Original Article

Ready to Use Norms for Arnett Bergman Soft-Tissue Cephalometric Analysis for South Indian Population

Abstract

Context: Variability of the soft-tissue drape in humans has complicated the accuracy of evaluating soft tissue profiles in diagnosis and treatment planning. **Aims:** The objective of the present study is to establish soft-tissue cephalometric norms for South Indian population using Arnett Bergman Soft tissue analysis. **Settings and Design**: This study was conducted at the Department of Orthodontics and Dentofacial Orthopaedics. **Subjects and Methods:** Lateral cephalograms of 60 individuals (30 males and 30 females), age ranging between 18 and 25 years, with orthognathic facial profiles were obtained in natural head position. True vertical line was drawn through subnasale parallel to the vertical reference plane. Measurements were done according to soft-tissue cephalometric analysis. **Statistical Analysis Used:** Student's *t*-test was used to compare the means between two groups. **Results:** The results of the study showed significant gender dimorphism, with men having thicker soft-tissue structures, larger vertical dimensions, deep-set midface structures, more upright incisors, and deeper inferior labial sulci than women. When compared with the standard norms, the South Indian population had significantly protruded dentition, thinner soft-tissue drape, shorter vertical face heights, prominent forehead and midface with retusive lower facial thirds and convex profiles as compared to Caucasians. **Conclusions:** Significant gender dimorphism was evident in the local population suggesting the need for separate set of norms for males and females. Distinct ethnic differences were found between Caucasians and the Indian population that were statistically significant, highlighting the importance of defining separate set of norms for ethnic groups. The norms obtained should be used as reference when planning treatment of a specific ethnic group.

Keywords: *Cephalometrics, diagnosis and treatment planning, esthetics, soft tissue*

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Introduction

Angle[1] was one of the first to write about harmony of the face and the importance of soft tissues. With the advent of cephalometric head films, various analyses were developed to quantitate facial esthetics with the sole aim of achieving harmonious hard tissue relationships. However, studies conducted by several researchers[2-4] indicated that the correlation between the hard and soft tissue changes is not a linear one and not all parts of the soft-tissue profile directly follow the underlying dental structures.

Over the years, several soft tissue analyses[5-9] were developed, where greater emphasis was given to clinical examination of soft-tissue function and esthetics. However, the reference planes taken were either the Frankfort horizontal plane or the cranial base, the orientation of which could differ significantly from person to person. To overcome these shortcomings, Arnett *et al*.[10] developed a new soft-tissue cephalometric analysis (STCA) that was based on natural head position (NHP) and a true vertical line (TVL) as the reference plane to measure the soft tissue norms. Soon, it was realized that there was a need to develop norms for different races since there are clinically significant variations in craniofacial morphology and soft tissues among various ethnic groups and normative data from one does not represent all. The concept of floating norms[11] emerged in an attempt to individualize treatment requirements according to a specific dental and skeletal pattern. In addition, the assessment of growth-related changes in the soft-tissue profile traits could prove critical to successful treatment planning and predicting the stability of results.[12,13]

Thus, the present study aims to derive and to compare soft tissue norms for male and female individuals of Central Kerala population based on Arnett Bergman

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cephalometric analysis, which would be useful for the local (Central Kerala) population in particular and the South Indian population in general.

Subjects and Methods

The study was conducted in the Department of Orthodontics and Dentofacial Orthopedics over a period of 18 months. Study tools included lateral cephalograms in NHP, transparent matte acetate sheets of 0.003 inches thickness, 0.3 mm HP lead pencil, and radio-opaque metallic markers. A convenient sampling technique was followed to obtain the sample.

The sample size was calculated using the formula: $4\,(SD)^2/d^2$

where, SD = Standard deviation in the previous study.

d = Absolute precision which was fixed to be 1.

4 = square of the Z value of alfa error at 5%.

The mean and SD for a variable (maxillary incisor position to TVL) was taken from the study done by Kalha *et al*.[14] and the sample size for the present study was fixed as 60.

