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ORIGINAL ARTICLE EXPERIMENTAL/SPECIAL TOPICS

Reliability of Nasofacial Analysis Using *Rhinobase*® Software

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Abstract

Objective Rhinoplasty is a constant challenge for the surgeon, where the correct evaluation of facial aesthetic parameters allows harmonic changes appropriate for each patient. The aim of this study was to compare the preoperative and postoperative results of nasofacial analysis, performed by *Rhinobase*® software (indirect anthropometry) compared with direct anthropometry (caliper), in patients undergoing aesthetic rhinoplasty.

Methods The authors assessed the reliability of using *Rhinobase*® software for measuring nasofacial characteristics in 20 individuals (18 F, 2 M). In each patient, the nasofacial analysis was performed before and after surgery. Two raters performed indirect anthropometry on each image on two separate occasions.

Results Intrarater and interrater reliability for most indirect anthropometric measurements had intraclass correlation coefficients greater than 0.8. Regarding intermethod reliability, Pearson correlation coefficients ranged from 0.6 to 0.9 for most measurements. The highest correlation was found in interalar width, chin vertical, and lower facial height. The Cronbach's α coefficient calculated for all measurements was 0.8.

Conclusions The *Rhinobase*® software is an easy and safe method for facial analysis. This study provides evidence of high reliability for several nasofacial measurements. The nasofacial analysis allows an accurate preoperative evaluation, surgical planning, and analysis of outcomes in rhinoplasty and may be a useful tool for both novice and experienced surgeons.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Nasofacial analysis · Facial anthropometry · *Rhinobase*® · Rhinoplasty

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Introduction

Aesthetic rhinoplasty is a constant challenge for the surgeon because its main objective is to create a nose that is aesthetically pleasing for the patient without compromising nasal function [1]. To achieve this goal, the correct evaluation of facial aesthetic parameters is fundamental to obtaining harmonic changes, and the rhinoplasty surgeon must have a solid understanding of these concepts. While neoclassical canons are a reference of ideal artistic beauty, their use has been limited because the real proportions usually differ from the aesthetic standard [2, 3]. In contrast, other methods have tried to define the ideal nose considering different facial measurements to determine the aesthetically proportioned nasal aesthetics for each individual patient. [4, 5]. However, to achieve any standard, measurements must be performed on the patient's face to understand the problem, plan the surgery and evaluate results.

We have used the term "Nasofacial Analysis" as the procedure of measuring each patient's face for planning and assessment in rhinoplasty. These preoperative dimensions, desired and real postoperative changes can be obtained by direct or indirect anthropometric methods. The direct methods use rulers and slide-calipers directly on the patient's face [6], while indirect techniques use the patient's photographs (printed or digital) to perform these measurements. The value of indirect anthropometry using photogrammetric facial analysis has been evaluated by several studies [7–13]. Obtaining measurements from photographs is cost-effective and widely applicable and provides a permanent record of the face, but it is time-consuming, not easy to perform and has not been correlated with direct nasofacial analysis [14].

In 2009, Apaydin et al. [15] developed *Rhinobase*®, an innovative comprehensive software for rhinoplasty that facilitates the storage and retrieval of patient information, serves as an educational and self-assessment tool to help both novice and experienced surgeons navigate through the art and science of rhinoplasty, helps make facial analysis an easy task for the surgeon, and saves the patients' images within the database. As this software seems to eliminate all the problems of facial analysis, and considering that direct anthropometry is still the best way to perform these measurements, we decided to parallel their outcomes. Consequently, the aim of this study was to compare the preoperative and postoperative results of nasofacial analysis performed by *Rhinobase*® software (indirect anthropometry) with those obtained by direct anthropometry (caliper) in patients undergoing aesthetic rhinoplasty.

Materials and Methods

Patients and Settings

The study was conducted between June 2013 and December 2013. After approval by the internal review boards, patients undergoing aesthetic rhinoplasty were included in the study and signed informed consent forms. Patients with functional nasal problems, dermatologic conditions or scars over the nose were excluded from the study.

