Nasal Morphology of the Chinese: 3D Reference Values for Rhinoplasty

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Abstract

Objective: To determine normative nasal measurements for Chinese young adults, conditioned on demographics.

Study Design: A cross-sectional descriptive study.

Setting: A university hospital

Subjects and Methods: 3D photographs were captured from 103 Chinese subjects between 18 and 35 years using a commercial stereophotographic system. Anthropometric landmarks were identified on these 3D surface images, measurements suitable for nasal analysis were performed, and contrasted against established Caucasian norms. Gender differences in anthropometric dimensions were also analyzed.

Results: Normative data for these measurements are made available. Linear nasal measurements, except those for mid-columella length, were significantly larger in males than females; further, the nasal tip angle and nasofrontal angle were significantly larger in Chinese females. Contrasts of these new data against published Caucasian norms revealed dimensions that differ for these two groups. The Chinese normative mean values for morphological nose width, nasal tip angle, nasofrontal angle, and alar slope angle exceeded those reported for North American Caucasians.

Conclusions: Gender-specific normative data for the Chinese nose were established in this study to provide a useful tool for surgeons in dealing with rhinoplasty. Moreover, the Chinese

nasal anthropometric measurements in this study are broader and flatter than those reported for North American Caucasians.

Introduction

Objective quantitative analysis of nasal morphology is a useful adjunct in surgical planning for rhinoplasty. In the past, 2D photographs have been employed in planning, using frontal, lateral, oblique, and basal nasofacial views. With the advent of reliable and rapidy-captured stereophotographic images, a single 3D photograph can readily substitute the aforementioned views.

Taking ethnicity into consideration during planning for rhinoplasty is key. Terms such as 'Asian Rhinoplasty' have been coined to address the East Asian population as a whole, and several distinctive anatomical features of the Korean[1,2] and Chinese[3] nose have been reported. Yet, the majority of published articles on the topic have focused on surgical technique to the exclusion of morphology of the Asian nose.

Initial work by Farkas and collegues have demonstrated the vaule of anthropometric measurements in surgical planning of rhinoplasty[4-7]. Ethnicity- and gender-specific reference values on the average dimensions of the nose are important during treatment planning for cosmetic, cleft, or post-traumatic rhinoplasty. Anthropometric normative data would provide tools for scaling measurements accordingly, via standardized scores, in the service of surgical alteration that is appropriate to patients' ethnic characteristics.

Even though several software packages are commercially available for planning rhinoplasty using 3D photos, they do not utilize normative data of nasal measurements as such reference values are currently unavailable. Most of the ethnic Chinese populations living overseas have migrated from Southern China[8] and are typically of 'Han' ancestry[9], thus norms on their nasal dimensions may be used by surgeons in countries with these populations when planning rhinoplasty. The aims of this study are to 1) establish gender-specific normative nasal measurements for Chinese young adults, and 2) compare Chinese nasal measurements to those reported for Caucasian young adults in the literature.

Materials and Methods

Study Sample

This cross-sectional study was conducted using stereophotographic facial images captured from 51 males and 52 females from Hong Kong meeting the following criteria.

1. Ethnic Chinese
2. Age between 18 to 35 years
3. Class I skeletal pattern
4. No facial or nasal deformities
5. No past history of facial plastic surgery or orthognathic surgery

This sample was similar to the one constituted for our previous anthropometric studies of this ethnicity.[10-12] The subjects included patients attending initial consultation for impacted third molars, dental students and staff of the Prince Philip Dental Hospital. The research protocol was approved by the Institutional Review Board of The University of Hong Kong/Hospital Authority Hong Kong West Cluster and adhered to the tenets of the Declaration of Helsinki.

Imaging Technique

The 3D facial photographs were captured with the 3dMDface stereophomogrammetric camera system (3dMD LLC, Atlanta, USA). Image capture was made while the subjects were seated, with acquisition taking less than 2 milliseconds.

Anthropometric Analysis of 3D photographs

All measurements were performed by a single investigator (YSNJ) using the *3dMDVultus* software. Anthropometric landmarks (Figure 1) suitable for nasal analysis were identified on the images according to definitions presented in Table 1. We introduced several new measurements that are not part of the traditional anthropometric analytic schemata.

Statistical Analysis

Means and standard deviations were computed for linear and angular measurements among landmarks. Two-sample Student's t-tests were applied to determine any significant differences between males and females for each measurement. These statistical tests were performed using PASW 18 software (SPSS, Chicago, IL, USA).

