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Assessment of Arnett's Soft Tissue Norms For Himachali Population Using Digital Tracing Method: A Cephalometric Study

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Abstract:
Background: *The analysis is a radiographic instrument that was developed directly from the philosophy expressed in Arnett and Bergman "Facial keys to orthodontic diagnosis and treatment planning, Parts I and II". The novelty of this approach, as with the "Facial Keys" articles, is an emphasis on soft tissue facial measurement. This article describes various soft tissue traits that contribute to an aesthetically pleasing face which should be considered during orthodontic treatment. The aim of the present study was to propose soft tissue norms for Himachali population.*
Materials and Methods: *Lateral cephalograms of 100 Himachali subjects (50 males and 50 females) of age group 18-25 years were taken in Department of Orthodontics, Himachal Institute of Dental Sciences, Paonta Sahib and tracing of soft tissue profile as well as related osseous and dental structures were made using Nemoceph software. Then Arnett's soft tissue traits were studied as described by Bergman.*
Results: *The present study showed that, a horizontal growth tendency in Himachali is acceptable esthetically. A fuller upper lip is considered balanced and esthetic. Increase in lip incompetency is considered unaesthetic.*
Conclusion: *An increased posterior height resulting in horizontal growth tendency is acceptable esthetically. Individual norms are necessary for a population in order to plan and deliver quality treatment.*
Keywords: *Himachali, soft tissue traits, treatment planning.*

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I. Introduction

Preservation of facial attractiveness is a primary goal of orthodontic treatment. Treatment planning requires knowledge of the parameters and normative data that helps to establish goals and predict the obstacles that need to be negotiated. Due to a complicated interaction of genetic and environmental factors the morphological features of an individual vary from race to race. Even within the same race, each subgroup had its own standards. Hence, the established norms for other ethnic group can not apply to the population of Himachal Pradesh. Therefore, the applicability of various soft tissue parameters proposed by Bergman, should be analyzed which will improve treatment planning for population of Himachal Pradesh.[1] As Soft tissue norms serve as a guideline in calculating change it has been suggested that certain cephalometric standards relating teeth to cranial or facial bones could ensure good facial form if adhered to as a treatment goal.[2] The attainment of facial soft-tissue proportionality is one of the principal goals in the treatment of dentofacial deformities and can be achieved with properly planned and executed orthognathic surgery techniques.[3] Therefore the aim of this study is to calculate the norms for the population of Himachal Pradesh so that the soft tissue cephalometric values of various parameters could be differentiated from that of other populations so as to guide the

orthodontist towards a better diagnosis and treatment planning of dentofacial deformities for the population of Himachal Pradesh.

II. Materials And Methods

This study was carried out in the Department of Orthodontics and Dentofacial Orthopaedics of Himachal Institute of Dental Sciences, Paonta Sahib (H.P). 50 Males and 50 females in the age group of 18-25 years who were residents of Himachal Pradesh were considered for the study. All subjects were examined by a panel of the faculty members of the Department of Orthodontics and Dentofacial Orthopaedics and reasonably balanced faces were selected. Small diameters silver beads of dimension 2 mm (approx.) were chosen for the use as metallic markers. All the cephalograms of patients were taken in natural head position with Carestream X-ray machine with model no CS8100 (2016). All the radiographs were traced using (Nemoceph) Dental Studio NX (2006) software after the calibration of the images. All the landmarks were marked manually using inbuilt autozoom feature of the software and the measurement of the values and was done automatically by the Nemoceph software. Ten radiographs were also retraced after one week to check the intra-operator reliability. The Arnett's soft tissue cephalometric analysis (STCA) [4] was performed considering:

1. Dentoskeletal factors:

- Maxillary occlusal plane (Mx OP) to true vertical line (TVL)
- Maxillary central incisor tip (Mx1) to maxillary occlusal plane (Mx OP)
- Mandibular incisor tip (Md1) to mandibular occlusal plane (Ms OP)
- Overjet(OJ)
- Overbite(OB)

