Alignment of Maxillary and Mandibular Midlines in Dentate Individuals: A Cross-sectional Analysis

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ABSTRACT

Introduction: The dental midline is a vital element in smile design. The maxillary and mandibular central incisors midline should ideally be positioned coinciding with each other, Incorrect placement of midlines would lead to instability in dental composition. The dental literature fails to disclose the data as to how nature positions the midline of anterior teeth.

Aim: To evaluate the relation between the midlines of maxillary and mandibular dental arches in the dentate population using standardised digital photographs.

Materials and Methods: This in-vitro cross-sectional study was carried out in the Department of Prosthodontics, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana, Ambala, Haryana, India between June 2021 to December 2022. A total of 155 dentate subjects (102 females and 53 males) of this demographic area, all within the age group 18-45 years of age were selected for present study. Full-face standardised photographs of the subject's frontal profile of occluding teeth in a retracted mouth were captured with a Digital Camera (Nikon D3200 DSLR). The collected samples of intraoral images were analysed in image analysing software (Digimiser version 6.0). Lines were constructed in the software to record the maxillary midline and mandibular midline to assess the coincidence or deviation between them. Direct measurements were also obtained within these constructed lines to record the distance of deviation. Direction (right/left) and distance of deviation were recorded. The collected data were subjected to appropriate statistical testing. The statistical analysis was done using the Chi-square test, t-test, etc., and performed in the statistical software International Bussiness Machine (IBM) Statisical Packages of Social Sciences (SPSS) statistics version 25 (Armonk, USA).

Results: The mandibular midline did not coincide with the maxillary midline in 134 (86%) of the tested population and within both genders and showed a significant (p-value-0.00) deviation of 1.88 mm after application of the t-test. Although 78 (50%) deviations were towards the left-side and 56 (36%) toward the right-side of the maxillary midline within both genders, the results were statistically insignificant with the Chi-square test.

Conclusion: Mandibular and maxillary dental midline fails to coincide in more than four-fifths of the subjects.

INTRODUCTION

A beautiful smile is considered an asset to humans and is believed to enhance a person's attractiveness and personality [1]. The dental midline is often considered to be the beginning point of a dental esthetic evaluation [2]. A face can be said to be in symmetry when the structure, dimension, and relative position of features on the opposite side of a line that is dividing it, are comparable to each other. This concept in clinical application means, the presence of coordination and balance [3,4]. A key element of providing a perceivably beautiful and esthetically enhanced prosthetic rehabilitation is the proper placement of dental midline about each other.

The maxillary and mandibular central incisors should be ideally positioned coinciding with each other or deviated at an aesthetically acceptable range during fixed or removable dental prosthesis. Incorrect placement of midlines would lead to instability in dental composition, causing tension, and making the observer feel the need to shift the line to its proper place to enhance stability and persistence [5].

Traditionally, dental casts have been utilised for estimating and measuring various smile parameters. In this modern day digital photography is more cost effective and much less invasive and provides a permanent record that can be retrieved and used at any point in the future.

There is a lack of sufficient scientific data regarding the percentage of coincidence and deviation among the maxillary and mandibular dental midline. Most of the literature regarding the coincidence of maxillary and mandibular midline is about the western population and not many studies have been done about the Indian population. So, the present study was aimed at addressing this problem and evaluating the relationship between the midlines of maxillary and mandibular dentition through digital photographs.

MATERIALS AND METHODS

This in-vitro cross-sectional study was carried out in the Department of Prosthodontics, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana, Ambala, Haryana, India between June 2021 to December 2022. A total of 155 dentate subjects of this demographic area were selected for present study among dental students and from within patients visiting the dental OPD. Written consent was obtained from the subjects, and they were explained about the procedure to be carried out. Ethical clearance was obtained from the Institutional Ethical Committee, Mullana (IEC-1785).

Sample size calculation: The sample size was calculated statistically using the formula:

$$\frac{z^2 \times p(1-p)/e^2}{1 \times (z^2 + p(1-p)/e^2 N)}$$

N=population size, z=z score, e=margin of error, p=standard of deviation.

Inclusion and Exclusion criteria: The participants included in the study were in the age group of 20-45 years, had permanent dentition, were without crowding in anterior teeth, and could follow verbal explanations and understand the written consent form. Subjects with prosthodontically replaced maxillary anterior teeth, with surgical

or traumatic facial asymmetry defects, with loss of tooth structure in maxillary anterior due to caries, restorations, extractions, and other pathologies, malformed or congenitally malformed anterior teeth, and high labial and lingual frenal attachment were excluded.

