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Does nasal morphology gets affected by growth pattern, skeletal malocclusion and gender dimorphism in an individual in north Indian population: A cephalometric study

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***Abstract*---**Background: Orthodontic patients primarily seek treatment for aesthetic reasons and due to paradigm shift from hard tissue to soft tissue, nasal morphology with associated structure

present in the middle third of face has drawn attention. Hence the retrospective study compared and correlated parameters between nasal morphology and gender dimorphism, skeletal pattern and skeletal malocclusion. Preorthodontic cephalograms of 180 patients were randomly selected following exclusion and inclusion criteria from North Indian population. Cephalograms were divided into three different groups according to various skeletal growth pattern, gender dimorphism and skeletal malocclusion and were further correlated with nasal parameters of each sample groups. Results: The results stated that there was a statistically significant correlation and differences were found between nasal parameters such as NLth(p=0.005), NTP(p=0.004) and skeletal parameters in males and females The results also explained that nasal parameters showed significant correlation with skeletal parameters among various growth pattern. There was statistically significant difference found NLth(p=0.035) and NTP (p=0.029) among growth pattern. On comparing nasal parameters in different classes of malocclusion, nasal parameter LNLA seems to be affected in all the three classes. Conclusion: The study concluded that nasal parameters get affected by growth pattern, skeletal malocclusion and sexual dimorphism in an individual.

***Keywords*---**nasal parameters, malocclusion, sexual dimorphism, growth patterns, paradigm shift.

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2.	Dr. Ruchira Munshi Orthodontics and Dentofacial Orthopaedics	CORRELATION BETWEEN NASAL MORPHOLOGY AND VERTICAL MAXILLARY SKELETAL PATTERN IN MALWA POPULATION: A CEPHALOMETRIC STUDY	Supervisor: Prof. Dr. Naveen Bansal Co- Supervisor: Dr. Sangeeta Sunda

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Introduction

Orthodontic patients primarily seek treatment for esthetic reasons and pleasing soft tissue is considered to be an important factor for a successful treatment.[1] Recent advancements and improved salient techniques for orthodontic diagnosis and treatment planning and paradigm shift from soft tissue to hard tissue have drawn attention towards these crafts in determining the facial growth and its direction, skeletal pattern and position of the dentition.[2] The soft tissue profile of an individual is mainly affected by 3 main facial proportions i.e., upper, middle and lower third. The middle third of the face is mainly predominated by the nasal profile of the patient. Due to nasal morphology and its correlations with associated structure, it has drawn attention over a period of times.[3] The nasal growth can be considered significant till the age of 14 years and didn't grew forward to the same extent as that of nasal bones.[4] Earlier studies further evaluated that there was relatively yearly increase in nasal length in downward and anterior direction of approximately 1.5mm.[5] Newer studies suggests that the nasal soft tissue growth almost gets completed till the age of 16 years in girls and 18 years in boys.[2] Therefore, the nasal component along with its growth component becomes an important part in the diagnosis and treatment planning as it affects the skeletal changes in the treatment planning.

The studies further suggests that the facial skeleton growth in vertical direction continues to a longer span as compared to that of the growth in transverse and sagittal direction.[6] Scott suggested that the cartilaginous nasal septum is an important growth centre which is further responsible to provide a thrust to the midface and pushes midface forward and downward.[7] The studies suggests that there is a strong correlation between nasal morphology as well as skeletal pattern and revealed that an upturned nose in an individual is significantly associated with inclination of palatal plane and anticlockwise rotation of maxilla.[8] Therefore, nasal component has a strong and peculiar feature associated with growth pattern of an individual which still remains unexplored. Chaconas evaluated that the nasal bridge was comparatively more pronounced in class II subjects as compared to that class I subjects. The nasal length also gets affected in relation to the malocclusion.[5] Hence there seems to be a correlation between malocclusion and the nasal morphology which seems to affect the facial profile of an individual.[9]

Nasolabial angle acuteness may be associated with maxillary dentition, short nasal projection and lower nasal tip.[10] Even the inclination of palatal plane can also affect nasolabial angle.[8] Therefore nasolabial angle seems to have an important correlation with midface and growth pattern of the face. Nasal morphology seems to be affected with respect to various ethnic and racial groups.[11] The nasal profile also gets affected by gender dimorphism.[12] There exists a lack of literature evidences and studies on correlation between the racial groups, gender dimorphism and nasal profile. Hence this study was aimed to establish any correlation between nasal morphology and various other parameters such as growth pattern and malocclusion of an individual of North Indian population of India.

The principle aims of the study hence included were to:

- Assess the relationship between nasal morphology and maxillary skeletal pattern.
- Correlate the relationship between the degree of upturn of the nose and the inclination of the palatal plane.
- Correlate the relationship of nasal depth and inclination of palatal plane.
- Assess the relationship between nasal morphology and gender dimorphism.
- Assess whether the correlation exists between nasal morphology and various skeletal malocclusion.

Materials and Methods

Study design

The retrospective cross sectional epidemiological study was conducted in Department of Orthodontics and Dentofacial Orthopaedics. The equipment required for the study were (Figure 3):

- Preorthodontic Cephalograms in Natural Head Position selected from the past records
- Acetate Matte Paper (0.003-inch thickness)
- Geometry Box
- X Ray viewer

Estimating the reliability of the cephalometric analysis, 45 randomly selected lateral cephalograms were traced twice by the same operator at an interval of 1 month. The measurement accuracy was obtained by calculating the error of the method and Houston's coefficient of reliability.

