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ELECTROMYOGRAPHY- ELECTROMYOGRAPHY IN ORTHODONTICS IN PARTICULAR AND DENTISTRY IN GENERAL : A REVIEW-II

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ABSTRACT: Electromyography is the recording and analysis of the electrical potentials of the muscle. Man has always been curious to know about his body and the surroundings. This led the mankind through many path breaking inventions that made human life easy. Much research has been done and documented in the field of bioelectricity which led to the present day electrodiagnostic procedures. .EMG as a diagnostic tool is a boon to the field of medicine. It plays a major and important role in different aspects of clinical medicine and dentistry. Hence an attempt has been made here to review the literature to acquaint the reader with history and invention of EMG and subsequent developments in that field. The literature on EMG in clinical medicine (part 1) and dentistry in general and orthodontics in particular (part 2) has been reviewed analytically.

KEYWORDS: Electromyography, EMG, Clinical medicine , Orthodontics

INTRODUCTION

In order to review the literature on EMG in orthodontics with some relevance and order, a division of the subject as following is essential- EMG as a supplemental aid in orthodontic diagnosis used in the diagnosis of abnormal muscle function in malocclusion, in determining the mandibular rest position and in determining the optimal bite in dual bite cases.

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EMG in Orthodontics in particular and Dentistry in general

EMG as an aid in treatment assessment is used in determining maxillomandibular relationships brought about by tooth movements, in assessing muscle function and balance before, during and after fixed and functional orthodontic therapy and orthognathic surgery.

EMG as a tool in orthodontic research is used to study temporomandibular joint articulation (TMJ Kinesiology), to study temporomandibular dysfunction, to study and compare muscle function in normal occlusion and malocclusions, to know whether abnormal muscle function can cause malocclusion and in the analysis of function and functional relationships of complex oral apparatus (especially masticatory muscles, tongue and buccinator mechanism).

Moyers[1] (1949) used electromyography mainly to analyze the role of temporomandibular musculature as an etiology of Angle's Class II malocclusion. All the masticatory muscles, suprahyoid muscles and mentalis muscle were investigated.

It was observed in the first place that there was a remarkable state of “tonus" in all parts of the muscle, in spite of the muscle having triple innervation. During elevation and depression of the mandible, there was uniformity of the spike potentials with regard to amplitude and frequency. Further, this uniformity was lost in cases of mandibular retroversion where greater contractions from the posterior fibres of the temporal muscle were observed. He thought that, this imbalance in the distribution of the activity was an etiological factor in the retroversion of the mandible. Pterygoid and masseter muscles presented a normal picture. The mentalis muscles were found to be hypertrophied in subjects with maxillary dental protrusion.

Moyers[2] (1950) further observed that the various movements of the temporomandibular articulation were regulated by the interaction of several muscles. In mandibular depression brought about by the lateral pterygoid and digastric muscles, the latter participates to a greater extent at the end of the movement than at the beginning. Elevation of the mandible was by the coordinated contractions of the medial pterygoid, masseter and temporal muscles. Lateral excursion of the mandible were by the ipsilateral contraction of the temporal and the contralateral contractions of the medial and lateral pterygoid muscles. Protraction of the mandible was by the simultaneous contractions of both the lateral and medial pterygoid muscles. Retraction of the mandible was by the contraction of the middle and posterior fibres of the temporal muscle. In all movements of the mandible, the suprahyoid group of muscles had an important rote in stabilizing the jaw.

Karau[3] (1956) concluded that the temporal muscle is best suited for movement and positioning of the mandible whereas the masseter functioned as a power muscle. The results indicated that harmony of the occlusal relations of the teeth, rather than sagittal relation of the mandible to the maxilla, was the primary determinant for muscular function.

Shpuntoff and Shpuntoff [4] (1956), concluded that the examination of masticatory muscles indicated that when one muscle is at physiologic rest, the others are also silent.

