INFLUENCE OF MASSETER AND TEMPORALIS MUSCLE ACTIVITY IN CLASS I HIGH AND LOW ANGLE CASES- AN ELECTROMYOGRAPHIC STUDY

By

Dr. SHEETAL SARA VERGHESE

Dissertation submitted to the

Kerala University of Health Sciences, Thrissur

In partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

in

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

Under the guidance of

Dr. BINNOY KURIAN

Professor & HOD

Department of Orthodontics & Dentofacial Orthopaedics

St. Gregorios Dental College, Kothamangalam,

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ABSTRACT

Background and Objectives:

Balanced muscular forces are one of the main factors required to achieve a stabilized environment within the development of the craniofacial complex and a stable occlusion. The normal occlusion is in a state of constant dynamic equilibrium. Thus, there is a balance of forces between muscles, which influences the position and stability of the teeth. Forces exerted during habitual functions such as mastication, swallowing and speech are robust enough to cause tooth movement, yet they do not continue for a long period to move teeth. Both jaw bone and teeth are responsive to this. Light sustained forces created by the tonic contraction of skeletal muscles are needed to retain the posture of mandible. Since the muscle function has substantial effect on craniofacial growth pattern, abnormal muscle function may explain certain abnormalities of facial morphology and forms of malocclusion. To understand the influence of masticatory muscles on craniofacial morphology, surface electromyography is routinelyused.

Objectives:

To study the muscle activity of anterior temporalis and masseter muscle in Class I high angle and class I low angle cases by electromyography.

Methodology:

In the present study, 63 subjects with Angle's Class I malocclusion were included. Lateral Cephalogram were taken for all subjects. All lateral cephalograms were traced and measured both manually and digitally. The cephalometric measurements are measured according to the Bjork sum and Jarabak ratio and the subjects were categorized into 3 Groups. Surface Electromyography of bilateral masseter and temporalis (anterior) muscles were performed with Ala -Tragus line parallel to the floor. Electromyographic examination was performed during swallowing, chewing and clenching. The mean values from both right and left sides were taken for analysis.

Results and Discussion:

The electromyographic activity was compared among 3 groups during the functional movements of both masseter and temporalis muscles. Group I (subjects with horizontal growth pattern) exhibited highest muscle activity with regard to both masseter and temporalis muscles. Though Group I exhibited highest values during swallowing, the values were not statistically significant with other groups and during chewing and clenching, Group III (subjects with vertical growth pattern) exhibited minimum activity during the functional movements.

Conclusion:

The existence of correlations between vertical craniofacial morphology and masticatory muscle activity in Class I malocclusion has been investigated in the study and during all functional movements evaluated, subjects with horizontal growth pattern exhibited highest muscle activity and showed a positive correlation between muscle activity and Jarabak ratio. Subjects with vertical growth pattern presented with the minimum muscle activity during chewing and clenching.

Keywords: Electromyography, Masseter, Temporalis, Craniofacial growth pattern

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INTRODUCTION

INTRODUCTION

The stomatognathic system is highly complex and has been studied by several researchers. Yet it is still unclear whether a genetically determined facial morphology influences the strength of masticatory muscles[1], or whether a strong musculature decides the form of the face. Balanced muscular forces are one among the main factors required to achieve a stabilized environment for the development of the craniofacial complex and a stable occlusion[2,3].

The normal occlusion is in a state of dynamic equilibrium, due to balanced muscular forces which influence the position and stability of the teeth. Forces exerted throughout habitual functions like chewing, swallowing and speech are robust enough to cause tooth movement, but these forces do not continue for longer durations to permit tooth movement. Among the dynamic activities, mastication is the one of the most important physiologic activity of the stomatognathic system. Masticatory muscle activity can serve as an important local environmental factor in regulating craniofacial growth[4]. Morphological features of the stomatognathic system like thickness of the muscles were also related to the vertical craniofacial dimension[5]. As facial muscles act in harmony, toachievefunctionssuchasspeechandmastication,theyalsohelpinmaintaining the position of mandible. This means that the facial muscles are always in a functionalstateevenwhenthebodyisatrest.Allmusclesthatareattachedtothe mandible have an influence in its movements as well as maintenance of its position.

Resting pressures usually exists for longer periods than functional pressures, but are generally lighter in magnitude. Hence, it is necessary to evaluate the relationship between facial growth pattern and masticatory muscles. Since the muscle function has substantial effect on craniofacial growth pattern, abnormal muscle activity may explain certain abnormalities of facial morphology as well as forms of malocclusion. To understand the influence of craniofacial muscles, surface electromyography is routinely used to assess muscle activity.

Masticatory muscles have been widely investigated electromyographically in individuals with different vertical facial characteristics[6]. According to

Basmajian&DeLuca"Electromyographyisthestudyofmusclefunctionthrough the electrical signal the muscles emanate"[7].

EMG is a valuable tool in orthodontic research and is used to study temporomandibular joint articulation (TMJ Kinesiology), temporomandibular dysfunction and to compare muscle function in normal occlusion as well as malocclusions. It is also used monitor abnormal muscle activity that causes malocclusion and in the analysis of functional relationships of stomatognathic system (especially masticatory muscles, tongue and buccinator mechanism) [6].

Marey in 1890, made the first actual recording of myoelectrical activity and also introduced the term "electromyography"[8]. In 1949, electromyography was used for the first time in orthodontics by Robert Moyers, mainly to analyze the role of temporomandibular musculature as an etiological factor for Angle'sClass IImalocclusion[9].

Hence Electromyography is a well-defined tool for recording and studyingthe fundamentalelectricalimpulsesofskeletalmuscleseitherbysuperficialorneedle electrodes.TherearetwotypesofEMGelectrodes:surfaceelectrodeandinserted electrodes. Inserted electrodes are further divided into two types: needle and fine wire electrodes. Needle electrodes are commonly used during neuromuscular evaluations. The needle electrodes are better than other available types in signal quality[10].

Surface EMG: The main aim of surface EMG is to detect signals from muscle fibers in the area of the detecting electrode. This procedure is non-invasive as wellasapainlessmethodwayofregisteringtheresultsthroughtheuseofsurface electrodes. Since Orthodontists have moved from a stable to a dynamic and functional concept of occlusion, awareness about the skeletal and muscular environment is necessary because orthodontic treatment plan is not only dependent on biomechanical factors alone but also on the dynamic state of the orofacial musculature. With the quantum leap in the electro diagnostic procedures, it is possible to record even minute electrical activity of biologic tissues.Inadditiontothis,"thepotential"ofEMGinorthodonticsisdiscussedin thecontextofdiagnosis,treatmentplanningandevaluationoftreatedresults.The orthodontistisencouragedtousethistoolinareasofresearchaswellastreatment [11].

In 1961, Grossman et al felt that the problem in orthodontic therapy was not mechanical alone, since the muscular influences were also responsible for the stabilityoftheendresult.Theyalsostatedthatanexactassessmentofthemuscle behavior prior to orthodontic treatment would enable the orthodontist to make a comparison and to assess any changes that might have occurred during treatment[12].

Manystudieshavebeencarriedouttodeterminetheinteractionbetweenfacial morphologyandmuscleactivityusingdifferenttechniques,butwithinconsistent findings[13,14]. This study is an attempt to evaluate the activity of masseter and temporalis muscles in class I high and low angle cases byelectromyography.

OBJECTIVES

AIM OF THE STUDY

- To study the activity of masseter and anterior temporalis on Class I high andlow angle cases usingelectromyography.

OBJECTIVES OF THE STUDY

- To determine muscle activities of masseter and anterior temporalis in normal, low and high angle class1cases.

- To understand the influence of craniofacial muscles on growthpattern.

BACKGROUND &REVIEW OFLITERATURE

BACKGROUND OF THE STUDY

The craniofacial morphology seems to be determined by both genetic influences and local environmental factors, among which masticatory muscle activity seems to play a significant role. The craniofacial growth occurs as a response to functional needs and is mediated by the orofacial musculature. Today, the main problem in orthodontic therapy is not mechanical. Appliances have reached higher levels of perfection that most malocclusions could easily be treated to predestined goals. Muscles of orofacial region directly influence the treatment outcome as well as its stability. Hence awareness about the skeletal and muscular environment is necessary. The existence of correlation between craniofacial morphology and masticatory muscle activity has often been investigated using different techniques, but with inconsistent findings. Retaining the achieved results are more challenging than the treatment itself. This study is an attempt to evaluate the influence of masseter and temporalis muscles in class I high and low angle cases by surfaceelectromyography.

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REVIEW OF LITERATURE

Moyers.R (1949)[15]made use of electromyography, to analyse the role of temporomandibular musculature as an etiological factor for Angle's Class II malocclusion. Masticatory muscles, suprahyoid muscles as well as mentalis muscle were investigated.

He observed 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 respect both to amplitude and frequency and this uniformity was lost in cases of mandibular retrognathism cases where greater contractions from the posterior fibres of the temporal muscle was observed. He concluded that, this imbalance in the distribution of the activity could be an etiological factor in the retroversion of the mandible. In subjects with maxillary dental protrusion the mentalis muscles was found to behypertrophied.

Grossman et al (1961) [10]suggested that the problem in orthodontic therapy was not purely mechanical since the muscular activity greatly influences the stability at the end of treatment. He also concluded that an exact assessment of the muscle behaviour before commencement of orthodontic treatment would enable the clinician to compare and assess any changes that might have occurred duringtreatment.

Okun.J.H (1962) [16]emphasized that prolonged use of Class II elastics during orthodontic treatment might affect the muscular pattern and electromyographically found that the muscle activity of posterior temporal muscle increases and masseteric muscle activity reduces. This action is reversed with the use of Class III elastics. In Class II cases undergoing treatment, masseteric activity was greater and temporal activity was found to increase in the marked crossbite cases. This could be related to the crossbite WHICH creates a marked tooth interference which limits the functional positioning activity of the temporal muscle.

Ahlgren et al (1973) [17]performed EMG activity in 80 children during chewing and found no significant correlation between cephalometric measurements and integrated EMG activity, there was a tendency for negative correlation between EMG activity and the gonial angle. Ahlgren also studied the maximum voltage amplitudes of surface EMG recordings from the masseter, anterior and posterior temporalis and showed that patients with acute gonial angles had lower levels of masseter muscle activity during swallowing, and higher anterior temporalis activity at rest than those with obtuse gonialangles.

Vitti et al (1975) [18]analysed the activity of circumoral muscles and tongue in 11 subjects with normal occlusion. During aberrant oral activity, a marked EMG response occurred in both muscles (orbicularis oris and genioglossus), in case of buccinator but only minimal increase in the muscle activity haveoccurred.