Nasal Surgery

All aesthetic rhinoplasty procedures were performed by the senior surgeon (PA) through an open rhinoplasty technique. During the operation, the nasal dorsum was treated by a component dorsal reduction approach, independently resecting the dorsal septum, the upper lateral cartilages and rasping of the bony dorsum. Osteotomies were performed using the internal approach locating the piriform aperture area through the same open rhinoplasty access. All patients underwent cephalic resection of the alar cartilages, transdomal, and interdomal sutures. Tip grafts and columellar strut grafts were used if required. Soft intranasal plugs were left for 24 h and the external thermoplastic splint was removed after 7 days.

Direct and Indirect Nasofacial Analysis

The nasofacial analysis parameters used were: middle facial height (MFH), lower facial height (LFH), radix projection (RP), nasal length (NL), chin vertical (CV), interalar width (IW), intercantal width (ICW), tip projection (TP), nasolabial angle (NLA), and chin projection (CP). A detailed description of cephalometric points, distances, and angles is summarized in Table 1. Direct anthropometry was performed by the senior author using rulers and calipers. The measurements obtained were recorded on a picture of the patient in frontal and lateral views using Microsoft Power Point software (Microsoft Corp, Washington, USA) as shown on Fig. 1.

For indirect anthropometry, frontal and lateral views were taken by the same photographer using a digital camera with flash (Nikon Coolpix P7100, Japan). The patient stood 2 m approximately away from the camera and the height was adjusted individually. Eyes were fully open and equally leveled, lips were closed with no smile, ears were symmetrically exposed, and the patient was asked to keep a normal and natural gaze to avoid rotations. Pictures were taken with a ruler on the side of the head or a previously known measurement for calibration purposes during photogrammetric analysis. The pictures were uploaded and calibrated in the *Rhinobase*® software. Specific landmarks were marked on the pictures, and the program calculated distances and angles automatically and displayed them in a continuous frame as shown in Fig. 2. Two other surgeons, different from the senior surgeon and unaware of the direct nasofacial analysis results, performed the *Rhinobase*® analysis. These surgeons worked independently and performed the analysis twice, with a difference of 30 days between the first and second measurements. Direct and indirect anthropometry was performed in the preoperative period and after 6 months of follow-up, using the same protocol.

Outcomes and Statistical Analysis

Statistical analysis was carried out using Stata version 10.0 for Windows (StataCorp, Texas, USA). To evaluate intrarater and interrater reliability of the *Rhinobase*® analysis, the intraclass correlation coefficient was calculated. When this coefficient is close to 1 it indicates high reliability, and when close to 0 low reliability [16]. The mean absolute difference was calculated by averaging the absolute difference between the first measurement and the

Table 1 Anthropometric parameters used for nasofacial analysis and their descriptions

Parameter	Descriptions
Glabella	Most protruded point of the forehead in the mid-sagital plane
Radix	Most retruded point in the area overlaying the fronto-nasal suture
Subnasale	Point where the columella merges with the upper lip in the sagittal plane
Nasal tip	Point of maximum anterior projection of the nose on the lateral view
Bisecting nostril axis	Line that divides the nostrils in 2 equal halves on the lateral view
Stomion	Point at which the upper and lower lip make contact
Menton	Lowest point on the soft tissue profile of the chin in mid-sagittal plane
Pgonion	Most anterior point on the soft tissue profile of the chin in mid-sagittal plane
Vertical facial plane	Line that starts at the radix an perpendicular to the Frankfurt plane
Franfurt plane	Horizontal line from the superior border of tragus and infra-orbital rim
Middle facial height (MFH)	Distance between glabella and subnasale
Lower facial height (LFH)	Distance between subnasale and menton
Radix projection (RP)	Distance between the anterior corneal plane and radix
Nasal length (NL)	Distance between radix and nasal tip
Chin vertical (CV)	Distance between stomion and menton
Interalar width (IAW)	Widest distance between the alar bases
Intercantal width (ICW)	Distance between right and left medial cantus
Tip projection (TP)	Distance between the alar-cheek junction and nasal tip
Nasolabial angle (NLA)	Angle between bisecting axis of the nostril and vertical facial plane
Chin projection (CP)	Distance from pgonion to the vertical facial plane