Latif[5](1957) found that the posterior fibres of temporalis muscle were active in maintaining the mandibular posture in the physiologic rest position, the temporalis was an ipsilateral abductor and a contralateral adductor of the mandible. In maximal opening of the mouth, the temporalis muscle acts as an antagonist to prevent dislocation of TMJ. All the parts of the temporalis muscle were active during molar occlusion.

Ahlgren[6](1960) did an electromyographic study on the theories on which Andresen based his activator therapy. He observed that the highest muscle activity was seen in the mandibular protractors with simultaneous inhibition in the activity of the retractors when biting on the appliance. This observation was contrary to that of Eshler but agreed with the original hypothesis of Andresen. When the activator was removed after wear at night, the mandibular retractors showed the greatest activity for about two hours before the initial pattern was reestablished.

It was hypothesized that intermittent muscle activity when the appliance was worn was not due to stretch but due to swallowing which was frequently necessary with the activator in the mouth, probably due to greater flow of saliva.

The principles in treatment with activator was re-education of the muscles as occlusal changes occur. It was observed that the reflex activity in the muscles could be changed to a new and more favorable contraction pattern reinforced and maintained by the afferent signals from the periodontal membrane when intercuspation of teeth were improved by the treatment. The stretch caused by protruding the mandible past the postural position did not elicit increased muscle activity. The tendency to return to the postural position is due to sheer passive tension of muscles and their tendons

. Porrit[7] (1960) concluded that a single occlusal interference was sufficient to change masticatory muscle contraction patterns and removal of occlusal interferences restored the symmetrical muscle contraction patterns and that interferences could inhibit muscle activity during movements of the mandible. Adaptation of the mandible was generally accomplished in a short time after the occlusal interferences were placed. The location of the interference on the tooth appeared to be more responsible for the change in muscle contraction patterns than the location of the tooth in the mouth. The temporal muscle seemed more sensitive to interferences than the masseter.

Grossman et al [8] (1961) felt that the problem in orthodontic therapy was not purely mechanical since the muscular influences were responsible as an etiologic factor of the problem and that they greatly influenced the stability of the end result. They also stated that an exact assessment of the muscle behaviour prior to commencement of treatment would enable the orthodontist to make a comparison and to assess any changes that might have occured due to treatment.

Okun [9] (1962), concluded that prolonged use of Class II elastics during treatment might affect the muscular pattern in such a way that the posterior temporal fibres became dominant and masseters became diminished electromyographically, this action being reversed in the case of Class III elastics. In Class II cases undergoing treatment, in isometric conctraction, masseteric activity showed greater increase in more severe anterioposterior discrepancies and temporal activity showed greater increase in the marked crossbite cases. This could be related to the crossbite creating a marked tooth interference which limited the functional positioning activity of the temporal muscle.

Winders [10] (1962) stated that normal swallow showed neither contraction of the perioral musculature nor an increase in buccal pressures bearing on the dentition. Only open bites showed increase in perioral pressures.

Ahlgren et al [11] (1973) observed that the post normal occlusions showed less EMG activity than normal occlusions during swallowing in the anterior temporal muscle and the masseter muscle. Further, postnormal occlusions showed longer duration of the activity during swallowing in the posterior than in the anterior part of the temporal muscle. While the reverse relationship was found normal occlusion.

Vitti et al[12] (1975) analyzed the activity of tongue and circumoral muscles in eleven individuals with normal occlusion. During aberrant oral activity (such as thumb sucking), a marked EMG response occurred in both orbicularis oris and genioglossus muscles, but only slightly increased activity occurred in the buccinator muscle.

These findings helped to explain the role of muscles as etiology of malocclusions seen in tongue thrusters and thumb suckers.