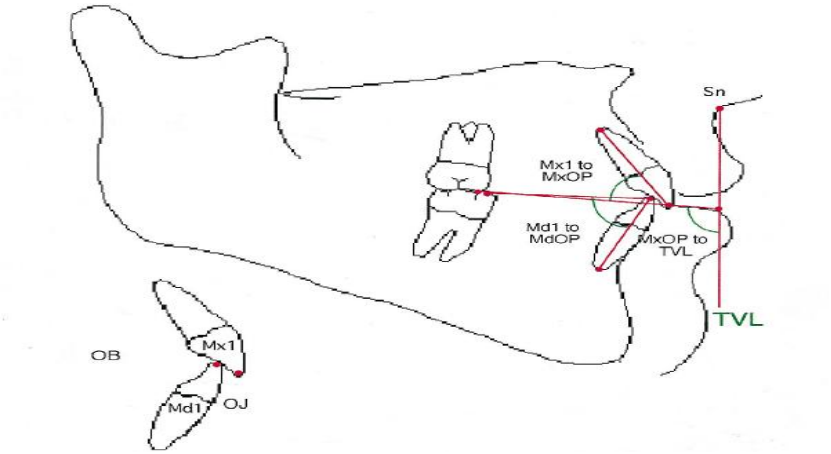

Fig 1. Dentoskeletal factors

2. Soft tissue structures:

- Upper lip thickness (upper lip anterior[ULA] to upper lip inside[ULI])
- Lip lip thickness (lower lip anterior [LLA] to lower lip superior[LLS])
- Pogonion –pogonion'(Pog –Pog')
- Menton –menton'(Me-Me')
- Upper lip angle (subnasale [Sn]- upper lip anterior [ULA]to true vertical line[TVL])
- Nasolabial angle (subnasale [Sn]- upper lip anterior [ULA] to subnasale [Sn]-Columella)

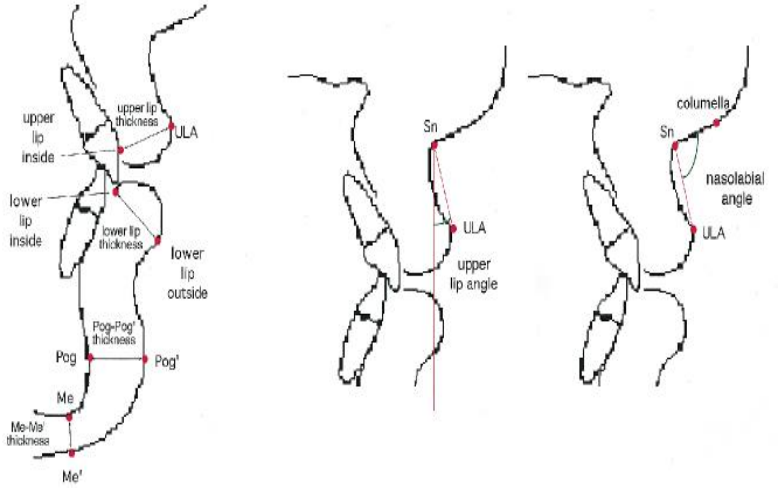

Fig 2. Soft tissue structures

3. Facial lengths:

- Facial heights (Nasion'[Na] to Menton'[Me'])
- Upper lip length (upper lip inferior [ULI] to subnasale[Sn])
- Interlabial gap(ILG)
- Lower lip length (lower lip superior [LLS] to Menton'[Me])
- Lower 1/3 of face (Subnasale[Sn] to Menton'[Me])
- Overbite (OB)
- Maxillary incisor tip(Mx1) exposure
- Maxillary height (Subnasale [Sn]to tip of maxillary incisor tip[Mx1])
- Mandibular height (Menton [Me]' to tip of mandibular incisor tip[Md1])

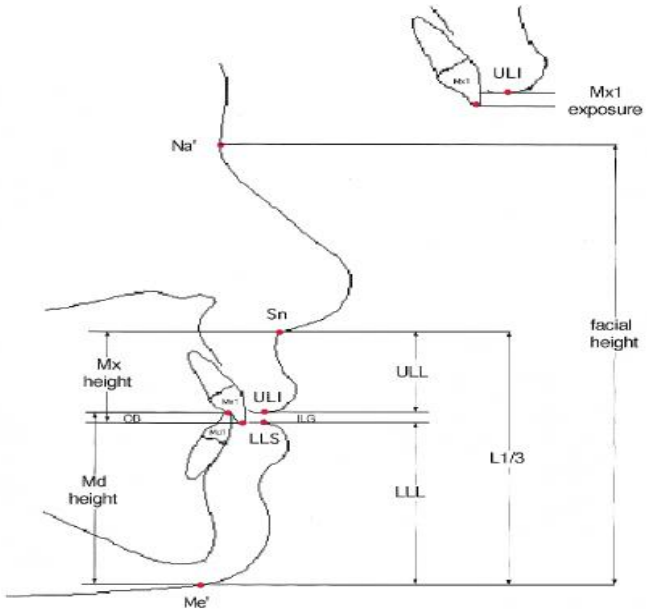

Fig 3. Facial heights / lengths

4. Projections to true vertical line :

- Glabella (G')
- Orbital rims (OR')
- Cheek bone (CB')
- Subpupil (SP')
- Alar base (AB')
- Nasal projections
- Subnasale (Sn)
- 'A' point
- Upper lip anterior (ULA)

