Full Length Research Paper

Face- central incisor form matching in selected south Asian population

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This research intended to examine the morphometric relationship between the face and inverted maxillary central incisor in Malays and Chinese. 120 volunteers who met defined criteria participated in the study. Measurements were made directly and on digital images of each subject's frontal facial view and the corresponding stone cast of the maxillary teeth. An image analyzer was used to divide the image of the face into 14 equal vertical sections from the pogonion to the widest area at the level of the nasion. Similar divisions were made on the labial aspect of the image of the inverted central incisor from the cervical area to the widest area of the incisal region (at the bi-contact level). In a later part of the study, 3 dentists were asked to assess the visual similarity between the form of the face and the form of the inverted central incisor. A statistically significant metric correlation was found between the 14 vertical sections of the face and those of the central incisor (p<0.05), indicating the presence of harmony between the face and tooth form in the Malays and Chinese. There is an agreement between the form of the inverted central incisor and the form of the face in Malays and Chinese. This matching is useful when selecting artificial anterior teeth in edentulous patients.

Key words: Morphometric relation, digital image analyzer, central incisor-face form matching.

INTRODUCTION

Teeth form selection is one of the most important steps in establishing optimum aesthetics in the replacement of lost natural teeth by artificial ones. Normally, the central incisor is used as a guide for the selection of the substitute anterior teeth. It is considered as the key tooth of the smile or appearance. Therefore, the selection of the central incisors is vital in order to satisfy the aesthetic demands of the patient and his relatives. The dentist's role would be as an advisor for the patient to make the appropriate choice of teeth in order to promote patient self-confidence, welfare and psychological relief. The tooth-face form matching theory is not new. James (1914) hypothesized the presence of harmony between the frontal inverted central incisor (CI) and the face form (Clapp, 1925). Much research had been conducted to find such morphologic matching using the visual perception method, computer shape matching according to Hausdorff distance (HDD) (Lindemann et al., 2004), simple or sophisticated statistical analysis or even genetic findings. However, controversy still exists since some findings do not support the existence of the tooth-face form matching. The contentious findings may be due to one of the following:

a) Different reference points or landmarks and instrumentation used in defining the tooth and face form.
b) Variable mathematical and technical analysis used when analyzing the results.

However, the theory of Williams is still the most universally acceptable method that provides desirable artistic harmony for teeth form selection in the absence of pre-extraction patient’s records. The law of harmony, as described by James Leon William in 1914 (Clapp, 1925) states that the contour of the human central incisor in the frontal plane could be classified into four major shapes: rectangular, triangular, round and ovoid. He claimed that the most pleasing aesthetic appearance is achieved
when the outlines of the individual's face form and the form of the inverted maxillary central incisor are matching. The face form, personality and expression, the proportions of the other parts of the face, the lip and eye forms and colors, may affect the agreeable facial look (Ahmad, 2005; Flores-Mir et al., 2004). In addition, the tooth shape and size, the arch form, the palatal contour and the teeth arrangement play a major role in the aesthetic appearance of the patient (Brigante, 1981; Sellen et al., 1998; Burchet et al., 1988). The three terms: sex, personality and age (SPA) were considered dentogenic terms that were introduced to the dental profession in early 1950 to describe the art, practice and techniques used to achieve aesthetic goals in prosthodontics (Burchet et al., 1988). A significant correlation was found between the forms of the face, the tooth, and the arch by superimposition of the form outlines, although this method applied high technology. Moreover, the accuracy of determining shape and size of teeth in an edentulous patient was not improved.

The cost and complexity of the measurement method also made it impractical for common application (Lindemann et al., 2004). The purpose of this investigation was to re-evaluate the hypothesis that the form of the inverted central incisor and the frontal face shape matched in Malays and Chinese.

