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SEMINARS

These papers, similiar to the Lectures to State Branches, are included in the Journal to avail others outside the State of origin of the material being presented to the particular teaching department. They have been segregated from the Lectures section because of their theoretical nature. The material is selected on the grounds that it is suitable background information for current clinical trends.

Electromyography in orthodontics

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(Printed with the kind permission of Dr V.C. West, Senior Lecturer in Orthodontics, University of Melbourne)

INTRODUCTION

Electromyography (EMG) is concerned with the detection, recording and interpretation of electrical activity in skeletal muscle. The first such records were produced in 1929 and a further 20 years had elapsed before the first EMG study of the jaw muscles was made by Moyers in 1949.

Since that time, EMG has become a widely used and useful tool in both experimental and clinical orthodontic research.

An understanding of EMG is of importance to the orthodontist, primarily to enable one to weigh up and assess the various claims and conclusions drawn, on the basis of EMG investigations, into the aetiology of malocclusion, the effect of various treatment modalities on the musculature and post treatment stability.

In this seminar it is intended to outline the principles and technique of EMG, examine the nature of the signals produced and to assess the evaluation of EMG records. It is then intended to examine the reports in the literature of relevance to orthodontics. The embryology and physiology of neuromuscular activity has been extensively covered in a previous seminar (Miles 1985).

The basis of electromyography (Functional considerations)

The motor unit: In normal mammalian skeletal muscle fibres probably never contract as individuals. Instead, small groups contract at the same moment. One finds that all the members of these groups are supplied by the terminal branches of one nerve fibre or axon, whose cell body is found in the anterior horn of the spinal grey matter. This cell body, plus the long axon running down the motor nerve, its terminal branches and all the muscle fibres supplied by these branches, together form a motor unit.

The number of muscle fibres in a motor unit varies widely, from fine control muscles of the eye with some ten fibres per unit, to the large coarse-acting muscles of the limbs, with some 2000 fibres per unit. The only figures available for the muscles of the jaw indicate 939:I for the Temporalis and 640:I for the Masseter (Gill 1977).

The motor units normally contract sharply upon arrival of a nerve impulse, at various frequencies, usually below 50 per second.

The motor unit potential: When an impulse reaches the motor end-plate, where the axonal branch terminates, a wave of contraction spreads over the fibre resulting in a brief twitch, followed by a rapid and complete relaxation. The duration of this twitch and relaxation varies from a few msec. up to 0.2 sec. During the twitch a minute electrical potential, with the duration of 1-2 msec. is generated, which is dissipated into the surrounding tissues. Because not all of the fibres of a motor unit contract at exactly the same time the electrical potential developed by the single twitch is prolonged to about 5-12msec. *It is this electrical discharge* as a result of a motor unit twitch, with a median duration of 0.9 msec., and a total amplitude measured in micro volts, *which is measured by EMG electrodes.*

With surface electrodes the durations are prolonged as the potentials are 'blurred' and with bi-polar needle electrodes, the duration is considerably shorter, the mean duration being 5 msec.

APPARATUS AND TECHNIQUE OF ELECTROMYOGRAPHY

1. Electrodes:

A wide variety of electrodes have been used in EMG. The two main types are surface or skin electrodes, and needle electrodes. A ground or negative electrode is also needed.

(a) *Bi-polar needle electrodes.*These are hypodermic needles with the tips of two fine wires exposed at the lumen, which are inserted into the muscle under investigation. This type of electrode discloses the discrete nature of the Motor Unit Action Potential (MUAP), because it records from only a small area of muscle.

(b) *Surface electrodes.* These are the commonly used electrodes in dental clinical applications of EMG. They consist of two metal discs placed over the muscle under investigation, with electrode jelly at the interface, to reduce electrical resistance to a minimum. Surface electrodes record the summation of potentials from active motor units over an ill defined muscle area.

Recently, ***a miniature surface electrode*** has been described (Yosheda, 1982) for assessing the EMG activity of the tongue, using fine silver wire and cyano-acrylate tissue adhesive. For investigations of the tongue muscle in functional activity, this appears to have some merit.

