Rhinology, 34, 66-74, 1996

Review of the functional anatomy of the cartilages and muscles of the nose*

Tj.D. Bruintjes[1], A.F. van Olphen[1], B. Hillen[2]

[1] Department of Otorhinolaryngology, University Hospital, Utrecht, The Netherlands
[2] Department of Functional Anatomy, Medical School, University of Utrecht, The Netherlands

SUMMARY

This paper reviews the anatomy of the nasal cartilages and muscles. Accurate anatomical knowledge of these structures may facilitate the design of a model to study the mobility and support of the lateral nasal wall and ala and may thus provide information on the dynamics of the valve area. It is concluded that a uniform description of nasal cartilages and muscles is still lacking. This is especially true for the attachments of the nasal cartilages to neighbouring structures, as well as the location and function of the muscles influencing the valve area. The use of uniform, preferably anatomical, terminology is encouraged.

Key words: nasal cartilages, nasal muscles, nasal valve, nasal ala, nasal dilator

INTRODUCTION

The site of maximum resistance to airflow in the nose has been a point of interest since the beginning of this century.

In 1882 Zuckerkandl described the *ostium internum* of the nose ("inneres Nasenloch") as the narrowest part of the nasal passage, a structure formed by the slit-like opening bounded by the caudal end of the lateral nasal cartilage and the septum. Later, the Dutch otorhinolaryngologist Mink introduced the more dynamic concept of a nasal valve formed by the mobile lateral nasal cartilage, being the airflow-regulating part of the nose (Mink, 1902, 1903, 1920). He assumed that the dynamics of the nasal valve were dictated primarily by the alar muscles regulating the width of the ostium and preventing collapse of the valve. Mink, thus, gave a clear functional and morphological definition of the nasal valve, attributing a major role to the lateral nasal wall in its regulatory function. Observations of Uddströmer (1940) and Van Dishoeck (1942) confirmed the importance of the nasal valve in the regulation of nasal patency. Since these early years many studies have been performed to elucidate the nature of the valve and the role of the lateral nasal wall and ala in its mobility. By measuring intranasal pressures with a fine catheter, Bridger (1970) was able to describe a "flow-limiting segment" extending from the junction of the lateral nasal and alar cartilage to the piriform aperture, the rigidity of the segment being determined by the lateral nasal cartilage, its attachments and the alar muscles. Bridger (1970) considered dilator muscles to be important in increasing the rigidity of the nasal valve. In similar physiological studies, other investigators found the main airflow resistance to be in the region of the piriform aperture with a minor role for the cartilaginous vestibule (Haight and Cole, 1983; Jones et al., 1988). This correlated with the findings from an anatomical study using luminal impressions by Bachmann and Legler (1972), who found the main resistance-regulating effect not to be in Mink's valve, but in the soft tissue dorsally to the lateral nasal cartilage near the piriform aperture.

It is evident that the actual site of main airflow resistance in the nose is still a matter of controversy. More in particular, the role of the mobile lateral nasal wall in valvular anatomy and in airflow regulation is still not well understood. Detailed anatomical knowledge of the supporting cartilaginous and muscular structures, as well as knowledge regarding the mechanism of mobility may provide more insight in the role of the lateral nasal wall in valvular function. Since a uniform description of the anatomical and functional properties of the nasal cartilages and muscles is lacking in the literature, we consider a review study indicated. The rhinosurgeon may benefit from accurate anatomical knowledge in the surgical management of nasal valve pathology.

* Received for publication May 11, 1995; accepted October 9, 1995

THE CARTILAGES

The cartilaginous framework of the external nose consists of five major cartilages and a variable number of smaller ones. There is considerable difference in terminology in the anatomical and surgical literature (Table 1).

