The relationship of facial anatomic landmarks with midlines of the face and mouth

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Statement of problem. The importance of the midline is well known to dentists. Currently, there are no verifiable guidelines that direct the choice of specific anatomic landmarks to determine the midline of the face or midline of the mouth.

Purpose. The purpose 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.

Material and methods. Three commonly used anatomic landmarks, nasion, tip of the nose, and tip of the philtrum, were marked clinically on 249 subjects (age range: 21-45 years). Frontal full-face digital images of the subjects in smile were then made under standardized conditions. A total of 107 subjects met the inclusion criteria. Upon applying exclusion criteria, images of 87 subjects were used for midline analysis using a novel concept called the Esthetic Frame. 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 and repeated twice. Reliability analysis and 1-sample *t* tests were conducted at alpha values of .001 and .05, respectively.

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.

Conclusions. Within the limitations of the study, the hierarchy of anatomic landmarks closest to the midline of the face in smile was as follows: the midline of the oral commissures, natural 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: natural dental midline, tip of philtrum, tip of the nose, and nasion. These relationships were the same for both genders and all ethnicities classified. (J Prosthet Dent 2009;102:94-103)

Presented as a table clinic at the American Academy of Fixed Prosthodontics meeting, February 2009.
Supported by the Tylman Grant award, American Academy of Fixed Prosthodontics.
Third place winner of the Academy of Prosthodontics Foundation award.

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Clinical Implications

The midline of the oral commissures, natural dental midline, and tip of the philtrum, in this order, can be chosen as preferential landmarks in the determination of the midline of the face and mouth in smile.

Symmetry, normalcy, sexual dimorphism, and youthfulness have been considered the classical elements of facial beauty.[1,2] By definition, symmetry is the "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."[3] This dividing line, which is used to attain symmetry, is known as the midline. It 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. Historically, a diverse number of facial anatomic landmarks located on the middle third of the face, such as the bisector of the pupils, nasion, tip of the nose, tip of the philtrum, and chin, have been used to determine the facial and dental midlines.[4,5] Some advocate the use of intraoral landmarks, such as the incisive papilla, for determination of the maxillary dental midline.[6,7] It has been argued in the literature whether the dental midline should be made coincident with the midline of the face or the midline of the oral commissures.[8] Some believe that making the dental midline coincident with the midline of the oral commissures is adequate, as patients tend to relate their dental midline to proximal structures rather than anatomic structures which are farther from the mouth.[9,10] However, the literature is not clear regarding verifiable guidelines for the determination of midlines of the face or mouth. Based upon convention and dogma, most clinicians choose one specific anatomic landmark and an imaginary line passing through it. Others use dental floss and hold it in front of the face from glabella to menton. Thus, the clinician is left with no predictable guidelines, and must determine the midline based on unverified landmarks.

In dental esthetics, it is more important that the maxillary dental midline and the facial midline coincide, than the mandibular and facial midlines. This is due to the dominant visibility of the maxillary anterior teeth in smile and function. The coincidence of facial, maxillary, and mandibular midlines is desirable, but not mandated. The maxillary dental and facial midlines have an important role in esthetics and occlusion in many disciplines, including removable and fixed prosthodontics, implant prosthodontics, orthodontics, and facial plastic surgery. Not being able to match the dental midline coincident to the midline of the face or mouth is a common cause of frustration for dentists. This generally results in elaborative procedures for correction, causing loss of clinical time.

Most of the literature available with regard to this topic is restricted to monographs written by various authors. Clinical studies have been limited to the amount of tolerance of deviated dental midlines from the facial midline, a span of approximately 2 to 3 mm.[5,11-14] Textbooks and monographs written by various authors reveal a division of thought with respect to whether or not the dental midline should be placed exactly coincident to the facial midline.[15] Lombardi suggests placing the dental midline in the location on the face where it appears most "stable."[8] Farkas[16] described the facial midline in anthropometric interest, as a line defined by 3 anatomic points: nasion, subnasale, and the gnathion or menton. However, this definition is not clear and does not lend itself to objectivity and repeatability for research purposes. The Glossary of Prosthodontic Terms,[17] American Association of Orthodontists (AAO) Glossary,[18] and the Glossary of Terms for the American Academy of Facial Plastic and Reconstructive Surgery[19] currently do not have any definitions for facial and dental midlines. To the authors' knowledge, there is no literature describing the relationship of the midline of the mouth to the midline of the face.

