ORIGINAL RESEARCH

Inheritance of Class III Soft Tissue Facial Features from Parents to Offsprings Using Photogrammetric Analysis Technique

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Abstract

Aim: The present study was undertaken to analyze the facial features in class III patients by measuring the facial frontal (linear) parameters and profile (angular) parameters and correlate them with parents to determine the inheritance of facial features.

Materials and methods: The sample consisted of 40 class III patients aged between 9 and 18 years based on skeletal ANB angle (less than 0 degrees) and Angle's class III classification. Frontal and profile photographs of the subjects and parents were taken in a standardized position according to ABO guidelines. The photographs were analyzed using custom-made software for measuring various frontal (linear) and profile (angular) parameters to check for the degree of resemblance of facial features with parents by determining mean value, standard deviation and by applying Student's *t*-test. The level of significance was set at 5% ($p < 0.05$).

Results: The common facial frontal (linear) parameters in sons and daughters which showed close mean inheritance ($p < 0.005$) with father were: 1. Al-Me/Ex-Al(R), 2. Al-Me/Ex-Al (L), 3. Al-Me/Ch-Me(R), 4. Al-Me/Ch-Me (L), 5. Ch-Me/Al-Ch(R), and 6. Ch-Me/Al-Ch(L). The common facial profile (angular) parameters in sons and daughters which showed close mean inheritance ($p < 0.005$) with mother were: 1. nasolabial angle (Cm-Sn-Ls), 2. nasofacial angle (G-Pog/N-Nd), 3. total convexity except nose (G-Sn-Pog), 4. upper lip projection angle (N-Pog/N-Ls), 5. lower lip projection angle (N-Pog/N-Li), and 6. Sn-Po-Gn. The only linear parameter which showed close mean inheritance with mother in both sons and daughters was: 1. ChR-ChL/AlR-AlL ($p = 0.0001$).

Conclusion: Facial frontal (linear) parameters showed close inheritance with father in sons and daughters, while profile (angular) parameters showed close inheritance with mother in sons and daughters. The linear vertical parameters have more inheritance in daughters than sons, while angular parameters have more inheritance in sons as compared to daughters. Overall, facial inheritance from father is more dominant in class III sons and daughters.

Clinical significance: The results of this study simplify the orthodontic treatment planning in subjects having class III malocclusion in terms of predicting the course of facial growth from parents. Such prediction can guide in forecasting the treatment outcome in complex malocclusion like class III. The results of this study revealed various parameters which are less heritable, having lesser genetic component, and mostly influenced by environment which can be modified through orthodontics and Dentofacial Orthopedics, thereby having lesser chances of relapse. The results of this study can also be utilized in the field of plastic surgery and forensic science.

Keywords: Class III inheritance, Epigenetic factors, Facial landmarks, Frontal linear, Profile angular, Photographic facial analysis.

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Introduction

The time of growth at which the human face development happens is considered of great interest in orthodontics and Dentofacial Orthopedics. This craniofacial complex is a derivation of varied developmental processes, where genetic expression, molecular interactions, hormonal and biomechanical environmental factors play early embryonic roles, throughout the later childhood and pubertal growth periods.[1–4]

Angle's categorization designates a class III malocclusion as a collection of situations where the mandibular 1st molar is positioned mesially in relation to the maxillary 1st molar.[5] This disparity can be caused by either skeletal or dentoalveolar tissues. The relative prominence of the mandible is caused by two different factors: one is pseudo-prognathism and the other is a gross imbalance in mandibular growth which can be either due to environmental, epigenetic, or genetic factors. It has also been reported that although the size of the face has more inclination toward genetic influence, the facial proportions are influenced mostly by environmental factors.[6]

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The idea that genetics has a role in mandibular prognathism causing class III malocclusion is supported by numerous studies.[7–10] Apart from the role of genetics, the various environmental factors associated with the development of class III are tonsilitis, complete oral breathing, congenital anatomic defects, pituitary gland abnormalities, endocrinal disturbances, habitual protruding of the mandible due to posture, trauma, disease, premature loss or irregular eruption of the permanent or deciduous molar. Due to the above factors, the orthodontic treatment of class III always poses a challenge to the orthodontist and is the most complex entity to treat among all classes.

According to Suzuki's[11] survey of Japanese households, 40% of the children were impacted if both parents were prognathic. Only 11.2% of the children were prognathic if neither parent was afflicted, compared to 20.2% of the children if one parent was affected. The inherited mechanism underlying reverse occlusion is complex. In an investigation of prognathism-affected families, Schulze and Wiese[12] found that penetrance was assessed to be 70% with varying expressivity and that inheritance was quite irregular.

In Orthodontics, Ricketts was the first to claim that the analysis of a physically beautiful face should be approached mathematically.[13] He discovered that three measurements in attractive faces were almost equal, i.e., from forehead to the eye, the eye to the mouth, and the nose to the chin.

Based on pictures, anteroposterior or lateral cephalograms, and three-dimensional facial scans, numerous researches have been carried out on the intricate process of growth as well as the development of the soft tissues of the face,[14,15] using traditional cephalograms to examine how parent's genes affect their children's skeletal craniofacial morphologies.[16,17] Studying these cephalograms has several disadvantages of being technique-sensitive, cost-effective, and radiation exposure as compared to using standardized photographs.