Table 1. Nomenclature of the nasal cartilages.

anatomical name (from *Nomina Anatomica*, 1989)	synonyms
cartilago septi nasi (septal cartilage)	quadrangular cartilage
cartilago nasi lateralis (lateral nasal cartilage)	upper lateral cartilage triangular cartilage lateral cartilage
cartilago alaris majoris (greater alar cartilage)	lower lateral cartilage alar cartilage lobular cartilage tip cartilage
cartilagines accessoriae (accessory cartilages)	sesamoid cartilages
cartilagines alares minores (lesser alar cartilages)	
sesamoid cartilages*	accessory cartilages

(*: not mentioned in *Nomina Anatomica*, 1989).

We have chosen to adopt the anatomical terminology, based on the 1989 edition of *Nomina Anatomica*. This edition describes a septal cartilage, a lateral nasal cartilage, a greater alar cartilage, minor alar cartilages and accessory cartilages (Figure 1). In addition, some authors describe one or more small sesamoid cartilages in the intercartilaginous region. These are not mentioned in *Nomina Anatomica* (1989).

The nasal cartilages will now be discussed in consecutive order, with special attention to the attachments that provide the cartilaginous framework with mobility. In this review are included several original studies on the anatomy of the nasal cartilages (Table 2) as well as established textbooks on anatomy or surgery of the nose.

Lateral nasal cartilage

The lateral nasal cartilages form, together with the septal cartilage, the upper cartilaginous vault of the external nose. One of the synonyms often used is "triangular cartilage" (Table 1), although the shape of the cartilage in the Caucasian nose is actually more quadrangular than triangular (Wayoff, 1969; Hinderer, 1971; Le Pesteur and Firmin, 1977; Daniel and Letourneau, 1988). On the cranial side the lateral nasal cartilage is overlapped by the nasal bone. In a detailed study Straatsma and Straatsma (1951) have demonstrated that the relationship of the lateral nasal cartilage to the nasal bone is a firm, side-to-side apposition with a variable degree of overlapping. This finding has been confirmed by Natvig et al. (1971), who showed the area of overlapping to be most predominant near the septum, progressively decreasing in a lateral direction. Most authors think the cartilage and bone to be intimately connected. Parkes and Kanodia (1981) consider the connection to be a "firm fibrous union, one of the strongest attachments of the cartilage to its adjacent structures." Bernstein (1975) maintains that the perichondrium of the lateral nasal cartilage makes a fairly loose attachment with the periosteum of the nasal bones.

Medially, the lateral nasal cartilage is connected to the septum. This relationship has been a point of confusion for a long time. Classically, the lateral nasal cartilages have been viewed as paired structures intimately connected to the septum, but not fused to it (Converse, 1955, 1964; Parkes and Kanodia, 1981). Straatsma and Straatsma (1951) have clearly demonstrated the upper one-third of the lateral nasal cartilage to be continuous with the septum and the lower two-third to be separated from the septum by a narrow cleft containing connective tissue. McKinney et al. (1986) have found fusion of the cartilages further caudally. The presence of a single uninterrupted cartilaginous unit has been confirmed by others (Bernstein, 1975; DeLaraGalindo et al., 1977; Daniel and Letourneau, 1988). The term "septodorsal cartilage" (or "septolateral cartilage") for the nasal septum and both lateral nasal cartilages, described in an earlier edition of the *Nomina Anatomica* (1939), therefore seems quite correct. De Lara Galindo et al. (1977) re-introduced the term in vain, since the latest edition of *Nomina Anatomica* (1989) makes no mention of it.

Greater alar cartilage

The greater alar cartilages form, together with the anterior nasal septum, the cartilaginous framework of the nasal lobule. The greater alar cartilage is traditionally believed to consist of a medial crus and a lateral crus, coming together in an area referred to as the "dome." The two domes are said to be connected by a ligamentous sling (interdomal ligament), that would offer additional support to the framework of the nasal tip (Janeke and Wright, 1971). For the transitional segment between the medial and lateral crus, Sheen and Sheen (1987) have introduced the name "middle crus." In this three-crural concept of the greater alar cartilage, which was elaborated upon by Daniel (1992), the

