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CLINICAL MEASUREMENT OF MAXIMUM MOUTH OPENING IN SAUDI CHILDREN AND ITS RELATION WITH DIFFERENT FACIAL TYPE

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ABSTRACT

Background: Decreased mouth-opening is a key factor in diagnosing most of the oral-health-related conditions. **Aim:** To assess the Maximum Mouth Opening and its correlation with facial types among children in Southern Saudi Arabia. **Method:** A cross-sectional study was conducted among the patients ranging from 2 to 12 years old. The maximum mouth opening was measured as the distance between incisal edge of maxillary and mandibular central incisors in the midline using the digital Vernier Caliper. Three readings of maximum mouth opening (MMO) were taken by the examiner and the average mean of these readings was taken as final MMO. Based on the calculated facial index, five facial types were determined and subjects were categorized and compared accordingly. The facial profiles, height, weight and BMI (Body mass Index) of the subjects was recorded as well. The data hence obtained was subjected to statistical analysis using SPSS (version 19.0, SPSS Incorporated, Chicago, IL, USA). **Results:** It was found that the mean value of maximum mouth opening of Hyperleptoprosopic (≥ 95.0) children was significantly higher than other children. The mean difference of mouth opening of Mesoprosopic (85.0 – 89.9) children was significantly lower than Leptoprosopic (90.0-94.9) and Hyperleptoprosopic (≥ 95.0) children. The mean difference of mouth opening of Leptoprosopic (90.0-94.9) was significantly lower than Hyperleptoprosopic (≥ 95.0). **Conclusion:** The overall mean value of maximum mouth opening among the subjects was found to be 47.33± 8.7. The maximum mouth opening of subjects was found to have an association with different facial types and facial profiles among the studied population.

Keywords: Association; children; facial type; Maximum mouth opening
INTRODUCTION

The distance between the mesio-incisal edge of the maxillary central incisors when the mouth is wide-open, known as Maximum Mouth Opening (MMO), also referred to as maximal inter-incisal distance (MID),\textsuperscript{1,2} is a very phenomenal parameter availed in the assessment of the range of vertical mandibular movements.\textsuperscript{3} TMJ dysfunction and reduced mouth opening caused due to various conditions such as oral-health related infections, malignancies involving the craniofacial region, fractures of jaws, and myopathies in the head and neck region.\textsuperscript{4} Moreover, it (MMO) provides the requisite information in designing prosthesis and dental appliances.\textsuperscript{5}

There exists no pertinent reference thus the clinicians are confronted with a somewhat difficult situation while assessing whether the mouth opening is limited or normal; hence the correlation of MMO with other related physiological parameters holds prominence therein. Previous researchers have observed the association of facial width and facial plastic surgeons, orthodontists and maxillofacial surgeons.\textsuperscript{9,10} Researchers have also reported that mouth opening varies with demographic variables such as the age, race, gender and body size (weight and height).\textsuperscript{11} Decreased mouth-opening is a key factor in diagnosing most of the oral-health-related conditions; its early and timely detection is of great significance insofar treatment and management is concerned.

Given the facts above, a study was planned and carried out to assess the Maximum Mouth Opening (MMO) and its correlation with facial types among children in Southern Saudi Arabia.
MATERIALS AND METHOD

A cross-sectional study was conducted among the patients who reported to the dental clinics of King Khalid University College of Dentistry, Abha, Saudi Arabia. A convenient sample of 555 was taken for the study with subjects ranging from 2 to 12 years old.

Prior to the conduct of study, ethical clearance was taken from scientific research committee, King Khalid University College of Dentistry,(IRB/KKUCOD/ETH/2020-21/013). All those patients whose parents/guardians gave the consent for participation, and were free from any oro-facial anomalies and had no history of trauma related to facial or dental structures were included in the study. Children with missing or fractured maxillary or mandibular incisors and those suffering from any cranio-mandibular disorders, bruxism or those who under-went any orthodontic treatment or who gave any history of Temporomandibular disorder (TMD) were excluded from the study. The subjects were made to sit in a straight upright position and head resting with back-support; and were asked to open mouth as wide as possible to measure the MMO. The maximum mouth opening was measured as the distance between incisal edge of maxillary and mandibular central incisors in the midline using the digital Vernier Caliper (Digimatic caliper, Mitutoyo, UK). Two examiners were calibrated for performing the clinical examination and the inter-examiner and intra-examiner reliability was assessed using kappa statistics. The kappa coefficient for inter-and intra-examiner reliability was found to be 0.87 and 0.91, respectively. Three readings of maximum mouth opening (MMO) were taken by each examiner and the average mean of these readings was taken as final MMO.

