Original Article

A Comparative Analysis of Interpupillary Distance and Corneal Diameter for Assessment of Width of Maxillary Central Incisor Using Digital Photography

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Abstract

Aim - The purposefulness of this study was to establish if a correlation existed between interpupillary distance, corneal diameter, and the width of the maxillary central incisor in selection of teeth .

Materials and methods - A total of 120 subjects-60 males and 60 females in the age group 18-26 years were selected based on predetermined selection criteria. On smiling the digital facial image constituting the teeth and the eyes were captured using standardized digital camera. The digital measurements of the interpupillary distance, corneal diameter (medial aperture height, tangential to cornea) and mesiodistal width of maxillary right central incisor in millimeters were analysed using Adobe Photoshop creative cloud software. The data was tabulated , to assess the association between the variables a Karl Pearson's Coefficient of Correlation was used.

Result –Although the Pearson correlation coefficient(PC) was relatively weak ($r<0.39$) a significant relationship existed between interpupillary distance and (right, left) maxillary central incisor width with p-value <0.01. A negligible positive correlation ($r< 0.27$) existed between right corneal diameter and (right, left) maxillary central incisor width with p value <0.01. A negligible positive correlation ($r< 0.28$) existed between left corneal diameter and (right, left) maxillary central incisor width with p value <0.01.

Conclusion - The correlations between interpupillary distance, right and left corneal diameter with maxillary central incisor were unable to produce a strong positive statistical association.

Keywords: Interpupillary Distance, Corneal Diameter, Width of Maxillary Central Incisor, Digital Photography, teeth selection.

INTRODUCTION

Complete denture treatment is successful only when it is functionally adapted and esthetically acceptable to the patient. Apart from teeth arrangement, facial harmony which determines the complete denture esthetics, is constituted by matching of shape, mould, color and size of teeth to that of the face[1].

Selection of anterior teeth plays most important role in determining aesthetics of complete denture[2]. According to Engelmeier, selection of the width of anterior teeth should be based on facial measurement and proportions[3].

Kassab NH and Wehner PJ etal used caliper or ruler and measured the dental casts or anatomical landmarks to correlated the dimensions of teeth and anthropometric parameters but accuracy of these measurements may vary since they measured manually [4,5].

Also, because of the compressibility of skin over these anatomic landmarks, error in recording the measurements cannot be avoided[6].

Currently, the biometric features of cornea can be used as persons identity which is a permanent identity for many years. It remains unchanged throughout the lifetime. The corneal dimensions may not vary even the pupil constricts by changing the light intensity [7].Interpupillary distance is stable and reproducible and does not modify after the age of fourteen[5].

The unavoidable human error can be eliminated by using equipment like computer. Sellen et al effectively demonstrated the dimensions of face and the teeth using computer [8].

As, there is a need to identify an acceptable method of determining the width of maxillary anterior teeth using a facial landmark that is relatively constant throughout lifetime and using equipment with minimized errors, in the current study, a computer software with standard analysis was to evaluate and correlate width of maxillary central incisor with corneal diameter and interpupillary distance in Nepalese population studying in Universal College of Dental Surgery, Bhairahawa, Nepal.

MATERIAL & METHODS

Selection Criteria:

Inclusion:

1. Patients having all-natural maxillary or mandibular teeth without malformation or fracture
2. Absence of gingival or periodontal pathology
3. Absence of anterior restorations of any kind
4. No history of orthodontic treatment
5. No interdental spacing or crowding
6. Patients having acceptable alignment.

Exclusion:

1. Carious maxillary central incisor
2. Fractured maxillary central incisor
3. Non vital maxillary central incisor
4. Incisors with crowns, restored incisors
5. Scarring in the upper lip
6. Cleft lip
7. Nasal infection
8. Any soft tissue or skeletal abnormality in face area
9. Subjects with hypermetropia, myopia, microcornea, macrocornea, congential anomalies.

1. Selection of the subjects:

Total of one hundred and twenty subjects aged between 18 and 26 years were selected based on complete enumeration system of all the students of Universal College of Dental Surgery, Bhairahawa, Nepal from first year to internship fulfilling all the inclusion criteriae. The study was conducted from 15TH March 2022 to 10TH June 2022,subjects were divided into two groups according to sex, males (60) and females (60). Prior to the study the ethical approval was taken from the institutional review committee(UCMS/IRC/041/21)

Obtaining photograph of the subjects and creating digital image in a computer file:

During the image capture the participants were asked to sit on a comfortable chair in an upright position. For the enhanced recording they were instructed to look straight ahead and smile to expose the maxillary anterior teeth. The chin was rested on a panoramic radiographic machine to support the head (Planmeca Proline PM 2002 CC; Planmeca). A white background with nonreflecting monochromatic, neutral was used. As colored background can reflect, so the background should be neutral white. Standardized digital photographs of the face were generated from frontal aspect using a digital camera.

