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Descriptive Morphological Features of the Nose—An Assessment of Their Importance for Plastic Reconstruction

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ABSTRACT: On a series of lateral radiographs of 154 males and 199 females from Vienna, Austria, 3 qualitative morphological features of the external nose were recorded. Their relationship to craniometric dimensions, age, and the contour of the nasal bones was tested using Wilks' stepwise discriminant analyses. All tests gave significant results at the 1% probability level, but, overall, correct assignment of the features to their categories did not exceed 61%. Although height dimensions were used for discrimination in females, the prominence of the nasal bones and age appeared to be the most important discriminating variables in both sexes. Analyses further revealed that the nasal bridge and the direction of the nasal septum are highly correlated, whereas the tip of the nose seemed to be independent; this may reflect the dependence of the latter on exogenous influences, especially nutrition. It was demonstrated that the profile line of the external nose does *not* follow its underlying bony structures, that is, the profile line of the nasal bones. Thus, the present study showed that obtaining soft tissue thicknesses alone is not sufficient for successful facial reconstruction, but that a more holistic approach should be used to elucidate the relationships between soft tissue cover and the underlying hyaline and bony structures.

KEYWORDS: physical anthropology, plastic reconstruction, nose, soft tissue

In a previous study the attempt was undertaken to predict the gross dimensions of the adult external nose in lateral view on the basis of several measurements taken from the skull [*1*]. Regression analyses revealed that the height and the length of the nose were relatively well predictable, whereas the nasal depth and the thickness of the soft tissue were greatly influenced by age, the latter being also determined by exogenous conditions, such as nutrition. The results further seemed to support the findings of orthodontic and plastic surgeons that the soft tissue cover tends to adjust to functional and structural anomalies or disharmonies of the bony profile [*2-5*].

The main components involved in determining the outline of the external nose are bones, cartilages, muscles, and integument. The bony framework of the external nose, which mainly supports its upper part, is composed of maxillae and ossa nasalia, while the cartilagenous framework consists of two upper and two lower lateral cartilages and the cartilage of the septum. In addition, occasional accessory cartilages, that is, cartilagines alares minores,

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may be found, which, however, are of little or no importance for the appearance of the nose. These structures are connected with each other by the continuity of the perichondrium and the periosteum [6]. It has been asserted that the size and shape of the cartilages, especially the lateral nasal cartilages and the cartilage of the septum, correlate with the bony structures as a result of their close proximity and, hence, the form of the external nose can be assessed on the skull [7-10]. Schultz [11], however, demonstrated that the cartilages vary considerably, although some ethnic differences may be apparent [11-15], and no clear-cut relationships have yet been found between bony and hyaline structures.

Of the three muscles—m. nasalis, m. procerus, and m. depressor septi—which are situated beneath the integument, only the latter influences the appearance of the external nose to some extent; its fibers ascend from the maxilla above the central incisors into the mobile part of the nasal septum. The integument covering the nose is very thin and loosely connected with the adjacent parts in the upper half, but it is usually thick and firmly adherent in the region of the tip of the nose. A considerable amount of subcutaneous fat can be found in this area [16].

For precise facial reconstruction as an identification tool it is obvious that shape components are of similar or even greater importance than the actual soft tissue dimensions [17,18]. In the present study, three qualitative morphological features of the external nose were recorded to investigate their relationship to craniometric dimensions, age, and the profile line of the nasal bones, which can also be recorded from the skull alone. In addition, intercorrelations of qualitative features were tested.

Material and Methods

The series of lateral radiographs of 154 males and 199 females examined, aged 21 to 83 years, came from the University Clinic of Dental and Plastic Surgery, Vienna. All individuals were well nourished and free from anomalies of the teeth, the jaws, or both. Nine craniometric measurements and four descriptive morphological features were recorded.

