their anxieties. In this study all subjects were trained for swallowing and maximum biting of habitual clenching, and recording procedure under the same situation. The study was done in a shielded room to eliminate outside electrical interferences. The patient sat upright on a chair without head support and Frankfort plane was positioned parallel to the floor in rest position, during swallowing and maximum bite of habitual clenching. Alignment of the electrodes was facilitated by palpation of the muscles; the patients were instructed to close their jaws in centric occlusion as forcibly as possible. Bipolar surface electrodes were placed on the skin about halfway between the origin and insertion of the muscles, parallel to the direction of muscle fibers, after cleansing the skin with 70% isopropyl alcohol, gel and covered with conductive paste to reduce impedance. A reference electrode was placed at forehead of the patients. An inter-electrode distance was 20 mm. Reference marked to electrode positions were made and recorded on transparent sheets. Subsequently, transparent sheets were taken during the first session as reference for future electrode placement. According to Ingervall and Bitsanis (2) and Miralles et al. (3), the placement of the electrodes was showed in Figure 4

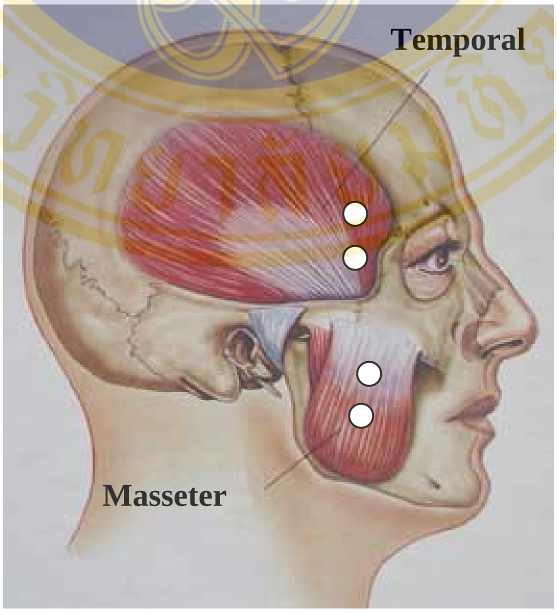

Figure 4. The placement of the electrodes.
Source: Sicher, 1980 (17)

Follow from Miralles et al. (3) and Ingervall and Thuer (4), the sequence of the EMG recording was described:

At each recording secession of swallowing, the records were made with the jaws 1) in the rest position of the mandible for 5 seconds, 2) during swallowing of saliva or little water, and then 3) in the rest position of the mandible for 5 seconds. A resting period was 1 minute between each swallowing. Of maximal bite of habitual clenching, the records were 1) in the rest position of the mandible for 5 seconds, 2) during maximal bite of habitual clenching for 5 seconds, and then 3) in the rest position of the mandible for 5 seconds. A resting period was 5 minutes between each maximal bite of habitual clenching allowed to avoid muscular fatigue.

All EMG recording sessions were replicated three times for swallowing and maximal bite of habitual clenching (the mean values of the record 1, 2 and 3 were calculated) The EMG recordings were made before the start of the treatment, at 3 months, 6 months and 12 months after the start of treatment and until Class I molar relation.

The maximum amplitude and duration of the muscle activities were measured in left and right sides during swallowing and maximal bite of habitual clenching for the masseter and anterior temporal muscles. The area under the signal of the muscle activities was measured in left and right sides of the masseter and anterior temporal muscles for swallowing and maximal bite of habitual clenching. The EMG values were used to evaluate the muscle activities during treatment (before the start of the treatment, at 3 months, 6 months and 12 months after the start of treatment and until Class I molar relation). According to De Luca (19), a common method used to quantify direct surface EMG is to the rectified signals; rendering the signal to have excursions of one polarity. The integrated rectified signals provide a measurement of the area under the signals and a specified interval of time. This value, the area/duration, was accurately calculated because of the average rectified value of the EMG signals. Therefore in this study, the mean area/duration was used to evaluate the masseter and anterior temporal muscle activities during the observation period.

Study Model Analysis

Angle's classification was used to assess anteroposterior position of upper first molar relative to lower first molar. Class I was defined as that position where mesio-buccal (M-B) cusp of upper first molar fits exactly into buccal groove of lower first molar. Any deviation from Class I was measured to the nearest half cusp width. Class II tendency was defined as M-B cusp of upper first molar moving mesial relative to buccal groove of lower first molar. Class III tendency was defined as M-B cusp of upper first molar moving distal relative to buccal groove of lower first molar. The study model was recorded with impression at the start of treatment, 3 months, 6 months and 12 months after treatment and until Class I molar relation. Angle's classification, overjet and overbite were evaluated at the same time of the oral examination.

Cephalometric Measurement

All subjects in this study were recorded with lateral cephalometric films, at the start, 6 months, 12 months after treatment and until Class I molar relation to evaluate cephalometric values (the ANB, Wits appraisal, Maxillary and Mandibular length, U1 to NA, L1 to NB, overjet and overbite changes). Each treatment radiograph was traced on an acetate paper, with a sharp-edge black pencil (0.3mm.) and a viewing box. A black surround was placed on the radiograph to cut-down background illumination, thereby, facilitating landmark identification. When bilateral structure gave rise to double images, the mid-point by estimation, as appropriate, was chosen. All tracings were then checked for accuracy by two orthodontists. The cephalometric measurement was measured by using digitization with a software program (Dentofacial planner version 5.3.2).

Magnification of Lateral Cephalometric Radiographs

The cephalograms used in this study were obtained from 3 types of x-ray machines. Each radiograph had individual marker then the magnification was calculated for each radiograph. Each marker was measured three times by the same digital veneer caliper (the mean values of measurements were calculated) and then compared with the true marker. The linear measurement there was multiple by the individual magnification for the accuracy.

Variables Used in the Study

The purpose of this study was to evaluate the muscle activities in Class II division 1 patients during 12 months of observation period and until Class I molar relation. The independent variables of this study were sex, skeletal, muscles, positions and functions. The dependent variables of this study were the muscle activities during the 12 month observation period and until Class I molar relation.

Reliability of the Measurement

In order to determine whether the measurements are reproducible, they were checked for reproducibility. To check for intrajudge validity, 10 radiographs were randomly selected from the subject group and redigitized after 1-week interval by the same examiner. For each replicated measurement, the method error statistic: Paired T-test and Dahlberg's method were used for testing the error of measurements (30-31).

The error of the measurements was calculated by the Dahlberg's modified method for small samples:

$$\text{Error of measurements} = \sqrt{\frac{\Sigma(x_1-x_2)^2}{2n}}$$

Where

x_1 = the original measurement

x_2 = the replicated measurement

n = the replication sample size

Statistic Analysis

The SPSS version 11.5-microcomputer program was used to perform the following calculations:

1. The repeated measures design was used to evaluate the changes in the muscle activities and cephalometric measurements during 12 months of observation period.

2. Paired T-test was used to determine significant differences between the muscle activities at start and the end of treatment (Class I molar relation).

