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Nose asymmetry correlates with external nose volume and area: 3D analysis of nasal dimensions in a young Turkish population

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Abstract

Objectives: The nose is a critical facial feature from the cosmetic and functional point of view. The effect of size and symmetry of the nose on beauty and function is a matter of concern for surgeons. In the present study, we performed 3D analysis of nose dimensions and investigated the correlation among them.

Methods: Facial mask of 40 (20 males and 20 females) young Turkish adults aged between19 and 26 years were recorded with a 3D scanner. Nose asymmetry, external nose volume, nose area, anatomical nasal index, nasal protrusion index, body height, body weight and body mass index were measured. The correlations among these measurements were investigated.

Results: The external nose surface area was measured as 18.2±2.1 cm^2 and external nose volume as 8.1±1.3 cm^3. A significant correlation was found between nose asymmetry value and external nose surface area ($r=0.33$, $p=0.03$), and also between nose asymmetry value and external nose volume ($p=0.34$, $r=0.03$).

Conclusion: Our study presents 3D quantitative data regarding nasal dimensions and correlation between the nose size and symmetry.

Keywords: 3D analysis; external nose area; external nose volume; nose asymmetry

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Introduction

The nose is a prominent feature of the face and located in the center. Its shape and therefore dimensions, like other parts of the human face, vary among human populations. Besides the basic physiological tasks of the nose, the size of the nose plays an important role in facial beauty. The smaller size of nose area and dimensions in women, or the averageness size of nose in man were perceived as attractive by men and women respectively.[1] Furthermore, as in other facial parts, the nose symmetry is another important parameter which contributes to facial expression and beauty.[1–3] Therefore, nose size and symmetry should be considered together.

Assessment of nasal dimensions and asymmetry is important for craniofacial and plastic surgery in order to restore the facial esthetics. Surgeons need accurate and reliable anatomical measurements obtained from the patients for planning and evaluating the outcome before and after the surgery.[4] The traditional analysis of facial features is performed using 2D photography method which has limitations. The emerging technologies enable more accurate and reliable measurements over 3D scans.[5] Additionally, these technologies allow more complicated surface analyses using thousands of facial soft tissue landmarks.[6] In both 2D and 3D methods, cephalometric analyses of facial soft tissue are performed by using soft tissue landmarks defined in previous studies.[7] The accurate placement of the soft tissue landmarks is an important issue in order to obtain reliable data.[8–10]

The aim of the present study was to measure nose asymmetry, external nose volume, external nose area, anatomical nasal index, nasal protrusion index, body height, body weight, body mass index and afterwards, to investigate the correlation among these measurements.

Materials and Methods

Ethical approval for this study was obtained from the Ethics Committee of Clinical Research of Akdeniz University (approval number 70904504/143). Written, informed consent for participation was obtained from the volunteers. Three-dimensional face scans of 40 volunteers (20 males and 20 females) aged between 19 and 26 years (mean age 22±2) were performed with a hand held light scanner (Artec™ Eva, Artec Group, Luxembourg). All volunteers were of Caucasian ethnic origin and with no history of underlying trauma, craniofacial disease or previous orthodontic treatment or surgery.

Face of each volunteer was scanned using the scanner. The volunteers were seated on a chair and asked to keep a natural head position determined by the volunteers own feeling of a natural head balance. In order to avoid motion artefacts, the volunteers were asked to remain still during scanning. Each face scanning took around 5 seconds. The ideal scan distance was determined by the distance adjustment indicator available in the Artec Studio 10 Software (version 9.2.3.15; Artec Group, Luxembourg, licensed). Using the distance indicator, true localization of the scanner was adjusted, either moving it closer or farther away to obtain the best possible face scan. The scanning was performed at a speed of 15 frames per seconds and the depth of the scanning field was adjusted to 400 mm for near and 1000 mm for far. The given data of the scanner by the manufacturer is between 0.4-1 m for work distance, up to 0.1 mm for 3D accuracy and up to 0.5 mm for 3D resolution. The three-dimensional surfaces were created by Artec Eva Studio 10 software in STL file format.

