Digital assessment of the relationship between facial and dental midline with various anatomical landmarks of face and oral cavity

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Abstract:

Introduction And Objectives: Symmetry plays a vital role in the perception of dentofacial aesthetics, and an understanding of the facial midline enhances the overall assessment and planning of dentofacial aesthetics. The central incisors should be positioned coincident with the midline in fixed or removable partial dentures. This study aims to evaluate the relationship between facial and dental midlines with various intraoral and extraoral anatomical landmarks of the face and oral cavity and relationship between maxillary and mandibular dental midline with the help of digital photographs in a dentulous population. **Method**: Three commonly used anatomical landmarks—the tips of the nasion, nose, and philtrum—were clinically identified in 150 participants. A frontal full-face digital photograph was utilized to analyse the midline based on the aesthetic framework. Deviations of these three landmarks from the facial midline were measured, with the maxillary midline serving as a fourth reference point. The discrepancy between the maxillary and mandibular dental midlines was also assessed. Alginate impressions were taken, and the resulting casts were evaluated under standardized conditions, with the labial frenum and incisive papilla marked for reference. **Results And Conclusion:**It can be concluded that the maxillary midline did not align with the facial midline and demonstrated a significant degree of deviation in terms of distance. Furthermore, the mandibular and maxillary dental midlines were not in alignment. Of all the facial landmarks examined, the nasion was found to be the closest to the facial midline, whereas the tip of the nose showed the highest degree of deviation. The tip of the philtrum displayed a deviation like that of the maxillary midline, making it a useful reference point for establishing the maxillary dental midline during prosthodontic treatment of missing anterior teeth. The labial frenum showed less deviation from the dental midline compared to the incisive papilla.

Keywords: Facial Midline, Dental Midline, Digital Image, Nasion, Philtrum, Tip of Nose, Incisive Papilla, Labial Frenum

Introduction:

A well-balanced smile is a major factor in human attractiveness, influencing confidence and how others perceive us. With the rise of cosmetic dentistry, prosthodontics now focuses not only on restoring teeth but also on enhancing overall facial aesthetics. Central to this is the facial midline, whose alignment with the dental midline—especially the maxillary central incisors—is crucial for creating visual harmony. However, traditional anatomical landmarks used to determine the midline vary widely among individuals and are often unreliable.

Digital photography has emerged as a powerful tool for accurate, repeatable facial analysis, enabling photogrammetry and standardized assessment frameworks such as Bidra'saesthetic frame. Despite these advances, research continues to show

frequent mismatches between facial and dental midlines, highlighting ongoing controversy and the lack of a universally accepted reference point.

The current study seeks to evaluate midline coincidence using standardized digital photographs and to identify the most dependable anatomical landmarks for clinical use. Achieving an ideal smile ultimately remains a blend of scientific precision, artistic judgment, and digital innovation.

Materials and methods:

This study was conducted in the Department of Prosthodontics at Dasmesh Institute of Research and Dental Sciences, Faridkot, involving 150 dentate participants (90 females, 60 males) aged 18–30 years. All subjects were informed about the digital analysis procedures and provided written consent. Selection was based on the presence of natural anterior teeth, absence of orthodontic or prosthodontic history, and no facial deformities.

Subjects with maxillary anterior restorations, facial asymmetry, malformed teeth, or poor-quality photographs were excluded.

Materials and Equipment

Alginate, Type III dental stone, and plaster of Paris were used to prepare study casts. Digital photographic analysis employed a Canon EOS 1300D camera on a tripod, Digimizer software, a Lenovo laptop, impression trays, a wooden jig, and standard clinical tools such as cheek retractors, stickers, mirrors, and scales.

Facial Landmark Identification

Three soft-tissue landmarks—nasion, tip of nose, and tip of philtrum—were marked using 2-mm adhesive stickers under standardized definitions to ensure consistency.
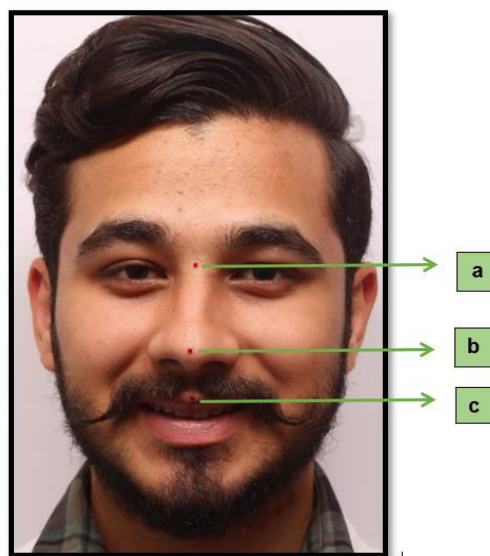
Fig. 1– Clinically marked facial anatomical landmarks showing a) Nasion, b) Nose Tip, c) Philtrum