Moss[13] (1975) studied the patterns of muscle activity in normal and malocclusion subjects before and after orthodontic treatment. He concluded that sbjects with normal occlusion showed a specific pattern of muscle activity and the masticatory muscle activity was high among each groups and there was a difference in muscle pattern between children and adults. Subjects with different malocclusions could be differentiated on the basis of their patterns of muscle activity. During treatment, muscle patterns changed. Depending on the type of treatment, they exhibited a more normal pattern of activity, once they were out of retention.

It was observed that patients treated with functional appliances had a greater chance of normal muscle patterns than those treated with multibanded light wire appliances when evaluated even after one or more year out of retention. The muscle activity could be palpated and this also could be used as a clinical aid to assess the position of the jaw. Following orthodontic treatment, muscle activity might give an indication of the stability of the result and the need for occlusal equilibration.

Choudary[14](1976) found that the buccinator muscles were electrically active at rest, both in normal and Class II Division 1 subjects. There was an increased electrical activity of the muscles of the malocclusion subjects during the rest position and swallowing. There was no significant difference in buccinator activity in normal and malocclusion subjects during swallowing.

Ingerval.B[15](1976) studied correlations between facial and bite morphology and the activity in the temporal and lip muscles during swallowing and chewing. The activity in the lower lip during swallowing was not correlated with any of the variables of the facial morphology, except the width of the upper dental arch. On the other hand, activity of the upper lip and temporalis during swallowing was correlated with a number of variables used for measuring facial form, like facial shape, inclination of the maxilla and mandible, facial height and prognathism. The number of chewing cycles required for trituration of the test media was negatively correlated with the number of teeth and with age. This was interpreted as adaptation in such a way that the number of cycles decreased with the development of dentition.

Perkins et al [16] (1977) did an EMG analysis of the buccinator mechanism and concluded that the orbicularis oris, buccinator and superior constrictor muscles should be viewed as a unit in swallowing, blowing, sucking, speaking, chewing and coughing. The components of buccinator mechanism which surrounds the dentition maintains equilibrium of occlusion. The buccinator and orbicularis oris played a definite role in beginning the swallow by producing a peristalitic like wave of contraction originating in the oral cavity and passing pharyngeally. The buccinator usually initiated the sequence followed quickly by the orbicularis oris.

Pancherz et al[17] (1978) investigated masticatory function in 9 patients with relapse and 10 patients without relapse of overjet subsequent to activator therapy. Masticatory efficiency was evaluated by chewing test and was related to the number of intermaxillary tooth contacts and EMG activity of the temporal ad masseter muscles. The results indicated reduced masticatory efficiency which was related to fewer intermaxillary tooth contacts and less EMG activity of the temporal and masseter muscles. In patients with relapse of overjet, masticatory efficiency and muscle activity was reduced in comparison with patients without relapse.

Ingervall et al[18] (1979) studied the activity of temporal and masseter muscles in individuals with dual bite. The subjects with dual bite had low postural activity of temporal muscle possibly indicating a protruded postural position of the mandible. The activity of the posterior temporal muscle was low during maximal bite in the intercuspal position and the same was true for the masseter activity during biting in the retruded position. Neither of the two mandibular positions examined gave a balanced activity during maximal bite in all three muscles examined. They also found that the duration of the muscle activity in the individual chewing cycles was longer in the subjects with dual bite than in the controls. This could be due to stability of the occlusion. The pattern of muscle activity during chewing indicated that the retruded mandibular position was used during chewing. It was therefore probably functionally beneficial to create a stable occlusion in the retruded mandibular position.

Hans Jorg[19] (1980) studied the electromyographic recordings of the lateral pterygoid muscle in Class II Division 1 malocclusions treated with activator. He concluded that the activator functioned only as a splint and that the protrusion of the mandible during wearing of the activator did not depend on activity of the lateral pterygoid muscle.

