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Anatomy of the nasal profile

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Abstract

There is a lack in the understanding of the variation within the thickness of the soft tissue structures (muscle, skin and fat) overlying the cartilaginous skeleton of the nose and their relationship to the dorsum shape. We examined such relationships by dissecting noses of six adult female and six adult male cadavers, comparing the internal anatomical structures to the external nasal profile. We found that the soft tissue structures differ in thickness along the dorsum and that these differences are individualized. Specifically, continuous presence of subcutaneous fat from root to tip was found in half the sample, one nose had fat only on the tip, another one only on the root, the four others at both positions. The nasalis muscle was identifiable in nine of the 12 noses, transversing the nose in half the sample, and in the remaining three, only the lateral section of the muscle was identified. The superior border of the septal cartilage does not form a linear extension of the profile contour of the nasal bones but angles downwards. The actual profile contour of the dorsum does not follow the profile of the nasal bones or the septal cartilage. These results may influence the current use of nasal guidelines in forensic facial approximation.

Key words craniofacial reconstruction; forensic facial approximation; lateral cartilage; septal cartilage; subcutaneous fat.

Introduction

Forensic facial approximation is the process by which an individual's face is reconstructed from the skull. Various guidelines are used to determine certain characteristics of facial features such as the width and position of the mouth (Taylor, 2001; Stephan, 2003; Wilkinson et al. 2003) and the projection of the eyeball (Swan & Stephan, 2005). These guidelines, however, are incomplete in the area of the nose, an important facial feature for the recognition of an individual. Rhinoplastic surgery has shown how slight differences in nasal shape can transform the look of an individual's face (Aston & Guy, 1977; Sullivan et al. 1996). There are several differing guidelines for reconstructing the nose (Gerasimov, 1971; Krogman & Iscan, 1986; George, 1987; Hoffman et al. 1991; Prag & Neave, 1997; Prokopec & Ubelaker, 2002; Stephan et al. 2003; Wilkinson, 2004). Each of these guidelines gives precise instructions, but produces perceptibly different results from each other. This may be because some nasal guidelines are based on skeletal anatomy, others on mathematical formulae determined from radiographic imagery. None of these studies that produce guidelines has investigated the variation in underlying nasal anatomy. There is no understanding of the variation within the thickness of the soft tissue structures (muscle, skin and fat) overlying the cartilaginous skeleton of the nose and their relationship to the dorsum shape. Nor is there an understanding of how this variation impacts upon the use of current guidelines in determining nasal shape.

The human nose is complex structurally and this complexity results in variation in nasal shape and form. Variation within muscles, skin and fat and their relationship to the profile shape are not well documented. Individual structure variation such as the dermocartilaginous ligament (Pitanguy et al. 1995) and the lateral cartilages (Straatsma & Straatsma, 1951) have been reported but the combined anatomical variation of the nasal profile has not yet been documented in depth. Anthropologists have produced categorical classifications of nasal types using the shape of specific nasal details as the defining characteristic (Martin, 1928; Comas, 1960). These nasal classifications are based on the surface characteristics of the nose such as the shape of the tip, the contour of the dorsum or root, and have not been linked to underlying structures. Anatomical information aimed specifically at the needs of facial approximation is difficult to find, as the variability in the anatomical structures needs to be documented. Due to the complexity of the nose and its role in facial recognition it is an important feature for both forensic and surgical craniofacial reconstruction. This paper contributes to our knowledge of nasal anatomy, but does not purport to change specific guidelines for nasal reconstruction.

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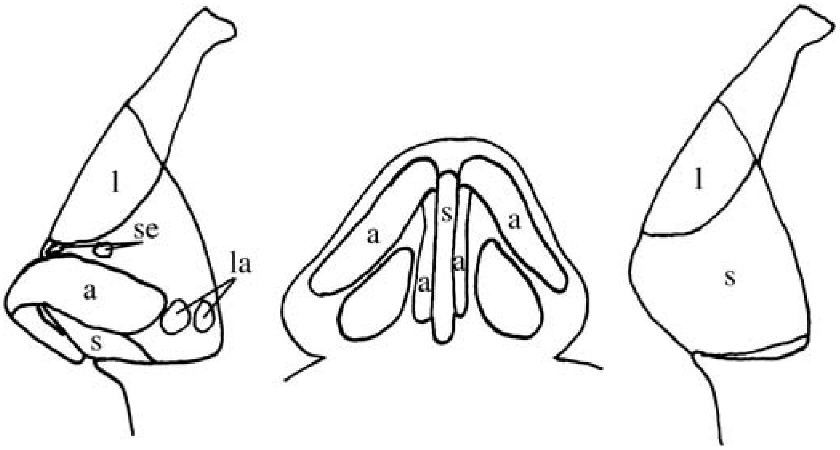

