A Study of Electromyographic Activity of Masseter and Temporalis Muscles and Maximum Bite Force in Patients with Various Malocclusions

Sarabjeet Singh Sandhu, Ashok Utreja, Sudesh Prabhakar, Navreet Sandhu, Rita Kashyap

ABSTRACT

Introduction and objectives: The relationship between form and function of the stomatographic system has been studied by several researchers and it is still not clear, whether a genetically determined facial morphology decides the strength of masticatory muscles, or whether a strong musculature influences the form of the face. The present study was done to relate muscle activity with various malocclusions.

Materials and methods: Sixty samples of younger age group were divided according to Angle classification. The electromyography (EMG) activity of masseter and temporalis and the maximum bite force (MBF) at intercuspal (molar) and anterior bite position (incisors) have been studied for different malocclusion groups. Influence of various independent variables like gender, overjet and overbite of the subjects on the bite force was also checked.

Results: MBF at intercuspal position (molar) and anterior bite position (incisal) were not significantly different between normal, Class I, Class II Division I and Class III malocclusion groups.

Conclusion: It was concluded that Class III malocclusion subjects showed the highest masseter and anterior temporalis postural rest activity and Class II Division I malocclusion showed the least anterior temporalis activity at both the intercuspal and interincisal positions during maximum voluntary biting.

Keywords: Electromyography, Needle electrodes, Bite force, Angle’s classification, Finger pressure.

INTRODUCTION

The stomatognathic system has been studied by several researchers, yet it is still unclear, whether a genetically determined facial morphology decides the strength of masticatory muscles, or whether a strong musculature influences the form of the face.

Several clinical and animal experimental studies have shown the significant role played by the masticatory muscle function in craniofacial growth. To evaluate clinically the physiologic characteristics of the masticatory muscles, various methods like measurement of myoelectric activity, bite force have been used. It has been shown that relatively large forces are generated when teeth are brought into occlusion and these forces decrease when the bite point is moved anteriorly. There is a controversial relationship between bite force and age and sex of patients. In some investigations, no difference between genders was detected, whereas in others, males produced greater bite force than the females. Bite force has been shown to increase with age till a specific age and then the levels start decreasing, but the cutoff age for this change is still not known.

There also exists much controversy regarding the pattern of electromyographic (EMG) activity in relation to craniofacial characteristics. Various studies have shown a higher EMG activity of masseter and temporalis in Class III malocclusions, than in Class I and Class II Division I malocclusions, wherein the muscle activity has been reported to be either similar or less in Class II Division I malocclusions. It is thus clear that no unanimity exists for the pattern of EMG activity in relation to different malocclusion groups, various mandibular positions, age and gender of the subjects. Past studies were usually limited to involving a specific muscle, a specific malocclusion or a specific position. Hence, this study was planned to overcome these limitations and had the following aims and objectives.

1. To measure the maximum bite force (MBF) in younger subjects with normal occlusion and with various malocclusions segregated by Angle’s classification.

Received on: 22/1/12
Accepted after Revision: 23/5/12

The Journal of Indian Orthodontic Society, April-June 2013;47(2):53-61
2. To study 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.

3. To check for the influence of various independent variables like gender, age, overjet, overbite and maximum finger pressure of the subjects on the muscle activity of masseter and temporalis and bite force.

MATERIALS AND METHODS

The present study was conducted in the Department.

Sample

The study comprised of 60 subjects who were divided into six groups as follows:

- Group A consisted of 15 subjects with normal occlusion.
- Group B consisted of 15 subjects with Angle’s Class I malocclusion.
- Group C consisted of 15 subjects with Angle’s Class II Division 1 malocclusion.
- Group D consisted of 15 subjects with Angle’s Class III malocclusion.

Young adolescents of 12 to 16 years were selected at random, from the patients reporting at Orthodontic Clinic.

Selection Criteria of Subjects

1. Normal occlusion (Group A)
   - Presence of Angle’s Class I molar relationship.
   - Normal overjet and overbite.
   - No crowding, spacing, rotations, cross bites or open bite.
   - No history of orthodontic treatment.
   - Presence of full complement of teeth.