CHAPTER V
RESULTS

The EMG in the Masseter and Anterior Temporal Muscles in Class II Div.1 Malocclusion Treated with Activator and Untreated with Activator during 12 Months of Observation Period.

In this study, 17 orthodontic patients were being treated for 12 months of observation period (8 boys and 9 girls, ages 8 years 1 month to 12 years 8 months). The means of area/duration of the muscle activities in masseter and anterior temporal muscles when the mandible was in the maximum bite of habitual clenching and swallowing during the start, 3 months, 6 months and 12 months of observation period were compared between the treated and the control groups (untreated group), the details were showed in Table 6-7, Figure 5-8.

There were no significant differences in sex, skeletal (open and normal) and muscles (masseter and anterior temporal), however there were significant differences in functions (maximum bite of habitual clenching and swallowing), sides (left and right) and time (start, 3 months, 6 months and 12 months) with $p < 0.05$.

At maximum bite of habitual clenching, the activities of masseter and anterior temporal muscles in the left and right sides were found significant decreases between at start of treatment and 12 months both in the two groups. In the treated group, there were significant decreases between at start and 12 months, 3 months and 12 months, 6 months and 12 months ($p < 0.05$). In the control group, there were significant decreases between at start and 3 months, at start and 6 months, at start and 12 months ($p < 0.05$). At 12 months of observation period, the EMG activities of both muscles in the control group were higher than in the treated group but showed significant differences only in the right side ($p < 0.05$).

At swallowing, the EMG activities in the treated group showed no significant decreases between at start and 12 months, and at start and 3 months of treatment in both sides of both muscles. However, it was found that there was a significant increase between 3 months and 6 months ($p < 0.05$), and a significant decrease between 6 months and 12 months of the treatment ($p < 0.05$) in both sides of anterior temporal muscles. For the masseter muscle activities, they showed no significant decreases between at start of treatment and at 12 months, but a significant decrease was found between at 6 and 12 months in both sides ($p < 0.05$). In the control group, the activities of masseter and anterior temporal muscles in both sides showed no significant decreases between at start and 12 months, with some decreases between at start and 6 months, and slightly increases between 6 months and 12 months. Accordingly, there were no significant differences between the groups at 12 months of observation period ($p < 0.05$).

Table 6. Means and SD (in µV/ms) Area/duration values of the muscle activities during maximum biting of habitual clenching.

Group	Left side					Right side				
	Start	3 month	6 month	12 month	Diff.	Start	3 month	6 month	12 month	Diff.
Masseter										
Activator (n=17)	140.44 ± 56.37	135.84 ± 53.73	146.56 ± 41.69	64.50 ± 22.99	*	189.41 ± 63.79	172.87 ± 67.30	176.77 ± 47.31	93.23 ± 28.66	*
Control (n=6)	259.84 ± 256.25	150.44 ± 86.56	105.24 ± 59.49	134.09 ± 72.41	*	332.91 ± 171.74	208.63 ± 105.11	188.01 ± 85.29	170.09 ± 61.37	*
Anterior temporal										
Activator (n=17)	147.62 ± 70.66	140.98 ± 72.56	136.23 ± 51.23	67.05 ± 24.70	*	193.43 ± 73.51	168.26 ± 82.49	172.45 ± 46.64	107.09 ± 27.34	*
Control (n=6)	213.02 ± 60.04	139.35 ± 55.48	104.99 ± 28.02	106.67 ± 28.62	*	334.22 ± 121.06	217.11 ± 82.85	175.90 ± 47.63	178.02 ± 58.28	*

Table 7. Means and SD (in µV/ms) Area/duration values of the muscle activities during swallowing.

Group	Left side					Right side				
	Start	3 month	6 month	12 month	Diff.	Start	3 month	6 month	12 month	Diff.
Masseter										
Activator (n=17)	15.04 ± 7.16	13.26 ± 12.63	17.57 ± 11.18	9.58 ± 7.76	NS	17.89 ± 13.44	13.40 ± 10.46	18.73 ± 12.53	11.83 ± 8.72	NS
Control (n=6)	36.41 ± 26.21	11.97 ± 8.43	9.53 ± 10.86	12.10 ± 13.18	NS	32.64 ± 21.54	15.29 ± 11.33	12.31 ± 15.20	11.26 ± 8.06	NS
Anterior temporal										
Activator (n=17)	17.71 ± 13.50	17.56 ± 11.48	24.57 ± 15.50	14.03 ± 8.76	NS	22.17 ± 17.63	17.80 ± 11.75	24.81 ± 11.68	17.14 ± 8.67	NS
Control (n=6)	46.65 ± 42.67	18.45 ± 11.44	12.18 ± 10.43	19.51 ± 14.52	NS	50.51 ± 47.33	20.98 ± 17.11	14.73 ± 12.75	19.79 ± 15.38	NS

NS = No significant difference at $p < 0.05$ (start-12month)

* = Significant difference at $p < 0.05$ (start-12month)

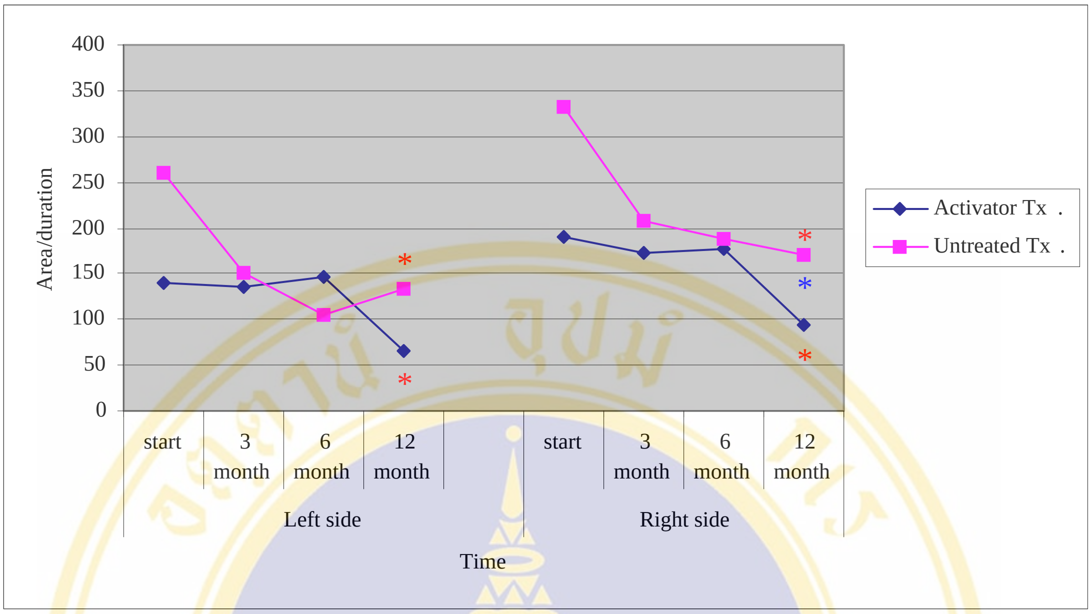

Figure 5. Means of Area/duration values of left and right masseter muscle activities (µV/ms) during maximum bite of habitual clenching between treated and untreated group.