Miller et al[15] was the first to study the clinical relationship of the dental midline and the facial median line, in a study involving a sample of 500 human subjects. No objective methods were used in this study. The authors demonstrated that 70.4% of the sample showed a coincidence of the dental midline and facial median line. Owens et al[20] conducted a multicenter study involving 5 centers around the world to compare facial appearance across 6 racial groups. Two hundred fifty-three subjects from the 5 centers were chosen. Coincidence of the dental midline with the line bisecting the interpupillary line was one of the analyzed variables. The results of the study showed that 70% of all subjects had their dental midline coincident with the line perpendicular to the interpupillary line. Latta[7] studied the relationship between facial midline and intraoral landmarks in 100 patients requiring maxillary dentures. The philtrum was used to represent the facial midline and its marking was transferred to a cast manually using an occlusal rim. The results showed that the incisive papilla was the closest landmark, followed by the maxillary frenum and the midpalatal suture. All of the previously mentioned studies have lacked objectivity in the

evaluation criteria for facial midlines.

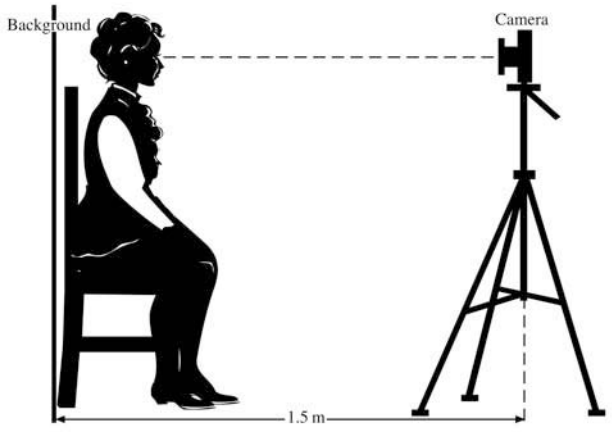
Thus, the gaps in knowledge in this field are the lack of a repeatable and verifiable definition for facial and dental midlines and lack of scientific information on relationships of specific anatomic landmarks with the facial midline. Furthermore, there is a lack of information about the relationship of the 2 standard midlines: midline of the face and the midline of the mouth. All of these provided the rationale for this study.

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. The facial anatomic landmarks analyzed were those traditionally used in clinical practice such as: nasion, tip of the nose (pronasale), tip of philtrum (labiale superioris), and dental midline. The null hypothesis was that there would be no difference between the chosen facial anatomic landmarks and the midlines of the face and oral commissures.

MATERIAL AND METHODS

Institutional Review Board approval (#07-117-2) was obtained for convenience sampling of 249 medical and dental students/employees with an age range of 21-45 years at the University of Connecticut Health Center. Each subject had 3 small marks placed by a single observer using a fine-tipped erasable marker, with a tip approximately 0.5 mm in diameter (Expo; Sanford Ink Co, Oak Brook, Ill) on the nasion, tip of the nose, and tip of the philtrum, to simulate a clinical situation. Standardization was given to application of all anatomic marks in terms of the standard anatomic and anthropologic definitions described below. A digital camera (Nikon D70s digital camera, 6.1 Megapixel; Nikon USA, Melville, NY) with a 105-mm lens and a point flash, as well as an additional flash with a wireless speedlight (Nikon SB-R200 Wireless Speedlight; Nikon USA), was used in the 12 o'clock position. The camera had an aperture setting of F4.5 and was mounted on a tripod (Canon Deluxe 200 Tripod; Canon USA, Lake Success, NY) with a standardized focus and at a standardized distance of 5 feet (1.5 m) from the subject. The lighting conditions remained the same for all the photographs. This procedure was similar to the protocol described by Owens et al.[20] Full-face digital images of subjects in smile were made, with the subject in a seated position. The head position was guided by the observer to assist the subjects in assuming their natural head position, an approach which has been well documented in the literature.[21-24] The height of the lens of the camera was adjusted on the tripod to match the eye level of the subject when seated upright with shoulders and head held straight and facing forward (Fig. 1). As the subject looked straight ahead at the lens of the camera on a tripod, the natural head position was standardized along both horizontal and vertical axes. As long as the eyes of a subject were not naturally located at different levels in the natural head position, any minor rotations of the head along the sagittal axis were nullified when the intercanthal line was digitally made parallel to the true horizontal before analysis. Imaging software (Adobe Photoshop CS2; Adobe Systems, Inc, San Jose, Calif) was used to digitally analyze the photographs.