- Maxillary incisor tip (Mx1)
- Mandibular incisor tip (Md1)
- Lower lip anterior (LLA)
- 'B'point
- Pogonion (POG')

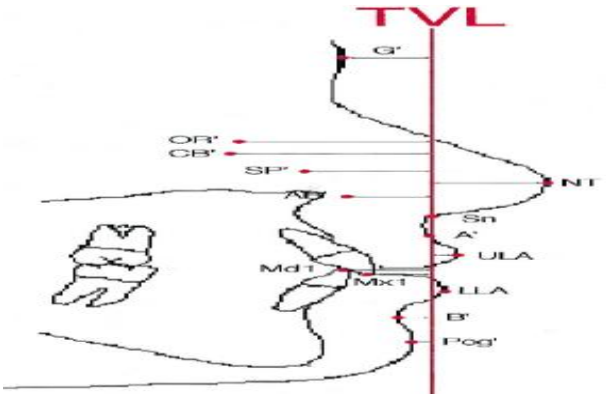

Fig 4. True Vertical Line Measurements

5. Harmony values:

- Intramandibular relations

1. Mandibular incisor tip (Md1) to Pogonion'(POG')
2. Lower lip anterior (LLA) to Pogonion' (POG')
3. 'B' point (B') to Pogonion' (POG')
4. Throat length (NTO to POG')

- Interjaw relations

1. Subnasale (Sn') to Pogonion' (POG')
2.'A'point (A') to 'B' point (B')
3. Upper lip anterior (ULA) to lower lip anterior (LLA)

- Orbit to jaws

1. Orbital rim (OR') to'A' point (A')
2. Orbital rim (OR') to Pogonion' (POG')

- Full Facial balance

1. Facial angle [Glabella'(G') to subnasale (Sn) to Pogonion' (POG')]
2. Glabella' (G') to 'A' point (A')
3. Glabella '(G') to Pogonion' (POG')

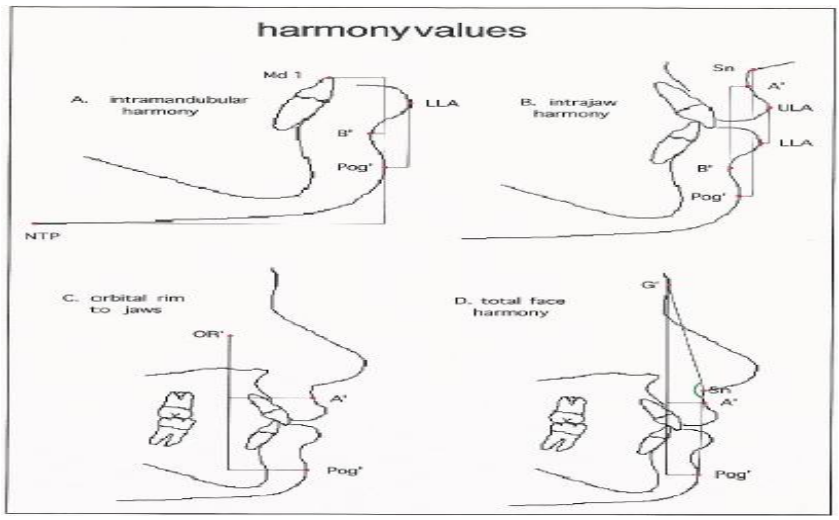

Fig 5. Harmony Values

Values of all parameters thus obtained were organized in the form of a master chart using Microsoft Excel and were statistically analyzed and compared with other ethnic populations.

III. Observations And Results

A study consisting of fifty males and fifty females was undertaken to study norms of the Himachali ethnic population based on Arnett's Soft Tissue Cephalometric Analysis study parameters. Normal values were calculated as mean ± 2SD for reference in the procedure. Significance of the difference between the males and females samples were tested with the Student't' test. A level of significance of 5% was assigned and P values were determined. Statistical analysis showed that the sexes were similar in some but not in all measurement.

