

Mathematic method to calculate the central incisor form using face records and vice versa

Laith Mahmoud Abdulhadi, Hana Abbas Mohammed

Abstract— Selection of anterior teeth depends mainly on Leon William theory that hypothesizes the presence of harmony between the face and inverted central incisor forms. If this theory is approved mathematically then the central incisor form and width could be predicted and calculated with acceptable precision in clinical practice. The purpose of this study was to predict the tooth form and mesiodistal width from the facial measurements. 145 young volunteers from different ethnic groups (Malays, Chinese, and Middle easterners) were selected according to well-defined criteria. Frontal standardized digital photos were taken for each person face and left central incisor. Then, the face and central incisor image length and widths (at different levels) were measured using digital image analyzer. The results revealed the presence of high metric dependence between the face and the left central incisor widths. A linear regression analysis was used to formulate a general equation to predict the central incisor width and form outline from the face measurement successfully. On the other hand, the face form can be predicted from the central incisor records

Keywords— Linear regression analysis, Tooth form prediction, Central incisor form prediction.

I. INTRODUCTION

ANTERIOR teeth width and form selection is one of the most important steps in establishing optimum natural aesthetics. This step should satisfy the patient and his relatives as well as the dentist, and promote patient self-confidence, welfare, and psychological relief. The inverted tooth-face form matching theory is not new. Leon William (1914) hypothesized the presence of a harmony between the frontal view of inverted central incisor and the face form and he classified the central incisor and face forms into 4 basic geometrical shapes for harmonious matching [1]. In addition, the most pleasing appearance can be achieved when the outline form of the inverted individual's face and that of the individual's maxillary central incisor are identical [1]. Many researches confirmed such morphologic similarity by using visual perception matching, computer shape matches according to Hausdorff distance (HDD), simple or sophisticated statistical correlation analysis [2] or even genetic

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L. M. Abdulhadi, is Associate Professor with the Faculty of Dentistry, University of Malaya, Kuala Lumpur 50603, Malaysia (phone:+6-03-7967-7482; fax: +03-7967-5435; e-mail: laithabdulhadi@um.edu.my).

H. A. Author, was with Mahsa University College, Block A, Pusat Bandar Damansara, Damansara Heights, 50490 Kuala Lumpur, Malaysia. She is now with the Department of Prosthetic Dentistry (phone:+603-20929999 ,Fax:+603-20934995; e-mail:hana_alani_2006@yahoo.com).

findings. However, some controversy is persisting.

On the other hand, the old theory of Leon William continues as the most universally acceptable method that provides artistic desirable harmony for anterior teeth form selection in the absence of pre-extraction patient's records. The Law of harmony (William, 1914) stated that the anterior teeth form in the frontal plane could be classified into three major shapes: rectangular, triangular, and ovoid.

The face form, personality and expression, the proportions of the other parts of the face, the lip, eye forms and colors, in addition, the oral cavity, the tooth shape and size, arch form, the palatal contour, and teeth arrangement may affect on agreeable facial look[3]-[7].

The literatures review for the last 3 decades revealed that the major concern of the researchers was to examine the existence of relationship as stated early by the law of harmony [6], [1] [8]-[10]. The recent studies showed the existence of a powerful morphometric relation between the face and inverted central incisor forms in different ethnic groups.[1],[9], [10]. However, looking in the literatures for the last decades revealed the absence of any research that was conducted to use of the presence of mathematical relationship between the face and the central incisor form in dental clinical application like prosthetic dentistry and forensic science Therefore, the finding can be extended by applying the regression analysis to find the best model-fit for the central incisor –face width relationship.

The purpose of this study was to propose and illustrate a method to predict the tooth contour from the face dimensions in the frontal aspect and vice versa.

II. MATERIALS AND METHODS

The ethical committee in the Faculty of Dentistry, University of Malaya had approved this study. Sample size inference for a power significance ($1-\beta$ err = 0.95) was estimated using G*Power 3.2.1 (free software) after a pilot study. Therefore, a mixed sample including 145 subjects and composed of 60 males and 85 females was used in this study. The model was composed of healthy completely dentate 65 Malays, 55 Chinese and 25 Middle Easterners. Their ages ranged between 17-25 years (mean= 22.3±1.575) (Table I).

