Original Article

Correlation between Intercanthal Distance, Intercanine Distance and the Mesiodistal Width of Maxillary Central Incisors; the Underlying Physical Parameters Defining Treatment Guidelines: A Cross-sectional Study

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Abstract

Background: While planning for the post-treatment rehabilitation of edentulous dental arches, most of the information is derived from anatomical landmarks of the face. If no pre-extraction records are available, it becomes difficult to plan for rehabilitation of such cases. **Aim**: To evaluate whether the intercanthal and intercanine distances can be used as a reliable guide to determine proportions of maxillary anterior teeth during the prosthetic rehabilitation of edentulous dental arches. **Materials and Methods**: This observational study included 500 subjects aged between 18-52 years. The mesiodistal width of maxillary central incisors and intercanthal and intercanine distances were measured for all study subjects; their correlation was assessed using Karl Pearson's correlation coefficient (r) test. **Results**: The findings of the present study showed a positive and statistically significant correlation between the mesiodistal width of the maxillary left central incisor and the intercanthal distance among the study subjects (r-value=0.093, *p*-value=0.037). No significant correlation was observed among the studied parameters in terms of gender among the included subjects. **Conclusion**: In the absence of pre-extraction records of the patients, the ratio between the mesiodistal width of the maxillary left central incisor and the intercanthal distance may be considered as a plausible source of information by the clinicians to determine the proportions of maxillary anterior teeth during the prosthetic rehabilitation of edentulous dental arches.

Keywords: Rehabilitation, Intercanthal Distance, Intercanine Distance, Anatomical Landmarks, Correlational Study

Introduction

Teeth are considered to be one of the most important features that contribute to the aesthetics of an individual. The size of the maxillary anterior teeth plays a vital role for optimized dental and facial aesthetics. If no pre-extraction records are available, it becomes difficult to plan for the rehabilitation of edentulous dental arches.[1,2] Since most facial anatomical landmarks are fixed, such as the length of the nose, facial length and/or the vertical facial height, bizygomatic width, width of eyes, the interpupillary distance, intercanthal and interalar widths, the length of the upper lip and the intercommisural width; most of the information are derived from these while planning for the post-treatment rehabilitation of edentulous dental arches.[3] Again, aesthetic analysis in orthodontics is based on a comprehensive and meticulous evaluation of a patient's facial harmony and smile, its

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relation to the face, and micro-aesthetics (analysis of the details of individual teeth and gums).[4-9]

The aesthetic grid analysis system, Index of Complexity, Outcome and Need (ICON), and Index of Orthodontic Treatment Need (IOTN), the use of digital photography and machine learning models are few such methods which have been used more commonly for analyzing the basic problems in the attributes towards restoring aesthetics in an individual.[10-12] Preliminary research has suggested that few of these landmarks act as a reliable guide during the prosthetic rehabilitation of edentulous dental arches. However, most of the studies conducted in this regard which have tried to evaluate the reliability of facial measurements for selecting dimensions of the teeth and especially maxillary anterior teeth among the various population subsets have concluded with conflicting results and varying opinions regarding their significance, while also significant inter-racial variations have been observed in these studies.[13-16] Hence, the present study was planned with a similar intent to evaluate whether such anatomical landmarks of the face, notably, the intercanthal and intercanine distances, can be used as a reliable guide to determine proportions of the maxillary anterior teeth during the prosthetic rehabilitation of edentulous dental arches.

Materials and Methods

The present observational study was conducted in a cross-sectional study design and included 500 subjects aged between 18-52 years. Only subjects who had all maxillary anterior teeth present/erupted with no spacing or crowding were included. Subjects were excluded if they had undergone orthodontic or restorative treatments, presented with carious or grossly destructed maxillary anterior teeth, or showed signs of malocclusion. Furthermore, subjects exhibiting signs of tooth wear in relation to maxillary anterior teeth, including age-related regressive alterations such as attrition, abrasion, erosion or abfraction, or displayed any dental or facial asymmetry due to dental or skeletal causes were also excluded. Additionally, individuals with diseases such as Cushing's syndrome or lipodystrophy, which might have altered facial contours, as well as those unwilling to participate, were excluded from the study.