Study Procedure

Each subject was made to stand at a standard photographic setup. The distance of the camera lens from the wall (white background) was 1.5 meters. The floor was marked using coloured tape for easy reproducibility. A metallic scale was horizontally fixed behind the subject to calibrate the image (with image editing software) and obtain precise measurements in real dimensions.

The digital camera (Nikon D3200 DSLR) was set on a tripod to stabilise it, and the lens height was adjusted to be the same as the height of the subject's eyes. The aperture setting of the digital camera was set to be f/4.5 and used with a 55-85 mm macro lens, which was kept at 1:1 magnification. A 1/60 second was kept as the standard shutter speed of the camera.

Each of the subjects was asked to look directly into the camera in their natural head position. Special care was taken to minimise rotations of the subject's head in the vertical axis by aiming to maintain parallelism with the assistance of guiding grid lines in the camera display or view finder.

The photographs were carefully captured and repeated twice while keeping the axis of the camera aligned with the occlusal plane of the subject. Photographs of the subject's frontal facial profile were then captured after placing a cheek retractor while the teeth were in maximum intercuspation. The images in occlusion were evaluated up close, to assess whether the upper and lower midlines coincide with each other and if not, to check the direction of deviation.

The photographs were uploaded into the software (Digimiser), and points were marked digitally between the incisal contacting point of maxillary central incisors, close to the incisal embrasure, and also near the cervical contacting point of the mandibular central incisor. Two separate parallel vertical lines were drawn using the length tool. The line created between the contact point of maxillary central incisors was considered the maxillary dental midline and was colour-coded red. Similarly created mandibular dental midline between the contact point of the mandibular central incisor was colour-coded blue [Table/Fig-1a-c].
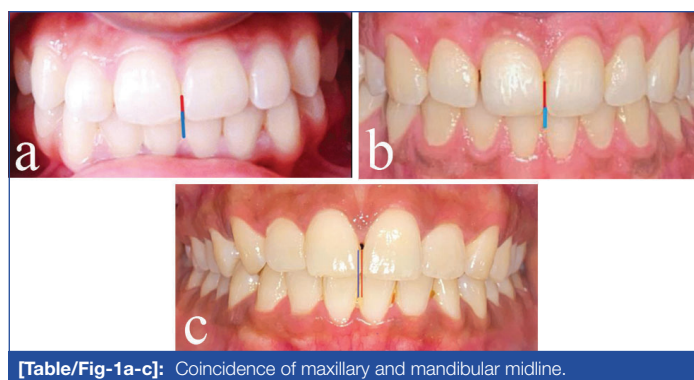

[Table/Fig-1a-c]: Coincidence of maxillary and mandibular midline.

The distance between the determined midline was measured using the length tool after being calibrated in the software using its calibration tool in measurement settings of the software by drawing a 10-millimeter line on the scale that was captured in the photograph and corresponding it to the millimeter unit tool. Thus, the obtained measurements were all calibrated according to the real dimensions of the photographs. The distance between the constructed maxillary and mandibular midlines was recorded in millimeters. The coincidence [Table/Fig-1] and direction of deviation of the mandibular dental midline to the left [Table/Fig-2a-c], or right [Table/Fig-3a-c], concerning the maxillary dental midline were also noted.
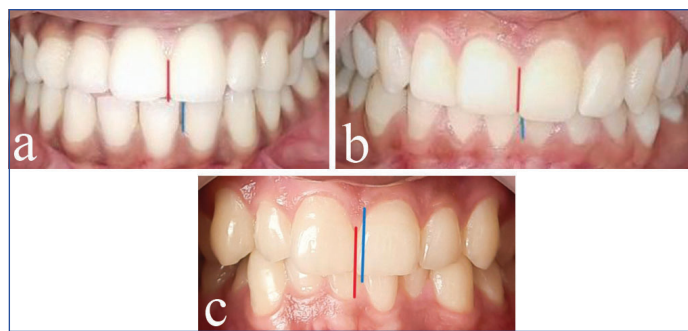
[Table/Fig-2a-c]: Deviation of mandibular midline toward left-side.
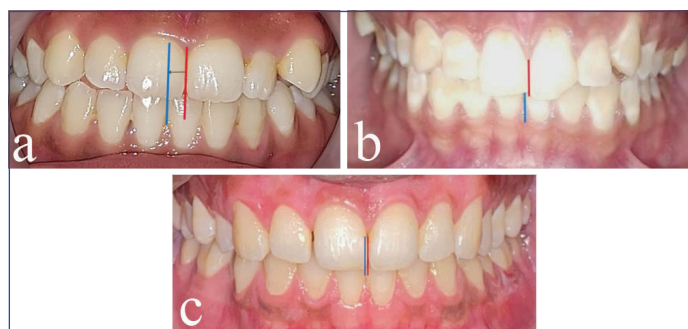
[Table/Fig-3a-c]: Deviation of mandibular midline toward right-side.