Pancherz[20](1980), in his EMG investigation of temporal and masseter muscles in children and adults with normal occlusion , concluded that the difference in EMG activity observed between children and adults could be attributed to age changes and for an exercising effect occurring during maturation

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Christensen.L..V.[21] (1980) evaluated the effects of an occlusal splint on integrated electromyography of masseter muscle in clenching in experimental subjects. He concluded that the mode of action of the splint in reducing the muscle activity might have been that of stretching.

Sheikhoeslam et al [22] (1982) compared clinical data of pain and tenderness and electromyopraphic recordings of 37 patients before and after treatment of functional disorders of the masticatory system. Muscle activity during maximal bite in the intercuspal position was not altered by treatment. It was concluded that the intermaxillary conditions and tooth contact during function played a role In the etiology of functional disorders as shown in EMG recordings.

Harradine and Kirschen[23] (1983) concluded that the effects of perioral musculature activity were dependent on the presence or absence of competent lip seal. Resting potentials of the perioral muscles influenced incisor position in subjects with competent lip seal, but, the intermittent activity of chewing, speaking and swallowing did not.

Moss and Willmot [24] (1984) investigated the cephalometric and EMG records of 31 patients with mandibular prognathism treated by mandibular surgery only. They found that the relapse of Class III cases treated by mandibular surgery only was related to the occlusion of the teeth, alteration in the muscle patterns and a lack of change in the position of the centroid of the tongue as the jaw was moved back with surgery.

Ahlgren et al [25] (1985) recorded electromyographic activity using intramuscular electordes from anterior, middle and posterior parts of the temporal muscle in 10 subjects with normal occlusion while the mandible was at rest and during exertion. Results showed that posterior part of the temporalis maintained the mandibular posture. Individual variations in EMG did exist among three divisions of the muscle. During exertion of the increased biting force, the EMG activity increased proportionally in all parts of the muscle. The EMG activity of the temporalis was related to the form and position of the mandible.

Haraldson et al[26] (1985) found that the EMG activity increased with increasing bite force. Clark and Carter [27] (1985) evaluated the effect of a sustained isometric clenching at various force levels and suggested a lack of contractile failure in the jaw closing muscles. Pain intolerance rather than neuromuscular fatigue was the limiting factor of a sustained submaximal or even maximal clenching effort.

Carels and Steenberghe[28] (1986) studied the change in neuromuscular reflexes in the masseter muscles during functional jaw orthopedic treatment using Bionator. They found that successful functional therapy was accompanied by specific transient changes in the reflex response of the masseter muscles. They concluded that neural pathway contributing to these observations originated in periodontal and muscular receptors and these might provide a clue for the mechanism underlying successful functional treatment.

Ingervall and Bistanis[29] (1986) studied the function of masticatory muscles before and during the first six months of the treatment of distoocclusIon wtth an activator. They found that the muscle activity in the rest position was low and was the same with or without the activator. The activity of the posterior portion of the temporal muscle in the rest position was comparatively high at the start of treatment but decreased during the period of observation

Ahlgren[30] (1986) studied the EMG pattern of temporalis muscle in normal occlusion. He found that the posterior part of the temporal muscle was active during posture, whereas no significant difference was observed in EMG activity of the three divisions of temporalis muscle in isometric contraction.

Wood et al[31] (1986) studied the electromyographic activity of the inferior part of the lateral pterygoid muscle during clenching and chewing. They found that, during chewing, activity appeared in the later intercuspal phase irrespective of the side used.

Harper et al[32] (1987) studied lateral pterygoid muscle activity in mandibular retrognatnism and it's changes in mandibular advancement by surgery. They demonstrated previously unreported abnormal activity patterns of the pterygoid muscles and their adaptive response to orthognathic surgery.

Widmer[33] (1987) suggested that central control was evident over the facilitation and inhibition of jaw opening and jaw closing muscle activity.

Stalberg and Eriksson[34] (1987) confirmed that masseter motor units contained fewer muscle fibres than those in large limb muscles. Further, small motor unit territories indicated local specialization which would favor fine adjustments of jaw movements. Their findings emphasized the unique structural and functional features of the human mandibular motor system.

