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Angular Photogrammetric Soft Tissue Analysis of the Nasofrontal, Nasolabial and Mentolabial Angle: A Cross Sectional Study

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Abstract

Objective: To determine angular soft tissue facial profile values of three relevant facial angles (Nasofrontal, nasolabial and mentolabial) for a sample of adult males and females in Kerala by using photogrammetric analysis and furthermore to identify sexual dimorphism between the samples.

Methods: In this investigation the soft tissue values for nasofrontal, nasolabial, and mentolabial angle of a young adult Keralite population (70 individual, 35 males and 35 females, 18–25 years of age) were studied. Standardized photographic records were taken in the natural head position (NHP) and the angular measurements obtained were digitally analysed by using nemoceph (6.0) software. The results obtained were subjected to descriptive statistical analysis, and sexual dimorphism were evaluated by using Student's t-test for males and females.

Results: Statistically significant ($P < 0.05$) gender difference was found for nasofrontal (G–N–Prn: $P < 0.009$) and nasolabial angle Cm-Sn-Ls ($P < 0.003$). The nasolabial and mentolabial angles showed wide individual variations.

Conclusion: The analysis of the soft tissue facial profile from photographic records provides information on the morphology of the profile and its relationship with the underlying dentoskeletal tissues**.** Soft-tissue facial measurements established by means of photogrammetric analysis in this study would facilitate orthodontists to carry out more quantitative evaluation, and the mean values obtained would assist in orthodontic diagnosis and treatment planning for Keralite adults.

Keywords: Photogrammetric analysis, Soft tissue analysis, Angular analysis, photometric study.

Introduction

Patients undergo orthodontic treatment for various reasons. Dental esthetics and improvement of facial balance hold the top priorities along with the correction of functional problems. The orthodontist's duty is to achieve occlusal and facial outcomes that would most benefit the individual patient. In addition to the functional treatment goals, the clinician should aim to enhance facial balance through appropriate diagnosis and treatment planning.

Beauty still remains one of the most debated concepts in Western literature. Margaret Hungerford stated that "beauty is within the eye of the beholder," while Shakespeare noted that beauty is "bought about by judgment of the eye".[1]The recognition of facial beauty is innate and therefore it becomes difficult to objectively define the components of attractiveness. Subsequently numerous facial angles and proportions are measured and then compared with normal or optimal values to assist in the esthetic assessment of the face.[2] It has been shown that the common facial proportions shown by attractive individuals tend to be near to the mean values of their population. Whilst 'averageness' is not the sole criteria for judging attractiveness, it is one of the most important factors. Therefore average facial proportions could be used for the quantitive assessment of beauty.[1] A great deal of highly relevant data representing mean proportions is available through the extensive work of Farkas and Munro.[3]

Variation in craniofacial morphology is present within and between populations. The concept of racial groups within the human population dates back to the 19th century. A 'racial classification' was developed by the German physiologist and anatomist, Johann Friedrich Blumenbach. He grouped modern humans into five broad categories (Caucasian, Mongoloid, Malayan, Ethiopian and American) based mainly on craniometric measurements.

India has been the meeting point of different races and tribes from times immemorial. Humans entered India from different parts of the world at different time periods adopting themselves. As a result, India has a varied population and diversified ethnic composition. Kerala a coastal state at the southwestern extremity of India is where the Caucasoid (Dravidian) and Australoid (Pre-Dravidian) form the major racial elements.[4]

When planning treatment, the clinician must take into account the normal ranges of variation within each major ethnic group. Furthermore, patients may request features from a different ethnic group possibly due to cultural influences. Therefore, it is useful to compare a patient's craniofacial morphology to the average for their nearest ethnic group. When craniofacial anthropometric and cephalometric data from a specific ethnic group are not available, the data from the nearest ethnic group may be employed to provide guidelines for diagnosis and treatment planning.[5] Clinicians must understand the characteristic features of different ethnic groups and appreciate ethnic variation in order to create a natural appearance.