Throckmorton (1980) [19]investigated the morphologic differences between patients with long and short face syndromes and correlated the mechanical advantage of masticatory muscles. The results suggest that greater bite force was reported for patients with the short face syndrome and these patients showed greater mechanical advantage in case of their adductormuscles.

Pancherz, H (1980) [20]compared temporal and masseter muscle activity in children and adults with normal occlusion. He investigated temporal and masseter muscle activity in male subjects with normal occlusion. EMG recordings were analysed quantitatively during maximal biting in intercuspal position and during chewing of peanuts. The results of the investigation revealed that masseter muscle activity was greater in the older age group than in the younger age group whereas temporal muscle activity was found to be the same in both the age groups. For the temporalis muscle, the chewing activity was found to have positive correlation to maximal biting activity in both age groups. For the masseter muscle a clear correlation between chewing and biting activity was found only in the younger agegroup.

Lowe et al (1984) [21]analysed the activity of orbicularis oris muscle at rest and during maximum intercuspation. The results revealed that the muscle activity was significantly higher in Class II division 2 subjects than in Class II division 1 and Class I subjects. Muscle activity was significantly reduced in anterior temporalis and masseter activity in the Class II division 1 when compared to Class I subjects for clenching. They also concluded that a higher resting level for masseter activity was observed in subjects with short mandible and steep occlusal plane.

Jimenez et al (1989) [22]studied the activity of masticatory muscles in three jaw registration positions electromyographically. The retruded contact position required more muscle activity and permitted less biting muscle activity. There was no significant difference in the muscle activity during the intercuspal position.

Miralles et al (1991) [23]observed the patterns of EMG activity of anterior temporal and masseter muscles in subjects with different facial types. They found that postural activity for temporalis as well as for masseter muscles was found to be 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 similar between Class III and Class I. During maximal voluntary clenching, the activity was not different among classes. They also observed high correlations between EMG activity, ANB angle and overjet.

Ferrario et al (1993) [24]measured electromyographic activities in 92 healthy men and women during rest position, centric occlusion and during clench. Mean potentials for males and females were similar except during clench, where males had higher electromyographic levels.

M. C. Raadsheer (1996) [25]investigated the correlation between the growth of human masticatory muscles and its relation with facial dimensions at different age. For each age group (and corrected for stature and weight), males had significantly thicker masseters than females. Variation in muscle size and facial dimensions mainly matched with variations in age, stature and weight, muscle thickness presented a negative correlation with anterior facial height and mandibular length, and a positively correlated with intergonial width as well as bizygomatic facialwidth.

Ueda et al (1998) [26]performed a study where the EMG activity of the masticatory muscles (masseter, temporalis and digastric muscles) was evaluated during day time with a portable EMG recording system. They observed a relationship between their measurements of skeletal divergence (mandibular plane angle and the ratios between anterior to posterior total and lower face height) and muscle activity, but no gender differences were observed.

C.R.S Faria et al (1998) [27]evaluated the temporal muscles (anterior), and the masseter and suprahyoid muscles electromyographically in 15 subjects with ages ranging from 18 to 35 years during mandibular rest position through a number of phases. The results of the experiments concluded that the position of the mandible at rest is effectively maintained by the viscoelastic properties of the muscles and tendons that counterbalance gravity.

K. Miyamoto et al (1999) [28]measured the masseter muscle activity during the whole day in children and investigated the differences between children and young adults. He found that masseter muscle activity during the daytime was higher in children than in young adults. During daytime as well as during sleep, the activity was greater in children. During mealtime, no significant differences were present between children and young adults.

Alarcon (2000) [29]and co-workers investigated electromyographic activity of masticatory muscles in patients with unilateral posterior crossbite pattern of masticatory muscles at rest position, during swallowing, and during mastication, in 30 individuals with unilateral posterior crossbite and compared them to 30 subjects with normal occlusion. The results pointed that the posterior temporalis of the non–crossbite side showed higher muscle activity than that of the side with crossbite, both during rest position as well as during swallowing. During chewing in crossbite patients, the right masseter muscle showed reduced muscle activity than in normocclusive subjects. The muscle activity of both anterior digastrics were higher in the crossbite subjects during swallowing.

Ferrario et al (2000) [30]evaluated the electromyographic (EMG) characteristics of masseter, temporalis and sternocleidomastoid (SCM) muscles during maximum voluntary teeth clench in 27 male and 35 female healthy young adults and then divided the subjects into two groups: (i) ‘complete’ Angle’s Class I and (ii) ‘partial’ Angle Class’s I malocclusion. In his study, he did not observe any significant differences between the activity of the masseter and temporalis muscles in both the groups.

Saifuddin et al. (2003) [31]investigated the nature of masticatory muscle activity and the balance in the bilateral symmetry of masticatory muscle activity in patients with jaw deformity and compared the resting activities of the muscles recorded during day and night and also during mastication. 15 patients with lateral shift of the mandible caused by transverse craniofacial deformity were included and 15 controls were used as the subjects in his study. Muscle activities were recorded from the bilateral masseter and anterior temporal muscles during daytime and also during sleep. The results proved that masticatory muscle activity is reduced in these jaw deformity patients in association with more prominent asymmetry of anterior temporal muscle activity than in the controls. It is recommended that these results are relevant to occlusal interference and instability due to malocclusion and lateral mandibular deviation.

SerraoG (2003) [32]evaluated the relation between vertical facial morphology and jaw muscle activity in healthy young men aged between 20-36 years. The aim of his investigation was to quantitatively analyse the relation between the activity of masticatory muscles and the inclination of the mandibular plane in a group of 73 healthy white men and he concluded from his study that the facial morphology and muscular function are significantlyrelated.

Patricia García-Morales et al (2003) [33]correlated maximum bite force, mechanical advantage and masticatory muscle electromyography (EMG) activity with craniofacial morphology of children with vertical growth patterns. From lateral cephalograms of 47 patients, 13 morphological and eight biomechanical measurements were recorded. Muscle efficiency was assessed using the correlation between bite forces and muscle activity levels. They concluded that greater hyper divergence is related to poorer mechanical advantage as well as lower maximum bite force.

K. Hiraoka (2004) [34]investigated masseter muscle activity during swallowing in seven healthy humans. To observe both the increase and the decrease of muscle activity, the subjects performed swallowing while low- intensity tonic clenching was maintained. Muscle activities were recorded from the right masseter muscle and the suprahyoid muscle complex and results revealed that an increase in the masseter muscle activity associated with swallowing was found. The increase may serve the purpose of stabilizing the mandible against contraction of suprahyoid muscles.

Farella.M (2005) [35]compared the long- term muscle activity of short- face subjects with that of long- face subjects in their natural environment. Digital photographs of the facial profile were obtained from a sample of 300 subjects and the ratio between anterior total and anterior lower facial height was calculated. The results suggest that habitual activity of masseter muscle in the natural environment was not influenced by the vertical craniofacial morphology.

Trawitsiki (2006) [36]studied the effect of treatment of dentofacial deformities on the electromyographic activity of masticatory muscles. He determined the influence of interdisciplinary treatment in cases of class III dentofacial deformities regarding the EMG activity of the temporal (T) and masseter (M) muscles. The study was conducted on 15 patients with class III dentofacial deformities concluded that there was an increase in EMG activity in the Temporalis and Masseter muscles after surgical correction of the dentofacialdeformity**.**

BK Cha et al (2007) [37]investigated the muscle activity of the anterior temporal and masseter muscles in different facial skeletal types. The sample consisted of 105 subjects and they were classified into six groups according ANB and SN-GoMe. They concluded that the more hyperdivergent tendency, the higher resting temporal muscle activity, and the lesser masseter muscle activity during clenching. Significant differences existed in their study with temporal muscle activity and masseter muscle activity according to sagittal and vertical facial skeletal types.

GeorgiakakI et al (2007) [38]assessed the thickness of the masseter muscle by means of ultrasonography and investigated the relationship between masseter electromyographic activity and muscle thickness bilaterally, during maximum voluntary clenches. There was a positive correlation between the masseter muscle thickness and the muscle EMG activity in subjects with healthy masseter muscles

Moreno I (2008) [39]determined the correlation between Angle's malocclusion, presence of a posterior crossbite, in male and female patients during the activity of the masticatory muscles in healthy dental students. The muscle activities are recorded for the masseter, anterior and posterior temporalis and digastric muscles; in three different tests: clenching at maximum intercuspation, swallowing and chewing. The results revealed that patients with Angle class II exhibited higher activity for temporalis muscles during swallowing and chewing; subjects with class III attained the highest muscle activity for the temporalis and masseter muscles during maximal voluntarycontraction.

Piancino M.G (2008) [40]considered the kinematics and masseter muscle activation in in 82 children with unilateral posterior crossbite and 12 children with normal occlusion during chewing of both soft bolus and a hard bolus. Both types of cycles in patients resulted in reduced muscle activity of masseter of the crossbite side than of the contralateral masseter. He concluded that during chewing on the crossbite side, the masseter activity was lowered on the mastication side (crossbite) and it remained same or increased on the non-affected side.

Andresen .E (2009) [41]evaluated the activities of the masticatory muscles in children with class II division 1 malocclusion treated with activator and compared them with untreated patients at the start of the therapy,1 year later to check the effectiveness of this functional appliance. The activity during clenching, chewing, and swallowing of the temporalis and masseter muscles was increased in both groups, particularly in the treatment group duringwhistling.

Vianna Lara M(2009) [42]reported a study where in the subjects were classified on the basis of their vertical facial characteristics into three groups—brachyfacial, mesofacial, and dolicofacial and the EMG recordings were obtained with three repetitions during mandibular rest, maximum voluntary contraction in intercuspidation, and simultaneous bilateral isotonic contraction and concluded that different vertical facial types do not determine distinct patterns of EMG activity for the masseter and anterior portion of temporal muscles during rest and bilateral mastication.

M.J.P. Coelho Ferraz (2009) [43]evaluated the chewing muscular dynamics by surface electromyography in 17 people with Angles Class I malocclusion during rest position and isometric position, the muscle activity of temporal muscle in its anterior portion was higher than the masseter muscle during rest position. The masseter muscle presented a higher action than the anterior temporal muscle during isometriccontraction.

Yousefzadeh et al (2010) [44]described the influence of vertical malocclusions on the electrical activity of temporalis, masseter, orbicularis oris, and digastric muscles using surface electromyography in patients with anterior open bite aged 10.1–13.2 years. The patients with malocclusions exhibited lower activity in the muscles during clenching and higher activity in the muscles of the balancing side during chewing when compared with healthy subjects.