Upon initial screening of 249 subjects, 142 of them did not meet the inclusion criteria, which were as follows: age range of 21-45 years, no history of any congenital conditions or trauma affecting facial form and appearance, no history of orthodontic treatment, no missing maxillary anterior teeth, no prosthetic maxillary anterior teeth, no interdental spacing in the maxillary teeth, ability to understand written informed consent documents and the verbal explanation. The inclusion criteria were applied based on the above data recorded on a separate sheet for each subject. The predetermined exclusion criteria were applied to the images of the 107 included subjects. The exclusion criteria were as follows: images with rotations of head around the vertical axis, obvious ophthalmic asymmetry, inaccurate clinical markings, and images without a good resolution. Upon applying the exclusion criteria, the total number of subjects used for midline analysis was 87 (Tables I and II). All images were made with the subject's head in a natural head position. Prior to making images, careful attention was given to ensure that the subjects did not rotate their heads, especially along the vertical axis. In addition, the analysis of subjects with heads rotated along the vertical axis resulted in the midline being obviously displaced, by a large amount, in a direc-



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

Table I. Application of exclusion criteria to sample for midline analysis

Exclusion Criteria	Number of Subjects Rejected
Rotation of head along vertical axis	8
Ophthalmic asymmetry	5
Inaccurate markings	5
Unreadable images	2
Total	20

Table II. Distribution of sample based on ethnicity and gender

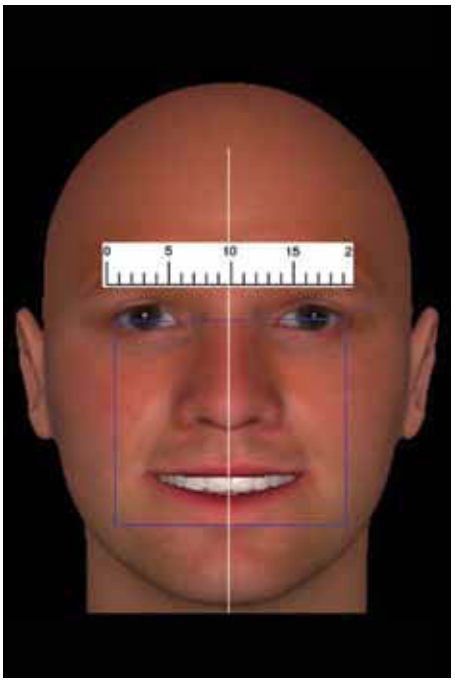
Category	Distribution
Asians	9
Blacks	9
Whites	50
Other ethnicities	19
Men	49
Women	38
Total	87

tion opposite to the side of rotation; hence, these subjects were excluded. The study excluded subjects who had obvious ophthalmic asymmetry (eyes located at different levels) when they were positioned in their natural head position. Subjects who were excluded due to obvious ophthalmic asymmetry were reanalyzed. The magnitude of asymmetry was quantified, resulting in exclusion of subjects with more than 1 degree of discrepancy between the true horizontal line and the intercanthal line. Finally, images which showed that the clinical markings did not conform to the standard anatomic definitions at a magnification of at least 200% were considered inaccurate, and they were excluded from the study.