In dentoskeletal factors, only the mean value of posterior height which was 97.05 ± 4.24 mm in males and 100.30 ± 4.64 mm in females showed a significant difference with p value < 0.001. The mean values of Mx1 to TVL, Mx1 – MxOP, overjet, Md1 to TVL, Md1-Md OP and overbite insignificant. (TABLE-I)

Among the soft–tissue measurements, the mean values of thickness of lower lip, soft tissue menton, upper lip and Pog-Pog' were 10.63 ± 1.58 mm, 8.18 ± 1.87 mm, 11.53 ± 1.39 mm and 12.78 ± 2.18 mm respectively for males and 9.62 ± 1.27 mm, 7.18 ± 1.77 mm, 10.95 ± 1.48 mm and 11.92 ±2.43 mm respectively for females and the differences in mean value were significant for thickness of lower lip and soft tissue menton with p value of 0.001 and 0.007 respectively. (TABLE-I)

Among Facial height/length measurement values, Upper lip length, upper incisor exposure to relaxed lip, lower lip length, lower 1/3rd height, total facial height, maxillary height, mandibular height and posterior height were 20.73 ±2.52 mm, 3.00 ±1.39 mm, 47.03 ±3.46 mm, 69.20 ± 5.11 mm, 124.28 ± 7.9 mm, 23.74 ±2.57 mm, 40.29 ±3.72 mm and 40.29 ±3.72 mm respectively for males and 19.04 ± 1.83 mm, 3.66 ±1.45 mm, 42.58 ± 3.61 mm, 63.21 ± 4.78 mm, 115.95 ± 6.34 mm, 22.71 ±2.52 mm, 37.12 ±2.54 mm and 100.31 ±4.63 respectively for females and the differences in means were significant with p values of < 0.001, 0.023, < 0.001, < 0.001, < 0.001, 0.046, < 0.001 and <0.001 respectively. The value for interlabial gap was insignificant. (TABLE-I)

In the projections to True vertical line, the measurement of glabella, soft tissue orbital rim and cheekbone were -9.84 ± 4.2 mm, -116.19 ± 9.23 mm and -24.21 ± 4.12 mm respectively for males and -7.80 ± 4.63 mm, -108.57 ± 6.27 mm and -19.29 ± 3.45 mm respectively for females and the differences in means were statistically significant with p value of .023, < .001 and < .001 respectively. Measurements of subpupil, nasal projection and nasal base were -16.17 ± 3.46 mm, 13.83 ± 2.40 mm and -9.79 ± 2.08 mm respectively for males and -12.05 ± 2.48 mm, 12.93 ± 2.04 mm and -8.22 ± 1.63 mm respectively for females and the differences in means were significant with p value of < 0.001, 0.047 and < 0.001 respectively. The projections of Upper lip anterior, Upper lip angle and nasolabial angle were 2.02 ±1.96, 7.43 ± 7.29° and 109.76 ±11.06° respectively for males and .93 ±1.98 mm, 3.84 ± 8.07° and 103.87 ±11.49° respectively for females and the differences in means were significant with p values of .007, .022 and .010 respectively. (TABLE-I)

Among the facial harmony values the values for forehead to maxilla, maxilla to orbital rim and mandible to orbital rim were 8.06 ±4.5 mm, 113.62 ± 7.19 mm and 109.20 ± 7.67 mm respectively for males and 5.81 ±4.6 mm, 106.59 ± 6.17 mm and 102.76 ± 9.66 mm respectively for females and the differences in means were statistically significant with p values of 0.016, < 0.001 and < 0.001 respectively. (TABLE-I)

