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Full Length Research Paper

The relationship of facial and dental midlines with various anatomic landmarks of face and oral cavity

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The aim of the study was to find out the relative reliability of different clinical anatomical landmarks to determine the midline of face and the hierarchy of facial anatomical landmarks closest to the midline of the face. The facial anatomical landmarks such as - nasion, tip of nose, tip of philtrum, incisive papilla and dental midline were chosen as they are commonly used in clinical practice. 100 patients were randomly selected; full face digital images were made with clinical markings on selected anatomical landmarks. Esthetic frame was constructed on each image with digital lines passing through each marked point. Casts were made for maxillary arch of each subject. Two sets of readings were tested using intra class correlation coefficients (ICCs) reliability test. To determine whether the selected landmarks differed from midline of face and mouth, a series of one - sample *t* test were conducted with alpha value of 0.5. 5 Relative facial midline value (RFV) and 4 relative commissural midline value (RCV) values were obtained for each subject. Two hierarchal orders were obtained; one defining the relation of various landmarks to midline of face and second for midline of mouth. Observation from casts revealed that incisive papilla lined up with defined dental midline. Intercommissural midline ranked closest to facial midline followed by dental midline, tip of philtrum, nasion, and tip of nose. Landmarks closest to midline of mouth are tip of philtrum, dental midline, nasion and tip of nose. Incisive papilla lies in direct relation to dental midline. Centre of mouth is reliable midline anatomical landmark for determining midline of face.

Key words: Esthetic frame, facial midline value (RFV), intra class correlation coefficients, intercommissural, philtrum, nasion, incisive papilla, maxillary arch.

INTRODUCTION

The word “aesthetic” implies beauty, naturalness and a youthful appearance relative to one’s age. Esthetics motivates the patient to seek dental treatment. Aesthetic dentistry has been called the “the art of the imperceptible” by McLaren and Rifkin. Symmetry, normalcy, sexual dimorphism, and youthfulness have been considered the

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classical element of facial beauty. The face is the key feature in the determination of human physical attractiveness. Symmetry is one of the factors that contributes to facial harmony, and in cases with oral rehabilitation, it determines the success of esthetic treatment (Eskelsen et al., 2009). Humans and many other animals are highly sensitive to deviations from bilateral symmetry, and they prefer symmetry over asymmetry (Brisman, 1980).

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 centre or axis.”This centre axis line, which contributes in symmetry, is known as the ‘midline’. All esthetic deviations revolve around midline. Historically various number of facial landmarks present in the middle third of the face, such as the bisector of the pupil, nasion, tip of the nose, tip of the philtrum and chin were used to define the facial and dental midline. Some authors prefer the use of intraoral landmarks, such as the incisive papilla, for defining maxillary dental midline. Modifications in genetic structure can lead to misalignment of these landmarks, such as chin position and the cartilaginous structure of the nose, while the philtrum of the lip is considered to be one of the most accurate of these anatomical guideposts as it is always in the centre of the face. The exceptions are cases in which there is deviation as a result of accident or congenital abnormalities such as cleft lip, palate etc.

By making dental midline coinciding with the midline of the mouth may be adequate, as patients find easier to relate their dental midline to proximal structures than landmarks which are away from the mouth (Bidra et al., 2009). A key element in smile design pivots around the midline as it unites the face and its features with dentition and the anterior teeth in particular.

From esthetical point of view maxillary dental midline should be coincident with the midline of face, than the mandibular midline. This may be due to the dominant attribution of the maxillary anterior teeth while smiling and functioning. The alignment of facial, maxillary and mandibular midlines in one line is desirable, but not mandated. Facial harmony depends upon interrelationship of the components of the face, such as the nose, eyes, lips, and chin, either in harmonious or symmetrical proportion. Its application in restorative and/or rehabilitation procedures can determine the esthetical success of treatment (Eskelsen et al., 2009).

Many studies conducted till dates have lacked the objectivity in the evaluation criterion for facial midlines. There is not much of information about the relationship of midline of the face and midline of the mouth. All these provide the rationale for this study.

The objectives of this study were:

1. To determine relationship of facial midline with different facial anatomical landmarks.
2. To determine the hierarchy of facial anatomical landmarks closest to the facial and dental midline.
3. To check whether the center of incisive papilla coincides with dental and facial midline or not in natural dentition.