Ethical Considerations

The details of the study were explained to all the participants from whom a voluntary written informed consent were voluntarily obtained before their inclusion. All reasonable efforts were made to ensure participant anonymity, and approval was obtained from the Institutional Ethics and Review Board (approval no. SDCH/IERB/01-89-2023) prior to the commencement of the study. Formal consent was also obtained from the relevant institutional authorities to use the data for academic and research purposes.

Methodology Used and Variables Measured

After recording a detailed case history for all study participants, the mesiodistal width of the maxillary central incisors and the intercanthal and intercanine distances were measured for all the subjects using a digital vernier caliper calibrated to a permissible error of approximately ±0.01mm. Three measurements were taken for each variable. The mesiodistal width of each central incisor was measured independently using a digital vernier caliper recording the distance from the most mesial to the most distal aspect of the tooth, with the widest dimension selected for analysis. The intercanthal distance was measured from the inner canthus of the right eye to the inner canthus of left eye while the subject was seated in an upright position, looking straight ahead. Care was taken to avoid compressing the soft tissues. For the intercanine distance, digital vernier caliper was placed between the distal-most aspect of right canine and the distal-most aspect of the left canine. Furthermore, all measurements were performed by a single examiner in order to eliminate inter-examiner bias. The mean of the three readings taken for each dimension were calculated and the data obtained subjected to statistical analysis. While taking the measurements, the intra-examiner agreement was found to be 0.9014 indicating fair reliability.

Sample Size Estimation

The Sample size was estimated using regression methods for correlation coefficient analysis. A sample correlation coefficient (r) of 0.1249 was selected based on a previous study that assessed the correlation between the mesiodistal width of maxillary central incisors and the intercanthal distance (in mm). The parameters utilized for this calculation were as follows:

Population's correlation coefficient (ρ)=0 Alpha (α) Error (%) =5
Power (%) =80
Sided=2
Required sample size (n)=500 subjects
Formula used to calculate sample size:

$$n = \left(\frac{Z_{1-\alpha} + Z_{1-\beta}}{C} \right)^2 + 3$$

$$Where \;\; C = 0.5 * \ln\left[\frac{(1+r)}{1-r} \right]$$

Where, (r)=Sample's correlation coefficient (r)=0.1249
z1-α=z-value for a level (1.96 at 5% α error or, 95% confidence)
z1-b=z-value for b level (0.842 at 20% b error or, 80% power)

Statistical Analysis

The data collected were entered into Microsoft Excel 2010, and statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics and Karl Pearson's correlation coefficient (r) tests were used to analyze the correlation among the studied parameters (mesiodistal width of maxillary central incisors, intercanthal distance and intercanine distance). An independent samples t-test was used to identify any significant differences between the studied parameters based on gender of subjects included in the present study. Prior to analysis, the normality of the data was tested using Shapiro-Wilk test; the data were found to follow a normal distribution. Consequently, Karl Pearson's correlation coefficient (r) test was applied rather

than Spearman's rank correlation. The statistical level of significance was set at 0.05, with *p*-values <0.05 considered statistically significant.

RESULTS

Table 1 presents the descriptive statistics for the measured parameters. The mean values were as follows: 17.1140±5.08201mm for the mesiodistal width of the maxillary central incisors, 30.7878±4.86784mm for the intercanthal distance, and 46.4248±6.41737mm for the intercanine distance.

Table 2 presents the comparison between the male and female subjects for the studied parameters [mesiodistal width of the maxillary central incisors and the intercanthal and intercanine distances (in mm)] using an independent samples t-test. No statistically significant differences were observed between genders for any of the parameters (p>0.05).