The measurements taken were defined by Martin and Saller [19] (head length) and by Goldhamer [20] and were further described in Macho's Fig. 1 [1]. They were:

(1) head length,

(2) height of the apertura piriformis (distance from rhinion to spina nasalis anterior),

(3) height of the bony nose (distance from nasion to spina nasalis anterior),

(4) distance from reference plane nasion-spina nasalis anterior to the most prominent point along the ossa nasalia (P maximum),

(5) height of P maximum in relation to nasion (P max. proj.),

(6) prominence of rhinion in relation to the plane nasion-spina nasalis anterior (Rhi. prom.),

(7) height of rhinion in relation to nasion,

(8) length of the ossa nasalia, and

(9) angle between the plane spina nasalis anterior-nasion and the spina nasalis anterior-rhinion plane.

The following qualitative morphological features were modified after Müller [21]. As the sample sizes were relatively small and not every category was equally represented, some groups were pooled. The profile line of the external nose was thus defined as:

(I) straight or slightly uneven,

(II) convex or hooked, or

(III) concave

and the form of the nasal tip as:

(I) pointed,

(II) round, or
(III) irregular or "squared."

The nasal septum was classified in relation to the Frankfurt Plane as pointing:

(I) upwards towards the tip of the nose,
(II) horizontal, or
(III) downwards.

The categories for the profile line of the nasal bones were defined by Hovorka [22]. Four classes were recorded:

(I) S-shaped,
(II) straight,
(III) concave, or
(IV) other.

Descriptive statistics for the measurements, by sex and age categories, will not be presented in this study but are to be found elsewhere [1].

For each sex, Wilks' stepwise discriminant analyses were performed to examine differences between the qualitative features of the external nose using a series of craniometric dimensions and age.

Chi-square tests for independence were then used to test the effects of the contour of the nasal bones in profile on the qualitative traits by sex. Thereafter, the influence of sex and age on the discrete features of the nose was analyzed. For this purpose, the sample was divided into five age categories of ten-year intervals (21 to 30 years, 31 to 40 years, . . . , > 61 years). Finally, the association between all three qualitative features was examined in a three-dimensional loglinear model using the General Linear Model System (GLIM) statistical package [23]. For all other statistics Statistical Package for the Social Sciences (SPSS) was used [24,25].

Results

Descriptive statistics for the nine craniometric measurements were given in a previous paper for the total sample and for each age category by sex [1]. Furthermore, the results of the analyses of variance for the age classes were also listed there. No significant changes with age were found in craniometric dimensions, but age-related differences were observed in variables regarding the external nose and the soft tissue cover. Therefore, age will be used as an independent variable in the multivariate analyses presented in this study.

Discriminant Analyses

Wilks' stepwise discriminant analyses were used in an attempt to establish whether the various categories defined for the form of the bridge, the tip, and the septum of the nose in profile can be assessed on the basis of craniometric dimensions and age. To validate the multivariate analyses, tests for equality of the group variance-covariance matrices were carried out using the 'M' criterion of Box [26]. Except for the contour of the bridge of the nose in males, all tests gave nonsignificant results, and the variance-covariance matrices can thus be considered homogeneous. Nevertheless, the results of all discriminant analyses will be described and discussed in the present study. All analyses were significant at the 1% probability level.

Table 1 lists Fisher's linear discriminant coefficients for the profile line of the nasal bridge for males and females. In the male analysis, the absolute prominence of the nasal bones as represented by P maximum and the prominence of rhinion, and its relative one, which is given by the angle, were found to be the most discriminating features. On the other hand,

TABLE 1—*Fisher's classification coefficients of Wilks' stepwise discriminant analyses for the three categories defined for the form of the bridge of the nose in profile based on craniometric dimensions and age. males and females. (I = straight or slightly uneven, II = convex or hooked, and III = concave.)*

Category	Form of the Bridge of the Nose					
	Measurements					
Males	P max.	Rhi.prom.	Angle	Age	*K*	
I	2.92	−0.35	0.02	0.17	−19.61	
II	3.42	−0.83	0.17	0.19	−23.46	
III	2.47	−0.85	0.34	0.15	−14.81	
Females	Rhi.-a.	Nas.-a.	Rhi.prom.	Os n.lg.	Age	*K*
I	2.89	5.50	0.61	0.92	0.27	−213.68
II	3.11	5.38	1.38	0.77	0.28	−220.38
III	3.27	5.17	−0.41	1.35	0.23	−207.76

the height of the nose and that of the apertura piriformis were the variables that contributed most in females; but the prominence of rhinion and the length of the nasal bones were also of importance for discrimination. In both sexes, age entered the analyses. The overall correct prediction of each feature to its group was over 53% in males and almost 60% in females (Table 2). Despite the small numbers of individuals with concave bridges of the nose, 60.0% of the males were correctly assigned to this group and in females it was 73.3%. Similar results were obtained for convex contours where the figures were 58.6 and 75.0%, respectively. Straight or slightly uneven bridges showed the lowest percentages of correct predictions.