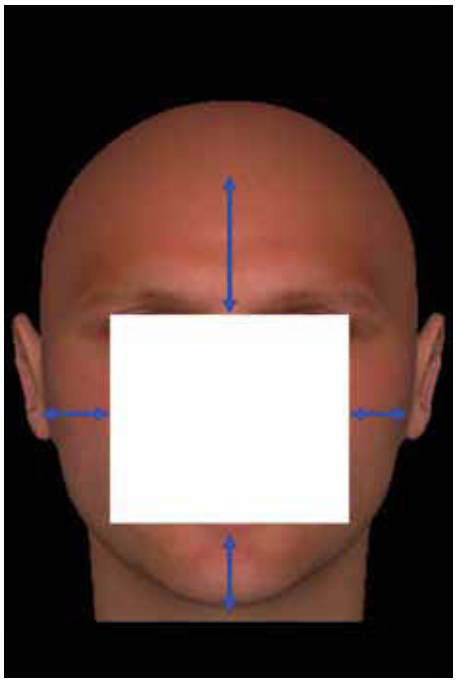
Standard definitions for anatomic landmarks were used for all purposes of the study. Lateral canthus was defined as the lateral angle formed by the meeting of the upper and lower eyelids.[3] Exocanthion was defined as the point at the outer commissure of the eye fissure.[16] Nasion was defined as the point in the midline of both the nasal root and nasofrontal suture.[3,16] Philtrum was defined as the vertical groove on the median line of the upper lip.[3] Commissure was defined as a point or line of junction between 2 anatomic parts (the lips).[3,17] Cheilion was defined as the point located at each labial commissure.[16] Tip of the nose (pronasale) was defined as the most protruded point of the apex of the nose.[16] These definitions were used for all clinical markings as well as to digitally construct an "Esthetic Frame."

The Esthetic Frame is novel and unique to this study. As it is almost impossible to define the midline of the face in both static and dynamic movements, the Esthetic Frame comprising of a rectangular enclosure was used to define the facial midline objectively. It was defined 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. Its superior border was defined by a line originating at the exocanthion of 1 eye and meeting the exocanthion of the other eye. This line helped to negate the effect of any minor rotations of the head along the sagittal axis. Subjects with ophthalmic asymmetry were excluded for analysis using this frame due to this reason. The 2 lateral borders of the frame were then drawn as perpendicular lines from the exocanthion of each eye and were parallel to each other. The inferior border of the frame was parallel to the superior line drawn at the most inferior border of the lower lip. This completed the 4 sides of the frame (Fig. 2). It was assumed that it was more imperative to obtain the midline of that portion of the face included in this Esthetic Frame, rather than the "true" midline using the "entire" face. It was also assumed that the tissues excluded from the Esthetic Frame, such as the chin, buccal soft tissues, and forehead, have little to do with the perception of the facial midline. This is simply because of the dynamic nature of the mandible, the irregular hypertrophies of the buccinators and masseter muscles, and the variable size of the forehead, all of which could potentially serve as confounding variables in midline perception (Fig. 3).

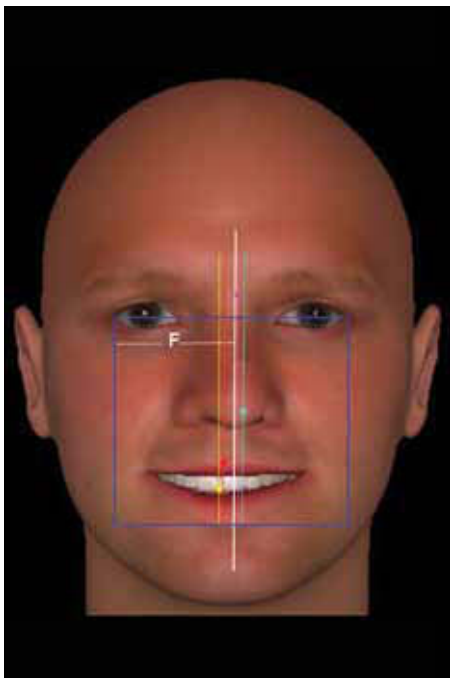
For this study, the facial midline was defined as the midline of the esthetic frame of the face. The dental midline was defined as the vertical line through the tip of the incisal embrasure between the 2 maxillary central incisors and parallel to the vertical lines of the esthetic frame of the face. The midline of the oral commissures was defined as a line bisecting the distance between the cheilions of the subject in smiling posture. Relative facial midline value (RFV) and relative commissural midline value (RCV) were 2 operational tools used to quantify the relationships of the anatomic landmarks to the respective midlines. The Esthetic Frame was first constructed on a subject's image digitally. The facial midline was established by bisecting the distance between the 2 lateral borders on the frame. Three vertical lines were then drawn along each of the anatomic points, which had been marked clinically. The fourth line was drawn along



2 Computer-generated human face (FaceGen Modeller; Singular Inversions, Toronto, Ont) to schematically illustrate concept of Esthetic Frame used to obtain objectivity and reliability.