Table 3 presents the correlations among the studied parameters [the mesiodistal width of maxillary central incisors and the intercanthal and intercanine distances (in mm)]. While most of the correlations were not statistically significant, the findings revealed a weaker, yet positive correlation between the mesiodistal width of maxillary left central incisor and the intercanthal distance (r=0.093, p=0.037).

Figure 1 illustrates the correlation between the mesiodistal width of maxillary left central incisor and the intercanthal distance observed in the present study.

Table 1: Descriptive statistics revealing the calculated mean values of the studied parameters [the mesiodistal width of maxillary central incisors and the intercanthal and intercanine distances (in mm)] among the study subjects

Specified dimension of the variable(s) (in mm)	Mean	S.D. (σ)
Mesiodistal width of #11 + #21	17.1140	5.08201
Intercanthal distance	30.7878	4.86784
Intercanine distance	46.4248	6.41737

#11- Maxillary right central incisor; #21- Maxillary left central incisor; S.D- Standard Deviation

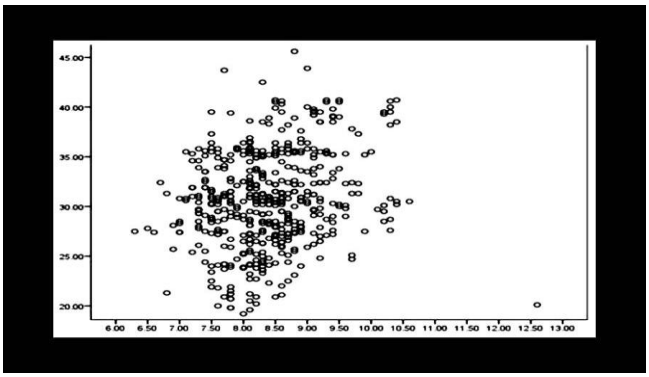


Figure 1: Correlation between the mesiodistal width of maxillary left central incisors and the intercanthal distances (in mm) among the study subjects . Along x-axis - Mesiodistal width of maxillary left central incisor; and Along y-axis - Intercanthal distance (in mm).

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Table 2: Comparison between male and female subjects for the studied parameters [the mesiodistal width of maxillary central incisors and the intercanthal and intercanine distances (in mm)] using samples t-test

Specified dimension of the variable(s) (in mm)	Male participants		Female participants		F-value	*p*-value
	Mean	S.D. (σ)	Mean	S.D. (σ)		
Mesiodistal width of #11	8.3904	0.76546	8.8141	5.83321	1.795	0.181
Mesiodistal width of #21	8.4240	0.76884	8.4502	1.56745	0.239	0.625
Intercanthal distance	30.8054	4.81341	30.7790	4.90209	0.042	0.837
Intercanine distance	38.0048	3.73314	50.6474	3.41040	1.663	0.198

#11- Maxillary right central incisor; #21- Maxillary left central incisor; S.D- Standard Deviation

Table 3: Correlation among the studied parameters [the mesiodistal width of maxillary central incisors and the intercanthal and intercanine distances (in mm)] among the study subjects using Karl Pearson's correlation coefficient (r) test

Specified dimension of the variable(s) (in mm)	*r*-value	*p*-value
Mesiodistal width of #11 and intercanthal distance	0.042	0.349
Mesiodistal width of #11 and intercanine distance	0.015	0.739
Mesiodistal width of #21 and intercanthal distance	0.093	0.037*
Mesiodistal width of #21 and intercanine distance	0.048	0.289
Combined mesiodistal width of maxillary central incisors and intercanthal distance	0.064	0.151
Combined mesiodistal width of maxillary central incisors and intercanine distance	0.027	0.551
Intercanthal and intercanine distances	0.064	0.153

#11- Maxillary right central incisor; #21- Maxillary left central incisor; *p<0.05- Statistically significant