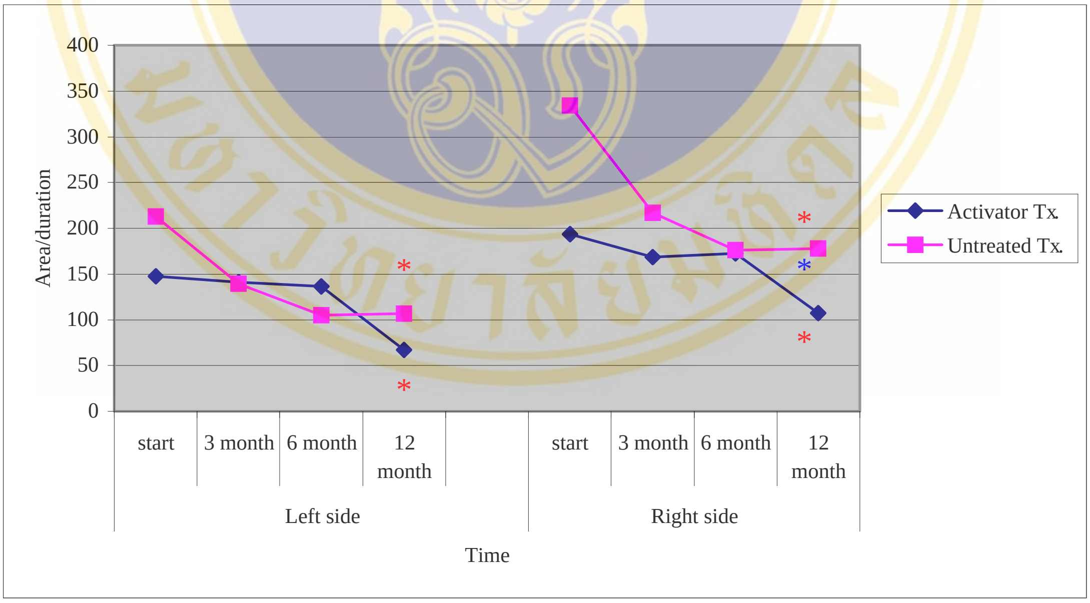

Figure 6. Means of Area/duration values of left and right anterior temporal muscle activities (µV/ms) during maximum biting of habitual clenching between treated and untreated group.

* = Significant difference at $p < 0.05$ (start-12 month)

* = Significant difference at $p < 0.05$ (treated- untreated)

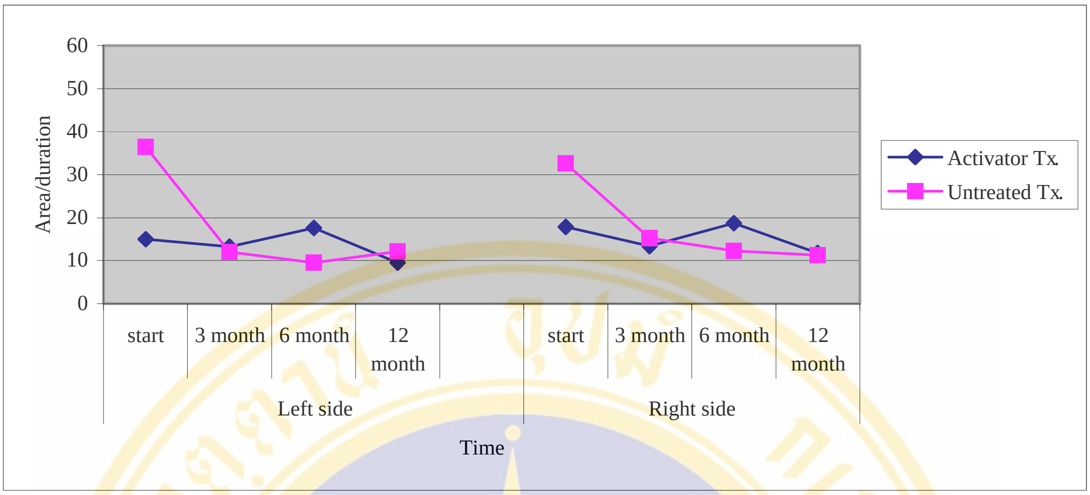

Figure 7. Means of Area/duration values of left and right masseter muscle activities (μV/ms) during swallowing between treated and untreated group.

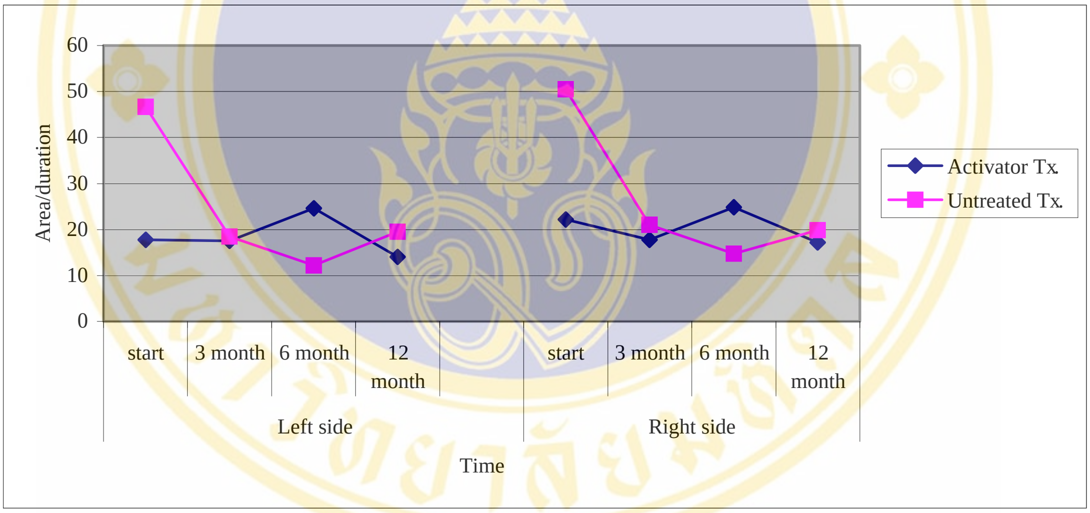

Figure 8. Means of Area/duration values of left and right anterior temporal muscle activities (μV/ms) during swallowing between treated and untreated group.

The EMG in the Masseter and Anterior Temporal Muscles in Class II Div.1 Malocclusion Treated with Activator until Class I Molar Relation.

The means of area/duration of the muscle activities in masseter and anterior temporal muscles when the mandible was in the maximum bite of habitual clenching and swallowing from the start of treatment until Class I molar relation in treated group, the details were showed in Table 8-9, Figure 9-10.

During maximum bite of habitual clenching, the activities of masseter and anterior temporal muscles showed a decrease after the start of treatment in both sides. However, these effects were significant differences in the right side of masseter muscles and both sides of anterior temporal muscles ($p < 0.05$). In swallowing, there were no significant differences between the start and the end of treatment. The EMG activities showed a slightly decrease in both muscles and both sides ($p < 0.05$).