Studies on soft tissue facial profile analysis among Indians are limited, and there are no reports of any angular photogrammetric studies conducted on the soft tissue facial profile of the Keralite population. Therefore this study was aimed to establish the angular soft tissue facial profile values for nasolabial angle (G-N-Prn), nasofrontal angle (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg) in a sample of adult males and females of Kerala by using photogrammetric analysis.

Materials and Methods

The subjects of this study were dental students from PSM dental college, Kerala. The age range was between 18-25years. A sample of 70 individuals was obtained (35 females and 35 males). Inclusion criteria for this study were individuals with Keralite parents and grandparents, full complement of permanent teeth irrespective of third molar status, class I occlusion with normal overjet and overbite(2-4mm), well-aligned maxillary and mandibular dental arches, average growth pattern with average clinical FMA, skeletal class I relationship determined clinically, minor or no spacing or crowding, bilateral class I buccal segments "molar and canine", class I incisor classification. Those individuals having history of previous orthodontic or prosthodontic treatment, maxillofacial or plastic surgery, individuals having any facial asymmetry, craniofacial trauma or congenital anomalies were excluded from this study. A brief questionnaire was completed by all individuals. Sociodemographic data was collected from the subjects along with the informed consent.

The photographic set-up consisted of a tripod (VCT -899 RM) which held a 35 mm camera (Canon, model 2000D) and a primary flash. A 100 mm focal lens was used in order to maintain the natural proportions. The tripod controlled the stability and the correct height of the camera according to the subject's body height. The camera was used in its manual position, with the shutter speed set at 1/125 per second, and the opening of the aperture f/11.

The subject was positioned on a line marked on the floor, and framed alongside a vertical scale divided into 5 cm segments. A plumb line was used to indicate the true vertical (TV). The scale allowed measurements at life size (1:1). On the opposite side of the scale and outside of the frame a vertical mirror was positioned approximately 110 cm from the subject (Figure 1). In order to take the records in the natural head posture, the subject was asked to walk a few steps, stand at rest facing the camera and near to the scale, look into their own eyes in the mirror, and place their arms at their side.[6]

The photographic records were digitized and analyzed using the nemoceph 6.0 software program for the Windows operating system. Three angles were analysed: nasofrontal, nasolabial and mentolabial (Figure 2). Quantitative variables were summarised as mean or standard deviation. Comparisons between male and female groups were done using t-test.

Results

70 individuals (35 males and 35 females) comprised the sample. The Student's *t*-test was applied to all variables to determine the influence of sex in the measurements (Table 1). Two of the angles showed sexual differences: nasofrontal (G–N–Prn, $P = 0.009$) and nasolabial angle (Cm-sn-Ls, P=0.003).

A wider nasofrontal angle was found in females (133.9 ± 5.893 degrees) than in males (130.16 ± 5.909 degrees). The greatest variability was found for the nasolabial and mentolabial angles, with high standard deviations and large confidence intervals.

Descriptive statistics data including mean, maximum, minimum, and standard deviations for photogrammetric angular measurements of nasofrontal angle angle (G-N-Prn), nasolabial (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg) are shown in Tables 1 and Figure 3. Student's *t*-test comparing male and female measurements are also given in Table 1 and Figure 3.

Variable	Group	Min.	Max.	Mean	Std. Deviation	Confidence interval	P value (Students t test)
G-N-Prn	Female	121	143	133.89	5.893	(131.92-135.84)	0.009
	Male	119	142	130.16	5.909	(128.21-132.10)	
Cm-Sn-Ls	Female	90	119	104.94	6.878	(102.64-107.23)	0.003
	Male	88	127	110.89	9.243	(107.85-113.93)	
Li-Sm-Pg	Female	114	141	128.11	6.292	(126.03-130.19)	0.220
	Male	115	140	130.05	7.090	(127.72-132.38)	

Table 1: Descriptive statistical data for nasofrontal angle (G-N-Prn), nasolabial angle (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg).