The anatomical landmarks selected are those commonly applied in clinical practice such as - nasion, tip of nose, tip of philtrum, incisive papilla and dental midline.

MATERIALS AND METHODS

100 subjects, both male and female of age group of 20 to 45 years were randomly selected from students and patients visiting the out-patient department, of the Himachal Dental College and Hospital Sundernagar Himachal Pradesh, India.

Digital image involving full face of each subject in smile were made, with the subject seated on chair. 3 small points were marked by a single observer using a fine tipped erasable marker, with a tip approximately 0.5 mm diameter on each subject. These points were placed on nasion, tip of the nose and tip of philtrum to simulate a clinical situation. The following inclusions criterions were observed for the selection of subjects for the study:

1. Age group between 20 and 45 years.
2. No history of congenital conditions or trauma affecting facial form and appearance.
3. No history of orthodontic treatment.
4. Presence of anterior natural teeth.
5. Absence of prosthodontically replaced maxillary anterior teeth.
6. Ability to understand written informed consent.

Exclusion criterions of photographs were as follows:

1. Images with rotated head position
2. Visible asymmetry involving eyes
3. Wrong clinical markings
4. Images with bad resolution

The digital camera (NIKON D40X digital SLR camera, 10.2 megapixels; Nikon Corporation, Japan) was mounted on a tripod stand with a standardized focus and at a standardized distance of 1.5 m (5 feet) from the subject (Figure 1). The lighting conditions remained same for study procedure.

Each subject was guided by the observer to assist itself in assuming the natural head position, as documented in the literature (Cooke, et al., 1990; Robert, 1948). The height of the camera lens was in line with the eye- level of each subject while sitting upright with shoulder and head held straight and facing the camera (Figure 1). The natural head position was evaluated in horizontal and vertical axis and absence of any rotations. Standard definitions for anatomic landmarks were used in this study. Following landmarks (Lateral canthus, Philtrum, Commissure) (Merrian, 2006) (Nasion, Tip of nose, Chelion, Exocanthion) (Farkas, 1994) were clinicaly marked to construct an “esthetic frame” digitally. Photographs were analyzed using Imaging software (Adobe Photoshop CS; adobe systems, Inc. San Jose, California, USA) for measuring the distance between the different anatomical landmarks.

The “esthetic frame” (Bidra et al., 2009) used for this study comprised of rectangular enclosure which defined the facial midline objectively. Esthetic frame denotes an area on the face, which includes objects of the esthetic interest such as midlines, cants, and smile parameters. Its upper border is formed by joining exocanthion of two eyes. This line was analyzed for parallelism with sagittal axis in natural head position. This omitted the effect of any minor rotations of the head along the sagittal axis. Subjects with eyes at

Figure 1. Showing set for photography.

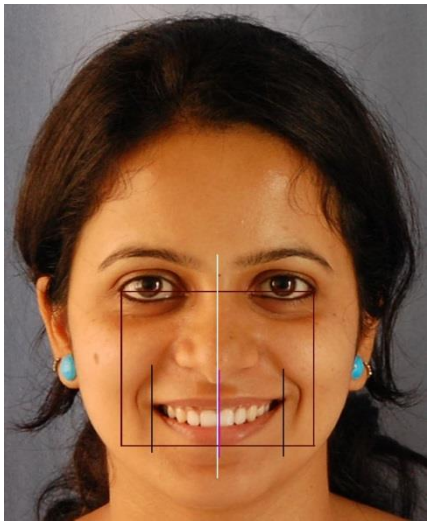


Figure 2. Representing esthetic frame.

different levels were excluded for analysis because of this region. The right and left borders of the frame were drawn as perpendicular bisectors to upper border at exocanthion of each eye. The lower border was drawn parallel to the upper border at the most inferior border of lower lip. This completes four sides of the frame (Figure 2).

In study, the facial midline (Figure 2 *White line*) was assumed as centre line of the esthetic frame. The dental midline was defined as the vertical line drawn parallel to the lateral border of the esthetic frame through the tip of the incisal embrasure between the two maxillary central incisors. The bisector of the distance between the cheilions of each subject in smiling posture (Figure 2 *Purple line*) was defined as midline of the oral commissures. Similarly lines were drawn passing through the marked landmarks that were parallel to lateral borders of esthetic frame (Figure 3).