Table I The composition and features of the sample

Ethnicity-Sex	No.	%	Mean Age	SD	Min	Max	Skew
Malays-♂	23	19.2%	23.35	1.555	19	25	-1.991
Malays-♀	42	35.0%	23.48	1.194	21	25	-0.663
Total Malays	65	44.8%	23.43	1.323	19	25	-1.393
Chinese-♂	25	20.8%	22.28	1.904	19	25	-0.122
Chinese-♀	30	25.0%	23.20	.761	22	24	-0.362
Total Chinese	55	38%	22.78	1.462	19	25	-0.824
Mid-East-♂	12	48%	20.90	2.257	17	25	0.264
Mid-East-♀	13	52%	20.67	1.614	19	23	0.496
Total Mid-Est	25	17.2%	20.84	2.111	17	25	0.321
Total sample	145	100.0%	22.3	1.575	17	25	-0.475

The inclusion criteria for selection of the sample imposed that the individuals should not been undergone any conservative treatment or prosthetic replacement for their anterior or posterior teeth and that were normally aligned, in addition to the absence of concurrent or previous orthodontic treatment. Subjects with gingivitis, periodontitis, enamel dysplasia, attrition and abrasion, amelogenesis imperfecta, dentinogenesis imperfecta besides teeth malformation were excluded from the study.

Each individual was photographed at a constant distance, height, and magnification using Nikon digital camera (Nikon Co.) mounted with macro lens (AF Micro Nikkor 60mm 1:28D, Japan) and a ring flash and fixed on a tripod. The distance was set at (150 cm) horizontally and (135 cm) vertically measured from the subject nose tip to the lens and the floor. Preliminary impression for the maxillary arch of each subject was made using irreversible hydrocolloid impression material (Kromopan 100 hours Hydrocolloid dust free iso 1563 class A type1. Italy) and perforated stock impression tray (Ash Co Ltd Hert fort shine, England) according to the manufacturer's instructions. The impression was poured using dental stone (Heraeus Kuzler Corp., Hanau, Germany). The most external boundaries of the left central incisor (CI) was marked on the cast using pencil marker (Ø 0.5 mm) then photographed using similar distance and height in relation to the tooth surface. The images were uploaded into the computer. The face and CI images were divided into 15 parts by 14 horizontal lines using the image analyzer software (Leica quin lite image analysis V2 7.1) (Fig.1).

The similar lines of the face and CI were measured in mm and correlated using linear correlation after calibration of the tooth and face dimensions.

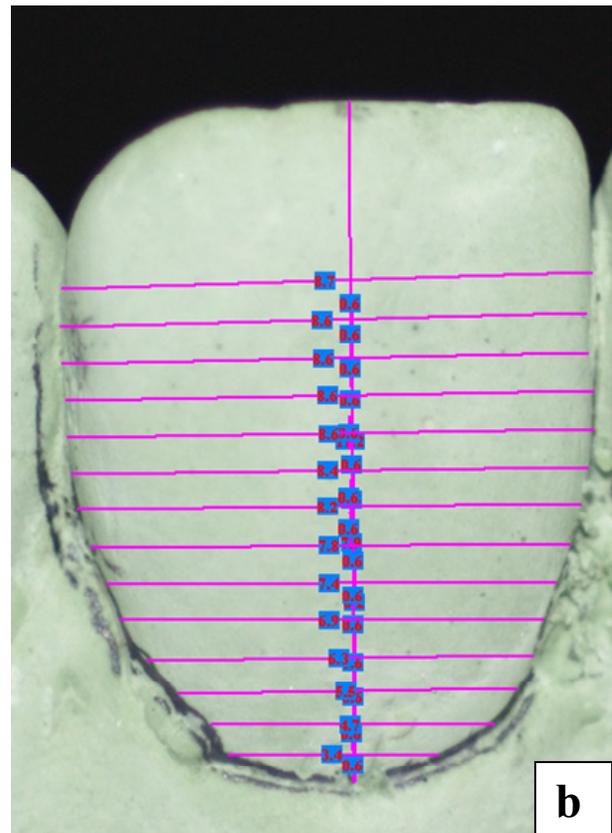
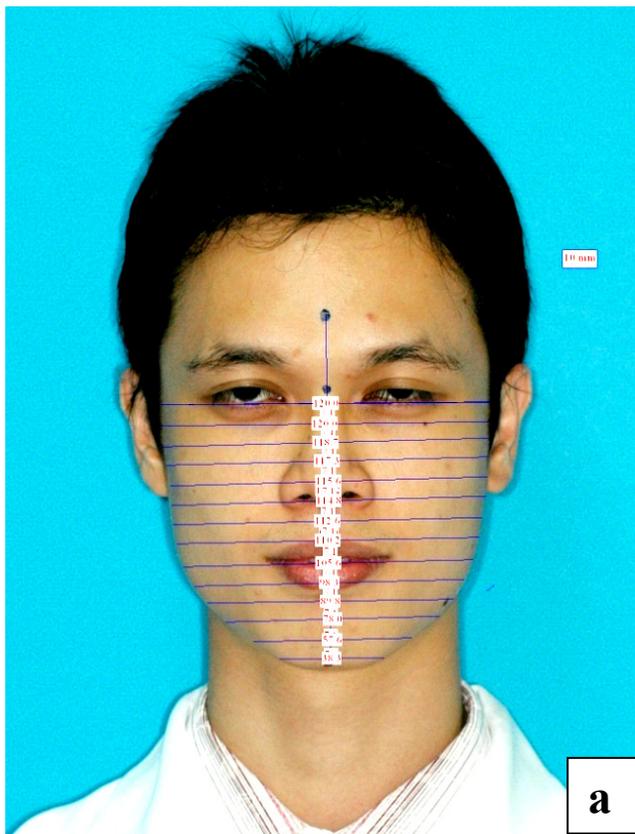