second. Technical error of measurement is calculated as $\sqrt{(\sum D^2/2N)}$, where D is the difference between measurements and N is the number of subjects measured. These statistics can be interpreted similar to a standard deviation [17]. The correlation between the data obtained by indirect anthropometry (*Rhinobase*®) and the data obtained by direct anthropometry in the pre- and postoperative period was also accomplished using the Pearson correlation test. Pearson correlation coefficient values are between 0 and 1, and higher estimates indicate higher reliability. Cronbach's α coefficient was used for internal consistency, and a p value $\leq$0.05 was considered to be statistically significant.

Results

A total of 20 consecutive adult patients met the inclusion criteria to be part of this study. There were 18 females and 2 males, with a mean age of 34.5 ± 8.7 years (range 18–55). The correlations between measurements performed by the same evaluator using the *Rhinobase*® software (intrarater variability) were greater than 0.9 for 8 of the 10 measurements, 0.88 for tip projection, and 0.79 for intercantal width. The mean absolute differences were less than 1 mm for all measurements. Technical error of measurement was less than 2 mm for 9 of 10 measurements and 3.13° for nasolabial angle (Table 2).

The correlations between measurements performed by different evaluators using the *Rhinobase*® software (interrater variability) were greater than 0.9 for 8 of the 10 measurements, 0.81 for tip projection, and 0.57 for interalar width. The mean absolute differences were less than 1 mm for 5 measurements, less than 2 mm for 2 measurements (RP, TP), 2.01 mm for intercantal width, 3.07 mm for interalar width and 3.17 mm for nasal length. The technical error of measurement was less than 2 mm for 6 of 10 measurements, 2.01 mm for intercantal width, 2.2 mm for interalar width, 2.36 mm for nasal length and 3.43° for nasolabial angle (Table 3).

The width of 95 % confidence interval for the intrarater and interrater correlation coefficient was less than 0.3 for most measurement. The width of the confidence interval lower than 0.3 supports an appropriate number of raters for the test [18].

The mean, standard deviation, and correlation coefficient for all nasofacial anthropometric measurements obtained by direct and indirect rhinometry (*Rhinobase*®) in the pre- and postoperative period are shown in Table 2. The Cronbach's α coefficient calculated for all measurements was 0.8. Almost all of the measurements demonstrated statistically significant correlations in the pre- and postoperative period. In the preoperative period, the anthropometric measurements with higher correlations were interalar width ($r = 0.89$, $p < 0.001$), chin vertical ($r = 0.89$, $p < 0.001$), lower and