Ciccone de Faria (2010) [45]paid attention to the different activities of the muscles in patients with either a skeletal or dentoalveolar malocclusion. Healthy patients presented the highest electrical activity in the temporalis and masseter muscles during maximal voluntary contraction and lower muscle activity was detected in subjects with a dentoalveolar anterior open bite and the lowest in patients with a skeletal open bite. Patients with a skeletal malocclusion exhibited the lowest electrical activity in the muscles duringchewing.

Tecco.S et al. (2010) [46]showed sEMG activity of the masseter muscles in patients with crossbite and the normal occlusion in rest position as well as during maximal voluntary clench on both sides, he suggested that posterior crossbite had no influence on the activity of masseter muscle. However, they detected a significant difference in muscle activity for the anterior temporalis muscle, which was higher on the crossbite side at rest side.

Saccucci et al (2011) [47]evaluated the change in upper and lower orbicular oris muscles created by a functional device in 13 children with Class II, division 1 malocclusion with deep bite and lip incompetence.15 children of the same age with normocclusion was taken. The electromyographic recordings were investigated before therapy, 3 and 6 months after the treatment. The treatment group showed a lower muscle activity of the lower orbicularis oris muscle compared with the control before the therapy, except during swallowing. From before treatment to 3 months after the therapy, treated group showed significant increase in muscle activity at rest. The upper orbicularis oris muscle showed a significant increase during protrusion of the mandible between the 3rd and 6th months after the treatment. After the treatment, patients showed activity similar to the control group.

William Custodio (2011)[48]studied the of influence of maximal occlusal force, of masticatory muscles by electromyographic (EMG) activity, and medial mandibular flexure (MMF) on vertical facial patterns. Based on Ricketts analysis Seventy-eight subjects were divided into 3 brachyfacial, mesofacial and dolychofacial. It was concluded that brachyfacial group exhibited maximum occlusal force and masticatory EMGactivity.

Sarabjeet Singh (2012) [49]measured the maximum bite force in subjects with normal occlusion with Angle's classification. He also analysed their EMG pattern for masseter and temporalis muscles during: (i) Postural rest position of mandible, (ii) maximum voluntary clenching in the intercuspal position and (iii) in anterior bite position. He concludedthatClassIIImalocclusionsubjectsshowedthehighestmasseterandanterior temporalis activity during postural rest. Class III malocclusion showed the highest and Class II Division 1 malocclusion showed the least anterior temporalis activity at both the intercuspal and interincisal positions during maximum voluntary biting.

Carla Maffei (2013) [50]evaluated the electromyographic activity of both the temporalis and masseter muscles as well as the mastication type of patients with skeletal unilateral posterior crossbite before and after orthodontic treatment. Orthodontic intervention combined with myofunctional therapy in patients with skeletal unilateral posterior crossbite provided an increase in the muscle activity of the masseter and temporalis muscles during rest and mastication.

Srikanth Gunturu (2013) et al [51]investigated the activity of facial and masticatory muscles on facial morphology. 15 subjects were classified into Class I, Class II, Class III groups based on their cephalometric landmarks. Electromyographic recording of Masseter, Temporalis and Orbicularis Orismuscles were performed and the activity of the muscles were correlated with their skeletal profiles. Postural EMG activity for masseter and Temporalis muscles were higher in class II subjects than in class I and class III subjects. The muscle activity was reduced in class I cases when compared to class II and class III subjects.

C.I.R Castaneda (2017) [52]compared the changes in electromyographical activity during different phases of orthodontic treatment. He measured bilateral electromyographic activity (EMG) of masseter for 30 seconds in maximum intercuspation. EMG activity was measured monthly for 15 months during 4 phases in orthodontic treatment: pre- treatment, splint wear; leveling and aligning; space closure; and finishing stage. From his studyheconcludedthat,itwasabletoidentifythechangesinmuscularactivityrelated with different stages of treatment, which opposes the popular belief of an adaptation in the muscular activity throughouttreatment.

Nickel (2017) [53]assessed the mechanobehaviour (temporomandibular joint loads, jaw muscle use) in different between facial types and its correlation with ramus height,.The correlations between facial and bite morphology and the activity in the temporal muscle as well as in the musculature of the lip during swallowing and chewing were studied in 50 girls, aged 9-13 years.Theyconcluded that brachyfacial individuals used their jaw muscles significantly more than dolichofacial individuals. Mechanobehaviour showed significant differences between facial types and was correlated with ramalheight.

Rahman.N (2018) [54]aimed to asses the association and correlation between the overjet and muscle activity (the masseter and temporalis muscles) in patients with Class II malocclusion in different genders using surface electromyography. The study consisted of 18 patients. Intraoral examination was carried out to distinguish Class II malocclusion. Masseter and temporalis muscle activity were recorded during rest, chewing, post chewing rest, clench and post clench rest. Normally patients with class II malocclusion exhibited increased overjet and abnormal muscle activity because of incompetent and short lip. The increased overjet is often associated with temporomandibular joint problem. The study showed a direct association of masseter muscle activity with overjet during chewing. It can be speculated that in class II malocclusion , with increased overjet can affect masticatory muscle function and indicated that the clench force of class II malocclusion patient may differ between males andfemales.

J Shim et al (2019) [55]assessed the impact of post-orthodontic occlusion on masticatory performance as well as chewing efficiency. 54 patients who have completed orthodontic treatment were categorized into two groups using the American Board of Orthodontics model grading system: 25 patients meeting ABO standards, the other 25 failing to meet the standards. Orthodontic detailing contributed to a more balanced activation of the temporalis muscles during clenching and also more efficient muscle recruitment but chewing efficiency was not improved.

I Ardani and co-workers (2020) [56]evaluated the difference in masticatory muscle activity in Class I and Class II malocclusion in Javanese patients by surface electromyography (sEMG). The samples consisted of 16 patients and were categorized based on Angle's classification into Class I and Class II malocclusion. Masticatory muscle activity by sEMG was performed during clenching. Temporalis, masseter, and suprahyoid muscle activity detected showed no significant difference in Class I and II malocclusion.

Sabarinath Prasad (2019) [57]tested a smartphone-assisted wireless device for assessing electromyographic (EMG) activity of the masseter muscle in freely moving individuals undertaking routine activities. EMG activity was detected unilaterally from the masseter muscle in 12 volunteers using surface electrodes connected to both a smartphone-assisted wireless EMG device and a fixed-wired EMG equipment. Smartphone-assisted monitoring of the jaw muscles represents a promising tool to investigate oral behavior patterns in free moving individuals. Smartphone-assisted monitoring of masticatory muscle activity may enable possible associations between excessive muscle activity, bruxism, dysfunction, and pain that have to be investigated.

Lipari et al (2020) [58]in his cross-sectional study evaluated the electromyographic (EMG) activity of lips and anterior temporalis muscles of children with competent or incompetent lips. The muscle activity of the superior orbicularis oris, inferior orbicularis oris,andanteriortemporalismuscleswererecorded.Theincompetentlipgroupshow ed lower EMG activity than competent lip group in both orbicularis oris muscles at rest, similar activity in both muscles during speaking and swallowing was observed. The difference in the muscle activity recorded in children with incompetent lips and with competent lips shows that the status of their musculature could affect the position and stability of their upper and lower anterior teeth.

Chen.C et al (2021) [59]assessed the relationship between vertical facial patterns and the masticatory activity influence on the molar anchorage and dental movement. His study included 18 patients who had completed orthodontic treatment with therapeutic symmetric extraction. The electromyographic examination was carried out at the time of bracket debond. The muscle activities of anterior temporalis and masseter muscles were recorded during the rest position and in functional positions. From his study he concluded that muscle activity in masseter muscles was higher in patients with more vertical and sagittal anchorage loss, patients with moderate muscle activity in masticatory muscles had better control in molaranchorage.

Sabarinath Prasad et al (2021) [60]investigated effects of electrode material, inter-electrode distance (IED), and conductive gel on electromyographic (EMG) activity recorded from the masseter muscle. They study concluded that inter electrode distance between 15 and 25 mm has a negligible effect on masseter muscle EMG. Graphene coated and silver nanowire embedded electrodes showed better results and can be considered as newer gel freealternative.

RELEVANCE

RELEVANCE OF THE STUDY

The stomatognathic system has been studied by several researchers, yet it is still unclear whether a genetically determined facial morphology influences the strength of masticatory muscles, or whether a strong musculature decides the form of the face. Awareness about the muscular environment is necessary as orthodontic treatment plan is not dependent on biomechanical factors alone but also on the orofacial musculature. All masticatory muscles are attached to the mandible directly and can have an influence on its movements as well as maintenance of its position. Hence, these muscles directly influence the orthodontic treatment outcome, as well as the stability of such treatments. Th present study is an attempt to evaluate influence of masseter and temporalis muscles in Class I high and low angle cases by electromyography.

METHODOLOGY

METHODOLOGY

Research design

A comparative analysis of masseter and temporalis muscle activity in class I high and low angle cases -An electromyographic study.

Research Setting

Department of Orthodontics, St Gregorios Dental College, Kothamangalam.

Consent and Ethical Approval

- Ethical clearance was obtained from the Institutional EthicalCommittee.
- Informed consent explaining the nature and purpose of the study was signed by all thesubjects.

Inclusion Criteria

- Angles Class IRelationship
- AgeGroup-18-26years
- Full set of permanent teeth (Except3rd molars, ifunerupted)

Exclusion Criteria

- No missing teeth andprosthesis
- No history of orthodontic treatment or orthognathicsurgery
- No symptoms of temporomandibular joint or jaw-muscledisorders
- No severe facialasymmetry.

Sampling Procedure

Sample size: S = (z2 (d (1 - d))/ e2) / 1 + (z2 (d (1 - d)) / e2)

Where,

S = sample size

P = population size

z = z-score

e = margin of error

d = standard deviation.

Sample size obtained -63

Methodology:

Lateral Cephalogram was taken for all subjects. All of the cephalograms were recorded with the same exposure parameters (kVp-64,mA-16 Exposure time 14.1sec) with the same magnification using Dentsply Sirona Orthophos XG (Fig 1).

All cephalograms were traced manually using acetate paper and also digitally using NEMO CEPH software.

The cephalometric measurements were traced according to the Bjork sum and Jarabak ratio [61,62].

$$\textbf{Jarabak's Ratio} = \frac{\text{Posterior facial height}}{\text{Anterior facial height}} \times 100$$

Bjork analysis: Sum of saddle angle, gonial angle and articular angle.

- Saddle Angle: Formed by joining N-S-Ar. is an assessment of the relationship between anterior and posterior lateral cranial bases.

- Articular Angl**e:** The constructed angle that lies between the upper and lower parts of the posterior contours of the facial skeleton. It indicates the position of themandible.

- Gonial Angle**:** The angle formed by the tangents to the body of the mandible and posterior border of the ramus. This angle expresses the growth direction of mandible.