2. Malocclusion (Groups B, C and D)
   - Classification of malocclusion according to molar relationship (Angle’s criteria).
   - Type of skeletal pattern (clinical diagnosis).
   - No history of orthodontic treatment.
   - Presence of full complement of teeth.
   - No large restorations/carious lesions on permanent first molars and incisors.
   - No open bite (anterior and lateral).

Apparatus

Bite Force Recorder

Bite force recorder\(^{10}\) used was a detailed state of the art apparatus which was carefully selected and individually crafted. This gnathodynamometer consisted of metallic fork and sensor, electronic instrument, batteries for instrumentation amplifier, instant standardization device and disposable polypropylene caps as its components.

Electromyographic Apparatus

EMG activity was recorded for masseter and anterior temporalis muscles on right side using concentric needle electrodes. A four channel Nicolet Viking IV EMG/EP system was used for recording the EMG activity (Fig. 1). It was a fully computerized system capable of performing various neuromuscular transmission tests. The equipment was set for recording maximum voluntary activity (MVA). The EMG signals were amplified and filtered by means of an instrumentation amplifier. These needles were autoclaved before use in each subject (Fig. 2).

Placement of Electrodes

Placement of Electrodes for Masseter Muscle

The concentric needle electrode was placed 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 (Fig. 3). This usually was also the mid portion and thickest part of the masseter muscle, which also becomes more prominent, when subjects were asked to bite harder on posterior teeth.
Placement of Electrodes for Anterior Temporalis Muscle

Electrode was placed about 1 cm above the zygomatic arch and 1.5 cm behind the orbital border (Fig. 4). Care was taken to prevent injury to superficial temporal artery. The orbicularis oculi muscle was also avoided. The ground electrode was placed on the side of the neck at C5 level.

Taking Records

The EMG of masseter and temporalis were done only on a representative sample (7 to 8 subjects) of each group and MBF was recorded for all subjects. The maximum finger pressure was also measured as an indicator of general muscle strength in all the subjects.

Recording of Maximum Finger Pressure

For measuring the maximal strength of finger-thumb grip of right hand, the subjects were asked to press the prongs of the fork between their thumb and forefinger of right hand, as hard as possible. The fork was held by the investigator while the test persons were pressing (Fig. 5). The registrations of finger force were repeated three times after a pause of 1 minute and the mean was recorded as the maximum finger pressure (M FRES).

Recording EMG and MBF Together

The subjects were made to sit upright with their head unsupported and positioned so that the Frankfort plane would be parallel to the floor. The EMG machine was set for recording MVA by measuring the peak to peak amplitude.

The bite force recorder was placed just adjacent to the screen display for EMG, so that the muscle activity (on screen) and the DPM recording could be simultaneously seen. The subjects’ MBF in both right first molar and incisors (which have been noted previously) were now used for recording peak
to peak amplitude of muscle activity. A ground electrode was placed on the side of the neck after applying conduction jelly (Fig. 6). The area of the masseter region was thoroughly cleaned by spirit and the concentric needle electrode placed (inserted) in the region previously marked. The subjects were asked to relax completely and the postural activity of the masseter muscle recorded three times.

The metallic fork was placed in the right maxillary first molar region and subjects were asked to bite maximally. A series of three recordings for MBF were taken with a gap of 1 minute in between each recording to prevent muscle fatigue. Similarly, the subjects were asked to bite maximally in interincisal position and series of three recordings were again taken. A similar procedure was repeated for the anterior temporalis muscle and readings for both muscle activity and MBF were noted.

**Studying Independent Variables**

The gender, overjet, overbite of all the subjects in four groups were also recorded to check for the influence of various independent variables on the muscle activity and bite force (dependent variables).

**STATISTICAL ANALYSIS**

Data were analyzed by conventional statistical methods, i.e. arithmetic mean and standard deviation. Difference between the means for the Groups A, B, C and D were tested by analysis of variation (ANOVA) followed by a multiple range test of modified LSD (Bonferroni) at 0.05 level of significance. The variables were interrelated to each other by Pearson correlation coefficient and partial Pearson correlation coefficient.