This study was undertaken to evaluate the facial features of class III subjects through linear and angular facial analysis on standardized photographs so that the diagnosis and treatment are simplified. Analysis of parents was also done to determine the level of inheritance of facial features from either parent to offsprings and the amount of genetic and environmental component involved, which might be a future deterministic in orthodontic and orthopedic treatment planning in class III cases for efficient treatment and less relapse tendencies.

Materials and Methods

The DA Pandu Memorial R V Dental College in Bengaluru, Karnataka, Research Sustenance and Institutional Review Board Committee provided the protocol and authorization for the study (IRB No: 336/VOL-2/2019). The DA Pandu Memorial RV Dental College in Bengaluru provided the sample used in this investigation. The 1964 Helsinki Declaration, its updates, and similar guidelines were adhered to throughout, as were the ethical guidelines set forth by the Institutional Research Committee. The study lasted for two years (2018–2020) and comprised 40 patients (Table 1), having class III relationship and their parents falling in the inclusion as well as exclusion criteria. Further, 40 patients were divided into 20 male and 20 female patients, labeled as sons and daughters, respectively. Both the parents were included in the study. With a power of 95%, an α error of 5%, and an effect size of 0.96465, the sample size was determined.

Table 1: Sample size tabulation

Group	*Sons (n)*	*Daughters (n)*	*Total sample (n)*
Patients	20	20	40
Parents (mother + father)	40	40	80
Total subjects	80	80	120

Table 2: Landmarks

Profile soft tissue landmarks used in this study	*Frontal soft tissue landmarks used in this study*
G: glabella	Tr: trichion
N: nasion	N: nasion
Po: porion	Sn: subnasale
Nd: nasal dorsum	ExR: exocanthion right
Pn: pronasale	ExL: exocanthion left,
Cm: columella	Alr: alare right
Sn: subnasale	AlL: alare left
A: A point	XR: the most right point according to bipupillary line
Ls: labiale superior	XL: the most left point according to bipupillary line
Li: labiale inferior	ChR: Cheilion Right
B: B point	ChL: Cheilion Left
Pog: pogonion	St: Stomion
Gn: gnathion	Me: Menton
Me: menton	

This study was a longitudinal randomized controlled comparative study.

Inclusion criteria: (1) age range between 9 and 16 years, (2) ANB less than 0 degrees, (3) concave profile on physical assessment of anteroposterior jaw relationship, (4) no problems with equilibrium or vestibular or balance issues, (5) no problems with hearing, vision, or swallowing, and (6) no deformities of the face or spine.

The following were the exclusion criteria: (1) any related syndrome; (2) any prior orthodontic intervention; (3) patients with any history of craniofacial or dental trauma; (4) any facial esthetic surgery; (5) significant asymmetry of the face; and (6) adopted or stepchildren.

Technique

Extraoral photographs (frontal and profile photographs) of the parents ($T_{P\text{-parents}}$) and their children (patients-T_0) were taken with a DSLR camera (D-52, Nikon Corporation) before the start of treatment. Standardization of the photographs was done using the method mentioned by Arshad F et al. in their related study[18] and as per guidelines of the American Board of Orthodontics.

Authentic identification cards provided by the Indian government served as proof of the biological connection between the child's parents.

The photographs taken were analyzed using a custom-made software with ample options for marking the landmarks and measuring linear and angular measurements (Tables 2 and 3, Fig. 1) with easy and instant readings measuring angular and linear values of soft tissue landmarks which were recognized on the profile and frontal aspects of patients and their parents photograph. The marking and measuring of these soft tissue landmarks and photogrammetric analysis on patients are shown and defined in

Table 3: Angles and ratios

Profile photograph analysis (Degree)	*Frontal photograph analysis (Ratio)*
Nose tip angle (N-Pn-Cm)	Tr-N/Sn-Me
Nasolabial angle (Cm-Sn-Ls)	N-Sn/Sn-Me
Nasomental angle (N-Pn/N-Pog)	Sn-St/St-Me
Mentolabial angle (Li-B-Pog),	XR-XL/Tr-Me,
Nasofrontal angle (G-N-Nd)	Ex-Me/Ex-Tr (right side)
Total convexity with nose (N-Pn-Pog)	Ex-Me/Ex-Tr (left side)
Total convexity except nose (G-Sn-Pog),	Al-Me/Ex-Al (right side)
Soft tissue ANB angle	Al-Me/Ex-Al (left side)
Upper lip projection angle (N-Pog/N-Ls)	Al-Me/Ch-Me (right side)
Lower lip projection angle (N-Pog/N-Li)	Al-Me/Ch-Me (left side)
N-Po-Sn	Ch-Me/Al-Ch (right side)
Sn-Po-Gn	Ch-Me/Al-Ch (left side)
	ChR-ChL/AlR-AlL

Figures 2 to 4. To prevent bias, the same operator conducted each measurement.