2. The electromyograph

Basically this machine is a high-gain amplifier with a preference or selectivity for frequencies in the range from about ten to several thousand Hz. (cycles per second).

The subject and paired recording electrodes can be shielded from outside electrical activity by use of the Faraday Cage. However the practical limit of amplification of the original voltages is limited by:

- Interception of some outside electrical activity.
- Skin movement around the electrodes.
- Electronic noise due to circuitry and amplifier imperfections.

With improvements in technology and techniques, *the Faraday cage is no longer considered to be essential.*

3. Reducing noise

While the use of a shielded room may remove most unwanted signals from the atmosphere and surrounding electrical fields, a ***major source of disturbance is movement artifact.*** Recently the use of an F.E.T. device (a dual field-effect transistor source follower), completely removes the interference of noise coming from cables, to the main amplifiers. Reducing the length of wire connections between amplifier and electrodes is also useful in improving signal-to-noise ratio.

4. Recorders
Today the multi-channel F.M. tape recorder is being widely used, and is regarded as the most accurate recorder. The data stored on magnetic tape is processed further into a quantitative state in various ways:

(a) On a cathode-ray oscilloscope.

(b) Onto paper, by pen writers.

(c) Into analogue computers. The analogue signal can be after various steps (such as intergration of spikes over time), converted for use in a digital computer. The latter can be programmed to make judgments that are quantitatively as accurate as the human eye.

Direct recorders are also available that produce immediate records of the EMG signal, on U.V. light sensitive paper. However, today, these systems are considered to be quite expensive to operate and are inferior to the computerised recording techniques now available.

TOWARDS UNDERSTANDING THE EMG SIGNAL
The lack of a proper description of the EMG signal is probably the greatest single factor, which has hampered the development of Electromyography into a precise discipline (Basmajian 1978).

1. The action potential
When the post synaptic membrane of a muscle is depolarised, the depolarisation propagates in both directions and is accompanied by a movement of ions, which generates an electro-magnetic field in the area. A recording electrode placed in this field will detect the potential or voltage (with respect to ground), whose time excursion is known as an action potential.

The individual fibre action potentials represent the contribution that each active muscle fibre makes to the signal detected at the electrode site, which is the motor unit action potential.

In human tissue the amplitude of the action potential is dependent on:

(a) The diameter of the muscle fibre.

(b) he distance from active fibre to the recording site.

(c) The filtering properties of the electrode.

(d) The geometric arrangement of the muscle fibres with respect to the electrode site.

Most MUAP's measured from fine wire electrodes, have an amplitude of 250 mV.

The electrical manifestation of a MUAP is accompanied by a contraction of the muscle fibres. In order to maintain a muscle contraction the motor units must be repeatedly activated. The resultant sequence of MUAP's is known as a motor unit action potential train.

2. Recruitment and firing rate
Recruitment describes the involvement of increasing numbers of motor units in depolarisation.

Firing rate describes the frequency of discharge of an individual motor unit.

Motor units don't discharge at constant intervals, thus discharges of a motor unit must be measured in terms of an average firing rate, measured over at least one second.

During a constant force isometric contraction, the firing rate decreases as a function of contraction time. Motor units active at the beginning of the contraction remain active throughout the contraction. Time dependent recruitment during a constant force isometric contraction might be expected, yet has not been observed to occur.

During force varying isometric contractions, the following interplay between firing rate and recruitment occurs:

- At the start of contraction recruitment is the dominant factor, with the smallest motor units recruited first. The firing rate at recruitment is unstable and has a minimal value of 5-6 pulses per second.
- Up to 30% of maximal voluntary contraction (MVC), recruitment is still the dominant factor, with progressively larger motor units being recruited, as the force increases. As a secondary factor, the firing rate also increases.
- For force levels from 30-70% of MVC, firing rate becomes the dominant factor. Some recruitment of increasingly larger motor units occurs as a secondary role.
- At force levels above 70% MVC, further increase in the firing rate continues to be the dominant factor, with little if any recruitment.

3. Frequency and amplitude
Interpreting the frequency and amplitude of the potentials obtained from contracting muscle is beset with difficulties. Because the word frequency implies at regular intervals, it may be more appropriate to describe the number of peaks per second, since recordings show that potentials occur at irregular intervals.