To assess the Facial type, the facial index was calculated using a formula:
Facial Index = Morphological Facial Length (n-gn) divided by Morphological Facial Width (zy-zy), multiplied by 100

{ Wherein: n, gn and zy signify:
Nasion (n): The midpoint on the soft tissue contour of the base of the nasal root at the level of the fronto-nasal suture.
Gnathion (gn): The most inferior midline point on the soft tissue chin contour.
Zygion (zy): The most lateral point on the soft tissue contour of each zygomatic arch}

Morphological facial height was measured as the straight distance measured between the nasion (nasal root(n)) to the gnathion, gn (the lowest mid-point of the mandible). Morphological facial width was measured as the widest distance between the zygomatic prominences. The most lateral point of the zygomatic arch was palpated on both sides and the ends of the caliper were placed on these points (zy-zy) for measurement.

From these two values (Morphological facial height and Morphological facial width), the facial index was determined.

Based on the calculated facial index, five facial types were determined and subjects were categorized and compared accordingly. Five types were as follows:
Hypereuryprosopic face (very broad face, range:<79.9), euryprosopic face (broad face, range: 80-84.9), mesoprosopic face(round face, range: 85-89.9), leptoprosopic face (long face, range: 90-94.9) and hyperleptoprosopic face (very long face, range: >95).12

The facial profiles of the subjects were assessed and recorded. The facial profile was assessed by viewing the superficial facial features from the subject's left side while the subject was made to sit in a comfortable upright position. The facial-profile was assessed by joining the following two reference lines: a line joining the forehead and the soft tissue
point ‘A’ (deepest point in the curvature of upper lip), and a line joining point ‘A’ and the soft tissue pogonion (most anterior point of the chin).\textsuperscript{13} Based on the relationship between these two lines, three facial profile shapes were recorded: a straight profile when the two lines form a nearly straight line, a convex profile when the two lines form an angle with concavity facing the tissue, and a concave profile when the two lines form an angle with convexity toward the tissue.

Height, weight and BMI (Body mass Index) of the subjects were also recorded. The data hence obtained was subjected to statistical analysis using SPSS (version 19.0, SPSS Incorporated, Chicago, IL, USA).

**RESULTS**
Out of the total 555 subjects, 184 were male children and 371 were female children ranging from 2 to 12 years of age with mean age of 4.99 ± 3.15. The overall mean value of maximum mouth opening among the subjects was found to be 47.33± 8.7. The mean MMO was found to be 49.47±0.49 in males while it was 46.29±0.48 in females, with a statistically significant difference between the two (Table 1). The maximum mouth opening was more in the females than males at all ages except at the ages of 2 and 3 years. This was however statistically significant at 2, 3,6,7,8 and 9 years of age (P<.01) (Table 2). MMO was found to be 47.45 among those subjects having no TMJ (Temporo-mandibular joint) abnormality and it was 46.68 and 46.98 among those having clicking and deviation respectively, with a statistically non-significant difference (Table 3).

It was found that the mean value of maximum mouth opening of Hyperleptoprosopic(=> 95.0) children was significantly higher than other children. The mean difference of mouth opening of Mesoprosopic(85.0 – 89.9) children was significantly lower than Leptoprosopic(90.0-94.9) and Hyperleptoprosopic(=> 95.0) children. The mean difference
of mouth opening of Leptoprosopic(90.0-94.9) was significantly lower than Hyperleptoprosopic(=> 95.0) (Table 4).

The maximum mouth opening value was 50.24 for those having concave facial profile while it was 44.6 and 48.3 for those with convex and straight profile respectively, with statistically significant difference (Table 5).