The scanned masks of each subject were imported into the same work space of Artec Eva Studio 10 Software (version 9.2.3.15; Artec Group, Luxembourg, licensed). Unwanted extraneous data except from the nose region were excluded. The upper borders of nose region were the planes connecting the landmarks “nasion” and “endocanthion” on both sides, the lateral borders were the planes connecting the landmarks “endocanthion” and “alar curvature” on both sides, and the lower border was determined by the horizontal plane passing through the landmark “subnasale”.

Five anthropometric soft tissue landmarks which have been used in the present study were as follows:

1. The soft tissue nasion (N) which was marked on the deepest concavity of the dorsum of the nose.
2. Pronasale (Prn) was identified as the most prominent point in the tip of the nose.
3. Subnasale (Sn) was identified at the base of the columella.
4. Right and left alar curvature point (AcR and AcL) were identified as the attachment point of right and left ala of the nose (**Figure 1**).

Eight nasal parameters calculated by using five anthropometric soft tissue landmarks were as follows:

1. Nose height (N-Sn): Length between soft-tissue nasion and subnasale
2. Nose length (N-Prn): Length between soft-tissue nasion and pronasale
3. Anatomical width of the nose (nose width) (AcR-AcL): Length between attachment point of right and left nasal curvature
4. Nasal tip protrusion (Prn-Sn): Length between subnasale and pronasale
5. Anatomical nasal index (AcR-AcL/N-Sn): The ratio of nose width to nose height

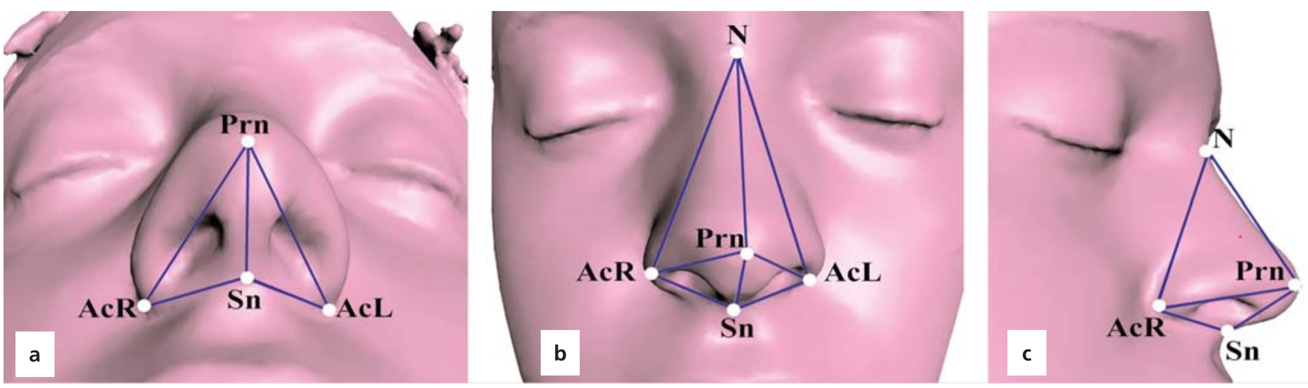

Figure 1. Nasal soft tissue landmarks and linear measurements. Inferior (**a**), anterior (**b**) and lateral (**c**) view of scanned nose. **AcL:** left alar curvature; **AcR:** right alar curvature; **N:** nasion; **Prn:** pronasale; **Sn:** subnasale. [Color figure can be viewed in the online issue, which is available at www.anatomy.org.tr]

6. Nasal protrusion index (Prn-Sn/N-Sn): The ratio of nasal tip protrusion to nose height
7. External nasal volume: This was approximated from the volumes of two tetrahedra. The base of the first tetrahedron was defined as the plane AcR-AcL-Prn, and vertex was defined in (N). The second tetrahedron had the same base and vertex was defined in (Sn)
8. Extemal nasal surface: The four surfaces forming the nose area were N-Prn-AcR, N-Prn-AcL, Prn-Sn-AcR, and Prn-Sn-AcL