Discussion

The present study was conducted to assess correlation between intercanthal and intercanine distances and the mesiodistal width of maxillary central incisors as potential physical parameters for defining treatment guidelines during the prosthetic rehabilitation of edentulous dental arches. The need for this assessment was to evaluate whether the anatomical landmarks of the face can be used as a guide to determine the proportions of the maxillary anterior teeth during the rehabilitation or replacement of such teeth, especially, if no pre-extraction records of the patient are available. The findings of the present study suggested a weaker, yet, positive correlation (r-=0.093) between the mesiodistal width of the maxillary left central incisor and intercanthal distance among the study subjects, while the results were found to be statistically significant (p-=0.037). The results of the present study were found to be in close accordance with the findings of the studies conducted by Al Wazzan [17] and Abdullah,[18] wherein the authors concluded similarly in favour of the intercanthal distance to be used as a reliable predictor of the maxillary central incisor width.

Similarly, significant correlations were also observed between the intercanthal distance and the width of maxillary anterior teeth, notably, maxillary central incisor teeth. In the study conducted by AL-Kaisy and Garib[19]; the authors also noted positive correlations that existed between the interpupillary distance and different tooth measurements in cases of maxillary anterior teeth, as well as between the interalar distance and the straight-line width of the six maxillary anterior teeth in the Kurdish population studied. Similar conclusions were also drawn in another study conducted by Pisulkar *et al*.,[20] wherein the authors observed a strong positive correlation between the intercanthal distance and the intercommisural width, and the width of maxillary anterior teeth with a moderately positive correlation observed between the interalar distance and the mesiodistal width of maxillary anterior teeth. In another similar study conducted by Mishra *et al*.,[21] to evaluate the inter-racial variations among the different facial parameters and the width of the maxillary anterior teeth, highly significant (p<0.001), yet weaker correlations were observed between the combined mesiodistal width of maxillary anterior teeth and the interpupillary distance as well as the interalar and intercommisural widths in the Aryan population. However, in the case of the descendants of the Mongoloid origin, similar correlations existed only between the combined mesiodistal width of the maxillary anterior teeth and the interpupillary distance. In the studies conducted by Kini and Angadi,[22] and Barman and Serin,[23] the authors observed a significant positive correlation between the interpupillary distance and intercommisural width, and between the interpupillary distance and the combined mesiodistal width of the maxillary anterior teeth based on the findings obtained in their studies. The study conducted by Kini and Angadi,[22] also observed a weakly positive correlation between the intercanthal distance and the combined mesiodistal width of maxillary anterior teeth irrespective of the gender and ethnicity of subjects included in the study.

This finding was in close accordance with the findings obtained in the present study, wherein a positive correlation was found between the mesiodistal width of maxillary left central incisor and the intercanthal distance among the study subjects, while no significant correlation was observed among the studied parameters in terms of gender. Hoffman *et al*.[24] and Attokaran and Shenoy,[25] also, concluded that interalar width be used as a reliable guide to determine proportions of the missing maxillary anterior teeth if no pre-extraction records are available for the patients. Contradictory results were however, obtained in the study conducted by Alshamri *et al*.,[26] wherein the authors observed no significant correlations between the interalar and intercommisural widths and the combined mesiodistal width of maxillary anterior teeth. However, statistically significant correlations were observed between the combined mesiodistal width of maxillary central incisors and the intercanthal distance, as well as between the interpupillary distance and the combined mesiodistal width of maxillary anterior teeth, and bizygomatic width and intercanine distances, in close accordance with the findings of the present study. Likewise, Al-el-Sheikh and Al-Athel[27] also found significant positive correlations between the interpupillary distance and interalar width and the combined mesiodistal width of maxillary anterior teeth based on the observations made in their study. The authors concluded that bizygomatic and interalar widths were more reliable indicators for establishing ideal width of the maxillary anterior teeth, particularly, in female subjects in a subset of the Turkish population used in the study conducted by Hasanreisoglu *et al*.[28]