The correlation coefficient (r) of MMO with age (.446) shows significant moderate positive correlation (p<0.01) while the correlation coefficient r of MMO with weight (-0.090) shows significant weak negative correlation (p<0.05). The correlation coefficient r of MMO with BMI (-0.096) shows significant weak negative correlation<0.05. The correlation coefficient r of MMO with Facial width (FW) (-0.087) shows significant weak negative correlation<0.05, while the correlation coefficient r of MMO with Facial-type (.107) shows significant weak positive correlation<0.01 (Table 6).
DISCUSSION

All clinicians and dentists, who deal with the oral cavity, dental infections, fractures, and other oral health issues, encounter various problems due to limited mouth opening among children. Restriction in mandibular mobility is an indicator of mandibular dysfunction that further determines the state of masticatory system in a patient. Hence the measurement of maximum mouth opening (MMO) becomes a relevant research topic for clinical practice. The current research aimed to assess the MMO among Saudi Arabian children and identify its association with demographics and different facial types. Data was collected from a convenient sample of 555 children ranging from 2 to 12 years of age, with a mean age of 4.99±3.15.

In this study, the average MMO was inbetween 25.33 mm to 71.67 mm, the mean falling at 47.33 mm; and the standard deviation of the sample was 8.7 mm. In a previous study by Moosa et al., the researchers found the mean value of MMO to be 46.15 mm ± 8.49 mm, which was in accordance to the results of our study. AlHammad et al., also found a similar value where the mean MMO for all subjects was 47.8 ± 6.9 mm. Most of the other studies reported similar values of MMO.

As per the statistical analysis, it was found that a majority of the respondents (52.1%) had Hyperleptoprosopic facial type. A lesser number of the respondents (20 %) had Leptoprosopic facial type, and still lesser (17.1%) had Mesoprosopic facial type. A statistically significant difference was found between MMO when compared based on facial profile;the mean MMO was higher in children with concave facial profile as compared to those with a convex facial profile. Considering the relation between MMO and facial type, the results determined that MMO was higher among respondents with Hyperleptoprosopic facial type. Compared with other facial types, the mean difference of
MMO of subjects having Mesoprosopos facial type was significantly lower than Leptoprosopos and Hyperleptoprosopos types. This is a novel contribution of the research since there are fewer researches in the previous literature that have determined the association or correlation between MMO and different facial types. Some studies, such as a study by Fukui et al.,\textsuperscript{17} found a significant relationship between MMO and facial types of female participants. Contrary to our findings, Fatima et al.,\textsuperscript{5} observed MMO being higher among children with leptoprosopos facial type; furthermore, the researchers determined that Hyperleptoprosopos facial type had lower MMO value.

When compared with respect to gender, 82.9% of male subjects and 37.9% of female subjects were found to have Hyperleptoprosopos facial type. Leptoprosopos was the second common facial type: a percentage of 10.9% of the male children and 24.2% of the female children had this facial type. The facial indices of males were consistently higher than those of their female counterparts at various ages, but differences were statistically significant at 2, 3, 7, 8, and 9 years of age. The male subjects were found to have hyperleptoprosopos facial type while the female subjects predominantly had leptoprosopos type except for those at 3, 6, 11, and 12 years.

As per the current study analysis, a statistically non-significant difference was found when the MMO of children was compared as based on Temporomandibular joint (TMJ) functioning. Few investigations have found that restricted mouth opening is usually associated with TMJ dysfunction syndrome;\textsuperscript{18} this observation was in contrast to the findings of our research.