Fig. 1 The nasal cartilaginous skeleton comprises several cartilages, the septal cartilage (s), the bilateral alar (a) and lateral (l) cartilages and varying numbers of lesser alar (la) and sesamoid (se) cartilages.

Anatomy

Although bones of the skull (frontal, nasal, maxillae) contribute to the skeletal framework of the human nose, most of its external shape is due to soft tissue structures rather than these underlying bones. Externally, the nasal profile consists of the root, dorsum, tip and columella, with the other sections of the nose consisting of the ala, alar sulcus and nostrils. These features are supported by underlying nasal structure consisting, besides bone, of cartilage, muscles, subcutaneous fat and possibly a ligament. The nasal skeleton consists of the nasal bones and the frontal processes of the maxillae. The anterior nasal spine projects from the medial superior border of the maxilla in the nasal cavity floor and is variable in shape and length (Kastenbaur & Masing, 1995; van de Graaff, 2002). Internally, although the nasal cavity is formed by several bones, only the nasal bones, maxillae, vomer and ethmoid bones support the nasal cartilaginous skeleton. This comprises several cartilages, the septal cartilage, the bilateral (greater) alar and lateral cartilages and varying numbers of lesser alar and sesamoid cartilages (Fig. 1). The nasal septum supports the other cartilages and soft tissues of the nose and strengthens the nasal framework by dividing the nasal cavity in two (Kastenbaur & Masing, 1995). Structurally, the vomer and the perpendicular plate of the ethmoid, in conjunction with the septal cartilage, combine to form the nasal septum. The vomer forms the posterior and inferior sections of the nasal septum and articulates with the ethmoid and the septal cartilage (Metheny, 1915; Basmajian, 1971). Anteriorly, the septal cartilage attaches inferiorly to the anterior nasal spine and superiorly to the lateral cartilages. As already described by Gray (1858 [2005]) the lateral cartilages are triangular in shape, and are thicker anteriorly where they attach to the septal cartilage. They are continuous with the septal cartilage along the superior border, separating anteriorly to allow movement during respiration (Kastenbaur & Masing, 1995). The lateral cartilages attach to the inferior surface of the nasal bones and may also attach to the frontal process of the maxilla (Gray 1858 [2005]; Straatsma & Straatsma, 1951; Natvig et al. 1971). Some, however, consider the lateral cartilages to be wing-like extensions of the septal cartilage (Basmajian, 1971; McKinney et al. 1986). The position and shape of the alar cartilages is influenced by the height of the nasal septum, although these cartilages do not attach directly to the maxilla (Kastenbaur & Masing, 1995). The unique shape of the medial and lateral crura of the alar cartilage (Natvig et al. 1971; Daniel, 1992) forms the columella (Daniel, 1992), the nasal tip in conjunction with the interdomal fat pad (Pitanguy et al. 1995; Copcu et al. 2003), and the outer nostril walls (Daniel, 1992). Between the lateral crura and the frontal process of the maxilla, below the inferior edge of the upper lateral cartilages in the intercartilaginous area are the small lesser alar cartilages (Gray, 1858 [2005]; Dion et al. 1978).