The inclusion criteria were

1. People reporting to the Dental College outpatient department (for seeking treatment in other departments for restorations, oral prophylaxis, or regular dental checkups) and students (from the medical, dental, and nursing colleges) in the age group of 18–25 years having full set of permanent dentition excluding the third molars
2. Orthognathic facial profile, competent lips, and Skeletal Class I relationship
3. Angles Class I molar relation with well-aligned arches having normal overjet and overbite
4. No spacing or crowding.

Exclusion criteria

1. Participants not willing to participate in the study
2. Any history of orthodontic, orthognathic, or prosthodontic treatment
3. Any craniofacial deformities, facial asymmetry, or dental malformations.

Procedure

The study was conducted after obtaining the Institutional Ethics committee clearance with clearance number IEC/M/05/2014/DCK. Written consent was taken from each of the selected participants before obtaining the cephalogram.

The study included sixty participants (30 males and 30 females), selected randomly from the local population, having orthognathic facial profiles and the age ranging between 18 and 25 years (mean age of females: 23 years, males: 24.3 years) with Angle's Class I molar relation. All the individuals were first examined clinically in NHP, seated condyles and with lips relaxed as described by Arnett and Bergman.[15,16] Metallic markers were placed on the right side of the participant's face to mark key midface structures as described by Arnett *et al*.[10] The participants were then asked to swallow and bite into centric occlusion. For obtaining the headfilm in NHP, the technique originally described by Moorrees and Kean[17] and others[18,19] was used. A thin vertical stainless steel chain with a metal ball attached at the end was suspended from the horizontal bar of the cephalostat's nasal positioner serving as a true vertical reference plane. After the participants assumed NHP, a lateral head film was obtained with seated condyles and relaxed lips. Taking radiographs in NHP had the advantage of eliminating variability associated with using other intracranial reference planes which have SD between 4.5° and 6° as compared to 2° for NHP.[20]

Standard 8 × 10 inches lateral radiographic head films were used for each participant on (KODAK 8000 C) Digital Panoramic and Cephlometric System (set at 75 Kvp, 12 mA and exposure time of 0.5 s). All the exposed films of standard size (8 × 10 inches KONICA MINOLTA) were developed and fixed in an automatic processor (DRYPRO MODEL 832; KONICA MINOLTA). All lateral cephalometric films were traced on the matte acetate sheets by the same operator. Similar conditions of the lightbox and general illumination were maintained during viewing and tracing of all headfilms. All reference points were first identified, located, and marked. The reference planes were drawn and when the bilateral structures cast double shadows on the film the technique of averaging the bilateral images was used.

The landmarks and measurements were taken according to the STCA, and TVL was established [Figure 1]. This line was drawn through subnasale parallel to the chain representing the true vertical and perpendicular to the NHP. For the projections to TVL, the horizontal distance between the various landmarks and the TVL were measured.

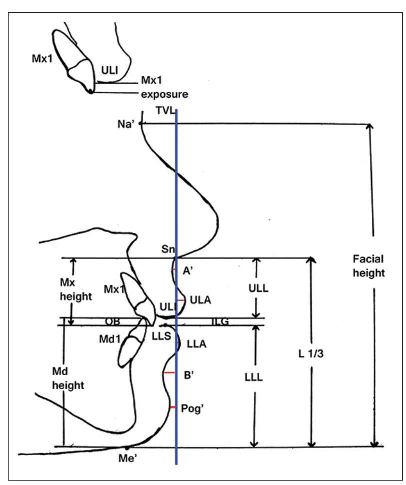


Figure 1: Facial lengths and projections to true vertical line measurements

Structures to the right of TVL were given a positive sign and those to the left of TVL were given a negative sign. Descriptive statistics (means, standard deviations and confidence intervals) were calculated for all the variables in both groups. The Student's *t*-test was used for comparing the means of the two groups. $P \leq 0.05$ was considered statistically significant.

