Facial reconstruction: Validation of the Tedeschi-Oliveira method for estimating the pronasale point in Brazilians

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Abstract: Forensic facial reconstruction aids in the process of human identification by facial recognition. The nose plays an important role in this process; however, its soft tissues wither away during cadaveric decomposition. There are few studies in the area of facial recognition of the Brazilian population, especially concerning Brazilian nasal prediction guides. This study aimed to test the hypothesis that the angle formed by the tangents drawn from the rhinion and prosthion points (nose tip) is equal to 90°, as proposed by the pioneer study by Tedeschi-Oliveira et al. (2016). It is important to highlight that this is the only method to date developed to predict the nasal tip in Brazilians, and has not yet been tested in other populations. Images of computed tomography scans of 228 individuals (171 females and 57 males) were screened according to the same criteria used by the authors of the primary study. The images were analyzed using the Horos® program, version 1.1.7 – 64 bit. The mean angle studied was about 90°, and any difference between this mean and the real angle measured did not significantly compromise the accuracy of the nose tip location. The findings tested in the present study corroborate the hypothesis investigated by Tedeschi-Oliveira et. al. Therefore, we suggest that the method be used in forensic practice to estimate nose tips in Brazilians.

Keywords: Forensic Sciences; Forensic Anthropology; Facial Recognition; Nose.

Introduction

Forensic facial reconstruction (or forensic facial approximation) is an auxiliary method that can be used to allow facial recognition in human identification processes, when the primary methods cannot be applied.[1] Small changes in facial structures may alter the final appearance and characterization of the face, and thus compromise recognition.[1]

It is known that the facial shape, as well as the morphology of facial features, depends on skull morphology, and hard (cartilaginous) and soft (muscle and adipose)[1] tissues partly influenced by an individual's sex, age and ancestry.[1]

The final characterization of the face is also influenced by the individual traits not related to bone formation, and congenital or predictable genetic manifestations, such as scars, wrinkles, birthmarks,

and others. The influence of these factors on facial recognition can be minimized by conducting studies to establish accurate technical-scientific parameters to estimate the face using the elements made available by the skull. For this reason, facial soft tissues are studied according to populations, sexes and ages.

The nose is located in the center of the face, and exerts great influence on facial recognition, together with the mouth and eyes.[1,2,3] As regards the influence of sex on nasal morphology, it is well established that women tend to have a smaller nasal structure than men;[4,5,6,7] this dimorphism becomes evident after childhood[4]. Furthermore, the nose is composed mostly of tissues that suffer decay after death (cartilaginous, muscular, adipose and vascular tissues), leaving few reliable bone parameters to enable approximation.[8,9,10,11] There are several studies in the literature that propose methods to acquire information on nasal approximation.[12,13,14,15,16,17,18,19,20,21,22,23] Stephan et al.,[15] for example, developed a technique based on regression equations to quantify links between the soft and hard dimensions of the nose. Macho[12] also proposed a technique based on the application of some measurements taken in the nasion-sella plane, using the regression equation to predict nasal height, length and depth. However, these methods often require complex tracing, which increases the chance of error upon reconstruction, and therefore makes them inadequate to apply in forensic practice.

In Brazil, studies on this facial recognition technique are still scarce, and the existing validated methods have been unable to make facial approximations that could be applied reliably to its population. This gap was partly filled by Tedeschi-Oliveira et al.,[24] who proposed a method of estimating a nasal projection from the rhinion and prosthion points, both landmarks on the bone surface. The authors believe that the junction of the tangents drawn from these points forms a vertex of approximately 90°, that is, the point where the tip of the nose would be located (pronasale point). It should be emphasized that their research was developed using radiographies of a Brazilian sample.

The present study aims to validate the method presented by Tedeschi-Oliveira et al.[24] using a different Brazilian sample and CBCT exams.

Methodology

The present study was approved by the research ethics committee of the School of Dentistry of the University of São Paulo, registered under protocol number 2.135.168. The sample consisted of 228 cone-beam CT images (171 females and 57 males) from the collection of the Laboratory of Image Analysis and Processing of the School of Dentistry, University of São Paulo (LAPI FO-USP). The inclusion criteria consisted of individuals of both sexes, aged ≥24 years, not having been submitted to any orthognathic surgery, with no craniofacial deformities, no rehabilitated canines or upper canine tooth loss.