In their review/compilation of the nasal muscle literature, Figallo & Acosta (2001) determined that up to eight nasal muscles have been identified. Of these, only two muscles, procerus and nasalis, are in a position to impact on the nasal profile. The procerus muscle has been documented as having two sections, but only the superior medial section of the muscle covers the nasal bones and inserts into the skin of the forehead and eyebrow (Figallo & Acosta, 2001; Bentsianov & Blitzer, 2004). The nasalis attaches to the maxilla transversing the dorsum of the nose and separates to attach to the greater alar cartilages and nostrils and the other nasal muscles and the septum. Distinguishing between the nasal muscles is difficult as the muscle fibres intertwine with each other. The eighth nasal muscle has been considered to be the posterior dilator naris (Gray, 1858 [2005]; Metheny, 1915). However, this muscle is considered by Figallo & Acosta (2001) and Letourneau & Daniel (1988) to be part of the nasalis muscle. These muscles, combined with the other soft tissues, are thought to have little impact on the shape of the nasal profile

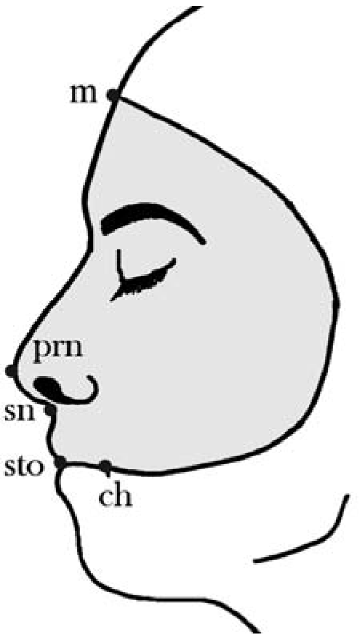

Fig. 2 The area dissected during this study in grey; a shallow sagittal cut from metopion (m) to pronasale (prn), and from subnasale (sn) to stomion (sto), and a semi-circular cut from metopion to chelion (ch).

(Macho, 1989; Prag & Neave, 1997); however, not all muscles are present in all individuals (Letourneau & Daniel, 1988).

A dermocartilaginous ligament is found medially in the upper section of the nose and continues down to join both medial crura before fusing with the septum (Letourneau & Daniel, 1988; Pitanguy et al. 1995). The thickness of this ligament contributes to the amount of bulging that shapes the nasal tip and its presence can cause the nasal tip to droop (Pitanguy et al. 1995). An interdomal fat pad has also been found in the tip area which may impact on the amount of tip bulge (Copcu et al. 2003).

The aim of this research is to document the anatomy of the nose and to understand correlations or relationships between the tissue layers and the external nasal profile.

Materials and Methods

The material used in this research consisted of six male and six female cadavers donated to the University of Adelaide for scientific/medical research. The age of the males ranged from 62 to 89 years with a mean of 75.6 years. The female age range was 67 to 90 years with a mean of 79.6 years. All cadavers were of European heritage and neither obese nor emaciated.

One side of the face was chosen to dissect, where possible, the side that had no lividity. An initial cut was made from the metopion, circling around the face past the temple, down the cheek and arcing in towards the chelion (Fig. 2). A shallow cut was made down the midsagittal line from the first cut along the nose, leaving the columella and cutting from subnasale to the stomion of the upper lip. The skin was removed taking care at the nasal tip due to the fragile nature of the skin and underlying structures in this area. The underlying musculature was defined by removal of the subcutaneous fat. Dissection was completed in five layers from superficial to deep and the structures were drawn and photographed (Fig. 3). Where the muscles were difficult to differentiate from the surrounding tissues, Weigert's variation of Lugol's solution was used to stain the muscles (Bock & Shear, 1972). To expose the cartilaginous skeleton, the muscles were removed from the dissected area (Fig. 3c). The eye was removed and the surrounding bone cleaned of remaining tissue. The alar cartilage was defined, recorded and then removed (Fig. 3d). Then the lateral cartilage was defined and recorded. To explore fully all aspects of the nasal area, the skin, muscles and subcutaneous fat were removed from the other side of the face. The second alar and lateral cartilages were recorded in the same way. This left the septal and lateral cartilages exposed. A small-bladed screwdriver with a modified bevelled edge was used to separate the lateral and septal cartilages from the nasal bones. The septal cartilage was separated from the vomer and ethmoid bones with a scalpel and the cartilage was removed with the use of forceps. After removal of the lateral and septal cartilages the skull was photographed (Fig. 3g).