The photographic images were made by a trained photographer in the same set up. Photographs were taken by using digital camera (EOS 5D; Canon India Pvt Ltd). An effective focal length of 61 AF points with EF-S Mount 50 mm lens 1.8 was used. The digital camera has a high-performance single-lens reflex camera featuring a fine detail, full-frame sensor of approximately 36×24 mm with 22.3 megapixels. A distance of 152 cm to the camera lens was standardized with a measuring tape and marked on the floor. A measuring paper tape was secured to the forehead of each participant to identify and homogenize the magnification error. All measurements i.e. interpupillary distance, corneal diameter and widths of central incisors were obtained using the ruler tool in the software.

The photograph was taken in such a way that complete face was shown focusing on the eyes and upper anterior teeth. The camera was positioned on the tripod, which could be adjusted to the subjects' height and keep the camera position consistent to avoid distortion. Cheek retractor was used to fully expose the maxillary anterior teeth, allowing for the measurement of the width of the maxillary central incisor. The image was imported after the image was captured ,saved in desktop as JPEG(joint photographic experts group) file and analysed using the image analyzing software (Photoshop creative cloud C6 2019; Adobe Systems Inc) which was used to edit the image and get comparable photographic results. Measurements of the interpupillary distance, right and left corneal diameter and mesio- distal width of right and left maxillary central incisors were made from digital facial photographic images.

2. Method of measuring using computer:

Image processing software (Photoshop creative cloud C6; Adobe Systems Inc.) was used to analyze the width of the interpupillary distance, corneal diameter and maxillary central incisors. The file containing photographs of the subjects was opened using the Photoshop software. The photo was automatically viewed. The toolbox was opened and the line tool command was clicked to make the measurements. The measurements were made by positioning the pointer on the line tool and held down using the mouse button on that tool.

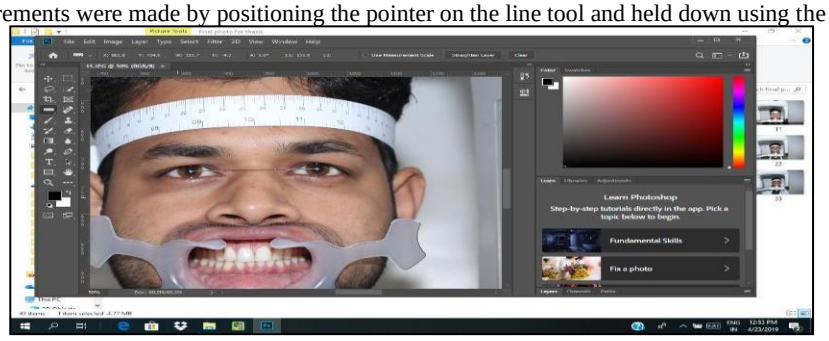

Figure 1. Photography showing interpupillary distance

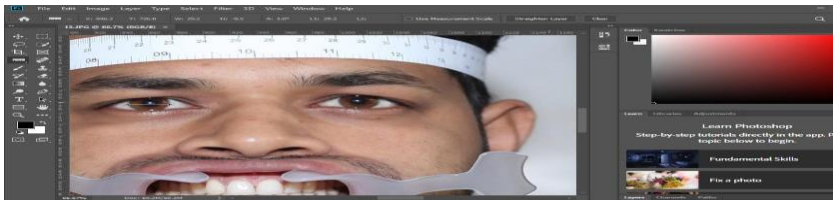

Figure 2. Photography showing corneal diameter

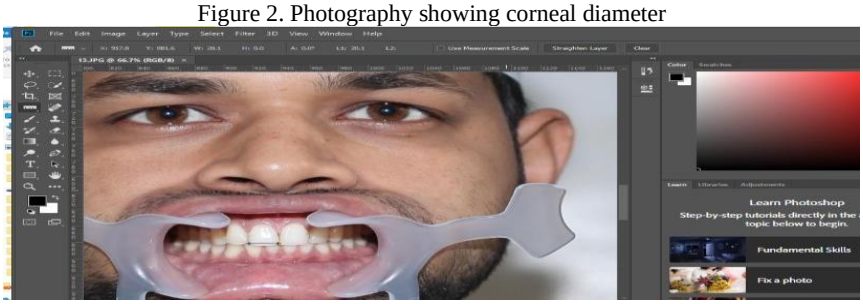

Figure 3. Photography showing mesiodistal width of maxillary central incisor

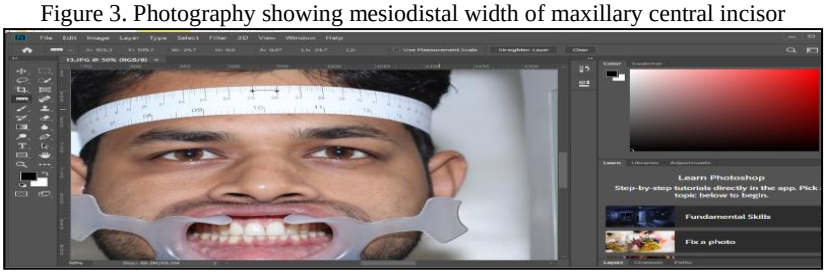

Figure 4. Photography showing the measuring paper tape distance on the photograph