The samples were analyzed using the Horos® open source software program, version 1.1.7 – 64 bit (Purview, Annapolis, Maryland, USA); all the Horos® tools used in this study are public domain. The analysis was performed entirely using multiplanar reconstruction (3D MPR) visualization, and maximum intensity projection (MIP) equal to zero, in order to minimize image distortion.

The study examiner marked the following points in the median sagittal plane with the point tool (Figure 1), following the same parameters as Tedeschi-Oliveira et al.:[24]

a. Rhinion (rhi): located at the lower border of the nasal bone
b. Pronasale (pn): located in the soft tissue, at the most prominent point of the nose (tip of the nose), aligned with the tangent that passes through the pogonion point (pg). This point was recorded as the 'actual pn.'
c. Prosthion (pr): the lowest point of the alveolar bone crest, located between the upper central incisors.

Once the points were marked, they were joined with the angle tool to gauge the rhi-pn-pr angle. This measurement was recorded as the 'actual angle' (Figure 2). Then, the angle tool was used to position
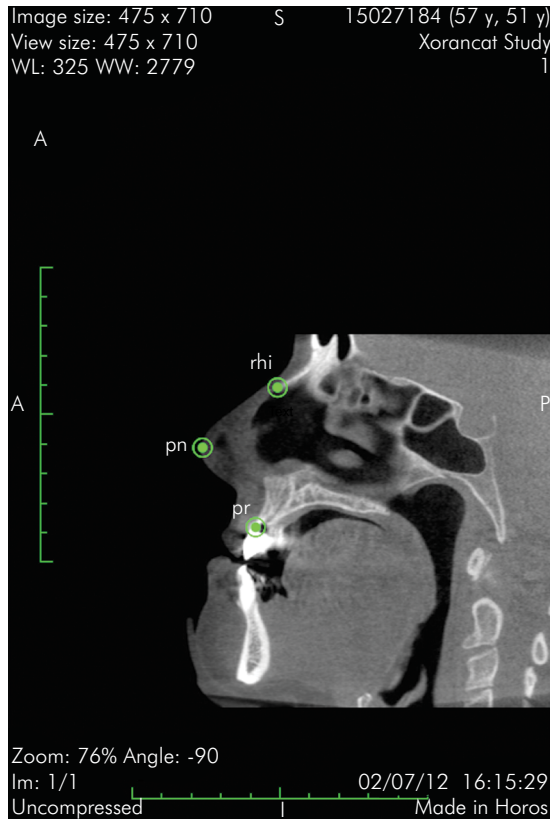
Figure 1. Sagittal window of multiplanar reconstruction with 0 mm MIP set, medial sagittal cut. The landmark establishes the rhi, pn and pr points.
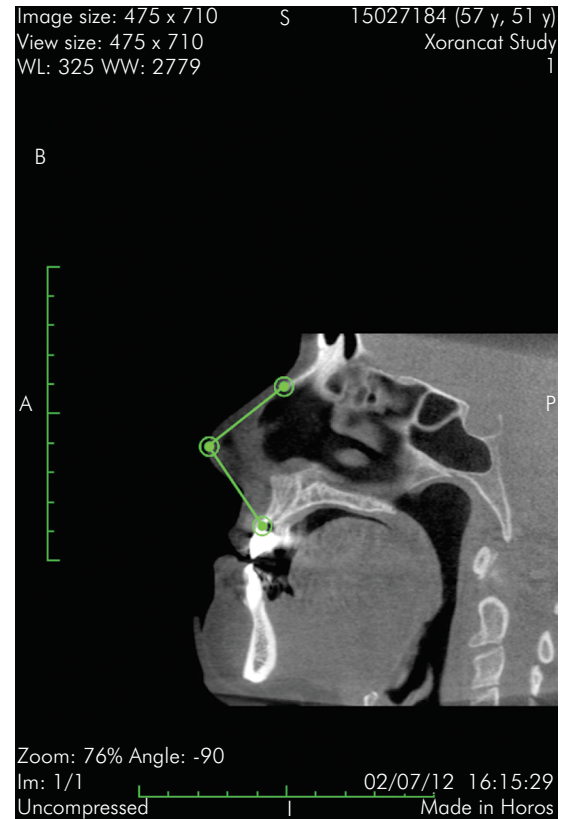

Figure 2. Sagittal window of multiplanar reconstruction with 0 mm MIP set, medial sagittal cut. The lines establish the actual angle.

the vertex in line with the pronasale point, until the value of the angle equaled 90°. This was recorded as the 'estimated angle,' and the vertex, as the 'estimated pn' (Figure 3).