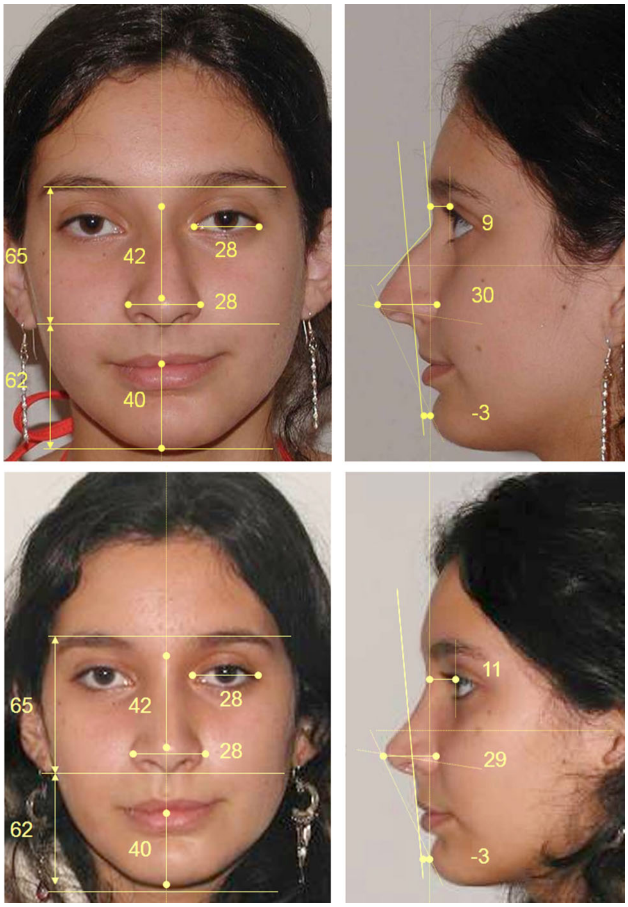

Fig. 1 Representative images of the nasofacial analysis process. Preoperative (*above*) and postoperative (*below*). Measurements made with calipers are recorded on a photograph of the patient

middle facial height ($r = 0.84$, $p < 0.001$), and the measurements with lower correlations were chin projection ($r = 0.56$, $p = 0.009$), nasolabial angle ($r = 0.71$, $p < 0.001$) and tip projection ($r = 0.62$, $p = 0.003$). In the postoperative period, the anthropometric measurements with higher correlations were interalar width ($r = 0.89$, $p < 0.001$), nasal length ($r = 0.85$, $p < 0.001$), and chin vertical with lower facial height ($r = 0.84$, $p < 0.001$), and the measurements with lower correlations were nasolabial angle ($r = 0.33$, $p = 0.16$) and chin projection ($r = 0.17$, $p = 0.46$) (Table 4).

Discussion

The objectivity of anthropometric measures in nasofacial evaluation is useful to both the surgeon and the patient. When planning a surgery, it can help us identify the suitable proportion and location of different anatomical variations [19]. After the operation, subjective impressions can differ from the objective realities. Patients generally forget the look of their preoperative nose very soon and may not appreciate true changes in it [6]. Objectively measured postoperative changes can facilitate communication and can help in outcome assessment [6, 20]. Direct measurements on the patient's nose (direct anthropometry) have been considered the gold standard for facial analysis, although it is sometimes difficult to measure angles and distances to virtual planes. On the other hand, indirect methods using printed or digital pictures (indirect anthropometry) have been questioned because taking a good picture is not easy, and doing all the landmarks patterns is complicated and time-consuming.

In this study, the authors used the software *Rhinobase*® for indirect anthropometry. The program setup files can be downloaded free of charge from www.rhinobase.net. It has a photographic analysis section that is very easy to use and decreases the time spent for the entire facial study to a maximum of 10–15 min [15]. After calibration by means of a ruler or known distance in the picture, landmarks are marked in the image and *Rhinobase*® automatically calculates all the distances and angles. The software also has different windows for clinical history, physical examination, surgery details, and postoperative follow-up, serving as an all-in-one solution for documentation of rhinoplasty patients. In this study, two independent surgeons performed the photographic analysis twice, separated by 30 days. After correlation of all these parameters, we observed that intrarater reliability was slightly better than the interrater reliability for certain anthropometric parameters (Tables 2, 3) and may reflect biases of individual observers, proving that the picture analysis of the software was reliable and consistent.

Certainly, it is important to note that the anthropometric analysis of digital photographs can also be performed with conventional programs such as Photoshop®, which can obtain measurements and angles by previous calibration [21].