Table 8. Means and SD (in µV/ms) Area/duration values of the muscle activities during maximum biting of habitual clenching (until Class I molar relation).

Activator Tx	Left side			Right side		
n=25	Start	End	Diff.	Start	End	Diff.
Masseter	130.25 ± 57.13	103.33 ± 55.29	NS	180.95 ± 69.36	143.70 ± 67.18	*
Ant.temporal	131.26 ± 64.44	104.14 ± 57.75	*	180.05 ± 66.31	137.92 ± 57.76	*

NS = No significant difference at $p < 0.05$

* = Significant difference at $p < 0.05$

Table 9. Means and SD (in µV/ms) Area/duration values of the muscle activities during swallowing (until Class I molar relation).

Activator Tx	Left side			Right side		
n=25	Start	End	Diff.	Start	End	Diff.
Masseter	14.23 ± 9.69	13.22 ± 13.43	NS	15.84 ± 13.01	14.34 ± 14.15	NS
Ant.temporal	20.24 ± 15.58	18.12 ± 13.44	NS	22.85 ± 17.60	18.44 ± 12.68	NS

NS = No significant difference at $p < 0.05$

* = Significant difference at $p < 0.05$

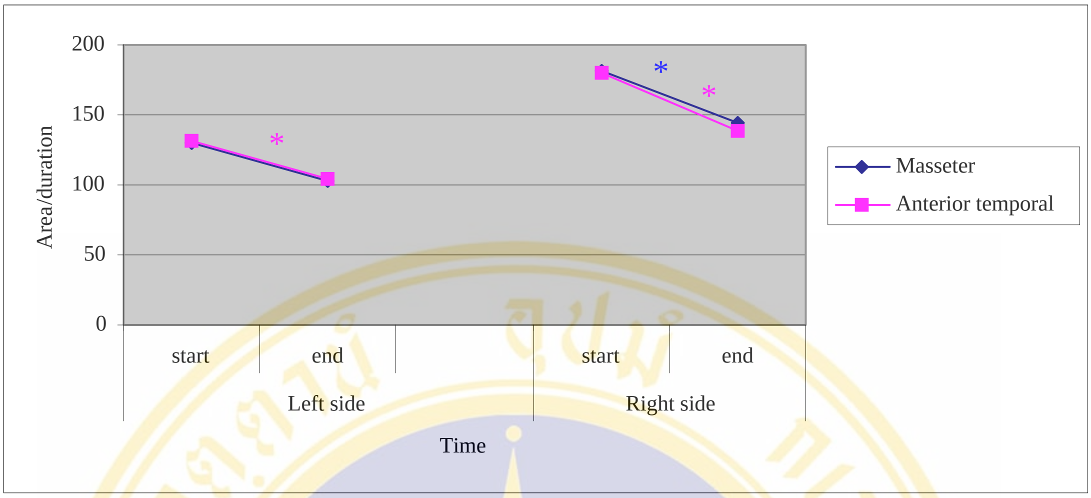

Figure 9. Means of Area/duration values of left and right muscle activities (µV/ms) during maximum biting of habitual clenching.

* = Significant difference at $p < 0.05$ in masseter muscle

* = Significant difference at $p < 0.05$ in anterior temporal muscle

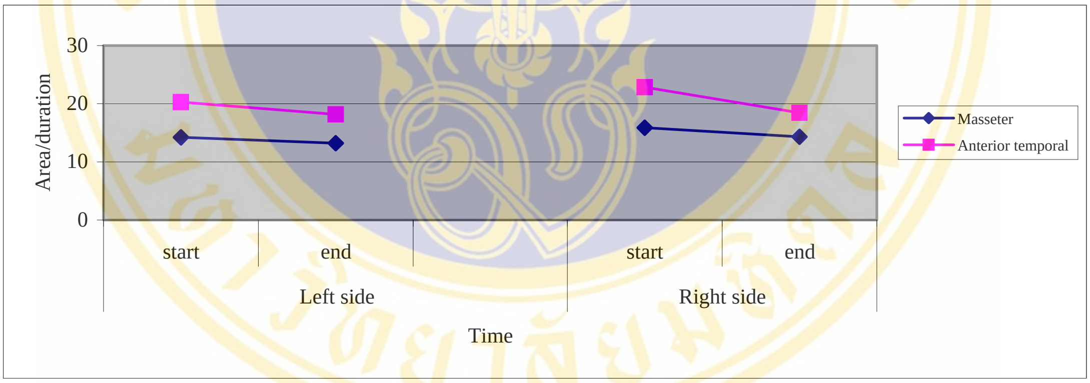

Figure 10. Means of Area/duration values of left and right muscle activities (µV/ms) during swallowing.

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Cephalometric Measurements

Error of the Measurements

The results of Paired T-test and Dahlberg's method were showed in Table 10-11. Paired T-test results showed no significant differences between the two measurements. The results from Dahlberg's method showed that measurement errors of SNA, SNB, ANB, Wits appraisal, Maxillary length, Mandibular length, MP, PP, MPPP, SNPg, U1 to NA, L1 to NB, overjet, overbite were 0.34, 0.31, 0.18, 0.74, 0.41, 0.32, 0.59, 0.46, 0.49, 0.38, 0.43, 0.50, 0.32, 0.24 respectively.

Table 10. Paired T-test of the Cephalometric measurements.

Cephalometric variable	Mean	SD	Std. Error Mean	t	Difference
SNA	-0.08	0.50	0.16	-0.51	NS
SNB	-0.04	0.46	0.14	-0.28	NS
ANB	-0.03	0.26	0.08	-0.37	NS
WITS	0.12	1.10	0.35	0.35	NS
Maxillary length	0.11	0.60	0.19	0.58	NS
Mandibular length	-0.13	0.45	0.14	-0.91	NS
MP	-0.30	0.82	0.26	-1.16	NS
PP	-0.03	0.69	0.22	-0.14	NS
MPPP	-0.29	0.66	0.21	-1.40	NS
SNPG	-0.05	0.56	0.18	-0.28	NS
U1-NA	-0.13	0.62	0.20	-0.66	NS
L1-NB	0.28	0.69	0.22	1.29	NS
OJ	0.00	0.47	0.15	0.00	NS
OB	-0.03	0.35	0.11	-0.27	NS

Table 11. Errors of the Cephalometric measurements.

Cephalometric variable	Error of Measurement
SNA	0.34
SNB	0.31
ANB	0.18
WITS	0.74
Maxillary length	0.41
Mandibular length	0.32
MP	0.59
PP	0.46
MPPP	0.49
SNPG	0.38
U1-NA	0.43
L1-NB	0.50
OJ	0.32
OB	0.24

NS = No significant difference at $p < 0.05$

* = Significant difference at $p < 0.05$

In the treated group, the clinical improvement was evident from a significant decrease in ANB angle, U1 to NA, overjet and overbite as well as changes in the molar relations. L1 to NB, Maxillary length and Mandibular length was increased significantly after the start of activator treatment. In untreated group, there were significant differences in a decrease of ANB, an increase of mandibular length and U1 to NA, but no significant difference in an increase of Maxillary length, L1 to NB, overjet, a decrease in overbite. However, the means of cephalometric values were significant differences between the treated and untreated groups only in overjet and overbite at 12 months of observation period (p-value < 0.05). The results were showed in Table 12. Extraoral and intraoral photographs of the patient showed in Figure 11-12.

