

## Functional Electromyographic Activities of Facial Muscles in Different Growth Patterns

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CC-BY 4.0Keywords Electromyography; Facial  
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## Abstract

**Objective:** To evaluate and compare the electromyographic (EMG) activity of masseter, temporalis, mentalis and orbicularis oris muscles during function in patients with different facial growth patterns.**Materials and methods:** 75 subjects (38 males and 37 females) with no history of previous orthodontic treatment, jaw surgeries, facial trauma and temporomandibular joint disorder were taken and divided into three groups based on their mandibular plane angle and gonial angle as hypodivergent, normodivergent and hyperdivergent. Lateral cephalograms were traced manually to determine facial type. Electromyographic recordings were done and muscle activities were evaluated at clenching position.**Results:** For temporalis hypodivergent group had the highest activity but the difference was not statistically significant ( $p=0.904$ ). For orbicularis oris hypodivergent group had the highest activity and this difference was statistically significant ( $p=0.007$ ). For mentalis hypodivergent group had the highest muscle activity and this difference was not statistically significant ( $p=0.052$ ). Only orbicularis oris muscle showed statistically significant difference in all the three groups during maximum clenching.**Conclusion:** Different facial growth patterns had a significant effect on the EMG activity of facial muscles during function. Orbicularis oris muscle activity showed significant difference among the three groups. Muscle activity was higher for the hypodivergent group as compared to the other groups. This indicates that the musculature in hypodivergent patients is strong and in hyperdivergent group is weak. This must be kept in mind while diagnosing and making the treatment plans for both the facial types.

## Introduction

Electromyography (EMG) is a very useful and reliable technique for evaluating muscle function and efficiency by detecting their electrical potentials. This makes it possible to assess the extent and duration of muscle activity [1,2]. EMG analysis of the masticatory muscles is an important instrument in orthodontic diagnosis, as it helps in the careful evaluation of muscle activity before and during treatment. It also guides the professional to select suitable therapy, as well as making the choice of more individualized retainers so as to minimize relapses [3]. The first effort to apply EMG to dentistry was made by Robert E Moyers [4]. He observed that the normal relations of teeth to each other in the same and opposing jaws were influenced by muscular balance. He used EMG mainly to analyze the role of temporomandibular musculature as an etiological factor for Angle's Class II malocclusion. All the masticatory muscles, including supra-hyoid muscles and mentalis muscle were investigated [5,6].

Allen Brodie mentioned that if we can learn to control the muscles through the important growth period, spontaneous unfolding of development would be seen which would lead to normal craniofacial development [7]. The relationship between masticatory muscle activity and malocclusions has been studied electromyographically by various researchers [3-6]. Many studies were concerned with the activity of the temporal and masseter muscles [8]. Currently, it is widely accepted that masticatory muscle function is related with craniofacial morphology. Based on the possibility of an interrelation between form and function; the masticatory muscles have been widely investigated in individuals with different vertical facial characteristics [9].

EMG evaluations of masticatory muscles have produced divergent results when individuals with different vertical growth patterns are compared. Some authors have observed that the amplitude of EMG values in temporal and masseter muscles is always greater in short-faced individuals [10]. Some articles mentioned that the longer the face of an individual, the greater the EMG activity of the temporal muscle [11]. Still others studies have shown that this muscle activity does not present any correlation with vertical face morphology [12]. 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, balanced individuals, and long-faced individuals and when comparing normal

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individuals to hyperdivergent individuals [13,14]. The habitual activity of the masseter muscle does not seem to be influenced by the vertical craniofacial morphology [15]. Thus to overcome this gap in literature regarding EMG activities of masticatory muscles this study was done to evaluate and compare the electromyographic (EMG) activity of masseter, temporal, mentalis and orbicularis oris muscles in patients with hypodivergent, normodivergent and hyperdivergent growth patterns.

## Materials and Methods

Pre-treatment lateral cephalograms of patients were taken from the Department of Orthodontics and Dentofacial Orthopaedics who came for orthodontic treatment. Written consent forms were taken from each of the patients after being informed about the nature of the study in detail. The study was approved by the local Ethical Committee. Each subject met the following inclusion criteria:

1. No mutilated dentition.
2. Absence of anterior or posterior open bite.
3. Absence of anterior or posterior cross bite.
4. No history of orthodontic treatment.
5. Absence of temporomandibular joint disorder.
6. No severe skeletal facial asymmetry.
7. No history of facial trauma, pathology or congenital anomaly.
8. No history of orthognathic or cosmetic surgery.