For each subject impression for maxillary arch was made with alginate (Algitex) and poured in type III Dental stone (Gypstone). Casts were retrieved from impression and a jig was used to make base for them (Harold, 1979). The jig consisted of rectangular wooden frame (Figure 4). Three holes were made at selected points on three sides of the frame and straight stainless steel pin was inserted into each hole. The tips of the three pins made a plane that was parallel to top and bottom planes of the frame. To secure the cast in a desired position three screws were also attached. The tip of the interdental papillae between maxillary central incisors and the maxillary first and second molars on the right side and the left side were chosen to serve as the reference points on the cast. The pins contacted at these reference points. Once the cast is oriented in the desired position, the screws were tightened to hold the cast inside the jig.

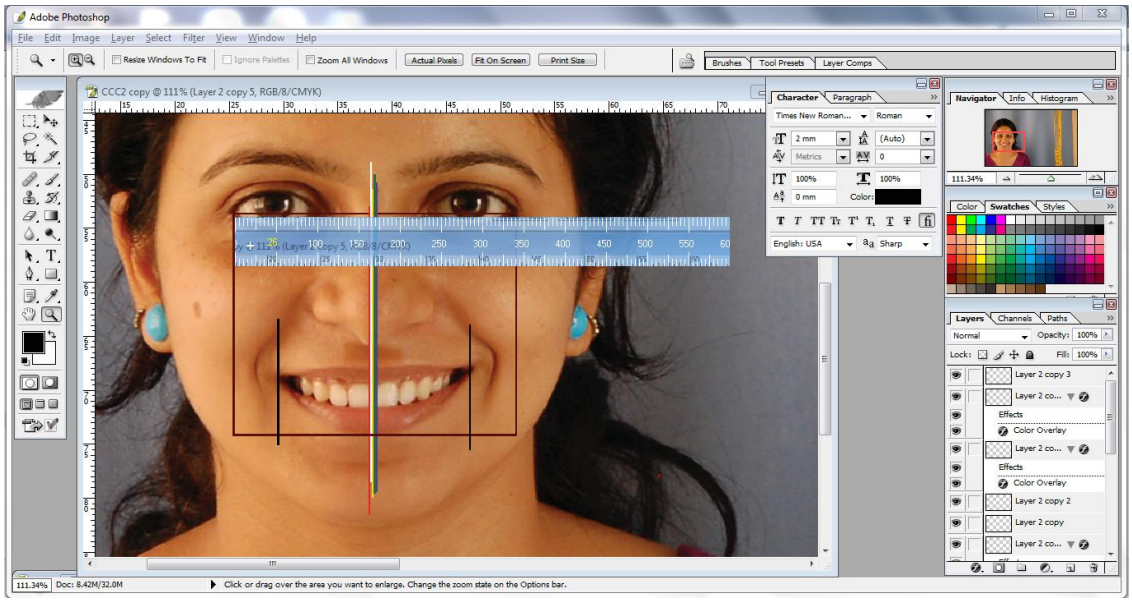


Figure 3. Various lines drawn through marked points and measuring their respective distances (Red-Dental midline, Blue-Nasion, Yellow-Tip of nose, Green-Philtrum).

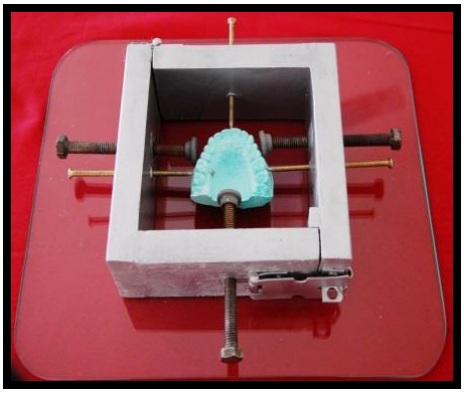


Figure 4. Shows orientation of cast within jig.

A thin mixture of type II dental plaster (Dentex) was placed on a flat glass plate. The jig along with cast was placed directly on the top of the plaster mixture and tapped lightly to seat the bottom edges of the jig to make uniform contact with the glass plate. Jig was removed and stone casts with plaster base were trimmed and polished. The retrieved casts were standardized with the occlusal plane parallel to the horizontal plane when the bases of the casts were placed on a flat horizontal surface.

The following anatomic landmarks were marked on the cast (Figure 5). The anterior point of the incisive papilla *Ia*, the posterior point of the incisive papilla *Ib* (Lau, 1993).