Sample Collection

Preorthodontic cephalograms of 180 patients were randomly selected from Department of Orthodontics and Dentofacial Orthopaedics pertaining to North Indian population based on criteria which were

Inclusion criteria

1. Subjects selected were between the age group of 16-27 years.
2. Good quality lateral cephalograms
3. Subjects having permanent dentition.

Exclusion criteria

1. Facial congenital anomaly
2. Prior history of orthodontic treatment,
3. Facial surgery
4. Trauma to face.

Cephalograms were divided into three different groups based on various skeletal growth pattern having 60 subjects each i.e., Group 1 subjects having horizontal

growth pattern, Group 2 having vertical growth pattern and Group 3 having average growth pattern based on various skeletal parameters and were further divided into two subgroups having males and females respectively and 3 subgroups of various skeletal malocclusions i.e., Class I, Class II and Class III subjects on the basis of ANB and β-angle. All the above-mentioned parameters were compared with nasal parameters for statistical correlation.

Cephalometric analysis

Seven facial skeletal parameters and six nasal soft tissue parameters were marked on the radiographs. Hand tracings were done using 3H pencil on acetate tracing paper.

Seven vertical facial skeletal parameters assessed were (Figure 1):

1. SN-GoGn angle (the mandibular plane inclination in relation to cranium)
2. Jarabak Ratio (It is the ratio of posterior facial height to anterior facial height)
3. N-ANS (anterior maxillary height)
4. ANS-Me (Lower Anterior Facial Height; LAFH)
5. SN-Pp (The angle formed between sella-nasion plane and palatal plane i.e., inclination of palatal plane)
6. Rakosi angle (The angle formed between Nasion, Condylion and Menton)
7. Angle of inclination (The angle between the perpendicular drawn from N on Se-N line and the palatal plane)

The soft tissue landmarks to assess the nose were (Figure 2):

1. Soft tissue nasion (N'): the point of greatest concavity in the midline between the forehead and the nose
2. Pronasale (Pr): the tip of nose (nasal tip).
3. Posterior columella point (PCm): the most posterior point of the lower border of the nose at which it begins to turn inferiorly to merge with the philtrum of the upper lip
4. Subnasale (Sn): the deepest point at which the columella merges with the upper lip in the midsagittal plane.
5. Labrale superius (Ls): the point indicating the mucocutaneous border of the upper lip.

The reference planes and variables used to assess the nose were (Figure 2):

1. Nasal length (N Lth): the distance between N' and Pr;
2. Nasal depth (N Dpt): the perpendicular distance between Pr and the line drawn through N' to Sn
3. Nasolabial angle (NLA): the angle formed by the intersection of the PCm tangent (A tangent drawn from PCm along the lower border of the nose at the approximate middle third) and the PCm-Ls line)
4. Nasal upward tip angle (UNLA): the posteroinferior angle formed when PCm tangent is extended anteriorly to intersect the Frankfort horizontal plane/lower border of the nose to Frankfort horizontal plane;

5. Upper lip inclination (LNLA): the antero-inferior angle formed by the PCm-Ls line extended superiorly to intersect the Frankfort horizontal plane/inclination of upper lip to Frankfort horizontal plane
6. Nasal tip angle (NTP): the angle formed by the axis of the dorsum and PCm tangent

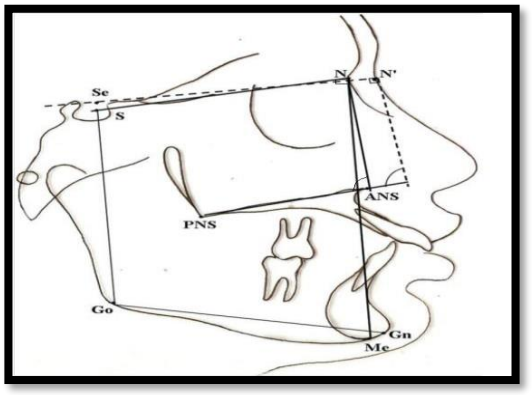


Figure 1: Figure showing vertical maxillary skeletal parameters

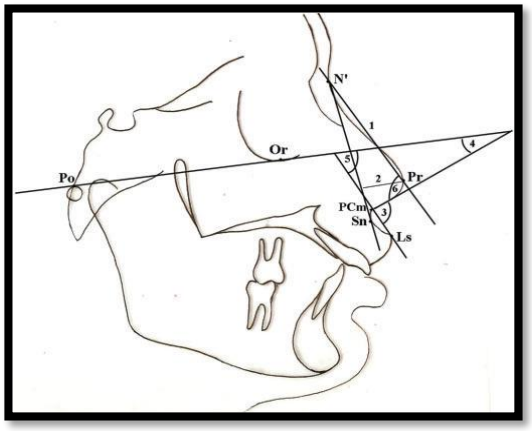


Figure 2: Figure showing nasal parameters

Figure 3: Armamentarium for the study

Error Analysis

In order to estimate the reliability of the cephalometric analysis, 45 randomly selected lateral cephalograms were traced twice by the same operator at an interval of 1 month. The measurement accuracy was obtained by calculating the error of the method and Houston's coefficient of reliability.