For the photographic documentation of each dissection level the head was placed in a craniophore and positioned 3° above the Frankfurt Horizontal plane. This set the head in a natural position, similar to that found in the photographs taken of a person during life, rather than Frankfurt Horizontal. A positioning sheet was used to ensure consistency during the photographic documentation. Photographs were taken with a digital camera (Nikon Coolpix 4500) mounted on a tripod with a spirit level to ensure the camera was horizontal.

Results and Discussion

Dissection revealed certain common characteristics of all specimens (Table 1, Figs 4 and 5). In all subjects the angle of the septum differed from the external nasal dorsum angle. The superior border of the septal cartilage did not form a linear extension of the profile contour of the nasal bones but angled downwards. The superficial profile contour of the dorsum did not follow the profile of the nasal bones or the septal cartilage. Macho (1989) found that the nasal bones and septal cartilage followed a similar angle, which differed from that of the nasal tip. Although the septal cartilage has been noted to protrude past the (greater) alar cartilages, resulting in a long nose (Aufricht, 1958), this variation was not observed during dissection. In all cases the alar cartilages are positioned anterior to the septal cartilage. As documented by Dion et al. (1978) all of the cartilaginous structures observed in this study exhibited asymmetry and variability, especially in the paired cartilages. The skin overlying the alar cartilages was denser than that overlying the lateral cartilages. The thickness of the soft tissues overlying the nasal dorsum also varied along the length of the nose. This is commonly observed in rhinoplasty, influencing nasal shape, as a straight skeletal and cartilaginous dorsal profile will not result in a straight dorsum shape, whereas reduction in the cartilaginous shape will achieve a straight external profile (Tardy & Brown, 1990). This point was illustrated in specimen 6, which had a