The casts were placed on the flat platform. A camera (Nikon D40) was mounted on stand , axis of lens was aligned vertically downward towards occlusal plane of maxillary cast and the distance between lens and platform was adjusted to 310 mm so that the photographs could be kept in equal proportions with casts (Michiko, 2004) (Figure 6). The digital data was processed with adobe photo shop software. The two points, *Ia* and *Ib* were joined digitally and line was extended on both sides. The extended line towards central incisors was carefully observed for its relation to contact area of two central incisors (Figure 7)

Relative facial midline value (RFV) and relative commissural midline value (RCV) were two working units which defined the relationships of the anatomic landmarks to the respective midlines. Relative facial midline value (RFV) of each landmark describes its relative closeness to the facial midline. The distance measured from the lateral border of the frame upto the facial midline was defined as constant “F”. Distance between nasion and lateral border of the frame was considered a variable “N”. The RFV was thus calculated by dividing N by F. RFVs for the other 3 anatomic landmarks: Tip of the nose “T”, tip of philtrum “P” and dental midline “D”, were calculated by dividing them by the constant F. Numerical values for N/F, T/F, P/F and D/F were thus obtained. Relative commissural midline value (RCV) describes relative nearness of an anatomic landmark to the midline of the oral commissures (center of the mouth). Distance from the midpoint of the inter-commissural line to the right/left cheilion was considered a constant term C. Similarly distances were measured between oral commissural line and other

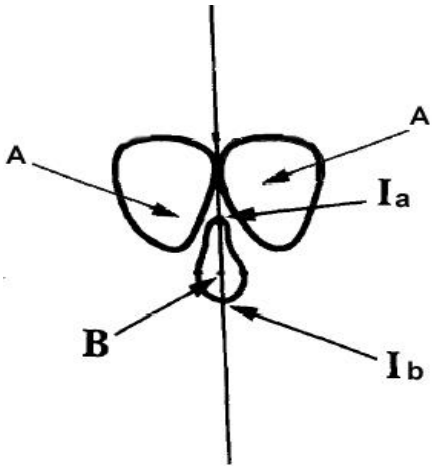


Figure 5. A- Max central incisors; B- Incisive papilla.

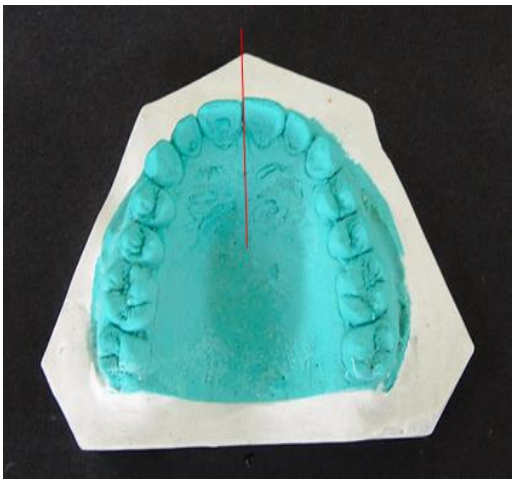


Figure 7. Cast image with line drawn digitally.

Figure 6. Set up for photography of cast.

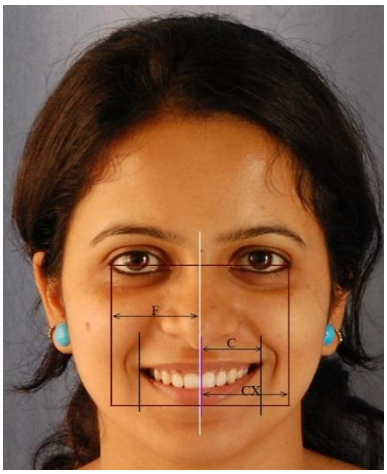


Figure 8. Representing distances F, C, CX

anatomic landmarks such as from nasion NX, from the tip of the nose TX, from the tip 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 distance between lateral border of the esthetic frame and the midpoint of the commissures was described as a variable called CX (Figure 8). Thus, the relationship between the midline of the commissures and the midline of the face was obtained by CX/F

The concept of RFV was to develop a quantifiable relationship between given anatomical landmark and the midline (face or mouth). This provides ratios which are comparable for all anatomic landmarks located in the esthetic frame and neglecting the need for matching the dimensions of image with the subject's face. The terms 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 the philtrum to the midline of the face and commissures; RFV4 and RCV4: relativity of the dental midline to the midline of the face and commissures and RFV5: relativity of the midline of commissures with the midline of face. For a perfect symmetrical face, all 5 of the RFVs and all 4 of RCVs will be equal to each other and to the numeral 1.

