Original Research Article

Evaluation and comparison of soft tissue cephalometric norms in gujarati population using holdaway analysis – A retrospective cephalometric study

Alap Shah[1], Sonali Mahadevia[2], Shreya Agrawal[1]*, Dhwani Pancholi[1], Bharvi Jani[1]

[1]Dept. of Orthodontics and Dentofacial Orthopedics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.
[2]Dept. of Orthodontics and Dentofacial Orthopedics, Ahmedabad Dental College, Ahmedabad, Gujarat, India.

Abstract

Aim and Objective: The aim of this study was to establish the soft tissue cephalometric standards through Holdaway analysis for adults of Gujarati ethnic descent and compare them to the norms provided for Caucasians.

Materials and Methods: A total of 500 lateral head films (250 males and 250 females) with balanced soft tissue profiles were chosen from people of Gujarati ethnic descent. Cephalometric measurements were made in accordance with Holdaway's interpretation. SPSS software was used to perform statistical analyses which included independent t-tests and Pearson correlation.

Results: The study revealed significant differences between Gujarati and Caucasian populations in several soft tissue measurements. Gujarati males exhibited greater skeletal convexity ($0.188°\pm1.79°$; $p \leq 0.0001$), reduced nose prominence (4.588 ± 2.86 mm; $p \leq 0.0001$), upper lip strain (1.06 ± 1.29 mm; $p \leq 0.0001$) and lower lip thickness (0.712 ± 1.89 mm; $p \leq 0.0001$) compared to Caucasian males. Gujarati females showed similar trends with increased skeletal convexity ($0.55°\pm1.71°$; $p \leq 0.0001$), reduced nose prominence (5.112 ± 2.47 mm; $p \leq 0.0001$), and increased H line angle ($20.052°\pm3.31°$; $p \leq 0.0001$). No significant gender differences were found within the Gujarati population.

Conclusion: Notable deviations from Caucasian norms in cephalometric standards for the Gujarati community were observed. Thus when formulating treatment plans for Gujarati patients, orthodontists and surgeons should take these cultural customs into account to provide personalized and efficient patient care.

Keywords: Holdaway analysis, Soft tissue norms, Guajarti population, Cephalometric Study

1. Introduction

The capability to discern a beautiful face is an innate human trait, but to convert them into definitive orthodontic treatment goals and objectives is difficult. Traditionally, orthodontists have relied on the hard tissue paradigm for diagnosis and treatment planning, which related the teeth to cranial and facial bones to establish certain cephalometric standards to achieve good facial forms.

Many researchers have demonstrated that the soft tissue drape varies considerably in thickness and posture which ultimately leads in shaping the facial structure.[1-5] Thus, orthodontic diagnosis and treatment planning has seen a gradual shift from hard tissue paradigm to soft tissue paradigm in the recent years.

Detailed soft tissue cephalometric analyses have been reported by Holdaway[4] and Legan and Burstone[6] to aid in the orthodontic diagnosis and treatment planning. However, as most of the hard tissue cephalometric analyses, these also have been carried out mainly in the Caucasian population. Age and the ethnic origin of the patients seeking orthodontic treatment need to be considered while planning the comprehensive and holistic treatment goals.

As there is an intricate interplay between genetic and environmental factors, morphological features exhibit variations among individuals of different races. Even within

*Corresponding author: Shreya Agrawal
Email: agrawal2987@gmail.com

a particular race, each subgroup has its unique features. Consequently, the established norms for other ethnic groups cannot be directly applied to the Indian population.[7-11]

Thus the present study was undertaken to determine the soft tissue cephalometric standards for adults of Gujarati ethnic origin and correlate these norms with that of Holdaway. These norms may be used for comprehensive orthodontic diagnosis and treatment planning.