Miralles et al [35] (1988) recorded electromyographic activity of anterior temporal and masseter muscles in 15 children with Class II Division 1 malocclusion undergoing treatment by activator. They found that the activity was significantly higher during swallowing with the appliance in the mouth which supported the rationale for the diurnal wear of the activator.

Jimenez[36] (1989) studied electromyography of masticatory muscles in three jaw registration portions (R.C.P-Retruded contact position , I P-Intercuspal position and M P- Muscular position). The retruded contact position (R.C.P.) required more positioning muscle activity and permitted less biting muscle activity. There was no significant difference in the muscle activity between the intercuspal position (I .P.) and muscular position (M.P.) registrations. Small changes in jaw position (anterior to R.C.P.) were not critical for the masticatory appratus, provided there was a good intercuspation. The results suggested that intercuspation in R.C.P. was not the optimal position.

Yuen et al[37] (1990) stated that the downward shifts in power spectrum of electromyograms of masseter and anterior temporal muscles during functional appliance therapy in children may be associated with changes in length of muscle fibre and / or recruitment patterns.

Miralles et al[38] (1991) studied the patterns of EMG activity of anterior temporal and masseter muscles in subjects with different facial types. They found that postural activity for both muscles was higher in Class III subjects whereas it was similar in Class I and Class II subjects. During swallowing, Class III subjects showed higher masseter muscle activity than in Class I and Class II subjects.Temporal muscle activity was not different between Class in III and Class I. During maximal voluntary clenching, activity was not different among classes. They also observed high correlations between EMG activity, ANB angle and overjet. It was concluded that skeletal classification used in the study had clinical relevance in treatment and prognosis as well as in the assessment of the relationship between muscular activity and craniofacial characteristics.

Stavridi and Ahlgren[39] (1992) found that the oral screen activator (OSAC) increased masseter activity during swallowing, but it remained unchanged during clenching. Lip pads increased mentalis activity during lip closure, but reduced mentalis hyperactivity during swallowing. The buccinator activity was insignificant and buccal shield did not change that activity..

Discussion

The pressing problem in orthodontic therapy today is not mechanical. Appliances have reached such perfection that most malocclusions could be treated to predestined goals. However, difficulty exists as the prevalent danger of relapse. The hope that knowledge of etiology would have a better prognosis in such cases is often in vain. The uncertainty in response to mechanics and stability of achieved results have been responsible for the various philosophies that have been put forth. Two cases with similar etiological factors may respond differently, a fact that is well known to all who practice orthodontics. Hence, the most pressing problem at present facing the orthodontist is a better understanding of the etiology of malocclusions and the changes that occur during treatment.

It is widely agreed that muscular influences are mostly responsible for the topography of the dental arches and is an important factor in the final stability of the treated result. Abnormal muscle behavior patterns as in short upper lip, incompetent lip seal, tongue thrust and hyperactive mentalis result in typical and well defined dental abnormalities. These aberrancies are all frequently seen and their importance is realized but it is by no means universally agreed that they are not amenable to treatment or to reeducation. For example, in Class n Division 1 malocclusion, the presence of hyperactive mentalis and flaccid upper lip is clear. EMG evidence supplements this diagnosis and serves as a record of this deviation from normal in black and white.

The fact that some cases with abnormal muscle function respond well to treatment and remain stable suggest that an adaptation in the muscle may have occurred. The present difficulty is the lack of an exact scientific assessment end quantification of existing muscle behavior prior to commencement of treatment, which would help the orthodontist to compare and assess any changes that may have occurred during treatment. Though many reports based on clinical observations of experienced clinicians are available, they are, nevertheless, open to error. Some of the abnormal muscle activities do disappear and may therefore be considered either as habits or as being amenable to re-eduction. Others persist and lead to relapse. It is, therefore, worthwhile to assess the muscular environment in these cases with the help of electromyography.