One of the main purposes of this study was to assess the correlation between direct and indirect anthropometry. Critics of indirect measurements state that taking an adequate picture is difficult, that measuring angles and lengths is a labor-intensive task, and that completing the entire analysis takes long periods of time. Although some authors have recommended very complex settings for photography [9–11, 22], the authors opted for a simple way of taking pictures using specific reference points to avoid asymmetry in part of the rotational axis of the head. Symmetric exposure of the ears, eyes equally leveled and natural gaze with the camera at the level of the nose were considered to avoid rotations in the horizontal, coronal, and sagittal planes, respectively. Despite the fact that previous knowledge of the different cephalometric points is required, the *Rhinobase*® software made measurements very easy and

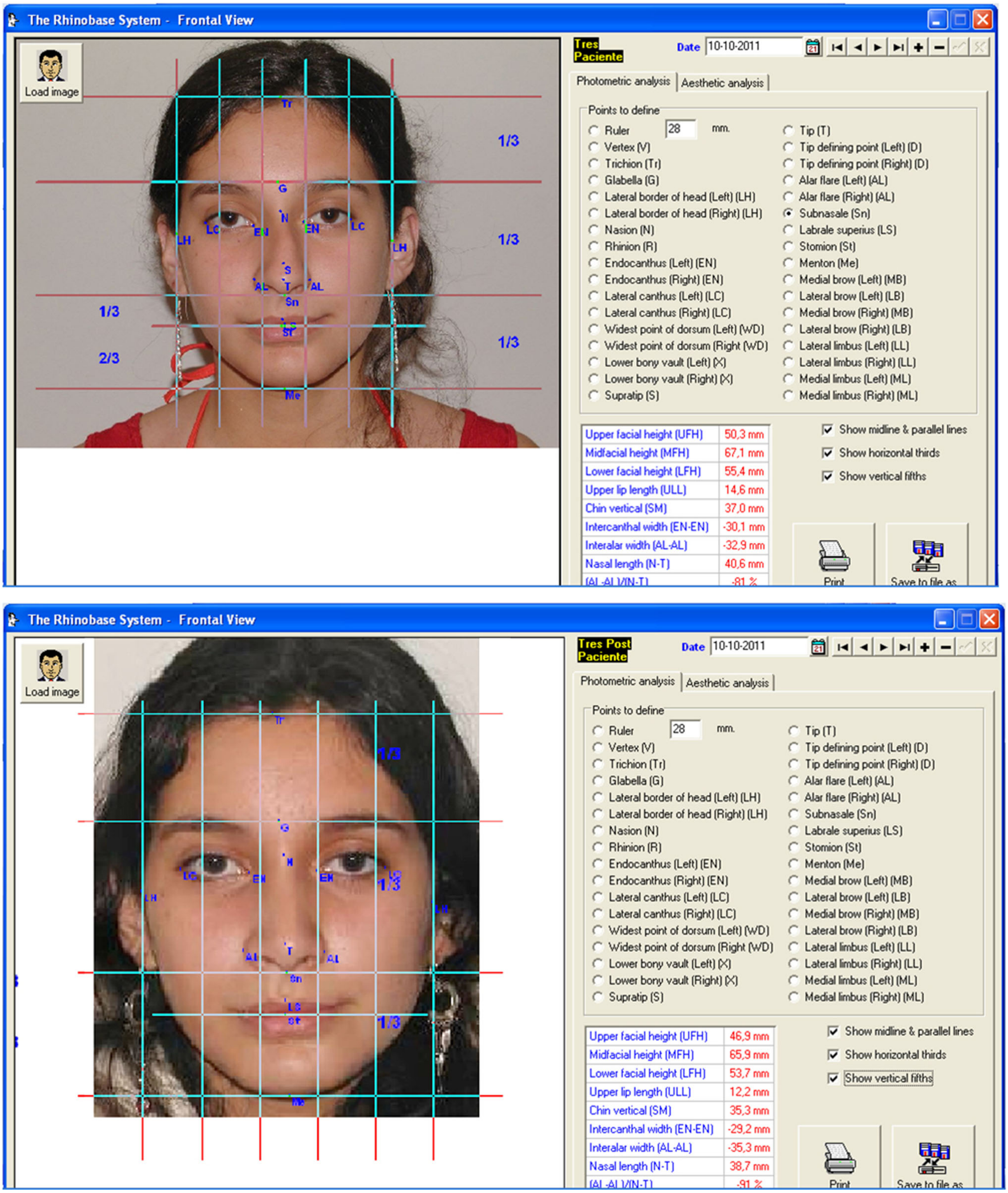

Fig. 2 Representative images from the Rhinobase software. Preoperative (*above*) and postoperative (*below*). Frontal and lateral views were taken with a ruler for calibration. After marking the landmarks on the picture, all the angles and distances were calculated automatically by the program

Table 2 Intrarater reliability of indirect anthropometry on *Rhinobase*® ($n = 20$)

Landmark	Correlation Coefficient (95 % CI)	MAD	TEM