The 'length' tool was used to draw a line between the actual and estimated pn points, in order to gauge the distance between these points. The distance measured was recorded as the 'actual distance.'

The estimated distance between the actual pn and the estimated pn was calculated based on the Tedeschi-Oliveira et al.[24] hypothesis that each degree of difference between the actual and estimated angles corresponds to 0.31 mm.

The statistical analysis was performed using the SPSS program (version 21). The distribution of the rhi-pn-pr angle was measured based on the mean and the range. Since the sample distribution was normal (Shapiro-Wilk), the t-test was used to check whether there was a difference between the actual and

estimated distances (actual pn – estimated pn). The same test was used to analyze whether there was a difference in the mean actual angle for the male and the female groups.

Results

A single examiner obtained the required measurements. The result of the intraclass correlation coefficient (ICC) test showed high intraexaminer agreement (ICC: 0.99).

The mean age of the female (n = 171) and male (n = 57) groups was similar (51.9 and 51.2, respectively), but the variation in age range was higher in the female (24-86 years) than in the male group (24–73 years).

The mean angle studied was 96.5° (± 4.1) for the entire sample, (n = 228), considering a range from 78° to 100°. The female group presented a higher

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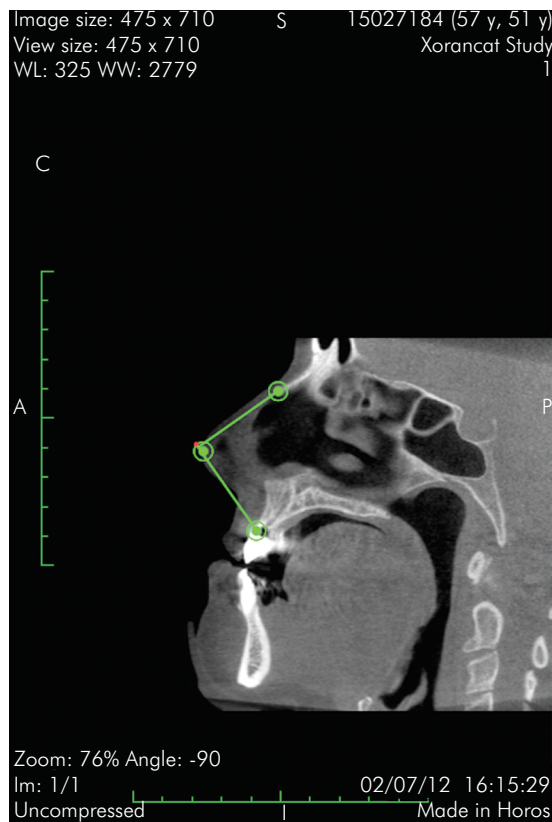
Figure 3. Sagittal window of multiplanar reconstruction with 0 mm MIP set, medial sagittal cut. The lines establish the estimated angle.

mean of 97.1º (± 3.4) (range of 83º to 100º), whereas the male group had a mean angle of 94.5º (± 5.3), with a greater range than the female group (78º to 100º). Table 1 shows the distribution of the mean rhi-pn-pr angle, according to each age group. Note that most of the female subjects (n = 71) were at an age level in which the mean rhi-pn-pr angle is greater than 90º. In the male group, there were more individuals (n = 20) in the age group that has a mean angle close to 90º (level 4).

The distance between the actual and estimated pn points was measured and resulted in 2.7 (±1.4) mm for the female group and 1.7 mm (± 2.1) for the male group. Finally, this analysis showed that the distance between the actual and estimated pn points obtained by direct measurement was different from that obtained according to the hypothesis that each 1º of difference in the rhi-pn-pr angle is equivalent to 0.31 mm (Table 2). The same diverging result was

Table 1. Mean (DP) rhi-pn-pr angle, according to age range for female and male groups.