The relation of frequency and amplitude of the potentials to the force of contraction has been studied by many workers. The number of peaks per second has been shown to increase with the force of contraction, but beyond a certain force the number of peaks decreased to some extent.

Since the 1920's, it has been generally accepted that the normal upper limit of the activation of motor units in man is about 50 per second.

The amplitude of an EMG potential increases almost linearly with the increase in force, and it also varies directly with the muscle tension, it the muscle is not allowed to shorten.

If the muscle is allowed to fatigue during continuous isometric contraction of given strength, there is a marked increase in the amplitude for a given tension, due to the recruitment of motor units which compensate for the decrease in the force of contraction occuring in the fatigued muscle fibres. (Joseph, 1960)

Given the various factors that affect the shape of an observed MUAP, it is not surprising to find variations in the amplitude recorded by one electrode, and even larger variations if MUAP's are recorded with different electrodes.

In normal muscle, the peak-to-peak amplitude of a MUAP may range from a few microvolts to 5mV.

4. The silent period
The silent period of a muscle is the period of cessation of activity which occurs when a twitch contraction is superimposed on a voluntary effort (e.g. electrically or by tendon tap). Its normal range is 87-151 msec. At the end of the silent period there is a rebound burst of EMG activity.

A different kind of silent period has been demonstrated in the muscles of mastication. Single stimulation of the teeth induces inhibition in the actively contracting temporalis and masseter muscles, with a 30-40 msec. latency. The same inhibition occurs from sudden unload of the muscles (Ahlgren, 1967; Griffin and Munro 1969). The inhibition in all the elevators is almost synchronous, and in most subjects there is a synchronous burst of activity in the depressor muscles, some 15-27 msec. after initial tooth contact (Basmajian, 1978).

5. Evaluation of records. (Qualitative? Quantitative?)
Evaluation of records whatever their type, is the most abused part of electromyography. One should consider carefully the reputation of the author of an EMG paper before evaluating his results and conclusions (Basmajian, 1978).

Evaluation of any record is of necessity, of two types; qualitative and quantitative. Many attempts have been made to make EMG records purely quantitative. Integration of EMG signals can provide an arbitary quantitative figure, derived from the variables of amplitude frequency and spike shape. The chief virtue of integration is the convenience of an immediate numerical readout. Its greatest dangers lie in its failure to discriminate between artifacts and EMG potentials.

Marx (1963), reported on the use of integrators in EMG investigations of orthodontic problems. His contribution established basic guidelines for the type and uses of apparatus, and for positioning of electrodes.

It has been shown that an integrated EMG signal can be related to isometric tension in a quantitative way, provided the conditions of the experiment are not changed, such as by removing and replacing electrodes. Also one must avoid the possibility of muscle fatigue, as the relationship between isometric tension and the EMG signal changes with fatigue.

There are even more complicating factors to consider in EMG analysis of dynamic performance. Under highly restricted conditions of excursion, load and speed of muscle contraction, quantitative relationships can be shown.

Such conditions are almost unobtainable in clinical situations, and they would be particularly difficult to obtain in studies of the muscles of mastication and other muscles of importance in orthodontics (Ralston 1961).

Basmajian (1978) comments: 'experience has shown that the easiest and in many cases the most reliable evaluation is by the trained observers visual assessment of results, coloured by his knowledge of the technique involved. Indeed, not only are the number of spikes important, but the amount of super-imposition (summation), and their height and type are important too'.

At best it seems, the evaluation of EMG records may be considered as only a semi-quantitative exercise.

ELECTROMYOGRAPHY IN ORTHODONTICS

Understanding normal muscle function

Since the early work of Moyers (1949, 1950) and Carlsoo (1952), a number of good EMG studies have been published, examining the oro-facial musculature in normal function.

An accurate picture of muscle function cannot be gained by anatomical dissection alone, and EMG studies have proved invaluable in furthering our understanding of the masticatory and peri-oral musculature in movement.

Basmajian (1978) presents an excellent review of the published reports on the functions of the muscles of mastication and the oro-facial muscles.