TABLE – I: Soft Tissue Cephalometric Parameters For Himachali Population

	Mean ± S.D. Females	Mean ± S.D. Males	Females v/s males p value
DENTOSKELETAL FACTORS			
Mx1 to TVL	-11.13 ± 3.01	-11.76 ± 3.13	.304
Mx1-MxOP	55.41 ± 4.85	55.14 ± 5.3	.791
Overjet	3.78 ± .85	3.83 ± .91	.754
Md1 to TVL	-14.48 ± 2.78	-15.39 ± 3.16	.132
Md1-Md OP	65.17 ± 5.66	62.87 ± 7.02	.075
Overbite	3.12 ± 1.71	2.78 ± 1.68	.316
Post height	100.30 ±4.64	97.05 ± 4.24	.001**
Mx1 exp.	3.66 ± 1.45	3.00 ± 1.39	.023*
SOFT TISSUE STRUCTURES			
Upper lip	10.95 ± 1.48	11.53 ± 1.39	.050
Lower lip	9.62 ± 1.275	10.63 ± 1.58	.001**
Pog-Pog'	11.92 ± 2.438	12.78 ± 2.18	.067
Menton	7.18 ± 1.77	8.18 ± 1.87	.007**
FACIAL HEIGHTS or LENGTHS			
Upper lip length	19.04 ± 1.83	20.73 ± 2.52	.001**
Interlabial gap	1.57 ± .75	1.42 ± .82	.365
Upper incisor exp. Relaxed lip	3.66 ± 1.45	3.00 ± 1.39	.023*
Lower lip length	42.58 ± 3.61	47.03 ± 3.46	.001**
Lower 1/3 height	63.21 ± 4.78	69.20 ± 5.11	.001**
Total facial height	115.95 ± 6.34	124.28 ± 7.9	.001**
Maxillary height	22.71 ± 2.52	23.74 ± 2.57	.046*

Mandibular height	37.12 ± 2.54	40.29 ± 3.72	.001**
Post height	100.31 ± 4.63	97.06 ± 4.24	.001**
TRUE VERTICAL LINE PROJECTIONS			
Glabella	-7.80 ± 4.63	-9.84 ± 4.20	.023*
Soft tissue or. Rim	-108.57 ± 6.27	-116.19 ± 9.23	.001**
Cheekbone	-19.29 ± 3.45	-24.21 ± 4.12	.001**
Subpupil	-12.05 ± 2.48	-16.17 ± 3.46	.001**
Nasal projection	12.93 ± 2.04	13.83 ± 2.40	.047*
Nasal base	-8.22 ± 1.63	-9.79 ± 2.08	.001**
Soft tissue A	-1.97 ± 1.2	-1.79 ± 1.28	.455
Upper inc. tip	-11.13 ± 3.01	-11.76 ± 3.13	.304
Upper lip ant	.93 ± 1.98	2.02 ± 1.96	.007**
Upper lip angle	3.84 ± 8.077	7.43 ± 7.29	.022*
Nasolabial angle	103.87 ± 11.49	109.76 ± 11.06	.010**
Lower incisor tip	-13.95 ± 4.8	-15.3 ± 3.16	.081
Lower lip anterior	-1.50 ± 2.33	-.37 ± 2.73	.028*
Soft tissue B	-9.31 ± 3.32	-9.6 ± 3.36	.646
Soft tissue Pog	-5.97 ± 4.92	-6.19 ± 4.05	.813
Throat length	59.81 ± 7.22	58.61 ± 7.86	.428
HARMONY VALUES			
Facial angle	165.57 ± 6.22	164.48 ± 4.95	.385
Forehead to max	5.81 ± 4.64	8.06 ± 4.51	.016*
Forehead to mand	1.39 ± 6.46	3.66 ± 5.91	.071
Max to Orbital rim	106.59 ± 6.17	113.62 ± 7.19	.001**
Mand to orbital rim	102.76 ± 9.66	109.20 ± 7.67	.001**
Nasal base to chin	6.40 ± 4.33	6.19 ± 4.05	.798
Mx base- Md base	7.33 ± 2.63	7.83 ± 2.91	.365
Lip to Lip	2.44 ± 1.59	2.41 ± 1.88	.932
Inc tip to chin	4.71 ± 3.38	5.57 ± 3.96	.245
Low lip to chin	4.89 ± 3.07	5.99 ± 3.16	.151
Chin contour	2.89 ± 2.18	3.42 ± 2.46	.257

Statistically significant value at *p ≤ 0.05, **p ≤ 0.01 and ***p ≤ 0.001

IV. Discussion

A person's ability to recognize a beautiful face is innate, but translating this into defined treatment goals is problematic. Recognizing beauty is not practiced nor is it difficult. The perception of beauty is an individual preference with cultural bias. Rules governing why a face is beautiful are not understood nor are required for anyone to say that a face is beautiful. Artists and health professionals have attempted to define and recreate an ideal. They recognize beauty, yet objective standards are difficult, despite unending attempts to clarify this concept. As health professionals have increased their ability to change faces, the necessity to understand what is and is not beautiful has intensified. [5] Historically, orthodontics has included facial harmony as one of its important goals along with occlusal excellence. Edward Hartley Angle suggested that if teeth were placed in optimal occlusion, good facial harmony would result.[2] The facial skeleton and its overlying soft tissue determine facial harmony and balance. It is the structure of the overlying soft tissues and their relative proportions that provide the visual impact of the face.[1]