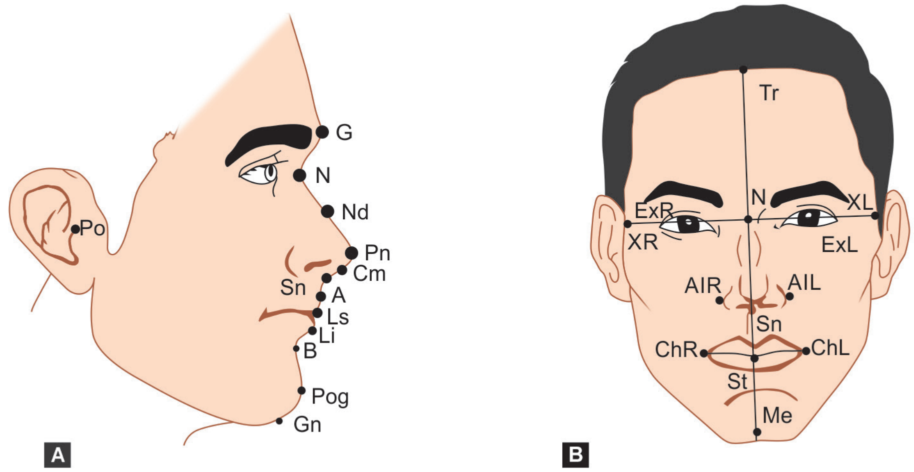
Statistical Analysis

The data was analyzed utilizing the statistical program Statistical Package for the Social Sciences (SPSS) 22.0 version 3.2.2. A statistical analysis was conducted after the linear and angular measurements of the parents as well as the children were entered into an Excel sheet. The standard deviation and mean were calculated. Student's *t*-test was applied to determine the comparison between the groups. The level of significance was set at 5% ($p < 0.05$).

Results

The facial resemblance of the son with father showed that the mean of six frontal (linear) parameters showed close inheritance with father ($p < 0.05$). Overall, the frontal facial measurements showed close resemblance between son and father, while profile angular measurements showed close inheritance with mother (Table 4, Fig. 5).

Six frontal (linear) parameters which showed close mean inheritance of sons with fathers which were statistically significant,



Figs 1A and B: Angular measurements in profile photograph and linear measurement in frontal photograph (representational picture). (A) Landmarks in the profile photograph; (B) Landmarks in the frontal photograph

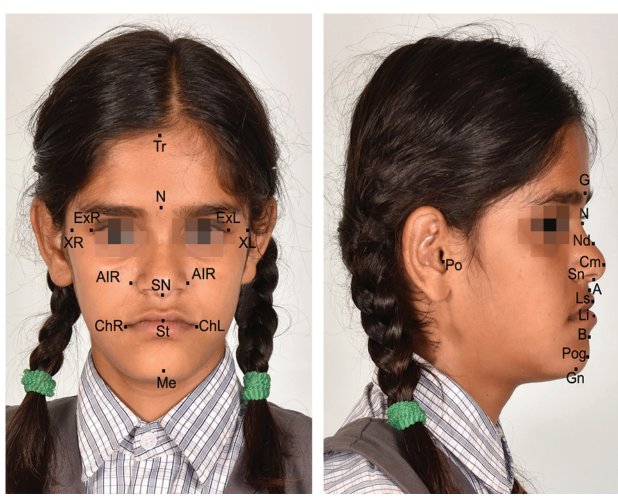


Fig. 2: Photogrammetric analysis done on standardized frontal and profile photographs of patient

