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RELATIONSHIP BETWEEN THREE MUSCLE ACTIVITY AND MORPHOLOGY OF CRANIOFACIAL DIVERGENCE. - AN ELECTROMYOGRAPHIC STUDY

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ABSTRACT

Objectives: To compare the Electromyographic (EMG) activity of the masseter, anterior temporal muscles and mentalis in different vertical facial types.

Materials and Methods: Clinical examination, cephalometric analysis, and Electromyographic examination were performed in 60 volunteers ranging from 16 to 26 years old. The volunteers were classified on the basis of their vertical facial characteristics into three groups— hyperdivergent, normodivergent and hypodivergent—by the grouping analysis. The EMG records were obtained with four different positions Postural rest position of the mandible ,Maximal voluntary clenching ,Maximal mouth opening ,Swallowing The equipment used for EMG reading was grass polygraph and amplifier (Nicolet Viking Vt,) and amplified signals were simultaneously recorded on the paper (Hewlett Packard, CA). Each direct EMG trace was converted to a mean voltage trace by an electronic averaging circuit connected to the polygraph. The speed used for recording was 500 mm/s. At the beginning and the end of each trace recording, Calibrating test and baseline recordings were performed.

Results: It was found that the highest mean amplitude was in Group I (416.6 + 97.1) followed by Group II (389.5 + 61.3) and the lowest mean value was in Group III (374.6 + 38.4). Statistical analysis by one-way ANOVA showed that there was no significant difference between Group I, II & III for position 'P1' in Muscle 'M1' (P=0.41). The statistical package SPSS (Statistical package for social science, version 4.0.1) was used for statistical analysis. Mean and standard deviation were estimated from the sample. The tests that were used for the statistical analysis were One Way Anova, Multiple Range Test by Tukey-HSD, Students 'T' Test.

Conclusion: In our study, the EMG revealed increased activity of masseter during clenching and increased activity of mentalis during swallowing in hypodivergent group when compared with normo divergentand hyperdivergent group. There was not much difference in muscle activity in the hyperdivergent group.

Key words: Electromyographic (EMG) Activity, masseter, Anterior temporal Muscles ,mentalis,Cephalometric analysis.

INTRODUCTION

Moss and Salentizin, hypothesized that human facial growth occurs as a response to functional needs and is mediated by soft tissue [1]. It is generally accepted that the shape of the face is determined by both genetic influences and local environmental factors. One of the most important environmental factors is masticatory muscle function. The function of oral and facial muscles is a multi disciplinary act of complex nature. Several studies have been conducted in the past to learn the characteristic nature of these muscles and their relationship to facial types. Electro myography [EMG] assessment of masticatory muscles have shown divergent results when individuals with different vertical facial growth are compared. Some authors have observed that the amplitude of EMG values in temporal[2 3 4] and masseter[2 4 6] muscles is always greater in short-faced individuals. While other authors have reported that, longer the face of an individual, the greater the EMG activity of the temporal muscle[5 6]. Still others report that this muscle activity does not present any correlation with vertical face morphology[6]. On the other hand, there are studies that do not show differences in the EMG activity of the masseter muscle when comparing short-faced individuals to balanced or long faced individuals and when comparing normal individuals to hyperdivergent individuals.[5] According to Farella et al7 and Cha et al, [5] the habitual activity of the masseter muscle does not seem to be influenced by the vertical craniofacial morphology. The studies done by Hans Pancherz proved a higher positive correlation in the EMG activity in maximum biting and chewing actions. Charles.H.Gibbs proved increased muscle activity when the teeth are in centric occlusion. Chong shan sai proved in habitual clench the mean and amplitude EMG value increases[9] Keisuke Mujamoto, Yasuo Isizuka, Kazuo Tanne-Changes in Masseter muscle activity during orthodontic treatment evaluated by a 24-hour EMG system and proved there is a increase in EMG value during a meal[10]. C.R.S gobbi et al [12]reported a difference in EMG values of the temporal and masseter muscles in rest and relaxation of the jaws [11]

Among the various functions that these muscles perform, clenching, opening and swallowing are the most frequent. Therefore most of the studies were done on these muscles. The masseter and temporalis muscles have an active role in accomplishing the above mentioned movements; however the action of mentalis muscle is of equal importance in the orthodontic point of view.