In the current study, mean MMO was higher in female subjects than in male subjects. However, the difference of mean MMO was statistically significant only at 2, 3, 6, 7, 8, and 9 years of age, when compared based on gender. This finding converges with few previously
reported studies\textsuperscript{19} that have revealed higher mean MMO values among female subjects. Hirsch et al.,\textsuperscript{20} conducted a longitudinal research and observed that female children and adults had higher MMO values, while male participants had lower values of MMO. Several contradicting studies were found in this context. A study by Sridhar & Jeevanandham\textsuperscript{21} investigated the association of MMO with age, gender, height, weight, and facial type among pediatric patients. The study found a concrete correlation between MMO and gender, wherein male subjects were found to have higher MMO values than females. Few other studies by Nagiet al.\textsuperscript{22} and Patel et al.\textsuperscript{23} reported similar deductions. Moosa et al.\textsuperscript{14} also observed that male participants had higher MMO than the females. Rashika and Gurunathan\textsuperscript{24} observed that male children had a greater MMO than female children. AlHammadet al.\textsuperscript{15} investigated the correlation between MMO, BMI, age, gender, and temporomandibular joint disorders in Saudi people. The researchers found that the mean MMO values of males were significantly greater than that of female participants. Al-Dlaiganand Asiry\textsuperscript{25} revealed that there lies a statistically significant difference between the mouth opening of males and females. According to Fatima et al.,\textsuperscript{5} there was a significant difference in MMO as per gender. The researchers also observed that MMO increases with an increase in age. On the contrary, Kumar et al.\textsuperscript{26} found no gender differences in relation to MMO. The study, however, observed significant association of MMO with respect to age, height and body weight. The variation in the findings of these researches might be attributed to the difference in sample size, study-setting, population, study-design and methodology.

In our study, Hyperleptoprosopic was most common among children, especially those with normal weight and overweight. The other facial-types were seen in a higher proportion among normal weight and overweight than underweight and obese children. The straight
facial profile was observed significantly higher in obese children than other groups. The concave facial profile was seen in higher proportions among underweight children while the convex facial profile was exhibited more by normal-weight children.

Our study found that MMO decreases with an increase in the weight of the respondents. As per the analysis, there was a significant positive correlation between MMO and facial type with age. A negative correlation was observed between MMO and facial type with BMI of the children. Moreover, MMO was observed to decrease with an increase in BMI and the facial width of the children. This observation was contradictory to the reports from the research conducted by Rashika and Gurunathan\textsuperscript{24}, wherein children with higher weight had a greater MMO than the other children. AlHammadet al.\textsuperscript{15} also determined a significant but weak positive correlation of MMO with height and weight.

In the current study, mean MMO was observed to increase with an increase in age. Similarly, Sridhar and Jeevanandham\textsuperscript{21} revealed through their study that MMO increased with an increase in age. Rashika and Gurunathan\textsuperscript{24} revealed a positive correlation between MMO, age, height, and body weight. The study reported a gradual increase in MMO as per the different age groups of the subjects. Koruyucuet al.\textsuperscript{27} found no statistically significant difference in mean MMO values based on gender of the subjects. However, the study found a positive association with respect to age. Al-Dlaigan and Asiry\textsuperscript{25} determined that regardless of gender, MMO increases significantly with age from the age of 12 years to the age of 14 years for the subjects included in their study. However, in contrast to our results, Moosa et al.\textsuperscript{14} found that mean MMO values reduced with increasing age of the subjects.

**Limitations:** A larger sample size could have been involved for establishing a more conclusive association of different parameters with maximum mouth opening. Different ethnic groups could be studied for increasing the external validity of the study outcome.
Conclusion

Within the limitations of the study, it was found that the overall mean value of maximum mouth opening among the subjects was 47.33± 8.7. The maximum mouth opening of subjects was found to have an association with different facial types and facial profiles among the studied population.

Abbreviations:

BMI: Body Mass Index
TMJ: Temporomandibular Joint
FW: Facial width
Zy: zygomatic
Gn: Gnathion
n: nasion
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Table 1. Maximum mouth opening of children according to gender

| Gender   | N   | Mean MMO (Standard error mean) | Mean difference (SEM) | p-value |
|----------|-----|-------------------------------|-----------------------|---------|
| Males    | 175 | 49.4724 (0.49251)             | 3.18114               | 0.000*  |
| Females  | 380 | 46.2912 (0.48143)             | 0.78437               |         |