**MATERIALS AND METHODS**

The sample size inference for a power significance (1-β err = 0.95) was estimated using G*Power 3.2.1 (free software) after a pilot study. Therefore, 120 individuals were included in this study. The Medical Ethics Committee of the University of Malaya approved this study. The sample consisted of 65 Malays and 55 Chinese subjects (48 males and 72 females) who were healthy and completely dentate. They were aged between 17 and 25 years (mean = 23.13±1.4). There was no history of mixed parentage for at least two generations in all the subjects. All volunteers completed a consent form to participate in this study. The subjects had not undergone any conservative treatment or prosthetic replacement for their anterior or posterior teeth. All their teeth were normally aligned with no history of orthodontic treatment. Patients with gingivitis, periodontitis, enamel dysplasia, attrition and abrasion, amelogenesis imperfecta, dentinogenesis imperfecta and other enamel and dentine abnormalities or teeth malformations were excluded from the study. Preliminary impressions for the maxillary arch of each subject were made using irreversible hydrocolloid impression material (Kromopan 100 h Hydrocolloid dust free iso 1563 class A type 1, Italy) following the manufacturer's instructions. Perforated stock impression trays (Ash Co Ltd Hert fort shine, England) were used when making the impressions. The impressions were poured using dental stone (Heraeus Kuzler Corp., Hanau, Germany). Three methods were used to check and confirm the presence of linear correlation between the face and the CI forms: The first method investigated the presence of correlation between the facial and the central incisor index using direct measurements. Hence, facial biometrical measurements (bizygomatic width and nasion-pogonion height) were recorded directly using the cephalometer and digital caliper. The measurements for CI were made directly on casts of the maxillary arch of each subject. The central incisor tooth length that extended from the midpoint of the incisal edge to the highest cervical curvature close to the gingival margin was recorded. The maximum tooth width was recorded at the level of the contact points with the adjacent tooth. The index was obtained by dividing the width/length *100%* (Figure 1). In the second method, the subjects were photographed at a constant position, distance, face height, and magnification using a tripod mounted digital camera (Nikon Co.)

**Figure 1.** The recording method of the face and CI using direct measurement.
with a macro lens (AF Micro Nikkor 60 mm f:28D, Japan) and a ring flash light. The distance was fixed at (150 cm) horizontally from the lens and (135 cm) vertically to the floor as measured from the subject's nose.

On the cast, the most externally visible labial borders of the left CI was marked using a mechanical pencil (0.5 mm) and photographed with a digital camera using fixed angulations, distance and magnification. The images were uploaded into a desktop computer. Using image analyzer system (IAS) and software (Leica Quin Lite image analysis V 27.1), the face and inverted CI images were divided into 14 equal vertical sections starting from the narrow end of both face and CI (Figure 2). A simple hypothesis assumes that if two objects without regular geometric forms and dissimilar dimensions (like in case of the face and tooth) were to be matched in their form, then a positive statistical linear quantitative relationship should exist between their parallel dimensions to confirm this matching. Therefore, the face and the CI images were divided into 14 equal vertical sections. The width of each vertical section was measured in millimeter (mm), and then each width of the vertical section of the face and CI were correlated using linear correlation after normality confirmation of data distribution. Prior to each record, the face, and tooth lengths were calibrated by making sure that the measurements made using the image analyzer were similar to the dimensions of the face and CI made using direct measurements. The face- CI morphometric matching was tested using two mathematical analyses to ensure that a linear correlation exists in both methods of analysis. Therefore, the width ratios and the simple records were used for this purpose: the 14 width measurements of the tooth and face were transformed into ratios by dividing the smaller dimension over the next one (starting from the narrow area part of the face and tooth) for 13 successive records. Hence, if the ratios between their successive widths are correlated, then the two objects matched in their forms:

Tooth ratio 1 (TR1) = Tooth width 1 (TW1)/tooth width 2 (TW2). TR1 -- TR13.

For the face, the same mathematical procedure was applied:

Face ratio 1 (FR1) = Face width 1 (FW1)/face width 2 (FW2). FR1 -- FR13.

In the third method, three dentists were asked to visually evaluate each subject's face and tooth form according to the William's classification. The 4 forms of teeth and face shape according to the Williams classification were printed on paper and placed in front of each dentist. They were then given photographs of each subject's face and dental cast and were asked to record into which one of the 4 shapes they would categorize each subject's face and inverted central incisor. Each dentist was given 2 min lap time per subject to make his evaluation and record his opinion. The results of the dentists' opinions were uploaded into 3 computers. Descriptive statistics were used to describe the features of the sample population and data distribution. The other tests used were P or NP correlation and Chi square (p<0.05).

RESULTS

The intra-examiner reliability of direct and image analysis records were checked using two sets of width measurement records (minimum and maximum widths); one set of the tooth and another of the face. Each record was repeated 3 times then analyzed using linear correlation. The results were highly significant (correlation coefficient: + 0.94 to 0.97, two-tailed at p<0.01). No significant correlation was found between the face and CI length and widths using direct measurements in the two groups (Table 1). On the contrary, a significant difference was recorded between facial and tooth measurements in both Malays and Chinese (Table 2). For the image analyzing method, a significant linear correlation between the face and CI widths was evident using Pearson correlation (r = +0.819, p<0.01, two-tailed, N: 1680) for
Table 1. Correlation test between the direct measurements of the face and CI in Malays and Chinese.

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Face</th>
<th>Spearman's correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisal width in Malays</td>
<td>Bizygomatic</td>
<td>0.186</td>
<td>0.138*</td>
</tr>
<tr>
<td>Incisal width in Chinese</td>
<td>Bizygomatic</td>
<td>-0.136</td>
<td>0.322*</td>
</tr>
<tr>
<td>Length in Malays</td>
<td>Nasion-Por</td>
<td>0.054</td>
<td>0.671*</td>
</tr>
<tr>
<td>Length in Chinese</td>
<td>Nasion-Por</td>
<td>-0.11</td>
<td>0.939*</td>
</tr>
</tbody>
</table>

*Not significant at 0.05 level, Por: porion.