A mirror image of nose region was generated for each subject with Autodesk Netfabb software (Netfabb, Parsberg, Germany, Free trial version) and superimposed on the original nose image. Afterwards, for quantitative nose asymmetry analyses, the distance between the original nose and its mirrored nose image was automatically computed by the Artec Studio 10 Software. Namely, the asymmetry value of the nose was indicated by using the root mean square (RMS) value of the distance between the original nose and the mirror nose surfaces. The volume or shape differences between two surfaces are evaluated using RMS value.[11–13] This value is the indicator of the variation between two surfaces in 3D and shows the disparity or similarity between the compared shapes. While the lower values indicate a more similar shape, the higher values indicate greater diversity. For a perfect overlapping, the value should optimally be as close to zero as possible. For the further detail of RMS see the study of Ozsoy (**Figure 2**).[14]

The Graphpad software (GraphPad Prism version 6.05, GraphPad Software Inc, San Diego, CA) was used for statistical analyses. In order to analyze intra-observer reliability, soft tissue measurements of randomly selected 10 subjects (5 males and 5 females) were measured two times by the same operator with a one-week gap.

To investigate the correlation between nasal asymmetry and the measured external nose volume, external nose area, anatomical nasal index, nasal protrusion index, body mass index, height and weight the correlation coefficient between these values were calculated. For normally distributed data, a Pearson's correlation coefficient was calculated, while a Spearman's correlation coefficient was computed for any abnormally distributed data.

Student t-test was used to compare gender differences. A p-value of less than 0.05 was considered statistically significant. Values were expressed as mean ± standard deviation (SD).

Results

We first examined the intra-observer reliability of our method. The correlation coefficient ($r=0.96$, $p<0.001$) showed that the intra-observer reliability of the method was very high. Descriptive statistically analyzed results for the measured parameters in both genders are represented in **Tables 1** and **2**.

Significant difference was observed between male and female in external nose volume and surface area. The mean value of external nose volume was approximately 30% higher and external nasal area is 12% larger in males compared to females. Additionally, mean nose width and height of male nose was 10% and 4% higher than the mean female nose, respectively. Mean body height, weight and BMI of male were 4%, 35% and 20% higher than the mean female values respectively.

A significant correlation was found between nose asymmetry value (as RMS) and external nose surface area ($r=0.33$, $p=0.03$) and also between nose asymmetry value (as RMS) and external nose volume ($p=0.34$, $r=0.03$). We did not find correlation in any other parameters. We further assessed the evidence of correlation according to the genders and no significant differences were found (**Table 2**).