Statistical Analysis

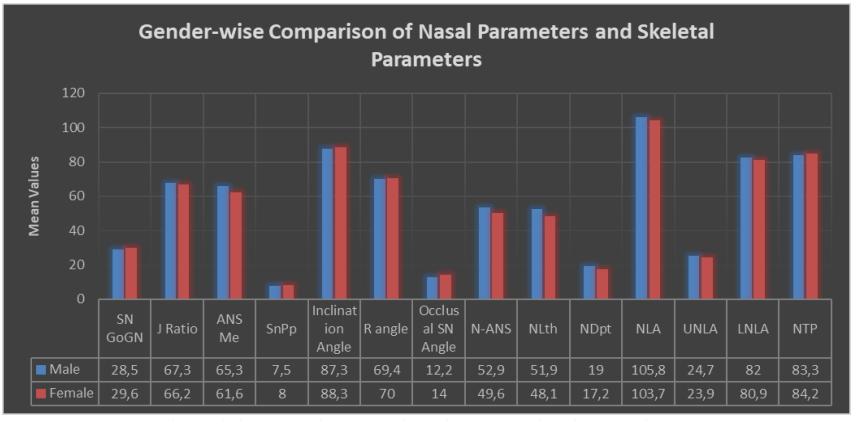
Statistical analysis was performed using software package of statistical analysis (SPSS for Windows, version 19, Armonk, NY: IBM Corp). Descriptive statistics were calculated as mean and standard deviations. Comparison of study parameters between males and females was done using independent t-test. Comparison among different classes of malocclusion and among various growth patterns were done using ANOVA (Analysis of Variance) followed by post-hoc Tukey's test for multiple comparisons. The level of significance for the present study was set at a P value of less than 0.05.

Results

Table 1 and Graph 1 depicting comparison of nasal and skeletal parameters between males and females

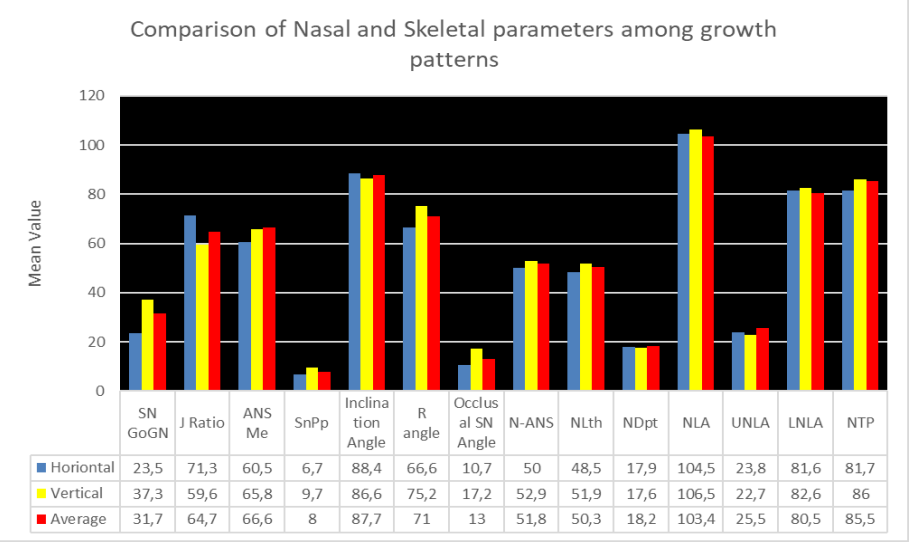
	Gender	N	Mean	Std. Deviation	Std. Error Mean	P value
SNGoGn	Male	70	28.5143	6.14497	.73446	.273
	Female	110	29.6091	6.73359	.64202	
JRatio	Male	70	67.2679	5.31862	.63570	.266
	Female	110	66.2296	6.52668	.62229	
ANSMe	Male	70	65.3143	7.66801	.91650	.003*
	Female	110	61.6909	8.07391	.76982	
SnPp	Male	70	7.5429	2.99606	.35810	.341
	Female	110	7.9909	3.11108	.29663	
Angle of	Male	70	87.3286	3.54565	.42379	.075

Inclination	Female	110	88.3364	3.76921	.35938	
R-angle	Male	70	69.4000	4.02312	.48086	.493
	Female	110	69.9273	5.56811	.53090	
Occlusal SN Angle	Male	70	12.2571	3.79430	.45351	.015*
	Female	110	14.0545	5.30334	.50565	
N-ANS	Male	70	52.9000	5.68535	.67953	<.001*
	Female	110	49.6000	5.14773	.49082	
NLth	Male	70	51.9714	6.91977	.82707	<001*
	Female	110	48.0727	6.19368	.59054	
NDpt	Male	70	18.9857	2.99029	.35741	<.001*
	Female	110	17.2455	3.23168	.30813	
NLA	Male	70	105.8143	11.05099	1.32085	.306
	Female	110	103.7364	14.43281	1.37611	
UNLA	Male	70	24.7571	8.13907	.97281	.475
	Female	110	23.9091	7.48153	.71334	
LNLA	Male	70	82.0286	10.21646	1.22110	.507
	Female	110	80.9182	11.34054	1.08128	
NTP	Male	70	83.3143	8.08208	.96599	.459
	Female	110	84.2273	8.02480	.76513	



The above-mentioned table and graph depicted that there was a statistically significant difference in relation to ANS-Me (P=0.003), Occlusal SN angle (P=0.015), N-ANS (P<0.001), NLth (P<0.001), NDpt (P<0.001) between males and females. Other differences were not found to be statistically significant (P>0.05).