**RESULTS**

The EMG activity of masseter and temporalis and the MBF at intercuspal (molar) and anterior bite position (incisors) have been studied for different malocclusion groups. The study was conducted on 60 subjects, who were divided into four groups, with each group consisting of 15 subjects (Groups A, B, C and D) between 12 and 16 years.

**Comparison of MBF and other Independent variables in Four Groups (Table 1)**

A comparison of MBF at intercuspal position (MBFP$_2$) and interincisal position (MBFP$_3$) was done for different malocclusion groups. The other variables like overbite (OBI$T$E) and overjet (O$J$E$T$) were also studied for the different groups. The results showed no significant difference at MBFP$_2$ and MBFP$_3$ between normal, Class I, Class II Division 1 and Class III malocclusion groups.

A comparison of overbite and overjet relation between the various malocclusion groups showed a significant difference at 0.05 level. There was a significant difference between Groups A and C; Groups B and C; Groups B and D and between Groups C and D when it comes to overbite. Subjects with Class II Division I malocclusion (Group C) showed the maximum overbite and those with Class III showed the minimum. Whereas for comparing the overjet, there was a significant difference between Groups A and B; Groups A and C; Groups B and C; Groups II and D and also between Groups C and D. The mean overjet for Class II Division I was largest and that for Class III was least.

**Table 1: Comparison of MBF and various independent variables in different malocclusion groups (n = 60)**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 15)</th>
<th>Group B (n = 15)</th>
<th>Group C (n = 15)</th>
<th>Group D (n = 15)</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) Mean ± SD</td>
<td>14.8 ± 1.47</td>
<td>14.4 ± 1.63</td>
<td>13.80 ± 1.26</td>
<td>14.6 ± 1.29</td>
<td>NS</td>
</tr>
<tr>
<td>MBFP$_2$ (N) Mean ± SD</td>
<td>445.48 ± 52.23</td>
<td>449.67 ± 66.37</td>
<td>457.56 ± 43.99</td>
<td>451.20 ± 59.35</td>
<td>NS</td>
</tr>
<tr>
<td>MBFP$_3$ (N) Mean ± SD</td>
<td>120.88 ± 15.91</td>
<td>120.12 ± 22.76</td>
<td>120.67 ± 28.57</td>
<td>108.49 ± 15.41</td>
<td>NS</td>
</tr>
<tr>
<td>F Press (N) Mean ± SD</td>
<td>47.78 ± 11.51</td>
<td>48.30 ± 13.37</td>
<td>43.93 ± 10.08</td>
<td>46.55 ± 10.00</td>
<td>NS</td>
</tr>
<tr>
<td>O Bite (%) Mean ± SD</td>
<td>17.66 ± 4.16</td>
<td>32.0 ± 15.78</td>
<td>60.66 ± 29.69</td>
<td>11.33 ± 8.33</td>
<td>b, d, e, f</td>
</tr>
<tr>
<td>O Jet (mm) Mean ± SD</td>
<td>1.76 ± 0.62</td>
<td>4.43 ± 2.06</td>
<td>8.46 ± 2.87</td>
<td>0.83 ± 0.64</td>
<td>a, b, d, e, f</td>
</tr>
</tbody>
</table>

Based on ANOVA of 0.05 level

a → A vs B  b → A vs C  c → A vs D
d → B vs C  e → B vs D
e → C vs D
f → A vs C

NS → Not significant

Where P$_2$ → Intercuspal position and P$_3$ → Interincisal position
A Study of Electromyographic Activity of Masseter and Temporalis Muscles and Maximum Bite Force in Patients

Comparison of EMG Activity in various Malocclusion Groups (Table 2)

EMG activity of masseter (M₁) and temporalis (M₂) were measured for 32 subjects, with eight in each group at three positions, that is at postural rest position (P₁), maximum intercuspal position (P₂) and interincisal position (P₃), when the subjects were biting maximally at P₂ and P₃ positions.

There was a significant difference in the postural rest activity between normal occlusion and Class III malocclusion, between Class I and Class III malocclusion and between Class II Division 1 and Class III malocclusion with higher value for Class III malocclusion in all the three comparisons. There was no significant difference in the postural rest activity between subjects with normal occlusion, Class I malocclusion and those with Class II Division 1 malocclusion.

