AN IN VIVO CLINICAL STUDY OF FACIAL MEASUREMENTS FOR ANTERIOR TEETH SELECTION

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ABSTRACT:
The esthetic aspect of complete denture construction is increasingly occupying an important role in prosthodontics. Denture patients desire a brand of denture esthetics closely paralleling the ideal esthetic values of the third decade of life. Many pre-extraction records will guide selection of appropriate tooth mold for each individual. These include diagnostic casts, photographs, roentgenograms, extracted teeth etc. When no pre-extraction records are available; it is difficult to select an appropriate tooth mold that can reestablish the naturalness of the individual patient. In such a scenario, various facial measurements and proportions aid in the selection of appropriate artificial tooth dimensions.

The “Golden proportion”, one of the building blocks of beauty, is one such guideline that can be applied to the profession of dentistry with assured success. The aim of present study is to find out which of the facial measurements are in golden ratio with anterior teeth and that can be used for artificial teeth selection.

KEYWORDS: Golden proportion, Divine Proportion, Phi (Ø = 1.618).

INTRODUCTION:

Leonardo da Vinci, a great artist and anatomist of the 15th century, stated that, “the face excels in beauty when compared with other anatomic divisions of human being.”

The correct proportion is essential for harmony and facial rhythm. If we study the beauty of nature, art or teeth, we will discover a common principle running through out. This magical proportion, known since antiquity is none other than the “GOLDEN PROPORTION”. Golden proportion is one of the building blocks of beauty that we can apply to our profession of dentistry with assured success. Kepler called Golden Proportion as “DIVINE PROPORTION”.

If an individual becomes edentulous due to any reason, many morphological changes occur in the face along with compromised function and speech. The candidate for complete denture first demands comfort, then appearance and lastly efficiency 2. The esthetic aspect of complete denture construction is increasingly occupying an important role in prosthodontics. The dentist is not creating a new artistic product when he constructs a denture. He is rebuilding a face in conformance with nature’s plan by replacing a visible and functional lost part 2. Denture patients desire a brand of denture esthetics closely paralleling the ideal esthetic values of the third decade of life.

Many pre-extraction records will guide selection of appropriate tooth mold for each individual. These include diagnostic casts, photographs, roentgenograms, extracted teeth etc 2. When no pre-extraction record is available; it is very difficult to select an appropriate tooth mold that can reestablish the naturalness of the individual patient. In such a scenario, various facial measurements can be taken as guide lines to select appropriate artificial teeth. These guidelines include Bi-zygomatic width, intercommissural width, interalar width, interpupilary width, intercanthal length as well as nose length 4.

The aim of present study is to find out which of the facial measurement is in golden ratio with anterior teeth and that can be used for artificial teeth selection.

Materials and Methods:

A total of 300 subjects (150 males, 150 females) within the age group of 20 – 25 years were selected from students of various colleges in the Nellore town of Andhra Pradesh. The subjects were not pre-evaluated for the presence of an aesthetic or unaesthetic smile 5.

The inclusion criteria for selection of subjects are 5:
1. Angle’s class I molar relation.
2. Optimal overjet and overbite (1-3mm)
Fig. 1. Measurement of mesio-distal width of each tooth.

Fig. 2. Measurement of interalar width at relaxed state.

Fig. 3. Measurement of intercommissural width at maximum smile.

Fig. 4. Measurement of outer canthus to outer canthus width.

3. No missing maxillary or mandibular anterior and posterior teeth.
4. No interdental spacing or crowding
5. No anterior caries or restorations
6. No history of orthodontic treatment
7. No gingival or periodontal conditions or therapy that would undermine a healthy tissue to tooth relationship.

The exclusion criteria for elimination of subjects are:

1. Evidence of gingival alteration or dental irregularities.
2. Apparent loss of tooth structure due to attrition, fracture, caries or restorations.
3. Obvious problems that could disfigure or otherwise affect the face and dentition.

Digital Vernier Calipers, Modified divider with screw thread to fix the divider in one position, Fascia type of face bow are used in recording measurements. Various measurements taken in each subject are:

**Dental measurements**

1. Mesio-distal dimension of mandibular four incisors (A).
2. Mesio-distal dimension of maxillary six anterior teeth (B).