Graph 2 and Table 2 represents comparison of nasal parameters and skeletal parameters among various growth patterns



Dependent Variable	Growth Pattern	Growth Pattern	Mean Difference	Std. Error	P value	95% Confidence Interval	
						Lower Bound	Upper Bound
SNGoGn	Horizontal Grower	Vertical Grower	-13.85042*	.58550	<.001*	-15.2368	-12.4640
	Horizontal Grower	Average Grower	-8.26542*	.54950	<.001*	-9.5666	-6.9643
	Vertical Grower	Average Grower	5.58500*	.60641	<.001*	4.1491	7.0209
JRatio	Horizontal Grower	Vertical Grower	11.65041*	.71148	<.001*	9.9657	13.3351
	Horizontal Grower	Average Grower	6.58401*	.66774	<.001*	5.0029	8.1651
	Vertical Grower	Average Grower	-5.06640*	.73690	<.001*	-6.8113	-3.3215
ANSMe	Horizontal Grower	Vertical Grower	-5.35847*	1.45574	.001*	-8.8055	-1.9115
	Horizontal Grower	Average Grower	-6.12847*	1.36623	<.001*	-9.3635	-2.8934
	Vertical Grower	Average Grower	-.77000	1.50775	.866	-4.3401	2.8001
SnPp	Horizontal Grower	Vertical Grower	-2.98814*	.61898	<.001*	-4.4538	-1.5225
	Horizontal Grower	Average Grower	-1.26814	.58092	.077	-2.6437	.1074
	Vertical Grower	Average Grower	1.72000*	.64110	.022*	.2020	3.2380

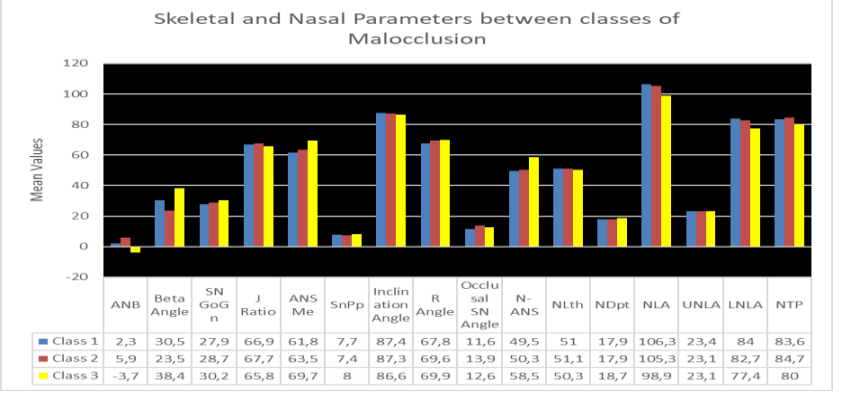
Angle of Inclination	Horizontal Grower	Vertical Grower	1.74873	.75182	.055	-.0315	3.5289
	Horizontal Grower	Average Grower	.70373	.70560	.580	-.9670	2.3745
	Vertical Grower	Average Grower	-1.04500	.77868	.374	-2.8888	.7988
R-angle	Horizontal Grower	Vertical Grower	-8.58898*	.69160	<.001*	-10.2266	-6.9514
	Horizontal Grower	Average Grower	-4.33898*	.64908	<.001*	-5.8759	-2.8021
	Vertical Grower	Average Grower	4.25000*	.71631	<.001*	2.5539	5.9461
Occlusal SN Angle	Horizontal Grower	Vertical Grower	-6.54619*	.87532	<.001*	-8.6188	-4.4736
	Horizontal Grower	Average Grower	-2.25119*	.82150	.019*	-4.1964	-.3060
	Vertical Grower	Average Grower	4.29500*	.90659	<.001*	2.1483	6.4417
N-ANS	Horizontal Grower	Vertical Grower	-2.90805*	1.16969	.037*	-5.6777	-.1384
	Horizontal Grower	Average Grower	-1.84305	1.09777	.217	-4.4424	.7563
	Vertical Grower	Average Grower	1.06500	1.21147	.654	-1.8036	3.9336
NLth	Horizontal Grower	Vertical Grower	-3.40763*	1.35611	.035*	-6.6187	-.1965
	Horizontal Grower	Average Grower	-1.73763	1.27273	.362	-4.7513	1.2760
	Vertical Grower	Average Grower	1.67000	1.40456	.462	-1.6558	4.9958
NDpt	Horizontal Grower	Vertical Grower	.26525	.68178	.920	-1.3491	1.8796
	Horizontal Grower	Average Grower	-.36475	.63986	.836	-1.8798	1.1503
	Vertical Grower	Average Grower	-.63000	.70613	.646	-2.3020	1.0420
NLA	Horizontal Grower	Vertical Grower	-2.04958	2.87107	.756	-8.8479	4.7487
	Horizontal Grower	Average Grower	.74542	2.69454	.959	-5.6349	7.1257
	Vertical Grower	Average Grower	2.79500	2.97364	.616	-4.2462	9.8362
UNLA	Horizontal Grower	Vertical Grower	1.08941	1.51406	.752	-2.4957	4.6745
	Horizontal Grower	Average Grower	-1.65559	1.42096	.476	-5.0202	1.7090
	Vertical Grower	Average Grower	-2.74500	1.56815	.190	-6.4582	.9682

LNLA	Horizontal Grower	Vertical Grower	-.97288	2.28788	.905	-6.3903	4.4445
	Horizontal Grower	Average Grower	1.10712	2.14721	.864	-3.9772	6.1914
	Vertical Grower	Average Grower	2.08000	2.36962	.655	-3.5309	7.6909
NTP	Horizontal Grower	Vertical Grower	-4.32119*	1.67218	.029*	-8.2807	-.3617
	Horizontal Grower	Average Grower	-3.83119*	1.56937	.042*	-7.5472	-.1151
	Vertical Grower	Average Grower	.49000	1.73192	.957	-3.6109	4.5909