Table 12. Means and SD of Cephalometric measurements.

Group	Start	6 month	12 month
Activator (n=17)			
ANB	6.35 ± 1.36	5.41 ± 1.38	4.86 ± 1.53
Maxillary length	78.00 ± 3.76	79.29 ± 3.55	80.04 ± 3.74
Mandibular length	98.35 ± 5.29	101.48 ± 4.90	103.37 ± 5.41
U-NA	31.43 ± 6.32	27.36 ± 5.39	25.76 ± 5.67
L-NB	28.58 ± 7.42	33.47 ± 7.07	33.70 ± 6.72
Overjet	8.21 ± 2.46	4.54 ± 1.84	3.56 ± 1.65
Overbite	5.74 ± 1.84	4.23 ± 1.28	3.51 ± 1.50
Control (n=6)			
ANB	7.12 ± 1.03	6.73 ± 1.15	6.45 ± 1.33
Maxillary length	78.59 ± 4.72	78.71 ± 4.46	79.91 ± 4.25
Mandibular length	96.19 ± 4.80	97.24 ± 5.94	99.11 ± 6.27
U-NA	27.08 ± 5.90	29.22 ± 6.27	30.92 ± 6.55
L-NB	33.27 ± 4.15	32.53 ± 4.12	33.82 ± 5.43
Overjet	7.52 ± 1.52	7.57 ± 1.83	7.72 ± 1.53
Overbite	6.10 ± 1.04	5.87 ± 1.07	5.78 ± 1.66

Figure 11. Extraoral and intraoral photographs of the patient treated with activator.

A: Lateral view = start (pretreatment), 6 months, 12 months of treatments

B: Start of treatment

C: 6 months of treatments

D: 12 months of treatments

A

B

C

Figure 12. Extraoral and intraoral photographs of the patient untreated with activator

A: Lateral view = start (pretreatment), 12 months of treatments

B: Start of treatment

C: 12 months of treatments

CHAPTER VI
DISCUSSION

It was our interest to study the EMG muscle activities in patients who were treated with activator. With the evidence that the mode of action of functional appliance therapy has been linked to the neuromuscular and skeletal adaptations to alter function in the orofacial region, it is believed that as a new pattern of function, dictated by the appliance, it leads to the development of a new morphologic pattern. It was concluded that as skeletal adaptations occur, the need for compensatory muscle function was reduced and followed by the stability of the treatment (32). However, it seems to be argued for some factors that might have influence during the experiments or studies. Several investigations had 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 (1-5, 20-27). In this study, patients were conducted to an active protrusion by activator appliance, allowed them for night wearing (6 pm. to 6 am.) to control for the treatment timing factor. All patients presented with well cooperation of activator treatment and of recording the period wearing. The construction bite was determined for the sagittal and vertical displacements of the mandible, also the degree and direction of appliance activation (6). According to Noro et al. (5), the magnitude of forces increased significantly with varying construction bite heights from 2 to 8 mm. In this study; because of the almost similar amount of overjet, all patients were guided for the incisors to an edge to edge relation and the construction bite height was 5 mm. between the cusps of the first molar in order to control the vertical dimension. Except one of the patients, she had a very large overjet and could not reach an incisal edge-to-edge relation with one step. Thus her activator appliance was activated in multiple stages during treatment. However, her result of EMG muscle activities was similar to others. For the vertical construction bite, the activator kept the mandible extended beyond the rest position and the elasticity of the muscles moves the mandible to forward position. Before the EMG recording, all subjects were trained for swallowing and maximum biting of the habitual clenching, and recording the procedures under the same situation. According to De Luca (19), he stated that a common method used to quantify direct surface EMG is to the rectified signals. The integrated rectified signals provide a measurement of the area under the signals and a specified interval of time. This value, the area/duration, is accurately calculated because of the average rectified value of the EMG signals. Therefore in this study, the area/duration was used to evaluate the masseter and anterior temporal muscle activities during the observation period.

Factors such as individual variations, age, gender, malocclusion, composition and shape of the face, connective tissue, and fat may affect all the characteristic and magnitude of signals recorded (18-19). Changes in muscle activities during treatment may be due to discomfort or pain, changes in the occlusal relationship between the maxillary and mandibular dentitions produced by tooth movement, the orthodontic appliance itself, unstable occlusal conditions affecting muscle contraction patterns, the dentition changing to a more stable occlusion, or a skeletal configuration with a different mechanical advantage. The details of the procedure in this study were indicated the effort to control the external factors for receiving the qualified EMG signals.

In Maximum Bite of Habitual Clenching during 12 Months of Observation Period

The results showed that the EMG activities of the masseter and anterior temporal muscles of both groups decreased both sides during 12 months of the observation period. Contrarily to others, it might be the differences in the method used. Several investigations were found not to be strictly compared because of the differences in types of electrodes, the electrode positioning and the methods of treatment used. It was claimed that the EMG activities from the muscles during maximum biting were markedly increased when the appliance was inserted because of the sudden change to a forward mandibular position, this situation may stimulate the muscular contraction (the active contraction from the appliance). When the child bites on the appliance, an unstable occlusion does not affect the EMG recording because this measurement was made with acrylic bite planes covering the occlusal surfaces of the teeth, thus eliminating irregularities in the occlusion (1, 2, 21, 22, 24). While in this study, we chose to record the muscle activities in maximum bite of habitual clenching to compare the EMG activities in the long term period of the effect of the passive tension, derived from the viscoelastic properties of the muscles after 12 months of activator treatment and until Class I molar relation. The results of the EMG activities of the masseter and anterior temporal muscles in maximum bite of habitual clenching showed significant decreases on comparison between the registrations at start and 12 months of treatment but no significant differences from at start to 6 months. Similarly, Ingervall et al. (2, 4) found a decrease in the EMG activities from at start to 6 months and at start to 12 months of treatment with no significant differences. This drop may be explained by instability of the occlusion during treatment and adaptation of the masticatory muscles. Moreover, the child in activator treatment may present a lack of the posterior antagonistic tooth contacts after the start of treatment when the altered mandibular position and change in tooth eruption. During maximum bite, therefore, the muscle activities decreased with lessening numbers of posterior teeth in contact and dropped dramatically when the incisors were in contact. Change in tooth position and intermaxillary relations brought about by treatment was reflected in a reduced EMG activity of masseter muscle. These changes caused the muscular imbalance and influenced the adaptation of the masticatory muscles. Supported by Carels and van Steenberghe (33-34) studied masseteric reflexes during tooth clenching after standardized taps on an upper incisor in children with Class II division 1 malocclusion before and during treatment with a Bionator functional appliance. They found a change in EMG pattern, which was due to the lack of posterior tooth contact. The EMG response varied with the degree of posterior antagonistic tooth contact. Supported by Goldberg (35), he found that during biting in maximal occlusion a vast number of mechanoreceptors, located in the periodontal ligaments of the posterior teeth, were activated; while this number of occlusal contacts was decreased in forward mandibular position or in the incisor edge-to-edge position that caused a decrease number of mechanoreceptors and altered EMG patterns of muscles. Similar to this study, the degree of occlusal stability affected muscle activities, after the start of treatment when the altered mandibular position and change in tooth eruption caused a decrease number of posterior teeth contact and apparently at 6 months to 12 months of treatment, which nearly in the incisor edge-to-edge position.