2. Materials and Methods

The current study is a retrospective cross-sectional cephalometric study conducted after approval from ethical committee of the institution.

$$\text{Unlimited population: } n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2}$$

The calculation for sample size at 95% confidence level and a 5% margin of error, assuming a population proportion of 0.5, indicated a need for at least 385 samples. Therefore, a total of 500 adult subjects (250 males and 250 females) from the Gujarati ethnic group were gathered for the study.

The criteria for selection of lateral cephalograms to be included required the subject to be of Gujarati ethnic origin, adult male or female with a seemingly balanced soft tissue profile and exhibiting an average growth pattern (Sn-MP – 32° ± 3°; Jaraback ratio – 62 % - 65%). The study excluded lateral cephalograms of individuals who had previously received orthodontic treatment, those with missing teeth (excluding third molars), and those with syndromes or craniofacial deformities.

The lateral cephalograms used in this study were of good quality, with all the landmarks being clearly identifiable. A cellulose acetate paper of 0.5 µm (micron) thickness and with sharp 3H pencil were used to trace all headfilms placed on a view box by the same examiner. The lighting conditions and overall illumination were consistent during the tracing of all headfilms. First, all reference points were identified, pinpointed, and labeled. The bilateral structures casting double shadows on the film were averaged and the reference planes were marked. Measurements were taken with consideration given to the magnification factor. The points and landmarks were taken according to Holdaway,[3-4] (**Table 1**). A single investigator analysed all radiographs to avoid inter–investigator variability. In order to measure the intra-investigator error, 20 randomly chosen cephalograms were traced twice one month apart.[6-7] The precision of angular and linear measurements was set to nearest 0.5 degree or 0.5 mm respectively.

2.1. Statistical analysis

SPSS software version 22.0 (SPSS Inc., Chicago, IL) was used to evaluate the data with a level of significance set at

p<0.05. Descriptive statistics were utilized to examine the mean and standard deviation within the study population groups. Shapiro Wilkinson test was used to assess the normality of the data. Inferential statistics, specifically the independent t-test, was employed to determine differences between groups. Pearson correlation was used to check the correlation between the groups.

3. Results

The mean, standard error and standard deviation of the Holdaway's soft tissue analysis for Gujarati males and females have been given in **Table 2** and **Table 3** respectively.

Normal values were calculated as mean ± 2 SD for reference in the treatment procedure. Significance of the difference between the male and female samples was tested with the independent t test. The values measured for gender correlation showed no significance statistically. (**Table 5**)

Soft tissue measurements of Gujarati males compared to those of Caucasian males showed that the Gujarati male population had statistically significant different skeletal convexity of 0.188° ± 1.79° compared to 0±0.88° in Caucasian population (p ≤ 0.0001), H line angle of 19.944° ± 3.13° compared to 10° ± 1.65° (p ≤ 0.0001), Nose tip - H line of 4.588 mm ± 2.86 mm compared to 19 mm ± 1.34 mm (p ≤ 0.0001), upper lip strain of 1.06 mm ± 1.29 mm compared to1.4 mm ± 0.67 mm (p ≤ 0.0001) and lower lip - H LINE of 0.712 mm ± 1.89 mm compared to 0 mm ± 0.88 mm (p ≤ 0.0001). (**Table 5**)

Soft tissue measurements of Gujarati females compared to those of Caucasian females showed that the Gujarati females had had statistically significant different skeletal convexity of 0.55° ± 1.71° compared to 0° ± 0.88° in Caucasian population (p ≤ 0.0001), H line angle of 20.052° ± 3.31° compared to 10° ± 1.65° (p ≤ 0.0001), Nose tip - H line of 5.112 mm ± 2.47 mm compared to 19 mm ± 1.34 mm (p ≤ 0.0001), upper lip thickness of 12.724 mm ± 1.92 mm compared to 15 mm ± 2.04 mm (p ≤ 0.002), upper lip strain of 1.096 mm ± 0.70 mm compared to1.4 mm ± 0.67 mm (p ≤ 0.0001), lower lip - H LINE of 1.358 mm ± 1.25 mm compared to 0 mm ± 0.88 mm (p ≤ 0.0001) and lower sulcus depth of 3.62 mm ± 1.49 mm compared to 5 mm ± 0.86 mm (p ≤ 0.0001). (**Table 6**)

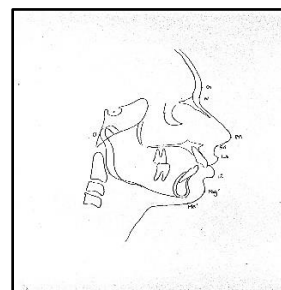The ideal norms for the Gujarati population are given in **Table 7**.