Most neurophysiologists now agree that EMG shows conclusively the complete relaxation of normal human striated muscle at rest. In other words, by relaxing a muscle, neuromuscular activity can be abolished. This does not mean there is no tone or tonus in the muscle. Tone of a muscle is determined both by the passive elasticity of muscular (fibrous) tissues and by the active, but not continuous contraction of muscle in response to the reaction of the nervous system to stimuli. Thus at complete rest, a muscle has not lost its tone even though there is no neuromuscular activity in it.

Temporalis. The main function of this muscle is molar occlusion, where all the fibres show marked activity. It also acts as an ipsilateral abductor and the posterior fibres are active in maintaining mandibular posture in the physiological resting position. During normal opening and protrusion it plays no role but during maximal opening it acts to prevent dislocation. In edge to edge occlusion, the anterior fibres particularly are active, while in retracting the protruded jaw the posterior fibres are more active.

Masseter. As would be expected, during forceful centric occlusion the masseter is very active. It is not an important muscle in the habitual resting position, though its superficial fibres show some activity in protrusion. It also acts in ipsilateral movements of the mandible and its deep fibres may assist in retraction.

Medial pterygoid. There is strong activity in this muscle during simple protraction (less so if the mandible is depressed). Unilateral contractions of the muscle cause contralateral abduction of the chin, especially if there is an added element of protraction.

Lateral pterygoid. This is the first active muscle during depression, and it reaches a peak of activity before other muscles become active. It is also very active during contralateral excursions, uncontrolled openings and protrusion of the mandible.

In an investigation using monkeys McNamara (1973) found the superior head only active in closing movements such as chewing, swallowing and clenching. The inferior head was active only during opening and protrusive movements. These findings were supported by Gibbs et al. (1975) in a human study, and lends credence to the suggestion that from both an anatomical and a functional point of view, the two heads of lateral pterygoid represent two separate muscles.

Digastric. This muscle comes into action after lateral pterygoid during wide opening and is not as important. Coughing and swallowing strongly recruit the activity of the digastric muscles.

Mentalis. This muscle raises and everts the lower lip, and shows considerable activity during swallowing.

Investigating aetiology and diagnosis

Many of the early studies related to orthodontics using EMG, attempted to determine whether abnormal muscle patterns could be considered as an aetiolgical factor in malocclusions.

Moyers (1949) compared the EMG activity in Class II div I cases with those of normal occlusal relationships, both before and after treatment. He observed that EMG patterns permitted classification of cases into loose groups, that alterations in muscle function patterns could result from malocclusions of teeth, and that orthodontic therapy could result in changes in the spike potentials in certain muscles. He concluded that deviation from the normal type of muscle contraction may be considered an aetiological factor in the formation of Class II div I cases.

Ahlgren (1966) studied EMG activity in chewing and found no significant differences between subjects with Class II div I and those with normal occlusions. He also found no relationship between EMG activity and cephalometrically measured skeletal form, whereas Moller (1966) did find several correlations between EMG activity and morphology.

Moss in a later study (1975), found that patients with normal occlusions show a typical pattern of EMG activity, which could be distinguished from those with Angles Class II/1, II/2, III and postural Class III, on the basis of their EMG activity.

Much has been reported in the literature on the influence of the peri-oral musculature on the position of the labial segments of teeth, and its role in the aetiology of malocclusion.

Schlossberg and Harris (1956) observed the peri-oral musculature in both normal occlusion and Class II div 1 cases, and noted early onset of mentalis activity in all the dysplasia cases, with increased amplitude as compared to the upper lip, in swallowing.

In an EMG study of resting posture, Marx (1965) concluded that the activity of upper and lower lip and mentalis muscles had no influence on the position of the incisors and that the activity may indeed be secondary to the tooth position. This may in turn be related to the dispersing effect of the tongue, the skeletal pattern and lip morphology.

Gustafsson and Ahlgren (1975) studied the function and level of activity of the mentalis and orbicularis oris muscles in subjects with different lip morphology. They found significantly greater activity in subjects with lip incompetence in the functions of lip closure, swallowing and chewing, as compared to subjects with normal lip position. Comparison with cephalometric values showed that subjects with incompetent lips and increased peri-oral activity had:

1. Greater lower anterior face height.
2. High mandibular plane angles.
3. Post-normal skeletal jaw relations.
4. Increased lower incisor proclination.