For the EMG activity of masseter at maximum intercuspal position when the patient was biting maximally, there was a significant difference in the activity at intercuspal position between normal occlusion and Class I malocclusion, with higher values for Class I malocclusion group and between normal occlusion and Class II Division 1 malocclusion, with more activity for the malocclusion group. There was no significant difference between the activity of Class III and normal occlusion, Class III and Class I malocclusion and between Class III and Class II Division 1 malocclusion; between the EMG activity of masseter muscle in different malocclusion groups. There was again no significant difference for the postural rest activity of temporalis muscle (M₂ P₁) for the different groups. The postural activity for temporalis muscle was highest for subjects with Class III malocclusion.

There was a significant difference in M₂P₂ between Class I and Class III malocclusion, with Class III showing larger activity and no significant difference in the M₂P₂ activity between Class I and Class II Division 1 malocclusion or between Class II Division 1 and Class III malocclusion. There was a significant difference of M₂P₃ between normal occlusion and Class III malocclusion, between Class I and Class III malocclusion and between Class II Division 1 and Class III malocclusion, with highest activity for Class III malocclusion as compared to others and between Class II Division 1 and Class I malocclusion, with lower activity for Class II Division I malocclusion.

Comparison of MBF and other Independent variables between Males and Females (Table 3)

Among the 60 subjects, there were 29 males and 31 females, who were nearly equally distributed among the four groups (A, B, C and D). There was no significant difference in age between males and females, applying the unpaired t-test showed a highly significant difference (p = 0.0005) between the males and females for MBF at intercuspal position.

Table 2: Comparison of EMG activity in various malocclusion groups (n = 32)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 8) Class I</th>
<th>Group B (n = 8) Class I</th>
<th>Group C (n = 8) Class I</th>
<th>Group D (n = 8) Class I</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁P₁ (µV) Mean ± SD</td>
<td>56.98 ± 14.00</td>
<td>56.75 ± 14.44</td>
<td>53.41 ± 7.60</td>
<td>76.29 ± 12.64</td>
<td>c, d, e, f</td>
</tr>
<tr>
<td>M₁P₂ (µV) Mean ± SD</td>
<td>2,716.73 ± 390.54</td>
<td>3,712.83 ± 621.09</td>
<td>3,658.75 ± 619.47</td>
<td>3,369.18 ± 698.49</td>
<td>a, b</td>
</tr>
<tr>
<td>M₁P₃ (µV) Mean ± SD</td>
<td>2,510 ± 234.98</td>
<td>2,624.17 ± 163.39</td>
<td>2,210.91 ± 421.90</td>
<td>2,490.36 ± 667.66</td>
<td>NS</td>
</tr>
<tr>
<td>M₂P₁ (µV) Mean ± SD</td>
<td>68.73 ± 10.19</td>
<td>65.77 ± 12.99</td>
<td>71.25 ± 19.17</td>
<td>80.14 ± 9.97</td>
<td>NS</td>
</tr>
<tr>
<td>M₂P₂ (µV) Mean ± SD</td>
<td>2,599.30 ± 393.08</td>
<td>2,418.21 ± 385.02</td>
<td>2,670.43 ± 814.03</td>
<td>3,370.32 ± 672.00</td>
<td>E</td>
</tr>
<tr>
<td>M₂P₃ (µV) Mean ± SD</td>
<td>1,673.87 ± 207.75</td>
<td>1,849.56 ± 276.66</td>
<td>1,372.79 ± 170.72</td>
<td>2,636.41 ± 504.56</td>
<td>c, d, e, f</td>
</tr>
</tbody>
</table>

Based on ANOVA of 0.05 level
a→A vs B  b→A vs C  c→A vs D  d→B vs C  e→B vs D  f→C vs D  NS→Not significant
Where M₁→Masseter; M₂→Temporalis; P₁→Postural rest position; P₂→Intercuspal position and P₃→Interincisal position