Table 1: Landmarks used in cechalometric analysis

Landmark	Description
Nasion (N')	Point corresponding to most anterior point of the frontonasal suture on the soft tissue line
Subnasale (Sn)	Point at the junction of the nasal septum and upper lip
Pronasale (Prn)	Point corresponding to most anterior point of the nose on the soft tissue line
Labrale superius (Ls)	Most superior point of the upper lip
Labrale inferius (Li)	Most inferior point of the lower lip
Pogonion (Pog')	Most anterior point of the soft tissue chin
Menton (Me')	Point corresponding to most inferior point on the mandibular symphysis on the soft tissue line
Gonion (Go')	Point corresponding to most posterior, inferior, and lateral point on the angle of the mandible on the soft tissue line
Point A	The deepest midline point on the premaxilla between the anterior nasal spine and prosthion (described by Downs)
H line	A line tangent to labrale superius and soft tissue pogonion
Facial plane	A line connecting soft tissue nasion (N') to soft tissue chin (Pog')
H – line angle	*The angle formed between the soft tissue facial plane and the H line*

Table 2: Cephalometric data- Male

	Mean	SD	SE	Min	Max
facial angle	88.82	5.796861	0.023187	87	97
upper lip curvature	3.836	1.52614	0.006105	0	7
skeletal convexity	0.188	1.795733	0.007183	-4	5
H line angle	19.944	3.136378	0.012546	9	27
Nose tip - H line	4.588	2.861163	0.011445	-1	11
Upper sulcus depth	5.232	3.370783	0.013483	-1	19
upper lip thickness	13.336	4.094765	0.016379	-1	19
upper lip strain	1.06	1.280781	0.005123	-1	11
lower lip - H LINE	0.712	1.896591	0.007586	-4	7
lower sulcus depth	4.012	1.92973	0.007719	-4	7
soft tissue chin thickness	10.924	1.763583	0.007054	7	15

Table 3: Cephalometric data- female

	Mean	SD	SE	Min	Max
Facial Angle	89.044	5.004205	0.020017	85	95
Upper Lip Curvature	3.696	1.60112	0.006404	-4	7
Skeletal Convexity	0.55	1.71712	0.006868	-3	5
H Line Angle	20.052	3.305949	0.013224	18	25
Nose Tip – H Line	5.112	2.479406	0.009918	-2	11
Upper Sulcus Depth	4.48	3.831136	0.015325	0	8
Upper Lip Thickness	12.724	1.924532	0.007698	8	17
Upper Lip Strain	1.096	0.703409	0.002814	0	2
Lower Lip - H Line	1.358	1.259697	0.005039	-2	3
Lower Sulcus Depth	3.62	1.495192	0.005981	0	7
Soft Tissue Chin Thickness	10.524	1.695118	0.00678	7	15

Table 4: Correlation analysis between gender

	Male	**Female**	**R value**	**P value**	**Significance**
Facial angle	88.82±5.79	89.044±5.01	-0.0091	0.92	NS
Upper lip curvature	3.836±1.52	3.696±1.61	-0.0957	0.89	NS
Skeletal convexity	0.188±1.79	0.55±1.71	0.079974	0.88	NS
H line angle	19.944±3.13	20.052±3.31	-0.1629	0.46	NS
Nose tip - H line	4.588±2.86	5.112±2.47	0.12999	0.39	NS
Upper sulcus depth	5.232±3.37	4.48±3.83	0.036444	0.79	NS
Upper lip thickness	13.336±4.09	12.724±1.92	0.023442	0.73	NS
Upper lip strain	1.06±1.28	1.096±0.70	-0.02415	0.73	NS
Lower lip - H Line	0.712±1.89	1.358±1.25	0.07664	0.88	NS
Lower sulcus depth	4.012±1.92	3.62±1.49	-0.04555	0.80	NS
Soft tissue chin thickness	10.924±1.76	10.524±1.69	0.090927	0.82	NS