Hence, the results of this study showed a decrease in EMG activities in masseter and anterior temporal muscle.

In untreated group, the EMG activities of masseter and anterior temporal muscles showed significant decreases between at start and 3 months, 6 months and 12 months in maximum bite of habitual clenching. This drop may be explained by instability of the occlusion during 12 months of observation period and adaptation of the masticatory muscles. The children showed the natural growth that change in mandibular position and change in the tooth eruption. Three patients showed the change in tooth eruption and other three patients showed an increase rotation of permanent teeth. It was found that change in the tooth position and intermaxillary relations are reflected in a reduced EMG activity of masseter muscle. These changes caused the muscular imbalance and influenced the adaptation of the masticatory muscles. In this study, the sample size of the untreated group was smaller than the activator treatment group. The characteristics of this group, however, from the results in clinical appearances and cephalometric measurements were representing appropriately. At the start of treatment, the EMG activities of the muscles in untreated group were higher than in activator group. The statistical results during 12 months of overall treatment showed that the EMG activities of masseter and anterior temporal muscles in untreated group higher than treated group in maximum bite of habitual clenching. These results may be indicating that change in occlusion and mandibular position in treated group higher than in untreated group.

Pancherz and Anehus-Pancherz (20) showed that treatment by maximum bite jumping with the Herbst appliance would result in an increase and equalization of the temporal and masseter EMG activities that full-time wearing of the appliance is importance since a continuous anterior functioning might elicit the muscle response more rapidly than a discontinuous one. While results of the Herbst appliance treatment in Leung and Hagg (21-22), showed that an increase significance of the masseter activities but the anterior temporal activities did not change significantly during treatment. The differing results are probably due to, the fact that the children treated with the Herbst appliance were corrected to a normal occlusal relationship after 6 months, while the children of the activator treatment were still in a transient stage of occlusal correction after 12 months of treatment. In this study, the subjects were in the active phase of activator treatment at the end of 12 months, and an improvement in sagittal discrepancy was apparently observed through a change in molar relation from Class II to Class I or Class III (overcorrected of treatment) in the most of the patients, excepted in one boy and two girls, there were almost completed Class I molar relation because of the anterior crowding. While in a transient stage of occlusal correction during 12 months of treatment, can be attributed to a lack of, or diminished number of occlusal contacts, thus influence on the EMG activities.

In Swallowing during 12 Months of Observation Period

In treated group, the EMG activities of the masseter and anterior temporal muscles slightly decreased between at start of activator treatment to 12 months with no significant differences. The EMG activities decreased from start of treatment to 3 months, increased significantly from 3 months to 6 months and decreased significantly from 6 months to 12 months in anterior temporal muscles and decreased significantly from 6 months to 12 months in masseter muscles. These results were varied during the observation period. It may be explained by the influence of the activator inserted at night only, that the frequency of saliva swallowing during sleep is very low. During saliva swallowing, it is a functional activity repeated between 600 and 2400 times each day (36). Aggarwal et al. (24) showed an increase of the EMG activity in the masseter and anterior temporal muscles in 6 months of Twin-block treatment for full time wearing. They found a significant difference with Twin-block, but no significant difference without Twin-block in the mouth.

In untreated group, the EMG activities of masseter and anterior temporal muscles in both sides showed no significant decreases between at start and 12 months of treatment.

In Activator Treatment until Class I Molar Relation

The result of the EMG activities in the patients who were treated until Class I molar relation (minimum of 3 months to maximum 22 months) showed a significant decrease from the start to Class I molar relation in right side of masseter muscles and both sides of anterior temporal muscles in maximum bite of habitual clenching. In swallowing, there were no significant decreases in the EMG activities of masseter and anterior temporal muscles. The explanation of these results was the same in a change from the start to 12 months of treatment.

In Rest Position

Several investigations showed no significant differences in rest position of the masseter and anterior temporal muscle activities (2, 4). The EMG activities of the muscles in this study could not detected by the electromyography device because of a very small electrical current.

In this study of 12 months of observation period, the clinical 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 activator treated patients. In contrary, the untreated patients showed no change in molar relation. In skeletal normal configuration, the occlusal acrylic covering was removed and guided to correct the dental deep bite. And in skeletal open configuration that the most of the children in Class II malocclusion, the occlusal acrylic covering were kept protecting the increasing of open configuration. Most of patients in activator treatment showed an increase in mandibular plane angle with no significant difference. The most of the patients in treated group were found that the activator resulted in lingual tipping of the maxillary incisors, labial tipping of the mandible incisors, decreased in overjet and overbite, But in untreated group, they showed slightly increased labial tipping of the maxillary and mandibular incisors, slightly increased in overjet and slightly decreased in overbite. Both groups showed a decrease in ANB, an increase in Maxillary length and Mandibular length but in treated group changed more than untreated group. At the end of 12 months, there were significant differences between groups in overjet and overbite. The results showed that in treated group overjet and overbite were lower than in untreated group.

The muscle activities showed in this study were examined only in 12 months of the activator treatment. All subjects were in the active phase of sagittal correction by the end of 12 months, wherein there was an unbalanced and reduced number of occlusal contacts in the posterior dental arch segments. And the small sample size of both groups may not be enough to draw definite conclusions. Thus the large sample size and the long term observation period should be achieved until the occlusion was completely corrected in stability position to reveal the definite conclusion in the EMG activities.

CHAPTER VII
CONCLUSION

This study was comprised of 31 co-operative patients: 13 boys and 12 girls in activator treated group; 2 boys and 4 girls in untreated group. Hand-wrist radiographs showed that their developmental stages ranged from before to just past the peak of pubertal growth spurt (PP_2 to MP_{3cap}). No clinical signs of temporomanibular joint disorders, any history of prior orthodontic treatment was found. All sample were skeletal type II with retrognathic mandible (ANB range from 4.7 to 9.2 degree, Wits appraisal range from –0.83 mm to 7.31 mm), Angle's Class II division 1, and well aligned or mild crowding, proclination or spacing of anterior teeth, large overjet (range from 4.54 to 14.49 mm.) and deep overbite (lower incisors occlude to palatal mucosa).