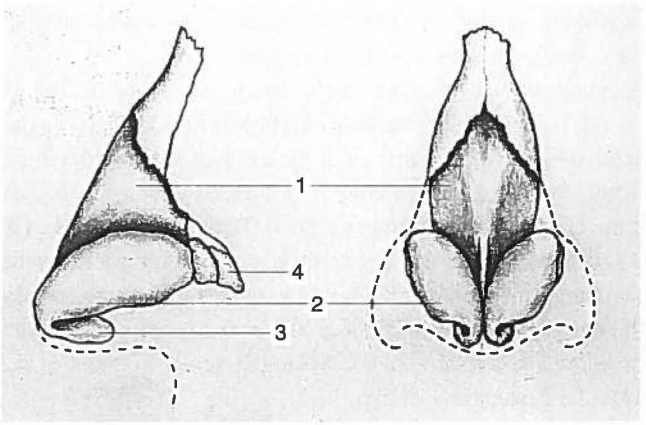

Figure 1. Anatomy of nasal cartilages. (1) lateral nasal cartilage; (2) lateral crus of greater alar cartilage; (3) medial crus of greater alar cartilage; (4) minor alar (or accessory) cartilage.

Table 2. Studies on the anatomy of the nasal cartilages.

author	system investigated	method	No. of specimens
Daley (1948)	GAC	unknown	
Straatsma and Straatsma (1951)	LNC	histology	20
Converse (1955)	LNC + GAC	unknown	
Cottle (1955)	nasal vestibule	unknown	
Gunter (1969)	GAC	dissection	34
Wayoff (1969)	nasal anatomy	unknown	
Janeke and Wright (1971)	LNC + GAC	dissection	20
Krmpotic-Nemanic et al. (1971)	GAC	dissection/histology	20
Natvig et al. 1971)	LNC + GAC	dissection	30
		histology	12
Drumheller (1973)	LNC + GAC	histology	4
Jost et al. (1973)	LNC + GAC	dissection/histology	?
		rhinoplasties	?
Bernstein (1975)	nasal anatomy	dissection/rhinoplasties	>100
De Lara Galindo et al. (1977)	LNC	dissection/histology	20
Le Pesteur and Firmin (1977)	LNC + GAC	dissection/histology	30
Dion et al. (1978)	nasal anatomy	dissection/histology	31
Zelnik and Gingrass (1979)	GAC	dissection	27
Daniel and Lessard (1984)	nasal anatomy	dissection	40
		rhinoplasties	>100
Lessard and Daniel (1985)	nasal anatomy	dissection	60
		rhinoplasties	25
McKinney et al. (1986)	LNC	dissection	10
		clinical patients	10
Daniel and Letourneau (1988)	nasal anatomy	dissection	>75
		histology	25
		rhinoplasties	200
Daniel (1992)	GAC	rhinoplasties	50

Abbreviations: LNC: lateral nasal cartilage; GAC: greater alar cartilage.

dome region is where the middle crus joins the lateral crus. Apart from the basic two- or three-crural design there is an enormous variety of shapes and conformations of the greater alar cartilage. This accounts for the great variation in the external configuration of the nasal lobule. Daley (1948) has studied the "morphologic deformities" of the greater alar cartilages, but has found it impossible to give an actual classification. Natvig et al. (1971) and Zelnik and Gingrass (1979) have proposed a classification system for the shape of the medial as well as the lateral crus. The importance of these classification systems lies primarily in the fact that they force the rhinosurgeon to pay careful attention to the individual shape and size of the greater alar cartilage in a rhinoplastic procedure.

Although the lateral crus is the main cartilaginous structure of the ala, it forms only a small part of the alar rim. The lateral crus approximates the free margin of the external naris border in its medial third and extends away from the border of the nostril as it travels posteriorly (Converse, 1955). This means that the caudal margin of the greater alar cartilage does not run parallel with the margin of the nostril. Some researchers even contend that the name alar cartilage is not accurate, as the actual ala of the nose consists primarily of soft tissue (Krmpotic-Nemanic et al., 1971; Le Pesteur and Firmin, 1977).

