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TO EVALUATE THE RELIABILITY OF DIFFERENT FACIAL ANATOMIC LANDMARKS CLOSEST TO THE MIDLINE OF THE FACE USING ESTHETIC FRAME CONCEPT IN TWO AGE GROUPS.

Dental Science

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ABSTRACT

Background & Objectives:
The midline is the fundamental reference for all esthetic deviations. Therefore, knowledge of the midline will invariably result in a better understanding of facial and dental esthetics. However, the literature is not clear regarding verifiable guidelines for the determination of midlines of the face or mouth. The aim of this study was to determine the hierarchy of facial anatomic landmarks closest to the midline of the face as well as midline of the mouth.

Objectives:
The objectives of the study were to define:
(1) The hierarchy of facial anatomic landmarks closest to the midline of the face;
(2) The hierarchy of facial anatomic landmarks closest to the midline of the oral commissures (mouth); and
(3) The relationship between the midline of the oral commissures and the midline of the face.

Material and methods:
- This study was conducted among subjects of Dakshin Kannada population.
- Frontal full-face digital photographs of the subjects (in smile) were made under standardized conditions using a digital camera and
- A tripod stand was used to place and orient the camera in the standardized position (camera was positioned 5 feet away from the patient; and the lens of the camera was adjusted at the patients' eye level).
- Imaging software (Adobe Photoshop CS5; Adobe Systems, Inc, San Jose, Calif.) was used to mark the anatomic landmarks and to digitally analyze the photographs.

Deviations from the midlines of the face and mouth were measured for the 3 clinical landmarks; the existing dental midline was considered as the fourth landmark. The entire process of midline analysis was done by a single observer.

Results:
The results indicated that each of the 4 landmarks deviated uniquely and significantly (P<.001) from the midlines of the face as well as the mouth.

Conclusion:
Within the limitations of the study, the hierarchy of anatomic landmarks closest to the midline of the face in smile were as follows: The midline of the oral commissures, dental midline, tip of philtrum, nasion and tip of the nose. The hierarchy of anatomic landmarks closest to the midline of the oral commissures was: tip of philtrum, dental midline, nasion and tip of the nose. These relationships were the same for both age groups studied.

KEYWORDS

Facial midline, Facial symmetry, Inter-commissural midline, Esthetic Frame.

Introduction:
The classical elements of facial beauty are Symmetry, normalcy, sexual dimorphism and youthfulness. Symmetry means "correspondence in size, shape and relative position of parts on opposite sides of a dividing line or median plane or about a center or axis"[1]. The midline, that is the fundamental of all esthetic deviations, is the dividing line, which is used to attain symmetry.

Thus for better understanding of facial and dental esthetics knowledge of the midline will be essential. In the History various facial anatomic landmarks like the bisector of the pupils, nasion, tip of the nose, tip of the philtrum, and chin, located on the middle third of the face have been used to determine the facial and dental midlines[2,3]. The use of intraoral landmarks, like the incisive papilla, for determination of the maxillary dental midline was also supported by some. Whether the dental midline should be made coincident with the midline of the face or the midline of the oral commissures was also point of argument in the literature.

Some were of the opinion that it is adequate by making the dental midline coincident with the midline of the oral commissures because patients will likely relate their dental midline to proximal structures and not to the anatomic structures as they are farther from the mouth[4,5].

The literature though is not clear regarding verifiable guidelines for the determination of midlines of the face or mouth. Most clinicians choose one specific anatomic landmark and an imaginary line passing through it based upon convention and dogma. Whereas, dental floss is used by others by holding it in front of the face from glabella to menton.

The clinician thus has to determine the midline based on unverified landmarks as he is left with no predictable guidelines.