**Facial measurements**

1. Interalar distance at relaxed state (C1) and maximum smile (C2).
2. Intercommissural distance during relaxed state (D1) and maximum smile (D2).
3. Distance from outer canthus of one eye to outer canthus of other eye (E).
4. Intertemple distance (F).

**Data collection**

Each subject was seated in a dental chair with the head upright supported by head rest, so that they look forward at the horizon and with the occlusal plane of the maxillary teeth parallel to the floor.

**Dental Measurements**

The interproximal contact points were used as reference points in measuring mesio-distal width of each tooth with modified dividers that could be fixed in position with a screw thread and that have finely pointed ends that fit interdentally. The measurements were made in a straight line, with the pointed members of the divider held parallel to the incisal edges and perpendicular to the facial surface of the tooth. After the divider is fixed in position, the pointed members were placed on a piece of white paper, so that the pointed members perforate the paper when gentle pressure was applied as shown in figure(Fig.1). The
distance between the perforations was measured to an accuracy of 0.01mm with digital vernier calipers. Each tooth was measured 3 times and the average of these values was obtained\(^2\).

The combined mesio-distal dimension of mandibular four incisors was obtained by adding the mesio-distal averages of each individual tooth (A). The combined mesio-distal dimension of maxillary six anterior teeth was obtained by adding the mesio-distal averages of each individual tooth (B).

**Facial measurements**

Interalar width both in relaxed state and maximum smile \(^1\). Interalar width is the external width of the alae of the nose; it is recorded at the widest points of the alae using digital vernier calipers. Interalar measurement is taken both at relaxed state and during maximum smile (Fig 2). Interalar distance at relaxed state was measured 3 times for each subject and the values were averaged \((C1)\). Likewise interalar distance at maximum smile is also obtained \((C2)\)\(^5,6,10,11\).

Intercommissural width both in relaxed state and maximum smile \(^7\). Intercommissural distance is the distance from the angle of mouth to other angle of mouth using digital vernier calipers. Intercommissural distance is recorded both during relaxed state \(^9,12,13\) and during maximum smile\(^8,9\) (Fig 3). Inter-commissural distance at relaxed state was measured 3 times for each subject and the values were averaged \((D1)\). Likewise the Intercommissural distance at maximum smile was obtained \((D2)\).

Outer canthus to outer canthus width \(^7\). The distance between outer canthus of one eye to outer canthus of other eye is measured from the lateral palpebral fissure of one eye to the other with digital vernier calipers\(^7\) (Fig 4). The measurement was taken 3 times for each individual and the values were averaged \((E)\).

Intertemple distance \(^7\). Temple is a point at the temporal soft tissue above the ears at the level of the eyebrows\(^10\). Intertemple distance is the horizontal distance between the temples on both sides of the head. This measurement is made with fascia type of face bow\(^7\). The face bow is adjusted so that the condylar rods of the bow are pointed at the temple points on either side of the head and the screws were tightened. Face bow is taken away from the subject and the distance between the condylar rods of the bow is measured using shorter arms of the vernier calipers. This measurement was also recorded 3 times and the values were averaged \((F)\). The data was statistically analyzed with the use of descriptive statistics and Pearson correlation matrix to determine the percentage of correlation existing between measured values.

**Results**

The measurements were tabulated \((Table I, Table II and Table III)\). An independent \(t\)-test and Pearson correlation coefficient were used to analyze the data using SPSS statistical package V-16. In this present study \(p < 0.05\) is considered as the level of significance.

The comparison of all the measured values between male and female subjects using independent \(t\)-test reveals that the mean coronal widths of central incisors and canines of male subjects were greater than the corresponding dimensions of female subjects with a highly significant value \(<-0.01\), the incisors being the widest teeth for both genders. The width of maxillary lateral incisors did not exhibit significant gender differences \(>-0.05\). All facial measurements including interalar distance at relaxed state and maximum smile, intercommissural distance at relaxed state and maximum smile, outer canthus to outer canthus width and intertemple distance were also significantly greater in males than females \(<-0.01\).

Pearson correlation matrix \((Table, I)\) was used to know the degree of correlation between dental measurements and facial measurements. Pearson correlation coefficients for combined dental widths of mandibular 4 incisors \((A)\), maxillary 6 anterior teeth \((B)\) and the facial measurements demonstrated a positive correlation.