As to the relationship of the lateral crus of the greater alar cartilage to the lateral nasal cartilage, anatomy textbooks merely state that they are attached to each other by connective tissue (Hollinshead, 1968; Williams et al., 1989; Romanes, 1987) or an aponeurosis, acting as a flexible membrane (Hinderer, 1971). Converse (1955, 1964) has termed this aponeurotic-like tissue "the suspensory ligament of the tip of the nose," whereas Griesman (1944) has called it the "intercartilaginous ligament." In most cases, the upper border of the greater alar cartilage overlaps the lower border of the lateral nasal cartilage. This overlapping of the lateral nasal cartilage by the greater alar cartilage has clearly been demonstrated by Drumheller (1973), who also has drawn drew attention to the lateral nasal cartilage curling to varying degrees laterally and upward on its caudal margin. Cottle (1955) has coined the term "returning" to describe this phenomenon, which possibly contributes to widening the cartilaginous vault and producing resistance to alar collapse during inspiration. The greater alar cartilage in some cases shows a curling medially and downwards on its superior margin. In this way an interlocked scroll is formed with the lower border of the lateral nasal cartilage, which may allow the lateral crus to pivot and slide up and down along its scroll (Bernstein, 1975). A classification of the different types of interdigitation has been given by Dion et al. (1978), the "interlocked scroll" being the most frequent one (52%). The other types of articulation were less frequent: 17% end-to-end, 20% overlap only, and 11% opposed scroll. Lessard and Daniel (1985) and Daniel and Letourneau (1988) also have found scroll formation in a majority of cases. The protrusion of the intercartilaginous

junction into the nasal lumen has been given different names: *limen vestibuli* (Dion, 1978; Bernstein, 1975), *limen nasi* or *internal naris* (Converse, 1955), and *plica nasi* (Le Pesteur and Firmin, 1977).

Sesamoid cartilages

The so-called sesamoid cartilages of the nose are not mentioned in *Nomina Anatomica* (1989), nor in established anatomy textbooks (Lang, 1989; Romanes, 1987; Williams et al., 1989). In general, sesamoid cartilages are found all over the human body, usually within tendons and in close relation to articular surfaces. The adjective "sesamoid" is derived from the close resemblance to sesame seeds (Romanes, 1987; Williams et al., 1989). Their presence in the intercartilaginous junction of the nose has been corroborated by several authors. In the majority of cases they are called sesamoid cartilages (Janeke and Wright, 1971; Drumheller, 1973; Bernstein, 1975; Le Pesteur and Firmin, 1977; Dion et al., 1978; Daniel and Lessard, 1984; Lessard and Daniel, 1985; Daniel and Letourneau, 1988), sometimes "accessory or sesamoid cartilages" (Hollinshead, 1968) or just "accessory cartilages" (Krmpotic-Nemanic et al., 1971). Usually, they are seen as small pieces of cartilage, in one single case as "rectangular cartilaginous lamellas with an axis parallel to the near cartilages" (Jost et al., 1973). One author describes that the sesamoid cartilages "may act as a ball-bearing mechanism making possible the rolling of the overlapping cartilages" (Griesman, 1944).

It has been suggested that the sesamoid cartilages are the result of fragmentation of the nasal cartilages in the ageing process (Krmpotic-Nemanic et al., 1971). This phenomenon would be responsible for the droop of the nasal tip in advanced age. This view is rightly rejected by others (Jost et al., 1973; Dion et al., 1978; Lessard and Daniel, 1985). One of the main arguments against this hypothesis is that it does not account for the presence of sesamoid cartilages in young patients.