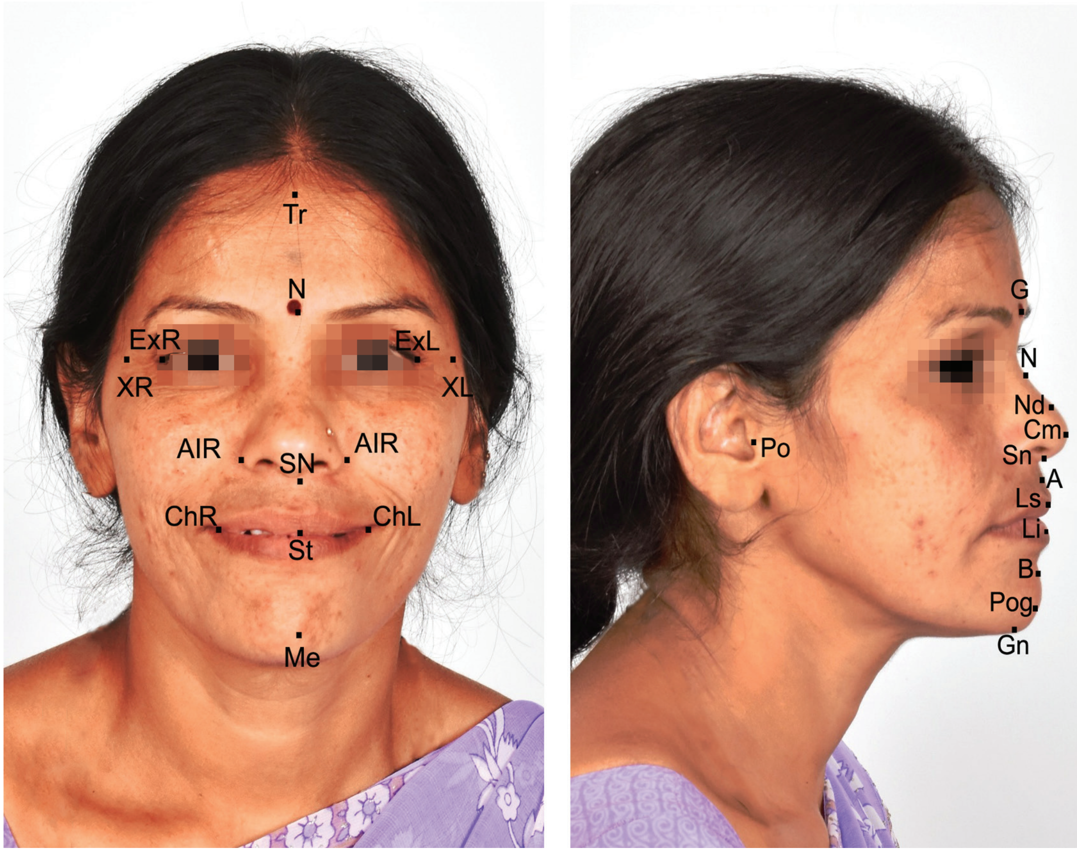


Fig. 3: Photogrammetric analysis done on standardized frontal and profile photographs of the patient's mother

Fig. 4: Frontal and profile analysis done on father standardized photographs using photogrammetric analysis

($p < 0.05$*): 1. Al-Me/Ex-Al(R)(0.87), 2. Al-Me/Ex-Al (L)(0.90), 3. Al-Me/Ch-Me(R)(1.36), 4. Al-Me/Ch-Me(L) (1.30), 5. Ch-Me/Al-Ch(R)(2.39), and 6. Ch-Me/Al-Ch(L)(2.38).

The frontal (linear) parameters which are nonsignificant ($p > 0.05$) but mean inheritance was closer (either parent) were: 1. Tr-N/Sn-Me (father), 2. N-Sn/Sn-Me (mother), 3. Sn-St/St-Me (mother), 4. XR-XL/Tr-Me (father), 5. Ex-Me/Ex-Tr right (father), and 6. Ex-Me/Ex-Tr left (father).

The only frontal linear parameter which showed close mean inheritance of mother ($T_0 = 16.53$, $p = 0.0001$) with offspring and was statistically significant ($T_0 = 1.87$, $p = 0.0001$) was: 1. ChR-ChL/AIR-AIL.

The ten profile (angular) parameters which showed close mean inheritance with mother and were statistically significant ($p = 0.0001$) were: 1. Nose tip angle (N-Pn-Cm), 2. Nasolabial angle (Cm-Sn-Ls), 3. Nasofacial angle (G-Pog/N-Nd), 4. Mentolabial angle (Li-B-Pog), 5. Nasofrontal angle (G-N-Nd), 6. Total convexity except nose (G-Sn-Pog), 7. Lower lip projection angle (N-Pog/N-Li), 8. Sn-Po-Gn, 9. soft tissue ANB, and 10. upper lip projection angle (N-Pog/N-Ls).

Nose tip angle (N-Pn-Cm) had same mean inheritance in sons ($T_0 = 122.21$) and mothers which was statistically nonsignificant (mean = 122.21, $p = 1.000$).

The only profile (angular) parameter of son with close mean inheritance to mother was N-Po-Sn but was statistically nonsignificant ($p = 0.167$). Total convexity with nose also called nasomental angle (N-Pn-Pog) has close inheritance with father but was statistically insignificant while mean inheritance differs with mother which is statistically significant.

The facial resemblance of daughter with father showed that the mean of eight frontal (linear) parameters were showing close inheritance with father ($p < 0.05$). Overall, the frontal facial measurements showed more resemblance between daughter and father, while profile angular measurements showed close inheritance with mother (Table 5, Fig. 6).

Eight frontal (linear) parameters which showed close mean inheritance of daughters with fathers were statistically significant,

Table 4: Comparison of mean, standard deviation of frontal linear parameters in ratio and angular parameters in degrees between son, mother and father using one-way ANOVA F-test in Class III subjects