75 patients were taken in the study after the inclusion criteria was followed (25 patients in each group). Age range of all the patients was between 18-40 years and average age was 27 years. Once the subject's mandibular plane angle as described by Tweed and gonial angle as described by Rakosi was measured they were placed into the respective groups

- Group I included 25 hypodivergent subjects (12 males, 13 females), (average age 29 years). Mandibular plane angle < 200, Gonial angle <1200.

- Group II included 25 normodivergent subjects (14 males, 11 females), (average age 25 years). Mandibular plane angle between 200-300, Gonial angle between 1200-1300.
- Group III included 25 hyperdivergent subjects (12 males, 13 females), (average age 30 years) Mandibular plane angle > 300, and Gonial angle > 1300.

All of the cephalograms were recorded with the same exposure parameters (KvP-80, mA-10 exposure time 0.5 sec) with the same magnification and the same machine (Kodak 8000C Digital and Panoramic System Cephalometer Rochester, NY, USA). All cephalograms were traced manually using lead acetate paper (0.003 inches thickness, 8x10 inches) and 4H tracing pencil by the same operator.

For EMG measurement, an EMG device of 16 channels was used, with 1000 amplifier gain, 20-Hz high-pass filter, and 500-Hz low-pass. A 12-bit Analog/Digital converter with data acquisition hardware was also used, with a 1000-Hz sampling frequency at each channel. The calibration in the experiment was from -2500 to +2500  $\mu$ V. Before the placement of the electrodes and the start of EMG recording, the whole procedure and instructions were given to the subjects. Each subject's skin was scrubbed with 96% alcohol to eliminate oiliness in the area and to facilitate adhesion of the electrodes so that transmission of the electrical signals could be captured. Bipolar surface electrodes, 10 mm in diameter, containing conductor gel were fixed on to the skin with Transpore Plastic Tape (Figure 1). A ground electrode was placed on the forehead to prevent electrical interference.

To record EMG activity of the masseter muscle, two electrodes per side were placed according to the direction of masseter muscle fibres 1 cm above and below the motor point on a line running parallel to the ear border (tragus) across the motor point. For the temporal muscle, two electrodes per side were attached about 1 cm above the zygomatic arch and 1.5 cm behind the orbital border (Figure 2).

For mentalis muscle, electrodes are placed 0.5 cm lateral to the midline, superior and inferior to the pogonion. For orbicularis oris muscle, the first electrode is placed 1cm above the cheilion. The second electrode is placed 1 cm medially. The patients were instructed to bite in centric occlusion with heavy forces. All the muscle activities were recorded during clenching.

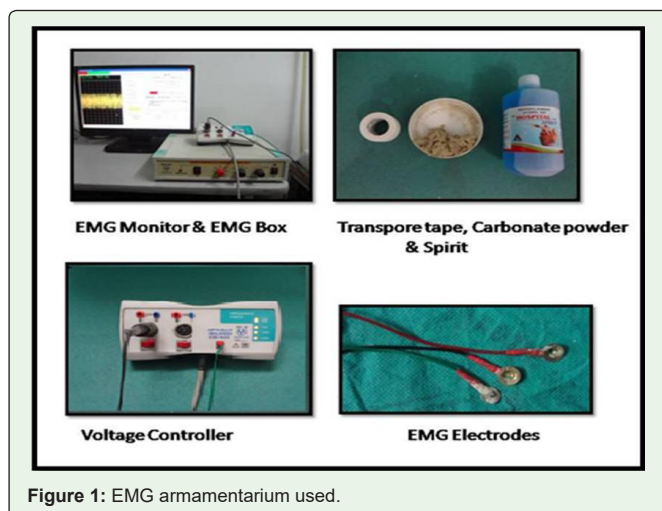


Figure 1: EMG armamentarium used.

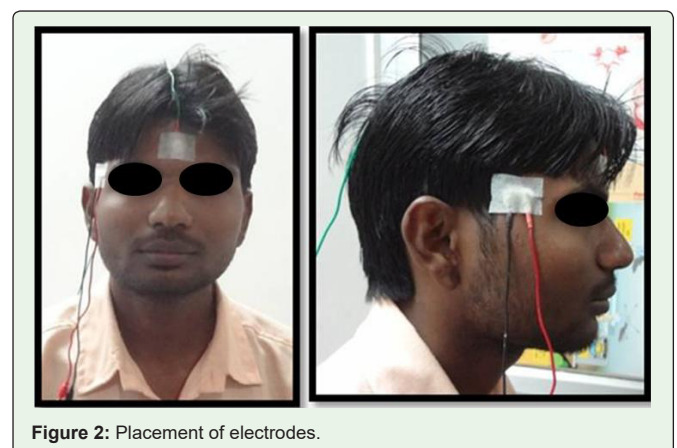


Figure 2: Placement of electrodes.