Results

On the basis of cephalometric hard- and soft-tissue measurements, mean and standard deviations were calculated for 30 males and 30 females of the population. The data were analyzed and comparisons were drawn using Student's *t*-test. Statistical analysis showed that, though the men and women were quite similar in the dentoskeletal aspect, they showed significant dissimilarities in the soft-tissue parameters. When comparison was made between the male and female samples and original STCA, the local sample showed significant differences in almost all variables.

Among the dentoskeletal factors [Graph 1], the mean values for overjet showed a statistically significant increase in males (2.88 mm) as compared to females (2.48 mm) of the present study group.

Soft-tissue structures [Graph 2]: Males showed a statistically significant increase in all the soft-tissue thicknesses as compared to females suggesting a thicker soft-tissue drape in the male sample.

Facial lengths [Table 1]: males demonstrated statistically significant increase in facial lengths. Maxillary incisor exposure and overbite were also found to be more in males; however, the difference was not statistically significant.

Projections to TVL [Table 2]: Statistically significant differences were seen in midface measurements, incisor projections and B' point with males showing higher mean measurements than females.

In facial harmony measurements, males and females of the present study showed significantly different harmony for Md1-Pog', B point'-Pog', A point'-B point', suggesting more upright incisors in males. The mean values for ULA– LLA (2.03 mm, 1.08 mm), orbital rim'-A point' (20.2 mm, 16.8 mm), orbital rim'-Pog' 16 mm, 13.3 mm in males and females, respectively, suggests deeper set midface structures in men.

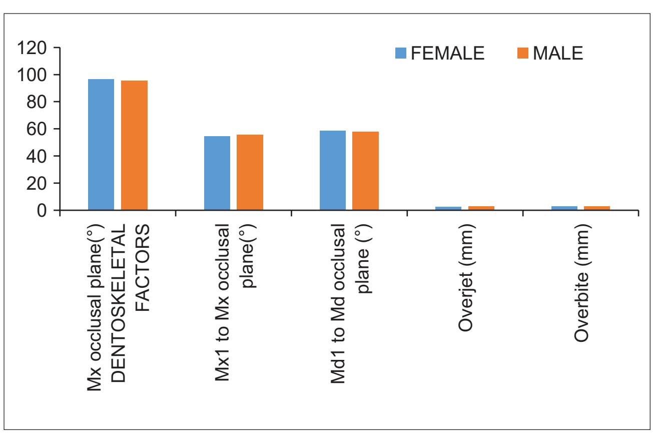
In comparison to standard norms by Arnett *et al*.,[10] the present study group depicted significant differences for almost all the variables reflecting the diversity of facial traits in different population groups. Table 3 gives ready to use norms for South Indian population.

Discussion

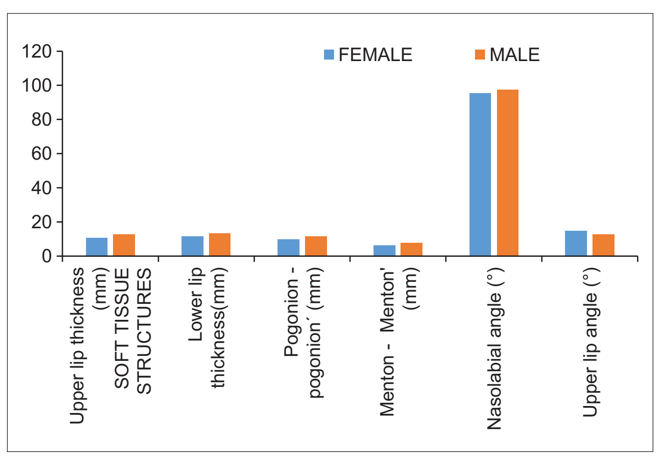
The STCA is a cephalometric instrument that represents the clinical extension of the philosophy detailed in "facial keys to orthodontic diagnosis and treatment planning." It serves as a guide for accurate soft-tissue examination by providing an objective evaluation of subjective data and integrating occlusal correction and soft-tissue balance.

