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Forensic facial reconstruction: Nasal projection in Brazilian adults

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ABSTRACT

The nose has a marked cognitive influence on facial image; however, it loses its shape during cadaveric decomposition. The known methods of estimating nasal projection using Facial Reconstruction are lacking in practicality and reproducibility. We attempted to relate the points Rhinion, Pronasale and Prosthion by studying the angle formed by straight lines that connect them. Two examiners measured this angle with the help of analysis and image-processing software, Image J, directly from cephalometric radiographs. The sample consisted of 300 males, aged between 24 and 77 years, and 300 females, aged 24 to 69 years. The proposed angle ranged from 80° to 100° in both sexes and all ages. It was considered possible to use a 90° angle from projections of the Rhinion and Prosthion points in order to determine the Pronasale position, as well as to estimate the nasal projection of Brazilian adults.

1. Introduction

Forensic Facial Reconstruction can be defined as an auxiliary technique to human identification. It can aid the investigations of unknown bodies, as images, produced from a reconstruction of an unidentified skull, can be broadcast by the media and recognized by a family member [1].

However, it is important to consider that many of individual variations found in humans have no relation to bone size and shape but are relevant to the concept of identity of a face. Variations such as birthmarks, scars and facial expressions may not be predicted by the analysis of the skull, so the exact representation of the face is greater than the scope of forensic techniques and scientific data alone.

Nevertheless, the scientific approximation of facial characteristics depends on the knowledge of population traits and averages over soft tissue thickness, overlying known craniometric points, also eyes and lips position, among others. Using these guidelines, one can successfully produce images that resemble the relationships of the cutaneous portions in the living person.

Mean values of these tissue data are often used when reproducing a face, which can add a certain level of imprecision [2,3]. For the same points, the thickness presents important variations, depending on the technique used for measurements, which are demonstrated in most studies [1,4–14]. Also, the level of errors within the studies is statistically acceptable, but they add a level of imprecision that interferes with the success of the field [2,15].

The nose has remarkable cognitive importance in facial recognition [16], as it often connects an individual to their morphology. However, the soft tissue components that define the nose's shape and projection have no known bone portion correspondence [16–18], and little of its appearance remains after tissue decomposition [19]. Therefore, nose reconstruction has been a target of constant questioning, as it lacks scientific validation in study and application of facial-reconstruction techniques [17].

With aging, many changes occur to facial tissues and must be taken into account during Facial Reconstruction, as they are likely to change the facial expression. Nasal projection increases with age, in a downward and forward direction [13,20–24]. This growth in the nasal region occurs even after the age of 20 years, considered the age when an individual's bone growth is complete. Most of this growth occurs until early adulthood, but the exact age varies according to individual features and may continue even after, although with less intensity [20,24,25].

Sex-related differences appear only after childhood, when facial growth accentuates the prominence of the nose in boys. Soares and Andrade [16], Enlow [21] and also Inada et al. [26] concluded that

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there are no differences in nasal projection between boys and girls in early childhood, when both tend to have short, round and snub noses. However, Albert et al. [27] found little information about head and face bone changes after adulthood.

The current guidelines for nasal projection prediction from skull elements are often inaccurate, especially because they require complex tracing and execution of the nasal form. In the last century, only a few studies have tried to determine nasal projection for specific use in Forensic Facial Reconstruction. The most noteworthy were presented by: Gerasimov [28]; Krogman and Íscan [29]; George [30]; Williamson [31]; Lebedinskaya et al. [32]; and Prokopec and Ubelaker [33]. A critical study carried out by Stephan et al. [34] testing the four most commonly used methodologies in Forensic Facial Reconstruction suggests that new parameters need to be considered in order to relate nasal projection to recognized skull points.

Our study proposes a methodology that uses elements of the skull to determine the nasal projection point (Pn). The craniometrical landmarks used should be easily identified in a dry skull to allow for direct 3D modeling and digital work. From the results of pilot studies, the investigated hypothesis is that the vertices of a 90° angle between projections from Rhinion and Prosthion points could provide good approximation of the Pronasal point.

2. Material and methods

From a Brazilian, adult population, the sample consisted of 600 lateral radiographs of the head (cephalometric radiographs) where 300 males and 300 females were selected from the archives of digital databases, available at four Institutes for Dental Radiology, located in Sao Paulo, Brazil. Authorization for the use of these archives was granted and stored. No subject was exposed to radiation and the ethics committee of the University of São Paulo approved the research by the number: FR 289336 protocol 131/2009

The inclusion criteria comprehended the availability of the lateral radiograph of individuals who were at least 24 years old who had not undergone orthognathic surgery and who had no craniofacial deformities, classified according to their biological gender and age. Radiographic images whose quality impaired the visualization of the three points considered in this study (Rhinion, Prosthion and Pronasale, in soft tissue) were excluded from the sample.