Table 3: Comparison of MBF and various independency variables between males and females in different malocclusion Groups (n = 60)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Male (n = 20)</th>
<th>Female (n = 10)</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE (years) Mean ± SD</td>
<td>14.68 ± 1.48</td>
<td>14.12 ± 1.31</td>
<td>0.48</td>
<td>NS</td>
</tr>
<tr>
<td>MBFP₂ (N) Mean ± SD</td>
<td>482.39 ± 43.56</td>
<td>421.59 ± 47.91</td>
<td>5.13</td>
<td>0.0005</td>
</tr>
<tr>
<td>MBFP₃ (N) Mean ± SD</td>
<td>120.82 ± 21.37</td>
<td>114.47 ± 21.45</td>
<td>1.15</td>
<td>NS</td>
</tr>
<tr>
<td>FPRESS (N) Means ± SD</td>
<td>53.57 ± 11.14</td>
<td>40.10 ± 6.28</td>
<td>5.79</td>
<td>0.0005</td>
</tr>
<tr>
<td>O BITE (%) Mean ± SD</td>
<td>32.41 ± 28.39</td>
<td>28.54 ± 23.02</td>
<td>0.58</td>
<td>0.04</td>
</tr>
<tr>
<td>O JET (mm) Means ± SD</td>
<td>3.82 ± 3.54</td>
<td>3.91 ± 3.46</td>
<td>−0.10</td>
<td>NS</td>
</tr>
</tbody>
</table>

Based on Student’s unpaired t-test.
Where P₂→Intercuspal position and P₃→Interincisal position
(MBFP$_2$) with a mean value higher for males, but there was no significant difference for incisal bite force. There was no significant difference between males and females for overbite and overjet measurements.

**Comparison of EMG activity between Males and Females in Younger Age Group (Table 4)**

There was no significant difference in the postural rest activity of the masseter muscle (M$_1$P$_1$), for the M$_1$P$_2$ and M$_1$P$_3$ activity between males and females. Similarly, for the temporalis muscle there was no significant difference in the postural rest activity (M$_2$P$_1$), for M$_2$P$_2$ and M$_2$P$_3$ activity between males and females. Although there was no statistical difference between the genders for muscle activity, but generally the activity for males was slightly higher than females for the various malocclusion groups (younger age group).

**Proportionality (RMP) of Mean Voltage (MP) to Maximum Bite Force (MBFP)**

The proportionality of mean voltage to MBF expressed the potential activity under the bite force unit and furthermore it eliminated the sex difference, because the MBF as well as the corresponding mean voltage was smaller for females or higher for males. This was equivalent to the slope of voltage/tension (V/T) curve, when determined for regression equation by least square method.

**Proportionality of Mean Voltage to Maximum Bite Force for Masseter (M$_1$) and Temporalis (M$_2$) for Group A, B, C and D (Table 5)**

The proportionality (RMP) was tested for 32 subjects, with eight in each group. The ratios between masseter activity (M$_1$P$_2$) and MBF (MBFP$_2$) at intercuspal position, i.e. RM$_1$P$_2$ for various groups, showed statistically significant difference between normal occlusion and Class II Division 1 malocclusion, with higher ratio for Class II Division 1 group. There was no significant difference in the ratio of masseter activity (M$_1$P$_3$) and MBF (MBFP$_3$) at interincisal position for different groups.

Similarly for RM$_2$P$_2$ for temporalis activity, a significant difference was seen in the ratios between Class I malocclusion and Class III malocclusion, with higher ratio for Class III malocclusion group. For the ratio RM$_2$P$_3$, there was a significant difference in the ratio between normal occlusion and Class III malocclusion with higher ratio for Class III malocclusion; between Class II Division 1 and Class III malocclusion with again higher value for Class III and between Class I and Class II Division 1 malocclusion with lower activity for Class II Division 1 malocclusion. Thus, the ratio was largest for Class III malocclusion group and least for Class II Division 1 malocclusion group.

**Pearson’s Product Moment correlation Coefficient between Electromyography, MBF and Independent Variables in Group A, B, C and D (Table 6)**

The correlation between age and MBF at molars was highly significant ($r: 0.488$) at $p < 0.001$ level, thus indicating that as the age increased, the MBFP$_2$ also increased. Though, the correlation between incisal bite force (MBFP$_2$) and age was not significant ($r: 0.236$). There was also a highly significant correlation ($r: 0.535$) at $p < 0.001$ between maximum finger pressure and age.