The primary goal of treatment becomes soft tissue relationships and adaptations, not Angle's ideal occlusion. This broader goal is not incompatible with Angle's ideal occlusion, but it acknowledges that to provide maximum benefit to the patient, ideal occlusion cannot always be the major focus of a treatment plan. Soft tissue relationships, both the proportions of the soft tissue integument of the face and the relationship of the dentition to the lips and face, are the major determinants of facial appearance. Soft tissue adaptations of the teeth (or lack thereof) determine whether the orthodontic result will be stable. Keeping this in mind while planning treatment is critically important.[6]

Many cephalometric analyses that have been proposed to achieve this goal are frequently of little value because they are based upon dentoskeletal landmarks which are not necessarily consistent with good facial esthetics. Clinicians have consequently used many empirical measurements to assess facial esthetics. With the use of surgical-orthodontic techniques to alter the soft tissue facial configuration and dentoskeletal relationships, there is a need for a more contemporary cephalometric analysis which assesses the dental, skeletal, and soft tissues of the dentofacial complex.[3] To achieve these optimum facial esthetics various soft tissue analysis such as profile analysis by A.M. Schwarz, Holdaway's analysis, Rickett's lip analysis, Steiner's lip analysis, Cephalometrics for Orthognathic Surgery (COGS) by Legan and Burstone and Soft tissue Cephalometric analysis (STCA) by Arnett have been devised.

The Soft Tissue Cephalometric Analysis is a radiographic instrument that represents the clinical extension of the philosophy detailed in "Facial keys to orthodontic diagnosis and treatment planning." This cephalometric soft tissue analysis guides soft tissue examination, as do these earlier articles, but with added

advantages. Because the STCA is a cephalometric analysis, profile soft tissue landmarks are easily seen, marked, and measured cephalometrically. Importantly, the midface metallic markers, for the first time, allow important soft tissues (orbital rim, cheekbone, subpupil, and alar base) to be easily seen, marked, and measured. **[4]**

The STCA has five distinct but cross-contributory elements:

- First, the system analyzes key dentoskeletal structures controlled by the orthodontist (Mx1 to MxOP, Md1 to MdOP) and surgeon (MxOP to TVL). Orthodontic and surgical manipulation of the dentoskeletal factors is key to facial profile and esthetics.
- Second, it measures key soft tissue structures that affect facial appearance.
- Third, it measures important vertical soft tissue lengths and soft tissue to hard tissue relationships.
- Fourth, it measures soft tissue points relative to the TVL, thus producing absolute projection values for each point.
- Fifth, the absolute values are then related to one another to test facial harmony. Harmony numbers provide a test of facial balance within the individual's face and, importantly, are independent of the true vertical anteroposterior placement.**[15]**

The present study was carried out in the Department of Orthodontics and Dentofacial Orthopaedics of Himachal Institute of Dental Sciences, Paonta Sahib (H.P). A sample of 50 Males and 50 females who were residents of Himachal Pradesh in the age group of 18-25 years were considered for the study. The subjects were first assessed clinically, in natural head position, seated condyles, and with lips at rest. Then, facial examination (frontal/profile) was used as described by Arnett and Bergman[5] with particular emphasis on midface structures that do not show on standard cephalometric analysis. In particular, orbital rim, subpupil and alar base contours were noted to indicate anteroposterior position of the maxilla.

Small diameters silver beads of dimension 2 mm (approx.) were chosen for the use as metallic markers on the basis of their excellent radio – opaque properties even in small dimensions and since they are light weight they could easily applied on the face to the precise location with the help of paper tape according to Arnett et al [4] in 1999. Next in the preparation for cephalometric radiograph, metallic markers in the form of small beads of silver were placed on the right side of the face to mark key mid face structures.