It is more important in dental esthetics that the maxillary dental midline and the facial midline coincide, than the mandibular and facial midline, which is mainly because of the dominant visibility of the maxillary anterior teeth in smile and function. This coincidence is not mandatory but it is desirable. Over and above the removable and fixed prosthodontics, implant prosthodontics, orthodontics, and facial plastic surgery the maxillary dental and facial midlines has an key role in esthetics and occlusion in many disciplines.[6]

There was lack of objectivity in the evaluation criteria for facial midlines in all the previous studies. The lack of a repeatable and verifiable definition for facial and dental midlines and lack of scientific information on relationships of specific anatomic landmarks with the facial midline are the gaps in the knowledge in this field. A lack of information about the relationship of the 2 standard midlines: midline of the face and the midline of the mouth is an addition to it, providing the rationale for this study.

And its main objectives were to define: (1) the hierarchy of facial

anatomic landmarks closest to the midline of the face; (2) the hierarchy of facial anatomic landmarks closest to the midline of the oral commissures (mouth); and (3) the relationship between the midline of the oral commissures and the midline of the face. Traditionally used facial anatomic landmarks in clinical practice such as: nasion, tip of the nose (pronasale), tip of philtrum (labiale superioris), and dental midline were also analyzed.

It was a null hypothesis that there is no difference between the chosen facial anatomic landmarks and the midlines of the face and oral commissures,

MATERIAL AND METHODS:

Convenience sampling of 249 medical and dental students/employees with an age range of 21-45 years at the University of Connecticut Health Center was obtained with the approval of Institutional Review Board approval .

A single observer simulated a clinical situation by placing 3 small marks in each subject using a fine-tipped erasable marker, with a tip approximately 0.5 mm in diameter (Expo; Sanford Ink Co, OakBrook, Ill) on the nasion, tip of the nose, and tip of the philtrum. Application of all anatomic marks in terms of the standard anatomic and anthropologic definitions described below was given standardization.
A digital camera (Nikon D70s digital camera, 6.1 Megapixel; Nikon USA, Melville NY) was used in the 12 o'clock position. It was having a 105-mm lens, a point flash and an additional flash with a wireless speedlight (Nikon SB-R200 Wireless Speedlight; Nikon USA).On the top of the tripod was the camera with an aperture setting of F4.5 (Canon Deluxe 200 Tripod; Canon USA, Lake Success, NY) a standardized focus and at a standardized distance of 5 feet (1.5 m) from the subject. There was a same lighting condition for all the photographs.The protocol described by Owens et al. was similar to this procedure. With the subject in a seated position full-face digital images in smile were made. The observer assisted the subjects in assuming their natural head position by guiding the head position, an approach that is also well documented in the literature.[7,8]

The subject was made seated upright with shoulders and head held straight and facing forward and the lens of camera's height was adjusted on the tripod so that it can match the eye level of the subject (Fig. 1). The natural head position was standardized as the subject looked straight ahead at the lens of the camera on a tripod, along both horizontal and vertical axes. Any minor rotations of the head along the sagittal axis were nullified provided that eyes of a subject were not naturally located at different levels in the natural head position once the intercanthal line was digitally made parallel to the true horizontal before analysis. Digital analysis of the photographs was done by Imaging software (Adobe Photoshop CS2; Adobe Systems, Inc, San Jose, Calif). 142 from 249 subjects, did not meet the inclusion criteria upon initial screening that is as follows:

In age group of 21-45 years there was no history of any congenital conditions or trauma affecting facial form and appearance, or of orthodontic treatment, or of missing maxillary anterior teeth, there no prosthetic maxillary anterior teeth, no interdental spacing in the maxillary teeth, there was ability to understand written informed consent documents and the verbal explanation.

On a separate sheet for each subject the inclusion criteria were applied based on the above data recorded.On the images of the 107 included subjects the predetermined exclusion criteria were applied.The following are the exclusion criteria: images with rotations of head around the vertical axis, obvious ophthalmic asymmetry, inaccurate clinical markings, and images without a good resolution.

After application of the exclusion criteria, 87of the total of subjects was used for midline analysis. The subject's head was made in a natural head position in all the images.

