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Comparative evaluation of facial soft tissue characteristics inherited between parents and off springs in families native of Himachal Pradesh-A photographic study

Amit Mehra[1], Sohinderjit Singh[1,*], Guneet Kour[1]

[1] *Dept. of Orthodontics & Dentofacial Orthopaedics, Himachal Institute of Dental sciences,, Paonta Sahib, Himachal Pradesh, India*

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ABSTRACT

Introduction: The form and function of the craniofacial complex is determined by a complex interaction between genetic and environmental factors thus influencing facial morphology. Facial photographs taken in a standardized pattern assumes great significance in studying heritability of soft-tissue facial features between parents and their offspring.

Aim: To evaluate the facial soft-tissue pattern of parents and their offspring with the help of standardized facial photographs and to find the degree of correlation between them.

Materials and Methods : A total sample of 120 children within the age-group of 16-25 years and their parents were selected from ethnic Himachal Pradesh population. Standardized photographs (frontal and right lateral) of entire sample were taken and then traced. Twenty-four parameters involving linear and proportional measurements were measured.

Results: Statistically significant correlations between parents and their offspring were found for upper facial height, total facial height, lip length at philtrum, chin projection, upper lip to S line, Nasal prominence, true vertical to tip of nose, true vertical to subnasale, true vertical to pogonion, vertical lip-chin ratio. Stronger heritability was found between daughters to their mothers than to their fathers. Sons showed heritability from both parents for Upper lip prominence to E-line and True vertical to Subnasale.

Conclusion: There was strong evidence indicating genetic contribution for both linear and proportional parameters. Highest correlations in inheritance of facial features was found between mother and daughter. Thus, parental data can be used to predict soft tissue facial form of offspring and information from siblings can also be used.

1. Introducion

The knowledge of structural make-up and growth pattern of craniofacial complex has great significance in clinical dentistry.[1,2] Biologists, Geneticists and anthropologists are constantly trying to de-mystify the reason of similarity of facial features among families of ethnic populations.[3–5] Various researches conducted among racial groups, siblings and twin studies have unveiled high heritability of human facial morphology.[5,6] The prediction of facial forms and dimensions of elder siblings who have completed growth helps in estimating facial features of younger siblings.[7,8] The purpose of this study was to compare the soft-tissue pattern of parents, their offspring and among the siblings using standardized frontal and profile photographs.

2. Materials and Methods

The study included 120 individuals selected from 30 families of Ethnic Himachal Pradesh population. Children were selected within the age-group of 16-25 years. Any family member having a history of previous orthodontic or surgical treatment or wearing dentures (complete or partial) were excluded from the study. Standardized facial

* *Corresponding author*.
E-mail address: sohinderjit@gmail.com (S. Singh).

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photographs (frontal and right lateral) of each subject were taken in Natural Head position (NHP) based on the method by Cooke and Wei (1988)[9] (Figures 1 and 2). The subject's head was oriented in such a way that Frankfort plane was almost parallel to the floor. The standardization of distance was achieved by asking the patient to stand on a line marked on the floor and framed alongside a vertical scale. Prior to taking photographs, the landmarks were identified by palpation and the black adhesive dots were placed on the subject's face.

Following landmarks were used in the study:[5–7] Tragion (T), Orbitale (Or'), Angle of mandible, Trichion (Tr),Soft tissue Nasion (N'), Subnasale (Sn') and Pogonion (Pg')

A 30-centimeter metal ruler was suspended on the rod which was parallel to the subject's nose in frontal and right lateral photographs. A plumb-line with 200-grams weight tied at its end was suspended from the scale held by a thick white thread that indicated the True Vertical (TV).[10 11 The scale allowed measurements at life-size (1:1). On the opposite side of the scale and outside the frame, there was a vertical mirror approximately 120-centimeters from the subject.

Nine landmarks were selected on the frontal photographs:[5–7]

1. Trichion (Tr)
2. Soft tissue nasion (N')
3. Orbitale (Or')
4. Inner canthus of eye (Ic)
5. Ala of nose (Aln)
6. Corner of mouth (Cm)
7. Subnasale (Sn')
8. Soft tissue Pogonion (Pog')
9. Soft tissue menton (Me')

Nine landmarks were selected on the profile photographs:[5–7]

1. Tragion (T)
2. Glabella (G)
3. Soft tissue point A (A')
4. Labrale superius (Ls)
5. Soft tissue point B (B')
6. Labrale inferius (Li),
7. Soft tissue Pogonion (Pog')
8. Soft tissue Menton (Me')
9. Point Cervical (C)

Then the photographs were cropped in 1:1 ratio with the help of Nikon NX2Software (Figure 3). The prints of the photographs were taken on 150 GSM photographic paper and traced on Lacquered polyester acetate Tracing paper using 0.3-mm tracing pencil (Figures 4 and 5).

Following planes were used in this study: Soft tissue mandibular plane (MP') and Facial plane (FP')

Following reference lines were used in this study: True vertical line (Tv), Harmony line (H line) and Esthetic line (E line)

The following linear measurements were made on frontal photographs:[5–7]

1. Upper facial height (UFH)
2. Lower facial height (LFH)
3. Total facial height (TFH)
4. Intercanthal width (IcW)
5. Nasal width (Nw)
6. Lip width (Lw)
7. Lip length at philtrum (Ll-ph)
8. Lip length at corner of mouth (Ll-Cm)

The following linear measurements were made on the profile photographs:[5–7]

1. Chin projection (chin –ptB)
2. Upper lip prominence to E line (Lp-E line-U)
3. Lower lip prominence to E line (Lp-E line-L)
4. Upper lip prominence to S line (Lp-S line-U)
5. Lower lip prominence to S line (Lp-S line-L)
6. Nasal prominence (Np)
7. Soft tissue subnasale to H line (Sn-H line)
8. True vertical to Glabella (Tv-G)
9. True vertical to tip of nose (Tv-Tn)
10. True vertical to subnasale (Tv-Sn)
11. True vertical to soft tissue point A (Tv-pt A)
12. True vertical to labrale superius (Tv-Ls)
13. True vertical to soft tissue point B (Tv-ptB)
14. True vertical to labrale inferius (Tv-Li)
15. True vertical to pogonion (Tv-pog)

The proportional measurement made on the profile photograph:[5–7]

1. Vertical lip-chin ratio (Vc/Lp)

The measurements on the true image-size (1:1) photographs were made manually using a Digital vernier caliper having a nearest of 0.01-millimeter accuracy.

The subjects were then paired in the following six groups:

1. Father-Son
2. Father-Daughter
3. Mother-Son
4. Mother-Daughter
5. Son-Daughter
6. Father-Mother

The arithmetic mean, standard deviation and correlation analysis for each group was then calculated using the measurements obtained from the tracings. All the tracings and measurements were done by a single operator.

Table 1: Comparison and correlation of linear and proportional parameters of Father-Mother and Father-Offspring Groups.

	Father and mother			**Father and son**			**Father and daughter**		
Parameter	r	t	p	r	t	p	r	t	
Upper Facial Height	-.246	4.649	.191 NS	.253	6.804	.177 NS	.215	6.505	.255 NS
Lower Facial Height	.136	5.528	.473 NS	.178	-.481	.347 NS	.299	5.955	.109 NS
Total Facial Height	.060	17.772	.754 NS	.433	9.202	.017 *S	.124	12.632	.514 NS
Inner canthus width	-.217	3.032	.248 NS	-.488	11.108	.006 *S	-.012	17.105	.949 NS
Nasal width	.158	10.800	.404 NS	-.398	20.205	.030* S	-.388	17.661	.034 *S
Lip width	.402	3.631	.028* S	.249	1.001	.185 NS	.219	3.362	.246 NS
Lip length at philtrum	.085	4.170	.656 NS	.384	2.105	.036* S	.275	5.171	.141 NS
Lip length at commissures	.206	9.297	.274 NS	-.409	19.240	.025 *S	.098	20.587	.606 NS
Chin-projection	.017	1.042	.927 NS	-.228	1.615	.226 NS	.023	2.239	.905 NS
Upper lip prominence to E-line	.075	-3.571	.695 NS	.374	-12.444	.042* S	.413	-11.072	.023* S
Lower lip prominence to E-line	.273	-1.673	.144 NS	.175	-6.709	.355 NS	-.168	-6.920	.375 NS
Upper lip prominence to S-line	.204	2.217	.279 NS	.215	-.541	.253 NS	.282	-.984	.131 NS
Lower lip prominence to S-line	.180	.716	.342 NS	-.187	23.391	.322 NS	.095	26.569	.619 NS
Nasal prominence	.289	-2.098	.122 NS	-.233	5.064	.215NS	-.448	5.309	.013* S
Soft tissue subnasale to H-line	.713	.551	<.001**S	.221	-1.928	.241 NS	.413	-2.111	.023 *S
True vertical to Glabella	.211	2.192	.263 NS	-.155	14.497	.415NS	-.154	13.611	.417 NS
True vertical to tip of nose	.272	-1.259	.146 NS	.108	2.054	.569 NS	.198	1.528	.293 NS
True vertical to Subnasale	.334	-.939	.071 NS	.573	2.446	.001** S	.602	1.227	<.001** S
True vertical to soft tissue point A	.247	2.199	.189 NS	.145	.101	.446 NS	.308	-.327	.098 NS
True vertical to labrale superius	-.201	-3.964	.286 NS	.108	-.961	.569 NS	.194	.151	.303 NS
True vertical to soft tissue point B	.259	3.099	.167 NS	.015	-1.725	.936 NS	.239	-.319	.204 NS
True vertical to labrale inferius	.091	1.550	.632 NS	.182	.633	.335 NS	-.068	2.549	.722 NS
True vertical to pogonion	.303	.941	.103 NS	.315	4.036	.090 NS	.215	-.404	.253 NS
Vertical lip-chin ratio	0.274	1.383	0.143 NS	O.286	2.221	0.125 NS	0.485	3.411	0.007 *S

The values were statistically significant at ≤ 0.05 * level and highly significant at < 0.001** level.

Fig. 1: Frontal Photographs of family

Fig. 2: Profile Photographs of family

Fig. 3: Nikon View NX2 Software

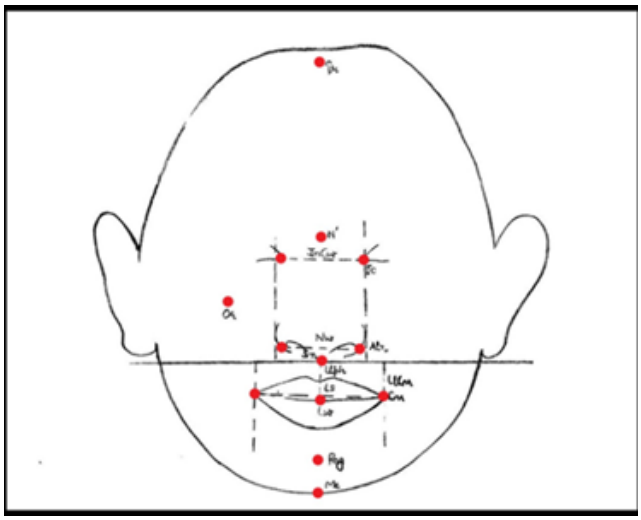

Fig. 4: Tracing of true image frontal photograph for linear measurements

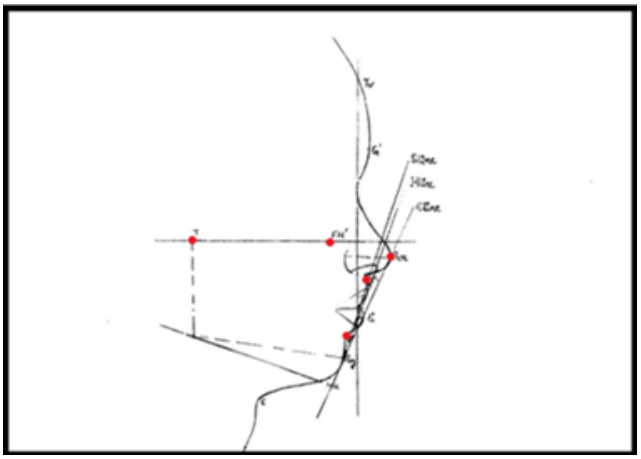

Fig. 5: Tracing of true image profile photograph for linear measurements

2.1. Ethical Committee Permission

The study was approved by the Ethical Committee of this institution.

2.2. Informed Consent

Informed consent was obtained from each subject for the purpose of this study.

2.3. Statistics

Data was subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS Inc., SPSS for Windows version 16, IBM, USA). Normality of data was done using Shapiro-Wilk test. Descriptive statistics were calculated as mean and standard deviations for each variable. Comparison of association of different variables among father, mother, son and daughter groups was done using Pearson's correlation. The level of statistical significance for the present study was fixed at a P-value < 0.05, any value equal or less than this was taken as statistically significant.

3. Results

Table 1 shows the correlation of linear and proportional parameters of father-mother and father-offspring group and its significance. Table 2 shows the correlation of linear parameters and proportional parameters of mother-offspring and son-daughter group and its significance.

For upper facial height, significant heritability was observed only between mother and son group (p value=0.027) while it was insignificant between all other groups. For Total facial height, significant heritability was observed in the similar sex group. The similarity was more in the father-son group (p value=0.017) and mother-daughter group (p value=0.002).

Table 2: Comparison and correlation of linear and proportional parameters between mother-offspring and son-daughter groups.

	Mother and Son			**Mother and Daughter**			Son and Daughter		
Parameter	r	t	p	r	t	p	r	t	p
Upper Facial Height	.403	.503	.027* S	-.008	-.344	.967 NS	.012	.855	.948 NS
Lower Facial Height	.177	-6.232	.348 NS	.369	-.430	.045 NS	-.100	-5.268	.598 NS
Total Facial Height	.269	-7.273	.150 NS	.550	-3.783	.002 *S	-.182	-3.162	.336 NS
Inner canthus width	.206	14.577	.275 NS	-.124	17.754	.514 NS	-.220	-1.857	.242 NS
Nasal width	-.001	13.141	.994NS	-.194	11.214	.305 NS	.208	-1.895	.270 NS
Lip width	.306	-2.260	.101 NS	.191	.286	.312 NS	.075	-2.125	.693 NS
Lip length at philtrum	.349	-2.888	.058 NS	.365	-.515	.047* S	.389	-2.982	.034 *S
Lip length at commissures	.064	6.486	.737 NS	.063	4.648	.741 NS	-.019	2.754	.922 NS
Chin-projection	.209	.953	.269 NS	.479	1.887	.007 *S	.275	-.645	.141 NS
Upper lip prominence to E-line	.163	-10.178	.388 NS	-.351	-6.245	.058 NS	.042	-.093	.825 NS
Lower lip prominence to E-line	.458	-6.840	.011 *S	.331	-7.583	.074 NS	.064	1.720	.736 NS
Upper lip prominence to S-line	.322	-3.362	.083 NS	.494	-3.939	.005 *S	.463	.682	.010 *S
Lower lip prominence to S-line	.062	25.444	.746 NS	.211	27.517	.264 NS	.128	.592	.500 NS
Nasal prominence	-.463	5.195	.010 *S	-.515	5.614	.004* S	.802	.666	<.001**S
Soft tissue subnasale to H-line	.381	-2.727	.038 *S	.274	-2.533	.144 NS	.156	-.267	.409 NS
True vertical to Glabella	-.051	14.134	.788 NS	-.237	12.301	.208 NS	.120	1.022	.526 NS
True vertical to tip of nose	.405	3.083	.026*S	.668	2.370	<.001**S	.554	-.023	.001**S
True vertical to Subnasale	.564	3.206	.001**S	.405	1.867	.027 *S	.737	1.734	<.001**S
True vertical to soft tissue point A	.063	-.828	.741 NS	.284	-.876	.128 NS	.812	.581	<.001**S
True vertical to labrale superius	.219	3.250	.245 NS	.122	5.600	.520 NS	.463	-1.464	.010* S
True vertical to soft tissue point B	-.329	-4.411	.076 NS	.287	-3.876	.124 NS	.016	-1.534	.931 NS
True vertical to labrale inferius	.114	-.894	.548 NS	.023	1.074	.903 NS	.339	-2.324	.067 NS
True vertical to pogonion	.179	5.134	.345 NS	-.460	-1.084	.011 *S	-.189	4.091	.318 NS
Vertical lip-chin ratio	0.385	0.893	0.036* S	0.386	1.300	0.035 *S	0.136	-0.203	0.473 NS

The values were statistically significant at ≤ 0.05 * level and highly significant at < 0.001** level.

Inner canthus width showed significant heritability only in the father-son group (p value=0.006). For nasal width, significant heritability was observed only to the father in both the sexes, (Father-son group: p-value=0.030, Father-daughter group: p-value=0.034). Lip width showed significant heritability only in the father-mother group (p-value=0.028).

For lip length at philtrum, significant heritability was observed in the similar sex group (p-value: father-son group=0.036, mother-daughter group= 0.047) and between the son-daughter group was 0.034. For lip length at commissures, significant heritability was observed only in father-son group (p-value=0.025).

For Upper Lip prominence to E-line, significant heritability was observed to father in both the sexes (Father-son group: p-value=0.042, Father-daughter group: p-value=0.023). For Lower Lip to E-line, significant heritability was observed only in the Mother-Son group (p value=0.011). For Upper Lip prominence to S-line, significant heritability was observed between Mother-Daughter and Son-Daughter groups (Mother-Daughter group: p-value=0.005, Son-daughter group: p-value=0.010). Nasal prominence was found to be highly significant in Son-Daughter group (p value$<$ 0.001), 635significant in Father-Daughter, Mother-Son and Mother-Daughter groups while it was insignificant in Father-mother and Father-Son groups.

For soft tissue subnasale to H line, the similarity was observed in the father-mother group (p value$<$ 0.001), father-daughter (p value=0.023) and mother-son group (p value=0.038). For True vertical to tip of nose, significant heritability to mother was seen in both the sexes and between the siblings. The similarity was higher in the mother-daughter group and between the siblings (p value $\leq$0.001) than in the mother-son group (p value=0.026). True vertical to subnasale showed significant heritability to both the parents in both the sexes and between the siblings. True vertical to soft tissue point A and true vertical to labrale superius showed high heritability only between the siblings. For True vertical to pogonion , significant heritability was found only between the Mother-Daughter group (p value=0.011)For the proportional measurement of vertical lip-chin ratio, daughter showed inheritance from both the parents while son showed heritability only from the mother (p value=0.036).

4. Discussion

The evaluation of the patient's facial soft tissue is one of the most important component of Orthodontic diagnosis and treatment planning. Since the shape of the human face depends on both the structure of the hard tissue (bone) and the soft tissue that covers it, soft tissue should be analysed for the correct evaluation of an underlying skeletal discrepancy because of individual differences in soft tissue thickness.

Traditionally, quantitative assessments of soft tissue were performed using lateral cephalometric radiographs. However, it was not possible to evaluate the soft tissues from the frontal view by using cephalometric radiographs. Soft tissue evaluation has also been carried out by means of different methods such as anthropometry, two-dimensional or three-dimensional photogrammetry, and three-dimensional imaging techniques. The notion that accurate measurements can be obtained from standardized photographs was given in 1940s.[12] Facial photography has been part of both pre-treatment and post-treatment orthodontic records. Graber stated that photograph assumes even greater importance when dentist do not have equipment for taking cephalograms, he considered photographs as essential diagnostic tool as various parameters that characterize facial patterns like facial height, facial depth, mandibular angle, and the positions of the upper and lower lips can be measured from the lateral view.[13]

Natural Head Position (NHP) was introduced into orthodontics in the late 1950s. It is a standardized reproducible position, with the head in an upright posture and eyes focused on a point in the distance at eye level such that the visual axis is horizontal. A typical method of registering NHP is based on the work of Solow and Tallgren (1971)[14] who cited Molhave (1958) in which subjects were asked to stand in an 'orthoposition' and look into their own eyes in a mirror after a series of neck flexion exercises. Ferrario et al (1994),[15] Fernandez Riveiro et al (2002)[16] and Annic-Milosevic et al (2008) described the standardized photographic technique for NHP recording.