The lateral (right or left) border of the frame or oral commisures was chosen according to deviation of anatomic landmark towards either side. Therefore, the shortest distance between lateral border of the frame and landmark was chosen. This resulted in RFV being less than1always. If two anatomic landmark coincided with each other's, the RFV recorded would be same for both. RFV value of 1 was assigned to those anatomic landmarks which were coincident with the facial or commissural midline. Each subject had a total of nine values recorded.

RESULTS

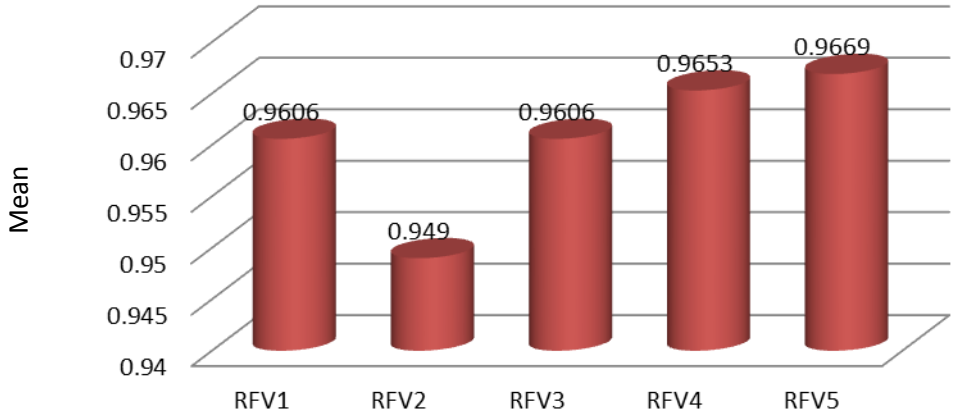
Two sets of data were obtained and were checked for reliability by performing intra class correlation coefficients (ICCs) between them. To analyze whether the marked landmarks were different from midline of face and mouth, a series of one - sample *t* test were conducted with alpha value of 0.5. Two sets of one sample t tests were

Table 1. One sample test representing mean for all 5 RFV values for 100 subjects.

Anatomical landmark	Total number of subjects	Mean	Std deviation
RFV1	100	0.9606	0.0300
RFV2	100	0.9490	0.0353
RFV3	100	0.9606	0.0306
RFV4	100	0.9653	0.0259
RFV5	100	0.9669	0.0267

Table 2. One sample test representing mean values of RCV from 100 subjects.

Anatomical landmarks	Total number of subjects	Mean	Std deviation
RCV1	100	0.9364	0.053
RCV2	100	0.9274	0.078
RCV3	100	0.9481	0.036
RCV4	100	0.9527	0.033



Graph 2. Hierarchical relationship of anatomic land marks with midline of face.

conducted. One set of 5 t tests was conducted for 5 specified anatomic measures to check their coincidence with facial midline. The analysis provided the difference between the mean ratio of each anatomic landmark and the midline of the face was statistically significant (P<0.001). Results are depicted in Table 1.

Second set of 4 t test was conducted to check whether the 4 specified anatomical landmarks lined up with intercommissural midline or not. Results for different RCV are depicted in Table 2.

Photographs of the cast were observed for the relation of incisive papilla with central incisors. Line was drawn digitally passing through the two points marked on the cast at anterior and posterior position of incisive papilla Table 3.

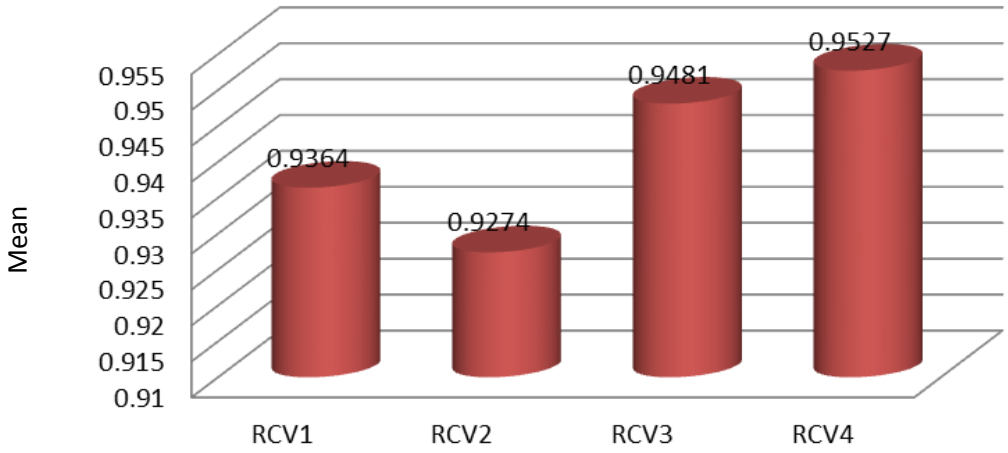
Graph 1 shows the comparison of the values obtained for facial midline.