Discussion

The purpose of this investigation was to obtain average parameters that define the soft-tissue facial profile of nasofrontal angle (G-N-Prn), nasolabial angle (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg) of a population residing in Kerala. The characteristics of the soft-tissue profile are affected by many factors, including ethnicity. As the profile varies according to the malocclusion, the present study used only Class I participants to establish norms. The inclusion criteria and methodology were formulated to identify normative values that can assist in diagnosis and treatment planning for those seeking orthodontic treatment or orthognathic surgery.

As it was intended to obtain a representative sample of normal Keralite subjects, patients who had a history of previous orthodontic or prosthodontic treatment, maxillofacial or plastic surgery and individuals having any facial asymmetry, craniofacial trauma or congenital anomalies were excluded from this study. Normal occlusion, which is not necessarily related to beauty, was the main criteria used to select the subjects.[7]

Cephalometry is considered as the gold standard in orthodontic diagnosis. However, a desirable skeletal pattern does not imply desirable facial aesthetics, nor does an undesirable skeletal pattern imply undesirable facial aesthetics.[8] Today, with rising concerns about radiation exposure, the importance of clinical photography subsequently is gaining momentum in orthodontic practice. In the present study, soft tissue facial measurements were established by means of photogrammetric analysis.

Photogrammetry is defined as 'the art, science and technology of obtaining reliable information about physical objects through processes of recording, measuring and interpreting photographic images'.[9] It was introduced as an alternative to direct measurements to obtain distances between facial landmarks using both two-dimensional and three-dimensional methods. The application of photogrammetry in orthodontics was first proposed by Stoner in 1955, who compared both pre- and post-treatment profiles with ideal profiles.[10] Since then, other soft tissue facial analyses based on standardized photogrammetric methods have been demonstrated by various authors.

Photogrammetric analysis offers several advantages for profile analysis. The angular measurements are not affected by photographic enlargement as in cephalometric analysis. Furthermore the angular photogrammetric profile analysis does not require expensive equipment and complex procedures, and it offers digitized results that are easily evaluated.[11]

It should be ensured that the head posture is same during the photographic recording procedure. NHP (Natural Head Position) is a consistent and reproducible position of the head when the individual is in an upright posture with the eyes focused at a point in the distance at eye level, assuming that the visual axis is horizontal.[12,13] Standardized photogrammetric records taken in NHP were used for this analysis.

Facial harmony is defined as the orderly and pleasing arrangement of the facial parts in profile. The relative profile concavity observed at nasion, subnasale and supramentale affects the total profile harmony. Therefore the angles formed at the profile concavity – nasofrontal, nasolabial and mentolabial respectively were decided to be measured in this study.[14]

In regards to differences between the sexes, the results of the current study were similar to those reported by Pandian et al[15] who analyzed the soft tissue facial profile of Indian population. In both studies, significant dimorphism was found between nasolabial and nasofrontal angles. Similar to the findings of Fernández-Riveiro et al[6], the greatest variability for Keralite males and females were found in the nasolabial and nasofrontal angles, with high standard deviations and large confidence intervals. Similar to the Galicians, Keralite women exhibited a wider nasofrontal angle.

The nasofrontal angle (G–N–Prn) demonstrates significant gender difference with wider angle in females (mean – 133.89) than males(130.16), this may indicate a more flattening of females forehead than males , this comes in agreement with Fernández-Riveiro et al.[6] (males = 138.57 **degrees**; females = 141.98degrees):Milosevic et al [16] (males = 136.38 **degrees**; females = 139.11 degrees) and Malkoç et al.[11] (males = 146.03**degrees**; females = 148.61degrees) also found gender differences in this angle. Study conducted by Devi et al[17] on Bengali population (males = 128.06 degrees, Females = 139.56degrees) also showed no statistical significant gender difference. Supporting the present study, the study conducted by pandian et al[15] on Indian population showed that Indians females (mean =135.79degrees) have significantly higher values than males (mean=132.13 degrees) of nasofrontal angle, which indicates that Indian females have prominent nose when compared to males.