Classification into Groups

- Group I: 21subjects with horizontal facial growth pattern (Bjork sum is less than 390), Jarabak's ratio more than65%.

- Group II: 21subjects with normal growth pattern (Bjork sum is equal or more than 390 but less than or equal to 402), Jarabak's ratio between62-65%.

- Group III: 21 subjects with vertical growth pattern (Bjork sum is more than 402), Jarabak's Ratio less than62%.

Procedure

The subjects were explained in detail about the examination. During its execution, they sat on the chair keeping an erect posture calm and relaxed environment and resting their feet on the floor. Subjects were positioned with the Ala- Tragus line parallel to the floor. The subjects are also instructed to keep their head and body still during the tests as the movements of the head and neck region or body might affect the surface electromyographic results. Bilateral masseter and temporalis muscles were evaluated. Superficial bipolar electrodes (Fig 3) are placed on the skin overlying masseter and temporalis muscles. A ground electrode was placed on the neck to prevent electrical interference (Fig4).

Prior to the placement of electrodes, the skin was scrubbed using 70 % alcohol (Fig 5) to reduce impedance between skin and electrodes. Bipolar surface electrodes (Cadwell) were used and was fixed on to the skin with Transpore tape (Fig6).

Location of electrodes

For anterior temporalis muscle, electrodes were attached about 1 cm above the zygomatic arch and 1.5 cm behind the orbital border (Fig 7)[64].

To record EMG activity of the masseter muscle, two electrodes per side were placed according to the direction of masseter muscle fibres on the cross point of a line from the external canthus of the eye to the angle of mandible and a line from the center of the tragus to the corner of the mouth. This is usually the middle and thickest part of the masseter muscle, which also becomes more prominent, when subjects bite harder on posterior teeth (Fig 8)[63].

Surface Electromyography

An electromyographic equipment was used to record EMG of facial muscles in functional positions (Fig 2). In all cases, the electromyographic tests were carried out by a singleoperator.

For EMG measurement, a single channel was used with 10KHz high-pass filter, and 200-Hz low-pass filter. A 16-bit Analog/Digital converter with data acquisition hardware was also used. Before the placement of the electrodes and the start of EMG recording, the whole procedure was explained and instructions were given to the subjects. The following were the functional examinations performed:

Swallowing registration: 20ml of water was measured using a measuring cylinder (Fig 9). Then the subject was given 20ml of water. They were asked to place in the oral cavity without swallowing it. The muscle activity is recorded when the subject is asked to swallow it (Fig 11) [65].

Chewing registration: For the purpose of chewing, specific brand of chewing gum (Orbit Chewing gum from Wrigley's Company) was used (Fig 10). The subjects were instructed to crush the gum first and to make it into a bolus of even consistency and is asked to keep it over posterior teeth of one side. The chewing started only when the signal was given and the muscle activity was recorded (Fig 12) [66].

Maximum voluntary clenching: All subjects are requested to apply maximum bite force possible for five seconds. Three consecutive recordings were performed and the mean was taken for analysis (Fig 13) [67].

The dependent variable was the mean quadratic value or RMS (root mean square), and signifies the average of the square values of the myoelectrical activity. The higher the RMS value, the greater will be the average of the electromyographic activity of the muscles recorded. The RMS represents an average value of the variation between the highest and the lowest point of the wavelength of the electromyographic activity. Activities of the right and left temporalis and masseter muscles were recorded with EMG recording system. Mean values from bilateral muscles were taken and analysed[68.]

Fig 1 :Cephalostat

Fig 2: Emg Machine

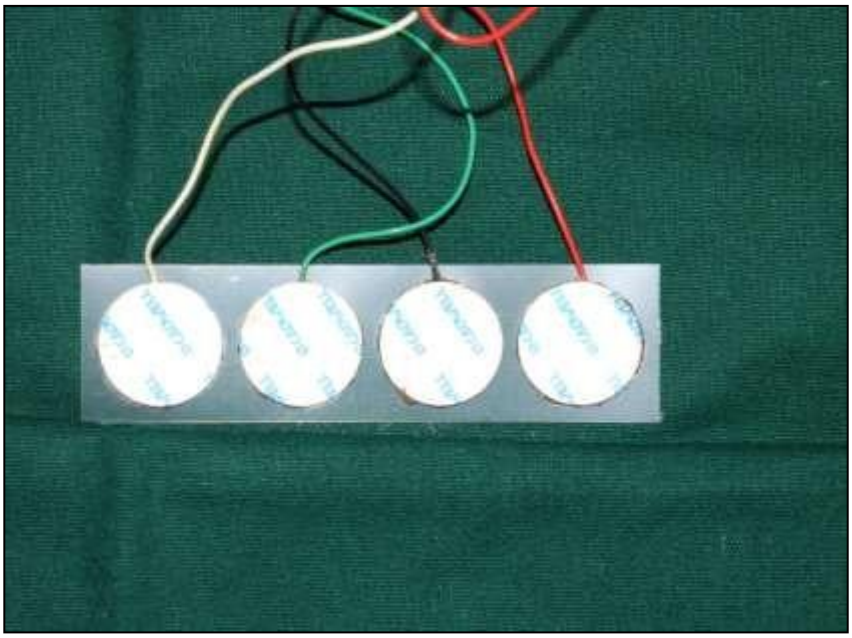


Fig 3: Surface Electrodes for electromyography

Fig 4: Ground electrode

Fig 5: 70 % Isopropyl alcohol

Fig 6: Transpore tape

Fig 7**:** Placement of electrode for anterior temporalis

Fig 8: Placement of electrode for Masseter

Fig 9: Measuring cylinder (measure 20mL of water)

Fig 10: Chewing gum

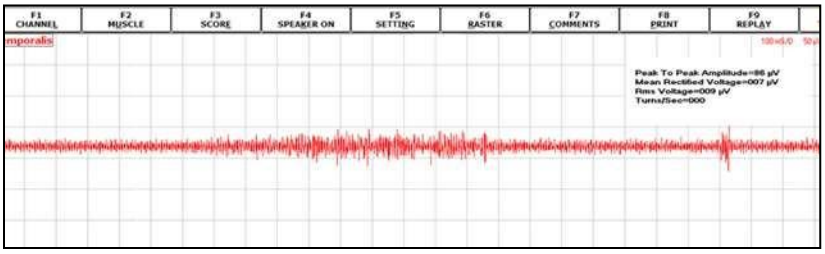


Fig 11: EMG recording during swallowing

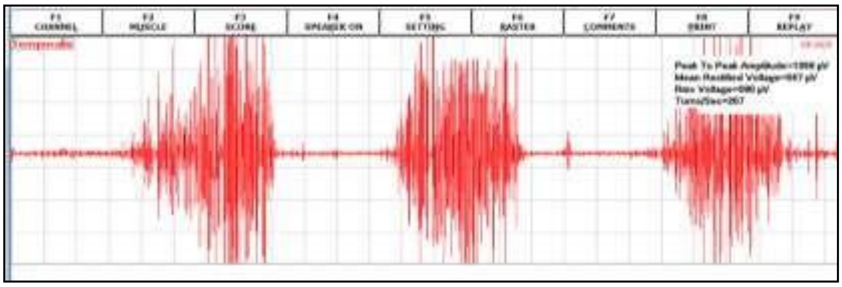


Fig 12: Emg recording during chewing

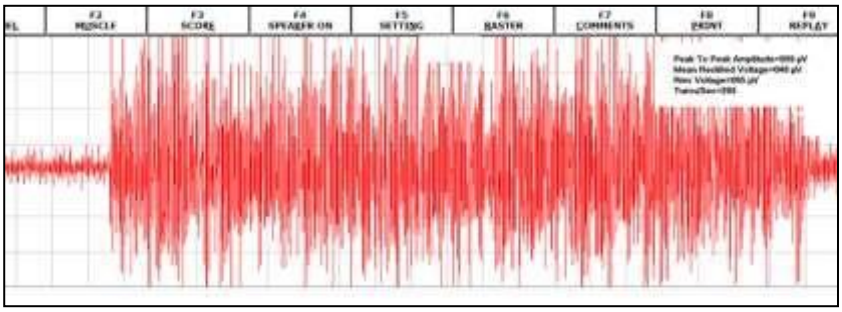


Fig 13: Emg recording clenching

RESULTS

RESULTS

In the present study, 63 subjects with Angle's class I malocclusion were classified into 3 groups based on Jarabak's ratio and Bjork's sum, wherein Group I represented subjects with horizontal growth pattern, Group II consisted of subjects with average growth pattern and Group III represented subjects with vertical growth pattern. Functional movements of bilateral masseter and anterior temporalis muscles were recorded during swallowing, chewing and clenching and the mean values were taken for analysis.

In case of Masseter muscle, Group I (subjects with horizontal growth pattern) revealed highest muscle activity during all functional movements and Group III (subjects with vertical growth pattern) exhibited minimum muscle activity.

In case of Temporalis muscle, Group I (subjects with horizontal growth pattern) exhibited higher activity during all functional movements whereas Group II (subjects with average growth pattern) exhibited least muscle activity during swallowing and Group III (subjects with vertical growth pattern) exhibited minimal activity during chewing and clenching.

Statistical Analysis

Data was analyzed using the statistical package SPSS 22.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using Shapiro Wilkinson test. Inferential statistics to find out the difference between and within the groups was done using One Way ANOVA and Tukeys Post hoc test.

GROUP 1			GROUP 2			GROUP 3		
SWALLOW	**CHEW**	**CLENCH**	**SWALLOW**	**CHEW**	**CLENCH**	**SWALLOW**	**CHEW**	**CLENCH**
10.6 ± 2.7	**52.6 ± 3.78**	**87.2 ± 4.2**	**10.36 ± 1.7**	**44.6 ± 3.2**	**76.46 ± 2.8**	**10.2 ± 4.3**	**37.4 ± 4.3**	**74.36 ± 3.8**

Table 1: Comparison of masseter muscle activity (mean values) between Group I, Group II, and Group III.

GROUP 1			GROUP 2			GROUP 3		
SWALLOW	**CHEW**	**CLENCH**	**SWALLOW**	**CHEW**	**CLENCH**	**SWALLOW**	**CHEW**	**CLENCH**
10.1 ± 2.7	**44.54 ± 3.64**	**84.34 ± 3.47**	**9.1 ± 2.8**	**42.2 ± 3.8**	**74.35 ± 2.78**	**9.64 ± 6.45**	**25.1±3.8**	**46.35±4.6**

Table 2: Comparison of temporalis muscle activity (mean values) between Group I, Group II, and Group III.