	T0 of sons		*Father*		*Mother*		*(T0) Sons vs father*		*(T0) Sons vs mother*	
Measurements	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*	*t-value*	*p-value*
Tr-N/Sn-Me	0.91	0.11	0.91	0.10	0.83	0.02	0.1036	0.9180	3.6144	0.0008*
N-Sn/Sn-Me	0.74	0.09	0.61	0.06	0.72	0.09	5.4108	0.0001*	0.7804	0.4397
Sn-St/St-Me	0.38	0.06	0.10	0.30	0.38	0.06	4.2604	0.0001*	–0.1508	0.8809
XR-XL/Tr-Me	0.61	0.06	0.64	0.06	0.55	0.07	–1.5193	0.1365	2.6570	0.0113*
Ex-Me/Ex-Tr (right side)	1.15	0.18	1.12	0.15	0.81	0.11	0.5154	0.6091	7.4116	0.0001*
Ex-Me/Ex-Tr (left side)	1.15	0.18	1.07	0.26	0.82	0.11	1.1101	0.2736	7.2256	0.0001*
Al-Me/Ex-Al (right side)	1.15	0.20	0.87	0.03	0.65	0.02	6.3005	0.0001*	11.3034	0.0001*
Al-Me/Ex-Al (left side)	1.14	0.19	0.90	0.07	0.63	0.03	5.3402	0.0001*	11.9282	0.0001*
Al-Me/Ch-Me (right side)	1.48	0.04	1.36	0.04	0.63	0.03	9.9534	0.0001*	79.6720	0.0001*
Al-Me/Ch-Me (left side)	1.45	0.05	1.30	0.22	0.62	0.02	3.0454	0.0041*	70.8908	0.0001*
Ch-Me/Al-Ch (right side)	2.46	0.06	2.39	0.06	1.09	0.05	4.1598	0.0002*	85.0448	0.0001*
Ch-Me/Al-Ch (left side)	2.44	0.07	2.38	0.07	1.08	0.05	3.0024	0.0046*	73.2107	0.0001*
ChR-ChL/AIR-AIL	1.87	0.01	1.73	0.03	1.75	0.03	22.0515	0.0001*	16.5366	0.0001*
Nose tip angle (N-Pn-Cm)	122.21	0.36	123.33	0.44	122.21	0.36	–8.9609	0.0001*	0.0001*	1.0000
Nasolabial angle (Cm-Sn-Ls)	97.17	0.05	92.22	0.18	93.56	0.27	119.1669	0.0001*	59.6857	0.0001*
Nasofacial angle (G-Pog/N-Nd)	27.37	1.51	35.69	1.15	32.95	0.63	–20.0305	0.0001*	–15.5489	0.0001*
Mentolabial angle (Li-B-Pog)	141.34	0.32	118.58	0.56	135.24	0.54	160.8187	0.0001*	44.5058	0.0001*
Nasofrontal angle (G-N-Nd)	148.38	0.50	142.42	0.45	144.46	0.40	40.6404	0.0001*	28.1049	0.0001*
Total convexity with nose (N-Pn-Pog)/nasomental angle	132.45	0.55	132.18	1.97	131.47	0.34	0.6114	0.5444	6.9471	0.0001*
Total convexity except nose G-Sn-Pog	166.39	0.29	158.85	1.46	162.41	0.35	23.2399	0.0001*	39.7740	0.0001*
Soft tissue ANB angle	–6.43	0.25	–3.50	0.19	–4.49	0.29	–42.4859	0.0001*	–23.2742	0.0001*
Upper lip projection angle (N-Pog/N-Ls)	–7.33	0.16	–2.46	0.17	–3.45	0.18	–95.2232	0.0001*	–72.6391	0.0001*
Lower lip projection angle (N-Pog/N-Li)	–4.45	0.23	1.69	0.23	–2.53	0.14	–84.6849	0.0001*	–31.8194	0.0001*
N-Po-Sn	36.87	2.06	38.32	1.36	36.18	0.86	–2.7041	0.0100*	1.4068	0.1672
Sn-Po-Gn	50.16	0.32	52.18	0.17	49.33	0.32	–25.5815	0.0001*	8.3742	0.0001*

$p > 0.05$, no statistical significant difference *$p < 0.001$, highly statistical significant difference

($p < 0.05$*): 1. XR-XL/Tr-Me (0.65), 2. Ex-Me/Ex-Tr (0.98) (R), 3. Ex-Me/Ex-Tr(L) (0.97), 4. Al-Me/Ex-Al(R) (0.83), 5. Al-Me/Ex-Al(L) (0.83), 6. Al-Me/Ch-Me(R) (1.22), 7. Al-Me/Ch-Me(L) (1.18), 8. Ch-Me/Al-Ch(R) (2.25), and 9. Ch-Me/Al-Ch(L) (2.23).

The frontal (linear) parameter which showed close inheritance of daughter with mother and was statistically significant ($p = 0.0001$): ChR-ChL/AIR-AIL (1.50), N-Sn/Sn-Me (0.33).

Sn-St/St-Me had same mean inheritance in the daughter, father, and mother but statistically significant in daughter and father only ($p = 0.0001$).

Tr-N/Sn-Me had same mean inheritance in daughter and father but a different inheritance from mother, both were statistically insignificant ($p = 0.85$, $p = 0.38$).

The six profile (angular) measurements which showed close inheritance of daughter with mother and were statistically significant were: 1. Nasolabial angle (Cm-Sn-Ls) (96.62), 2. Nasofacial angle (G-Pog/N-Nd) (33.80), 3. Total convexity except nose (G-Sn-Pog) (159.49), 4. Upper lip projection N-Pog/N-Ls (-3.41), 5. Lower lip projection (N-Pog/N-Li) (–1.38), and 6. Sn-Po-Gn (49.18).

Mentolabial angle (Li-B-Pog) ($p = 0.0001$) and soft tissue ANB angle ($p = 0.0003$) showed close inheritance with father and are statistically significant.