Measurements for the Chinese were compared to those published by Farkas[13] for the North American Caucasian young adults. Previous research[14-16] have demonstrated that that anthropometric values from 3D facial photographs are akin to manual anthropometry and that measurements from both techniques can be combined or compared statistically.

The mean, SD and sample size (N) value for each measurement from the two studies were compared with the Welch corrected unpaired t-test using GraphPad QuickCals[17] online calculator (GraphPad Inc, California, USA). The Cohen's d was calculated for evaluating the effect size between the two studies as well as the gender differnces within the Chinese sample. This metric assesses the degree of difference between groups[18] and conveys the size of an effect in relation to the SD. The effect size can be categorized as small, medium, large and very large using the threshold values 0.2, 0.5, 0.8 and 1.3 respectively.[19]

The reliability of the measurements were assessed by repeating the same measurements on a set of randomly selected 11 images at least 3 weeks after the initial session. The technical error of measurement (TEM) was calculated using the following formula.[20]

$$TEM = \sqrt{\frac{\sum d^2}{2n}}$$

d = difference between measurements

n = number of measurements

Results

The mean age of the male and female groups were 24.2 and 23.58 years, respectively (group contrast, p=0.372). The TEM for most of the linear measurements were below 1 mm with only the error for anatomical nose width (ac-ac) and nasal bridge length (n-prn) being 1.02 and 1.1 mm respectively. All angular measurements had a TEM of less than 1.7 degrees with only the alar slope angle (al-prn-al) having an error of 2.44 degrees.

Linear nasal measurements other than the mid columella length were significantly larger in males than females (Table 2). The nasal tip angle and nasofrontal angle were significantly larger in females. No statistically significant gender differences were detected in relation to other angular measurements. The nasal index (al-al/n-sn x 100) was significantly larger in males while nasal tip protrusion width index (sn-prn/al-al x 100) was greater in females (Table 3).

Significant differences in relation to facial anthropometric norms were observed between Chinese and their Caucasian counterparts (Table 4). Using the combined interpretation of the Cohen's d and *p*-values, the most striking differences common to both genders noted in Chinese compared to North American Caucasians were the larger morphological nose width (al-al), alar length (prn-ac), nasal tip angle (n-nb/sn-cm), nasofrontal angle (g-n-nb), and alar slope angle (al-prn-al). Nasal tip protrusion (sn-prn) and nasal bridge length (n-prn) for both genders was statistically smaller in Chinese than Caucasians, while anatomical nose width (ac-ac) and nose height (n-sn) was larger only in Chinese males. However, gender differences for these measurements were noted in terms of their effect size.

Discussion

In his recommendation for the practice of aesthetic rhinoplasty for the next millennium, Yellin[21] in 1997 stated that "*our patient population continues to be more racially diverse; Caucasian normative standards of facial analysis are no longer sufficient. What is required is a broader understanding of ethnically specific facial features*". Though more than a decade has passed since Yellin's statement, anthropometric norms for Chinese young adults are still not available in the literature. This study was designed to overcome this limitation, and was conducted in the interest of planning rhinoplasty for these Chinese patients.

We compared the Chinese norms to those corresponding values by Farkas[13] for North American Caucasians young adults. Several studies[14-16] conducted in the past demonstrated that digital anthropometric measurements on 3D facial photographs can be used as an alternative to manual anthropometry with good validity and reliability. Thus, comparing the digital measurements from Chinese to the manual measurements by Farkas[13] will not result in a major discrepancy. The Chinese nose appears to be broader and flatter than Caucasians. The larger morphological nose width (al-al), nasofrontal angle and alar slope angles along with shorter alar length (prn-ac) among Chinese support this finding. These observations are in agreement with the results of Aung *et al*[22] conducted with laser scanned images for Singapore Chinese. They reported that nose in this group is characterized by wide alae, prominent alar lobules and decreased tip projection. The wide alae (i.e., the lateral al-al distance) in Chinese compared to Caucasians had a large effect size, than alar base width (ac-ac); this would operationally define thick and prominent alae.

Several new landmarks and measurements were developed for this project; these are not part of the traditional anthropometric pantheon, were introduced in this study to facilitate more flexible characterization of the 3D nasal morphology.

Several methodologic details bear on these anthropometric measurements: Traditional right- and left-columella measurements rely on the highest point on the columella crest at the apex of each nostril. As both nostrils do not conform to the same shape the value for right and left columella length could be different. For example, the corresponding values for males in the current study were 12.92 mm and 11.71 mm. Confusion was avoided by defining a new landmark columella midpoint which lies on the columella crest corresponding to apices of the nares. A new measurement, mid-columella length (sn-cm), gives a single value that gives an indication about the columella height. The subnasal protrusion angle (ac-sn-ac) is also a novel measurement that indicates the degree of projection of the subnasale in relation to the nasal base.