STATISTICAL ANALYSIS

The statistical analysis was done using the Chi-square test, t-test, and performed in the statistical software IBM SPSS Statistics version 25 (Armonk, USA).

RESULTS

Direction of deviation of maxillary and mandibular dental midline: Only 14 % i.e., 21 of 155 subjects' maxillary and mandibular midline coincide. In 5 (9.4%) of 53 males and in 16 (15.7%) of the 102 females the two midlines coincide [Table/Fig-4].

Variables	Number of subjects	Coincide	Deviation	Deviation	
				Left	Right
Total subjects (mean age 24)	155	21 (13.5%)	134 (86.5%)	78 (50%)	56 (36%)
Males	53	5	48	28	20
Females	102	16	86	50	36
Pearson's Chi-Square	1.165[a]	0.559 (Asymptotic significance (2-sided))			
Likelihood ratio	1.226	0.542 (Asymptotic significance (2-sided))			
Number of valid cases	155				
	Zero cells have expected count less than 5. The minimum expected count is 7.18.				

[Table/Fig-4]: Showing coincidence and non coincidence and chi-square test of maxillary and mandibular midline in total subjects, male and female.

In 86% i.e., 134 of a total of 155 subject maxillary and mandibular midline doesn't coincide. Left deviation and right deviation were seen in 78 (50%) and 56 (36%) of the total subjects respectively [Table/Fig-4]. A higher percentage of all mandibular dental midlines deviated towards the left-side of maxillary dental midlines in both sexes. The Chi-square test shows there was a statistically insignificant difference in direction of deviation among males/females [Table/Fig-4]. So, there is no association in direction concerning sex in the direction of deviation of the mandibular dental midline to the maxillary dental midline.

Distance of deviation of maxillary and mandibular dental midline: Within a total 155 of subjects the mandibular dental midline showed a mean distance of shift of 1.8 mm. This distance of deviation is statistically significant (p-value=0.00) with a t-test, within males, the mean distance of shift was 2.03 mm, whereas shift was 1.79 mm in females. The mean distance of shift was greater in males although

this difference was statistically insignificant on the application of the t-test (p-value=0.322) [Table/Fig-5].

Maxillary to mandibular deviation_distance	N	Mean	Std. deviation	Std. error mean	t	Sig. (2-tailed)
Total subjects	155	1.88090	1.415983	0.113734	16.538	0.00
Males	53	2.03781	1.508193	0.207166	0.994	0.171
Females	102	1.79936	1.366163	0.135270		

[Table/Fig-5]: Descriptive statistical data and t-test regarding distance of deviation (mm) of mandibular dental midline from maxillary dental midline in total subjects, males and females.

DISCUSSION

Midline being a prime factor for restoration in the aesthetic zone, a Prosthodontist must correctly be able to determine the patient's natural midline because this leads to a balanced and symmetrical, beautifully enhanced composition of the patient's smile. Conversely, Graber LW and Lucker GW prioritised spacing, dental crowding, and overjet as more important contributing factors for satisfactory dental appearance, as compared to midline deviations [6]. The requirement of an error-free placement of dental midline was challenged by Kokich VO et al., Golub J advocated that precise placement of the midline of dental arches can be the contributing cause of an artificial look [7,8].

Digital analysis of photographic records shows a promising future Vucovic A et al., has successfully validated its outcomes through their research [9]. The 2D facial photographs act as vital tools which are non invasive to the patient, have no time constraints in making appropriate measurements, and lead to a permanent record that can be used and reused at any given point of the analysis. A 3D scanner might be more precise, but is not feasible due to its high cost of set-up.

Standardisation of photographs and calibration of images in software (Microsoft Powerpoint; Golden Ratio 1:1, Microsoft 200) to make direct measurements were done concerning standard protocols as advocated by Jayalakshmi NS et al., and Cardash HS et al., Eskelson E et al., [5,10,11]. Rotations of the head can be reduced but not always be nullified. Alarabi AM et al., stated that 5° head rotations were acceptable for midline analysis and did not significantly lead to errors in the results [12].