A clear correlation between any of the muscle activity and age was not seen. There was a positive correlation ($r: 0.453$)
at $p < 0.01$ level between masseter activity at interincisal position ($M_P^1$) and temporalis activity at interincisal position ($M_T^1$), thus showing that when biting maximally at interincisal position, there was an increase in activity in both the muscles. A positive correlation between MBFP$_2$ and MBFP$_3$ was also seen ($r: 0.289$) at $p < 0.05$, that is the subjects who were biting harder molars were also biting with more force at incisors. A negative correlation ($r: -0.439$) at $p < 0.01$ was seen between overbite and temporalis activity at interincisal position with that is as the overbite increased, the $M_T^2$ activity decreased.

A similar negative correlation ($r: -0.624$) at $p < 0.001$ was seen between overjet and $M_T^2$. A positive correlation ($r: 0.777$) at $p < 0.001$ was also seen between overjet and overbite.

**DISCUSSION**

This study was conducted on 60 subjects, who were divided into four groups, with each group consisting of 15 subjects. The Angle’s classification was chosen as selection criteria because this enabled to investigate a large number of individuals without using radiographs, thereby fulfilling strict ethical considerations relating to radiation protection. This was also to check whether the criteria for sample classification could be used for differentiating between the various malocclusion groups with regard to pattern of electromyography (EMG) of masseter and temporalis and MBF at intercuspal and interincisal positions. In 1975, Moss used Angle’s classification to differentiate between malocclusion subjects and clearly showed a difference between the muscle activity for the various malocclusion groups, while Kiliarides et al. in 1993 also studied various malocclusion groups as divided by Angle’s I classification and found no significant difference between their bite forces.

Only those children were chosen for recording EMG, for whom active orthodontic treatment was to be started, thus taking into consideration of a possible continued study to be done later to see the influence of treatment on EMG of masseter and anterior temporalis and bite force. An attempt was also made to elucidate the relation between gender and general muscle strength as judged from the strength of the finger-thumb grip.

The bite force recorder used was more sensitive, accurate, reproducible, compact, battery operated, hygienic due to disposable covers and has the ability to produce accurate readings in a simplified way which is very helpful and suitable for field studies as well as the clinics.

Various types of electrodes have been used for recording EMG but concentric needle electrodes were selected for the study because of many advantages like only one electrode to be inserted, more accurate assessment, easy to place in hairy region (anterior temporalis) and bite force. An attempt was also made to elucidate the relation between gender and general muscle strength as judged from the strength of the finger-thumb grip.

The mean MBF for younger age group sample was $450.98 \pm 54.83$ N for intercuspal position and $117.54 \pm 21.47$ N for interincisal position, which were close to those obtained by

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age</th>
<th>$M_P^1$</th>
<th>$M_P^2$</th>
<th>$M_P^3$</th>
<th>$M_T^1$</th>
<th>$M_T^2$</th>
<th>$M_T^3$</th>
<th>MBFP$_2$</th>
<th>MBFP$_3$</th>
<th>O Bite</th>
<th>O Jet</th>
<th>F PRES</th>
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$a = p \leq 0.05$; $b = p \leq 0.01$; $c = p \leq 0.005$; $d = p \leq 0.0001$; Where $M_i \rightarrow$ Masseter; $M_T \rightarrow$ Temporalis; $P_i \rightarrow$ Postural rest position; $P = \rightarrow$ Intercuspal position and $P_T \rightarrow$ Interincisal position; MBF $\rightarrow$ Maximum bite force
previous studies in the similar age groups. Some workers have reported a higher value for MBF, while others have reported lower values as compared to the present study. The MBF at intercuspal position (molar) and anterior bite position (incisal) was not significantly different between normal, Class I, Class II Division I and Class III malocclusion groups. This was in agreement with Kiliarides et al. No unanimity exists between different studies, regarding the function of masticatory muscles and its relation to sagittal deviations of the facial morphology and occlusion of teeth.