It is mandatory for the orthodontist to have a thorough knowledge of the effect of these muscles in the two extreme facial types, which has an upper hand in the diagnosis, treatment planning and the success of treatment.

With this in mind, this study was conducted to measure the intensity of muscle activity in the extreme facial types in comparison with patients of the normal facial type. Therefore, the aim of the present study was to evaluate the three facial types i.e. hyperdivergent, hypodivergent and normodivergent by studying the muscle activities of Masseter, Temporalis and mentalis and correlating to the facial types.

MATERIALS AND METHODS

Sixty subjects were selected for this study. Of these, twenty were hyper divergent, twenty were hypo divergent and twenty were of the normodivergent growth pattern. The normodivergent group was considered as the control group. The subjects were selected from the age of 16 to 26 years. The cases were selected from the patients registered for treatment at the Department of Orthodontics, Saveetha Dental College and Hospitals. The examinations were conducted in accordance with the protocol approved by the Ethical Committee Research. The criteria used for selection were the Frankfort – horizontal plane and mandibular plane angle. If this angle was less than or equal to 20^o, it was considered as low angle. Between $20\text{-}30^0$, it was considered as normal and above 30^o was considered to be high angle. Twenty subjects were studied under each category. The subjects had not undergone any orthodontic treatment earlier and they had no history of any temperomandibular joint problems. Full complement of permanent dentition was present. These subjects were explained in detail of the procedure and a written informed consent was obtained.

A detailed clinical examination of these patients was carried out and the history was obtained. For all the patients, models, Photographs, Lateral cephalogram and orthopantomogram were taken. The lateral Cephalogram was traced and depending on the measurements, the subjects were classified as hyper divergent, hypo divergent or normal.

The patient was asked to relax and was explained about the procedure in detail to avoid wrong values due to anxiety. Prior to recording Electromyography (EMG) of the muscle, the patient is made to sit in an upright position. The patient was asked to shave if he is a male, as the presence of hair will inhibit the myoelectric stimulus to the muscle. Electrodes were placed on the motor centers using the key guidelines for anterior Temporalis, Masseter (AJO, 1999, O.P Kharbanda) and for Mentalis.

The EMG readings were taken in the following positions of the mandible.

1. Postural rest position of the mandible
2. Maximal voluntary clenching
3. Maximal mouth opening
4. Swallowing

The equipment used for EMG reading was grass polygraph and amplifier (Nicolet Viking Vt, specify name of company of manufacture of EMG machine, place and country of manufacture) and amplified signals were simultaneously recorded on the paper (Hewlett Packard, CA). Each direct EMG trace was converted to a mean voltage trace by an electronic averaging circuit connected to the polygraph. The speed used for recording was 500 mm/s. At the beginning and the end of each trace recording, Calibrating test and baseline recordings were performed.

The numerical values were obtained from the polygraph were tabulated for individual patients. The amplitude for every muscle (anterior Temporalis, Masseter and Mentalis) were measured by maximum peak calculated from the baseline and was represented by mill volts and the total number of peaks were calculated as the duration (ms). These parameters were taken into consideration for every muscle (M1, M2 and M3) and for all patients.