The relationship between the nasal base (columella) and the upper lip, analyzed by the nasolabial angle (Cm–Sn–Ls), is important in assessing the upper lip. It is one of the facial profile parameters with great clinical uncertainity and so should be interpreted with caution. The nasolabial angle (Cm-Sn-Ls) is clinically relevant in orthodontic diagnosis and treatment planning and it is used as a part of extraction decision. As it is related to the anteroposterior position and inclination of the maxillary anterior teeth, its dimension can be altered by orthodontics or orthognathic surgery.

Burstone [18]reported a nasolabial angle of 74 ± 8 degrees in a Caucasian adolescent sample with a normal facial appearance. Likewise, McNamara et al. reported a nasolabial angle of 102.2 ± 8 degrees for males and 102.4 ± 8 degrees for females in a study on lateral cephalograms of adult Caucasians with pleasing facial aesthetics.[11] Yuen and Hiranaka reported an angle of 102.7 ± 11 degrees for males and 101.6 ± 11 degrees for females in a study of Asian adolescents on standardized photographic records.[16]

In the present study the nasolabial angle was the most significant angular variable of the soft tissue profiles between the genders. The nasolabial angle of this study (Cm-Sn-Ls for males = 110.89±9.243 degrees, females = 104.94±6.878 degrees) showed statistically significant gender difference in agreement with the findings of previous study by Milosevic et al[16]. They found the nasolabial angle as the most significant angular variable between the genders (Croatian males = 105.42 degrees and females = 109.39 **degrees**). Malkoc et al[11] also found this angle with large variations between males and females (Turkish males = 101.09 **degrees**; females = 102.94 **degrees**). However , Riveiro et al[6] found no significant gender difference (males = 137.6 **degrees**; females = 134.5**degrees**) Supporting this study , the study conducted by Devi et al[17] on the nasolabial angle (Cm-Sn-Ls for males = 107.39 **degrees**; females = 100.88 **degrees**) of Bengali population also showed statically significant gender differences. Further supporting this, in the study done by pandian et al[15], males show significantly higher values of nasiolabial angle than females which is suggestive of increased proclination of maxillary anteriors in males as compared to Indian females.

Mentolabial angle (Li–Sm–Pg, males = 130.05± 7.090 degrees, females = 128.11±6.292 degrees) also showed great variability in this study. According to Bergman[19] a more pronounced mentolabial angle can be observed in Class II and vertical maxillary deficiency cases. The uprighting of the lower incisors tends to enlarge the angle. The mean value according to Burstone[18] is 122.0 ± 11.7 degrees.

In this study, the mentolabial angle (Li-Sm-Pg) showed no significant gender difference (males = 130.05 degrees ; females = 128.11 degrees).In a study by Milosevic et al.[16], there was a great gender difference for this angle (males = 129.6 **degrees**; females = 134.50 **degrees**). Malkoc et al[11] **in his study on Turkish adults** also found significant gender difference (males = 130.19 **degrees**; females = 137.19 **degrees**). These results differ from those of Riveiro et al[5] (Li–Sm–Pg, males = 130.7 ± 9 degrees, females = 131.4 ± 11 degrees) in agreement with the present study where no significant gender difference was found. Lines et al[20]reported that deeper mentolabial sulci were preferred in males and it ranged between 120 and 130 degrees.

In the study by Devi et al[17] on Bengali population, the mentolabial angle (Li-Sm-Pg) had no significant gender difference (males = 124.8 **degrees**; females = 123.06 **degrees**) supporting this study. The mentolabial angle (Li–Sm–Pg) was found to be wider in males (132.79±9.45 degrees) than in females (128.60±9.28 degrees) in the study conducted Indian population by Pandian et al.[15] This is in agreement with the present study which denotes that mandibular anteriors are upright over the basal bone in Indian males as compared to females.

Conclusion

The following conclusions were drawn from the study:

• The result of the present study showed statistically significant ($P < 0.05$) gender difference in 2 parameters out of 3 parameters

• There were significant gender differences in the nasofrontal angle and nasolabial angle.