There were great individual intercessional and intracessional differences in electromyographic activities of the muscles investigated before and during activator treatment. Thus the careful in selection of sample, methods of recording, types of the electrode, the placement of the electrode and method of treatment should be performed. The results from this study revealed that

1. In maximum bite of habitual clenching

1.1 The EMG activities of the masseter and anterior temporal muscles in activator treated and untreated groups decreased with significant differences in both sides at 12 months of observation period ($p<0.05$).

1.2 When compared both groups at 12 months of observation period, the EMG activities of both muscles in untreated group were higher than in treated group but showed significant difference only in the right side ($p<0.05$).

2. In swallowing

2.1 The EMG activities of the masseter and anterior temporal muscles in activator treated and untreated groups tended to decrease with no significant differences in both sides at 12 months of observation period ($p<0.05$).

2.2 There were no significant differences between groups at 12 months of observation period ($p<0.05$).

3. In activator treated group until Class I molar relation

3.1 The EMG activities in maximum bite of habitual clenching decreased in both sides and both muscles, but showed significant differences only in the right side of masseter and both sides of anterior temporal muscles ($p<0.05$).

3.2 In swallowing, the EMG activities tended to decrease in both sides and both muscles, but showed no significant differences ($p<0.05$).

Clinical Implication

This study showed that the clinical improvements were found in facial profile and molar relation in the treated patients, while the complete neuromuscular adaptation had not occurred at 12 months of treatment records and until Class I molar relation. Therefore, the treatment timing should be prolonged until the complete occlusion is achieved to evaluate the neuromuscular adaptation and for preventing the relapse.

Limitation

1. The small sample size in this study could not be divided into subcategories of skeletal pattern, sex, overjet, which may cause the different results and may not be enough to reveal the definite conclusions.

2. The electromyographic device in this study comprised of 5 channels that could measure only two muscles per time. This situation therefore made the procedure to the longer time for recording. Thus this might affect the emotion and psychology of the patients, consequently varied the results.

3. The term period of the observation in this study may not be enough to reveal the definite conclusions. So the observation should be prolonged to the long term treatment.

4. Ethics affected on the collection of sample. It is not commonly for the patients not to be treated when malocclusion was found. Thus in this study, the untreated group was small sample size.

Suggestions

1. The observation should be continued in the long term treatment until the occlusion was completely corrected in stability position to reveal the definite conclusion in the EMG activities.

2. Collecting more sample sizes and suitable methods should be performed for the future study.

REFERENCES

1. Ahlgren J. Early and late electromyographic response to treatment with activators. Am J Orthod Dentofac Orthop 1978;74(1):88-93.
2. Ingervall B, Bitsanis E. Function of masticatory muscles during the initial phase of actvator treatment. Eur J Orthod 1986;8:172-84.
3. Miralles R, Berger B, Bull R, Manns A, Carvajal R. Influence of the activator on electromyographic activity of mandibular elevator muscles. Am J Orthod Dentofac Orthop 1988;94(2):97-103.
4. Ingerval B, Thuer U. Temporal muscle activity during the first year of Class II Division 1 malocclusion treatment with an activatior. Am J Orthod Dentofac Orthop 1991;99(4):361-8.
5. Noro T, Tanne K, Sakuda M. Orthodontic forces exerted by activators with varying construction bite heights. Am J Orthod Dentofac Orthop 1994;105(2):169-79.
6. Bishara SE, Ziaja RR. Functional appliances: A review. Am J Orthod Dentofac Orthop 1989;95(3):250-8.
7. Andresen V, Haupl K. Funktions-kieferorthopadie; Die Grundlagen des Norwegischen System. Leipzig: JA Barth; 1936 (2nd reference).
8. Herren P. The activator's mode of action. Am J Orthod Dentofac Orthop 1959;45:512-27 (2nd reference).
9. Harvold EP. The activator in interceptive orthodontics St. Louis: The CV Mosby Company; 1974 (2nd reference).
10. Moyers RE. Temporomandibular muscle contraction patterns in Angle Class II Division 1 malocclusions: an electromyographic analysis. Am J Orthod Dentofac Orthop 1949;35:837-57.
11. Ahlgren J, Ingervall B, Thilander B. Muscle activity in normal and postnormal occlusion. Am J Orthod Dentofac Orthop 1973;64(5):445-56.
12. Ingervall B, Thilander B. Relation between facial morphology and activity of the masticatory muscles. J Oral Rehab 1974;1:131-47.

13. Pancherz H. Activity of the temporal and masseter muscles in Class II Division 1 malocclusions- an electromyographic investigation. Am J Orthod Dentofac Orthop 1980;77(6):679-88.

14. Lowe A, Takada K, Taylor L. Muscle activity during function and its correlation with craniofacial morphology in a sample of subjects with class II division 1 malocclusions. Am J Orthod Dentofac Orthop 1983;84(3):204-11.

15. Lowe A, Takada K. Association between anterior temporal, masseter, and orbicularis oris muscle activity and craniofacial morphology in children. Am J Orthod Dentofac Orthop 1984;86(4):319-30.

16. Miralles R, Hevia R, Contreras L, Bull R, Manns A, Carvajal R. Patterns of elecctromygraphic activity in subjects with different skeletal facial types. Angle Orthod 1991;4:277-84.

17. Sicher. Oral anatomy. 7 ed. St.Louis: Mosby; 1980:142-54.

18. Scott Day. Important factors in surface EMG measurement. Bortec Biomedical Ltd publishers; 2002:1-17.

19. De Luca CJ. Surface electromyography: Detection and Recording. DelSys Incorporated publishers; 2002:1-16.

20. Pancherz H, Anehus-Pancherz M. Muscle activity in Class II Division 1 malocclusions treated by bite jumping with the Herbst appliance. Am J Orthod Dentofac Orthop 1980;78(3):321-9.

21. Leung DK, Hagg U. An electromyographic investigation of the first six months of progressive mandibular advancement of the Herbst appliance in adolescents. Angle Orthod 2001;71(3):177-84.

22. Hagg U. Muscular Adaptation to Gradual Advancement of the Mandible. Angle Orthod 2003;73(5):525-31.

23. Tallgren A, Christiansen RL, Miller RL. Effect of a myofunctional appliance on orofacial muscle activity and structures. Angle Orthod 1998;68(3):249-58.

24. Aggarwal P, Kharbanda OP, Mathur R, Duggal R, Parkash H. Muscle response to the Twin-block appliance: An electromyographic study of the masseter and anterior temporal muscles. Am J Orthod Dentofac Orthop 1999;116(4):405-14.

25. Mc Namara JA. Neuromuscular and skeletal adaptation to altered function in orofacial region Am J Orthod Dentofac Orthop 1973;64:578-606.

26. Sessle BJ, Woodside DG, Bourque P, Gurza S, Powell G, Voudouris J, Metaxas A, Altuna G. Effect of functional appliances on jaw muscle activity. Am J Orthod Dentofac Orthop 1990;98(3):222-30.

27. Yamin-Lacouture C, Woodside DG, Sectakof PA, Sessle BJ. The action of three types of functional appliances on the activity of the masticatory muscles. Am J Orthod Dentofac Orthop 1997;112(5):560-72.