Graph 2 shows the comparison of the values obtained in relation to midline of mouth.

DISCUSSION

Null hypothesis was rejected on the basis of results which show that selected facial anatomic landmarks and the midlines of the face and oral commissures are different.The midline is the most important focal spot in an esthetic smile. Esthetic appearance is intensified when the maxillary midline coincides with the midline of the face. The coincidence of both lines is recognized by the patients. As no human face is symmetrical, there can be no hard and fast rule for determining facial midline. But off center midline is readily recognized by the patient (Tjan and Miller, 1984).

Standardized definitions for facial midlines are not available in the literature. Therefore, the facial midline was determined by using the esthetic frame concept as suggested by Bidra et al. (2009) and Moshkelgosha et al. (2014). Craig (2002) had also used similar concept consisting of grid analysis system. The esthetic grid



Graph 1. Hierarchical relationship of anatomic land marks with midline of mouth.

system was created to analyze the basic problems that detracted from the concept of an attractive smile. This study was limited to mouth and no relation with soft tissue facial landmarks was drawn. Integrating facial guidelines with dental composition using grid highlights deviations from ideal, there by assisting in treatment planning.

Midline discrepancies are not related to either age or gender. Lay person are less susceptible to change in midline discrepancy as compared to dental clinicians but become more perceptible with increasing magnitude (Kokich et al., 1999; Rosensteil and Rashid, 2002). General principles of facial photography, head position, camera position and lightning were used as reviewed by Lewis et al. (1990). Anthony (1984) used photographs of smiling subjects to analyze various esthetic factors in smile (Tjan and Miller, 1984). Eskelsen et al. (2009) and Jayalakshmi et al. (2013) also used photographs of smiling subjects to visualize deviation of midlines in comparison to known soft tissue landmarks (Lewis et al., 1990).

Validity of the natural head position and its long term reproducibility over a period of up to 15 years has been proved by Li Peng (Cooke, et al., 1990). Lundstrom (1992) compared natural head position recorded photographically with the lateral head radiographs of same patients. It was found that natural head position (NHP) represented a realistic appearance of patients and could be used as basis for cephalometric analysis (Lundstrom and Lundstrom, 1992). Subject with smile position was chosen for, as it is a standard for esthetic analysis and it revealed the dental midline as well.

The markings were made clinically in accordance to standard definition of each anatomic landmark (Farkas, 1994). The lines on the image were drawn digitally passing through these markings thus providing more clinical relevance of marked points.

Various observations of present study depicted in Table 1 and 2. Table 1 show mean values of RFVs for each anatomical landmark chosen. It clearly indicates Inter commissural line (RFV5 - 0.9669) as closest landmark to facial midline defined. It was found from a previous study done by Bidra et al. (2009) that the midline of the oral commissures was the most reliable anatomic landmark while analyzing the hierarchical order for facial midline as it ranked closest to the facial midline. Miller through his study also concluded that center of mouth as reliable point for placing midline (Miller et al., 1979; Farhan et al., 2014).

The anatomic landmark that ranked closest to the facial midline in this population as shown by the results of the present study in Graph 1, was the inter-commissural midline .The hierarchical order so obtained was in order of Inter commissural line then dental midline, tip of philtrim, nasion and tip of the nose. It was found for the present population that dental midline and inter commissural line differed in hierarchical position with a minute difference.

The second part of the study evaluated the proximity of these anatomical landmarks with the center of the mouth (commissures). Table 2, Graph 2 shows that the dental midline (RCV 0.9527) ranked highest, followed by philtrum, soft tissue nasion and tip of the nose when compared to midline of the mouth. The tip of the nose was only landmark which deviated most in relation to facial midline. However this study did not addressed the axial angulations of the dental midline in its analysis.