The three profile (angular) parameters which showed close inheritance of daughter with father but statistically not significant: 1. Nose tip angle (N-Pn-Cm) ($p = 0.564$), 2. Total convexity with nose/nasomental angle (N-Pn-Pog) ($p = 0.572$, 3. N-Po-Sn) ($p = 0.147$).

The only profile (angular) parameter which showed close inheritance of daughter with mother but statistically nonsignificant was nasofrontal angle (G-N-Nd) ($p = 0.0029$).

Discussion

Familial tendencies can easily be identified by a person's nose tilt, jaw shape, grin expression, and other facial traits. The present study aimed to estimate the influence of heredity on family members by observing similarities and differences in facial features between a class III child and his mother and father from standardized photographs. These facial similarities among

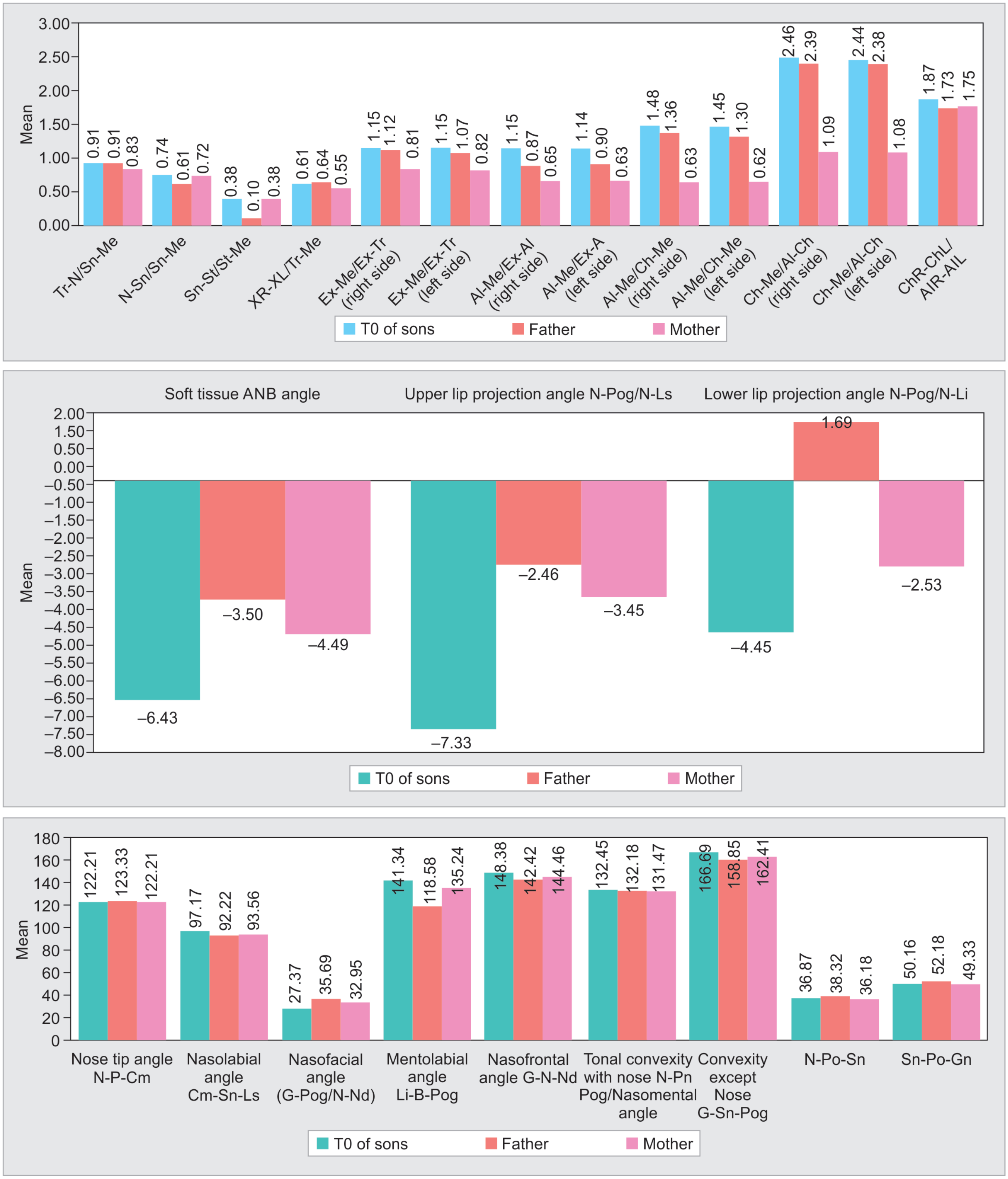


Fig. 5: Comparison of facial features at T0 of sons with father and mother in Class III

Table 5: Comparison of mean, standard deviation of frontal linear parameters in ratio and angular parameters in degrees between daughter, mother and father using one-way ANOVA *F*-test in Class III subjects