Table 2. Chi square test of the tooth and face index in the Malays and Chinese.

<table>
<thead>
<tr>
<th>Teeth index</th>
<th>Facial index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square</td>
<td>18.070</td>
</tr>
<tr>
<td>DF</td>
<td>2</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.00*</td>
</tr>
<tr>
<td>DF</td>
<td>40.305</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.00*</td>
</tr>
</tbody>
</table>

*Significant difference at p<0.05.

Table 3. Dentists assessment of the similarity between CI and face form.

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>1st dentist</th>
<th>2nd dentist</th>
<th>3rd dentist</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Malays</td>
<td>Chinese</td>
<td>Malays</td>
</tr>
<tr>
<td>Form agreement (%)</td>
<td>67.7</td>
<td>61.1</td>
<td>75.3</td>
</tr>
<tr>
<td>Chi-square</td>
<td>72.12*</td>
<td>44.009*</td>
<td>95.625*</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>67.06</td>
<td>38.127</td>
<td>85.30</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00*</td>
</tr>
</tbody>
</table>

*Significant agreement at p<0.05.

The correlation between the face and CI width ratios was positive and highly significant for the two studied genders and the two ethnic groups (r = +0.973, p<0.01, two-tailed; N: 1560). The results of visual perception suggested the presence of positive relationship between the face frontal shape and the inverted central incisor form (Table 3). Generally, there was significant difference in assessment results among the three dentists. However, the assessors agreed on the presence of similarity between the face contour and the inverted tooth form.

DISCUSSION

Standardized digital still imaging was used to capture the face and the maxillary central incisor images in order to limit the variability in recording and measuring due to soft tissue mobility. The inconsistency was reduced by repeated measurements and reliability tests. Many techniques have been attempted to disclose the presence of similarity between the labial view of the inverted CI and the face soft tissue boundary (Sellen et al., 1998; Brodbelt et al., 1988; Lindemann et al., 2004; Wolfart et al., 2004). However, the image analyzer seems to be more practical, easy to perform and offered acceptable precision and reliability. Before performing the test, a pilot study showed that the face width started to decrease gradually beyond the bizygion area. Therefore, the maximum facial width was considered at the bizygion level or slightly higher so that it resembled the tooth form. Hence, the result indicated the presence of highly significant correlation between the (face-tooth) widths. This implied a close similarity in their shapes within this predetermined area (pogonion-bizygion). This finding is similar to that described by Lindemann et al. (2004) who used the same anatomical limits of the face and the CI.

The visual assessment by a dentist is superior to...
the visual perception of a layperson due to the dentist's clinical and professional experience. The responses from the 3 dentists therefore provided acceptable accuracy of results (Bell, 1978; Marunick et al., 1983). However, this method may be less convenient as it incorporates a lot of bias since it depends on many variables related to experience, background, social agreement and personnel preference (Flores-Mir et al., 2004). The total agreement among the dentist's assessments regarding the form matching was 86% for the face while it was 66.4% for the tooth. This result indicated an acceptable reliability among their evaluation. It seemed that the identification of the face form was easier than the tooth form. In this research, the width ratios were used for the first time to investigate the presence of a correlation between the CI and the face. Our findings were not in agreement with previous studies (Sellen et al., 1998; Bell, 1978; Mavroskoufis et al., 1980; Ferreira et al., 2007; Wolfart et al., 2004) due to the use of different reference measurements and analyzing methods. However, it is in harmony with the findings of Lindemann et al. (2004). The statistical difference between the dimensions of the face and CI in Malays and Chinese signified that the theory of Williams is applicable in different ethnic groups and gender. Therefore, the index of the CI and the face may be used in forensic dentistry to identify the ethnicity of unknown cadavers with mutilated faces.

In addition, the results of the linear regression analysis of the tooth-face form used in this study may be applied to predict the form of the central incisor for any edentulous patient or to predict the face dimension and form from the intact CI in forensic dentistry. Within the limits of this study, the following may be concluded:

1) The facial and CI measurements and indices were significantly different in the Malays and Chinese.
2) There was a significant linear correlation between the widths of the face and CI in Malays and Chinese within the defined anatomical limits in the frontal plane. This metric finding indicates the presence of harmony between the face and the inverted central incisor.
3) A visual matching of the face and the tooth form was generally seen.
4) The findings supported Williams' theory regarding the presence of harmony between the forms of the face and the inverted central incisor.

REFERENCES