Fig. 1 a,b The method of dividing the CI and the face into 15 divisions

The data were analyzed using SPSS version 17 for normality of distribution and parametric linear correlation between the face and CI variables. In addition, regression analysis was applied to find the best curve fit. Two primary models were proposed one for the CI and another to the face (Fig 2) to predict their dimensions and forms alternatively using the available data.

III. RESULTS

The total number of measurements was equal to 4060 records for the CI and the face. A high linear correlation ($r^2 = +.67$, $p < 0.05$) was found between the CI and face dimensions (Table II, Fig 3).

Table II Correlation coefficient between the face and CI widths

R	R Square	Adjusted R Square	Std. Error of the Estimate
.819	.670	.670	.977

Table III The coefficient and constant of the linear equation

	Unstandard.Coe		Standard.Coe	t	Sig.
	B	Std. Error	Beta		
F1	.054	.001	.819	58.140	.000
(Constant)	1.502	.098		15.301	.000

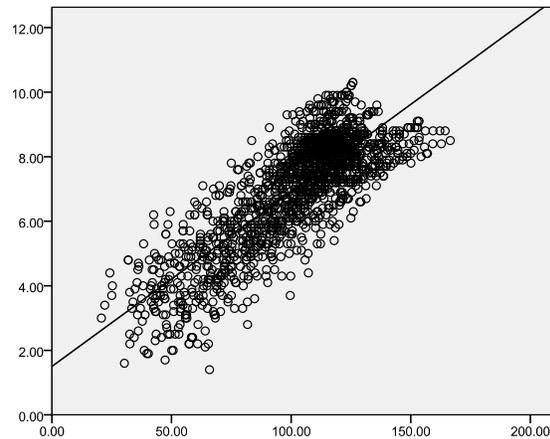
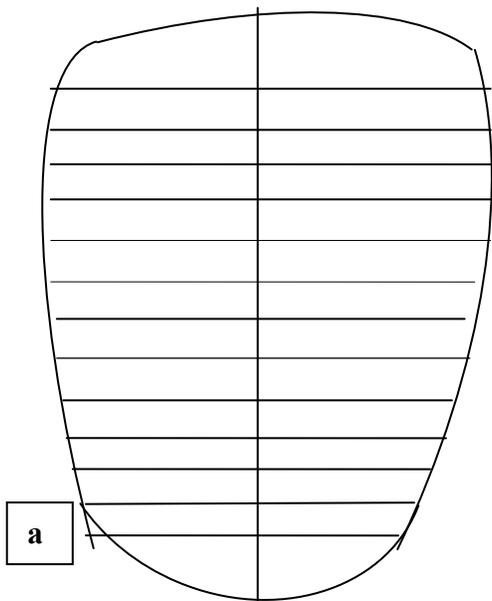


Fig 3 Scatter gram of the Face-Tooth relationship

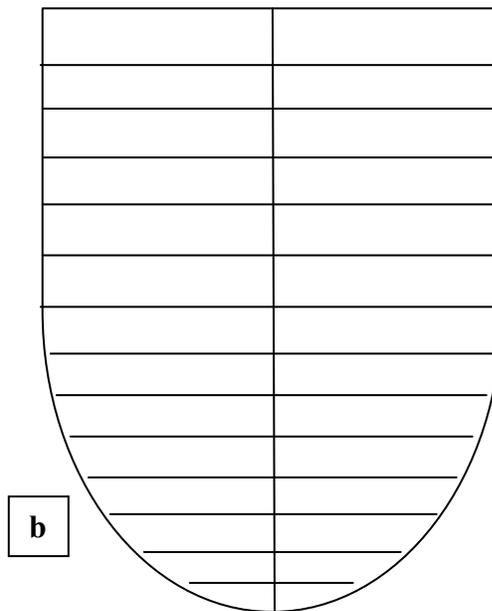
Table IV The mean of the face and CI lengths of the sample