The pointer was positioned on the mid pupil of one eye and the mouse button was clicked to measure the interpupillary distance. Then the pointer was dragged to the mid pupil point on the other eye and the mouse button was clicked again. The navigator on the corner of the screen gave the measurement in the scale (Figure 1). After positioning the pointer on the tangential height of medial corneal aperture the mouse button was clicked to measure the distance of right and left side of the cornea(Figure 2). The pointer was dragged from maximum convexity of the mesial side of the tooth to the distal side to measure the width of maxillary central incisor of both right and left side (Figure 3). The averaging of values were done after recording all the parameters 3 times.

In addition, an algebraic proportion may be established from the photograph for the magnification error. The known factors are the actual measuring paper tape distance, the measuring paper tape distance on the photograph and the width of the maxillary central incisor on the photograph(Figure 4). The unknown factor is the width of the natural maxillary central incisor. The proportion is arranged as:

$$\frac{\text{Actual measuring paper tape distance}}{\text{Measuring paper tape distance on the photograph}} = \frac{X}{\text{width of maxillary central incisor on photograph}}$$

OBSERVATIONS AND RESULTS

Statistical Analysis:

All the statistical analyses were performed using the Statistical Package for Social Science (SPSS), version 20.0 for windows. Using Intraclass Correlation Coefficients (ICC) Intraobserver reliability was assessed. Significance for all statistical tests were predetermined at. $p<0.01$.

For each participant the mean, standard deviation, range, minimum value and maximum value of every parameter were calculated. Pearson's correlation coefficient test was used to analyze the data.

Results:

(Tables 1 and 2)show that the Pearson correlation between interpupillary distance and widths of both right and left maxillary central incisors was found to be 0.39 at < 0.01 level at 2-tailed. The PC showed a weak positive correlation between interpupillary distance and widths of both right and left maxillary central incisors which was statistically significant.

Table 1: Correlation between interpupillary distance(IPD) and right maxillary central incisor width(Right CW).

			IPD (mm)	Right CW (mm)
IPD (mm)		PC	1	0.397**
		P value		<0.01
		N	120	120

Right CW (mm)		PC	0.397**	1
		P value	<0.01	
		N	120	120
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 2: Correlation between interpupillary distance and left maxillary central incisor width(Left CW).

			IPD(mm)	Left CW (mm)
IPD (mm)		PC	1	0.392**
		p-value		<0.01
		N	120	120
Left CW (mm)		PC	0.392**	1
		p-value	<0.01	
		N	120	120
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 3: Correlation between right corneal diameter and right maxillary central incisor width.

		Right cornea(mm)	Right CW (mm)
Right cornea (mm)	PC	1	0.276**
	p-value		0.002
	N	120	120
Right CW (mm)	PC	0.276**	1
	p-value	0.002	
	N	120	120

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

Table 4: Correlation between right corneal diameter and left maxillary central incisor width.

		Right cornea(mm)	Left CW (mm)
Right cornea (mm)	PC	1	0.280**
	P-value		0.002
	N	120	120
Left CW (mm)	PC	0.280**	1
	P-value	0.002	
	N	120	120

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

(Tables 3 and 4) show that the Pearson correlation between right corneal diameter and widths of both right and left maxillary central incisors was found to be 0.27 at <0.01 level at 2-tailed. The PC showed a negligible positive correlation between right corneal diameter and widths of both right and left maxillary central incisors which was statistically significant.

Table 5: Correlation between left corneal diameter and right maxillary central incisor width.

		Left cornea (mm)	Right CW (mm)
Left cornea (mm)	PC	1	0.283**
	P-value		0.002
	N	120	120
Right CW (mm)	PC	0.283**	1
	P-value	0.002	
	N	120	120

Table 6: Correlation between left corneal diameter and left maxillary central incisor width(Left CW).

		Left cornea (mm)	Left CW (mm)
Left cornea (mm)	PC	1	0.289**
	p-value		0.001
	N	120	120
Left CW (mm)	PC	0.289**	1
	p- value	0.001	
	N	120	120

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

(Tables 5 and 6)show that the Pearson correlation between left corneal diameter and widths of both right and left maxillary central incisors was found to be 0.28 at <0.01 level at 2-tailed. The PC showed a negligible positive correlation between left corneal diameter and widths of both right and left maxillary central incisors which was statistically significant.