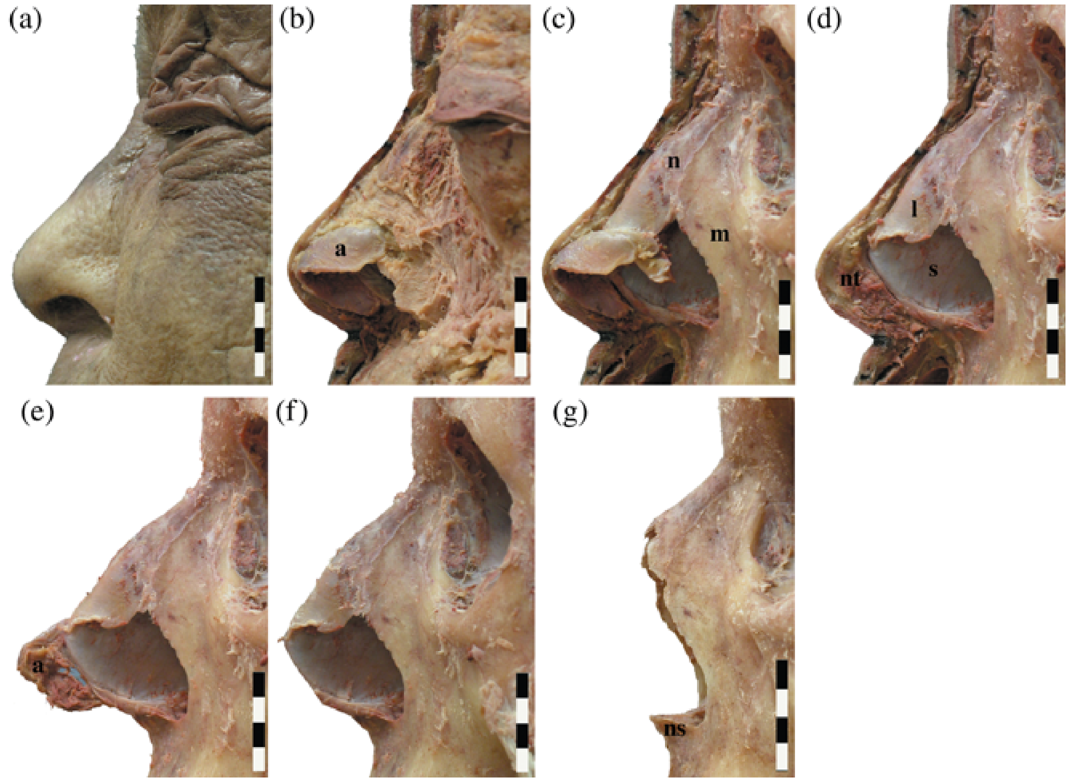

Fig. 3 The left lateral view, as structures appear in the dissection they are labelled. (a) The nose. (b) First level of dissection showing the muscles and the left alar cartilage labelled (a). (c) Second level of dissection: the (n) left nasal bone, (m) left maxilla. (d) Third level of dissection, the (l) left lateral cartilage, (s) septal cartilage and (nt) right section of the nasal tip. (e) Fourth level of dissection: the (a) right alar cartilage. (f) Fifth level of dissection showing the now totally exposed lateral and septal cartilages. (g) The lateral view of the bony skeleton and the exposed (ns) nasal spine. The scale is 20 mm.

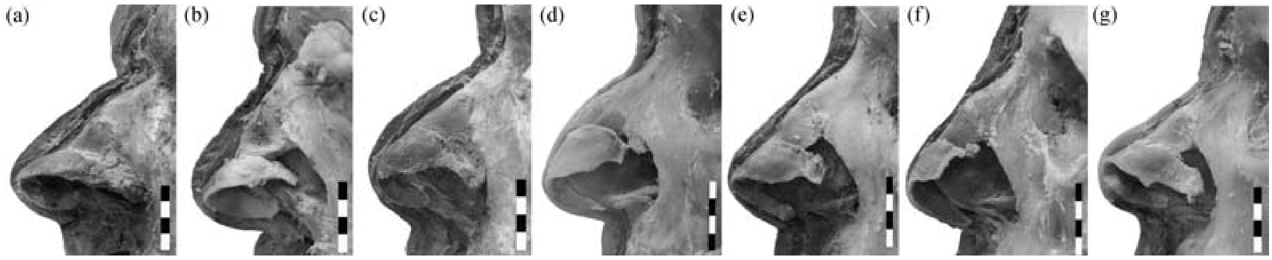

Fig. 4 Examples of the second level of dissection in specimen 4 (a), 5 (b), 6 (c), 7 (d), 8 (e), 9 (f) and 10 (g).

straight skeletal and cartilaginous dorsal profile; however, due to the overlying soft tissues the external dorsum shape was convex (Figs 4c and 5c). If the shape of the lateral and septal cartilages can be inferred from the skull, the nasal profile would be approximated with greater accuracy. Although the angle of the superior border of the septal and lateral cartilages differed from that of the external nose, the angle combined with the approximate positioning of the nasal tip would still be visually more accurate than several of the guidelines currently in use.

The shape and position of the alar cartilages visually influenced the nasal tip shape and asymmetry, findings comparable to those of Hatzis et al. (2004). The lesser alar and sesamoid cartilages found during dissection, as expected, did not visually influence the external nasal shape; a conclusion consistent with the findings by Macho (1989). Further research would be required to find indirect correlations between alar cartilage shapes/sizes and underlying bony structure.

Several variations of the structures were found. Although all the alar cartilages were anterior to the septal cartilage, seven of the noses had alar cartilages that were superiorly positioned above the junction of the superior and anterior borders of the septal cartilage, specimens 1–5 and 11–12. The angle of the anterior border of the septal cartilage was visually similar to the angle of the columella in six of the dissected noses, specimens 1–3 and 6–8 (Fig. 5c–e). The angle of specimen 4 could not be determined as the anterior

Table 1 The common characteristics found in the nose of all 12 specimens both prior and during dissection