	N	Min	Max	Mean	SD	Skewness	Std. Err	Kurtosis	Std. Err
LT	145	6.70	9.80	8.1	.833	.409	.221	-.817	.438
LF	145	72.80	133.23	108.2	9.574	-.866	.221	2.650	.438



$$Y = 1.502 + 0.054 (X)$$

Central Incisor Model



$$X = (Y - 1.502) / 0.054$$

Face form model

Fig. 2 The models of CI (a) and the face (b)

The application of regression analysis yielded a general linear model that represented the best curve fit. The resulted linear formula can be used to estimate the CI widths from the face dimensions (Table III). The mean CI and face lengths were 8.1 ± 0.83 mm and 108.2 ± 9.6 mm respectively in addition to the other results are shown in Table IV.

The linear formula to calculate the CI widths at variable heights from the face dimensions is

$$Y = 1.502 + 0.054 (X) \quad (1)$$

Y represents the width of the CI in mm at any height
X represents the face width at analogous height to CI

On the other hand, the formula (2) used to calculate the face width from the remaining CI when necessary

$$X = (Y - 1.502) / 0.054 \quad (2)$$

X in mm symbolizes facial width at any location
Y in mm CI width at any similar height to face

When the face and CI lengths were correlated statistically, the result was not significant at $p < 0.05$. Therefore, the mean CI and face length can be used to replace the length in the CI or face models taking into consideration the mean and standard deviation of their measurements (Fig 2)

IV. DISCUSSION

Singer (1993) demonstrated the importance of understanding the single concept in shaping dental restoration. They defined the face of a tooth as the area of the buccal surface on both anterior and posterior teeth that is bounded by transitional lines and angles as viewed from the facial aspect. According to this concept the apparent face is the portion of the face that is visible to the viewer from any angle view. The perimeter of the apparent face is dictated by the position of the viewer relative to the tooth. For example, from the frontal view, the entire incisor faces are visible, but usually only the mesial half of the faces of maxillary canines [11].

Ethnicities have shown that there is specific preference regarding the teeth size and color selection to capture youth and look. The patient's own natural teeth may or may not have been aesthetic but it is the image of youth and attractiveness that is remembered [12].

Many techniques have been introduced for teeth selection and aesthetic rehabilitation however the principles have no metrical or anatomical bases. For example the indicator that is introduced by Dent Supply company and the automatic instant selector suggested by Austenal Company [13].

The selection and measurement of the teeth and the face widths might be biased due to many factors. For example, the actual CI boundary cannot be recorded accurately due to the close teeth contact and the presence of interdental gingivae

which covers the tooth proximal surface. The face image in frontal plane was measured from widest area to the gnathion. In reality the similarity between the tooth-face forms using the former limits produced excellent matching. However, the theory of Leon William described the limits to be including the front also. This hypothesis was the cause of many studies failure to find such mathematical similarities. The only matching was evident when the measurements were limited to the widest area of the face as well as the central incisor. The measurement reliability was used to The inter-examiners reliability of 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 $p < 0.01$).

The prediction of the tooth dimensions in the labial aspect leads to calculating the tooth form using linear regression analysis method. The mathematic method produced consistent and more objective results when compared to visual assessment or visual matching which are more subjective and depend on personal experience and taste rather than actual metric principles. In addition, this method offers a precise face or CI models based on real object measurements so that less errors may be anticipated during the search for the proper CI-face dimension –form. Furthermore, many scientific and clinical applications are expected to profit of this method like in forensic medical and dental practices to reconstruct missing or disfigured parts of the face using the remaining CI to calculate the form and dimension properly.

Calculation of the central incisor form using of the face measurements or visa-versa by replacing them in the formulated equation is a new method of teeth selection. The result of this study supports the theory of Leon William in part and can make advantage of his assumption of face-CI form classification by predicting the shape directly from the real measurements of the face and then classify the resulted teeth dimension into different categories according to the face dimensions. The results can be tabulated for faster teeth or face form assortment in daily practice.

Therefore, visual perception is no longer used for face matching due to its subjectivity [14], [15].

The application of this method is slightly time-consuming without the use of additional simple software that calculates the 14 widths of the predicted CI form. A further advancement of this method is the use of prototype machine to modify the selected anterior teeth accordingly. A classification of the resulted CI forms in a similar way to that of Leon William may provide the dentists with a further simple guide to select form and dimension of central incisor in frontal plane. The predicted forms of CIs through the use of facial dimensions can be classified according to defined criteria and a chart may be used following the width of the face to provide immediate tooth selection. Another advantage of this method is the possible application in maxillofacial replacement or anaplastology to predict the face form and dimensions in case

of big structure loss from the remaining CI especially when the results are combined with prototype machine.