With the midface structures marked, the Natural Head Position was recorded. The subjects were asked to swallow and bite into centric occlusion. A cephalogram was obtained with subjects positioned in natural head position, seated condyle, and with lips at rest. The natural head position was recorded based on the method proposed by Cooke and Wei [7] in the year 1988 according to which the subject tilted the head forward and backward with decreasing amplitude until a comfortable position of natural balance was achieved.

With the mirror, the subject was then requested to look into the reflection of their eyes in a mirror located 200 cm ahead. Special care was taken to ensure that the head was not moved when the ear posts were carefully inserted.

The digital cephalograms obtained were then traced with the help of (Nemotec) Dental Studio 2006 software. After the cephalometric soft and hard tissue landmarks were measured on 100 facially balanced subjects of Himachali origin, dentoskeletal, soft tissue, vertical, projection and facial harmony norms and SDs were established. The values were obtained and statistical analysis was done with Student's t test.

The STCA integrates occlusal correction and soft tissue balance. Of all the STCA [4] measurements, only five relate hard tissue to hard tissue points: maxillary occlusal plane, maxillary incisor to maxillary occlusal plane, mandibular incisor to mandibular occlusal plane, overbite, and overjet. These hard tissue relationships are measured because to a large extent they control the esthetic outcome of occlusal treatment.[4]

The remaining measurements of the STCA emphasize soft tissue dimensions (ie, upper lip length) or soft tissue to hard tissue dimensions (ie, upper incisor to upper lip exposure). The STCA is not meant as a stand-alone cephalometric analysis. It is meant to be used in combination with clinical facial examination and cephalometric treatment planning, to provide clinically relevant soft tissue information with checks and balances (between cephalometric and clinical facial findings). **[4]**

This study highlights the differences in facial structures of various ethnic groups which has been reported by many authors.[10] Also, in various populations, differences can be seen between the gender, and attempts both in the past and in this study were made to establish separate norms for men and women. Himachali males and females show considerable sexual dimorphism with increased soft tissue thicknesses, facial lengths, retruded midface in males whereas females had steeper occlusal plane and more convex profile. The comparison between Himachali population and Caucasian population suggested that Himachali population had increased soft tissue thickness, decreased facial height, midface deficiency, flatter occlusal plane and more convex profile. The comparison between Himachali population and South Indian population suggested that Himachali population had decreased soft tissue thicknesses, midface deficiency, increased facial heights and more convex profile. A comparison of Himachali males and females showed that the the Himachali males had

increased anterior facial height as compared to Himachali females which is supported by a similar trend found in Caucasian [15] and South Indian population [10] suggesting a vertical growth pattern in Himachali males as compared to females whereas the females had increased interlabial gap as compared to males suggesting more incisor display in Himachali females as compared to Himachali males. (TABLE-I)

Himachali males have a less prominent chin than South Indian males and this should be taken care of when planning to retract the lower incisors or plan extraction in the lower arch. Himachali males also had thinner upper lips and lower lips which suggests that care should be taken while retracting the incisors as the lip thickness varies among the populations because of which same amount of incisor retraction would cause a greater change in soft tissue in Himachali males as they have thinner lips, shorter lip length and decreased interlabial gap as compared to Caucasian population who have thicker lips, greater lip length and increased interlabial gap. The values for Pog-Pog´ and menton were also lesser for Himachali males as compared to South Indian males. The facial / length measurements must be taken into consideration before treatment planning as the presence and location of vertical abnormalities is indicated by assessing maxillary height, mandibular height and upper incisor exposure which may result in unesthetic appearance of the face as the facial heights should remain in a defined ratio and proportion. The glabella and soft tissue orbital rim are deeply situated structures among the Himachali males as compared to Caucasian males and so before execution of any treatment plan the midface structures should be evaluated so as not to worsen the profile of the patient. These findings show that group specific norms are an essential prerequisite for accurate evaluation of orthodontic patients. What is normal for one ethnic group might not be for another. The attainment of facial soft-tissue proportionality is one of the principal goals in the treatment of dentofacial deformities and can be achieved with properly planned and executed orthognathic surgery techniques. It gives a detailed view of the fact that the goals of treatment should be gender specific thereby fulfilling the criteria of sexual dimorphism. It would also help to evaluate the progress of treatment in various stages.

V. Conclusion

The facial skeleton and its overlying soft tissue determine facial balance and harmony. It has also been suggested that separate norms for distinctive populations are necessary and that not all patients can be treated to one set of norms and this study supports this conclusion. This reinforces the concept of the STCA so pertinently conceived by Arnett et al.

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