Basmajian et al. (1975) conducted an EMG investigation into the activity of the tongue and circumoral musculature. They found no activity during rest periods and only slight to very slight activity during normal oral functions. 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 in buccinator. They concluded that these findings helped to explain classical malocclusions seen in thumb suckers and tongue thrusters.

Baril and Moyers (1960), in an earlier study, addressed the question of whether thumb sucking could alter facial muscle function. They noted firmly established and persistant abnormal muscle patterns, especially in mentalis and orbicularis oris, but considered one could not assign a cause-effect relationship between thumb sucking and muscle pattern.

It is evident from the foregoing that there is a measurable difference in the EMG activity between patients with normal occlusions and those with different types of malocclusions. However, is the abnormal activity a primary cause or a secondary effect of the malocclusion?

In many cases the muscle probably plays a secondary role in functionally adapting around an existing malocclusion. This is supported by the evidence of muscles returning to normal activity following correction of the occlusion. Of course even in this adaptive role, the muscles may be partly responsible for the degree of severity of the malocclusion and for perpetuating the problem.

The possibility of an endogenous abnormal muscular activity cannot be ruled out as a direct cause of malocclusion. The failure of EMG patterns to return to normal in some cases following orthodontic treatment, associated with relapse provides some evidence of this.

INVESTIGATING THE EFFECTS OF TREATMENT

There have been many efforts to investigate the effects of orthodontic treatment on the musculature and EMG techniques lend themselves to the examination of the changes occurring in muscle activity.

Functional appliances: Uncertainty still exists as to the mode of action of functional appliances. Several EMG studies have attempted to assess the effect of these on the muscles.

In a small study to investigate the neuromuscular response to activators, Ahlgren (1960) concluded that during sleep, no increase in muscle activity occurred. Thus he seriously questioned the principal that an activator works as a functional stimulator. He also noted that after long periods of activator treatment in Class II cases, it seemed possible to permanently change the basic contraction pattern of jaw muscles.

In a later study in 1978, Ahlgren concluded that day use of the activator stimulated protractor muscles and inhibited retractor muscles, yet at night, there was no functional stimulation. The activator appears to operate mainly by tissue stretch and accompanying elastic rebound.

Grosfeld (1965) presented a paper on EMG activity before and after functional appliance treatment in Class II/I cases, and found that changes toward a more normal pattern occurred with treatment. This she suggested was due to the functional re-training of muscles. During discussion on this paper Tulley commented that he disagreed with this suggestion. He felt the change in muscle activity was secondary to the tooth movement.

In a monkey experiment, McNamara (1973) studied the EMG changes following functional mandibular protrusion. He found an initial increase in activity of superior lateral pterygoid, peaking at 8 weeks and returning to normal levels by 12 weeks. He surmised that as skeletal adaption to functional protrusion occurred, the need for compensatory muscle function reduced. The timing of the appearance and disappearance of these changes was related to the rate and extent of skeletal and dento-alveolar adaption occurring.

On removal of the appliance, a new imbalance occurred and similar EMG changes were noted as above. In the mature animals a return to the pre-treatment relationships was seen, with little or no change in maxilla or mandible. In young animals, the response varied from total retention to total relapse of the skeletal changes. McNamara concluded that the TMJ was not an immutable structure, but an articulation capable of functional adaption. The author rightly advises caution in extrapolating findings from animal studies to the human situation.

Moss (1975) looked at EMG changes in class II/11 cases before and after functional appliance treatment. He noted a slight decrease in mean muscle activity after treatment, and felt that relapse could be related to the unchanged EMG activity, before and after treatment and after retention, seen in some cases. In another aspect of this study he found that 50% of the cases studied had a distal path of closure into CO, as indicated by the bi-lateral early activity of the posterior fibres of temporalis. In a further animal experiment, McNamara (1980) studied soft and hard tissue adaptions in functional protrusion, using cemented gold inlays. He noted in the first week, increased masseter and reduced anterior temporalis activity, together with increased activity of superior head of lateral pterygoid. It was found that the variables of muscle activity, histological change and increased mandibular growth appear to be closely connected. It would seem that increased lateral pterygoid activity during growth is followed by an adaptive response at the condyle, leading to the deposition of bone which restores the balance to the system, whereby muscular activity returns to normal levels.