The ratios of combined width of mandibular 4 incisors to the outer canthus to outer canthus width \((4.19)\), the intercommissural width at maximum smile \((2.68)\), the interalar width at rest \((1.608)\) were showing maximum coincidence with golden proportion \((Table II)\). The ratios of combined width of maxillary 6 anteriors to the outer canthus to outer canthus width \((2.35)\), the intercommissural width at maximum smile \((1.91)\), the interalar width at rest \((0.9)\), were showing maximum coincidence with golden proportion \((Table III)\). But, the degree of coincidence is less with maxillary 6 anteriors than with mandibular 4 incisors. The present study showed that there exists a constant ratio \((2.04)\) between the combined width of mandibular 4 incisors and the combined width of maxillary 6 anteriors which is slightly different from that of golden ratio \((1.618)\).

The percentage of coincidences \((fig.5)\) was higher with three of the facial measurements. Of the three facial measurements the outer canthus to outer canthus width \((93.65%)\) showed highest coincidence, next comes the intercommissural width during maximum smile \((92.63%)\) and next comes the interalar width at relaxed state \((91.93%)\).

**Discussion**

According to Golden Proportion Hypothesis, the combined mesio-distal width of maxillary 6 anteriors is in golden relation \((1.618)\) to the combined mesio-distal width.
Table 1. Pearson correlation matrix between all the dental measurements and facial measurements.

<table>
<thead>
<tr>
<th></th>
<th>Man sum-A</th>
<th>Max sum-B</th>
<th>IAR-C1</th>
<th>IAS-C2</th>
<th>ICR-D1</th>
<th>ICS-D2</th>
<th>OC-OC-E</th>
<th>T-T-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man sum-A</td>
<td>1.000</td>
<td>0.635**</td>
<td>0.212**</td>
<td>0.230**</td>
<td>0.117*</td>
<td>0.209**</td>
<td>0.218**</td>
<td>0.157**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.043</td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.006</td>
</tr>
<tr>
<td>Max sum-B</td>
<td>0.635**</td>
<td>1.000</td>
<td>0.321**</td>
<td>0.299**</td>
<td>0.269**</td>
<td>0.315**</td>
<td>0.340**</td>
<td>0.203**</td>
</tr>
<tr>
<td></td>
<td>P 0.000</td>
<td></td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.000</td>
<td>P 0.000</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Significance (P):
- Highly significant < 0.01
- Significant < 0.05

Table 2. Comparison of the coincidence of the ratios of combined width of Mandibular 4 incisors and facial measurements with golden proportion.

<table>
<thead>
<tr>
<th></th>
<th>A/B</th>
<th>C1/B</th>
<th>C2/B</th>
<th>D1/B</th>
<th>D2/B</th>
<th>E/B</th>
<th>F/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured (Means of ratios)</td>
<td>0.49</td>
<td>0.9</td>
<td>0.88</td>
<td>1.02</td>
<td>1.51</td>
<td>2.35</td>
<td>3.04</td>
</tr>
<tr>
<td>Ratio in accordance with Golden proportion</td>
<td>0.618^1</td>
<td>1^2</td>
<td>1^3</td>
<td>1.618^4</td>
<td>1.618^5</td>
<td>2.618^6</td>
<td>4.24^7</td>
</tr>
</tbody>
</table>

(Ø = 1.618) 1 = Ø, 2 = Ø, 3 = Ø, 4 = Ø^2, 5 = Ø^3, 6 = Ø^4, 7 = Ø^5

Table 3. Comparison of the coincidence of the ratios of combined width of Maxillary 4 incisors and facial measurements with golden proportion.