In the present study, the tip of philtrum ranked third in the hierarchy, followed by midlines of mouth and dental midline. This makes the tip of philtrum as a more reliable landmark for locating midlines of face and mouth.

The nasion, from its position can be considered near to the middle of the face, but its relation hasn't been determined in studies yet. From results of the current study its clear that, the soft tissue nasion cannot either of midlines. A study done by Eskelson et al. (2009) concluded that there is no significant relation between

Table 3. Relation of incisive papilla with central incisors.

Total no subjects	Line coinciding with central incisors	Line not coinciding
100	92	8

maxillary midline and bisector to interpupillary line. In most clinical situations these three anatomical landmarks, namely the midline of commissures, tip of philtrum and dental midline appeared to be more relevant for determining midline of face. Smith in his study found that there was no demonstrable relationship between intercanine width and inter alar width or skeletal nasal aperture (Mavroskoufis, 1981).

Many clinicians have cited the difficulty of choosing suitable replacement for natural teeth in edentulous patients and arranging them in a natural and esthetic way. Errors at this stage can often leads to patient rejection despite the prosthesis being well-constructed, comfortable, and efficient.

The present study differed from previous studies on basis of selection of landmarks used for calculating midline and methodology. Use of ratio's RFV and RCV as tools to determine the relationship of landmarks is advantageous rather than using linear measurements as it provides simple comparable results.

Same landmark had different ratios in relation to both midlines stating the difference in closeness; however this does not change the hierarchy for the same. It is good for a clinician to know the hierarchy of anatomic landmarks that could be used in locating the midline for a particular patient, rather than to find out the mean linear deviations of anatomic landmarks of a certain population.

The third part of the study (Table 3) goes in favor of previous studies done by Mavroskoufis et al. (1981), Jacob and Gazit (1975) and Grave (1987) proving that incisive papilla lies in between two central incisors and remains constant even after extraction. Study done by Harper on incisive papilla concludes the presence of incisive papilla in center of two maxillary central incisors in dentate patients and in center of ridge in edentulous patients (Peng and Cocke, 1999). Lau (1993) had done similar study in Chinese population and proved the position of incisive papilla in relation to central incisors. As we have already defined dental midline as an imaginary line passing through two central incisors in vertical direction, so the relation of incisive papilla with dental midline and other facial landmarks can be drawn on imaginary horizontal line with vertical dental midline. However no clinical study has yet been done to prove direct relation of incisive papilla with known anatomical landmarks.

Future studies can be done to prove this relation. Also consideration should be given for: (a) Degree of normal resorption and abnormal resorption under tissue bearing appliances; (b) The growth of certain posterior teeth below the occlusal plane and its effect on position of papilla.

The current study was done by a single observer and population was chosen based on convenience sampling. Thus the chances of variation were limited. Similar studies in different geographical areas including larger population can be done to confirm the results of the present study.

Conclusion

Many authors have discussed the relation various landmarks in creating midline which tends to balance the facial components of both sides. Nature has arranged such landmarks ubiquitously around imaginary midline which divides face into two parts. Its human perception which tend to relate these landmarks for marking midline. Based on the limitations of the present study, it can be concluded that:

1. There is significant difference between the mean ratios of the chosen anatomic landmarks (nasion, tip of nose and philtrum) and the midlines of the face and the mouth;
2. The hierarchy of anatomic landmarks closest to the midline of the face are:

i. Inter commissural midlines
ii. Dental midlines
iii. Tip of philtrum
iv. Nasion
v. Tip of the nose

3. The hierarchy of anatomical landmarks closest to the intercommissural midline are:

i. Tip of philtrum
ii. Dental midline
iii. Nasion
iv. Tip of nose

4. Incisive papilla lies in center of central incisors thus it is related to dental midline

Human eye is best evaluator; in comparison to defined ideal situations errors will be evident if a long contemplative look is taken at the teeth arrangement. For creating ideal conditions in dental esthetics there is need for detailing at basic levels. Indeed, the perceptive principles may be regarded as the cellular elements of

which the tissue of denture esthetics is composed. With thorough knowledge of these principles one can artistically design the denture esthetics and can visualize the outcome of teeth arrangement even before a single tooth is placed in wax.

Conflict of Interests

The authors have not declared any conflict of interests.

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