OTHER EFFECTS OF TREATMENT

While a number of studies have investigated the effects of functional appliances, less work has been done on the EMG effects of other types of treatment.

Grossman (1961) felt that EMG techniques provided an exact and reliable scientific tool for assessing Maxillo-Mandibular relationships and were able to establish characteristic EMG patterns before, during and after treatment.

In his study of different malocclusions he found:

In Class II/I cases treated with activators, there was a decrease in the activity of temporalis and masseter, with the greatest decrease in the posterior fibres of temporalis.

In Class II/II cases EMG has contributed to the understanding of some of the problems involved, observing that the mandible seems to move forward once the maxillary incisors are proclined. At the start of treatment Class II/II cases showed a distal displacement pattern of EMG and after proclination of the incisors, the myogram became normal. Thus an abnormal pattern (retrusive before treatment), has after treatment, become a fairly normal pattern of EMG activity.

In Class III cases, although they respond to treatment, often one does not get normal EMG patterns. In cases where the EMG pattern is not normal after treatment, long term follow up was suggested, to monitor the possibility of relapse.

In his observations on Class III cases, Grossman's findings were at variance with those of Moss and Chambers (1974) who found that after treatment of Class III cases, the muscle activity did return to more normal levels.

Tallgren (1966) conducted a study to determine the optimal saggital jaw relationship in which the intercuspal position should be established, in the orthodontic treatment of dual bite cases. Optimal muscle function was displayed in the posterior occlusal contact position. This indicated that in the treatment of dual bite cases, the intercuspal position (CO), should be established in the posterior occlusal relationship.

Moss (1975) examined the EMG characteristics of different types of malocclusion and found that:

Class II/I cases were similar to normal, except anterior temporalis activity was increased.

Class II/II cases were similar to normal, but anterior and posterior masseter activity was increased.

Skeletal Class III cases had increased muscle activity in all areas except anterior masseter fibres, as compared to normal.

Postural Class III cases were similar to normal except posterior temporal fibres were less active and anterior masseter fibres were more active.

In examining post treatment EMG activity in Class II/I cases he noted one would expect to see a return to normal activity, provided the teeth were in a normal relationship. Cases treated with functional appliances did show a return to normal patterns, where as those treated with Begg did not have a pattern of activity similar to normal.

Many of the EMG studies of changes following treatment have very small populations, one should bear this in mind when interpreting data derived from such studies.

Occlusal Balance and the TMJ

A number of EMG studies have stressed the importance of achieving a balanced occlusion following orthodontic treatment, in preventing any muscular and TMJ problems.

In an early, unilateral study of temporalis, Jarabak (1956) assessed neuro muscular and TMJ disturbances, due to imbalances in occlusion. Increased temporalis activity was noted, which could be reduced following splint therapy.

Grossman (1961) found that in some cases of TMJ disorders. EMG revealed abnormal muscle patterns with associated malocclusions. The patterns frequently shown in these cases, is one of deviation of the mandible on closure from rest position to habitual bite, with an unbalanced muscle pattern. Following treatment with bite positioner, bi-lateral symmetry of muscle pattern returned.

An important step in the analysis of jaw function, is to determine the path of closure from CR to CO. An unusual way to determine the condylar position is the 'Myo-Centric technique' of Jankelson (1969). This uses electrical stimulation to obtain CR via surface electrodes - the Myo-Monitor. CR determined in this way is routinely anterior to that achieved by the disclusion approach, (Graber and Swain 1985).

Bessette (1973) undertook an evaluation of the Myo-Monitor, and found that the technique did not produce group function of muscles. He felt that the Myo-Monitor stimulated the muscles directly, rather than by way of the motor nerve. No contraction of the medial pterygoid was noted in this study, indicating that the technique did not stimulate all the muscles.

Graber comments: 'Since surface electrodes are used in the Myo-Centric technique and since this results in more stimulation of the superficial muscles than the deep, the validity of the electrical stimulation approach (to finding CR) remains questionable'.