One way ANOVA:

		GROUP 1	GROUP 2	GROUP 3	F value	Sig
SWALLOW	MEAN	10.6	10.36	10.2	0.084	0.91
	SD	2.7	1.7	4.3		

Post hoc test :

Group(I)	Group(J)	Mean difference (I-J)	95% of confidence interval		PValue
			Lower	upper	
GROUP 1	GROUP 2	-0.24	-2.5925	2.1125	0.96
	GROUP 3	-0.40	-2.7525	1.9525	0.91
GROUP 2	GROUP 3	-0.16	-2.5125	2.1925	0.98

Table 3: Comparison of Swallowing Between Three Groups (Masseter)

One way ANOVA:

		GROUP 1	GROUP 2	GROUP 3	F Value	sig
CHEW	MEAN	52.6	44.6	37.4	81.77	0.0001*
	SD	3.78	3.2	4.3		

Post hoc test :

Group(I)	Group(J)	Mean difference (I-J)	95% of confidence interval		P Value
			Lower	upper	
GROUP 1	GROUP 2	-8	-10.8615	-5.1385	0.0001*
	GROUP 3	-15.2	-18.0615	-12.3385	0.0001*
GROUP 2	GROUP 3	-7.2	-10.0615	-4.3385	0.0001*

Table 4- Comparison of Chewing Between Three Groups (Masseter)

<u>One way ANOVA:</u>

		GROUP 1	GROUP 2	GROUP 3	F Value	sig
CLENCH	MEAN	87.2	76.46	74.36	71.298	0.0001*
	SD	4.2	2.8	3.8		

<u>Post hoc test :</u>

Group(I)	Group(J)	Mean difference (I-J))	95% of confidence interval		P VALUE
			Lower	upper	
GROUP 1	GROUP 2	-10.74	-13.5159	-7.9641	0.0001*
	GROUP 3	-12.84	-15.6159	-10.0641	0.0001*
GROUP 2	GROUP 3	-2.1	-4.8759	0.6759	0.172

Table 5- Comparison of Clenching Between Three Groups (Masseter)

One way ANOVA:

		GROUP 1	GROUP 2	GROUP 3	F Value	Sig
SWALLOW	MEAN	10.1	9.1	9.64	0.268	0.765
	SD	2.7	2.8	6.45		

Post hoc test :

Group(I)	Group(J)	Mean difference (I-J)	95% of confidence interval		P Value
			Lower	upper	
GROUP 1	GROUP 2	-1	-4.2904	2.2904	0.74
	GROUP 3	-0.46	-3.7504	2.8304	0.93
GROUP 2	GROUP 3	0.54	-2.7504	3.8304	0.91

Table 6 - Comparison of Swallowing Between Three Groups (Temporalis)

One way ANOVA:

		GROUP 1	GROUP 2	GROUP 3	F Value	Sig
CHEW	MEAN	44.54	42.2	25.1	160.49	0.0001*
	SD	3.64	3.8	3.8		

Post hoc test :

Group(I)	Group(J)	Mean difference (I-J)	95% of confidence interval		P VALUE
			Lower	upper	
GROUP 1	GROUP 2	-2.34	-5.1917	0.5117	0.127
	GROUP 3	-19.4	-22.2917	-16.5883	0.0001*
GROUP 2	GROUP 3	-17.1	-19.9517	-14.2483	0.0001*

Table 7 - Comparison of Chewing Between Three Groups (Temporalis)

One way ANOVA:

		GROUP 1	GROUP 2	GROUP 3	F Value	sig
CLENCH	MEAN	84.34	74.35	46.35	568.56	0.0001*
	SD	3.47	2.78	4.6		

Post hoc test :

Group(I)	Group(J)	Mean difference (I-J)	95% of confidence interval		P Value
			Lower	upper	
GROUP 1	GROUP 2	-9.9	-12.8008	-7.1792	0.0001*
	GROUP 3	-37.99	-40.8008	-35.1792	0.0001*
GROUP 2	GROUP 3	-28	-30.8108	-25.1892	0.0001*

Table 8 - Comparison of Clenching Between Three Groups (Temporalis)

Interpretation of Results:

Table 1 compared the muscle activity of masseter muscle during swallowing, chewing and clenching. The mean values from Group I was found to be the highest amongst the other groups during all functional examinations. Group III exhibited the lowest activity among all the groups

Table 2 compares the muscle activity of temporalis muscle during swallowing, chewing and clenching. The mean values from Group I was found to be the highest amongst the other groups during all functional examinations. Group II exhibited lowest activity during swallowing and Group III exhibited minimal activity during clenching and chewing.

Table 3 compares the masseter muscle activity during swallowing between three groups statistically by ANOVA and further intragroup comparison was done using Post hoc tests. Group I exhibited highest activity and Group III showed minimal activity during swallowing.

Table 4 compares the masseter muscle activity during chewing between three groups statistically by ANOVA and further intragroup comparison was done using Post hoc tests. Group I exhibited highest activity and Group III showed minimal activity during chewing.

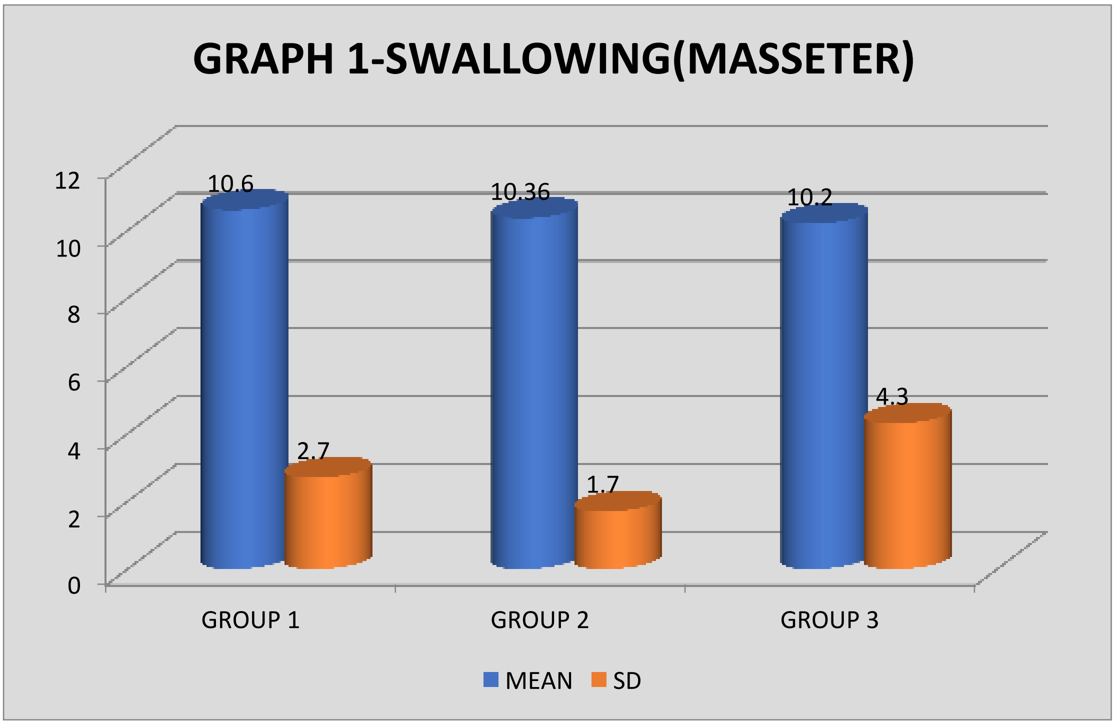
Table 5 compares the masseter muscle activity during clenching between three groups statistically by ANOVA and further intragroup comparison was done using Post hoc tests. Group I exhibited highest activity and Group III showed minimal activity during clenching.

Table 6 compares the temporalis muscle activity during swallowing between three groups statistically by ANOVA and further intragroup comparison was done using Post hoc tests. Group I exhibited highest activity and Group II showed minimal activity during swallowing.

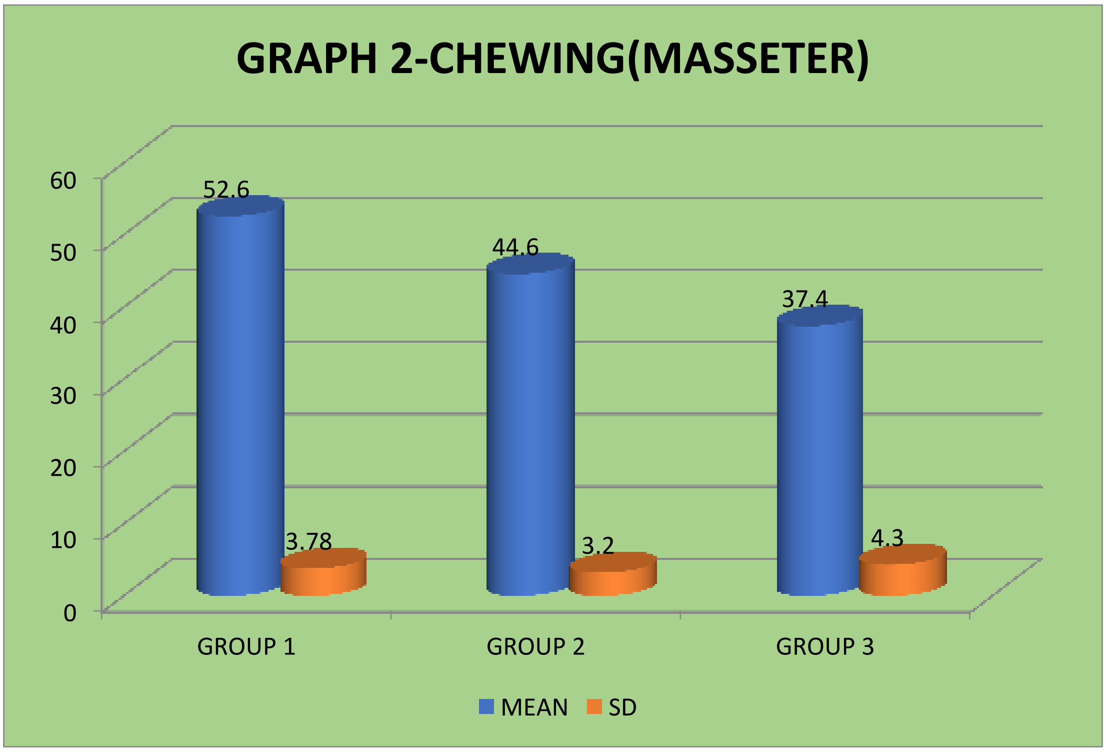
Table 7 compares the temporalis muscle activity during chewing between three groups statistically by ANOVA and further intragroup comparison was done using Post hoc tests. Group I exhibited highest activity and Group III showed minimal activity duringchewing.