Middle facial height (MFH)	0.99 (0.99–1.00)	0.18	1.84
Lower facial height (LFH)	0.99 (0.96–1.01)	0.43	1.54
Radix projection (RP)	0.99 (0.99–1.00)	0.13	0.49
Nasal length (NL)	0.93 (0.75–1.11)	0.09	0.77
Chin vertical (CV)	0.91 (0.73–1.09)	0.29	1.28
Interalar width (IAW)	0.98 (0.94–1.02)	0.54	0.78
Intercantal width (ICW)	0.79 (0.20–1.37)	0.11	1.18
Tip Projection (TP)	0.88 (0.64–1.12)	0.70	1.13
Nasolabial angle (NLA)	0.93 (0.74–1.12)	0.32	3.13
Chin projection (CP)	0.95 (0.84–1.05)	0.31	0.45

CI confidence interval, *MAD* mean absolute difference, *TEM* technical error of measurement

Table 3 Interrater reliability of indirect anthropometry on *Rhinobase*® ($n = 20$)

Landmark	Correlation Coefficient (95 % CI)	MAD	TEM
Middle facial height (MFH)	0.96 (0.84–1.07)	0.10	1.68
Lower facial height (LFH)	0.96 (0.85–1.06)	0.76	1.56
Radix projection (RP)	0.94 (0.77–1.11)	1.47	1.15
Nasal length (NL)	0.91 (0.73–1.09)	3.17	2.36
Chin vertical (CV)	0.99 (0.98–1.00)	0.99	1.25
Interalar width (IAW)	0.57 (0.10–1.76)	3.07	2.20
Intercantal width (ICW)	0.93 (0.79–1.07)	2.01	2.01
Tip projection (TP)	0.81 (0.44–1.18)	1.67	1.71
Nasolabial angle (NLA)	0.91 (0.73–1.09)	0.34	3.43
Chin projection (CP)	0.98 (0.94–1.01)	0.01	0.54

CI confidence interval, *MAD* mean absolute difference, *TEM* technical error of measurement

Table 4 Correlation results between *Rhinobase*® and direct anthropometry measurements performed in the pre- and postoperative period