Standardized Photography

Participants were photographed against a white background with the camera fixed 1.5 m away and aligned at eye level. Camera settings included f/11 aperture, 1:1 macro magnification (55–85 mm), and 1/80 shutter speed. A metallic scale was placed behind subjects for calibration. Two frontal images were taken for each subject: one natural-smile photograph and one with cheek retractors in place and teeth in maximum intercuspation. Each photo was repeated to ensure accuracy.

Fig. 2 - Digital Photographic Setup

**Digital Esthetic Frame Construction**

Smiling photographs were uploaded to Digimizer for analysis. An esthetic frame was digitally constructed using a rectangle bordered superiorly by a line connecting both exocanthions and inferiorly by the lower lip contour. The facial midline was defined as a vertical line bisecting the superior border. All borders were color-coded for clarity, with the facial midline displayed in yellow.
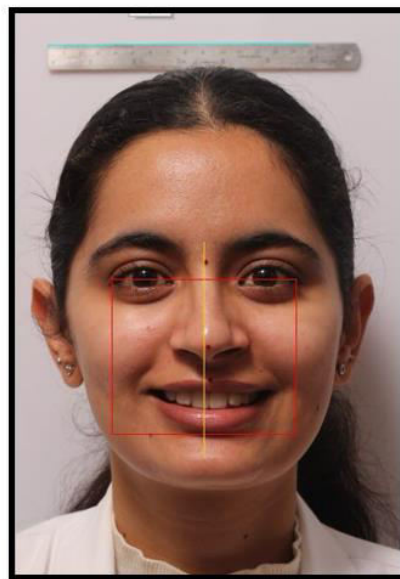
Fig. 3 – Construction of facial midline (color coded yellow) through the center of esthetic frame (color coded red)

Facial Landmark Midline Measurements

Parallel lines were created through each marked anatomical point—pink (nasion), green (nose tip), and white (philtrum). After software calibration using a 150-mm reference on the scale, the perpendicular distance and direction of deviation from the facial midline were measured in millimeters.
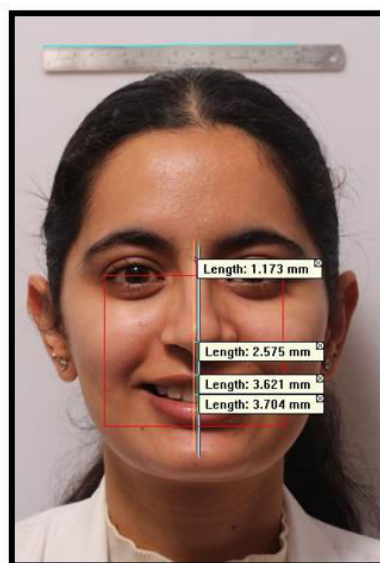
Fig. 4 – Measured values of deviation between FM and each variable shown

Dental Midline Identification (Smiling View)

The maxillary dental midline was digitally established by drawing a vertical blue line through the maxillary central incisor embrasure, parallel to the esthetic frame's borders. Its deviation from the facial midline was measured and recorded.

Maxillary–Mandibular Midline Assessment (Retracted View)

Retracted-view photographs were used to compare maxillary and mandibular dental midlines. Vertical lines—navy blue (maxilla) and black (mandible)—were drawn through the respective incisal embrasures. Deviations and directions were documented.

Fig. 5 – Non-co-inciding Maxillary (color coded "Dark blue") and Mandibular (color coded "black") dental midline.

Intraoral Cast Analysis

Maxillary impressions were made using alginate and poured in dental stone. Casts were photographed from a fixed vertical orientation using a custom box setup for consistent imaging. Anatomical landmarks—the anterior and posterior points of the incisive papilla and labial frenum—were marked and digitally connected. These lines, color-coded navy blue (incisive papilla) and purple (labial frenum), were compared with the yellow-coded dental midline. Distances were measured in millimeters to evaluate alignment accuracy.