	T0 of daughters		*Father*		*Mother*		*(T0) Daughters vs father*		*(T0) Daughters vs mother*	
Measurements	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*	*t-value*	*p-value*
Tr-N/Sn-Me	0.75	0.03	0.75	0.02	0.76	0.04	–0.1834	0.8554	–0.8713	0.3890
N-Sn/Sn-Me	0.59	0.02	0.55	0.02	0.56	0.03	3.6895	0.0007	3.0231	0.0045*
Sn-St/St-Me	0.33	0.01	0.33	0.01	0.33	0.01	102.9185	0.0001*	–0.8745	0.3873
XR-XL/Tr-Me	0.63	0.02	0.65	0.02	0.64	0.02	–2.3253	0.0255*	–1.5147	0.1381
Ex-Me/Ex-Tr (right side)	1.08	0.04	0.98	0.05	0.95	0.04	7.1762	0.0001*	9.7242	0.0001*
Ex-Me/Ex-Tr (left side)	1.08	0.04	0.97	0.05	0.95	0.04	7.3792	0.0001*	10.9331	0.0001*
Al-Me/Ex-Al (right side)	0.92	0.04	0.83	0.02	0.81	0.04	10.2223	0.0001*	8.7138	0.0001*
Al-Me/Ex-Al (left side)	0.92	0.03	0.83	0.03	0.81	0.04	9.2210	0.0001*	9.1562	0.0001*
Al-Me/Ch-Me (right side)	1.28	0.05	1.22	0.04	1.21	0.05	4.1828	0.0002*	4.4908	0.0001*
Al-Me/Ch-Me (left side)	1.26	0.04	1.18	0.04	1.19	0.05	4.6723	0.0001*	4.8049	0.0001*
Ch-Me/Al-Ch (right side)	2.31	0.02	2.25	0.02	2.24	0.03	8.5292	0.0001*	8.5106	0.0001*
Ch-Me/Al-Ch (left side)	2.30	0.04	2.23	0.03	2.24	0.03	5.6438	0.0001*	5.5053	0.0001*
ChR-ChL/AIR-AIL	1.67	0.02	1.32	0.03	1.50	0.04	53.3001	0.0001*	19.7567	0.0001*
Nose tip angle N-Pn-Cm	123.38	0.34	123.50	0.85	122.95	0.68	–0.5875	0.5604	2.5221	0.0160**
Nasolabial angle Cm-Sn-Ls	99.21	0.07	95.58	0.14	96.62	0.20	102.0691	0.0001*	53.5932	0.0001*
Nasofacial angle (G-Pog/N-Nd)	27.82	0.73	35.84	1.04	33.80	0.63	–28.1039	0.0001*	–27.6123	0.0001*
Mentolabial angle (Li-B-Pog)	140.48	0.67	136.40	0.75	135.03	0.62	18.0694	0.0001*	26.7315	0.0001*
Nasofrontal angle (G-N-Nd)	145.21	0.50	143.50	0.36	144.66	0.58	12.3294	0.0001*	3.1896	0.0029
Total convexity with nose (N-Pn-Pog)/nasomental angle	133.32	0.19	133.26	0.46	132.57	0.14	0.5691	0.5726	14.0745	0.0001*
Total convexity except nose (G-Sn-Pog)	160.77	0.58	158.67	0.52	159.49	0.37	11.9289	0.0001*	8.2467	0.0001*
Soft tissue ANB angle	–4.28	0.25	–3.66	0.67	–3.33	0.30	–3.9337	0.0003*	–10.9464	0.0001*
Upper lip projection angle (N-Pog/N-Ls)	–10.25	0.11	–3.39	0.22	–3.41	0.22	–126.5085	0.0001*	–124.7785	0.0001*
Lower lip projection angle (N-Pog/N-Li)	–3.18	0.07	–1.23	0.07	–1.38	0.07	–89.8397	0.0001*	–82.7829	0.0001*
N-Po-Sn	36.26	0.12	36.32	0.14	34.25	1.40	–1.4785	0.1475	6.3796	0.0001*
Sn-Po-Gn	48.29	0.35	50.19	0.31	49.18	0.16	–18.2077	0.0001*	–10.3567	0.0001*

$p > 0.05$, no statistical significant difference *$p < 0.001$, highly statistical significant difference

parents, siblings, and relatives highlight the genetic basis of craniofacial development.

The strong association between the underlying skeletal structures and the surface soft tissues has been noted in a number of studies[19,20] which supports the assessment of the facial surface to assess growth changes. Errors are decreased when using parent–child correlations to predict face growth, which by itself clearly suggests that these dimensions are influenced by heredity. However, there are more environmental evolutions in dental variations.

The results of the present study showed (Tables 4 and 5, Fig. 6) that the overall facial frontal (linear) measurements showed more resemblance of the sons to father ($p < 0.05$). It is contrary to the findings of Lin et al.[21] and in partial concurrence with the results of the study by Lahoti SK et al.,[22] where the latter study showed heritability in vertical lines from glabella, subnasale, and pogonion. In the present study where vertical dimension did not show much inheritance which can be attributable to the influence of environmental factors on lower third of the face. In sons out of the thirteen linear parameters, the following did not show statistically significant inheritance: 1. Tr-N/Sn-Me, 2. N-Sn/Sn-Me, 3. Sn-St/St-Me, 4. XR-XL/Tr-Me, 5. Ex-Me/Ex-Tr(R), 6. Ex-Me/Ex-Tr(L). whereas in daughters only one parameter having statistically insignificant inheritance was Tr-N/Sn-Me. The rationale behind this result is that Sn, Me, and St points are located in the lower part of the face and are more influenced by external influences, while trachion (Tr) is a variable landmark because of differences in the hairline. These results are beneficial as orthodontic changes induced in these parameters would not be much vulnerable for relapse.