Table 2 and graph 2 showed multiple comparisons between nasal and skeletal parameters among various growth patterns which stated that:

- For NLth, there was a statistically significant difference between horizontal and vertical growers (P=0.035). No statistically significant difference was found between horizontal and average growers (P=0.362) and between vertical and average growers (P=0.462).
- For NTP, there was a statistically significant difference between horizontal and vertical growers (P=0.029) and between horizontal and average growers (P=0.042). No statistically significant difference was found between vertical and average growers (P=0.957).
- For Occlusal SN angle, there was a statistically significant difference between horizontal and vertical growers (P<0.001), between horizontal and average growers (P=0.019) and between vertical and average growers (P<0.001).
- For ANS-Me, there was a statistically significant difference between horizontal and vertical growers (P=0.001), between horizontal and average growers (P<0.001). No significant difference was found between vertical and average growers (P=0.866)

Table 3 and Graph 3 depicts comparison of nasal parameters and skeletal parameters among various skeletal malocclusions



Dependent Variable	Malocclusion	Malocclusion	Mean Difference	Std. Error	P value	95% Confidence Interval	
						Lower Bound	Upper Bound
ANB	Class 1	Class 2	-3.60440*	.26008	<.001*	-4.2211	-2.9877
	Class 1	Class 3	6.10714*	.32949	<.001*	5.3259	6.8884
	Class 2	Class 3	9.71154*	.33327	<.001*	8.9213	10.5017
Beta Angle	Class 1	Class 2	7.07418*	.29402	<.001*	6.3770	7.7713
	Class 1	Class 3	-7.88095*	.37248	<.001*	-8.7641	-6.9978
	Class 2	Class 3	-14.95513*	.37676	<.001*	-15.8484	-14.0618
SNGoGn	Class 1	Class 2	-.80220	1.25443	.799	-3.7765	2.1721
	Class 1	Class 3	-2.23810	1.58918	.340	-6.0062	1.5300
	Class 2	Class 3	-1.43590	1.60742	.646	-5.2472	2.3754
JRatio	Class 1	Class 2	-.76264	1.21541	.805	-3.6445	2.1192
	Class 1	Class 3	1.09762	1.53975	.756	-2.5532	4.7485
	Class 2	Class 3	1.86026	1.55742	.459	-1.8325	5.5530
ANSMe	Class 1	Class 2	-1.71429	1.55616	.515	-5.4040	1.9755
	Class 1	Class 3	-7.96429*	1.97143	<.001*	-12.6387	-3.2899
	Class 2	Class 3	-6.25000*	1.99405	.006*	-10.9780	-1.5220
SnPp	Class 1	Class 2	.28846	.64330	.895	-1.2369	1.8138
	Class 1	Class 3	-.25000	.81498	.949	-2.1824	1.6824
	Class 2	Class 3	-.53846	.82433	.791	-2.4930	1.4161
Angle of Inclination	Class 1	Class 2	.04670	.64040	.997	-1.4717	1.5651
	Class 1	Class 3	.72619	.81130	.644	-1.1975	2.6498
	Class 2	Class 3	.67949	.82061	.686	-1.2662	2.6252
R-angle	Class 1	Class 2	-1.86813	.83326	.068	-3.8439	.1076
	Class 1	Class 3	-2.13095	1.05563	.112	-4.6339	.3720
	Class 2	Class 3	-.26282	1.06774	.967	-2.7945	2.2689
Occlusal SN Angle	Class 1	Class 2	-2.31319*	.88445	.027*	-4.4103	-.2161
	Class 1	Class 3	-1.01190	1.12048	.639	-3.6686	1.6448
	Class 2	Class 3	1.30128	1.13333	.486	-1.3859	3.9885
N-ANS	Class 1	Class 2	-.81044	.92678	.657	-3.0079	1.3870
	Class 1	Class 3	-9.04762*	1.17410	<.001*	-11.8315	-6.2637
	Class 2	Class 3	-8.23718*	1.18757	<.001*	-11.0530	-5.4214
NLth	Class 1	Class 2	-.13187	1.32843	.995	-3.2817	3.0179
	Class 1	Class 3	.58929	1.68293	.935	-3.4011	4.5796
	Class 2	Class 3	.72115	1.70224	.906	-3.3150	4.7573
NDpt	Class 1	Class 2	-.02885	.56112	.999	-1.3593	1.3016
	Class 1	Class 3	-.87500	.71086	.437	-2.5605	.8105
	Class 2	Class 3	-.84615	.71902	.469	-2.5510	.8587
NLA	Class 1	Class 2	1.03434	2.47783	.908	-4.8408	6.9095
	Class 1	Class 3	7.34524	3.13907	.054	-.0977	14.7882
	Class 2	Class 3	6.31090	3.17508	.119	-1.2175	13.8392
UNLA	Class 1	Class 2	.31593	1.47535	.975	-3.1822	3.8141
	Class 1	Class 3	.30952	1.86906	.985	-4.1222	4.7412
	Class 2	Class 3	-.00641	1.89051	1.000	-4.4889	4.4761
LNLA	Class 1	Class 2	1.28571	2.04680	.805	-3.5674	6.1388
	Class 1	Class 3	6.57738*	2.59301	.033*	.4292	12.7256
	Class 2	Class 3	5.29167	2.62276	.112	-.9271	11.5104

NTP	Class 1	Class 2	-1.07005	1.55189	.770	-4.7497	2.6096
	Class 1	Class 3	3.66071	1.96603	.154	-1.0009	8.3223
	Class 2	Class 3	4.73077	1.98858	.052	.0157	9.4458