Discriminant analyses between different forms of the nasal tip revealed the prominence of the ossa nasalia and age to be the most important variables in both sexes (Table 3). In addition, the length of the nasal bones contributed in the male computation. Overall, correct assignment was much better in males than in females, the figures being 60.4 and 41.2%, respectively (Table 4). Furthermore, no clear-cut picture emerged as to which category was

TABLE 2—*Correct assignment of the bridge of the nose in profile to their respective groups based on craniometric dimensions and age for males and females.*

Group	Sex	*N*	Predicted Group Membership		
			I	II	III
I	m	86	42	26	18
	f	124	63	30	31
II	m	58	16	34	8
	f	60	13	45	2
III	m	10	4	0	6
	f	15	3	1	11

53.25% correctly classified, males (m)
59.80% correctly classified, females (f)

TABLE 3—*Fisher's classification coefficients of Wilks' stepwise discriminant analyses for the form of the tip of the nose in profile based on craniometric dimensions and age, males and females (I = pointed, II = round, and III = irregular or "squared").*

Category	Form of the Tip of the Nose			
	Measurements			
Males	P max.	Os n.lg.	Age	*K*
I	0.53	1.40	0.17	−24.00
II	0.39	1.67	0.18	−30.02
III	0.65	1.43	0.16	−25.50
Females	P max.	Age	*K*	
I	2.98	0.15	−18.41	
II	3.51	0.16	−24.58	
III	3.45	0.15	−23.26	

TABLE 4—*Assignment on dimensions of the bony nose and age to the three categories defined for nasal tip forms, males and females.*

			Predicted Group Membership		
Group	Sex	*N*	I	II	III
I	m	8	4	2	2
	f	17	11	3	3
II	m	128	20	80	28
	f	142	42	62	38
III	m	18	4	5	9
	f	40	15	16	9

60.39% correctly classified, males (m)
41.21% correctly classified, females (f)

easiest to predict. In males, round nasal tips yielded the best results (62.5%), while in females, prediction was best for pointed noses (64.7%). The two remaining categories were equally well predicted in males (50.0%), but in females, the lowest percentage of correct assignment was found for squared tips, and only 22.5% could be correctly classified to that group.

With regard to the direction of the nasal septum, Wilks' stepwise discriminant analyses gave inconsistent results for males and females (Table 5). In males only the prominence of the nasal bones (P maximum and the prominence of rhinion) and age entered the computations, but they were almost all craniometric dimensions in females, except for head length and the height of the apertura piriformis. Discrimination was best for downwards pointing septi (Category III) in both sexes (Table 6). Of the males and females, 56.3 and 70.0%, respectively, were correctly assigned to this group. The category with horizontal bottoms appeared to be least predictable and the figures were only 40.0 and 47.3%, respectively. Overall, the correct classification was 44.8% in males and 53.3% in females.

TABLE 5—Fisher's classification coefficients of Wilks' stepwise discriminant analyses for the direction of the nasal septum in relation to the Frankfurt Plane, based on craniometric dimensions and age, males and females (I = upwards, II = horizontal, and III = downwards).