	Specimen number											
Structure characteristic	1	2	3	4	5	6	7	8	9	10	11	12
External nose												
Partial nasal lividity on dissected side	–	✓	–	–	✓	–	–	–	✓	–	✓	✓
Full nasal lividity on dissected side	–	–	–	✓	–	✓	–	✓	–	–	–	–
Visibly appears to have been broken in life	–	–	–	✓	✓	–	–	–	–	–	–	✓
Hump visible at root	✓	✓	–	✓	–	–	–	–	–	–	–	–
Hump visible at dorsum	✓	–	–	–	–	–	–	–	–	✓	✓	✓
Nasal tip angled downwards	–	–	–	–	–	–	✓	–	✓	–	–	–
Nasal tip angled upward	✓	✓	✓	–	–	–	–	–	–	✓	–	–
Bulbous nasal tip	✓	✓	✓	✓	✓	✓	–	–	–	✓	–	–
High nasal root	–	–	–	–	–	–	–	–	✓	–	–	✓
Fine skin on dorsum	–	✓	✓	–	–	–	✓	✓	✓	–	–	✓
Fine skin on tip	✓	✓	–	–	–	–	✓	✓	✓	–	–	✓
Thick skin on dorsum	✓	–	–	✓	✓	✓	–	–	–	✓	✓	–
Thick skin on tip	–	–	✓	✓	✓	✓	–	–	–	✓	✓	–
Hook nose	–	–	–	–	–	✓	✓	–	–	–	–	–
Left side of face dissected	–	–	–	✓	✓	✓	✓	✓	✓	✓	✓	✓
Right side of face dissected	✓	✓	✓	–	–	–	–	–	–	–	–	–
Muscles												
Nasalis identified transversing the nose	–	–	✓	–	✓	✓	✓	–	–	✓	✓	–
Nasalis identified, lateral section only, not evident across midline	✓	–	–	✓	–	–	–	✓	–	–	–	–
Unsure if nasalis present	–	✓	–	–	–	–	–	–	✓	–	–	✓
Subcutaneous fat												
Presence of subcutaneous fat at the nasal root	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
Presence of subcutaneous fat at the nasal dorsum	–	✓	–	✓	✓	–	–	✓	–	–	✓	✓
Presence of subcutaneous fat at the nasal tip	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓
Alar cartilages												
Superior and anterior to septal cartilage	✓	✓	✓	✓	✓	✓	–	–	–	–	p	✓
Anterior to septal cartilage only	–	–	–	–	–	✓	✓	✓	✓	✓	–	–
Lateral cartilages												
Attached to septal cartilage on the midline	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
Septal cartilage												
Columella angle mirrors septal angle	✓	✓	✓	?	–	✓	✓	✓	–	–	–	–
Extends beyond lateral cartilage	p	p	✓	p	p	✓	✓	✓	✓	✓	✓	–

Undeterminable (?), partially (p).

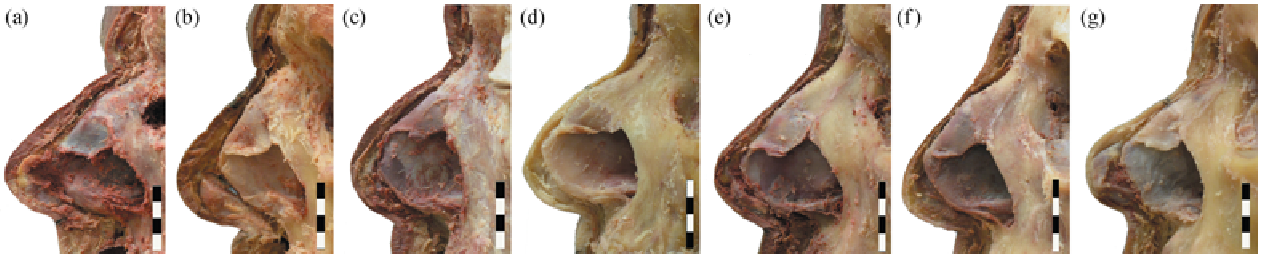

Fig. 5 Examples of the third level of dissection in specimen 4 (a), 5 (b), 6 (c), 7 (d), 8 (e), 9 (f) and 10 (g).

border was not uncovered during the third level of dissection (Fig. 5a). We found that the soft tissue structures differed in thickness along the dorsum and that these differences were individual (0.7–9.7 mm). Specifically, continuous presence of subcutaneous fat from root to tip was found in half the sample (specimens 2, 4, 5, 8, 11, 12) (Figs 4a,b,e and 5a,b,e for examples), one nose had fat only on the tip (specimen 7) (Fig. 5d), another one only on the root (specimen 9) (Figs 4f and 5f), and the four others at both positions (specimens 1, 3, 6, 10) (Fig. 5c,g for examples).