The 3-D photos used in this study were acquired from subjects recruited from Hong Kong. The sample studied here constitutes a normal control group rather than an epidemiologic population sample. The Hong Kong Chinese belong to the common ‘Han’ ethnicity, the largest ethnic group in the People's Republic of China (92% of its population). Therefore our sample would depict traits limited to this ethnic group. However, subtle morphological differences might exist among Han Chinese of different regions of the country especially between the Northern and Southern China. Therefore, these results would be more applicable to populations with ancestry in Southern China, as most Hong Kong people are decendents from this region. It is important to note that such demographic-specific variations are likely be found within all ethnicities, including individuals of “Caucasian” and “African” ancestry.

Stereophotogrammetry represents a useful technique for acquiring nasal morphometry. One benefit of utilizing these images rather than direct examination for repeated direct examination of patients is that they can be stored digitally and be readily available for subsequent analysis. Further, commercial software capable of accommodating 3D photographs for digital planning rhinoplasty are now available. Thus, these new normative 3D anthropometric data geared to Chinese ethnicity, as generated from this study, would be of value for quantitative planning of cosmetic or post-traumatic rhinoplasty for this group. This is an important initial step in furthering our understanding of the non-Caucasian nose for application to surgical planning for rhinoplasty. A potential future research direction would be to study the desired changes in nasal shape that Chinese patients are increasingly requesting. Such information would be useful to further refine the goals of rhinoplasty for Chinese patients.

Conclusion

Gender-specific 3D normative data for Chinese nasal morphology were established and are published here in a form that permits computation of standardized (z-) scores. These data are designed to provide a useful tool for surgeons in surgical planning of rhinoplasty, and for potential post-operative assessment. The Chinese nose appears to be broader and flatter than that of North American Caucasians. Linear nasal measurements, except for the mid-columella length, were significantly larger in males than females, whereas the nasal tip angle and nasofrontal angle were significantly larger in females.

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Figure Legends

Figure 1. Anthropometric landmarks used in this study (Ac - Alar curvature point, Al – Alare, c' - Columella apex, cm - Columella midpoint, n - Nasion, nb - Nasal bridge point, Prn –Pronasale, Sn – Subnasale)

Table 1. Anthropometric landmarks used in this study

Name	Abbreviation	Definition
Nasion	n	The midpoint on the soft tissue contour of the base of the nasal root[23]
Pronasale	prn	The most protruded point of the nasal tip[24]
Subnasale	sn	The midpoint of the angle at the columella base where lower border of the nasal septum and the surface of the upper lip meet[25]
Alare	al	The most lateral point on each alar contour[25]
Alar curvature point	ac	The most lateral point in the curved baseline of each ala indicating the facial insertion of the nasal wingbase[25]
Columella apex	c'	The most anterior, or the highest point on the columella crest at the apex of the nostril[24]
Columella midpoint*	cm	The midpoint on the columella crest that transects the lines connecting apices of the nares
Nasal bridge point*	nb	A point located in the midline of the nasal bridge in between n and prn

*Newly defined landmarks

Table 2. Normative measurements for the Chinese nose

Measurement	Gender	Mean	SD	Cohen's d	P-value
Linear Measurements					
Morphological nose width (al-al)	M	37.83	2.90	1.66*	< 0.001
	F	33.24	2.64		
Anatomical nose width (ac-ac)	M	34.54	2.78	1.43*	< 0.001
	F	30.63	2.68		
Nasal tip protrusion (sn-prn)	M	18.68	2.27	0.46	0.022
	F	17.74	1.82		
Nose height (n-sn)	M	53.05	3.88	0.73	< 0.001
	F	50.46	3.18		
Nasal bridge length (n-prn)	M	44.65	4.05	0.58	0.004
	F	42.50	3.36		
Mid columella length (sn-cm)	M	8.63	1.49	0.06	0.795
	F	8.55	1.35		
Right columella length (sn-c')	M	12.92	1.43	0.83†	< 0.001
	F	11.81	1.23		
Left columella length (sn-c')	M	11.71	1.45	0.57	0.005
	F	10.92	1.31		
Right alar length (prn-ac)	M	29.71	2.21	1.16†	< 0.001
	F	27.19	2.15		
Left alar length (prn-ac)	M	29.34	2.39	1.35*	< 0.001
	F	26.24	2.20		
Angular Measurements					
Nasolabial angle (cm-sn-ls)	M	102.14	9.82	0.36	0.074
	F	105.60	9.66		
Nasal tip angle (n-nb/sn-cm)	M	88.65	6.96	0.48	0.016
	F	92.22	7.81		
Nasofrontal angle (g-n-nb)	M	141.01	4.77	0.51	0.011
	F	143.51	5.06		