	Direction of the Nasal Septum in Profile								
Category	Measurements								
Males	P max.	Rhi.prom.	Age	*K*					
I	2.74	−0.37	0.17	−17.94					
II	2.44	0.04	0.18	−19.79					
III	3.11	−0.34	0.23	−25.43					
Females	Nas.-a.	P max.	P proj.	Rhi.prom.	Rhi.ht.	Os n.lg	Angle	Age	*K*
I	22.28	4.94	−0.68	−43.26	−9.80	−4.70	25.00	0.35	−458.52
II	22.37	4.95	−0.73	−43.38	−10.03	−4.47	25.13	0.36	−464.84
III	22.77	4.84	0.41	−41.05	−11.56	−4.59	26.35	0.41	−483.96

TABLE 6—*Correct assignment on craniometric dimensions and age to the directions of the nasal septum defined, males and females.*

			Predicted Group Membership		
Group	Sex	*N*	I	II	III
I	m	48	24	14	10
	f	79	47	26	6
II	m	90	30	36	24
	f	110	44	52	14
III	m	16	4	3	9
	f	10	2	1	7

44.81% correctly classified, males (m)
53.27% correctly classified. females (f)

Analyses of the Morphological Features

Chi-squares were then used to first test for the independence of the contour of the nasal bones and the other descriptive morphological features of the external nose. In both sexes, the profile line of the bridge of the nose gave insignificant results with that of the nasal bones (males: $\chi^2 = 6.40$, degrees of freedom [df] $= 6, p = 0.38$; females: $\chi^2 = 7.21$, df $= 6, p = 0.30$). The tip of the external nose (males: $\chi^2 = 9.92$, df $= 6, p = 0.13$; females: $\chi^2 = 9.55$, df $= 6, p = 0.15$) and the direction of the septum in profile (males: $\chi^2 = 3.54$, df $= 6, p = 0.74$; females: $\chi^2 = 3.76$, df $= 6$, $p = 0.71$) were similarly not associated with the nasal bones at the 1% probability level. Thus, the shape of the ossa nasalia in profile was omitted from all further analyses.

Thereafter, the remaining qualitative morphological features were analyzed for the independence of age. The material was divided into five age categories. In males, the contour of the nasal bridge was found to be independent of age ($\chi^2 = 7.21$, df $= 8, p = 0.51$) and so was the tip of the nose ($\chi^2 = 4.97$, df $= 8, p = 0.76$) and the direction of the bottom of the nasal septum ($\chi^2 = 12.03$, df $= 8$, $p = 0.15$). Similar results were obtained in females (bridge: $\chi^2 = 7.64$, df $= 8, p = 0.47$; tip: $\chi^2 = 9.59$, df $= 8, p = 0.29$). However, analysis of the bottom of the nose gave a chi-square value significant at the 1% probability level ($\chi^2 = 22.63$, df $= 8, p = 0.004$). Examination of the chi-square in each field revealed that the significant result was almost entirely due to downwards pointing noses in age Class V, where seven out of the ten individuals with this feature were found.

No sex differences were found at the 1% level for the profile line of the nose ($\chi^2 = 2.43$, $p = 0.30$), the tip of the nose ($\chi^2 = 5.90, p = 0.06$), and the bottom of the nose ($\chi^2 = 5.40$, $p = 0.07$). The sexes were thus pooled to test the association between all three qualitative features in a three dimensional log-linear model. The profile line of the bridge of the nose and the direction of the septum gave insignificant results after allowing for the effects of the tip of the nose, but the chi-square value was highly significant when the interaction of the form of the nasal tip was eliminated ($\chi^2 = 38.22$, df $= 4, p = 0.000$). From this analysis it can thus be concluded that the nasal septum and the profile line of the bridge of the nose are highly associated, whereas the form of the nasal tip is independent of both of them.

As the bottom of the nose revealed significant results with age in females, it was further attempted to test for a four-dimensional interaction between the three recorded features and age. However, the sample sizes were found to be too small to allow for this statistical analysis.

Discussion

The appearance of the external nose is determined by a variety of structures, of which the nasal bones and the cartilages are the most salient ones, but regrettably, in radiographs the soft tissue components cannot be clearly distinguished. In the present investigation the effects of the ossa nasalia on the outline of the external nose were tested. Furthermore, as muscles and integument play a minor role in determining nasal shape, the study thus—although indirectly and only limited—elucidated the relationships between bony and hyaline structures.