Table 2 The mean measurements of the subcutaneous fat found at the root, dorsum and tip of the nose in males and females, respectively

	Subcutaneous fat thickness		
	Root	Dorsum	Tip
Male *n* = 6			
Average	0.24	0.10	0.38
SD	0.18	0.11	0.21
Female *n* = 6			
Average	0.26	0.05	0.19
SD	0.13	0.08	0.19

Table 3 The nasiolabial and nasal spine/maxilla angle in degrees for each individual. $R = -0.51$

Specimen number	Sex	Nasolabial angle	Nasal spine angle
1	F	112	88
2	F	128	50
3	F	140	108
4	M	122	97
5	M	75	141
6	M	110	109
7	M	93	89
8	M	104	80
9	F	98	92
10	F	118	83
11	M	101	128
12	F	95	109

The amount of subcutaneous fat was minimal; its thickness in all individuals was less than 1 mm (maximum thickness range 0.3–0.7 mm). Within the limited range of body weight for our sample there was no relationship found between the weight of the individual and the amount of subcutaneous fat present on the nose (Table 2). There was also no sexual dimorphism found.

The nasalis muscle was identifiable in nine of the 12 noses, transversing the nose in half the sample, whereas in the remaining three, only the lateral section of the muscle was identified (Table 1). Variability was also present in the bony skeleton of the nose, particularly in the nasal spine. Kastenbaur & Masing (1995) indicate that the shape of the nasal spine may determine the angle of the nasal tip projection. The nasiolabial angle was compared to the nasal spine/maxilla angle (Table 3) to determine whether there was a relationship between them. The nasal spine/maxilla angle was taken between a vertical line running along the anterior margins of alveolar process of maxillae and a line through the centre of the anterior nasal spine. The centre of the anterior nasal spine was chosen as this line is used in facial reconstruction guidelines (Stephan et al. 2003; Rynn & Wilkinson, 2006). Comparison of the angles (Table 3) shows no relationship. In fact the correlation coefficient as calculated is negative. This indicates that the nasal spine/maxilla angle is not indicative of the nasiolabial angle. Although the variability of the nasal spine was corroborated during this study, the shape of the columella reflected the shape of the anterior border of the septal cartilage rather than the shape of the nasal spine. This may indicate a link to nasal growth as the nose continues to grow anteriorly and inferiorly until adulthood (Subtelny & Rochester, 1959). In this adult sample, however, no correlation was found between the nasal profile measurements and the age of the specimens (Table 4 and Fig. 6). The lack of increase in nasal length and height measurements due to age in adults was also observed by Macho (1986). Orthodontic studies have linked the shape of the skeletal profile to the nasal profile, for example a concave skeletal profile will also have a concave nasal profile (Subtelny & Rochester, 1959; Robison et al. 1986).

This study of the nasal profile shows how the shape, positioning and thickness of the underlying structures vary among individuals. Understanding of the variation may find practical use.

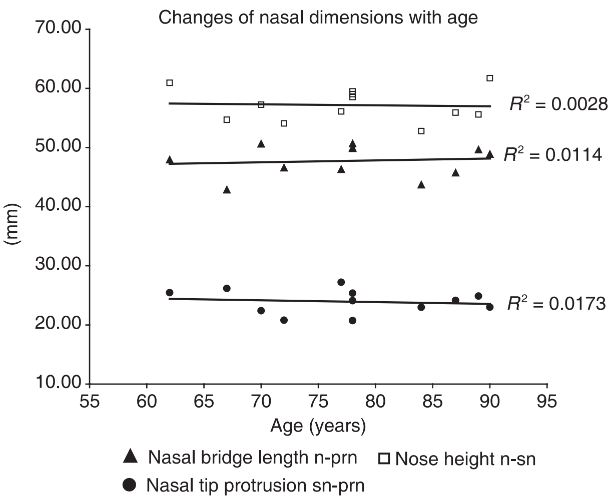

Fig. 6 The changes of nasal profile dimensions with age.

Table 4 The nasal profile dimensions – nasal bridge length (n-prn), nose height (n-sn) and nasal tip protrusion (sn-prn)

	Nasal dimensions in relation to sex		
	n-prn	n-sn	sn-prn
Male *n* = 6			
Average	49.2	58.1	24.9
SD	1.7	2.1	1.6
Female *n* = 6			
Average	46.3	56.3	23.0
SD	2.8	3.3	2.1
t-test	2.2	1.1	1.8

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