The hinge area

Posteriorly, the lateral crus of the greater alar cartilage may extend so that it is in actual contact with the bone (Dion et al., 1978). Even an overlapping of the two has been described (Gunter, 1969; Bernstein, 1975), in which case the perichondrium of the cartilage is said to be attached to the periosteum of the maxilla. More often there is a broad area of soft tissue, bounded by the posterior part of the lateral crus of the greater alar cartilage, the lateral nasal cartilage and the edge of the piriform aperture. This so-called hinge area or "external lateral triangle" (LePesteur and Firmin, 1977) may be deprived of supporting structures ("empty triangle"), in which case it is clearly a weak part of the lateral nasal wall and may collapse. It may, however, contain one or more pieces of cartilage forming an extension of the lateral crus to the piriform aperture. These cartilages are purported to be contained in the same perichondrial sheath (Bernstein, 1975) or in an aponeurosis (Daniel and Lessard, 1984). Several authors have described one or more of these cartilages, albeit without uniformity in terminology: lesser alar cartilages (Hollinshead, 1968; Dion et al., 1978; Romanes, 1987; Williams et al., 1989; Lang, 1989), sesamoid cartilages (Janeke and Wright, 1971; Bernstein, 1975; LePesteur and Firmin, 1977), and accessory cartilages (Daniel and Lessard, 1984; Lessard and Daniel, 1985; Daniel and Letourneau, 1988; Lang, 1989). Gilbert and Feit (1955) believe that during motion of the lobule, the lateral crura slide over these cartilages, "simulating the hinge-joint action of a moat bridge." Hence the term *hinge area.*

LePesteur and Firmin (1977) consider these accessory or lesser alar cartilages to be part of a continuous osseous-cartilaginous ring ("un anneau circulaire solide osteo-cartilagineux"), made up of the inferior part of the septum, resting on the nasal spine of the maxilla, the medial and lateral crura and a chain of small cartilages. An essential feature of this chain would be the "elastic rigidity" of the alar part of the ring (Daniel and Letourneau, 1988).

THE MUSCLES

The literature on nasal muscles is rather limited. Original research that has been performed on the nasal musculature is scarce (Table 3), therefore the majority of information in this review is derived from a broad array of anatomy textbooks, recent as well as old.

The 1989 edition of *Nomina Anatomica* only mentions four muscles of the nose: *M. nasalis* (with a transverse and alar part), *M. depressor septi*, *M. levator labii superioris alaeque nasi*, and *M. procerus.* The procerus muscle is also described as belonging to the orbital group of muscles (Hollinshead, 1968), whereas the *M. levator labii superioris alaeque nasi* is also considered to be part of the group of upper labial muscles (Hollinshead, 1968; Romanes, 1987). Apart from these muscles, various other muscles are described by different authors: one or two dilator muscles (Sappey, 1889; Eisler, 1912; Testut, 1928; Braus-Elze, 1929; Griesman, 1944; Paturet, 1951; Rouvière, 1962; Hollinshead, 1968; Daniel and Letourneau, 1988; Letourneau and Daniel, 1988), a *M. compressor narium minor* (Letourneau and Daniel, 1988; Tardy, 1990), a *M. apicis nasi* or "muscle of the nasal tip" (Eisler, 1912; Braus-Elze, 1929; Lang, 1989), and a *M. anomalus nasi* (Eisler, 1912; Braus-Elze, 1929; Letourneau and Daniel, 1988; Daniel and Letourneau, 1988; Tardy, 1990). The nasal muscles are said to be interconnected by a fascial network, thus forming the so-called *superficial musculo-aponeurotic system* (SMAS) of the nose (Daniel and Letourneau, 1988; Tardy, 1990). This nasal SMAS would be continuous with the SMAS covering the rest of the face.