The derived soft tissue values can be considered as normal values for Keralite population. The mean values obtained from this sample can be used for comparison with records of subjects with the same characteristics and ethnicity. The values can be used for comparison of subjects with malocclusions, thereby guiding orthodontists to develop proper diagnosis and treatment plan so that facial harmony can be achieved.

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Legend Figure

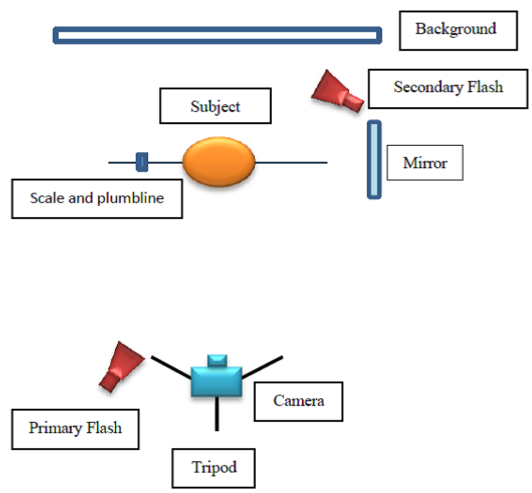

Fig. 1: Sketch of photographic setup

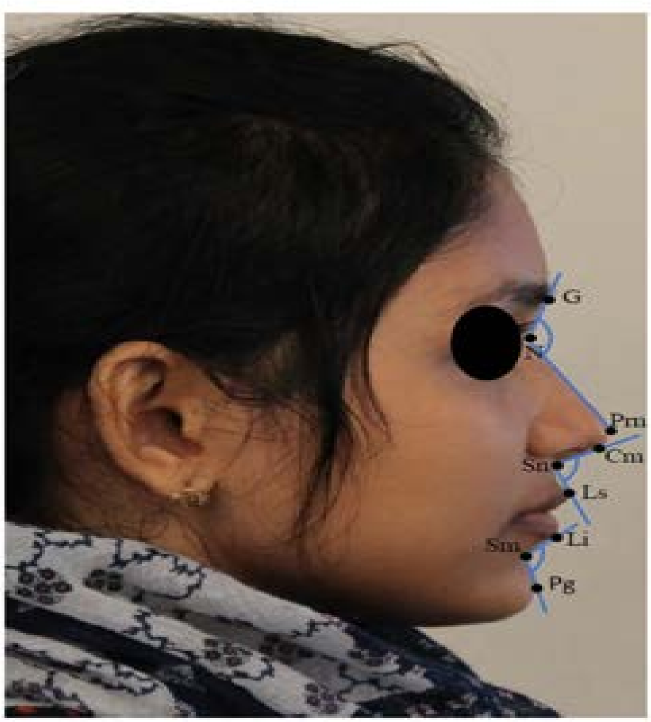

Figure 2: Photogrammetric analysis of nasofrontal angle (G-N-Prn), nasolabial angle (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg) in a female subject

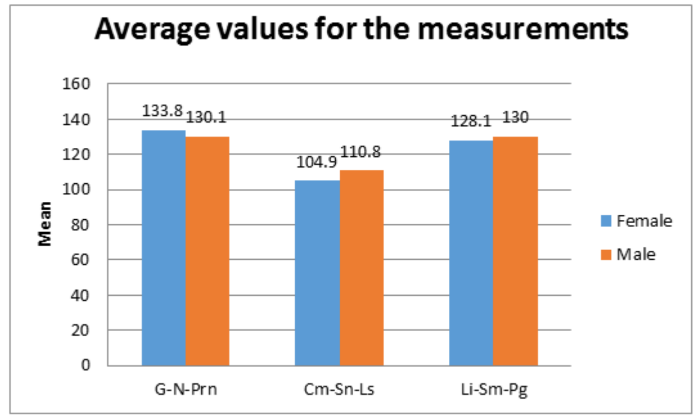

Figure 3: Graph indicating average values of the measurements of nasofrontal angle (G-N-Prn), nasolabial angle (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg)