Heritability of Facial Characteristics between Parents and Offsprings: A Photographic Study

Seema Kapil Lahoti, Ashok M Karia, Kapil B Lahoti

ABSTRACT

Aims and objectives: Facial morphology is influenced by both genetic and environmental factors which interact in complex ways to determine the form and function of the craniofacial complex. Many studies have been done to know the amount of heritability of the skeletal components but hardly are known about the heritability of soft tissue pattern which is compared by everyone as soon as the child born. Cephalometry and photography is used in orthodontics to document the appearance of the face. Considerable progress has been made in the development of its application in orthodontics. Thus, the study was done to know the heritability of soft tissue pattern between parents and their offsprings by using photographs.

Materials and methods: The sample consisted of 140 children and their parents. Material was collected from both the genders of children above the age of 16 years. Frontal and right lateral photographs of the entire sample were taken in the standardized pattern. Tracings were made on all the photographs. Twenty-seven parameters of linear and proportional measurements were measured.

Results: Statistically significant correlations between parents and their offspring were found. It was found that daughters had greater genetic influence from both the parent than sons. Higher correlation was found for the mandibular position, chin prominence, nasal prominence, nasal width, lip length at philtrum, facial height and lip prominence.

Conclusion: The evidence of significant genetic contribution was there for linear and proportional parameters. Sons showed stronger heritability to their mothers than to their fathers while daughter showed heritability from both the parents. Thus, the soft tissue form of offspring can be predicted from parental data and the information from the siblings can also be used.

Keywords: Facial height, Facial proportion, Genetics, Inheritance, Soft tissue analysis.

INTRODUCTION

After the sex of a newborn baby is determined, perhaps the most common question put to the parents by the relatives and friends is ‘whom does he or she looks like?’ The frequency of this question attests to a kind of common knowledge that the child resembles like one of the parent.1 To know the validity of the important role of heredity in determining the child’s morphology, many studies had been carried out.

The role of various factors on the growth of hard tissue components has been emphasized in orthodontic research and literature. However, utmost importance should also be given to the soft tissue covering, which ultimately determines the appearance of an individual.2 Burstone stated that, in diagnosing an orthodontic case, the soft tissue should be a criterion as well as the dental and skeletal structures because the soft tissue is the final determiner of facial esthetics and harmony.3 Lack of emphasis on soft tissue is probably due to lack of literature as well as variability in soft tissue thickness.

If the incidence of similarity of facial features among the siblings could be established, the information obtained from the facial features of the elder siblings, if any who have completed growth, could be utilized for estimating how the facial features of their younger siblings are likely to develop.

Chang et al investigated the inheritance of the facial features by the offspring’s from their parents using frontal photography. But the limitations of the study were the variability which could occur due to dissimilar gender offspring’s and consideration of only the frontal view. The purpose of this study was to compare the soft tissues pattern of parents and their offspring’s and among the siblings with the help of frontal and profile photographs.4

MATERIALS AND METHODS

The study comprised of 140 individuals drawn from 35 families. Each family comprised of father, mother, a son and a daughter. Children above the age of 18 years were included. If any of the family members had ever undergone any
orthodontic or surgical treatment or wearing complete or partial dentures were not included. The standardized frontal and right lateral photographs of each family member were taken (Figs 1 and 2). The head of the subject were kept in such a way that the Frankfort plane was almost parallel to the floor. The subject was positioned on a line marked on the floor, and framed alongside a vertical scale to standardize the distance. Before the photos were taken, the landmarks were identified by palpation and the adhesive dots were placed on the subject’s face (Figs 1A and B). These landmarks were as follows:5-8
- Tragion (T)
- Orbitale (Or’)
- Angle of mandible
- Trichion (Tr)
- Soft tissue nasion (N’)
- Subnasale (Sn’)
- Pogonion (Pg’).

An inch scale was suspended on the rod which was parallel to the subject’s nose in frontal and right lateral photographs. Total landmarks on the frontal photographs were eight and on the lateral photographs were nine. Then the prints of the photos were taken and traced on the acetate paper. The following facial landmarks were identified and used in the analysis:

The landmarks located on the frontal photograph (Fig. 2A) were as follows:5,9 Tr, N’, Or’, inner canthus of eye (Ic), ala of nose (Aln), corner of mouth (Cm), Sn’, Pg’, soft tissue menton (Me’).

The landmarks located on the profile photograph (Fig. 2B) were as follows: T, glabella (G’), soft tissue point A (A’), labrale superius (Ls), soft tissue point B (B’), labrale inferioris (Li), Pg’, Me’, point ‘C’.

The planes used in this study were as follows:1,5,7,10-12 (Figs 2A and B):
- Soft tissue mandibular plane (MP’)
- Facial plane (FP’).

The lines used in the analysis were as follows (Figs 2A and B):
- True vertical line (Tv)
- Harmony line (H line)
- Esthetic line (E line).

The linear and proportional measurements were measured on the frontal and right lateral photographs. The 24 linear measurements (Figs 2A and B) included in this study were as follows:1,5-8,12

The measurements done on the frontal photographs:
- Upper facial height (UFH)
- Middle facial height (MFH)
- Lower facial height (LFH)
- Total facial height (TFH)
- Intercanthal width (InCw)
- Nasal width (Nw)
- Lip width (Lw)
- Lip length at philtrum (LlPh)
- Lip length at corner of mouth (Llcm)

The measurements done on the lateral photographs (Fig. 2B):
- Chin projection (Cp)
- Lip prominence to E Line–upper (ULp)
- Lip prominence to E Line–lower (LLp)
Heritability of Facial Characteristics between Parents and Offsprings: A Photographic Study

Statistical Analysis

The true image size photographs of a family were printed and traced (Figs 2A and B). The measurements were done on the tracing. Pairs were formed between father-son, father-daughter, mother-son, mother-daughter, son-daughter and father-mother. Using these measurements the arithmetic mean, standard deviation and correlation analysis were calculated for each group. The tracings and measurements were done by one operator.

To find out the statistical significance Student t-test was used. Statistical significance was judged at the 5% level. The probability values were considered to be highly significant at p < 0.01 level, significant at <0.05 level and nonsignificant at >0.05 level.

RESULTS

Table 1 shows the correlation of linear parameters of father–offspring and its significance. Table 2 shows the correlation of linear parameters of mother–offspring, among the siblings and its significance. Table 3 shows the correlation of proportional parameters of father–offspring and its significance. Table 4 shows the correlation of proportional parameters of mother–offspring, among the sibling and its significance.

For the middle facial height, heritability was observed in the same sex group. The similarity was found between the father and son (p < 0.05) (Table 1). Total facial height showed high heritability to the parents in both the sexes. The similarity of son was found to be higher to both father and mother as compared to the daughter (p < 0.01) (Tables 1 and 2). The intercanthal width showed the heritability which was significant between the mother-son only (p < 0.05) (Table 2). For the nasal width, high heritability to the parents was observed in both the sexes (p < 0.05) (Table 2). The similarity was more in the similar sex group. The similarity was more between father-son and mother-daughter (p < 0.01) (Tables 1 and 2). For the soft tissue subnasale to H line, high heritability to the parents was observed in both sexes. The similarity to the mother was higher than to the father (p < 0.01) (Tables 1 and 2).

For true vertical to glabella, heritability was observed for both the sexes. The son only showed the inheritance from both the parents while daughter showed the higher significance from the mother. For true vertical to glabella, heritability was observed for both the sexes. The son only showed the higher significance from the mother (p < 0.01) (Tables 1 and 2). For true vertical to tip of nose, the heritability was observed for daughter from mother (p < 0.01) (Table 2).

For true vertical to subnasale, the similarity between the father and son was significant (p < 0.01) while it was highly significant between mother-daughter group (p < 0.01) (Tables 1 and 2). For true vertical to soft tissue pogonion, the high heritability was found only between the mother and daughter (p < 0.01 while it was significant between the siblings (p < 0.05) (Table 2).

For true vertical to labrale inferius and true vertical to soft tissue pogonion, the high heritability was found only between mother and daughter (p < 0.01) (Table 2). Chin prominence, heritability was found only to the mother in both the sexes. However, daughter-mother similarity was higher than son-mother similarity (p < 0.01) (Table 2). Lip length at philtrum
also showed strong heritability to the parents in both the sexes. Similarity between the similar sex was more than for the opposite sex (p < 0.01) (Tables 1 and 2).

For lip length at corner of mouth, the heritability was found only for the father and son (p < 0.05) (Table 1). Upper lip prominence to E line, the heritability was found to the parents for both the sexes. The similarity was observed for the father and daughter (p < 0.05) but the similarity to the mother was higher than to the father for both the sexes (p < 0.05) (Tables 1 and 2). Lower lip prominence to E line, the heritability was found in both the sexes but it was more significant in the opposite gender group (p < 0.01) (Tables 1 and 2).
Upper lip prominence to S line, the heritability was found in both the sexes but it was more significant in the opposite gender group (p < 0.05) (Tables 1 and 2). Lower lip prominence to S line, the heritability was found for both the parents to son only and it was significant between the siblings also (p < 0.05) (Tables 1 and 2). Nose prominence, high heritability was found only to the mother in both the sexes (p < 0.01). However, daughter-mother similarity was higher than son-mother similarity (p < 0.05) (Table 2).

Proportional Measurements

Vertical height ratio, the heritability was found to the parents for both the sexes. However, it was more significant in the same gender group. Father-son similarity (p < 0.01) was higher than mother-daughter similarity (p < 0.05) (Tables 3 and 4).

For lower vertical height-depth ratio, the heritability was observed only in the father-son (p < 0.05) (Table 3). For the vertical lip-chin ratio, the high heritability was observed only in the mother-son (p < 0.01) (Table 4).

DISCUSSION

A measure of successful orthodontic treatment is the observable enhancement of facial esthetics; therefore evaluating the soft tissue profile both before and after treatment is an integral part of orthodontic treatment.14 Appearance therefore is one of the primary functions of the face, however, the dentition of an attractive and pleasing face is subjective with many factors involved.15 Edward Wuerpel, the distinguished art professor who greatly influenced Dr Angle, stated ‘Beauty is the finest expression of human emotions’.15

Predicting the adult facial form and dimensions of siblings and twins has fascinated the imagination of the orthodontic community for many years. Every orthodontist would like to see that the corrected positions of the teeth in a child are in harmony with the fully grown face of the same individual. There is considerable evidence to suggest that different components of the soft tissue profile have differing rates and timing of growth, and that all parts of the soft tissue profile do not grow in direct proportions to their skeletal bases.2

Many studies in the past have focused on the genetic control of the architecture of the facial skeleton (Harris, Sheldon, Van der Linden, Litton et al and Chang et al).4,16-19 Relatively lesser number of studies has aimed at the genetic transmission of the soft tissue characteristics. Moreover, most of the studies assess the similarity of the craniofacial features of the parents and the offsprings. Such studies are undoubtedly of great importance in estimating the adult facial proportions of the child, this information may prove inadequate or misleading under certain circumstances. When one or both the parents of a child are not available or alive at the time of initial examination or when the gap between the parents of a child is very large (in which case, the old age changes in the parents facial features may create a hurdle in correctly assessing their facial characteristics), the information from the study of the sibling could be more useful, if the correlation between the facial features of the siblings is studied and established.

Findings of this study were compared with other genetic studies that focused on skeletal and soft tissue structures. Suzuki and Takahama stated that ‘the face of the offspring often resembles that of at least one of his or her parents’. The results of this study were applied to Suzuki’s hypothesis.20 In this study, almost in all parameters, the offspring resembled the parents. However, there was more resemblance in the opposite sexes but few parameters showed the similarity for similar sex group.

Size and shape are the primary parameters in the study of growth. It has been suggested that there is a stronger genetic influence on the shape of facial features than on it size.21 But changes in the shape seen during growth are more difficult to define.21 As far as size of the individual features of the overall sample was concerned, the correlation was higher between the parents and offsprings. This was similar to the earlier studies.2,22

Table 3: Correlation of proportional parameters of father–offspring and its significance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Father and mother</th>
<th>Father and son</th>
<th>Father and daughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical height ratio</td>
<td>0.31</td>
<td>0.52</td>
<td>0.18</td>
</tr>
<tr>
<td>Lower vertical height-depth ratio</td>
<td>0.26</td>
<td>0.40</td>
<td>0.28</td>
</tr>
<tr>
<td>Vertical lip-chin ratio</td>
<td>-0.15</td>
<td>0.32</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Note: Highly significant (HS) at p < 0.01, significant (S) at p < 0.05, nonsignificant (NS) at p > 0.05