**Table 1:** Comparison of EMG activities of facial muscles at clenching at different muscular sites.

Muscular Site	Group I (n=25)		Group II(n=25)		Group III (n=25)		Statistical Significance	
	Mean	SD	Mean	SD	Mean	SD	't'	P
Masseter	378.5	86.15	464.13	73.25	365.25	76.79	1.357	0.266
Anterior Temporal	373.63	106.21	360.88	98.06	363.88	73.08	0.102	0.904
Orbicularis Oris	237.88	124.01	133.25	64.5	211.63	117.32	5.338	0.007
Mentalis	202.25	85.75	139.4	62.38	180.38	91.76	3.106	0.052

SD - Standard Deviation , "t"- degree of variation, p=0.05 value of significance.

Subjects sat on a dental stool in an upright position in a shielded room. EMG signals obtained using a 1000-Hz sampling frequency was transformed into absolute values and amplifier was connected directly to the ground electrodes. This eliminated any electrical disturbance caused by unwanted movement of the electrodes. Activities of the right and left side temporal, masseter, orbicularis oris and mentalis muscles were recorded with EMG recording system (Figure 3). Mean values of both the left and right side muscles were taken and compared.

**Statistical Analysis**

A master file chart was created and the data was statistically analyzed on a computer with Statistical Package for Social Sciences (Version 15.0). A data file was created under dBase and converted into a microstat file. The data was subjected to descriptive analysis for mean and standard deviation. Group differences were analyzed with one way analysis of variance (Anova).

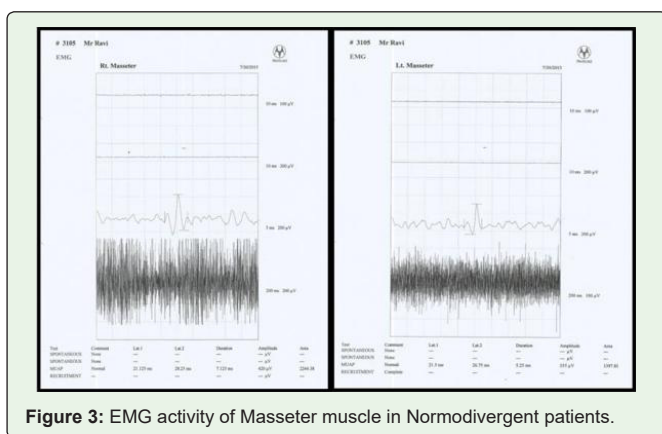
**Results**

Clenching activity of Masseter muscle of Group II was highest as compared to the other groups but this difference was not found to be statistically significant (p=0.266). Difference in clenching activity of Temporalis muscle was highest in Group I and this difference was not found to be statistically significant among the other groups (p=0.904). Clenching activity of Orbicularis Oris muscle of Group I and Group III were higher than as compared to Group II and this difference was found to be statistically significant (p=0.007). Clenching activity of Mentalis muscle of Group I and Group III was found to be higher as compared to Group II but difference among the above groups was not found to be statistically significant (p=0.052) (Table 1).

**Discussion**

Temporal and masseter muscles help in mastication by facilitating functional movement of the mandible. EMG recordings were taken of the above mentioned muscles along with the mentalis and orbicularis oris. These muscles were taken because surface electrodes could be used easily. The needle electrode would be an invasive procedure which would be required for recording the EMG activity of the pterygoid muscles (lateral and medial). This had a risk factor and many patients were not ready to give consent. Mandibular growth and oral musculatures adaptations may have an impact on treatment results. Masticatory system, in which these muscles play the most active role, is the jaw clenching. Due to this, recordings were taken during clenching activity [13]. Sherrington pointed out that a single motor nerve fibre and the group of muscle fibres that it supplied could be considered as a functional unit. Each time the nerve fibres discharged the muscle fibres that it innervates would contract; Sherrington described this functional unit as a motor unit. When a motor unit is activated by a nerve impulse, the action potential is delivered to each muscle fibre of that unit by the alpha motor neuron. The membrane of each muscle fibre undergoes an electrochemical change and it contracts generating its own action potential. The action potentials from the active muscle fibres can be measured by EMG [14]. This study was performed with EMG of various facial muscles in subjects with hypodivergent, normodivergent and hyperdivergent growth patterns.