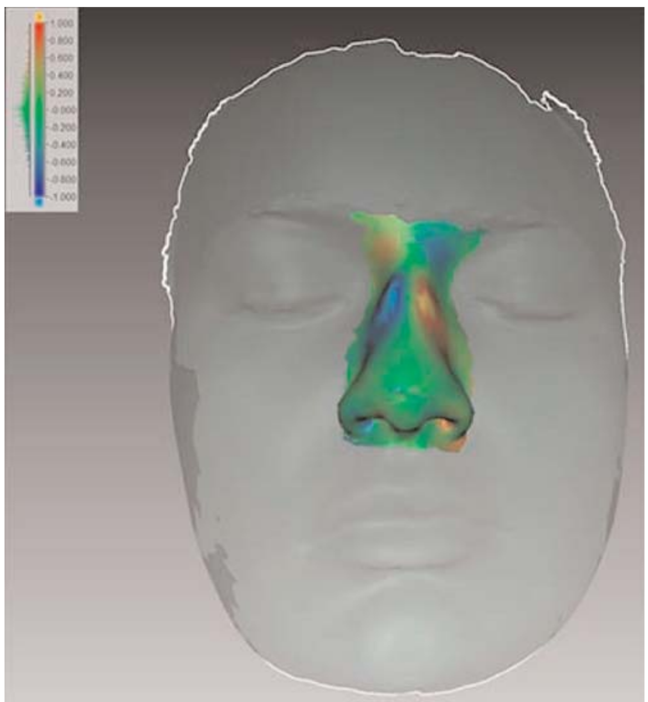

Figure 2. Image showing the deviation color maps after superimposition of original and mirrored facial scans of the same subject. The colored deviation map legend in the upper left corner shows the millimeter scale. The map changes in color from blue, which corresponds to negative distance, to red, which corresponds to positive distance; green means that the distance between surfaces at that particular point is close to zero. [Color figure can be viewed in the online issue, which is available at www.anatomy.org.tr]

Table 1
Means and standard deviations of the measurements compared by sex using t-test.

Gender	Nose asymmetry	Nose volume (cm³)	Nose surface area (cm²)	Nose width (mm)	Nose height (mm)	Anatomic nasal index (%)	Nasal protrusion index (%)	Body height (m)	Body weight (kg)	Body mass index (BMI)
Males	0.52±0.2	9±1*	19.5±1.7*	34.7±2.5*	53.9±3.5*	64±8	32±4	1.76±0.06*	77.5±12.9*	24.7±3.4*
Females	0.43±0.1	7.19±0.9	17.1±1.7	31.6±1.6	51.7±3	61±4	34±39	1.69±0.04	57.9±6.3	20.3±1.75
Total	0.48±0.16	8.1±1.3	18.2±2.1	33.1±2.6	52.8±3.4	63±6	33±4	1.72±0.07	67.7±14.2	22.5±3.5

*Indicates significant difference between male and female ($p<0.05$).

Discussion

In this study, we analyzed the anthropometric parameters of the nose with a 3D method and reported the external nasal volume and area of young Turkish males and females for the first time in the literature. Examination of the correlation among the measurements showed that nasal asymmetry corelates with nasal volume and area.

We demonstrated the nasal asymmetry using surface topography measurement method. In this method, the asymmetry of the nose was calculated by comparing the whole surface with the mirror image of the surface, instead of comparing a few determined landmarks between the right and left sides. The advantage of the present method is that, every point composing the surface can be included to the calculation and a quantitative data can be obtained. Additionally, colored surface maps demonstrate a visual data which makes it easy to understand the alteration at any points of the surface. Another advantage of our method is that all measurements were performed on a single scanned data in contrast to 2D methods. In 2D methods, the measurements are performed from several images which are captured from different aspect of the nose. This may cause increment of variability cussed by different landmark identification or caliper positioning in every aspect.

There are several non-invasive techniques for facial analyses using 3D reconstruction. They offer significant changes in the process of diagnosis, such as structured light scanner, laser scanning, contact digitization, magnetic resonance imaging and stereo photogrammetry.[6] The most important advantage of such systems is the speed in data acquisition. Quick acquisition of the image reduces the effect of subject movements, and therefore increase accuracy of the measurements. The accuracy and reproducibility of 3D imaging systems have been confirmed by several studies.[5,15,16]

Table 2
Correlation between nose asymmetry and determined nasal measurement.

	Males		Females		Total	
	r	p	r	p	r	p
Nose volume	0.19	0.43	0.34	0.14	0.34	0.03*
Nose surface area	0.22	0.34	0.27	0.26	0.33	0.03*
Nose width	0.10	0.66	0.19	0.42	0.26	0.11
Nose height	0.09	0.7	0.41	0.07	0.25	0.11
Anatomic nasal index	0.07	0.78	-0.16	0.05	0.08	0.61
Nasal protrusion index	0.37	0.11	-0.11	0.63	0.13	0.41
Body height	-0.39	0.09	0.17	0.46	-0.02	0.88
Body weight	-0.23	0.33	-0.03	0.9	0.06	0.71
Body mass index	-0.06	0.81	-0.09	0.71	0.13	0.44

*$p<0.05$

There are several studies focusing on nasal morphometric parameters which differ among the races and genders. Most of them provide data concerning basal values which are obtained from a local population.[17–21] Such anthropometric data play a key role in clinical evaluations, in point of providing a precise diagnosis for different syndromes and evaluating and planning surgical treatment.