Careful attention was given prior to making images so as to ensure that the subjects did not rotate their heads, particularly along the vertical axis, moreover, the midline was obviously displaced, by a large amount, in a direction opposite to the side of rotation; in the analysis of subjects with heads rotated along the vertical axis, such subjects were excluded.

The use of these definitions was for all clinical markings as well as for digitally constructing an “Esthetic Frame.”[9]
The Esthetic Frame comprising of a rectangular enclosure was used to define the facial midline objectively as it is almost impossible to define the midline of the face in both static and dynamic movements. Its definition is, as an area on the human face, within which items of esthetic interest such as midlines, cants, and smile parameters are sensitively perceptible and objectively verifiable.

The definition of its superior border was a line originating at the exocanthion of 1 eye and meeting the exocanthion of the other eye. It helped to negate the effect of any minor rotations of the head along the sagittal axis. Because of this reason subjects with ophthalmic asymmetry were excluded for analysis using this frame. The 2 lateral borders, parallel to each other were then drawn as perpendicular lines from the exocanthion of each eye of the frame. The superior line drawn at the most inferior border of the lower lip was parallel to the inferior border of the frame.

The 4 sides of the frame was completed by this (Fig. 2). An assumption was made that it was more imperative to obtain the midline of that portion of the face included in this Esthetic Frame, instead of the “true” midline using the “entire” face.

Even an assumption was made that the tissues such as the chin, buccal soft tissues, and forehead excluded from the Esthetic Frame, have least connection with the perception of the facial midline. Owing to the dynamic nature of the mandible, masseter muscles the irregular hypertrophies of the buccinators, and the variable size of the forehead, all of which can be as confounding variables in midline perception.

The facial midline's definition was given as the midline of the esthetic frame of the face for this study. The dental midline's definition was given as the vertical line through the tip of the incisal embrasure between the 2 maxillary central incisors and parallel to the vertical lines of the esthetic frame of the face.

The midline of the oral commissures definition was given as a line bisecting the distance between the cheilions of the subject in smiling posture. The relationships of the anatomic landmarks was quantified by the 2 operational tools i.e Relative facial midline value (RFV) (Fig 3) and relative commissural midline value (RCV)(Fig.4) to the respective midlines.

The first construction on a subject's image digitally was the Esthetic Frame (Fig. 2). After bisecting the distance between the 2 lateral borders on the frame the facial midline was established. Thereafter clinically marked three vertical lines were drawn along each of the anatomic points. The fourth line was drawn along the subject's existing dental midline as defined above Relative facial midline value (RFV) definition was given as the relative closeness of an anatomic landmark to the facial midline. (Fig. 3). The lateral border's measured distance from of the frame to the defined facial midline was considered a constant called “F.” The measured distance from the lateral border of the frame to the nasion was considered a variable termed “n.” And the RFV was obtained by dividing n by F.

Same way the RFVs were obtained for the other 3 anatomic landmarks: tip ofvthe nose (t), tip of philtrum (p), and dental midline (d), by dividing them by the constant F. Thus the numerical values for n/F, t/F, p/F, and d/F were obtained.

The definition of Relative commissural midline value (RCV) was given as the relative closeness of an anatomic landmark to the midline of the oral commissures (center of the mouth). The constant termed C was the measured distance from the midpoint of the intercommissural line to the right/left cheilion. The measured distances (variables) were: from the nasion, nx, from the tip of the nose, tx, from the tip of philtrum, px, and from the dental midline, dx. Then the RCV was obtained by dividing nx/C, tx/C, px/C, and dx/C. Cx was described as a variable called the measured distance from the lateral border of the Esthetic Frame to the midpoint of the commissures . Thus, by dividing Cx/F, the relationship between the midline of the commissures and the midline of the face was obtained.