In the analysis of treatment results, one question that has been and is of interest is," How far functional stimulation and environmental influences can lead to changes in the masticatory apparatus? ". Of particular interest to the orthodontist is the maxillomandibular relationship. The question as to whether the mandible can change it's position during treatment is of fundamental interest.

Andresen, Gresham and Ricketts had strongly expressed the view that the maxillomandibular relationship could be altered successfully with the help of functional appliance therapy, whereas Bjork, Hovell and Softley contradicted this opinion[40]. Most of these statements are based on clinical observations, study models and cephalometric roentgenograms. Cephalometric findings, however accurate, are often difficult to interpret, as it is impossible to differentiate between normal growth changes and those due to therapeutic measures. In this regard, electromyography offers an exact and reliable scientific tool for making this assessment.

The determination of physiologic rest portion and centric relation of the mandible to the maxilla is of paramount importance in all areas of dentistry. Initially, these were derived from geometric relations with roentgenographic evidence correlating the position of the condyle in the glenoid fossa. These measurements made with intraoral and extraoral devices and registration materials have not been accurate. Absence of any muscle activity is apparent in the definition of physiologic rest position of the mandible. Determination of lack of activity in muscles is beyond the perception of hurnan senses. Hence, an apparatus which is sensitive enough to detect, amplify and record muscle potentials which are far below human perception should be employed. The method devoid of assumptions and that is most convenient in the study of muscle action is electromyography.

Dual bite is defined as an occlusion with an abnormally long anteroposterior difference between the retruded and intercuspal positions of the mandible. The average "normal" distance between most retruded and intercuspal position varies between 0 and 2 mm. If the distance is more than 2 mm, the occlusion is classified as a dual bite. The patient in this situation has two occlusal positions that he can easily establish in which the upper and lower teeth interdigitate. The most anterior of these positions is the intercuspal position of the mandible and the most posterior is close to or coincident with the retruded position of the mandible. Uncertainty exists as to whether or not dual bite predisposes individuals to functional disturbances of the masticatory system and which of the mandibular positions should be considered the optimal intermaxillary relationship. Electromyography is a valuable aid in determining the optimum bite in dual bite cases.

The temporomandibular articulation, one of the unique joints in the human body, has been favourite for study by anatomists and physiologists. However, a thorough knowledge of the functioning of this articulation is important to the oral and maxillofacial surgeons, the otorhinolaryngologist, the prosthodontist and the orthodontist. EMG, as a research tool has been of much help in the study of TMJ kinesiology as well as in the diagnosis of temporomandibular dysfunction. The role of function and functional relationship of the complex oral apparatus (masticatory muscles, tongue and buccinator mechanisms) is of concern to the orthodontist because of its influence on the development of occlusion. EMG is a valuable research tool in studying the function and functional relationship of the oral apparatus in normal occlusion and malocclusion.

SUMMARY AND CONCLUSION

In the past, orthodontists depended mainly on static and stable records in the form of plaster models and head films for diagnosis and planning. It is now an established fact that the oral musculature plays a dynamic role in the establishment and maintenance of occlusion. Since Orthodontists have moved from a stable to a dynamic and functional concept of occlusion, it is mandatory that orthodontist knows how a muscle functions. In this context, thorough knowledge of physiology of skeletal muscle contraction is mandatory for an orthodontist.

With the quantum leap in the electrodiagnostic procedures in the recent years, it is possible to record even minute electrical activity of biologic tissues. Sometimes, orthodontic clinicians may have to resort to the use of EMG for diagnosis and assessment of cases under treatment. If one wishes to use a diagnostic apparatus or for that matter any apparatus, he should have basic knowledge about that particular paraphernalia related to the system and the examination procedure.

In addition, potential of EMG in orthodontics is discussed in the context of diagnosis, treatment planning and evaluation of treated results. The orthodontist is encouraged to use this tool in areas of research as well as treatment.