In one of his earlier EMG studies, Ahlgren (1963) investigated cuspal interferences before and after treatment. There was a lack of co-ordination of temporal and masseter muscles on closure to centric occlusion, chewing and swallowing. This co-ordination was improved following occlusal equilibration. Ahlgren concluded that assessment of cuspal interferences and occlusal harmony was important with respect to orthodontic diagnosis, treatment and prognosis.

Haralabakis(1964) in a study of the EMG changes following the treatment of posterior cross bite by bi-lateral expansion, found the typical muscular imbalances seen before therapy disappeared with treatment. The author suggested the cross bite alters and conditions muscle patterns and that moving the teeth into normal buccal relationship allows normal muscle patterns to occur.

Following orthodontic treatment, muscle activity may give an indication of the stability of the end result, and the possible need for occlusal equilibration. Moss (1975) observed that some cases that showed relapse following treatment, were cases where muscle patterns had not changed during treatment. Absence of change in the muscle patterns is an indication of lack of adaption of the soft tissues to the new tooth position.

In a study of experimentally induced occlusal interferences, Randow (1976) noted that the activity of temporalis could both increase and decrease in different subjects, but masseter activity always decreased. He further noted that EMG changes could be associated with TMJ pain, dysfunction, clicking joints and painful musculature; thus re-inforcing the prevailing view that occlusal interferences are undesirable.

Following an EMG investigation into lateral pterygoid function, Juniper (1984) has provided an insight into the pathogenesis of TMJ dysfunction. The results indicated the inferior head, normally active only in opening, protrusion and lateral deviation, became active in closing and clenching in patients suffering pain. Patients with painless clicks behaved as normals. It was suggested that in cases of TMJPD, the superior head of lateral pterygoid becomes inefficient as a joint stabiliser due to meniscus damage, and the inferior head is recruited to further assist stabilisation of the TMJ and to minimise further damage.

BIOFEEDBACK

A role for the EMG technique in the management of TMJPD has been described by Budzynski and Stoyva (1973). This involves the technique of biofeedback, whereby the data from a specific body function is amplified and played back to the patient in a visual or auditory form.

Compact EMG equipment, using surface electrodes, is available to amplify and display the output to the TMJ patient in 20 minute sessions in the surgery. The operator sets a threshold level in the form of a row of lights, and as the patient consciously strives for and achieves relaxation, the lights go out in proportion to the decrease in EMG activity. Of course in a multi-factorial condition such as TMJPD, biofeedback has only limited application. Unless the aetiology is purely one of stress/tension, this technique would be treating only the effect of the condition and not its cause.

Basmajian (1975) commented on the role of the tongue during swallowing, and noted that during normal swallowing most of the pressure from the tongue is expended against palatal tissue. However, in the tongue thrust or infantile swallowing pattern, these forces are directed more at the dentition, producing the classically flared maxillary and mandibular incisors and anterior open bite. He expressed the hope that in future studies biofeedback training could be used to help re-train such aberrant muscle habits.

This appears to be a most useful potential use of electromyography in orthodontics, with the possibility of achieving post-treatment stability in cases that either have, or could relapse following treatment.

SUMMARY AND CONCLUSION

Electromyography has proved an important and useful tool, with a wide variety of applications in the orthodontic field. It has provided an insight into:-

- Normal Muscle Function
- Aetiology of Malocclusion
- Diagnosis and Treatment Planning
- Neuro-muscular effects of Functional Appliances
- Post Orthodontic Stability.

However, because of the lack of standardisation of techniques, particularly in the early studies, caution is advised when comparing the results of different studies and assessing the validity of the conclusions drawn.

The technique has been found to be wanting, when attempts have been made to use the method for direct numerical comparison, between patients and between different studies.

Future development of EMG techniques, particularly in the biofeedback area holds some promise in the further understanding of post-treatment relapse, its management and even its prevention.

DEFINITIONS

Electromyography:- The recording and study of the intrinsic electrical properties of skeletal muscle.
Electromyogram:- The record obtained by electromyography.
Electromyograph:- The instrument used in electromyography.

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