All collected data were recorded for statistical evaluation of the relationship between facial, maxillary, and mandibular midlines and the reliability of different anatomical landmarks.

Fig. 6 – Set up for Cast Photography
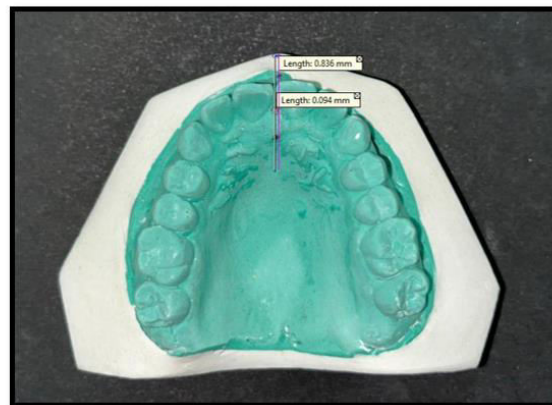
Fig. 7 - Measured values of deviation between DM and each variable shown.

Results:

This study evaluated deviations between the facial midline (FM) and multiple anatomical reference points, using FM as the fixed baseline. Measurements included the maxillary midline (MM), nasion, nose tip, and philtrum tip. Statistically significant differences were found among all four landmarks. Overall, the greatest deviation occurred between the FM and nose tip (Group 3; 1.918 mm), followed by the MM (Group 1; 1.296 mm), philtrum (Group 4; 1.231 mm), and nasion (Group 2; 0.979 mm).

Sex-based comparisons showed similar patterns. Among females, the highest deviation also appeared in Group 3 (1.953 mm), followed by the MM (1.384 mm), philtrum (1.364 mm), and nasion

(0.904 mm). Males demonstrated the same trend, with Group 3 showing the greatest deviation (1.865 mm), then the MM (1.163 mm), nasion (1.091 mm), and philtrum (1.032 mm).

Across all participants, right-side deviation was most common for deviations from the facial midline. In contrast, maxillary–mandibular midline discrepancies showed no significant difference between intraoral reference points and revealed a predominance of left-side deviation. Males exhibited a higher mean maxillary–mandibular deviation (1.833 mm) than females (1.488 mm), with an overall mean of 1.671 mm.

Left-side deviation was the most frequent pattern in maxillary–mandibular alignment: 57.8% of females and 53.3% of males showed left deviation, compared with 24.4% and 35.0% showing right

deviation, respectively. In the total population, 56.0% exhibited left-side deviation, 28.7% right-side, and 15.3% showed no deviation.

These results indicate consistent variation among anatomical midline landmarks and highlight a notable tendency toward left-side deviation in maxillary–mandibular alignment across both sexes.

Table 1- Descriptive statistical data regarding distance of deviation (mm) of various extraoral landmarks from the facial midline in total subjects.

	N	Mean	Std. Deviation	Std. Error	95% CI Lower Bound	95% CI Upper Bound	Minimum	Maximum
FM to MM	150	1.296	1.093	0.089	1.120	1.472	0.040	6.860
FM to Nasion	150	0.979	0.849	0.069	0.842	1.116	0.030	4.740
FM to nose tip	150	1.918	1.464	0.120	1.682	2.154	0.110	6.930
FM to Philtrum	150	1.231	1.083	0.088	1.057	1.406	0.050	5.800

Table 2- Post Hoc Analysis of the compared data.

Group Comparison (I – J)	Mean Difference	Std. Error	Sig.
Group 1 vs Group 2	0.317 *	0.132	0.017 { Sig}
Group 1 vs Group 3	−0.622 *	0.132	0.001 { Sig}
Group 1 vs Group 4	0.064	0.132	0.626 { Non-Sig}
Group 2 vs Group 3	−0.939 *	0.132	0.001 { Sig}
Group 2 vs Group 4	−0.252	0.132	0.046 { Sig}
Group 3 vs Group 4	0.687 *	0.132	0.001 { Sig}

(Group 1- Facial midline to maxillary midline, Group 2- Facial midline to Nasion, Group 3- Facial midline to nose tip, Group 4- Facial midline to Philtrum)

Table 3-Descriptive statistical data regarding distance of deviation (mm) of various intraoral landmarks from the dental midline (DM) in total subjects.

Group	N	Mean	Std. Deviation	Std. Error	P value	Significance
DM to Labial Frenum	150	0.516	0.496	0.040	0.565	Non-Sig
DM to Incisive Papilla	150	0.548	0.476	0.038		

Table 4 -Descriptive statistical data regarding distance of deviation (mm) of maxillary and mandibular midline among subjects.