Among the dentoskeletal factors, overjet was significantly greater in males of the local population. On the contrary, studies by Arnett *et al*.[10] (Caucasians), Lalitha and Kumar[21] (Andhra, India) and Uysal *et al*.[22] (Turkish adults) showed no gender differences for any of the dentoskeletal components of the STCA. When compared with STCA, the local sample had flatter occlusal planes, decreased overjet, and overbite (2.5 mm) as compared to Caucasians.

In the soft-tissue structures, all soft tissue thicknesses were significantly greater in males than females which was in agreement with the studies done by Arnett *et al*.[10] and others.[14,21-24] Nasolabial angle did not show any significant gender differences in the present and other studies.[10,21-22,25] However, in studies by Kalha *et al*.[14] and others[24,26] men showed more acute nasolabial angle than women. Scheideman *et al*.[27] reported that the orientation of the nasolabial angle to the rest of the face is more important than the angle itself, as an apparently "normal" nasolabial angle may, in fact, be oriented quite abnormally. In



Graph 1: Comparison of dentoskeletal factors between males and females



Graph 2: Comparison of soft-tissue structures between males and females

Table 1: Independent student *t*-test for comparing facial lengths between males and females

Facial length	Gender	Mean	SD	*t*	*P*
Nasion' to Menton' (mm)	Female	106.5	4.6	−5.49	<0.001
	Male	113.7	5.5		
Upper lip length (mm	Female	17.8	1.9	−4.34	<0.001
	Male	19.9	1.8		
Interlabial gap (mm)	Female	0.5	0.6	0	1
	Male	0.5	0.7		
Lower lip length (mm)	Female	39.8	2.6	−4.68	<0.001
	Male	43.3	3.2		
Lower 1/3 of face (mm)	Female	58.3	4.3	−4.87	<0.001
	Male	63.7	4.3		
Overbite (mm)	Female	2.5	0.9	−1.39	0.168
	Male	2.8	1.0		
Mx1 exposure (mm)	Female	2.5	1.2	−0.94	0.348
	Male	2.8	1.0		
Maxillary height (mm)	Female	20.2	2.5	−3.27	0.002
	Male	22.1	2.0		
Mandibular height (mm)	Female	40.2	2.1	−5.91	<0.001
	Male	44.1	2.9		

SD: Standard deviation

Table 2: Independent student *t*-test for comparing true vertical line projections between males and females

Projections to TVL	Gender	Mean	SD	*t*	*P*
Glabella (mm)	Female	−6.6	3.9	0.4	0.641
	Male	−7.1	3.7		
Orbital rims (mm)	Female	−17.9	2.5	4.7	<0.001
	Male	−21.3	2.9		
Cheek bone (mm)	Female	−24.1	2.7	5.8	<0.001
	Male	−28.9	3.6		
Subpupil (mm)	Female	−13.7	1.8	6.4	<0.001
	Male	−17.7	2.7		
Alar base (mm)	Female	−8.2	1.4	6.0	<0.001
	Male	−10.7	1.6		
Nasal projection (mm)	Female	12.4	1.6	0.2	0.82
	Male	12.3	1.7		
A point' (mm)	Female	−1.0	0.5	0.5	0.564
	Male	−1.1	0.8		
Upper lip anterior (mm)	Female	2.4	1.1	0.3	0.753
	Male	2.3	1.2		
Mx1 (mm)	Female	−7.0	3.4	4.4	<0.001
	Male	−10.1	1.5		
Md1 (mm)	Female	−10.0	1.8	6.3	<0.001
	Male	−13.0	1.7		
Lower lip anterior (mm)	Female	1.2	2.2	1.5	0.128
	Male	0.4	1.8		
B point' (mm)	Female	−6.4	2.4	2.5	0.014
	Male	−8.0	2.4		
Pogonion' (mm)	Female	−4.6	2.7	0.9	0.329
	Male	−5.4	3.0		