Although the gross dimensions of the external nose appear to be fairly well predictable [*1*], the overall correct assignment of qualitative morphological traits did not exceed 61%. Of the features studied, the form of the tip of the nose was the one best predicted in males (60.4%), followed by the contour of the bridge (53.3%) and the direction of the nasal septum (44.8%). In females, the results were slightly different. The profile line of the nasal bridge yielded the highest percentage of correct assignments with almost 60% and the direction of the nasal septum was similarly well predictable (53.3%). However, only 41.2% of the tips could be correctly classified. With regard to the measurements used for discrimination, it emerged that the prominence of the nasal bones and age were the features selected for all analyses. Furthermore, the height dimensions of the nose or the piriform aperture or both were found to contribute in the female discriminant functions with one exception, the tip of the nose.

Nonparametric statistics revealed that the shape of the nasal bones has apparently little or no influence on the appearance of the external nose. Considering the results of the multivariate analyses it may thus be concluded that absolute and relative prominence of the nasal bones is of greater importance than the actual outline of the bones. These findings can partly be reconciled with the claims of some authors, who stressed the importance of rhinion for reconstruction [*7,8,15*]. However, the present results also seem to indicate that the profile line of the external nose does not necessarily follow the underlying bony structures, but appears to adjust to functional disharmonies [*2-5,15*]. Nevertheless, it should be borne in mind that the nasal bones are very seldom symmetrical [*22*] which, however, cannot be assessed on lateral radiographs. It cannot be excluded that such asymmetries may have influenced the results.

In forensic anthropology the issue of age changes has mainly been raised to clarify questions related to paternity, and alterations of qualitative features were studied on photographs from childhood to senile age [*27-30*]. These and morphometric studies revealed that the bridge of the nose tends to become more convex while the nasal septum sinks down with advancing age [*16,17,27,28,31-35*]. The tip, however, does not change significantly [*16,35*]. Although age entered all stepwise discriminant analyses, contingency tests gave significant results only for the female direction of the nasal septum. However, inspection of the male table revealed that there was a tendency towards downwards pointing noses in advanced age categories; that the result was not significant statistically could partly be due to the smaller sample size in that sex. No clear-cut trend was observed regarding the alterations of the bridge of the nose with age, but concave bridges were very seldom found in higher age categories in both sexes.

It is further noteworthy that the bridge and the septum are highly correlated, whereas the tip of the nose was found to be independent of both of them. The results of the three-dimensional log-linear model appear to support the findings that the tip is especially influenced by exogenous conditions and nutrition [*16,29,30,35*], and it may thus seem correct that squared tips only reflect the outline of the lower cartilages more clearly than round noses [*27*].

Nevertheless, the nose must be viewed as a morpho-functional entity, and although some morphological associations have been investigated in the present study, the functional aspect should also be considered. With regard to apparent ethnic differences, the importance of prognathism for nasal forms is well known [*11,14*], and recently it has been suggested that bite forms, mastication, and occlusional patterns should be taken into account for successful facial reconstruction [36]. Although no individual with pathologies was included in the analyses, it seems to be clear that a more detailed analyses is required to shed light on the influence of the jaws on the nasal features.

In conclusion, the prominence of the nasal bones and age influence the shape of the external nose and correct predictions can be made to a certain extent. Although the bridge of the nose and the nasal septum are highly correlated, the tip was found to be independent of both of them and note that particularly this feature is susceptible to subcutaneous fat deposition. It further appears that the nasal septum sinks down with age while there is a trend towards increase in convexity of the bridge. However, this latter finding could not be confirmed statistically in the present study. As contingency tables of the shape of the nasal bones in profile with the other morphognostic features did not yield significant results, it may be inferred that there obviously exists a trend of the soft tissue cover to adjust to disharmonious bony profiles.

The external nose is a very complex morphological organ which forms a functional unit with the masticatory apparatus, and the present study has demonstrated that its soft tissue contour does not strictly follow the underlying bony structure. Therefore, it must be emphasized, that knowledge of soft tissue thicknesses is not sufficient if one aims at accurate facial reconstruction. It is hoped that in the near future new, more sophisticated techniques, such as computed axial tomography scanning, will be used to test for the three-dimensional shape of the face and its underlying structures. These methods will ultimately help to overcome difficulties one is faced with when working with either radiographs, cadavers, or more recently, ultrasound [37] to obtain information necessary for plastic facial reconstruction.

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