3 Tissues excluded from Esthetic Frame have little to do with perception of facial midline.



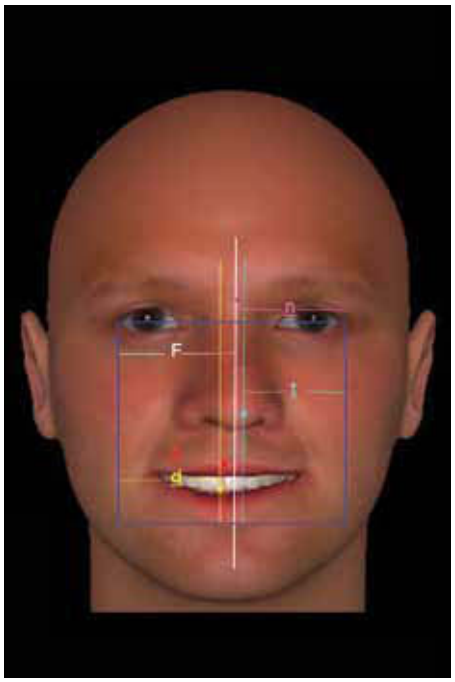
4 Computer-generated human face seen in Figure 1 was digitally altered to produce deviated anatomic landmarks. Figure illustrates methodology of lines drawn along each deviated anatomic landmark and determination of facial midline.

the subject's existing dental midline as defined above (Fig. 4).

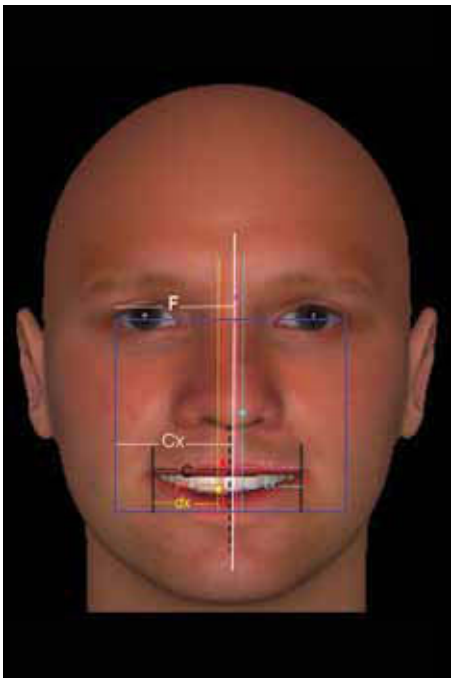
Relative facial midline value (RFV) was defined as the relative closeness of an anatomic landmark to the facial midline. The measured distance from the lateral border of the frame to the defined facial midline was considered a constant called "F." The measured distance from the lateral border of the frame to the nasion was considered a variable termed "n." The RFV was then obtained by dividing n by F. Similarly, RFVs were obtained for the other 3 anatomic landmarks: tip of the nose (t), tip of philtrum (p), and dental midline (d), by dividing them by the constant F. Numerical values for n/F, t/F, p/F, and d/F were thus obtained (Fig. 5).

Relative commissural midline value (RCV) was defined as the relative closeness of an anatomic landmark to the midline of the oral commissures (center of the mouth). The measured distance from the midpoint of the intercommissural line to the right/left cheilion was considered a constant termed C. 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. The RCV was then obtained by dividing nx/C, tx/C, px/C, and dx/C. The measured distance from the lateral border of the Esthetic Frame to the midpoint of the commissures was described as a variable called Cx. Thus, the relationship between the midline of the commissures and the midline of the face was obtained by dividing Cx/F (Fig. 6).