Development of a proportional relationship between an anatomic landmark and the midline in question was the primary reason to use RFV and RCV. A standard common denominator for all anatomic landmarks within the esthetic frame was ensured from this and the

need for size matching the images with the subject's face was negated. RFV1 and RCV1 were the assignments for relativity of landmarks for both midlines: relativity of nasion to midline of the face and commissures; RFV2 and RCV2: relativity of tip of the nose to midline of the face and commissures; RFV3 and RCV3: relativity of tip of the philtrum to midline of the face and commissures; RFV4 and RCV4: relativity of dental midline to midline of the face and commissures; and RFV5: relativity of the midline of the commissures with the midline of the face. Thus, all 5 of the RFVs and all 4 of the RCVs would be equal to each other and to the numeral 1 in perfect symmetry.

Based on the direction of deviation of the anatomic landmark the right or left lateral border of the esthetic frame or the commissures was chosen. And hence the shorter distance to the lateral border of the frame was always chosen. Thus, an RFV and an RCV could never be a number greater than the numeral 1.

The same RFV or RCV value was recorded. If a line drawn along one anatomic landmark coincided with any of the other landmarks. An RFV or RCV value of 1 was assigned if an anatomic landmark was coincident with the facial or the commissural midline.[9]

9 values were recorded per subject in total, along with gender and ethnicity. To ensure reliability and validity the entire process of data analysis was repeated twice. By using intraclass correlation coefficients (ICCs) a reliability analysis test was performed between the first and second set of data.

A series of 1-sample *t* tests were conducted with an alpha value of .05 to determine whether the selected landmarks significantly differed from the midline of the face and mouth, Finally, the determination of whether there was a significant correlation between RCV1 (nasion) and RCV2 (tip of the nose), as nasion and tip of the nose showed reversal in hierarchy in relationship to the midline of the commissures was done by a Pearson correlation analysis.

RESULTS:

Ranging from 0.85 to 0.96, Intraclass correlation coefficients (ICCs) for reliability analysis of RFV and RCV measures made 2 times revealed that all the reliabilities were acceptable. This indicated a high consistency between measurements made the first and the second time by the same rater. analysis 1 measured Items are paired with same items measured at analysis 2 (for example, RFV11 = "RFV1"measured the first time, and RFV12 = "RFV1" measured the second time).

Beyond the alpha value of .001 All ICCs were statistically significant (Table III). They conducted Two sets of 1-sample *t* tests. One set of 5 *t* tests was conducted to test the null hypothesis which meant that the ratios of the 5 specified anatomic measures did not differ from 1.00 (whether they all lined up with the facial midline).

It was indicated from the analysis that the difference between the mean ratio of each anatomic landmark and the midline of the face was statistically significant ($P<.001$). The closest was the midline of the commissures next was the dental midline, tip of philtrum, nasion, and the tip of the nose (Table IV) (Fig. 7).

For testing the null hypothesis a second set of 4 *t* tests was conducted in such a way that the mean ratios of the 4 specified anatomic measures did not differ from 1.00 (whether they all lined up with the intercommissural midline).

It was indicated by the results that the difference between the mean ratio of each anatomic landmark and the midline of the commissures was statistically significant ($P<.001$), the same was similar to the previous analysis.

The closest was the natural dental midline then was the tip of philtrum, tip of the nose, and nasion (Table V) (Fig. 8).Considering all ethnicities these hierarchical relationships remained the same for both genders.

Any significant association between the 2 samples was determined by a Pearson correlation analysis, RCV1 (nasion) and RCV2 (tip of the nose), as nasion and tip of the nose showed reversal in hierarchy in relationship to the midline of the commissures.

Table VI shows that RCV1 and RCV2 are significantly correlated at a .05 level (2-tailed), indicating these 2 values were similar to each other; hence, the hierarchy is negligible.

DISCUSSION:

The rejection of the null hypothesis was supported by the results that there would be no difference between the chosen facial anatomic landmarks and the midlines of the face and oral commissures

No standard definition for facial midline is given in the literature. So, the authors defined the facial midline using the Esthetic Frame.

The validity of the natural head position and its long-term reproducibility over a period of up to 15 years was shown by many authors.[7]

Inherent human errors in marking the anatomic landmarks clinically cannot be eliminated even though meticulous care and clinical judgment were exercised during the marking procedure.