Table 3 and Graph 3 depicted multiple comparisons between skeletal and nasal parameters between various classes of malocclusion which showed that:

- For ANB, there was a statistically significant difference between Class 1 and Class 2 (P<0.001), between Class 1 and Class 3 (P<0.001) and between Class 2 and Class 3 (P<0.001).
- For Beta Angle, there was a statistically significant difference between Class 1 and Class 2 (P<0.001), between Class 1 and Class 3 (P<0.001) and between Class 2 and Class 3 (P<0.001).
- For ANS-Me, the statistically significant difference was observed between Class 1 and Class 3 (P<0.001) and between Class 2 and Class 3 (P=0.006). There was no statistically significant difference in ANS-Me between Class 1 and Class 2 (P=0.515).
- For R angle, the multiple comparison did not find a statistically significant difference between any of the classes of malocclusion (P>0.05).
- For N-ANS, the statistically significant difference was observed between Class 1 and Class 3 (P<0.001) and between Class 2 and Class 3 (P<0.001). There was no statistically significant difference in N-ANS between Class 1 and Class 2 (P=0.657).
- For LNLA, the statistically significant difference was observed between Class 1 and Class 3 (P=0.033). There was no statistically significant difference in LNLA between Class 1 and Class 2 (P=0.805) and between Class 2 and 3 (P=0.112).
- Other differences were not statistically significant (P>0.05).

Table 4 showed statistically significant correlation between various nasal parameters and various vertical skeletal parameters in males and females.

- SNGoGn showed a statistically significant strong positive correlation with NLth (P=0.005) and NTP (P=0.004).
- J Ratio showed a statistically significant strong negative correlation with NLth (P=0.009).
- Angle of Inclination showed statistically significant strong negative correlation with NLth (P<0.001) and weak negative correlation with NDpt (P=0.024).
- SN-Pp showed statistically significant positive correlation with NDpt (P=0.049).
- Occlusal-SN Angle showed statistically significant positive correlation with NTP (P=0.016).
- ANS-Me showed statistically significant strong positive correlation with NLth (P<0.001) and NDpt (P<0.001) where as weak negative correlation with UNLA (P=0.014).

		NLth	NDpt	NLA	UNLA	LNLA	NTP
SNGoGn	Pearson Correlation	.210**	.057	.008	.030	-.040	.215**
	P value	.005	.448	.913	.688	.595	.004
	N	180	180	180	180	180	180
JRatio	Pearson Correlation	-.193**	-.037	.112	.055	.056	-.094
	Sig. (2-tailed)	.009	.617	.135	.462	.459	.209
	N	180	180	180	180	180	180
ANSMe	Pearson Correlation	.579**	.293**	-.047	-.184*	.135	.059
	P value	.000	.000	.534	.014	.071	.431
	N	180	180	180	180	180	180
SnPp	Pearson Correlation	.111	.147*	.021	-.010	-.055	-.052
	P value	.139	.049	.780	.890	.464	.485
	N	180	180	180	180	180	180
Angle of Inclination	Pearson Correlation	-.343**	-.168*	-.035	.092	-.059	-.105
	P value	.000	.024	.638	.218	.428	.162
	N	180	180	180	180	180	180
R-angle	Pearson Correlation	.199**	.062	.026	-.061	.041	.208**
	P value	.008	.407	.725	.412	.585	.005
	N	180	180	180	180	180	180
Occlusal SN Angle	Pearson Correlation	.004	.041	.104	.077	.045	.179*
	P value	.956	.589	.165	.306	.546	.016
	N	180	180	180	180	180	180
N-ANS	Pearson Correlation	.858**	.520**	-.049	-.223**	.043	.017
	P value	.000	.000	.509	.003	.565	.824
	N	180	180	180	180	180	180

Table 4

		NLth	NDpt	NLA	UNLA	LNLA	NTP
SNGoGn	Pearson Correlation	.195*	-.034	.015	-.022	-.028	.219**
	P value	.017	.684	.860	.792	.731	.007
	N	180	180	180	180	180	180
JRatio	Pearson Correlation	-.140	.054	.061	.020	.051	-.147
	P value	.088	.515	.457	.811	.540	.073
	N	180	180	180	180	180	180
ANSMe	Pearson Correlation	.517**	.241**	-.025	-.162*	.077	.069
	P value	.000	.003	.763	.048	.352	.403

	N	180	180	180	180	180	180
SnPp	Pearson Correlation	.198*	.098	.008	-.043	-.060	-.030
	P value	.015	.233	.927	.600	.470	.717
	N	180	180	180	180	180	180
Angle of Inclination	Pearson Correlation	-.416**	-.159	-.075	.037	-.053	-.168*
	P value	.000	.053	.361	.655	.518	.041
	N	180	180	180	180	180	180
R-angle	Pearson Correlation	.144	-.032	.035	-.065	.029	.224**
	P value	.081	.702	.674	.434	.729	.006
	N	180	180	180	180	180	180
Occlusal SN Angle	Pearson Correlation	.039	-.002	.135	.049	.104	.208*
	P value	.641	.981	.101	.555	.208	.011
	N	180	180	180	180	180	180
N-ANS	Pearson Correlation	.852**	.507**	-.005	-.167*	.007	.028
	P value	.000	.000	.951	.041	.935	.738
	N	180	180	180	180	180	180

Table 5

Table 5 depicted that statistical correlation was found between various nasal parameters and skeletal parameters among various growth patterns. Statistically significant correlations were found between various skeletal and nasal parameters which are:

- ANS-Me showed statistically significant strong positive correlation with NLth (P<0.001) and NDpt (P=0.003) whereas negative correlation with UNLA (P=0.048).
- SNPp showed statistically significant positive correlation with NLth (P=0.015).
- Occlusal-SN Angle showed statistically significant positive correlation with NTP (P=0.011)
- Angle of Inclination showed statistically significant negatively strong correlation with NLth (P<0.001) and weak negative correlation with NTP (P=0.041)
- J Ratio showed no statistically significant correlation with any parameter.
- SNGoGn showed a statistically significant positive correlation with NLth (P=0.017) and strong positive correlation with NTP (P=0.007) whereas R angle showed significant strong positive correlation with NTP (P=0.006).
- N-ANS showed statistically significant strong positive correlation with NLth (P<0.001) and NDpt (P<0.001) whereas weak negative correlation with UNLA (P=0.041)

Table 6 showed that statistically significant correlation existed between various skeletal and nasal parameters between various classes of malocclusion. There was a statistically significant correlation existed between:

- ANB showed a statistically significant weak negative correlation with NLth (P=0.034) and strong negative correlation with NDpt (P=0.002) where as positive correlation with UNLA (P=0.039) and NTP (P=0.011).
- Beta Angle showed a statistically significant positive correlation with NLth (P=0.044), NDpt (P=0.008) whereas negative correlation with UNLA (P=0.027) and NTP (P=0.007).
- SNGoGn showed a statistically significant negative correlation with LNLA (P=0.016).
- J Ratio showed a statistically significant positive correlation with NLA (P=0.041).
- ANS-Me showed statistically significant positive correlation with NLth (P=0.002) and NDpt (P=0.022).
- SN-Pp showed no statistically significant correlation with any parameter.
- Angle of Inclination showed statistically significant negative correlation with NLth (P=0.042).
- R Angle showed no statistically significant correlation with any parameter.
- Occlusal Angle showed statistically significant negative correlation with NLA (P=0.005)
- N-ANS showed statistically significant positive correlation with NLth(p=0.000) and NDpt (p=0.000)

Table 6

		NLth	NDpt	NLA	UNLA	LNLA	NTP
ANB	Pearson Correlation	-.185*	-.268**	.010	.180*	-.090	.221*
	P value	.034	.002	.906	.039	.304	.011
	N	180	180	180	180	180	180
Beta Angle	Pearson Correlation	.175*	.228**	-.006	-.193*	.100	-.232**
	P value	.044	.008	.946	.027	.254	.007
	N	180	180	180	180	180	180
SNGoGn	Pearson Correlation	.091	.116	-.161	-.018	-.210*	-.023
	P value	.300	.187	.065	.833	.016	.790
	N	180	180	180	180	180	180
JRatio	Pearson Correlation	-.060	-.115	.178*	.041	.165	.084
	P value	.492	.188	.041	.643	.059	.337
	N	180	180	180	180	180	180
ANSMe	Pearson Correlation	.272**	.199*	.002	-.053	-.008	-.008
	P value	.002	.022	.981	.548	.930	.930
	N	180	180	180	180	180	180

SnPp	Pearson Correlation	.090	.086	-.030	-.057	.016	-.155
	P value	.303	.326	.734	.519	.855	.075
	N	180	180	180	180	132	180
Angle of Inclination	Pearson Correlation	-.177*	-.118	.016	.082	-.042	.045
	P value	.042	.176	.851	.351	.634	.608
	N	180	180	180	180	132	180
R-angle	Pearson Correlation	.088	-.013	-.065	-.006	-.133	.096
	P value	.316	.881	.457	.946	.129	.273
	N	180	180	180	180	180	180
Occlusal SN Angle	Pearson Correlation	.042	.108	-.246**	-.119	-.199*	-.133
	P value	.635	.219	.005	.176	.022	.128
	N	180	180	180	180	180	180
N-ANS	Pearson Correlation	.339**	.337**	.029	-.078	.091	-.021
	P value	.000	.000	.738	.371	.302	.808
	N	180	180	180	180	180	180

Discussion

The soft-tissue of the face plays an important role in facial aesthetics, speech, and other physiologic functions. Thus, it is recognized by all clinicians that success of orthodontic treatment is closely related to the changes in soft tissues of the face.[13] The nose mainly dominates the middle third of the face and lies almost in close harmony with chin and lips. Thorough knowledge of these structures and their relationships, and the changes expected during and after growth with orthodontics and surgical treatment is essential for an orthodontist to achieve desired goals.[14] Therefore, the present study was conducted to correlate nasal parameters and skeletal parameters in North Indian population. 180 preorthodontic cephalograms were selected and divided into males and females between age group of 16-27 years. The subjects were further divided into various growth patterns and skeletal malocclusions. Nasal features vary from race to race, sex to sex and based on their characteristic size and shape. Hence it becomes imperative to determine whether nasal features get affected by gender dimorphism, growth patterns and skeletal malocclusions.