Fig 1: EMG Machine

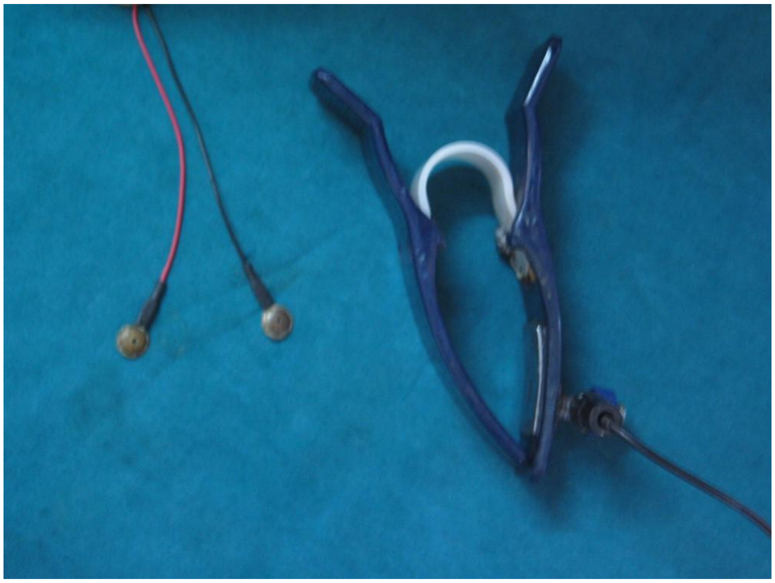

Fig 2: Silver recording electrode

Fig 3: Ground electrode conducting paste

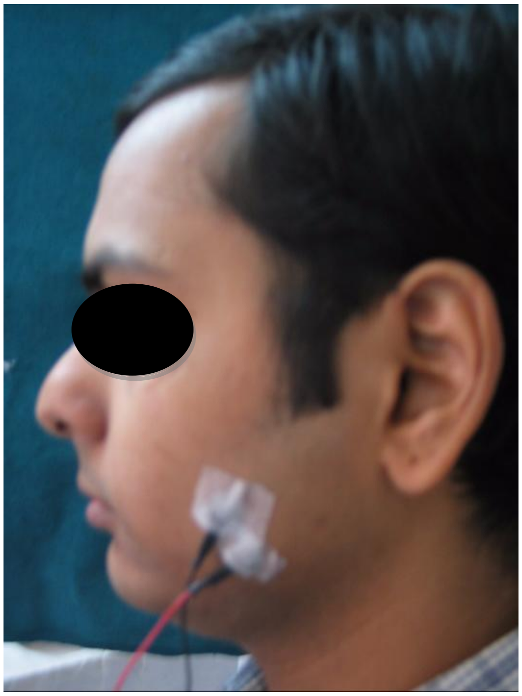

Fig 4: Masseter

Fig 5: Temporalis

Fig 6: Mentalis

Table 1- Mean, standard deviation and test of significance of mean values between different study groups within each position for M1, M2, M3

M1	Position	Group	Mean +S.D	P- Value *	Significant # groups at 5 % level
	P2	I	378.1+ 28.2		
		II	471.4 + 51.9		
		III	398.5 + 42.3	0.0001 (S)	II vs I II vsIII
M1	**Group**	**Position**	**Mean +S.D**	**P- Value ***	**Significant groups at 5 % level**
	II	P1	401.9+55.6		
		P2	471.4+51.9		
		P3	401.9+59.2		
		P4	399.5+69.5	0.03 (S)	P2 vs P4
P1	**Group**	**Muscle**	**Mean +S.D**	**P- Value ***	**Significant groups at 5 % level**
	II	M1	471.4+51.9		
		M2	397.3+52.9		
		M3	392.9+49.4	0.003 (S)	MI vs MII MI vs MII
Group II	**Position**	**Muscle**	**Mean +S.D**	**P- Value ***	**Significant groups at 5 % level**
	P2	M1	471.4 + 51.9	0.003 (Sig)	NIL
		M2	397.3 + 52.9		
		M3	392.9 + 49.4		

Table 2 - Comparison of mean values between Group I and Group II within each position for different muscles.