References

1. Moyers.R. E. Temporomandibular muscle contraction patterns in Angle's Class II Div 1 malocclusions. An EMG analysis. Am. J.Orthod.1949; 35: 837-857. http://dx.doi.org/10.1016/0002-9416(49)90078-0
2. Moyers. R. E. An EMG analysis of certain muscles involved in temporomandibular movements. Am.J.Orthod.1950;36(7):481-515. http://dx.doi.org/10.1016/0002-9416(50)90063-7
3. Karau.R.E. An EMG comparsion of the temporal and masseter muscle of orthodontically treated and untreated malocclusion. (Abstract). Am.J.othod.1956; 42(10);792.
4. Shpuntoff and Shpuntoff. A study of physoilogic rest position and centric position by electromyography. J.Prosth. Dent.1956; 6 (5):621-628. http://dx.doi.org/10.1016/0022-3913(56)90006-3
5. Latif. A. An EMG study of the temporalis muscle in normal persons during selected positions and movements of the mandible. Am.J.Orthod.1957; 43 (8) ;577-591. http://dx.doi.org/10.1016/0002-9416(57)90161-6
6. Ahlgren. An EMG investigation of the response to activator. Am. J. Orthod. 1960; 46 (1); 57. http://dx.doi.org/10.1016/S0002-9416(60)80010-3
7. Porrit.J E. An EMG study involving occlusal interferences. Am.J.Orthod.1960; 46 (1) ;57http://dx.doi.org/10.1016/S0002-9416(60)80011-5
8. Grossman et al. EMG as an aid in diagnosis and treatment analysis. Am.J.orthod. 1961; 47(7); 481. http://dx.doi.org/10.1016/0002-9416(61)90190-7
9. Okun.J.H. EMG study of Class II cases during orthodontic treatment. Am. J. Orthod. 1962;48;474-78. http://dx.doi.org/10.1016/0002-9416(62)90266-X
10. Winders.R.V. Recent findings in myometric research. Angle.Orthod.1962; 32(1); 38-43.
11. Ahlgren et al. Muscle activity in normal and post normal occlusion. Am.J.orthod. 1973; 64; 445 – 56. http://dx.doi.org/10.1016/0002-9416(73)90258-3
12. Vitti et al. EMG investigations of the tongue and circular muscular sling with fine wire electrode. J.Dent.Res.1975; 54 (4); 844-9. http://dx.doi.org/10.1177/00220345750540042401