Table 4: Correlation of proportional parameters of mother–offspring, among the sibling and its significance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mother and son</th>
<th>Mother and daughter</th>
<th>Son and daughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical height ratio</td>
<td>0.23</td>
<td>0.38</td>
<td>0.32</td>
</tr>
<tr>
<td>Lower vertical height-depth ratio</td>
<td>0.07</td>
<td>0.28</td>
<td>0.29</td>
</tr>
<tr>
<td>Vertical lip-chin ratio</td>
<td>-0.51</td>
<td>0.14</td>
<td>-0.28</td>
</tr>
</tbody>
</table>

Note: Highly significant (HS) at p < 0.01, significant (S) at p < 0.05 and nonsignificant (NS) at p > 0
Size of the nose showed the lowest correlation among the other parameters. This can be explained on the basis of following studies. In a longitudinal study, Subtelny observed that the nose showed a continuous downward and forward increment of growth. According to Genecov et al anteroposterior growth and increased anterior projection of nose continued in both males and females after the skeletal growth has subsided.\(^2,22\)

Hunter, Balbach and Lamphier reported a family-line study in which the correlation coefficients were computed between parents and adult offspring whose facial growth was complete. Hunter and associates found that the father-offspring relationship was stronger than the mother-offspring relationship for linear measurements of the skull and that the most significant variable for predicting a measurement in one of the parents.\(^23\) The present study did not agree with these previous studies in showing a strong father-offspring relationship. However, both paternal and maternal measurements showed the strong relationship in different parameters.

In some genetic studies like by Baydas done on Anatolian Turkish siblings measuring craniofacial variables, suggested that the vertical dimensions of the face have more genetic influence, whereas sagittal components and variables related to the dentition seem to be more environmentally influenced.\(^1,21,24\) In this study, vertical facial proportion showed higher heritability between the father-son while moderate heritability between mother-daughter. Vertical lip-chin ratio also showed the higher heritability among the mother-son group while the lower vertical height to depth ratio showed moderate heritability between the father-son.\(^1,25,26\)

The results of this study agree with the study done by Manfredi that the vertical proportion of the face had a strong genetic influence whereas the depth of the face as determined by the lower vertical-height depth ratio had moderate genetic influence. From a therapeutic point of view, these results indicate that the chance of success in orthopedic treatment of vertical facial structures is not compared with the facial depth.\(^27\)

In this study, vertical facial proportion showed higher heritability between the father-son while moderate heritability between mother-daughter. Vertical lip-chin ratio also showed the higher heritability among the mother-son group while the lower vertical height to depth ratio showed moderate heritability between the father-son.

The daughter’s in the study were affected similarly by both parents while son were affected mainly by mothers and for some parameters only by fathers. The findings of Suzuki and Takahama, Zekic, Karia and Johannsdottir et al agree with our findings that daughters are more affected by their parents than are son.\(^14,20,26,28,29\) Lin et al also reported relatively low father-son correlations regarding the parent-offspring similarity of the maxillofacial profile.\(^30\) However, our results do not agree with a previous study that reported a stronger father-offspring relationship. There were many parameters which showed similarity between father-son and mother-daughter.

The results regarding soft tissue heritability of Vanco et al coincide with the findings of our study. Vanco et al reported that genetic factors appear to contribute to the aspects of the facial shape related to facial height but make smaller contributions to observed variations in the nose and lip form.\(^31\) Results of Manfredi et al study coincide with this study as they found that the lower lip E line measurement and the lower third of the face showed strong genetic control but in this study, the lower facial height showed very low genetic control.\(^27\) This means that minimal changes to achieve a stable vertical modification are necessary from the clinical point of view.

**CONCLUSION**

The finding of the study showed that the highest correlation was found between the father-son and mother-daughter while lowest correlation was found for many of the parameters between the opposite sex pairs. Daughter showed equal inheritance from both the parents. The total facial height, lip and chin prominence showed the stronger heritability while the nose and lip form showed the lowest correlation. For the ratios of horizontal and vertical measurements, the highest correlation was seen between the mother and son.

The result of this study indicates that there is a fairly strong genetic control in the transmission of the soft tissue facial characteristics. In general, reliable data describing soft tissue facial profiles can be obtained from photographs of subjects adopting a proper head posture. Further studies should be carried out on the big sample size using the parameters of this study which showed the highest correlation.

**REFERENCES**