In yet another similar study conducted by Ellakwa *et al*.,[29] the authors again concluded that the average length and width of the maxillary arch and the interalar width were highly reliable and provided the strongest predictive relationship with the combined mesiodistal width of maxillary anterior teeth (r=0.38-0.4) in absence of patients' pre-extraction records. Similarly, a

moderately positive correlation was observed between the interalar width and the combined mesiodistal width of maxillary anterior teeth and canine cusp width (r=0.439, r=0.374 respectively). A weakly, positive correlation was observed between the intercanthal distance and the combined mesiodistal width of maxillary anterior teeth and canine cusp width (r=0.335, r=0.303 respectively). In the study conducted by Strajnić *et al*.,[30] which is in close accordance with the findings of the present study however, the differences between the two genders were found to be statistically significant for all the parameters (p<0.01) in that study unlike the present study wherein no positive correlation was observed among the studied parameters in terms of gender. In another study conducted by Kurien *et al*.,[31] confirmed the reliability of interalar width in determining the circumferential arc width to be used as a reference during the prosthetic rehabilitation of edentulous dental arches. Again, the proportion of the interalar width to the width of the root of the nose was observed to be a reliable clinical indicator for determining the proportions of maxillary central and lateral incisor widths, as concluded in the studies by Sülün *et al*.,[32] and Reddy *et al*.[33] No such direct correlations were confirmed in the studies conducted by Esan *et al*.[34] and Deogade *et al*.[35]

However, a more recent study conducted by Wang *et al*.,[36] reinvigorated the discussion regarding the possibility of using different anthropometric measurements to predict the relative proportions of missing maxillary anterior teeth in absence of the required details, the authors suggested further studies to develop specific mathematical formulae that could be used in conjunction with the facial measurements to ensure accurate results. On similar lines, the findings of the present study, call for further research across different population frameworks, using various regression models along with adequate representation of the subjects from diverse races and ethnicities, to reach valid conclusions. This aligns with the findings of Isa *et al*.,[37] Nalawade *et al*.,[38] and Tripathi *et al*.,[39] who concluded that there is need to develop specific regression equations for more precise prediction of research question. Regarding the present study, the major advantage is the explicit methodology employed, wherein the readings were taken directly from the subjects using a highly accurate digital vernier caliper which was calibrated with a permissible error of the order of ±0.01mm, rather than from study models because of the high likelihood of inaccuracies including dimensional variations occurring during the preparation of casts from the impressions obtained from the subjects and patients.

Limitations of the Study

One of the major limitations of the study is the analysis of a single-source data, which calls for further multicentric studies with larger sample sizes, and adequate representation of populations from different geographic locales, races and ethnicities for the validation of results. Such research may also help in optimizing orthodontic treatment goals by establishing standards devised for a particular population group in future, as well as help in identifying the true patterns existing in a given population. The weak, though statistically significant correlation observed between the mesiodistal width of maxillary left central incisor and the intercanthal distance among the study subjects (r=0.093, p=0.037) mandates further studies in this regard to reach valid conclusions. Further research utilizing more evolved technologies including higher imaging modalities and methodologies involving a combination of methods for patients' analysis, may also help in standardizing a methodology that can be employed for the error-free collection of the data, which will be of obvious help in future orthodontic treatment planning.

Conclusion

The findings of the present study suggest a weak, yet positive, correlation between the mesiodistal width of maxillary left central incisor and the intercanthal distance among the study subjects; surprisingly, no significant correlation was observed among the studied parameters in terms of gender. Based on these findings, it can be concluded that in the absence of pre-extraction records of the patients, the ratio between the mesiodistal width of the maxillary left central incisor and intercanthal distance may be considered by clinicians as a probable source of information to determine proportions of maxillary anterior teeth during the prosthetic rehabilitation of edentulous dental arches.

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Conflicts of Interest

There are no conflicts of interest

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