*Statistically significant
Table 2. Mean Maximum mouth opening according to the age and gender of subjects

| Age   | GENDER | N   | Mean     | Std. Error Mean | P value  |
|-------|--------|-----|----------|-----------------|----------|
| 2 years Male | 17    | 50.0980 | 1.64837 |                  | .000**    |
|       Female | 177   | 41.4238 | 0.47895 |                  |          |
| 3 years Male | 21    | 52.5873 | 2.13325 |                  | .003**    |
|       Female | 105   | 45.9810 | 0.87684 |                  |          |
| 6 years Male | 5     | 47.1333 | 1.43217 |                  | .002**    |
|       Female | 4     | 56.0833 | 1.22001 |                  |          |
| 7 years Male | 30    | 47.9889 | .91845  |                  | .000**    |
|       Female | 4     | 59.6667 | 1.45933 |                  |          |
| 8 years Male | 41    | 48.9675 | .74507  |                  | .000**    |
|       Female | 42    | 54.6944 | 1.38049 |                  |          |
| 9 years Male | 57    | 49.3450 | .90521  |                  | .004**    |
|       Female | 20    | 54.5667 | 1.48543 |                  |          |
| 10 years Male | 4     | 51.5000 | 2.93289 |                  | .961#     |
|      Female | 9     | 51.3333 | 1.78557 |                  |          |
| 11 years Male | 4     | 56.7500 | 1.49304 |                  | .073#     |
|      Female | 6     | 60.6667 | 1.18634 |                  |          |
| 12 years Male | 5     | 58.2333 | 3.81576 |                  | .930#     |
|       Female | 4     | 58.7492 | 4.14833 |                  |          |

** Statistically highly significant; # Statistically non-significant
| TMJ                        | N   | Mean   | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum | P value^ |
|----------------------------|-----|--------|------------|-------------|-------------|---------|---------|----------|
| NAD (No Abnormality detected) | 340 | 47.4588| .46727     | 46.5397     | 48.3779     | 25.33   | 70.33   | 0.746*   |
| Clicking                   | 128 | 46.6810| .78862     | 45.1205     | 48.2416     | 34.00   | 67.00   |          |
| Deviation                  | 45  | 46.9852| 1.11539    | 44.7373     | 49.2331     | 31.33   | 61.33   |          |

#Statistically non-significant
Table 4. Association of Maximum Mouth opening with Facial Types

| Facial Types           | N  | Mean  | Std. Error | 95% Confidence Interval for Mean | Minimum | Maximum | P value |
|------------------------|----|-------|------------|---------------------------------|---------|---------|---------|
| Hypereuryprosopic(<=79.9) | 11 | 48.0000 | 3.1836      | 40.906 - 55.093                  | 34.00   | 70.33   | 0.010   |
| Euryprosopic(80.0 - 84.9) | 49 | 43.3572 | 1.3428      | 40.657 - 46.057                  | 25.33   | 65.33   |         |
| Mesoprosopic(85.0 - 89.9) | 95 | 46.6246 | 0.87886     | 44.879 - 48.369                  | 32.00   | 67.00   | 0.010   |
| Leptoprosopic(90.0-94.9) | 11 | 47.6892 | 0.89985     | 45.905 - 49.472                  | 32.33   | 67.67   |         |
| Hyperleptoprosopic(=>95.0) | 28 | 48.0911 | 0.48307     | 47.140 - 49.041                  | 25.67   | 71.67   |         |

^ By one way ANOVA, a vs b, a vs c and b vs c are significant, * Significant p<0.05
Table 5. Maximum Mouth opening of children with their Facial Profile

| Facial Profile | N   | Mean     | Std. Error | 95% Confidence Interval for Mean | Lower Bound | Upper Bound | Minimum | Maximum | P value* |
|---------------|-----|----------|------------|---------------------------------|-------------|-------------|---------|---------|----------|
| Convex        | 201 | 44.6045a | .60860     | 43.4044                          | 45.8046     | 30.67       | 67.67   |
| Straight      | 266 | 48.3509b | .53594     | 47.2956                          | 49.4061     | 25.33       | 67.00   |         |
| Concave       | 88  | 50.2443c | .75156     | 48.7505                          | 51.7381     | 36.67       | 70.33   |         |