The facial profile (angular) measurements showed more resemblance toward mother in class III sons, especially the parameters related to the nose: N-Pn-Cm (nose tip angle), G-N-Nd (nasofrontal angle), nasofacial angle (G-Pog/N-Nd), showed more inheritance which form the angles of Powell's esthetic triangle.[4] However, according to Genekov et al.[23] anteroposterior growth and increased anterior projection of the nose continue even after

Fig. 6: Comparison of facial features at T0 of son with father and mother in Class III

cessation of growth in both sexes. Out of 12 angular parameters, the two parameters which did not show inheritance and were statistically insignificant were :N-Pn-Pog (nasomental angle) and N-Po-Sn.

Suzuki and Takahama[24] and Zekic[25] showed that daughters were more affected by both parents than were sons which is contrary with the findings of our study where the facial resemblance of sons and daughters was with both the parents. However, the frontal linear parameters were having more inheritance toward fathers and profile angular parameters showed more resemblance with the mothers in both the sexes.

Profile angular measurements with daughters showed facial resemblance with mother which was statistically significant ($p > 0.05$). The profile angular measurements showed resemblance with mother in class III daughters with the inheritance not seen in the following parameters: 1. Nose tip angle (N-Pn-Cm) ($p = 0.564$), 2. Total convexity with nose/nasomental angle (N-Pn-Pog) ($p = 0.572$), and 3. (N-Po-Sn) ($p = 0.147$) which is in partial agreement with the results of Johansndottir et al.[26] who found strong heritability in these soft tissue characteristics in daughters from both parents.

A significant finding of the study was the frontal (linear) parameter which showed close inheritance of sons and daughters with mother and was statistically significant ($p = 0.0001$) was the mouth–nose width index (ChR-ChL/AlR-AlL) pointing toward the fact that the intercommissural width (Ch-Ch) and the inter-alar width (Al-Al) have resemblance with mother in sons and daughters. Daughters have less nasal index value. This is in concurrence with Sarver's observation that the width of the alar base is influenced by inherited characteristics.[27]

The present study showed strong genetic inheritance for the upper 2/3 of the face and less inheritance for the lower 1/3 of the face, pointing for more chance of success and lesser relapse tendency of orthodontic treatment in the lower third which is in disagreement with the study of Manfredi et al.[28] who stated that heritability is more dominant in the anterior vertical parameters of the lower face. The inheritance of linear parameters is more from father and angular inheritance is more from mother which is in partial agreement with the study of Nakata et al.[29] and the results of Aksakalli S and Demir.[30]

There are both maternal and paternal influences on the facial features of offspring; however, father's inheritance seems to be more dominant in class III which is in agreement with the findings of Hunter et al.[16] who stated that the father–offspring relationship was strong. Overall, correlation of facial features existed between both the parents and their offspring's which is similar to other studies.[23–31] The genetic inheritance is significant in the frontal linear measurements than profile angular measurements, which is in concurrence with the study of Baydaş B et al.[32] and goes with the fact that the combination of genetic and environmental factors governs the basic skeletal form.

The strong point of the present study is that both sexes were taken into account. Further longitudinal studies covering a time period from childhood to adolescence should be conducted to track the progression of facial features in class III subjects.

This study revealed parameters that have less heritability and can be intervened orthodontically or by Dentofacial Orthopedics as the lesser genetic component has a better prognosis with lesser chance of relapse. Therefore, preventive orthodontic approaches can also be tried by considering the probability of inheritance from parents.

The facial analytic method used in this study may enable the clinician to choose early and right dentofacial and orthodontic treatment modalities for modifying the growth areas that are not strongly inherent and having less chance of relapse thus saving time. Intervention at the right time can also save the later development of fully established class III malocclusion by knowing the facial features of class III prevalent in family pedigree.

Conclusion

Facial inheritance from father is more dominant in class III sons and daughters in the vertical dimension, In Class III, the lower face has equal environment and genetic influence. The predominance of each factor needs to be studied. Lesser the genetic component in any parameter, more the chances for a successful orthodontic and Orthopedic correction with lesser chances of relapse.

This study revealed various parameters which are having strong genetic component from parents to offsprings, one such is the mouth–nose width index (ChR-ChL/AlR-AlL) which has close resemblance with mother in sons and daughters.

The results of this study emphasize the importance of evaluation of the facial features of the parents that can aid in determining the dominance of the facial features which is inherited from either of the parents that can be successfully used for forecasting facial soft tissue growth in offspring and in deciding the further course and prediction-based treatment for complex malocclusion like class III in orthodontics.

Apart from orthodontics, the results of this study can also be used in genetic studies, forensic study and, and beneficial to plastic surgeons which can provide them norms for the facial analysis and surgical esthetic correction.

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