Variable	n	Mean angle (º)
Female group	171	
Level 1	12	98.4 (± 1.4)
Level 2	37	97.8 (± 2.7)
Level 3	51	97.2 (± 3.4)
Level 4	71	96.6 (± 4.0)
Male group	57	
Level 1	7	96.4 (± 4.4)
Level 2	14	96.8 (± 3.7)
Level 3	16	92.2 (± 6.3)
Level 4	20	94.2 (± 5.1)

Level 1: 24 to 33.9 years; Level 2: 34 to 43.9 years; Level 3: 44 to 53.9 years; Level 4: over 54 years of age.

observed when considering each group of individuals according to sex.

Discussion

There are few studies in the forensic literature on facial reconstruction that use Brazilian samples, thus making it difficult to establish reliable parameters for facial approximation in this population. The sample described herein was composed only of Brazilian individuals. In addition, the present study used a sample of cone-beam CT images instead of lateral radiographies. Cone-beam CT images feature better dimensional stability than radiographies, thus making the results of the present study potentially more reliable.

Facial recognition does not depend only on the accuracy of the reconstruction.[2,3] Notably, the research in this area conducted by other studies has contributed toward increasing the accuracy level of these sculptures, thus promoting better recognition rates in a forensic context.[1] Therefore, it is important to establish a standard and reproducible method for estimating each facial feature. Tedeschi-Oliveira et al.[24] proposed a method to estimate the location of the nasal tip, validated by the present study.

As in their pioneer research, the present study found a higher average angular vertex (rhi-pn-pr) for women than men. The mean angle studied was higher than 90º

Table 2. Difference between actual and estimated distances of actual and estimated pn points.

Variable	T value[*]	p-value[*]	T value[**]	p-value[**]	T value[***]	p-value[***]
Actual distance	21.5	< 0.001	24.2	< 0.001	5.8	< 0.001
Estimated distance	23.4	< 0.001	26.6	< 0.001	6.4	< 0.001

*whole sample (n = 228); **female group (n = 171); ***male group (n = 57).

in the female group. However, the inaccuracy of the nose tip location, considering a 90° angle, was off by only 2.7 mm (± 1.4). This difference was smaller in the male group (1.7 mm ± 2.1), corroborating the findings of Tedeschi-Oliveira et al.[24] The estimated nose tip was placed about 3 mm from the actual pronasale point, a difference too small to compromise the facial set, thereby resulting in successful recognition. The angle in question was also analyzed, considering stratification of the sample by age group. Considering both sexes, the angle ranged from 92° to 98°, corroborating previous findings[24] that the value of the angle is about 90°.

The literature points out that nose size increases as age progresses.[7] Sforza et al.[7] observed that age influenced the volume, area, linear distances, proportions and nose angle of their studied sample. Almost all parameters analyzed in their study increased with advancing age, except the angle of the nose tip (formed by the junction of the nasal, pronasale and subnasale points). This decreased with increasing age, indicating that the nasal tip turns down over one's lifetime.

The age of the present study sample ranged from 24 to 86 years for the female group and from 24 to 73 years for the male group. However, the angle did not vary significantly across the different age levels, but maintained its distribution frequency of about 90°. The same was reported in the study by Tedeschi-Oliveira et al.[24] Thus, the method proposed by these authors can be applied to adult skulls, regardless of the estimated age.

The sample of this study, like that of Tedeschi-Oliveira et al.,[24] was composed of individuals from the southwestern region of Brazil. Since Brazil has a very mixed population, the Tedeschi-Oliveira technique should be validated in other Brazilian regions, in order to confirm the results in a population with ethnical characteristics potentially distinct from those of the southwestern sample.

Finally, the present study tested the hypothesis that each 1° of difference between the actual and estimated rhi-pn-pr angle (considering the 90° value) represents 0.31 mm of deviation between the actual and the estimated pn points.[24] However, these findings do not corroborate the hypothesis put forward by the Tedeschi-Oliveira study.

Conclusion

This study validated the technique presented by Tedeschi-Oliveira et al.,[24] and established its applicability to a Brazilian sample, with minimum variation. The results prove that a reliable nasal tip may be sculpted using the proposed 90° method.

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