Muscle	Position	Group I Mean ± S.D.	Group II Mean ± S.D.	P-Value *
M1	P1	385.7±56.2	401.9±55.6	0.53 (NS)
	P2	378.1±28.2	471.4±51.9	<0.0001(Sig)
	P3	419.1±77.8	401.9±59.2	0.59 (NS)
	P4	410.0±95.9	399.5±69.5	0.78 (NS)
M2	P1	382.6±44.7	382.8±80.2	0.99 (NS)
	P2	396.2±42.9	397.3±52.9	0.96 (NS)
	P3	392.1±56.6	393.5±33.6	0.95 (NS)
	P4	429.2±50.9	403.7±40.2	0.23 (NS)
M3	P1	379.7±77.5	392.3±69.9	0.71 (NS)
	P2	400.6±75.3	392.9±49.4	0.79 (NS)
	P3	384.7±52.8	446.7±77.5	0.05 (Sig)
	P4	393.1±45.0	415.0±59.6	0.37 (NS)

RESULTS AND DISCUSSION

It was found that the highest mean amplitude was in Group I (416.6 + 97.1) followed by Group II (389.5 + 61.3) and the lowest mean value was in Group III (374.6 + 38.4). Statistical analysis by one-way ANOVA showed that there was no significant difference between Group I, II & III for position ‘P1’ in Muscle ‘M1’ (P=0.41). The statistical package SPSS (Statistical package for social science, version 4.0.1) was used for statistical analysis. Mean and standard deviation were estimated from the sample. The tests that were used for the statistical analysis were One Way Anova, Multiple Range Test by Tukey- HSD, Students ‘T’ Test.

In the table 1 where there was a comparison between all the three groups in different positions of the mandible the mean amplitude of Group II (471.4 + 51.9) is significantly higher than the mean amplitude in group I (378.1 + 28.2) and Group III (398.5 + 42.3) in the M1 where the P< 0.05. But there were no other statistically significant in other values. In table 1 the comparison revealed the mean amplitude in P2 (471.4+51.9) was significantly higher than the mean amplitude in P4 (399.5+69.5) where the P value < 0.05. However, no other contrasts are statically significant in Group II of M1.

Table 2 Group II, mean amplitude in M1 (471.4+51.9) is significantly higher than the mean amplitude in M2 (397.3+49.4) where the P value<0.05. However, there is no significant difference in mean amplitude between M2 and M3 i.e. P value is>0.05.Similarly, there is no significant difference between M1, M2 and M3 for Group I (P= 0.60) and Group III (P=0.039). In table 22 the mean amplitude in M1 (471.4+51.9) is significantly higher than the mean amplitude in M2 (397.3+ 52.9) and M3 (392.9+49.4) the P value is <0.05. However, there is no significant difference in mean amplitude between M2 and M3 (P>0.05) for position P2 in Group II. Student's independent t-test (table24) showed the mean amplitude in Group II (471.4 + 51.9) is significantly higher than Group I (378.1+ 28.2) (P<0.0001) for the position P2 in M1. Similarly, the mean amplitude in Group II (446.7+ 77.5) is significantly higher than the mean amplitude in Group I (384.7+ 52.8) for the position P3 in M3 (P=0.05). However, there is no significant difference in mean amplitude between Group I and Group II for the other positions in M1, M2 and M3 (P>0.05).

DISCUSSION

Electromyography has been used for the past 50 years although recently it has become more prominent in the dental literature. The musculature participating in the movements of the jaw have been studied in normal individuals by use of electromyography. Deviations from this normal have been found in individuals resulting in malocclusion, methologic condition of the muscles themselves, chewing habits or malposition of individual teeth.

Although most clinicians believe that clinical observation and cephalometry provide sufficient evidence for diagnosis and treatment planning, diagnosis will be incomplete without a reference to EMG data because the clinician has inadequate knowledge of the dynamic activity of the muscles portrayed on the cephalometric radiograph or clinical observation.

The aim of this study was to evaluate the various patterns of EMG activity in subjects with different skeletal facial types. A strong correlation exists between craniofacial morphology and masticatory muscles activity during chewing, swallowing and clenching. To elucidate the relationship between masticatory muscle activity and facial morphology, it is necessary to analyze muscle activity over a period of time. Most investigators have used surface EMG primarily to describe the superficial muscle activity of temporalis and masseter muscles as these are the most important muscles of mastication and its perceived role in the control on mandibular movements.

In this study temporalis, masseter and mentalis muscle activity was recorded with the help of surface electrodes using Nicolet Viking VT machine. The activity was recorded during postural, isometric clenching, swallowing and opening position[12].