* P value adjusted for multiple comparisons.
Table 6. Correlation of Maximum mouth opening with different parameters of subjects

| MMO AVERAGE | MMO AVERAGE | AGE | WEIGHT | HEIGHT | BMI | FL | FW | TMJ | F- TYPE |
|-------------|-------------|-----|--------|--------|-----|----|----|------|---------|
| Pearson     | .465**      | -.090* | -.029 | -.096* | .059 | .087* | .025 | .107* |
| Correlation | .000        | .035  | .490   | .023   | .167 | .041 | .555 | .012  |
| N           | 555         | 555   | 555    | 555    | 555  | 555 | 555 | 555   |

| AGE         | AGE         | Pearson | -.090* | 1      | -.228** | -.178** | -.107* | .107* |
|-------------|-------------|---------|--------|--------|---------|---------|--------|-------|
| Correlation | .465**      | 1       | -.228**| -.178**| -.107*  | .107*   | .350** | .034  |
| P value     | .000        | .000    | .000   | .011   | .012    | .000    | .425   | .000  |
| N           | 555         | 555     | 555    | 555    | 555     | 555     | 555    | 555   |

| WEIGHT      | WEIGHT      | Pearson | -.090* | 1      | .707**  | .546**  | .348** | .478* |
|-------------|-------------|---------|--------|--------|---------|---------|--------|-------|
| Correlation | .228**      | 1       | .707** | .546** | .348**  | .478*   | .069   | .085  |
| P value     | .035        | .000    | .000   | .000   | .000    | .000    | .034   | .046  |
| N           | 555         | 555     | 555    | 555    | 555     | 555     | 555    | 555   |

| HEIGHT      | HEIGHT      | Pearson | -.029 | .178** | 1       | -.195*  | .430** | .362** |
|-------------|-------------|---------|--------|--------|---------|---------|--------|-------|
| Correlation | .049        | .000    | .000   | .000   | .000    | .000    | .000   | .158  |
| P value     | .000        | .000    | .000   | .000   | .000    | .000    | .000   | .000  |
| N           | 555         | 555     | 555    | 555    | 555     | 555     | 555    | 555   |

| BMI         | BMI         | Pearson | -.096* | -.107* | .546**  | .195*   | 1      | .014  |
|-------------|-------------|---------|--------|--------|---------|---------|--------|-------|
| Correlation | .023        | .011    | .000   | .000   | .000    | .737    | .000   | .259  |
| P value     | .023        | .011    | .000   | .000   | .000    | .737    | .000   | .259  |
| N           | 555         | 555     | 555    | 555    | 555     | 555     | 555    | 555   |

| FL          | FL          | Pearson | .059  | .107*  | .348**  | .430**  | -.014 | 1     |
|-------------|-------------|---------|--------|--------|---------|---------|--------|-------|
| Correlation | .167        | .012    | .000   | .000   | .737    | .006   | .339  | .000  |
| P value     | .023        | .011    | .000   | .000   | .000    | .737    | .006   | .339  |
| N           | 555         | 555     | 555    | 555    | 555     | 555     | 555    | 555   |

| FW          | FW          | Pearson | -.087* | .350** | .478**  | .362**  | .242** | .117* |
|-------------|-------------|---------|--------|--------|---------|---------|--------|-------|
| Correlation | .041        | .000    | .000   | .000   | .000    | .006   | .572   | .000  |
| P value     | .041        | .000    | .000   | .000   | .000    | .006   | .572   | .000  |
| N           | 555         | 555     | 555    | 555    | 555     | 555     | 555    | 555   |
|       | Pearson Correlation |   |   |   |   |   |   |   |
|-------|---------------------|---|---|---|---|---|---|---|
| TMJ   |                      | .025 | .034 | .069 | .033 | .048 | .041 | .024 | 1 | .011 |
|       | P value              | .555 | .425 | .103 | .438 | .259 | .339 | .572 | .793 |
|       | N                    | 555 | 555 | 555 | 555 | 555 | 555 | 555 | 555 |
| F-TYPE| Pearson Correlation | .107 | .346 | -.085 | .060 | -.186 | .680** | -.645** | .011 | 1 |
|       | P value              | .012 | .000 | .046 | .158 | .000 | .000 | .000 | .793 |
|       | N                    | 555 | 555 | 555 | 555 | 555 | 555 | 555 | 555 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

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