A Study to Correlate Various Facial Landmarks with Intercanine Distance

Abstract
Context: Ideal interaction of dental and facial beauty proportions highly influences a harmonious facial appearance. Racial anatomical variations have been significantly noted and using these norms during prosthodontic rehabilitation will be greatly helpful in successful treatment outcome. Aim: The present study aims to correlate various facial landmarks (interpupillary distance [IPD], intercanthal width, bizygomatic width [BZW], and interalar width) with intercanine distance (ICaD) in Indian young adults to determine the mesiodistal width of the maxillary anterior teeth in edentulous patients. Setting and Design: This is an observational cross-sectional study. Materials and Methods: This study was conducted in 500 individuals ranging in age from 18 to 28 years. IPD, intercanthal width, BZW, and interalar width were measured with a digital caliper (accuracy - 0.01 mm). A “T” shaped flat metal plate called “canine tip marker” was made to mark the tips of the maxillary canines, which were further measured with the digital caliper. The data were summarized in table form and were statistically analyzed. Statistical Analysis Used: Student’s t-test and ANOVA test were used. Results: A significant correlation (P < 0.001) was found between these landmarks with ICaD, in which interalar width shows highest degree of correlation (r = 0.639). ANOVA test showed that maximum number of individuals had < 5% variability range between actual values and calculated values of ICaD for all extraoral facial landmarks except intercanthal width. Conclusion: Combination of various facial and oral factors should be considered while selecting artificial teeth. Regression equations obtained can be well used during teeth selection to achieve a significant result.

Keywords: Bizygomatic width, interalar width, intercanine distance, intercanthal width, interpupillary distance

Introduction
The human face plays an important role in highlighting human individuality, identity, and personality, not to mention our social identity. In an economically, socially, and professionally competitive world that is steadily cutting across the gender lines, an overall attractive and pleasant look is becoming a necessity. Successful restoration of teeth within the esthetic boundaries results in a distinctly positive effect on the patient’s self-esteem and quality of life. As dentists, one of our goals is to restore optimal dentolabial relations of the maxillary anterior teeth, in harmony with the overall facial appearance. However, there are little scientific data in the dental literature to serve as a guide for defining the proper size and shape of anterior teeth or determining normal relationships for them. A harmonious dentition of an individual has been found to be comprised of proper shape, size, and arrangement of the maxillary anterior teeth.[1]

Depending on the patient’s expectations and the expertise of the dental practitioner, several factors may be appropriately used as a tool for anterior teeth restoration. Gender characteristics and tooth, arch, and face form correlation are few common principles used regarding esthetic features of teeth forms.[2‑7] Some authors emphasized the role of maxillary and/or mandibular canine teeth in gender identification.[8] It has been noted that gross disharmony between the size of face and teeth has displeasing effects, and for this reason, it is desirable to have some dependable criteria for the selection of tooth sizes in artificial replacement.[7]

McGee stated that the surface anatomy of the oral tissues helps locate the proper position of the anterior teeth on the denture base. Arranging teeth at their natural place generally resulted in more esthetic appearance and provided comfort and satisfaction to the patient.[8]

During prosthetic rehabilitation, several anatomic measurements have been advocated for proper selection of anterior

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teeth. Among them, some of landmarks commonly used by different authors are the distance between canine eminences, intercommisural width, bizygomatic width (BZW), interalar width, interpupillary distance (IPD), and intercanthal width.\textsuperscript{[9‑20]} An ideal interaction of dental and facial beauty criteria have been associated with a variety of factors resulting in a balanced smile. Many attempts have been made to quantify the selection of anterior teeth in a complete denture, but little consensus on an effective method has been reached. Johnson studied cephalometric radiographs of various racial groups (Japanese, Chinese, Filipino, Black, and Caucasian) to discuss the esthetics and prosthodontics implication of racial variations.\textsuperscript{[21]} He reported that the knowledge of racial norms for facial appearance helps practitioners in successful treatment planning as it would be consistent with the facial appearance for patients of different races.

The present study was planned to evaluate the correlation between various facial landmarks such as IPD, intercanthal width (ICD), BZW, and interalar width (IAD) with intercanine distance (ICaD) in young adult Indian population for predicting the mesiodistal width of the maxillary anterior teeth during teeth selection in edentulous state, which is an important step during denture rehabilitation procedure even in implant-supported prosthesis.

Materials and Methods

This study was conducted with 500 individuals (250 males and 250 females) ranging in age from 18 to 28 years in prosthodontics department of the institution. These individuals were selected among the students pursuing their undergraduate and postgraduate course in the institution. The criteria for selection of individuals included (a) no missing maxillary or mandibular anterior teeth, (b) sharp canine tips with no obvious sign of wear, (c) well-aligned anterior teeth, (d) no interdental spacing or crowding, (e) no history of orthodontic treatment, (f) teeth in healthy periodontal condition, (g) no anterior restorations, (h) no evidence of tooth structure loss due to attrition, erosion, abrasion, or trauma, (i) no apparent defect, deformity, or asymmetry of the face, and (j) no vision defect related to abnormal pupillary size and position with pupils showing normal reaction to light. Informed consent was obtained from all individuals before their participation. Ethical clearance was obtained from the Institutional Ethics Committee (Ref code: ECM-B/P6). All measurements were made by the same investigator to maintain the standardization of the procedure.