The result of a recent study describing the average values of the nasal anthropometric measurements in a young Turkish male population (ranging in age from 18 to 30 years) reported the mean height (N-Sn) of the nose as 56.92±0.44 mm, width of nose (AcR-AcL) as 23.14±0.28 mm.[17] In another study, the authors analyzed facial soft tissue of healthy Turkish young adults (ranging in age from 18 to 24 years) with a photographic method and reported the mean height (N-Sn) of the nose as 5.19±0.75 mm.[22]

The external nasal volume and area measurements are other parameters in evaluation of nasal dimensions. In the literature, there is no study reporting the external nasal volume and nasal area of Turkish population. For the estimation of nasal volume and area, different geometric approximations were used. By using two defined tetrahedral method, Ferrario et. al.[19] approximated the external nasal volume and area. They reported the volume as 11.16±1.33 cm^3 and the area as 22.6±2.15 cm^2 in adults (aged 19 to 32 years). With the same approximation method, in an anthropometric study which measures the external nose in 18–25 year old Sistani and Baluch aboriginal women in southeast of Iran, the external nose surface area was measured as 17.52±2.12 cm^2 in Sistani group, and 18.94±1.6 cm^2 in Baluch group.[20] In the same study, the nasal volume was reported as 4.79±0.35 cm^3 and 5.23±0.45 cm^3 in Sistani and Baluch groups, respectively. External nasal parameters of 1000 healthy Egyptians aged 20–70 years were analyzed with a photogrammetric method and the external nasal volume was reported as 4.58±3.57 cm^3 in males and in 4.02±2.93 cm^3 in females for a 20–30 years age group.[18] The value of external nasal area was 17.67±1.6 cm^2 in males and 15.58±1.7 cm^2 in females. External nose volume in fifty young adults was calculated as 9.06±1.3 cm^3 in males and 7.03±1.2 cm^3 in females using a formula developed by mathematician David Bash.[23] The findings of Bash are very close to our measurements. In a mix longitudinal study, Burke et al.[24] approximated the nasal volume by using facial contour map created by stereometrics camera and contour plotting machine. In the aforementioned study, the nasal volume of the 26 boys and 26 girls between the ages of 9 and 16 years were reported as 15.2 cm^3 and 11.2 cm^3, respectively.

The contribution of symmetry and averageness of facial features to facial beauty is matter of concern. Thornhill et al.[25] noted that averageness and symmetry could both contribute to the attractiveness of averaged composites. Langlois et al.[26] rejected the symmetry hypothesis. They argued that facial symmetry is not attractive and, therefore, cannot be in charge of the attractiveness of averaged composites. By using the photographic images which were rated by the subjects, they showed that there was no correlation between symmetry and attractiveness. Additionally, Kowner et. al.[27] showed that perfectly symmetrizing using a software make the faces less attractive than the originals. However, in contrast to aforementioned works, several studies reported significant correlations between facial symmetry and attractiveness.[1,28,29]

Although the face is generally one of the most revealing parts of body, evidence suggests that most people focus on the region of the nose, eyes and mouth.[30] Size of the facial features is important factor for attractiveness and the average face features are perceived more attractive.[31,32] Grammer et al. showed that while the women rate larger nose as healthy and attractive, men rate smaller nose as attractive.[1] Men whose noses are near the means of the distributions received higher ratings than men whose noses were either smaller or larger than average.[33] In our study, in order to investigate the correlation among symmetry and size, we performed quantitative measurements instead of inspecting rating of participants in photographs. We believe that our data contributes to the literature by presenting new quantitative data.

Conclusion

The effect of nose size and asymmetry on facial beauty has been discussed in several studies. In our study, we inspected both parameters and presented quantitative data concerning nasal dimensions and correlation among them. The limitation of our study is the number of subjects; therefore, the findings of the present study needs to be confirmed with large cohort studies.

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