Alar slope angle (al-prn-al)	M	103.93	6.89	0.23	0.252
	F	102.30	7.45		
Subnasal protrusion angle (ac-sn-ac)	M	130.80	8.59	0.27	0.180
	F	133.00	7.97		

Effect size for gender differences: †- large effect; * - Very large effect

Table 3. Propotional indices for the Chinese nose

Index	Gender	Mean	SD	Cohen's d	p-value
Nasal bridge index (n-prn/sn-sn x 100)	M	84.15	4.18	0.01	0.948
	F	84.2	3.28		
Nasal index (al-al/n-sn x 100)	M	71.76	8.4	0.73	< 0.001
	F	66.15	6.88		
Nasal tip protrusion width index (sn-prn/al-al x 100)	M	49.6	6.63	0.63	0.002
	F	53.56	5.88		
Columella length-nasal tip protrusion index (sn-cm/sn-prn x 100)	M	46.17	5.66	0.37	0.063
	F	48.17	5.13		

Table 4. Differences in anthropometric measurements between Chinese and North American Caucasians

Measurement	Gender	N	Chinese Mean	SD	N	Caucasian Mean	SD	Numeric Difference	Cohen's d	P-value
Morphological nose width (al-al)	M	51	37.8	2.9	109	34.9	2.1	2.9	1.2†	< 0.001
	F	52	33.2	2.6	200	31.4	2.0	1.8	0.8†	< 0.001
Anatomical nose width (ac-ac)	M	51	34.5	2.8	86	32.8	2.3	1.7	0.7	< 0.001
	F	52	30.6	2.7	45	30.5	2.2	0.1	0.0	0.794
Nasal tip protrusion (sn-prn)	M	51	18.7	2.3	109	19.5	1.9	-0.8	0.4	0.028
	F	52	17.7	1.8	200	19.7	1.6	-2.0	1.2†	< 0.001
Nose height (n-sn)	M	51	53.1	3.9	109	54.8	3.3	-1.7	0.5	0.007
	F	52	50.5	3.2	200	50.6	3.1	-0.1	0.0	0.777
Nasal bridge length (n-prn)	M	51	44.7	4.1	109	50.0	3.6	-5.3	1.4*	< 0.001
	F	52	42.5	3.4	200	44.7	3.4	-2.2	0.6	< 0.001
Right columella length (sn-c')	M	51	12.9	1.4	109	11.6	1.7	1.3	0.8†	< 0.001
	F	52	11.8	1.2	200	11.5	1.7	0.3	0.2	0.232
Left columella length (sn-c')	M	51	11.7	1.5	109	11.5	1.7	0.2	0.1	0.473
	F	52	10.9	1.3	200	11.4	1.7	-0.5	0.3	0.049
Right alar length (prn-ac)	M	51	29.7	2.2	109	35.0	1.6	-5.3	2.8*	< 0.001
	F	52	27.2	2.2	199	31.5	1.8	-4.3	2.1*	< 0.001
Left alar length (prn-ac)	M	51	29.3	2.4	109	35.0	1.7	-5.7	2.7*	< 0.001
	F	52	26.2	2.2	198	31.4	1.8	-5.2	2.6*	< 0.001
Nasolabial angle (cm-sn-ls)	M	51	102.1	9.8	109	99.8	11.8	2.3	0.2	0.228
	F	52	105.6	9.7	200	104.2	9.8	1.4	0.1	0.359
Nasal tip angle	M	51	88.7	7.0	109	71.7	7.4	17.0	2.4*	< 0.001

(n-nb/sn-cm)	F	52	92.2	7.8	45	67.4	7.4	24.8	3.3*	< 0.001
Nasofrontal angle (g-n-nb)	M	51	141	4.8	109	130.3	7.4	10.7	1.7*	< 0.001
	F	52	143.5	5.1	200	134.3	7.0	9.2	1.5*	< 0.001
Alar slope angle (al-prn-al)	M	51	102.3	7.5	42	63.9	5.8	38.4	5.7*	< 0.001
	F	52	103.9	6.9	45	59.4	5.3	44.5	7.2*	< 0.001

Effect size for racial differences: †- large effect; * - Very large effect