	Preoperative				Postoperative			
	Rhinobase®	Direct anthropometry	Pearson	*p* Value	*Rhinobase*®	Direct anthropometry	Pearson	*p* Value
Middle facial height (MFH)	60.79 ± 7.86	61.35 ± 6.08	0.84	<0.001	62.05 ± 6.93	61.63 ± 6.11	0.79	<0.001
Lower facial height (LFH)	61.29 ± 9.42	60.2 ± 6.1	0.84	<0.001	61.84 ± 7.84	60.52 ± 5.46	0.84	<0.001
Radix projection (RP)	13.33 ± 3.44	10.50 ± 1.93	0.79	<0.001	12.26 ± 2.28	10.35 ± 1.13	0.72	<0.001
Nasal length (NL)	34.38 ± 3.46	39.22 ± 4.84	0.77	<0.001	36.5 ± 5.33	39 ± 5.25	0.85	<0.001
Chin vertical (CV)	40.91 ± 6.48	40.55 ± 5.32	0.89	<0.001	41 ± 6.16	40.8 ± 4.74	0.84	<0.001
Interalar width (IAW)	31.99 ± 4.46	31.7 ± 3.31	0.89	<0.001	32.07 ± 4.54	31.75 ± 3.3	0.89	<0.001
Intercantal width (ICW)	30.58 ± 4.66	30.6 ± 3.64	0.82	<0.001	30.09 ± 4.02	30.55 ± 3.64	0.76	<0.001
Tip projection (TP)	22.68 ± 2.72	26.1 ± 3.16	0.62	0.003	24.57 ± 3.17	26.6 ± 2.83	0.79	<0.001
Nasolabial angle (NLA)	103.91 ± 11	99 ± 8.82	0.71	0.0004	102.11 ± 24.25	104.5 ± 8.25	0.33	0.16
Chin projection (CP)	4.98 ± 2.81	4.2 ± 3.62	0.56	0.0098	4.41 ± 2.15	3.35 ± 2.53	0.17	0.46

fast. After using this technique, a couple of times and gaining experience, the time taken for the complete nasal analysis is no more than 15 min. In addition, the results of this study support the claim that indirect anthropometry using *Rhinobase*® software is a suitable method for facial analysis, providing reliable data that correlate well with direct anthropometry with a high internal consistency (Cronbach's $\alpha = 0.8$). The value of alpha (α) ranges from 0 to 1 and increases when correlations between the instrument items increase [23].

Correlations were very high for almost all of the measurements between direct and indirect anthropometry in the pre- and postoperative periods (Table 2). Interestingly, correlations were higher for lengths between solid points such as inter-alar distance, chin vertical, nasal length, lower, and middle facial height. In contrast, measuring angles or distances between points and virtual planes showed the lowest correlations, such as nasolabial angle and chin projection. In our opinion, this is not attributed to the *Rhinobase*® software but to problems in direct anthropometry. Making measurements of angles and distances between intangible landmarks is difficult when done directly on the face of the patient. And sometimes more than measurements, these are approximations that increase variability. For example, the nasolabial angle is not easy to measure directly, and it is even more difficult to deal with the distance of the pgonion and the virtual vertical plane coming from the radix perpendicular to the Frankfurt plane [24, 25]. At this level, computerized calculations may be even more accurate than direct measurements and should be considered to have an advantage over direct methods [13, 14, 26].

In the present study, indirect measurements were performed on two-dimensional photographs that may require recalibration to actual life size with the use of a ruler. However, the nose is a three-dimensional structure, and subtle irregularities can be difficult to visualize in two dimensions. The three-dimensional imaging systems employ linear and spatial parameters, the images are reproducible and maintain the proportions of the face independent of technique, photographer, camera, and lighting. Furthermore, rather than measure straight point-to-point distances, which is possible with two-dimensional photographs, the distances from point to point can be measured along the contour of the nose with three-dimensional imaging software [27]. Heicke et al. evaluating the reliability of craniofacial anthropometry using three-dimensional digital stereophotogrammetry, found high reliability for several measurements in 40 individuals [28]. Comparing the results of their study with our own, we believe that 3D technology may further improve many of the correlation coefficients. However, a key difference that may explain the increased reliability using 3D imaging is the protocol that uses dots on the face to note landmarks and requires palpation.

The pre- and postoperative results were evaluated using *Rhinobase*®, reflecting the change in the anatomical landmarks. Undoubtedly the next challenge will be to assess the same anatomical elements in a few years to review any change.

In conclusion, the *Rhinobase*® software is an easy and safe indirect method for facial analysis. This study provides evidence of high reliability for several nasofacial measurements. The nasofacial analysis allows accurate preoperative evaluation, surgical planning, and analysis of outcomes in rhinoplasty, and it can be a useful tool for both novice and experienced rhinoplasty surgeons.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest to disclose.

Ethical Approval Not required.

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