DISCUSSION

In prosthodontic treatment aesthetic plays a vital role in patients' satisfaction .Fabrication of a natural looking denture is not an easy task[9].The use of facial measurements as a guide for selection of anterior teeth for complete denture have been used in the past like interzygomatic distance, inner and outer canthus measurement, interalar, mouth and philtrum of upper lip widths and face length (Nasion–Gnathion)[1].

There will be some amount of human error when we use anatomic landmarks for selection of teeth to complete denture. Hence, the present investigation has been done by using a computer. Various authors have used computer for investigation and accurately recorded the measurements[6].

The interpupillary distance remains equally constant once the growth of the individual stops[1]. Among all the anthropometric parameters, interpupillary distance which remains fairly constant may become a reference guide and also very easy practically to use as a guide in determining the width of the maxillary anterior teeth[1].

In research SLR camera was used because it has many advantages like high quality photographs , it allows us to change lenses and alter different type of flash. After taking photographs operator can check whether he or she have a usable image and you can download photographs onto a computer within minutes. Transferring image file to personal computer is easy via USB connection[10,11].In this study EF- S Mount lens camera was used .The advantage of using the lens was smaller the lens aperture, the greater the depth of field point and also high frame sensor which allows distortion free images[10,11].

With advent of digital photography high quality dental images can be obtained and same can be processed with software which gives data. The use of digital facial photography is a non-invasive method which is accurate and yet very cost effective[11]. Extensive use of digital technique of assessments helps the clinician to access ,store easily and analyze frequently in the absence of patient photographs[11].

To bring standardization and uniformity, all the photographs were taken by one photographer over a fixed distance . Digital technique was used to capture image and stored in desktop. As it has many advantages like reduces human errors and it can be easily transferred and stored using JPEG file.

JPEG file has many advantages like compressibility, compatibility with all devices and software, it is vibrant and colorful. It has many advantages operator can edit the image and get comparable photographic results. Software also has ruler too which allowed operator to measure the required facial measurements in research. Reliability of digital measurements have been found comparable to manual measurements. [11,12,13]

The results of table 1 and 2 is supportive to the previous studies done by Habbu et al[1],Anitha et al[12],Ellakwa et al[14], Sharma et al[15],Al-Kaisy and Garib[16] and Jogeswar et al [17] and contradict to the findings by Wazzan and colleague[18] and Hussain MW et al[19] who found no significant correlation.

Hemalatha K, Chander NG, Anitha KV did a study to determine the correlation between the horizontal visible iris diameter (HVID) of the eye and the mesio distal width of the maxillary central incisor tooth in dentate Indian population. Authors stated HVID of the eyes can be used to estimate the mesio distal width of the maxillary central incisor tooth. The result of table 3, 4, 5 and 6 is supportive to the previous studies done by Hemalatha et al[12]

Jogeswar B, Sangama S evaluated the relationship between the interpupillary distance (IPD) and the combined mesio distal width of maxillary central incisors (MDW of MCIs) to establish their morpho metric criterion and there significance in two ethnic group of north east India.

The mesiodistal width of maxillary central incisors and IPD of all the sample revealed high degree of statistical significance regardless of ethnicity and sex . The values of mesiodistal width of maxillary central incisors and IPD can be used as a guide in determining the dimensions of each other[17].

The balance of the facial architecture and dental dimensions is very important for the rehabilitation of the emotional circumstances of tooth loss. Through this methodology, the width of the anterior teeth can be predicted offering a better esthetic result to oral rehabilitation as compared to conventional methods. The study incorporated the basic of the computer program to analyze correlation between cornel diameter, inter papillary distance and width of maxillary central incisor in Nepalese population, which may be helpful in clinical practice . In future dentist need more advanced technology-based software which can be help full in selecting teeth which has better efficiency then manual system .

CONCLUSION

1. There was a weak positive correlation between interpupillary distance and widths of both right and left maxillary central incisors which was statistically significant.
2. There was negligible positive correlation between right corneal diameter and widths of both right and left maxillary central incisors which was statistically significant.
3. There was negligible positive correlation between left corneal diameter and widths of both right and left maxillary central incisors which was statistically significant.
4. Final decision about tooth selection should be made during trial insertion stage and should be confirmed through consultation with the patient.
5. As the predictive strength is not strong, interpupillary distance and corneal diameter can be used as an additional guide or initial tentative step for determining the width of the maxillary central incisor during the initial selection of artificial teeth in the absence of pre-extraction record.

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Ethics statement: The study was approved by the institutional review committee Universal College of Dental Surgery, Bhairahawa, Nepal .Ethical approval number UCMS/IRC/041/21.

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