TVL: True vertical line; SD: Standard deviation

comparison with standard values of STCA, our participants have thinner soft tissues, increased upper lip angle and more acute nasolabial angle than Caucasians. A study conducted by Bergman *et al.*[12] on longitudinal changes in the soft-tissue profile traits between ages 6–18 years, nasolabial angle remained relatively constant with age whereas the upper and lower lip thicknesses increased with age. However, Formby *et al.*[13] reported decrease in

Table 3: Ready to use norms for South Indian population

Factors	Mean±SD							
	South Asian population		Kalha *et al*. study		Lalitha *et al*. study		Arnett *et al*. study	
	Females	Males	Females	Males	Females	Males	Females	Males
Mx1 to Mx occlusal plane (°)	54.26±5.02	55.36±5.04	55.87±6.66	54.47±5.71	46.73±18.20	49.03±5.11	56.8°±2.5°	57.8°±3.0°
Md1 to Md occlusal plane (°)	58.4±4.82	57.87±5.07	64.60±13.03	64.27±15.60	63.43±5.45	64.50±5.34	64.3°±3.2°	64.0°±4.0°
Overjet (mm)	2.48±0.72	2.88±0.78	2.60±0.76	2.90±0.88	3.7±0.65	3.71±0.79	3.2±0.4	3.2±0.6
Overbite (mm)	2.53±0.99	2.88±1.04	3.12±0.87	3.18±0.96	3.68±1.21	3.95±1.04	3.2±0.7	3.2±0.7
Upper lip thickness (mm)	10.7±1.04	12.58±0.94	12.13±2.01	13.58±2.72	11.90±1.74	14.68±2.41	12.6±1.8	14.8±1.4
Lower lip thickness (mm)	11.51±1.09	13.18±1.18	13.03±1.56	14.80±2.43	15.86±1.77	17.88±2.25	13.6±1.4	15.1±1.2
Pogonion - Pogonion’ (mm)	9.78±1.52	11.5±1.54	11.30±1.78	13.45±2.52	12.63±2.27	14.25±2.32	11.8±1.5	13.5±2.3
Nasolabial angle (°)	95.43±5.59	97.45±7.29	103.47±13.08	97.27±9.42	104.60±9.17	100.86±9.90	103.5°±6.8°	106.4°±7.7°
Nasion’ to Menton’ (mm)	106.55±4.60	113.78±5.55	122.03±7.03	132.73±8.80	123.23±5.00	133.96±5.51	124.6±4.7	137.7±6.5
Upper lip length (mm)	17.81±1.94	19.96±1.89	19.62±3.77	22.33±3.57	20.73±2.16	22.0±2.08	21.0±1.9	24.4±2.5
Interlabial gap (mm)	0.51±0.68	0.51±0.72	1.20±1.56	0.15±0.48	2.85±0.85	3.25±0.98	3.3±1.3	2.4±1.1
Lower lip length (mm)	39.81±2.60	43.33±3.17	41.13±9.65	48.82±7.15	44.50±3.14	48.63±3.74	46.9±2.3	54.3±2.4
Lower 1/3 of face (mm)	58.3±4.26	63.75±4.38	63.13±9.07	72.40±7.41	65.93±4.47	72.45±4.59	71.1±3.5	81.1±4.7
Mx 1 exposure (mm)	2.56±1.22	2.85±1.08	0.87±1.48	0.15±0.48	3.20±1.11	2.88±1.29	4.7±1.6	3.9±1.2
Maxillary height (mm)	20.2±2.58	22.16±2.03	24.93±5.24	24.82±3.32	23.66±2.65	24.48±2.28	25.7±2.1	28.4±3.2
Mandibular height (mm)	40.23±2.14	44.13±2.91	44.50±5.69	50.73±4.49	46.45±2.66	52.76±2.91	48.6±2.4	56.0±3.0
Mx 1 (mm)	−7.05±3.49	−10.13±1.53	−9.80±2.81	−11.82±3.32	−9.20±2.53	−11.98v3.30	-9.2±2.2	-12.1±1.8
Md 1 (mm)	−10.06±1.88	−13.01±1.70	−13.07±2.96	−15.17±3.17	−13.60±2.43	−15.86±5.93	-12.4±2.2	-15.4±1.9
B point’ (mm)	−6.41±2.41	−8.03±2.49	−8.27±2.96	−8.05±3.18	−6.98±22.70	−8.48±4.45	-5.3±1.5	-7.1±1.6
Pogonion’ (mm)	−4.66±2.79	−5.41±3.09	−6.90±3.40	−5.48±3.34	−6.08±3.22	08.48±4.45	-2.6±1.9	-3.5±1.8
B’ to Pog’ (mm)	1.75±1.06	2.68±1.74	2.07±1.04	3.17±1.64	−2.3±1.08	−3.3±1.88	1.75±1.06	2.68±1.74
Facial angle (°)	167.61±4.63	167.11±3.87	161.30±14.26	166.77±8.30	167.66±4.62	169.43±4.40	167.61±4.63	167.11±3.87