Ueda et al. [9] reported in a study that masseter muscle activity was significantly higher in the low angle group than in the high angle group for both children and adults. In the present study the masseter muscle activity was highest for the normodivergent group. Our results matched the results of the above mentioned study as they had taken the same range of measurement in measuring the mandibular plane angles. Various studies demonstrated a negative correlation between the mandibular plane angle or gonial angle, and masseter muscle activity at the maximal voluntary contraction [12,14,17]. In addition, the cross-sectional area of the masseter muscle, measured with ultrasonography, showed a negative correlation with the vertical facial height. Thus, it may be concluded that comparatively low muscle activity during everyday life as well as greater muscle activity or the corresponding muscle size is significantly correlated to vertical morphology of the craniofacial skeleton. A possible explanation for this is that craniomorphologic characteristics shown by brachyfacial subjects, such as lower gonial angle and reduced maxillary height can provide mechanical advantages to the oral musculature by forwarding the position of the load application point, which leads to a decrease in the loading moment arm, as seen in long-faced subjects [15]. Furthermore, it is well established that temporal and masseter muscles of brachyfacial subjects have larger cross-sectional areas



**Figure 3:** EMG activity of Masseter muscle in Normodivergent patients.

and consequently greater muscular force [16-19]. This indicated that vertical facial morphology has a direct influence on muscular load generation [20].

Adhikari et al. [21] recorded the EMG activity of temporal and masseter muscles during maximum clenching and chewing. No significant EMG activity was detected during clenching which is the same as the present study. The study done by Cha and Kim [22] showed opposite results. They evaluated temporalis, masseter muscles and the Temporalis/Masseter ratio at rest and clenching status. EMG activity was found in both the groups at rest position and clenching. Another study by Monteiro and Regalo concluded that a significant increase in the activity of temporal muscle at muscular rest is seen [23].

There was no significant difference in clenching masseter, temporalis and mentalis muscle activity among the groups. There was no significant difference in the groups but Group I (hypodivergent) showed a higher temporal muscle activity than the other groups. These recordings were different with the findings observed in a study performed by Vianna-Lara et al. [12] who compared the EMG activity of masseter and anterior portion of temporal muscle in different vertical facial types during maximal voluntary contraction and simultaneous bilateral isotonic contractions. Results showed that at clenching temporal and masseter muscles presented statistically significant differences among the groups.

Group I (hypodivergent) showed higher orbicularis oris and mentalis muscle activity. These recordings indicate that brachyfacial subjects presented higher level of orbicularis oris and mentalis activity followed by dolichofacial group. This is due to the fact that brachyfacial subjects exerted more effective muscular contraction than dolichofacial subjects [6,7,9,17]. The orbicularis oris muscle activity was significant when it was compared with all the groups. Group I had the highest activity while Group II had the lowest activity. This could be due to the fact that in Group II (normodivergent) more facial musculature balance is seen due to average growth. All the muscles must be equally contributing to facial balance and functional movements. In Group I (hypodivergent) the muscles are stronger and due to this they have a high activity [8]. In Group III (hypodivergent) their activity is reduced due to weak musculature and also the fact that other muscles may be contracting more than normal to achieve facial musculature balance [8]. These findings imply that more the hyperdivergent tendency, the lesser increase in clenching of the muscle activity, than expressed by other group. Therefore, we can say that hyperdivergency might have a significant effect on the clenching potentials of the muscles.

In this study, the EMG analysis allowed evaluation of the activity of the masseter, temporal, orbicularis oris and mentalis muscles groups at maximum effort clenching. Besides, statistical differences did not show differences in clinical term, there were changes in the muscle activation pattern resulting from the vertical facial type. The fact that subjects with shorter face presented greater EMG activation, compared to long face subjects in the same situations, can be a sign of muscular differences of the stomatognathic system caused by morphologic features of the cranio-mandibular complex [14,17].

## Conclusion

- i. At clenching state masseter, temporal and mentalis muscles did not show any remarkable EMG activity in all the three groups.
- ii. During maximum clenching, EMG activity of Orbicularis Oris muscle showed significant differences among the three groups. Due to this the hypothesis was rejected.
- iii. EMG activity of masseter muscle during maximum clenching was significantly more than the rest of the muscles i.e. temporal, mentalis and orbicularis oris among all the divergent groups.

There were changes in the muscle activation pattern resulting from the vertical facial type and subjects with shorter face presented greater EMG activation as compared to long face subjects. This can be a sign of muscular differences of the stomatognathic system caused by morphologic features of the cranio-mandibular complex.

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