Table 5: Comparison of cephalometric data with males

	Study population	**Caucascian**	**P value**
Facial angle	88.82±5.79	91 ±2.98	0.68
Upper lip curvature	3.836±1.52	3±0.79	0.66
Skeletal convexity	0.188±1.79	0±0.88	0.0001*
H line angle	19.944±3.13	10±1.65	0.0001*
Nose tip - h line	4.588±2.86	19±1.34	0.0001*
Upper sulcus depth	5.232±3.37	5±1.86	0.65
Upper lip thickness	13.336±4.09	15±2.04	0.08
Upper lip strain	1.06±1.29	1.4±0.67	0.0001*
Lower lip - h line	0.712±1.89	0±0.88	0.0001*
Lower sulcus depth	4.012±1.93	5±0.86	0.14
Soft tissue chin thickness	10.924±1.77	11±0.85	0.87

*P<0.05 is statistically significant

Table 6: Comparison of cephalometric data with females

	Study population	**Caucascian**	**P value**
Facial angle	89.044±5.01	91 ±2.98	0.68
Upper lip curvature	3.696±1.61	3±0.79	0.61
Skeletal convexity	0.55±1.71	0±0.88	0.0001*
H line angle	20.052±3.31	10±1.65	0.0001*
Nose tip - h line	5.112±2.47	19±1.34	0.0001*
Upper sulcus depth	4.48±3.83	5±1.86	0.65
Upper lip thickness	12.724±1.92	15±2.04	0.02*
Upper lip strain	1.096±0.70	1.4±0.67	0.0001*
Lower lip - h line	1.358±1.25	0±0.88	0.0001*
Lower sulcus depth	3.62±1.49	5±0.86	0.0001*
Soft tissue chin thickness	10.524±1.69	11±0.85	0.87

*P<0.05 is statistically significant

Table 7: Ideal norms for gujarati population

Parameters	**For males**	**For females**
facial angle	88.82 ± 5.7	89.044 ± 5.04
upper lip curvature	3.836 ± 1.52	3.696 ± 1.60
skeletal convexity	0.188 ± 1.79	0.55 ± 1.71
H line angle	19.944 ± 3.13	20.052 ± 3.3
Nose tip - H line	4.588 ± 2.86	5.112 ± 2.47
Upper sulcus depth	5.232 ± 3.37	4.48 ± 3.83
upper lip thickness	13.336 ± 4.09	12.724 ± 1.92
upper lip strain	1.06 ± 1.28	1.096 ± 0.70
lower lip - H LINE	0.712 ± 1.89	1.358 ± 1.25
lower sulcus depth	4.012 ± 1.9	3.62 ± 1.49
soft tissue chin thickness	10.924 ± 1.76	10.524 ± 1.69

4. Discussion

Soft tissue cephalometric measurements are crucial and highly effective in diagnosing and planning orthodontic treatments. Facial form, harmony and aesthetics are mainly dependent on the soft tissue balance. Norms derived from Caucasian populations are not applicable to individuals from other racial groups without modification. Alcade et al. conducted a study establishing soft-tissue norms specifically for Japanese adults, highlighting that norms based on Caucasian populations are not suitable as references for diagnosing and treating Japanese patients. Similar studies have been done for individuals belonging to different ethnic orgin in countries such as Saudi Arabia[17] and Korea[18] as well as in different population of India, like South Indian population[19] and North Indian population.[20] As India is a country with amalgamation of various ethnic races, it becomes necessary to establish normative data for each ethnic race, as it might help in determining and evaluating treatment procedures and effects respectively. To establish the norms a well sized sample is required so that the population is represented accurately. The aim of the present study was to obtain Holdaway's soft tissue cephalometric norms for Gujarati population.