Table 8 compares the temporalis muscle activity during clenching between three groups statistically by ANOVA and further intragroup comparison was done using Post hoc tests. Group I exhibited highest activity and Group III showed minimal activity during clenching.

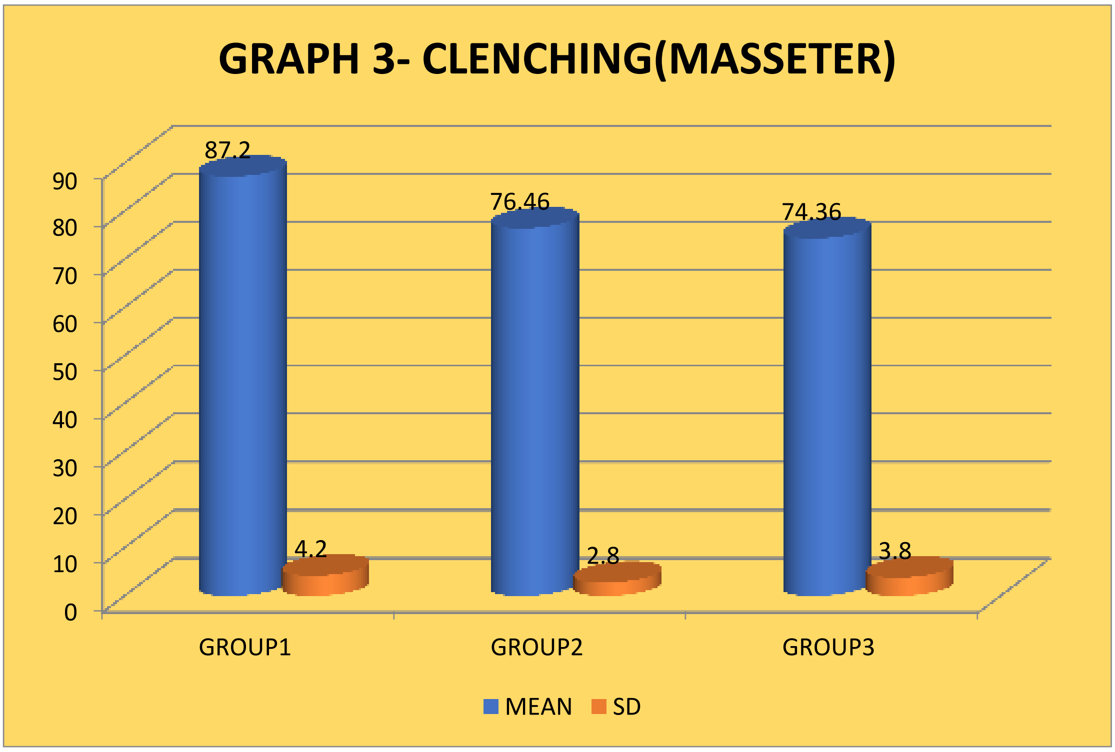
GRAPHS:



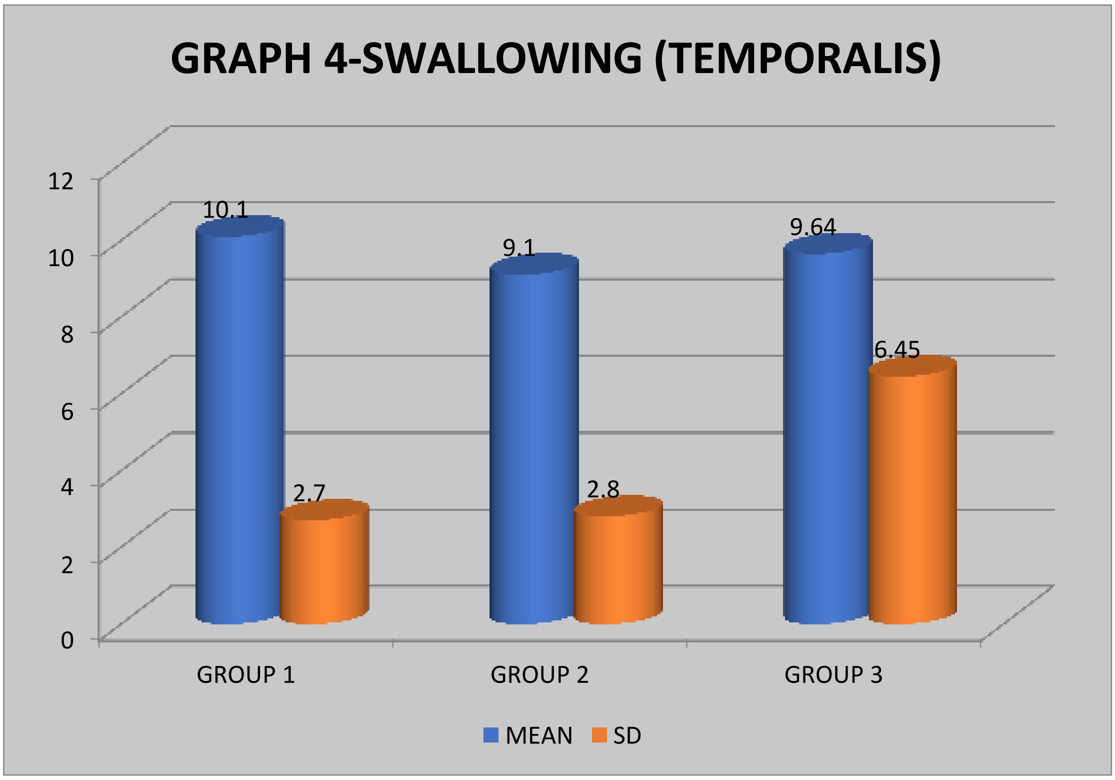
Graph 1: Comparison of Masseter muscle activity between Group 1, 2, 3 duringswallowing.



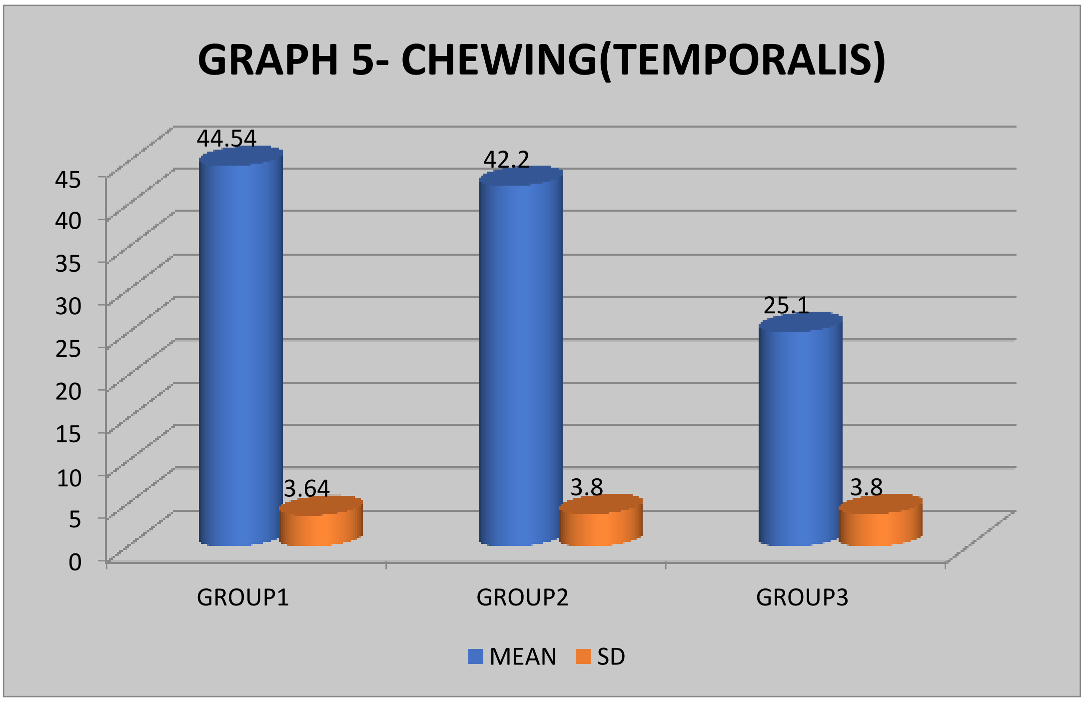
Graph 2: Comparison of Masseter muscle activity between Group 1, 2, 3 duringChewing



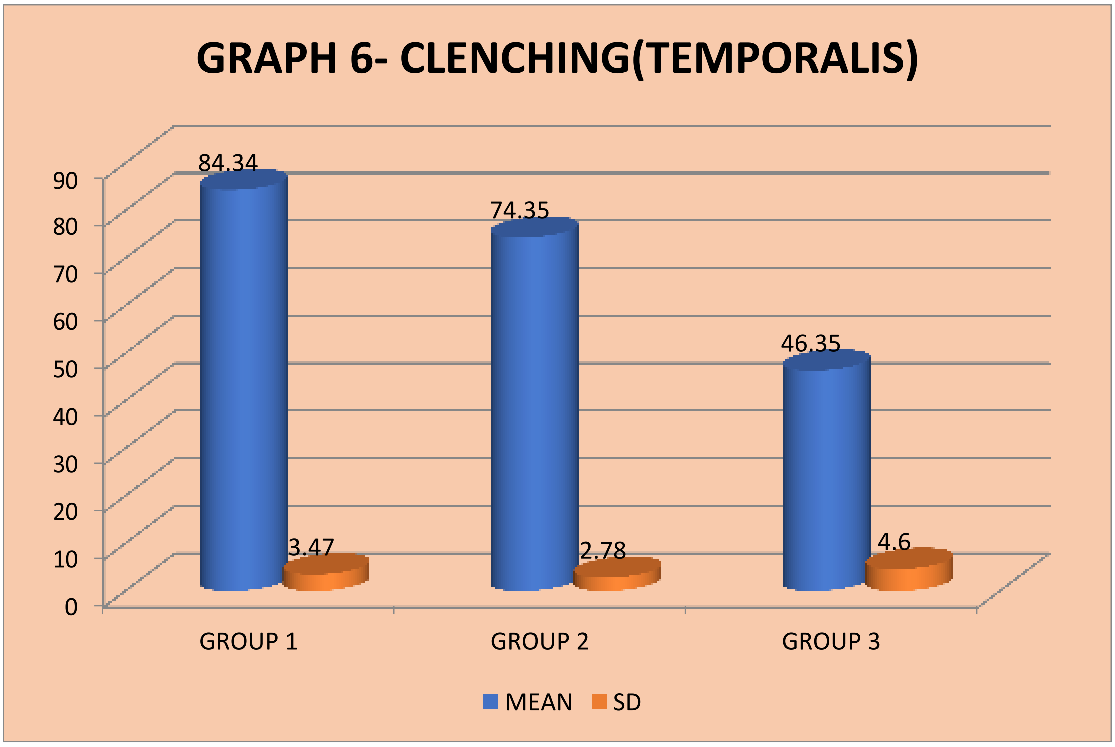
Graph 3: Comparison of Masseter muscle activity between Group 1, 2, 3 duringClenching



Graph 4: Comparison of Temporalis muscle activity between Group 1, 2, 3 duringswallowing.