Of the various clinical landmarks most difficult was the marking the soft tissue nasion and the tip of the nose due to the inherent anatomy of the nose[10]. Hence, the future studies are needed to verify these results and these anatomic landmarks should be carefully considered. They even considered the use of cephalometrics, but have not used, as the same would not simulate a clinical situation for recording the midline. They considered the midline of the oral commissures as a determined anatomic landmark while analyzing the hierarchical order for facial midlines. In comparison to all of the landmarks analyzed it ranked the closest to the facial midline. It may be revealed by this that nature centers the mouth quite symmetrically in relationship to the eyes. The dental midline in this population was ranked second for midline of the face and midline of the commissures, with no history of orthodontics.

The axial angulations of the dental midline in its analysis was not addressed in the study protocol. And it was indicated in the results that a symmetrical pattern might exist in nature in arranging the dental midline with respect to the face and commissures.

Thus, as reported by the authors in the past, they inferred that the incisive papilla, usually found in between the 2 maxillary central incisors, may be an acceptable landmark for the determination of midlines. They needed Future studies to verify this.

For representing the facial midline the philtrum or tip of the vermillion border has been assumed by several studies in the past. It was shown in the present study that the tip of the philtrum ranked third in the hierarchy that was superseded only by the midline of the commissures and the dental midline. The credibility of the tip of the philtrum as a reliable landmark in the determination of the midlines of the face and mouth is reinforced by this. They considered nasion to be a good location along the middle fifth of the face, but its relation to the facial and commissural midline has not been studied previously.

Soft tissue nasion may not be an adequate clinical landmark to determine either of the Midlines based on the current study. Moreover, its distant location from the dental midline may not result in easy determination and analysis. With regard to the facial midline the tip of the nose was the most deviated landmark. Though, it ranked higher than the nasion considering the midline of the commissures.

It was shown by the Pearson correlations used to examine the relationships of these 2 anatomic landmarks that these 2 values were similar; hence, the reversal of hierarchy could be due to a sampling error and is insignificant. (Table. 1)

Furthermore, for most clinical situations, both of these landmarks ranked lowest in their proximity to the midlines of the face and mouth; the ranking of the first anatomic landmarks, i.e the midline of the commissures, tip of philtrum, and dental midline, appears to be more relevant.

RFV and RCV (ratios) was used in the study as tools to examine the relationship of the anatomic landmarks and develop the hierarchy. This could be a limitation in the study, theoretically as ratios by nature cannot differentiate whether the observed difference is due to the numerator or denominator term.

However, the authors believe that it is more important for a clinician to know the hierarchy or the best choice of anatomic landmarks that could be used in the determination of midline for a particular patient, instead of knowing the mean linear deviations of anatomic landmarks of a certain population.

Furthermore, as the image dimensions did not correspond to the exact dimensions of the subject's face. The applied methodology would not have permitted sufficient accuracy to analyze linear deviations, the direction of deviation of each anatomic landmark with regard to the midlines was not reported by the authors, as it has little clinical applicability.

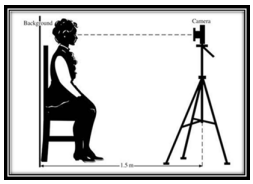
Depending upon the midline in question; the numerical values of the mean ratios were different for the same landmark. However, it did not affected the hierarchy of landmarks. Finally, a single observer did the study and the population chosen in this study was based on convenience sampling, with the sample distribution being approximately normal. Baseline information was provided in this study that was about the hierarchical relationships of various facial anatomic landmarks to the midlines of the face and mouth. To confirm the results similar studies on different samples are needed

CONCLUSIONS:

Following conclusions were drawn based on the limitations of this study:

1. Significant difference was found between the mean ratios of the chosen anatomic landmarks and the midlines of the face and mouth.
2. Anatomic landmarks closest to the midline of the face in the hierarchy is:
   (1) midline of the commissures, (2) dental midline, (3) tip of philtrum, (4) nasion, and (5) tip of the nose.
3. Anatomic landmarks closest to the midline of the commissures in the hierarchy is:
   (1) dental midline, (2) tip of philtrum, (3) tip of the nose, and (4) nasion.