Radiographs used were standardized for lateral cephalometric technique and were part of digital archives saved in the "TIFF" (Tagged Image File Format) format. The technical data provided reported distances between the source of the X-ray and the mid-sagittal plane of 152 cm; the head position was maintained by a cephalostat device; the exposure time was set to 1 s and the magnification rate provided by the device was approximately 10. As the reported magnification does not alter angular measurement, no correction was necessary for making reliable angular measurements.

Radiographs were assessed using the program Image J (31), version 1.43n/JAVA 1.6 0_10 (32 bit). Sample images were renamed and identified according to the serial number of the file, initial, age and sex of each individual.

Once in Image J, with the aid of the pencil tool, the following points were selected and marked as described (Fig. 1):

a) Rhinion (Rhi): limit of the lower nasal bone or the lowest point of the nasal bone on the mid-sagittal plane;
b) Pronasale (Pn): the most prominent point of the nose in the soft tissue. To determine this point on the teleradiographs, an E line as recommended by Ricketts (32) was traced, which crosses the Pogonion (Pg') point in the soft tissue and forms a tangent with the Pronasale (Pn) point, using the "Straight line selections". As the most anterior point of the nose convexity, it coincides with the method described by other authors [35] that refer its location to a perpendicular projection of the Frankfurt plan crossing the tip of the nose soft tissue. This is possible as lateral cephalographs used were made in standardized position.
c) Prosthion (Pr): the lowest point of the upper alveolar ridge, located between the upper central incisors on the mid-sagittal plane.

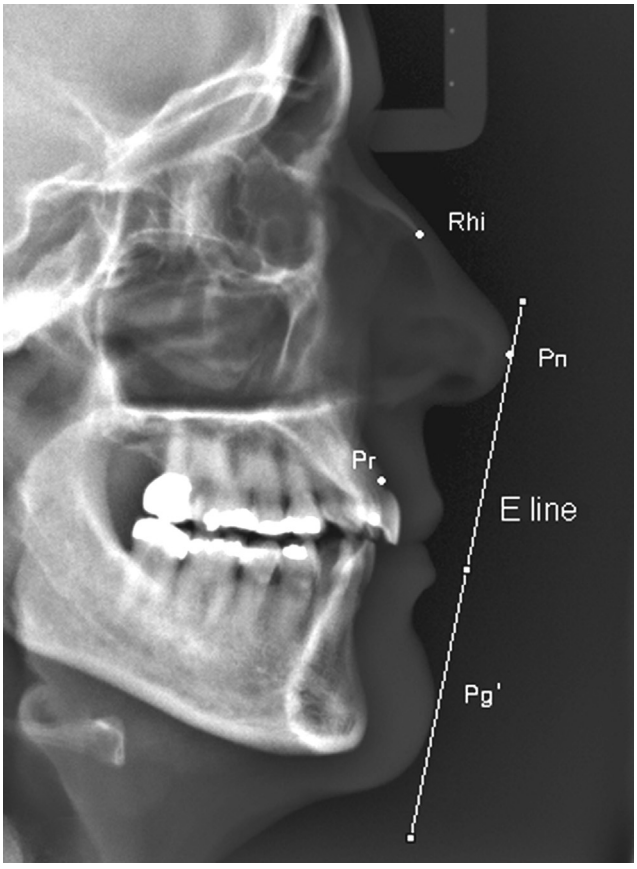

Fig. 1. Pr, Pn and Rhi points on the cephalometric radiograph.

The selection of this point was planned based on its easy location on the surface of a dry skull, which is ideal for practical application in forensic facial reconstruction.

Once the points were marked, the Angle tool was used to measure the angular relationship between the points Rhi.Pn.Pr. This real measure was stored as the Real Angle (RA).

From previous pilot studies of the first 20 images, results showed a mean value of 90° from the projection of Pronasale and Rhinion. The same mean value of the angle was observed after the collection of the RA of the entire sample. This supported the use of a Suggested Angle (SA) of 90° between the projections.

To establish a reproducible way for measuring the Real Pronasale point, the Rhi-line projection is a continuance of the angulation of the nasal bone, a clear reference in cephalometric images. The Pr projection is a linear trajectory from the alveolar ridge, starting at the Pr point and crossing the real Pn. Both projections were chosen as easily identifiable features in the bone surface of a dry skull (Fig. 2). The Suggested Pn position was estimated by fixing the angle of 90° between this lines, with the reference in the nasal bone projection. The perpendicular line is transported until it reaches the Pr point at the alveolar ridge.