The analysis of muscle activity (EMG) showed a pattern of activity which put the Class III cases farthest from the normal occlusion, the Class II Division I next, followed by Class I malocclusion, which were nearest to the normal occlusion group. It seems therefore that pattern of muscle activity influences the Class III malocclusion the most and Class I the least. Lowe et al reported negligible activity of anterior temporalis at the postural rest position, but this was contrary to our findings in which we recorded a definite postural activity in anterior temporalis (Table 2), as also reported by Ahlgren et al and Miralles et al. For the postural rest activity of masseter muscle, Class III malocclusion showed maximum postural rest activity as compared to other malocclusions, which was in agreement with the results of earlier studies. The increased postural EMG activity in Class III subjects could be related to difference in the position and rotation of the jaws in these subjects as both of these factors could determine a change in muscle action axis and an increase in the gravitational component, causing a higher stimulation of neuromuscular spindles of jaw elevator muscles and thus reflexively increasing postural EMG activity as also explained by Miralles et al in 1994. This higher postural activity could also explain the more important role of muscle in the etiology of Class III malocclusion.

There was a significant negative correlation between overjet and postural masseter activity (M,P) (Table 3). There was least amount of overjet in Class III subjects; hence this might also explain higher postural activity in Class III malocclusion group, while lower activity in Class II Division I malocclusion group, where the overjet was large. This might be explained by the fact that in Class III cases, both the masseter and anterior temporalis muscles are in a hyperactive state to hold the mandible forward, unlike in Class II Division I cases where they are in a more relaxed state.

While comparing similar parameters between males and females in younger age group, significantly higher level of force in males was seen in the present study which fits well with the findings of Corruncini et al and Ingervall and Minder. There was also a significant difference in maximum finger pressure between the genders, with males showing higher values, which was in agreement with previous studies.

While studying proportionality of mean voltage to MBF for Groups A, B, C and D, for the masseter muscle, significant difference was seen in the ratio RM,P with higher ratio for subjects with Class II Division I malocclusion. This could be explained by the higher masseter activity at intercuspal position seen in subjects with Class II Division I malocclusion (Table 2). For temporalis muscle, RM,P and RM,P ratios showed much highest values for Class III and least for Class II Division I malocclusion. On comparing the ratios of mean voltage to MBF between masseter and temporalis muscles (Table 5), it clearly revealed a higher ratio for masseter muscle. This was equivalent to more steeper slope of regression curve for the force vs EMG in masseter as compared to temporalis, which has also been described, previously.

Pearson product correlation coefficient between electromyography, bite force and independent variables in younger age group showed a highly significant positive correlation between MBF at intercuspal position and age, indicating that force increased with age. A positive correlation between MBFP and MBFP revealed that individuals who were biting harder at molars were also biting harder at incisors. Ringqvist also showed a high correlation between incisor and molar bite force. When overjet or overbite was related to bite force, no significant correlation was found. A similar finding has been reported previously by various authors. A negative correlation was seen between overbite and temporalis activity at interincisal position that is as the overbite increased, the M,P activity decreased. This could explain the low value of M,P in Class II Division I malocclusions. Moller found a significant correlation between vertical overbite and EMG activity for the posterior temporalis. Similar was the case while relating the overjet.

Future studies of similar nature should consider the following:
1. The direction of loading on the sensor should be more controlled to prevent eccentric loading, as it is shown to influence both the magnitude of bite force and pattern of RMG activity recorded.
2. The pattern of EMG activity of other muscles like suprahyoid, posterior temporalis, medial and lateral pterygoid for their possible influence on the etiology of malocclusion.
3. The influence of orthodontic treatment on the EMG activity of masseter and temporalis.

CONCLUSION

The present study was undertaken to evaluate the MBF and EMG pattern of masseter and anterior temporalis muscles among young adolescents with normal occlusions and with various malocclusions segregated by Angle’s classification. The following conclusions were drawn from the present study:
1. Maximum bite force at intercuspal position (molar), anterior bite position (incisal) and maximum finger pressure were not significantly different between normal and malocclusion groups.
2. Class III malocclusion subjects showed the highest masseter and anterior temporalis postural rest activity.
3. 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.
4. There was a highly significant positive correlation of MBFP2 and maximum finger pressure with age, indicating that both MBFP2 and finger pressure increased with age in younger subjects.
5. There was a negative correlation between overjet/overbite and temporalis activity at interincisal position (M2P3) thus, indicating that as the overjet/overbite increased, the M2P3 activity decreased.

REFERENCES