A digital caliper with a least count of 0.01 mm was used to measure the IPD, intercanthal width, BZW, and interalar width. Individuals were instructed to sit in upright position with their eyes looking at the horizon. Retaining the same position, the external jaws of the caliper were carried in such a way that they were in correct alignment with the medial angles of the palpebral fissures of the eyes to measure intercanthal width [Figure 1a]. For measuring interalar distance, the external jaws of the caliper were adjusted in a way that the jaws make a gentle contact with the maximum contour of the alae of the nose [Figure 1b]. Centers of both pupils were measured for IPD [Figure 2a] and prominent part of zygoma was used to measure BZW [Figure 2b] in the same postural position of individuals. A “T” shaped flat metal plate called “canine tip marker” was specifically fabricated to mark the maxillary canines tips.\textsuperscript{[20]} The horizontal arm of the “canine tip marker” was used for marking the canine tips, which measured 5 cm in length and 1 cm in width having rounded ends. The vertical arm of the marker, which was used for holding the tool during recording the canine tips, measured 7.5 cm in length and 1 cm in width. During measurement of canine tips, carbon soot was used to blacken one side of the horizontal arm of the canine tip marker. The marker was carried by holding the vertical arm, parallel to the floor in such a way that markings of the cusp tips of the right and left maxillary canines were obtained on the blackened soot [Figure 3a]. The caliper was used to measure the distance between the marks of the tips of maxillary canines obtained on the horizontal arm [Figure 3b]. Interpersonal variations in landmark selection were reduced by employing consensus of three observers and interpersonal difference during measuring was minimized by single person recording all landmarks. Holding the caliper parallel to floor required precise concentration and coordination of the observer and using digital caliper well served the purpose of precise recording. The whole procedure was performed three times for each individual and the mean values of each landmark were calculated. Bivariate correlation and linear regression were performed to obtain a modeling equation. Percentage variability of calculated values from actual values for different methods was compared using ANOVA test. The confidence level of the study was kept at 99%; hence, \( P < 0.001 \) indicated a statistically significant association.

![Figure 1](image_url)
Results

The bivariate analysis, irrespective of genders [Table 1], shows that except intercanthal distance, all the three variables had a moderate correlation ($r = 0.5–0.7$) with intercanine distance. Intercanthal distance had mild correlation ($r = 0.422$; i.e. $r = 0.3–0.5$). All the correlations were statistically significant ($P < 0.001$). For males [Table 1], the pattern of correlation was similar to that observed for overall assessment. However, among females [Table 1], the pattern was changed with intercanthal distance, interpupillary distance, and bizygomatic width showing mild correlation only ($r = 0.3–0.5$) while interalar distance showed moderate correlation. Scatter diagrams [Figures 4-6] show the positive correlation of different landmarks with intercanine distance in both the gender groups.

The regression equations generated were as follows:

- $\text{ICaD}_{\text{IAD}} = 17.737 + 0.488 \times \text{IAD}$
- $\text{ICaD}_{\text{IPD}} = 13.088 + 0.376 \times \text{IPD}$
- $\text{ICaD}_{\text{BZW}} = 0.300 \times \text{BZW} - 0.293$
- $\text{ICaD}_{\text{ICD}} = 24.117 + 0.358 \times \text{ICD}$.

Based on the above regression equation, Table 2 shows the range of percentage variability of calculated values from actual values of ICaD when compared among different landmarks. It was observed that mean differences between calculated and actual ICaD measurements were statistically significant with different facial landmarks. For IAD, the differences from actual measurements were relatively lower ($3.21 \pm 2.56\%$) whereas mean differences from actual measurements were higher for ICD ($3.93 \pm 2.86\%$). For IPD and BZW, mean differences from actual measurements were moderate ($3.43 \pm 2.67\%$).

| Pearson correlation | ICaD | ICD | IPD | BZW | IAD |
|--------------------|------|-----|-----|------|-----|
| Combined ($n=500$) | 1    | 0.422** | 0.593** | 0.592** | 0.639** |
| Male ($n=250$)    | 1    | 0.445** | 0.592** | 0.603** | 0.524** |
| Female ($n=250$)  | 1    | 0.329** | 0.481** | 0.446** | 0.592** |

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

ICaD=Intercanine distance, ICD=Intercanthal width, IPD=Interpupillary distance, BZW=Bizygomatic width, IAD=Interalar width
Table 2: Range of percentage difference between actual values and calculated values of intercanine distance

| Range of variability | IAD, n (%) | IPD, n (%) | BZW, n (%) | ICD, n (%) |
|----------------------|------------|------------|------------|------------|
| <1%                  | 108 (21.6) | 97 (19.4)  | 90 (18.0)  | 86 (17.2)  |
| 1%-5%                | 283 (56.6) | 277 (55.4) | 292 (58.4) | 121 (24.2) |
| 5%-10%               | 101 (20.2) | 114 (22.8) | 106 (21.2) | 279 (55.8) |
| >10%                 | 8 (1.8)    | 12 (2.4)   | 12 (2.4)   | 14 (2.8)   |