This study was conducted with the objective to compare and co-relate the heritability of soft tissue pattern of parents and their offspring with the help of linear and proportional parameters calculated on standardized frontal and profile photographs taken in Natural head Position (NHP). In our study, significant heritability was observed only between the mother-son group and this finding was corroborated by Patil B.C. et al (2016),[6] who also reported significant heritability in-between the mother-son group only. The most probable reason for close correlations between mother-son group may be attributed to sex-linked inheritance. Significant heritability was observed only between the mother-son group which again may be attributed to sex-linked mode of inheritance. These results were in contrast to the previous studies conducted by Vairage B.C. (2016),[5] Lahoti et al (2013)[7] and Hyun-Jin Kim et al (2013)[17] which showed no heritability in any parent-offspring group. Tina and Eman (2010)[18] conducted a study and suggested that the lower facial height had more heritability than the upper facial height though this can be attributed to the fact that those were cephalometric studies and the landmarks were skeletal rather than soft tissue landmarks.

In this study, significant heritability was observed between the mother-daughter group (p-value=0.002) and the

father-son group. The results of our study were corroborated with a similar photographic study by Lahoti et al (2013)[7] except in that study there was a significant correlation between the mother-father group also. In a similar study by Hunter et al (1970),[2] significant heritability of TFH was found in all parent-offspring groups except in father-son group.

According to Saunders (1969),[19] the slightly lower percentage of significant correlations in mother-son pairings may be due to one of two factors. It may be simply that the age difference between parents compared to their offspring still has an effect on reducing the relationship between mothers and their sons. Or it may be that sons and daughters are slightly closer to their fathers because of a secular trend in growth, which leaves mature offspring closer in size to their fathers. Previous studies by Lahoti et al (2013)[7] showed significant correlation between the mother-son group only (p value$<$ 0.05) which may be related to Sex-linked inheritance. In a similar study done by Patil B.C. (2016),[6] a stronger correlation was observed in the father-son group and son-daughter group than in the mother-son group.

The most striking finding in this study is the high level of significant correlations between parents and offspring and between siblings, especially when they are contrasted with the correlations of fathers to mothers. The highest expected level of correlation is compatible with a polygenic theory of inheritance. The high correlations in this study are due to control over age of the children, as all the offspring taken are in the post-pubertal group.

Hunter et al (1969)[2] compared parents to children who are in post-pubertal period and attained growth. The present study is similar to that of Hunter, but it has employed smaller sample sizes and higher number of variables. Hunter and associates[2] and Nakata and colleagues[20] reported a much stronger relationship between fathers and off spring than between mothers and offspring for five craniofacial measurements. They could offer no explanation for this finding but attributed the result to sample bias.

5. Conclusion

An improvement in our knowledge of the etiology of orthodontic problems, possibilities, limitations of orthodontic treatment and treatment planning is based on a thorough understanding of the inheritance of the facial soft-tissue characteristics.

This study signifies the fair genetic control in the transmission of soft tissue facial characteristics. The findings of this study may assist in the prediction of future growth and treatment planning in orthodontic practice. Highest correlation in the inheritance of the facial features was found between the mother and daughter. The following parameters showed significant correlation; Upper facial height (UHF), Total facial height (TFH), Lip length at philtrum (Llph), chin projection (Chin-ptB), Upper lip to S line (Ls-Eline-U), Nasal prominence (Np), True vertical to tip of nose (Tv-Tn), True vertical to Subnasale (Tv-Sn), True vertical to pogonion (Tv-pog), Vertical lip-chin ratio (Vc/Lp).

Lowest correlation in the inheritance of facial features was observed between the father and daughter. The following parameters showed significant correlation: Nasal width (Nw), Upper lip prominence to E line (Lp-Eline-U), Nasal prominence (Np), Subnasale to H line (Sn-H line), True vertical to subnasale (Tv-Sn), Vertical lip-chin ratio (Vc/Lp).

The degree of correlation found in our study could be used for the predetermination of adult facial dimensions using parental facial dimensions. This study gives an idea whether the facial morphology is on account of the hereditary pattern or due to environmental changes.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Amit Mehra Professor

Sohinderjit Singh Professor and HOD

Guneet Kour Post Graduate Student

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