The analysis showed the absence of metric relationship between the face and the tooth lengths. We suggested the use of the mean value of tooth or face lengths and the standard deviations to classify the CIs and faces into 3-5 metric classes to be used to calculate the CI or face length of the models during prediction of the CI width using the linear regression formula at different width levels. The result will be a CI or face frontal view.

How can the findings of this study be applied in daily dental practice? The face or the CI was photographed using the same distance and height. Then, face or CI is measured using the facial image analyzer either manually or digitally. A model of the face or CI is configured by The facial width records are input in the equation to find the CI widths and the form. A central incisor model (Figure 2) is used as a basic form that can be modified according to the predicted dimensions taking into consideration the length of the CI depending on the face length as mentioned earlier. In addition, the reconstruction of the face can profit of advanced technique based on this prediction method with some modifications.

V. CONCLUSION

A new method has been presented for calculating the tooth form and dimensions in frontal plane using the facial dimensions as a references and vice versa. This method can be used to calculate the face form as well as the central incisor forms and can be applied in many disciplines. Further enhancement can be achieved by incorporating a software and prototype machine to produce central incisor form, dimension from face dimension and vice versa.

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Laith M. Abdulhadi (M'2011), This author became a Member (M) of NAUN in 2011. Abdulhadi is borne in Iraq, in 1955 and obtained his BDS (dentistry, University of Baghdad, Baghdad, Iraq, 1977), CES (Anthroplogy, Genetic, Compared Anatomy, University Paris 7, Paris, France, 1981), CES (Rehabilitation of Totally edentates, University Paris 7, Paris, 1982),(Rehabilitation of Partially edentates, University Paris 7, Paris, 1983), and Doctorate in Dental Sciences(Occlusion and Axiography, University Paris 7, Paris, France 1984). The author's major field of study is prosthodontics and Maxillofacial Rehabilitation.

He worked as a Senior Lecturer in the University of Mosul, Iraq, as Assistant Professor in Mosul and Baghdad University from 1984-1999. He was recruited by the University of Sana'a, Yemen in 1999 until 2005 as Associate professor and Dean of the faculty of dentistry, and then promoted to Professor in 2003. He is currently Associate Professor in the Department of Prosthetic Dentistry, Faculty of Dentistry University of Malaya. He started his work in University of Malaya since 2005. Some of his publications;

- [1] LM Abdulhadi." Multiple retentive means for prosthetic restoration of A large facial defect. A case report" C. J. D. .R ,vol. 13, no.1, pp. 61-66. 2010
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The current and previous research interests are concerning the Maxillofacial new retention technique and enhancement of materials used, Medical-grade silicone color matching experiments, Biometry, Implants, Axiography, Occlusion, Temporomandibular dysfunction. Bone resorption mechanism and influencing factors.

Prof. Abdulhadi is a member of the following professional societies;

1. The European Prosthodontics Association
2. International Conference of Education, Research and Innovation, 2011
3. International Association of Dental Research-Malaysian Section.
4. American Prosthodontics Society (1993).
5. Iraqi Dental Association.
6. Association of American Dental Education

Prof.Abdulhadi is a reviewer for the NUAN organization in 2011. Journal of Oral Implantology , Journal of Oral and Maxillofacial Implantology, Journal of Dental Research, and WSEAS Organization.

Hanna A. Mohammed. Mohammed is born in Iraq, in 1954 and obtained her BDS(dentistry, University of Baghdad, Iraq, 1977), (MDS, University of Baghdad, Baghdad, Iraq, in 1989). The author's major field of study is Prosthodontics and Maxillofacial replacement.

She worked as s Lecturer in the University of Mosul, Iraq, and in Baghdad University from 1984-1999. She was recruited by the University of Sana'a,

Yemen in 2000 until 2005 as lecturer in the faculty of dentistry, and then recruited in Thamar University , Yemen as Assistant Professor, 2006-2007. She is currently Associate Professor in the Department of Prosthetic Dentistry, Faculty of Dentistry ,MAHSA University College. She started her employment in University of Malaya in 2008. Some of her publications;

[1] HL. Mahmoud, LM. Abdulhadi, H.A. Mohammed, Comparison of Spectrometer, Digital Camera, and Scanner Reproduction of Captured Skin Colour (IFMBE Proceedings 35, p. 33-37,2011)

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