<table>
<thead>
<tr>
<th></th>
<th>B/A</th>
<th>C1/A</th>
<th>C2/A</th>
<th>D1/A</th>
<th>D2/A</th>
<th>E/A</th>
<th>F/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured (Means of ratios)</td>
<td>2.04</td>
<td>1.688</td>
<td>1.8</td>
<td>2.09</td>
<td>2.68</td>
<td>4.19</td>
<td>6.21</td>
</tr>
<tr>
<td>Ratio in accordance with Golden proportion</td>
<td>1.618^1</td>
<td>1.618^2</td>
<td>1.618^3</td>
<td>2.618^4</td>
<td>2.618^5</td>
<td>4.24^6</td>
<td>6.85^7</td>
</tr>
</tbody>
</table>

(Ø = 1.618) 1 = Ø, 2 = Ø, 3 = Ø, 4 = Ø^2, 5 = Ø^3, 6 = Ø^4, 7 = Ø^5
of mandibular 4 incisors. The interalar width is same as combined mesio-distal width of maxillary 6 anterior teeth. Intercommissural width is in golden relation (1.618) to the combined mesio-distal width of maxillary 6 anterior teeth. The outer canthus to outer canthus width in turn is in golden relation (1.618) to inter-commissural width. The intertemporal distance again is in golden relation (1.618) to outer canthus to outer canthus width.

The common ratios of the geometric progression are 0.618 and 1.618. Any decreasing function is multiplied by 0.618 and any increasing function by 1.618 to get the next result. As per the Golden Proportion Hypothesis, the four lower incisors form a basic unit of 1.0 with Ø relations going to maxillary six anterior teeth and also to the nose to the mouth Ø to the eyes Ø and the head Ø. Based on the measurement of each parameter, rest of all the parameters are predicted according to the Golden Proportion Hypothesis.

In the present study the outer canthus to outer canthus width is showing maximum percentage of coincidence with Golden Proportion, next is the intercommissural width during maximum smile and next is the interalar distance in relaxed state. In the literature there are many studies that supports the use of intercanthal distance. I.e., distance between inner canthi of both eyes for selection of artificial anterior teeth for completely edentulous patients but limited research has been done to evaluate the usefulness of outer canthal width for artificial tooth mold selection. Medial and lateral canthi are the angles formed at the junction of lids on medial and lateral aspects of eye. Lateral canthus is about 5-7mm from the lateral orbital margin and lies in contact with the eye ball. Lateral canthi are more acute than the medial canthi. It forms an acute angle of about 60° with eyes wide open and an angle of 30°-40° with eyes open in a normal way. Lateral canthi are formed earlier than medial canthi during embryonic growth.

According to present study results, outer canthus to outer canthus width is showing highest percentage of coincidence with Golden Proportion especially when combined width of mandibular 4 incisors is taken as the basic unit, i.e., outer canthal width is Ø times the “A” (combined width of mandibular 4 incisors).

The facial measurement that has next higher percentage of coincidence with Golden Proportion is intercommissural width during maximum smile. Some problems have been faced in measuring the intercommissural width during maximum smile. These include difficulty in standardizing the maximum smile position, difficulty in reproducing the same position, asymmetric smile in few individuals due to some muscle tone differences.

The facial measurement that has next higher percentage of coincidence with Golden Proportion is interalar distance at relaxed state.

CONCLUSION:

Within the limitations of the present study, the following conclusions can be made:

1. Outer canthus to outer canthus width, intercommissural width at maximum smile and interalar width at relaxed state are the three facial measurements that showed higher percentage of coincidence with Golden Proportion especially when combined mesio-distal width of mandibular 4 incisors were considered as basic unit.

2. Out of above three facial measurements, the outer canthus to outer canthus width showed highest percentage of coincidence (93.65%). So, this facial measurement can be used for the selection of combined mesio-distal width of mandibular 4 incisors for denture patients. (OC-OC width / 4.24).

3. Present study revealed that there exists a constant ratio (2.04) between combined mesio-distal width of mandibular 4 incisors and combined mesio-distal width of maxillary 6 anterior teeth which is slightly different from that of Golden Proportion (1.618). So, the combined mesio-distal width of maxillary 6 anterior is obtained by multiplying combined mesio-distal width of mandibular 4 incisors with 2.04.
4. Intercommissural width at maximum smile and interalar width at relaxed state also showed higher percentages of coincidence. So, these facial measurements can also be used as a guide for selection of anterior teeth.

There was only limited research in literature on outer canthus to outer canthus width as a guide for selection of anterior teeth in denture patients. So, future research should focus on this measurement and its significance as a guide for anterior teeth selection in a wide group of population. It is always advisable to select artificial anterior teeth based on more than one facial measurement when no pre-extraction records were available. Also new techniques should be found to standardize the measurements of the intercommissural and interalar width at maximum smile.

References

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