Graph 5: Comparison of Temporalis muscle activity between Group 1, 2, 3 during Chewing.



Graph 6: Comparison of Temporalis muscle activity between Group 1, 2, 3 duringClenching.

DISCUSSION

DISCUSSION

According to Melvin Moss, human facial growth occurs as a response to functional needs. Masticatory muscles are believed to influence and, in turn, be influenced by facial growth and subsequent orthodontic and dentofacial orthopaedic treatment. [69] Therefore, the craniofacial morphology has been determined by both genetic influences as well as local environmental factors, among which masticatory muscle activity seems to play a substantial role.

Awareness about the skeletal and muscular environment is necessary because orthodontic treatment plan is not only dependent on biomechanical factors alone but also on the orofacial musculature. The fact that some cases with abnormal muscle function respond well to treatment and remain stable suggests that an adaptation in the muscle may have occurred. Hence, masticatory muscles directly influence the orthodontic treatment outcome, as well as the stability of such treatments. The main muscles associated with mastication are anterior and posterior temporalis, superficial and deep masseter, superior and inferior lateral pterygoid, medial pterygoid and digastric muscles.

Normal occlusion is in a state of dynamic equilibrium and there is a balance of forces between muscles. Forces exerted during habitual functions such as mastication, swallowing and speech are strong enough to cause tooth movement; but these forces do not continue for a longer duration to permit tooth movement. The jaws as well as teeth are responsive to this light but prolonged pressure.

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 potential from the active muscle fibres can be measured by electromyography. The present study was thus performed with electromyography to correlate the influence of masseter and temporalis in class I high and low angle cases.

Surface electromyography (EMG) is a reliable non-invasive technique for evaluating muscle activity by detecting the electrical potentials via electrodes placed overlying the skin. In orthodontics, surface electromyography is widely used to help and treat patients with temporomandibular disorders (TMD), as well as to assess stomatognathic system dysfunctions in patients with malocclusions or to monitor orthodontic therapies.[6]

The existence of correlations between vertical craniofacial morphology and masticatory muscle activity has been widely investigated by several authors but direct comparison of the present study with previous studies is limited because none of the previous researchers compared the influence of masseter and temporalis activity in Class I high, average and low growth pattern.

In the present study, the activity of masseter and anterior temporalis muscles were evaluated because surface electrodes used could easily be placed for electromyography. To register the activity of medial and posterior fibres of the temporalis muscles, removal of hair was necessary, therefore was not acceptable by most subjects. The needle electromyography would be required for recording the activity of the pterygoid muscles (lateral and medial) because of their anatomic locations. Intramuscular /needle electromyography therefore possess risk of infection and other complications; therefore, these muscles were excluded from the present study.

Swallowing:

Swallowing is a frequent physiologic act. Vaiman stated that the rate of spontaneous swallowing of saliva in healthy individuals is once every 2 minutes and 15 seconds [72,73] .Masticatory muscles act in coordination with other pharyngeal and laryngeal muscles during swallowing. In case of both masseter and temporalis muscles during swallowing, Group I exhibited highest activity when compared to other groups, though the values were not statistically significant among the three groups. In case of Masseter muscle activity Group III exhibited lowest activity and with Temporalis Group II exhibited least muscle activity, but these values are not statisticallysignificant.

Chewing:

When comparing the electrical activity of the masticatory muscles, evaluated in each facial pattern group during chewing, a statistically significant (0.0001) difference was verified for group I. The pattern of electromyography varieswith chewing different types of food. So, a particular variety of chewing substance - the chewing gum of a particular brand (Orbit-Wrigley's company) was supplied to all the subjects. Consistency of the gum remains more or less same even after repeated chewing and hence was chosen for the present study.[74] The results from the present study showed that the muscle activity during chewing is highest in Group I followed by Group II and was minimum in Group III. This finding supports the positive correlation between muscle activity and Jarabak ratio. A possible explanation could be that the lower bite force in hyperdivergent people might allow greater eruption of the posterior teeth which is otherwise directly related to excessive tooth eruption and backward rotation of the mandible.[75] Another possible elucidation for this is that craniomorphologic characteristics exhibited by brachyfacial subjects, such as lower gonial angle can provide mechanical advantages to the oral musculature by forwarding the position of the load application point, which leading to a decrease in the loading moment arm, as seen in long-faced subjects. Moreover, it is well recognized that temporal and masseter muscles of brachyfacial subjects have larger cross-sectionalareas.

Ueda et al also reported in their study found that masseter muscle activity was significantly higher in the low angle group for both children and adults [11]. The findings from the present study disagree with those of Farella M who did not report any correlation between masseter muscle activity and craniofacialmorphology[35.]

However, the results of the present study also disagree with Michelle Santos Vianna, where they concluded that different vertical facial types did not determine distinct patterns of EMG activity for the masseter and anterior portion of temporal muscles during rest or bilateral mastication[42]

<u>Clenching:</u>

Masticatory system, in which these muscles play the most active role, is during jaw clenching and hence these recordings were also analysed during this activity. During clenching, Group I revealed highest muscle activity in regard to both masseter and temporalis muscles, Group III exhibited least muscular activity during clenching with regard to both masseter andtemporalis.

In terms of the correlation between temporalis muscle activity and facial type during clenching, Group III group exhibited significantly lower muscle activity when compared with Group I (mean values were 84.3 and 43.5 for group I and group III respectively). Negative correlations between Jarabak's ratio and muscle activity was found during clenching .

According to Profit, long face individuals exhibited significantly less bite force during maximum clenching than individuals with standard vertical facial dimension. Increased loading of the jaws associated with masticatory muscle function increases sutural growth and stimulates bone apposition resulting in greater transverse growth of the maxilla and broader bone bases for the dental arches as well an increase in the masticatory musclefunction.[1]

The present study agrees with Moller and Ingervall who have reported a negative correlation between mandibular plane angle and clenching for Temporalis Muscle. Bakke and Michler also supports that maximal voluntary clenching was negatively correlated to anterior face height and mandibular inclination with vertical jaw relation. These results oppose Cha and Kim who evaluated temporalis, masseter muscles during clenching and found no difference among groups during clenching. [65]

The recordings from the present study concords with Vianna-Lara et al. who compared the EMG activity of masseter and anterior portion of temporal muscle in different vertical facial and the results showed that at clenching temporal and masseter muscles presented statistically significant differences among the groups.[42]

The results of the present study opposesAdhikari et al. who recorded the EMG activity of temporal and masseter muscles during maximum clenching and chewing and found no significant differences in EMGactivity.[76]

According to Faria et al, patients with a skeletal malocclusion exhibited the lowest electrical activity in the muscles during chewing. They evaluated the different activities of the muscles in patients with either a skeletal or dentoalveolar malocclusion. Healthy patients presented the highest electrical activity in the temporalis and masseter muscles during maximal voluntary contraction and lower muscle activity was detected in subjects with a dentoalveolar anterior open bite and the lowest in patients with a skeletal openbite.[45]

Prates et al compared masseter muscle activity in patients with different facial growth pattern and in his clinical and electromyographic evaluations did not indicate any difference between muscle activity in different facial patterns.[77]

Clinical Implications:

According to the present study, the facial type defined by the cephalometric morphology reflects a specific underlying muscular pattern. The teeth would be controlled with natural anchorage in a brachyfacial pattern, where the musculature is strong, but there would be less muscular anchorage in dolichofacial subjects who presents with weak mandibular musculature. It seems that weaker the musculature, the lesser it overcomes the molar-extruding and bite-opening effects of orthodontic treatment.

It has been pointed that brachyfacial patterns would allow greater expansion of the arches during treatment, in contrast to dolichofacial patterns with generally weaker mandibular muscle forces that allows lesser expansion during treatment.[78]

It has been shown that, if premolars are extracted in dolichofacial patients, there could be a slight increase in the vertical dimension, whereas, in brachyfacial patients, there is likely to cause no change or even a slight decrease. Extrusion of posterior teeth with growth and treatment has been revealed to be the reason for maintenance of the vertical dimension during treatment involving premolar extractions.

Most orthodontic mechanics are extrusive and this extrusion appears to maintain or even increase the vertical dimension during orthodontic treatment. There is a greater possibility for the undesirable extrusion of molars in dolichofacial subjects than brachyfacials, who have stronger musculature that tends to resist extrusive forces during orthodontic treatment. Moreover if molar extrusion occurs during treatment in brachyfacial patients, there is a strong tendency toward reintrusion through the influence of the muscles during swallowing and chewing. Thus, it might be difficult to cause permanent extrusion of the molars and backward rotation of the mandible in brachyfacialpatients.

Orthognathic surgery attempts to correct the abnormal skeletal facial profiles by altering the spatial relations of the bone there by affecting the muscles of mastication. But the long term stability of surgical results will be dependent on the adaptation of these facial muscles to their final position.[79]

Even for the management of similar malocclusions the choice of treatment mechanics, the timing of treatment, and extraction decision might be different for different vertical patterns. Under the terms in which this study was performed, it was possible to conclude that the masticatory muscles influenced the growth pattern.

Limitations of the study:

The quality of the signals is better with needle electromyography but due to the invasiveness of the procedure surface electromyography waschosen.

EMG analysis of masseter and temporal muscles only could be considered a limitation of this study; the contribution of other muscular groups such as medial and lateral pterygoids etc was not taken into consideration.

Future scope of study:

Future studies involving other masticatory as well as suprahyoid muscles are necessary to verify the possible physiologic mechanisms involved in this complex relationship between functional responses of the stomatognathic system and morphologic craniofacial factors.

CONCLUSION

CONCLUSION

The existence of correlations between vertical craniofacial morphology and masticatory muscle activity in Class I malocclusion has been investigated in the study and the following conclusions can be made:

- During all functional examinations evaluated, subjects with horizontal growth pattern exhibited highest muscle activity and showed a positive correlation between muscle activity and Jarabakratio.
- During swallowing, subjects with horizontal growth pattern exhibited higher muscle activity, though their values were not statisticallysignificant.
- Subjects with vertical growth pattern exhibited the least muscle activity during chewing andclenching.