13. Moss. Function, fact or fiction. Am.J.Orthod.1975; 67:625-646. http://dx.doi.org/10.1016/0002-9416(75)90138-4
14. Choudary A.K.B. An EMG study of the buccinator muscles in normal and Cl II Div I malocclusion cases.1976; JIDA.;48.
15. Ingerval.B. Facial morphology and activity of temporal and lip muscles during swallowing and chewing. Angle. Orthod.1976; 46 (4); 372-380.
16. Perkins et al. EMG analysis of the "Buccinator mechanism" in human beings. J.Dent.Res.1977; 56 (7); 783-94. http://dx.doi.org/10.1177/00220345770560071301
17. Pancherz, Margareta, Anechus. Masticatory function after activator treatment. An analysis of masticatory efficency,occlusal contact condition and EMG activity. Acta. Odont.Scand 1978;36(5); 309-16. http://dx.doi.org/10.3109/00016357809029081
18. Ingerval et al. Function of temporal and masseter muscles in individuals with dual bite. Angle.Orthod.1979; 49 (2); 131-40.
19. Hans Jorg Auf der Maur. EMG recordings of the lateral ptergoid muscle in activator treatment of class II Div 1 malocclusion cases. Eur.J.Orthod.1980; 2: 161-71.
20. Pancherz. Temporal and masseter muscle activity in children and adults with normal occlusion; An EMG investigation. (Abstract). Acta. Odont Scand.1980; 38(6); 343 – 8. http://dx.doi.org/10.3109/00016358009033603
21. Christensen. L. V. Effects of an occlusal splint on integrated EMG of masseter muscle in experimental tooth clenching in man.(Abstract). J of oral Rehabil.1980; 7(4); 281-8. http://dx.doi.org/10.1111/j.1365-2842.1980.tb00446.x
22. Sheikholeslam and Holler.E. and Lous. Postural and maximal activity in elevators of mandible before and after treatment of functional disorders.(Abstract). Scand.J.Dent Res.1982; 90(l):37-46.
23. Harradine Kirshen. Lip and mentalis activity and it's influence on insisor position ;A Quantitative EMG study. Brit. J. Orthod.1983;10 (3);114-27.
24. Moss and Willmot. A cephalomatric and EMG investigation of patients treated for correction of mandibular prognathism by surgery only. Brit.J.Orthod.1984;11 (2):59-68.
25. Ahlgren et al. An EMG analysis of temporalis function of normal occlusion. Am.J.orthod.1985;87; 230-239. http://dx.doi.org/10.1016/0002-9416(85)90044-2
26. Haraldson et al. Relationship between myoelectric activity in masticatory muscles and bite force. Scand.J.Dent.Res.1985; 93(6);539-45.
27. Clark and Carter. EMG study of human jaw closing muscle endurance. Fatigue and recovery at various isometric force levels. (Abstract). Arch.Oral.BioI.1985; 30 (7) ;563-9.
28. Carels and Steenberg. Changes in neuromuscular reflexes in the masseter muscles during functional jaw orthopedic treatment in children. Am. J Orthod.1986; 90 (5) ;410 - 9.
29. Ingerval and Bistanis. Function of masticatory muscles during the initial phase of activator treatment. Eur.J.orthod 1986; 8 :172 – 84.
30. Ahlgren. EMG pattern of temporlais in normal occlusion. Eur.J.orthod.1986:8; 185-191.
31. Wood et al. EMG activity of the inferior part of the human lateral pterygoid muscle during clenching and chewing. Arch.Oral.Biol.1986; 31 (4); 245 – 53. http://dx.doi.org/10.1016/0003-9969(86)90056-7
32. Harper et al. Lateral Pterygoid muscle activity in mandibular retrognathism and response to mandibular advancement surgery.Am.J.orthod.1987; 91(1); 70-6.
33. Widmer.C.G.. Jaw opening reflex activity in the inferior head of lateral pteryoid muscle in man. Arch.Oral.Biol.1987; 32 (2):135-42. http://dx.doi.org/10.1016/0003-9969(87)90057-4
34. Stalberg and Eriksson. A scanning EMG study of the topography of human masseter single motor units. Arch.Oral.Biol.1987;32(11):793-97. http://dx.doi.org/10.1016/0003-9969(87)90005-7
35. Miralles et al. Influence of the activator on EMG activity of mandibular elevators. Am.J.Orthod.1988; 94(2); 97-103.
36. Jimenez. EMG of masticatory muscles. Am. J . orthod.1989; 95 (4) : 282-7.
37. Yuen et al. Changes in power spectrum of EMG of masseter and anterior temporal muscles during functional appliance therapy in children. Am. J. Orthod.1990; 97(4); 301-7.
38. Miralles et al. Patterns of EMG activity in subjects with different facial types. Angle.Orthod.1991; 61(4):277-84.
39. Stavridi .R and Algren.J. Muscle response to the oral screen - activator. An EMG study of the masseter, buccinator and mentalis muscles. Eur.J.Orthod.1992;14;339–349.
40. Grossman et al. EMG as an aid in diagnosis and treatment analysis. Am.J.orthod.1961; 47(7); 481. http://dx.doi.org/10.1016/0002-9416(61)90190-7

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