Fig.1: Schematic illustration showing methodology of obtaining standard digital images of subject in natural head position.



(Fig. 2):The digitally constructed "Esthetic Frame "

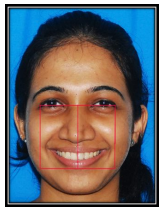
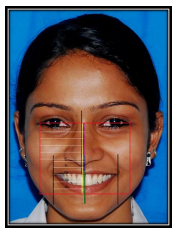


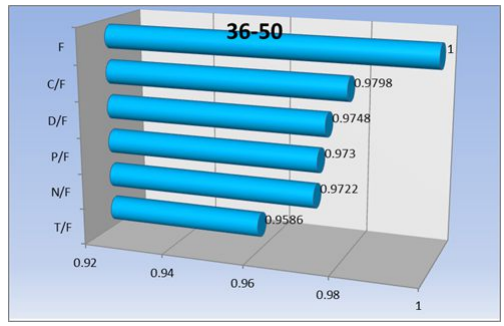
Fig.3: Relative facial midline value (RFV) of the different anatomic landmarks to the facial midline

Fig.4: Relative commissural midline value (RCV) of the different anatomic landmarks to the commissural midline.



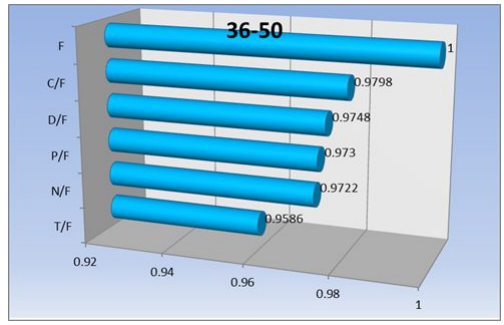
Graph 1:- Comparison of facial midline with different anatomical land marks in 17-35 years age group

Graph 2:- Comparision of facial midilne with different anatomical land marks in 36-50 years age group.

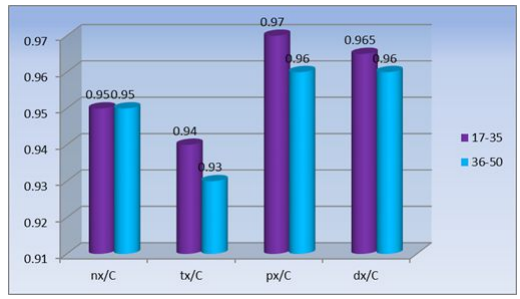


Graph 3:- Comparison of midline of oral commisures with different anatomical land marks in 17-35 years age group.

Graph 4:- Comparison of midline of oral commisures with different anatomical land marks in 36- 50 years age group.



Graph 5: Comparison of facial midline values between the age group 17-35 and 36-55 years



Graph 6: Comparison of midline of oral commissure values between the age group 17-35 and 36-55

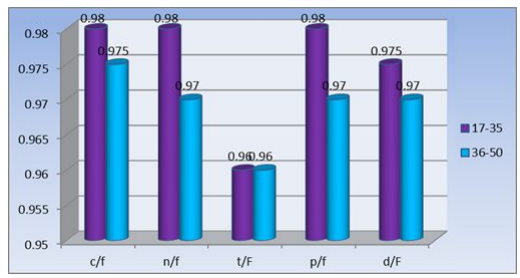


Table 1: Pearson correlation coefficient between Natural dental midline and Tip of philtrum to demonstrate reversal of hierarchy.

		Natural dental midline	Tip of philtrum
	Pearson correlation	1	0.041
Natural dental midline	Significance (2-tailed)		0.035
	n	50	50
	Pearson correlation	0.041	1

Tip of philtrum	Significance (2-tailed)	0.035	
	n	50	50

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