Subjects with an age group of 16-27 years were selected for the study because the growth of the nose occurred in downward and forward direction during maturity as stated by Subtelny.[15] On the contrary, Behrent's study depicted that growth of the nose occurred in vertical dimension even after puberty.[16] The study was further supported by Meng et al and Posen et al.[17,4] Hence the best age group that depicted better results was from 16-27 years. The sample size selected for study was 180 after consulting the statistician and was divided into males and females as growth of the nose gets affected by sexual dimorphism supported by Fernandez et al.[18]

Robinson et al stated that skeletal profile affects the nasal profile of an individual. Therefore, the sample was further divided into various growth patterns as horizontal, vertical and average growth pattern and were compared with their nasal parameters in order to correlate whether the skeletal growth affect nasal growth or not. Nasolabial angle, various other nasal parameters and skeletal malocclusion have a significant relation with each other. Therefore, the samples selected were further divided into skeletal Class I, Class II and Class III.[19]

Gulsen A. et al extensively studied various nasal forms and assessed the relationship with underlying hard tissue structures in Anatolian Turkish adults.[20] The results of the mentioned study stated that nasal length and nasal depth were affected by sexual dimorphism whereas the parameters such as nasomental angle, nasolabial angle and nasal base angle does get affected by skeletal angle and malocclusions. The findings of our study explains that there is a statistical difference of nasal length and nasal depth between males and females i.e., males tend to have a different nose as compared to females which was in concurrence with studies done by *Mestrovic et al and Scavone H. et al.*[21,22]

Fitzgerald et al mainly studied nasolabial angle and its relation with facial structures. They found that there were no significant skeletal relationships found with respect to soft tissue profile of nasolabial region.[23] Our study also illustrated that there was a strong correlation found between LAFH and UNLA i.e., if there is increase in lower anterior facial height, the nose becomes less upturned. Our study further stated that angle of inclination showed significant correlation between nasal tip angle i.e., if the maxilla is upwardly turned, nasal tip seems to become less pointed in growth pattern subjects. With respect to skeletal malocclusion, our study further illustrated that ANB and β-angle showed significant correlation with UNLA and also explained that there was a statistically significant correlation between nasolabial angle J-ratio and Occlusal-SN angle on comparing nasal parameters with skeletal malocclusion. Therefore, the findings of our study stated that soft tissue structures get affected by underlying skeletal relationships.

Genecov et al compared nasal profiles and determined relation of soft tissue development to hard tissue development. The study results stated that there was a significant role of soft tissue in development of hard tissue as compared to males and females.[24] They further stated that there was no significant difference between nasal development and skeletal class of the subjects. The findings of our present study supported the above-mentioned study in aspects that nasal development and nasal profiles seems to get affected on sexual dimorphism and showed significant concurrence with another study done by *Starck WJ et al.*[25] The present study stated that nasal profile gets affected on different skeletal classes of subjects i.e., there was statistically significant differences of nasal profiles in skeletal Class I, Class II and Class III subjects respectively which were affected by upper lip inclination and was further supported by the studies done by *Taha A.A. and Ahmed A.S.* and *Perovic T.M. et al.* [26,27]

Alhuwaizi A. et al conducted a study to evaluate nasolabial angle in Iraqi subjects with Class I, II and III skeletal relationships. They concluded that there was no gender variation detected in nasolabial angle. They further stated that there was

no statistical difference found in nasolabial angle in the three skeletal classes of malocclusion.[28] The present study showed a similarity with above mentioned study and found that there was no statistical difference in nasolabial angle between males and females and further remained in concurrence with the study done by *Dua V, Gupta S et al.*[29] Further, our study also supported that there was no statistical difference between nasolabial angle and skeletal classes of malocclusion. On the contrary, the present study revealed that nasolabial angle gets affected by various skeletal parameters such as J-Ratio and occlusal-SN angle in various classes of malocclusion i.e., nasolabial angle increases, if there is decrease in occlusal-SN angle in skeletal class I, class II and it is vice-versa in case of skeletal class III subjects.

Hwang et al conducted a study to compare soft tissue profile in males and females in Korean and European-American adults and stated that there was insignificant statistical difference found in nasolabial angle between males and females.[30] Therefore, the above-mentioned study shared similar agreements with the current study and states that nasolabial angle does not get affected by sexual dimorphism. A study done by *Aljabaa A. et al* showed significant difference between nasal length and nasolabial angle in Saudi males and females having class I skeletal base.[31] The present study findings hold the similar point of view that nasal length showed statistically significant difference between males and females. The present study showed contrast in view with another study done by *Bagwan A.A. et al* which stated that nasolabial angle was acute in males as that of females.[32]

Based on the present study, it is suggested that nasal parameters hold statistically significant differences with skeletal parameters in sexual dimorphism, growth patterns and skeletal malocclusions. Therefore, the study holds importance with respect to soft tissue aspect mainly nasal parameters that should be taken into consideration in diagnosis and treatment planning. The clinical significance of this study is to emphasize the importance of nasal aspects (especially nasal shapes, nasal length, nasal depth, nasal tip angle) during diagnosis and treatment planning.

Conclusion

On the basis of results obtained, the following conclusion have been drawn:

- Nasal parameters especially nasal length and nasal depth gets affected by gender dimorphism and seems to have a larger nose as compared to that of females.
- The results depicts that the nose tip seems to be less pointed, if there is greater inclination of palatal plane in gender dimorphism.
- Nasal length and nasal tip angle seem to be more in increased mandibular plane angle cases where as nasal depth seems to be decreased in increased mandibular plane angle cases. With respect to inclination of palatal plane, the nasal depth seems to get increased in all the growth patterns.
- Nasal length seems to get affected more in horizontal and vertical growers as compared to that of average growers.

- Nasal parameters such as nasal length, nasal depth, nasolabial angle, upward nasal tip angle and nasal tip angle gets affected by skeletal parameters among skeletal class I, Class II and Class III.
- Upper lip inclination seems to be more in class I cases than in class II cases and lowest in class III cases.

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