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ANNEXURES

Annexure I – Masseter muscle activity in Group 1 during swallowing

Group I (Masseter)	
Swallowing (Left) in µV	**Swallowing (Right)** in µV
11	11
7	7
11	10
8	10
9	12
11	10
12	9
9	12
8	13
9	12
8	13
9	12
8	13
9	12
8	13
9	12
12	12
13	8
11	11
12	10
11	10

Masseter muscle activity in Group I during Chewing

Group I (Masseter)	
Chewing (Left) in µV	**Chewing (Right)** in µV
50	57
37	58
62	60
45	53
45	57
50	51
44	42
46	49
59	60
52	54
54	45
46	50
59	66
44	61
49	55
53	62
51	41
49	54
65	66
60	58
62	59

Masseter muscle activity in Group I during Clenching

Group I (Masseter)	
Clenching (Left) in µV	**Clenching (Right)** in µV
88	87
114	122
92	85
81	89
84	89
50	60
88	74
160	164
110	102
80	80
77	72
86	57
95	89
85	84
79	88
93	98
79	88
56	59
82	82
87	86
85	80

Masseter muscle activity in Group 2 during Swallowing

Group II (Masseter)	
Swallowing (Left) in μV	**Swallowing (Right)** in μV
11	11
7	7
11	10
8	12
9	8
11	12
9	10
11	9
12	12
9	13
8	12
9	13
8	12
9	12
12	8
13	11
11	10
12	10
11	10
12	10
11	11

Masseter muscle activity in Group 2 during Chewing

Group II (Masseter)	
Chewing (Left) in µV	**Chewing (Right)** in µV
39	45
37	35
39	40
44	53
54	45
56	54
44	41
37	65
42	40
44	41
36	33
44	41
57	55
43	42
51	64
42	40
45	44
37	39
39	40
37	44
43	41

Masseter muscle activity in Group 2 during Clenching

Group II (Masseter)	
Clenching(Left) in µV	**Clenching (Right)** in µV
75	66
84	56
63	83
67	69
83	86
71	80
93	88
66	46
77	89
93	90
70	77
83	89
69	70
73	82
79	75
85	78
82	80
87	81
79	76
81	88
63	77

Masseter muscle activity in Group 3 during Swallowing

Group III (Masseter)	
Swallowing (Left) in µV	**Swallowing (Right)** in µV
11	9
12	9
11	9
9	12
11	8
9	12
11	10
12	9
9	12
8	13
9	12
8	13
9	12
12	12
13	8
11	11
12	10
11	10
8	10
9	12
11	8

Masseter muscle activity in Group 3 during Chewing

Group III (Masseter)	
Chewing (Left) µV	**Chewing (Right)** µV
29	30
28	39
48	45
44	41
36	33
44	41
37	65
42	40
44	41
36	33
44	41
36	33
44	41
37	40
42	40
44	41
36	33
39	40
44	27
44	41
36	33

Masseter muscle activity in Group 3 during Clenching

Group III (Masseter)	
Clenching(Left) µV	**Clenching (Right)** µV
52	60
66	52
60	66
83	69
70	80
73	68
65	46
80	89
63	60
88	88
70	68
79	88
66	65
82	82
87	86
79	80
71	79
63	83
75	74
73	98
71	80
74	70

Annexure II – Temporalis muscle activity in Group 1 duringSwallowing

Group I (Temporalis)	
Swallowing (Left) µV	**Swallowing (Right)** µV
8	9
18	14
9	8
12	10
10	10
11	11
9	11
10	9
8	13
12	9
9	12
8	13
9	11
12	12
13	8
11	11
12	10
8	13
12	9
9	12
8	13

Temporalis muscle activity in Group 1 during Chewing

Group I (Temporalis)	
Chewing (Left) µV	**Chewing (Right)** µV
37	65
42	40
44	31
36	33
58	27
45	29
70	50
82	80
36	33
42	40
44	41
36	33
56	87
37	65
42	40
44	41
36	33
36	33
42	40
36	41
36	33

Temporalis muscle activity in Group 1 during Clenching

Group I (Temporalis)	
Clenching (Left) µV	**Clenching (Right)** µV
98	90
77	61
89	81
91	80
98	97
88	89
87	90
82	80
79	78
95	89
93	96
79	88
56	60
82	82
87	86
79	89
88	85
79	88
85	88
88	87
79	88

Temporalis muscle activity in Group 2 during swallowing

Group II (Temporalis)	
Swallowing (Left)in µV	**Swallowing (Right)** µV
10	10
10	10
7	8
11	8
8	13
11	10
12	9
9	12
8	13
9	12
8	13
9	11
12	12
13	8
11	11
12	10
10	10
11	11
9	11
9	12
8	13

Temporalis muscle activity in Group 2 during Chewing

Group II (Temporalis)	
Chewing (Left) µV	**Chewing (Right)** µV
37	57
42	40
44	41
36	33
36	33
37	65
42	40
44	41
36	33
44	41
36	33
56	50
37	29
42	40
44	41
36	33
78	65
88	65
87	87
44	41
36	33

Temporalis muscle activity in group 2 during Clenching

Group II (Temporalis)	
Clenching(Left) μV	**Clenching (Right)** μV
74	72
79	81
71	66
80	80
79	78
76	79
75	79
73	76
79	88
63	77
79	87
56	88
82	82
87	80
79	80
81	73
68	65
78	66
70	50
69	60
66	63

Temporalis muscle activity in Group 3 during swallowing

Group III (Temporalis)	
Swallowing (Left) μV	**Swallowing (Right)** μV
11	12
9	10
9	9
8	13
10	10
11	10
10	11
12	10
9	12
11	8
9	12
11	10
12	9
9	12
8	13
9	12
8	13
9	11
12	12
13	8
9	12

Temporalis muscle activity in group 3 during Chewing

Group III (Temporalis)	
Chewing (Left) µV	**Chewing (Right)** µV
37	30
28	26
27	26
22	21
27	25
29	26
28	24
25	26
29	27
36	33
25	24
37	33
22	35
27	26
25	23
26	26
35	29
27	35
37	27
42	32
24	28

Temporalis muscle activity in group 3 during Clenching

Group III (Temporalis)	
Clenching(Left) µV	**Clenching (Right)** µV
40	58
36	34
41	40
49	38
40	42
36	44
42	46
44	48
54	58
44	40
43	42
42	41
67	59
41	39
48	42
43	45
59	53
54	51
54	53
47	49
43	48

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LIST OF ABBREVIATIONS USED

EMG	Electromyography
sEMG	Surface electromyography
kVp	Kilovoltage peak
mA	Milliamperage
SPSS	Statistical Package for the Social Sciences
Fig	Figure
Sig	Significant

സമ്മത പത്രം

സെ റ് ഗ്രീഗോറിയോസ് ഡെന്റ കോളേജിലെ ഓ ത്തോഡോന്റിക്സ് വിഭാഗം നടത്തുന്ന “ഇ ഫ്ലുവെ സ് ഓഫ് മാസ്റ്ററെ ആ ഡ് ടെംപോറലിസ് മസ്സി ആക്ടിവിറ്റി ഓ ക്ലാസ് I ഹൈ ആ ഡ് ലോ ആംഗി കേസെസ്സ് - ആ ഇലെക്ട്രോമയോഗ്രാഫിക് സ്റ്റഡിയി ” പങ്കെടുക്കുവാന് എനിക്ക് സമ്മതമാണ്. പഠനത്തെ കുറിച്ചുള്ള എല്ലാ വിവരങ്ങളും എനിക്കറിയാവുന്ന ഭാഷയി എന്നോട് വിവരിച്ചിട്ടുണ്ട്. ഏതു നിമിഷവും പഠനത്തി നിന്നും പിന്മാറാമെന്നും ഇത് തുട ന്നുള്ള ചികിത്സയെ ബാധിക്കില്ല എന്നും ,ചികിത്സാ വിവരങ്ങളുടെ സ്വകാര്യത നഷ്ടപ്പെടുത്താതെ സൂക്ഷിക്കുമെന്നും ഉറപ്പു ന കിയിട്ടുണ്ട്. ഇതിന്റെ ഭാഗമായി ഫോട്ടോഗ്രാഫ്സ് എടുക്കുന്നതിനും റിസ ച്ച് പ്രസിദ്ധീകരണങ്ങളി പബ്ലിഷ്ചെയ്യുന്നതിനും എനിക്ക് സമ്മതമാണ്.

പേര് /ഒപ്പു /വിരലടയാളം :

തീയതി :

പരിശോധകന്റെ പേര്/ഒപ്പു :

അഡ്രെസ്സ് :

INFORMED CONSENT

I ,the undersigned, hereby declare that I was fully told and understood about the dissertation study and the following analysis conducted by Dr. Sheetal Sara Verghese named : “Influence of masseter and temporalis muscle activity on class I high and low angle cases-An Electromyographic study” as a part of the completeness of her MDS programme as per KUHS regulations.

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UNDER THE MANAGEMENT OF MJSCE TRUST, PUTHENCRUZ
CHELAD , KOTHAMANGALAM, ERNAKULAM DIST, KERALA - 686681

ETHICAL CLEARANCE CERTIFICATE

SGDC/152/2018/3384/7 **Date:- 20-12-2018**

To,

Dr.Sheetal Sara Verghese
St. Gregorios Dental College
Chelad, Kothamangalam

Dear Dr.Sheetal Sara Verghese

Subject: Ethics Committee Clearance Reg.

Protocol- Influence of masseter and temporalis muscle activity on class I high and low angle cases-an electromyographic study

After the Institutional Ethics Committee (TEC) held on 19th of December 2018, this study was examined and discussed. After the consideration, the committee had decided to approve and grant clearance for the aforementioned study.

The members who attended the meeting at which the protocol was discussed were:

1. **Dr. CKK Nair – Former BARC science**
2. **Dr. OmmenAju Jacob – Dean, St. Gregorios Dental College, Chelad**
3. **Dr. Cinu Thomas A – Scientist, Senior Lecturer, Department of Pharmaceutical Sciences Center for Professional and Advanced Studies**
4. **Rv. Fr. Shanu K. Paulose**
5. **Lissy Jose – Former Member Women's Welfare Association**
6. **Adv. Jose Aranjani – Advocate**
7. **Dr. Sauganth Paul – Senior Lecturer, Department of Biochemistry, St. Gregorios Dental College**
8. **Dr. Eapen Cherian – Secretary**
9. **Dr. Jain Mathew – Principal and Head of the Department, Department of Conservative Dentistry and Endodontics**
10. **Dr. George Francis – Head of the Department, Department of Prosthodontics Crown & Bridge**
11. **Dr. Binaoy Kurian – Head of the Depaertment, Department of Orthodontics &Dentofacial Orthopeadics**

Dr. CKK Nair
Chairman Institutional Ethics Committee
St. Gregorios Dental College, Chelad

Dr. Eapen Cherian
Secretary

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