In our study, the EMG activity of masseter was active during clenching and mentalis was active during swallowing in hypodivergent group. There was not much difference in muscle activity in the hyperdivergent group. The Masseter muscle in hyperdivergent group showed no difference in comparision to the normodivergent group but there was a increased activity of this muscle in hypodivergent group during the clenching position. There was no difference in the activity of the muscle in other position in the same group.

Radol Mirrals et al [13]concluded that during the postural activity of the mandible, the masseter and temporalis showed very well expressed EMG activity Eiko Mushimoto[14], Haruyasu Mitani.[11](1982) Concluded that the chewing side Masseter muscle was predominantly active. J.C.Hickey, R.W. Stacy[15] (1957)The authors have proved with the Electromyographic studies of Masseter and anterior Temporalis that there is a increased activity of these muscles in the closing action. Charles.H.Gibbs[16] (1975)He proved that the Electromyographic activity of the Masseter muscles occurs when the jaws are closed with the teeth in centric occlusion during normal clenching and is longer in activity and less variability on the working side than on the non-working side.

The temporalis muscle showed no difference in activity in the different facial types. The same can be confirmed from studies by Serrao et al [4]and Ueda et al[6], who reported significantly lower EMG values for temporal muscles for long faced individuals when compared to those with short faces. T.Mark Peterson et al did not reveal significant activity of EMG in both high and low angle cases. J.Mark Peterson, et al [17] (1983) Studied the relationship between the mandibular rest position in subjects with high and low mandibular plane. Electromyographic studies were done and no significant differences were observed for high and low angle groups. Hiroshi .M. Ueda et al[7] (2000) Temporalis muscles activity presented no significant relationship with the craniofacial morphology. The mentalis muscle showed increased activity in swallowing in hypodivergent group. There was no obvious activity in the other facial types.

In comparison to Ingervall and Thilander[2] studies, it was found that that in hypodivergent individuals, the masseter and mentalis activity was highly significant whereas the temporalis did not reveal any significant changes. Hence, individuals with brachyfacial pattern can be expected to have a well expressed masseter and mentalis muscle activity. Hans Pancherz[18] in his landmark study as well as Cha et al[5] concluded that there was very minimal EMG activity of masseter and Temporalis muscle during clenching and swallowing, and there was no difference in the temporalis during clenching. In our study, the EMG activity of masseter was active during clenching and mentalis was active during swallowing in hypodivergent group. There was not much difference in muscle activity in the hyperdivergent group.

During swallowing, only masseter revealed significant activity. There was no difference in the temporalis activity during maximal voluntary clenching. In our study, in postural activity for masseter and temporalis, No significant EMG activity was seen, but in clenching and swallowing in hypodivergent groups, masseter and mentalis were active. Temporalis muscle did not have any significant activity in any of the groups. Our study revealed that in low angle cases, the masseter is significant in clenching and mentalis is significant in swallowing. Temporalis was not significantly active in any mandibular movements. In the high angle cases, none of the muscle activity was significant compared to low angle and normal group.

CONCLUSION

Face is the index of mind and the oral cavity is the index of health and sound balance between the two is the key to success for any orthodontic treatment modality.Human facial growth and maintenance is a response to functional needs mediated by the soft tissue and maximum by the muscles of mastication, which holds the stomatognatic apparatus in fact.

This study can be summarized stating that there is a strong correlation between craniofacial morphology and masticatory muscle during chewing, swallowing, maximal clenching and postural rest position. The maximum increase in the muscle activity was found for the hypodivergent group during swallowing and clenching for the masseter and mentalis muscle. Hence we can conclude that the bite opening modalities in any mode of appliance is always tough in brachyfacial patterns. As revealed in our study the masseter and the mentalis shows significant muscle activity during clenching and swallowing. It is always advisable to use special modalities for correcting and retaining skeletal deep bite in brachyfacial individuals.

Further studies are advocated to demonstrate the muscle activity throughout the day i.e. over a 24hours period and also in abnormal craniofacial condition.

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