28. Sawaengkit P, Anuwongnukroh N, Dechkunakorn S, Sonthilawat P. Sagittal jaw base relationships in Thai norms. J Dent Assoc Thai 1992;42:62-8.

29. Suchato W, Chaiwat. J. Cephalometric Evaluation of the dentofacial complex of Thai Adults. J Dent Assoc Thai 1984; 34:233-42.

30. Dahlberg G. Statistical methods for medical and psychological students. New York: Interscience Publications;1940.

31. Houston WJB. The analysis of errors in orthodontic measurements. Am J Orthod Dentofac Orthop 1983;83:382-90.

32. Carels C, van der Linden F. Concepts on functional appliances' mode of action. Am J Orthod Dentofac Orthop 1987; 92(2):162-8.

33. Carels C, van Steenberghe D. Posterior periodontal loading plays a key role in the suppression of a short latency excitatory reflex in the masseter muscle in children being treated with the Bionator. Eur J Orthod 1986;8:84-90.

34. Carels C, van Steenberghe D. Changes in neuromuscular reflexes in the masseter muscles during functional jaw orthopedic treatment in children. Am J Orthod Dentofac Orthop 1986;90(5):410-9.

35. Goldberg LJ. Masseter muscle excitation induced by stimulation of periodontal and gingival receptors in man. Brain Res 1971;32:369-81.

36. Lear C, Flanagan J, Moorries C. The frequency of the deglutition in man. Arch Oral Biol 1965;19:83-9.

APPENDIX

No. 97/2004

Documentary Proof of Ethical Clearance
The Committee on Human Rights Related to
Human Experimentation
Mahidol University, Bangkok

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Title of Project: EMG Study of Masseter and Temporal Muscles in Class II Div. 1 Malocclusions Treated with Activators

Principal Investigator: Assistant Professor Paisal Chaiwat

Name of Institution: Faculty of Dentistry

Approved by the Committee on Human Rights Related to Human Experimentation

Signature of Chairman: ______________________
(Professor Dr. Srisin Khusmith)

Signature of Head of Institute: ______________________
(Professor Dr. Pornchai Matangkasombut)

Date of Approval: 27 AUG 2004

ใบยินยอมให้ทำการวิจัย

โดยได้รับการบอกกล่าวและเต็มใจ (Informed Consent Form)

การวิจัยเรื่อง การศึกษาคลื่นไฟฟ้ากล้ามเนื้อของกล้ามเนื้อแมสซีเตอร์และเทมโพรอลส่วนหน้าในผู้ที่มีการสบฟันผิดปกติประเภทที่2 ชนิดที่1 ซึ่งทำการรักษาด้วย เครื่องมือแอคติเวเตอร์ EMG Study of Masseter and Anterior temporal muscles in Class II div.1 malocclusion Treated with Activator.

วันให้คำยินยอม วันที่ ....เดือน. .... พศ. ....

ก่อนที่จะลงนามในใบยินยอมให้ทำการวิจัยนี้ ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัยหรือจากยาที่ใช้ รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

ผู้วิจัยรับรองว่าจะตอบคำถามต่างๆ ที่ข้าพเจ้าสงสัยด้วยความเต็มใจ ไม่ปิดบังซ่อนเร้น จนข้าพเจ้าพอใจ

ข้าพเจ้ามีสิทธิที่จะบอกเลิกการเข้าร่วมในโครงการวิจัยนี้เมื่อใดก็ได้ และเข้าร่วมโครงการวิจัยโดยสมัครใจและการบอกเลิกการเข้าร่วมการวิจัยนี้จะไม่มีผลต่อการรักษาโรคที่ข้าพเจ้าจะพึงได้รับต่อไป

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะเกี่ยวกับตัวข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะในรูปที่เป็นสรุปผลการวิจัย การเปิดเผยข้อมูลเกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่างๆ ที่เกี่ยวข้อง กระทำได้เฉพาะกรณีจำเป็นด้วยเหตุผลทางวิชาการเท่านั้น

ผู้วิจัยรับรองว่าหากเกิดอันตรายใดๆ อันเนื่องจากการวิจัยดังกล่าว ข้าพเจ้าจะได้รับการรักษาพยาบาลโดยไม่คิดมูลค่าตามมาตรฐานวิชาชีพ และจะได้รับการชดเชยรายได้ที่สูญเสียไประหว่างการรักษาพยาบาลดังกล่าว ตลอดจนเงินทดแทนความพิการที่อาจเกิดขึ้น

ผู้วิจัยรับรองว่าหากมีข้อมูลเพิ่มเติมที่ส่งผลกระทบต่อการวิจัย ข้าพเจ้าจะได้รับการแจ้งให้ทราบโดยไม่ปิดบัง ซ่อนเร้น

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ และได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ

ลงนาม... ผู้ยินยอม

ลงนาม...พยาน

ลงนาม...พยาน

ในกรณีที่ผู้ยินยอมตนให้ทำการวิจัยไม่สามารถอ่านและเขียนหนังสือได้ จะต้องได้รับการยินยอมในขณะที่ยังมีสติสัมปชัญญะ และระบุข้อความไว้ตามนี้ ข้าพเจ้าไม่สามารถอ่านหนังสือได้ แต่ผู้วิจัยได้อ่านข้อความในใบยินยอมนี้ให้แก่ข้าพเจ้าฟังจนเข้าใจดีแล้ว ข้าพเจ้าจึงลงนาม หรือประทับลายนิ้วหัวแม่มือของข้าพเจ้าในใบยินยอมนี้ด้วยความเต็มใจ

ลงนาม...ผู้ยินยอม

(หรือประทับลายนิ้วหัวแม่มือ)

ลงนาม...พยาน

ลงนาม...พยาน

ในกรณีที่ผู้ยินยอมตนให้ทำการวิจัยยังไม่บรรลุนิติภาวะ จะต้องได้รับการยินยอม จากผู้ปกครองหรือผู้อุปการะโดยชอบด้วยกฎหมาย

ลงนาม...ผู้ปกครอง/ผู้อุปการะ
โดยชอบด้วยกฎหมาย

ลงนาม...พยาน

ลงนาม...พยาน

ในกรณีที่ผู้ยินยอมตนให้ทำการวิจัยไม่สามารถตัดสินใจเองได้ (เช่น กรณีผู้ยินยอมตนให้ทำการวิจัยอยู่ในภาวะหมดสติ) ให้ผู้แทนโดยชอบด้วยกฎหมาย หรือผู้ปกครอง หรือญาติที่ใกล้ชิดที่สุดเป็นผู้ลงนามยินยอม

ลงนาม...ผู้แทน/ผู้ปกครอง/ญาติ

ลงนาม...พยาน

ลงนาม...พยาน

ชื่อ..นามสกุล..

ใส่เครื่องมือเวลา 18.00 น. – 6.00 น.

วัน/เดือน/ปี	เวลาที่ใส่เครื่องมือ	เวลาที่ถอดเครื่องมือ	หมายเหตุ

BIOGRAPHY

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