Group	N	Mean	Std. Deviation	Std. Error
Females	90	1.488	1.110	0.401
Males	60	1.833	1.406	0.385
Overall	150	1.671	1.303	0.393

Discussion:

The clinical significance of aligning the dental midline with the facial midline remains debated. Graber and Lucker (1980) argued that factors like spacing and dental crowding influence esthetics more than midline discrepancies, whereas Hulsy (1970) highlighted midline position as an important contributor to smile attractiveness. Other authors, including Golub (1988) and Frush (1971), cautioned that an overly exact midline may appear artificial. Kokich et al. (1999) similarly questioned the necessity of perfect midline alignment for achieving an esthetic result. Despite these differing views, the golden proportion concept reinforces the idea that facial beauty depends on proportional harmony, making the alignment of the maxillary midline an important consideration in prosthetic rehabilitation. Based on this rationale, the present study evaluated the relationship between the facial and maxillary midlines and the significance of their alignment in anterior prosthodontic treatment.

Traditionally, anatomical landmarks such as the interpupillary line, nasal tip, philtrum, and chin have been used to identify the facial midline. However, inconsistencies in these landmarks—such as pupillary asymmetry, nasal deviation, and mismatches between upper and lower dental midlines—limit their reliability. Furthermore, midline shifts may result from congenital or acquired conditions including cleft lip and palate, hemifacial microsomia, neurofibromatosis, trauma, or temporomandibular joint ankylosis. Thorough diagnosis is therefore essential to distinguish pathological deviations from normal variations.

Bidra et al. (2009) introduced the Esthetic Frame Concept, which analyzed midlines and landmarks using proportional measurements in Adobe Photoshop. Despite its usefulness, the method was limited by the inability to convert relative digital measurements into direct linear values. Contemporary image-analysis technologies, including the calibrated digital method used in the present study, address this limitation. By incorporating reference objects of known dimensions, these methods allow accurate conversion of digital measurements into real-world values, as previously validated by Moshkelgosha (2014) and Owens (2002).

The present study found notable discrepancies between the facial midline and several anatomical landmarks. The maxillary dental midline (M = 1.296 mm), nasion (M = 0.979 mm), philtrum tip (M = 1.231 mm), and nose tip (M = 1.918 mm) all exhibited measurable deviations. These results are consistent with studies by Kurian (2018), Farhani (2019), Bidra (2009), Singh (2016), and Surender (2020). However, other research (Khan 2019; Miller 1979; Vucovic 2010; Jain 2018) reported higher midline coincidence, which may reflect methodological differences or population-based variations in facial morphology.

In this study, the nasion showed the least deviation from the facial midline, although its reliability has been questioned due to difficulties in marking soft tissue and observer variability. The nose tip demonstrated the greatest deviation, confirming earlier findings that identify it as an unreliable facial midline marker due to its susceptibility to trauma, anatomical variation, and conditions such as deviated nasal septum. In contrast, the philtrum tip emerged as a more dependable reference point

Among intraoral landmarks, the labial frenum (0.516 mm deviation) showed slightly greater reliability than the incisive papilla (0.548 mm deviation), aligning with earlier findings by McVay (1984). Although differences were minor, the labial frenum appears to offer marginally better precision in approximating the dental midline.

Limitations

Despite standardized photography and calibrated measurement techniques, some degree of error is inevitable. Additional studies involving larger sample sizes, varied age groups, and diverse ethnic backgrounds are recommended to further validate these findings.

Conclusion:

Within the limitations of the study, the following conclusions can be derived:

✓ The facial anatomical landmarks closest to the facial midline, in order of proximity, were: nasion > philtrum > maxillary midline > tip of the nose. The tip of the nose showed maximum and nasion showed least deviation from facial midline.

✓ The tip of the philtrum and the maxillary midline exhibited comparable mean deviations from the facial midline. Therefore, the philtrum tip may serve as a reliable reference point for identifying the maxillary midline during the prosthetic rehabilitation of missing anterior teeth.

✓ The labial frenum can serve as a more suitable landmark than incisive papilla and is frequently considered a reliable reference point for locating the position of the maxillary central incisors.

✓ The maxillary and mandibular dental midlines demonstrated significant misalignment, with males (88.3%) showing a slightly higher average deviation than females (74%).

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