SD: Standard deviation

the upper lip thickness in the male sample between 18 and 42 years of age. These growth changes should be kept in mind while planning treatment for individuals for achieving optimal stability of results.

For facial length measurements, significant gender dimorphism was evident in the current sample with males demonstrating a higher mean value for all facial length parameters. Studies by Arnett *et al*.[10] and others[14,22-24] also showed similar results. When compared with Caucasians, our participants have shorter face heights. Scheideman *et al*.[27] in their cephalometric study on normal adults reported that the distance LL-Me’ (lower lip vermilion– Menton’) was 55% of lower face height instead of 50% and there was a significant gender difference with males significantly longer in the inferior half of lower facial third. They suggested that the difference in facial height can be significant in treatment planning as facial height discrepancies can be indications to increase or decrease facial height. Peck *et al*.[28] also reported significantly higher values for upper lip length and maxillary height in males which was in agreement with results of the present study. Maxillary incisor exposure was more in males whereas Arnett *et al*.,[10] and others[14,22,23] showed a significantly higher exposure in females than in males.

Among the facial length parameters, upper lip length, lower lip-chin length, and lower 3rd of face were found to increase with growth whereas the maxillary incisor exposure remained constant and interlabial gap showed decrease in size with growth.[12] According to Formby *et al*. the mean increase in total face height was 2.8 mm during adulthood.[13]

Projections to TVL in males from Orbital rim, cheekbone, subpupil, and alar base were found to be significantly higher than in females of the current study group. These results were in harmony with the results of Arnett *et al*.[10] and others.[21,22,24] Nasal prominence did not show any gender differences. In contrast, males were reported to have significant nasal prominence in comparison to females as observed by Arnett *et al*.,[10] and others.[14,21,22] Scheideman *et al*.[27] evaluated nasal prominence relative to nasal height and upper lip length. According to them the horizontal nasal prominence was approximately one-third the vertical height of nose, while the columellar length was approximately 90% of the upper lip length. It was found to be higher in males. Since nasal tip (NT) prominence and the alar bases are frequently affected by maxillary surgery, these gender differences should be taken into account while planning surgery for such patients.

In the current study, women had more proclined maxillary and mandibular incisors than men and the difference was statistically significant ($P < 0.001$). Similar results were also obtained in studies by Arnett *et al*.,[10] and others[14,22,23] while Shindoi *et al*.[24] reported no significant gender differences in Japanese adults.

The mean value for B point' in males was significantly higher (more negative) than females suggesting deeper labial sulci in the male group. This was in agreement with the results of Arnett *et al*.,[10] and others[23,29] and was in disagreement with the findings reported by Kalha *et al*.,[14] and others[21,22,24] where the difference was not statistically significant.