The primary reason to use RFV and RCV was to develop a proportional relationship between an anatomic landmark and the midline in question. This ensured a standard common denominator for all anatomic landmarks within the esthetic frame and negated the need for size matching the images with the subject's face. The assignments for relativity of landmarks for both midlines were: RFV1 and RCV1: 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, in perfect symmetry, all 5 of the RFVs and all 4 of the RCVs would be equal to each other and to the numeral 1. The right or left lateral border of the esthetic frame or the commissures was chosen, based on the direction of deviation of the anatomic landmark. Therefore, 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. If a line drawn along one anatomic landmark coincided with any of the other landmarks, the same RFV or RCV value was recorded for both. If an anatomic landmark



5 Method of determination of RFV values for each anatomic landmark. F: midline of face/midline of esthetic frame; n: distance between nasion and lateral border of esthetic frame; t: distance between tip of nose and lateral border of esthetic frame; p: distance between tip of philtrum and lateral border of esthetic frame; d: distance between dental midline and lateral border of esthetic frame.



6 Method of determination of RFV5 and RCV values for each anatomic landmark. F: midline of face/midline of esthetic frame; C: midline of oral commissures; Cx: distance between midline of commissures and lateral border of esthetic frame; nx: distance between nasion and oral commissures; tx: distance between tip of nose and oral commissures; px: distance between tip of philtrum and oral commissures; dx: distance between dental midline and oral commissures.

was coincident with the facial or the commissural midline, then it was assigned an RFV or RCV value of 1.

A total of 9 values were recorded per subject, along with gender and ethnicity. The entire process of data analysis was repeated twice to ensure reliability and validity. A reliability analysis test was performed between the first and second set of data using intraclass correlation coefficients (ICCs). To determine whether the selected landmarks significantly differed from the midline of the face and mouth, a series of 1-sample *t* tests were conducted with an alpha value of .05. Finally, a Pearson correlation analysis was performed to determine 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.

RESULTS

Intraclass correlation coefficients (ICCs) for reliability analysis of RFV and RCV measures made 2 times revealed that the reliabilities were all acceptable, ranging from 0.85 to 0.96, indicating a high consistency between measurements made the first and the second time by the same rater. Items measured at analysis 1 are paired with same items measured at analysis 2 (for example, RFV11 = "RFV1" measured the first time, and RFV12 = "RFV1" measured the second time). All ICCs were statistically significant beyond the alpha value of .001 (Table III).

Two sets of 1-sample *t* tests were conducted. One set of 5 *t* tests was conducted to test the null hypothesis that the mean ratios of the 5 specified anatomic measures did not differ from 1.00 (whether they all lined up with the facial midline). The analysis indicated that the difference between the mean ratio of each anatomic landmark and the midline of the face was statistically significant ($P<.001$). The midline of the commissures was the closest, followed by the dental midline, tip of philtrum, nasion, and the tip of the nose (Table IV) (Fig. 7).

A second set of 4 *t* tests was conducted to test the null hypothesis 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). In line with the previous analysis, the results indicated that the difference between the mean ratio of each anatomic landmark and the midline of the commissures was statistically significant ($P<.001$). The natural dental midline was the closest, followed by the tip of philtrum, tip of the nose, and nasion

TABLE III. Reliability analysis table

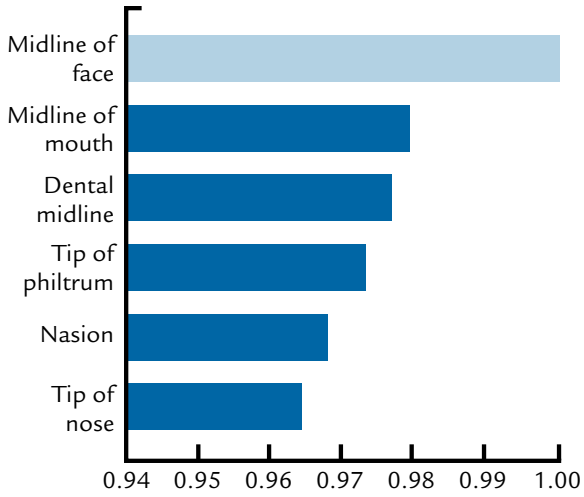
Item Pair		Reliability
RFV11 (nasion)	RFV12	0.85
RFV21 (tip of nose)	RFV22	0.92
RFV31 (tip of philtrum)	RFV32	0.87
RFV41 (dental midline)	RFV42	0.85
RFV51 (midline of commissures)	RFV52	0.86
RCV11 (nasion)	RCV12	0.93
RCV21 (tip of nose)	RCV22	0.96
RCV31 (tip of philtrum)	RCV32	0.90
RCV41 (dental midline)	RCV42	0.94

RFV: Relative facial midline value
RCV: Relative commissural midline value

TABLE IV. One-sample *t* test for hierarchy of landmarks for midline of face

Landmark	Mean	Standard Deviation	*P*
Midline of commissures (RFV5)	0.979	0.017	<.001
Dental midline (RFV4)	0.977	0.018	<.001
Tip of philtrum (RFV3)	0.974	0.021	<.001
Nasion (RFV1)	0.967	0.019	<.001
Tip of nose (RFV2)	0.965	0.025	<.001

RFV: Relative facial midline value

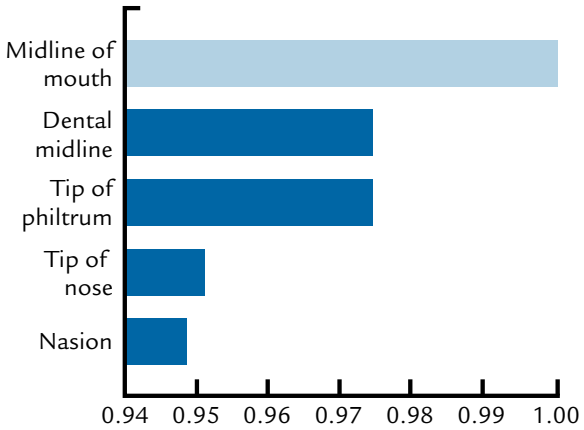


7 Hierarchical relationship of anatomic landmarks with midline of face.

Table V. One-sample *t* test for hierarchy of landmarks for midline of commissures

Landmark	Mean	Standard Deviation	*P*
Dental midline (RCV4)	0.9751	0.023	<.001
Tip of philtrum (RCV3)	0.9748	0.024	<.001
Tip of nose (RCV2)	0.9512	0.034	<.001
Nasion (RCV1)	0.9477	0.032	<.001

RCV: Relative commissural midline value



8 Hierarchical relationship of anatomic landmarks with midline of mouth.

Table VI. Pearson correlation coefficient between RCV1 and RCV2 to demonstrate reversal of hierarchy

		RCV1	RCV2
Nasion (RCV1)	Pearson correlation	1	0.229
	Significance (2-tailed)		0.033
	n	87	87
Tip of nose (RCV2)	Pearson correlation	0.229	1
	Significance (2-tailed)	0.033	
	n	87	87

RCV: Relative commissural midline value

(Table V) (Fig. 8). These hierarchical relationships remained the same for both genders and all ethnicities considered.

A Pearson correlation analysis was done to determine any significant association between the 2 samples, 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 results support rejection of the null hypothesis that there would be no difference between the chosen facial anatomic landmarks and the midlines of the face and oral commissures. There is no standard definition for facial midline in the literature. Therefore, the authors defined the facial midline using the Esthetic Frame. Many authors have shown the validity of the natural head position and its long-term reproducibility over a period of up to 15 years.[21-24] In the present study, the natural head position was guided to the true horizontal by a single investigator, and care was taken to ensure that the subjects did not ro-

tate their heads along the vertical axis. However, human error in detection of this rotation cannot be ruled out. The smiling image of the subject was chosen for all purposes of analysis, as it is a standard for esthetic analysis, and it revealed the dental midline as well. No subject in this study had a grossly asymmetric smile or a smile which did not reveal the maxillary central incisors. All exclusion criteria reported in this study was stringently applied to minimize the number of confounding factors.

This study was designed to be as clinically applicable as possible; therefore, the markings for each anatomic landmark were made clinically and not on the digital image. The lines on the image were drawn along these markings. Although meticulous care and clinical judgment were exercised during the marking procedure, inherent human errors in marking the anatomic landmarks clinically cannot be eliminated. Of the various clinical landmarks, marking the soft tissue nasion and the tip of the nose was most difficult due to the inherent anatomy of the nose.[16] Hence, the results related to these anatomic landmarks should be carefully considered, and future studies are needed to verify these results. The use of cephalometrics was considered, but not used, as it would not simulate a clinical situation for recording the midline.

The midline of the oral commissures was considered as a determined anatomic landmark while analyzing the hierarchical order for facial midlines. It ranked the closest to the facial midline, in comparison to all of the landmarks analyzed. This may reveal that nature centers the mouth quite symmetrically in relationship to the eyes. The dental midline in this population with no history of orthodontics was ranked second for midline of the face and midline of the commissures. The study protocol, however, did not address the axial angulations of the dental midline in its analysis. The results indicate that a symmetrical pattern might exist in nature in arranging the dental midline with respect to the face and commissures. Thus, it can be inferred that the incisive papilla, usually found in between the 2 maxillary central incisors, may be an acceptable landmark for the determination of midlines, as reported by authors in the past.[6,7] Future studies are needed to verify this. The philtrum or tip of the vermillion border has been assumed by several studies in the past to represent the facial midline.[5,7,10-12,14,15] The present study showed that the tip of the philtrum ranked third in the hierarchy, superseded only by the midline of the commissures and the dental midline. This reinforces the credibility of the tip of the philtrum as a reliable landmark in the determination of the midlines of the face and mouth.

The nasion has been considered 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. Based on the current study, soft tissue nasion may not be an adequate clinical landmark to determine either of the midlines. Furthermore, its distant location from the dental midline may not result in easy determination and analysis. The tip of the nose was the most deviated landmark with regard to the facial midline. However, it ranked higher than the nasion with regard to midline of the commissures. Pearson correlations used to examine the relationships of these 2 anatomic landmarks showed that these 2 values were similar; therefore, the reversal of hierarchy could be due to a sampling error and is not significant. Furthermore, both of these landmarks ranked lowest in their proximity to the midlines of the face and mouth; for most clinical situations, the ranking of the first 3 anatomic landmarks, namely, the midline of the commissures, tip of philtrum, and dental midline, appears to be more relevant.

The study used RFV and RCV (ratios) as tools to examine the relationship of the anatomic landmarks and develop the hierarchy. Theoretically, this could be a limitation in the study, as ratios by nature cannot differentiate whether the observed difference is due to the numerator or denominator term. However, from a clinical standpoint, 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, rather than to know mean linear deviations of anatomic landmarks of a certain population. Furthermore, the applied methodology would not have permitted sufficient accuracy to analyze linear deviations, as the image dimensions did not correspond to the exact dimensions of the subject's face. The authors did not report the direction of deviation of each anatomic landmark with regard to the midlines, as it has little clinical applicability. The numerical values of the mean ratios were different for the same landmark depending upon the midline in question; however, the hierarchy of landmarks was not affected. Finally, the study was done by a single observer and the population chosen in this study was based on convenience sampling, with the sample distribution being approximately normal. This study provides baseline information about the hierarchical relationships of various facial anatomic landmarks to the midlines of the face and mouth. Similar studies on different samples are needed to confirm the results.

CONCLUSIONS

Based on the limitations of this study, the following conclusions were drawn:

1. There was a significant difference between the mean ratios of the chosen anatomic landmarks and the midlines of the face and mouth.

2. The hierarchy of anatomic landmarks closest to the midline of the face is: (1) midline of the commissures, (2) dental midline, (3) tip of philtrum, (4) nasion, and (5) tip of the nose.

3. The hierarchy of anatomic landmarks closest to the midline of the commissures is: (1) dental midline, (2) tip of philtrum, (3) tip of the nose, and (4) nasion.

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Acknowledgements
The authors thank Patricia Montgomery for her support with the images and all participants who volunteered for the study.