In studies done over the years, attaining a natural head position was considered the true horizontal plane. This idea has been validated by Peng I and Cooke MS in their research [13]. In present study, the intercanthal line was parallelised to the true horizontal which as result nullified any minor rotation of the subject's head in the sagittal axis. This was done before starting the digital analysis using digitiser software.

Evaluating photogrammetric records of various facial soft tissue in the natural head position has been practiced and validated by Zhang X and Anic-Milosevic S A et al., [14,15]. The upright posture of the head while the eyes are focused on a point in the distance of eye level was validated as being the standardised and reproducible natural head position which was explained by Lundstorm A in their study [16].

In the current study, only 14 % of subjects displayed coinciding dental midlines of maxillary and mandibular dentition, which was similar to results reported by Jayalakshmi NS et al., and Cardash HS et al., and Miller EL et al., [5,10,17]. Miller EL et al., conclude in their study that maxillary and mandibular midline fail to coincide in almost (71.2%) three fourth of the population [17]. Similarly, Jayalakshmi NS et al., found that in 80% of subjects, Sharma V et al., found that in 68.3% of subjects maxillary and mandibular midline did not coincide [5,18].

Similar to present study Miller EL et al., and Sharma V et al., also conclude that the difference between the two sexes was not found to

be statistically significant [17,18]. In Sharma's V et al., study the max and min midline coincide in 33% of males and 30% of females [18], whereas Miller EL et al., is 26.9% male and 28.3% female [Table/Fig-6] [17].

Author and year of the study	Location		Coincide	Does not coincide	Left-side	Right-side
Sharma V et al., 2010 [18]	Bapuji dental college Davangere	Male	66/200 (33%)	134/200 (67%)	67/134 (50%)	67/134 (50%)
		Female	61/200 (30.5%)	139/200 (69.5%)	64/139 (48%)	71/139 (52%)
Miller EL et al., 1979 [17]	University of Alabama school of dentistry	Male	50/186 (26.9%)	136/186 (73.1%)	-	-
		Female	89/314 (28.3%)	225/314 (71.7%)	-	-
Jayalakshmi NS et al., 2013 [5]	Oxford dental college, Bengaluru		42/208 (20%)	166/208 (80%)	-	-

[Table/Fig-6]: Summary of different authors for maxillary and mandibular midline deviation [5,17,18].

In between maxillary and mandibular dental midlines, the coincidence was not commonly seen, during positioning of artificial teeth Hickey JC and Zarb GA advocated the idea of the two midlines being placed coinciding with each other [19]. Mavani S observed 64.5% coincidence within the midlines of dental arches [20]. Research by Bhateja N et al., showed 65% coincidence among dental midlines [21]. The contrasting results to the current research may be a result of carrying out the study in orthodontic pre-treatment photographic records and because of including patients in their mixed dentition phase.

When compared with the shift of mandibular midline to maxillary midline on which side they had shifted. It was found that the majority of deviation was observed towards the left direction (although insignificant statistically) which was also seen in the study by Eskelsen E et al., and Sharma V et al., [11,18].

In present study mean deviation of 1.88 mm was seen between the maxillary and mandibular dental midline Similar to present study Sharma V et al., also found that the midline shifted in the range of 1.1 mm-2.0 mm with 60% of subjects [18]. With mean shift was 2 mm. The acceptable range of deviation that would still satisfy patients' aesthetic demand is up to 2 mm between maxillary midline and facial midline [5,10,22].

Limitation(s)

A limitation of present study is the lack of recorded diversity in the sample population regarding their origin. Although the majority of subjects share a common origin, the absence of detailed documentation regarding the diversity within the sample may limit the generalisability of the findings. The current study was carried out in 2-dimensional images of the face which is a 3D object. Using advanced imaging technology, 3D face scanners can be a futuristic approach to present study.

CONCLUSION(S)

In 134 (86%) of the dentate population, the midlines of maxillary and mandibular dental arches do not frequently coincide and the mean distance of deviation was 1.88 mm. The majority percentage of deviations was seen towards the left-side of the patient's face. The strict establishment of coinciding maxillary and mandibular midline during prosthetic rehabilitation of missing anterior teeth is not required, as this relationship does not exist in the 86% dentate population.

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