With respect to soft-tissue chin measurements, the present study did not show any significant gender differences. The results were in concordance with results of Arnett *et al*.[10] and others.[14,21-23] while Shindoi *et al*.[24] reported significantly retruded chin in Japanese females as compared to males. Scavone *et al*.[30] in a study on Japanese-Brazilian adults found no significant gender differences for NT, ULA, LLA, B', Pog' projections to TVL.

Scheideman *et al*.[27] reported that females had equally prominent chins as males. They observed that the upper lip was slightly anterior, lower lip was just posterior and the chin was an average of 4.2–4.5 mm posterior to the vertical reference line and suggested that more prominent lips, shallow labiomental fold and prominent B point deemphasize chin prominence in females, creating an appearance of a more recessive chin. This was in harmony with the findings of the present study. McBride and Bell[31] in their study used a “natural” vertical reference line passing through subnasale perpendicular to natural horizontal to assess the relative prominence of nose, lips, and chin. They believed that in Caucasian adults, chin should be tangent to this line while the lips should lie slightly anterior.

Spradley *et al*.[32] in their study on assessment of the anteroposterior soft-tissue contour of the lower facial third observed that the upper lip was located 0.5 mm more anteriorly in females than males. In the male group, the lower lip fell slightly posterior to the vertical whereas in the female group, it was located slightly anteriorly to the vertical. This was in support of Ricketts[33] view, who believed that females were naturally more protrusive in lip region than males. In both genders, the soft-tissue Pogonion was posterior to the vertical, with the male Pogonion about 0.5 mm posterior than that of females. They stated that, in general, females have slightly fuller lip regions and shallower labial sulci than males and chins that are at least as relatively prominent as those of males.

When compared with standard values of STCA our participants showed depressed cheekbones while protrusive midface in the subpupil and alar base region. The projections to TVL from A', B', and Pog' suggested retrusive lower faces with deeper labial sulci and retruded chins. Decreased nasal prominence, increased maxillary, and mandibular incisor projection suggest a more protrusive dentition in the local population. Evaluation of growth changes on these parameters suggested that NT and chin continue to get displaced anteriorly during all ages, making teeth appear less prominent and lip area flattened.[12,13]

For the evaluation of facial harmony, the intramandibular measurements for Md1-Pog', B point'-Pog' and throat length (NTP neck-throat-point – Pog') were found to be lower while LLA-Pog' measurement was higher in the present sample suggesting proclined incisors and recessive chins in South Indian population. Higher Sn-Pog' measurement in Interjaw relationship also suggested retrusive chins in the South Indian population. The total facial harmony suggested an overall convex profile as indicated by higher facial angle in the present study group.

These differences in the soft- and hard-tissue parameters between males and females of the South Indian population and between ethnic groups points toward a diversity of facial traits which are subject to geographical variations. To ensure accuracy in diagnosis and treatment planning, local norms should be used as reference, however, orthodontist must make exceptions and use individualized norms as and when required to best serve patient's esthetic outcomes.

The soft-tissue analysis should not of course take the place of a comprehensive clinical examination of the patient. Rather, it may sway the decision as to which procedure will result in most optimal esthetics. To conclude, ideal treatment planning should affect the facial trait in a positive fashion coming closer to the standard norms.

Conclusions

1. Soft-tissue cephalometric norms were established for South Indian population using Arnett Bergman soft-tissue analysis

2. Significant gender dimorphism was evident in the South Indian population suggesting the need for separate set of norms for males and females
3. Distinct ethnic differences were found between Caucasians and the South Indian population that was statistically significant, highlighting the importance of defining separate set of norms for ethnic groups
4. The norms obtained should not be strictly interpreted as rules, but, rather as guides or basis for comparison
5. Orthodontists and surgeons should be cognizant of these differences when interpreting measurements and must individualize treatment planning using local norms as reference.

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Conflicts of interest

There are no conflicts of interest.

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