Mean percentage variability±SD (range) in percentage

3.2±2.56 (0-14.31) 3.43±2.67 (0.01-17.11) 3.43±2.67 (0.0-15.73) 3.93±2.86 (0.02-15.20)

Outcome of ANOVA test (F)=6.544; P<0.001. ICD=Intercanthal width, IPD=Interpupillary distance, BZW=Bizygomatic width, IAD=Interalar width, ANOVA=Analysis of variance, SD=Standard deviation

Discussion

One of the most confusing and difficult aspects of prosthetic rehabilitation is the selection of appropriately sized maxillary anterior denture teeth. Some of the studies suggest that in the overall appraisal of esthetics, we utilize the principles of proportion, balance, rhythm, and empathy, and various parts of the face and body are related ideally to this proportion. It was advocated that when selecting the teeth for complete denture, the dentist should select a form which harmonizes with the form of patient’s face and also in proportion to the size of the mouth, general body skeleton, age, gender, and personality. Use of the oral commissures as guides for the selection and placement of upper anterior teeth needs to be discouraged now as musculature loses adequate support with increased period of edentulism, lost alveolar structures, or rehabilitation with improper denture prosthesis. Use of those facial landmarks which are comparatively more stable with time should be encouraged as guide points. In the present study, stable extraoral facial landmarks such as IPD, intercanthal width, BZW, and interalar width were chosen to establish a guide for teeth selection.

For measuring canine tips, a modified tool was used. The tips of the cusps of the canines, obtained on the horizontal arm of the canine tip marker, were found to be more distinct, easily measurable, accurate, reliable, noncumbersome, mostly technique invariant, and cost-effective as compared to the measurements taken from a dental stone model. Wax incisal edge registration used by Hoffman et al. for marking canine tips was not a suitable procedure because of inherent susceptibility to distortion of wax.

In the present study, association of ICaD with ICD, IPD, BZW, and IAD in males and females when evaluated separately as shown in Table 1 indicated very mild differences in correlation which was found to be not very significant clinically. Nevertheless the mean values of all landmarks studied were found to be slightly higher in males as compared to females. This finding was supported by Smith, Varjao and Nogueira, and Tripathi et al. It was found that irrespective of genders, except ICD, all the three variables had a moderate correlation (r = 0.5–0.7) with ICaD while ICD had mild correlation (r = 0.422; i.e. r = 0.3–0.5). All the correlations were statistically significant (P < 0.001). However, in a predictive modeling, using the same dataset for generating regression equation and then applying it back might result in a systematic error which results in almost similar mean value despite the independent values being different significantly. Hence, the extent of variability of each independent actual value from the calculated value of ICaD was analyzed in terms of percentage variation in Table 2. It shows that for all facial landmarks except ICD, most individuals had <5% variability. In this study, Interalar width showed the highest possibility of correlation and this finding was also supported by Mavroskoufis and Ritchie, Hoffman et al., Ahn et al., Hasareisoglu et al., Wehner et al., and Tripathi et al. However, Smith, Latta et al., and Varjao and Nogueira opposed the idea of correlation between interalar width and ICaD. There was mild correlation found between intercanthal width and ICaD which supports the finding of Al Wazzan and Abdullah who suggested that it can be used to estimate the mesiodistal width of maxillary anterior teeth for edentulous patients. The result of a study done by Gomes et al. showed that intercanthal distance, IPD, and intercommissural width were related to the highest probability of correlation with mesiodistal dimension of the anterior teeth. It was estimated that the combined width of the six anterior teeth measured slightly less than one-third of the BZW, which predicted the use of BZW as important landmark for the selection of maxillary anterior teeth size. The relationship expression of ICaD and BZW obtained in regression equation in the present study also supports this finding. Using regression methods,
the widths of the anterior teeth within the population tested may be predicted by a combination of the facial dimensions studied. The present study was done with 99% confidence level \((P < 0.001)\), and thus using regression equation, intercanine distance can be well estimated on the population group.

Although an attempt has been made in the present study to evaluate relationship between ICaD with various stable extraoral landmarks in Indian population, there is a need to include other reliable extra- and intraoral landmarks for establishing guidelines and formulae as esthetics today is of great concern and largely related to symmetry and proportion. More studies are needed to establish rules and criteria selection in various other races too for successful replacement of missing teeth.

**Conclusion**
The extraoral landmarks recorded in the study (IPD, intercanthal width, BZW, and interalar width) showed significant correlations with the ICaD of the young individuals studied. As these landmarks remain stable with time, these can be used as guide during teeth selection in elderly patients. On the basis of minimum mean differences and maximum number of cases showing <5% error, interalar width was considered to be the best suitable landmark for the selection of teeth while intercanthal width was least preferable. The measurement of mesiodistal width of anterior teeth can be well predicted by the use of regression expression obtained with reference to various landmarks studied.

**Declaration of patient consent**
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**
There are no conflicts of interest.

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