The present study found that the soft tissue measurements of Gujarati males when compared to those of Caucasian males showed that the Gujarati male population had a more convex profile (skeletal convexity) due to more forwardly placed maxilla in relation to chin. A reduced nose prominence of Gujarati males was observed on measurements. The probable reason for this is increased skeletal convexity and thus a forwardly placed maxilla. A reduced upper lip strain as well as upper lip thickness was found when compared to the white males. The increased measurement of H angle is due to increased convexity of profiles. Compared to Caucasian males, the lower lip in Gujarati population was found to be in a more anterior position in relation to the H line. Also, the distance from the inferior sulcus to the H line shortens as the lip assumes a more anterior position.

Furthermore, the difference of soft tissue measurement between Gujarati females and Caucasian females was comparable to those of gujarati males and Caucasian males. tissue measurements of Gujarati females compared to those of Caucasian females showed that the Gujarati females had a more convex profile, reduced nose prominence, increased gap between subnasale to the Harmony line, reduced upper lip thickness, increased H angle, reduced upper lip strain, lower lip in a more anterior position in relation to the H line and reduced inferior sulcus depth. The results of the study conducted by Sachan et al. in the North Indian population are consistent with the findings of the current study.[20]

In the current study, men exhibited more prominent lips and chin protrusion compared to women. This difference primarily was the result of thicker soft tissue structures present in men. On comparison with the standard values from soft tissue cephalometric analysis (STCA).[21] decreased the average thickness and standard deviations of the soft tissue chin and upper lip in men and women in the present study were found, indicating a prevalence of thinner soft tissue structures among the subjects.

For a harmonious drape of soft tissues, the increase skeletal convexity must increase the H line angle and the soft tissue facial angle for different degrees of facial convexity. In the present study men had lower mean H line angle values than those of females, suggesting the latter had a more convex profile amongst the study population.

The lower sulcus depth is invariably affected by the axial inclination and position of lower incisors. Thus the depth may be considered an indicator of the amount of change required in position of lower incisors during treatment planning. In the present study, lower sulcus to the H line for women was less than that for men.

The variances observed in soft-tissue parameters across different racial groups underscore the significance of establishing specific norms or ideals tailored to each group. The present research sheds light on the disparities in facial structures among diverse ethnicities, as has been reported previously by many authors.[22-24] Many researchers have advocated for the implementation of separate norms tailored to specific populations, emphasizing that a single set of norms cannot adequately accommodate all patients.19[19]. What is considered normal for one ethnic group may not apply to another. Furthermore, disparities between genders within various populations are evident, which lead to establishment of separate norms for men and women.

A key benefit of this study lies in providing standardized lateral soft-tissue cephalometry measurements specifically tailored to Gujarati population of both genders. This aids in diagnosis and planning treatments for orthodontic and surgical procedures, thereby predicting stable post-treatment results. Although the present study is adequate to establish soft tissue norms for Gujarati population, further studies to assert this can be undertaken. Despite digital cephalometry, supported by special softwares, offering various advantages such as enhanced efficiency and reproducibility, the conventional cephalometry still remains the gold standard for the cephalometric measurements.[25] Further study could be undertaken to compare and affirm the results of the present study with those from digital tracing and analysis.

5. Conclusion

Significant differences were observed between Caucasian and Gujarati facial characteristics, including deeper midfacial structures, protruding dentitions, more convex profiles, reduced upper lip thickness, and diminished nasal

prominence. These findings underscore the importance for orthodontists and surgeons to individualize treatment plans based on local norms specific to Gujarati individuals rather than relying on established norms for white populations.

6. Source of Funding

None.

7. Conflict of Interest

None.

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