There is wide disagreement regarding the number as well as the nomenclature of the different nasal muscles (Table 4). As to the function of the nasal muscles several classification systems are used. The most commonly used is the division in dilators and compressors of the nose: a *dilator* assisting in widening the nasal opening, and a *compressor* compressing the nasal opening (Romanes, 1987; Williams et al., 1989). In addition, Griesman (1944) distinguishes elevator and depressor muscles: *elevator muscles* shorten the nose, and *depressor muscles* lengthen the nose. Independent of their shortening or lengthening effect, the majority of nasal muscles is said to assist in widening the nasal

Table 3. Studies on the anatomy of the nasal muscles.

author	system investigated	method	No. of specimens
Griesman (1944)	nasal muscles	unknown	
Schmalix (1968)	nasal muscles	unknown	
Zide (1985)	nasal muscles	unknown	
Daniel and Letourneau (1988)	nasal anatomy	dissection	>75
		histology	25
		rhinoplasties	200
Letourneau and Daniel (1988)	nasal muscles	dissection	20
		histology	10

opening. Griesman's classification has been adopted by Letourneau and Daniel (1988), and by Tardy (1990) in his textbook on surgical anatomy. An alternative functional classification has been proposed by Schmalix (1968): he prefers the use of the terms abductor, adductor, and inward rotator – instead of dilator and compressor. Zide (1985) believes that the nasal musculature, more specifically both transverse parts of the nasalis muscle and the procerus muscle moves on the nasal skin, instead of actually contracting or dilating the nares. Since it is not clear what the role of each muscle in the lateral nasal wall mobility is, all muscles will be discussed consecutively with special emphasis on their possible functional implication(s).

M. nasalis

The *M. nasalis* is invariably seen as an important constituent of the nasal muscular network; it consists of a transverse and an alar part. In French anatomy textbooks, the transverse part is described as a separate transverse muscle, whereas the alar part is not mentioned as such (Sappey, 1889; Testut, 1928; Paturet, 1951; Rouvière, 1962; see Figure 2b). The transverse part of the *M. nasalis* is usually described as arising from the maxilla and inserting, together with the opposite muscle, into an aponeurosis on the nasal dorsum. Sometimes, it is said to have its origin in the aponeurosis on the nasal dorsum and its insertion into the skin of the nasolabial sulcus (Sappey, 1889; Testut, 1928; Paturet, 1951; Rouvière, 1962). The small alar part of the *M. nasalis* is described as arising from the maxilla, together with the transverse part (Figures 2a and 2c). The alar part is attached to the alar skin (according to most authors) or the cartilaginous ala (Williams et al., 1989; Hollinshead, 1968; Letourneau and Daniel, 1988). Eisler (1912) and Schmalix (1968) describe two muscle bundles in the alar part, a lateral one going to the skin of

Table 4. Nomenclature of the nasal muscles.

anatomical name (from *Nomina Anatomica*, 1989)	synonyms
M. nasalis	
1. pars transversa (transverse part)	M. transversus M. compressor naris M. triangularis nasi
2. pars alaris (alar part)	M. dilatator naris (posterior) M. myrtiformis (lateral bundle)
M. depressor septi	M. myrtiformis (medial bundle)
M. levator labii superioris alaeque nasi	M. levator alae nasi M. quadratus labii superioris
M. procerus	M. pyramidalis
M. dilatator naris*	M. alaris (major) M. alae nasi M. dilatator naris anterior M. dilatator naris posterior
M. apicis nasi*	M. dilatator naris anterior M. compressor narium minor
M. anomalus nasi*	M. innominatus

(*: not mentioned in *Nomina Anatomica*, 1989).

the alar rim (corresponding to the alar part as described above) and a medial one going to the septum and medial crus of the greater alar cartilage (probably the equivalent of the *M. depressor septi*, which will be discussed later). These muscle bundles seem to correspond with the so-called *M. myrtiformis* which is described in French anatomy textbooks (Sappey, 1889; Testut, 1928; Paturet, 1951; Rouvière, 1962; see Figure 2b). In the French literature, the alar part of the *M. nasalis* is not described as such.

There is no consensus of opinion concerning the action of the *M. nasalis*. Usually, the transverse part is attributed with a compressor function, although Schmalix (1968) speaks about an adductor function. Sappey (1889) and later Testut (1928) and Griesman (1944) assert that the transverse part acts as a semicircular nasal sphincter. In contrast, Rouvière (1962), Paturet (1951) and Braus-Elze (1929) assert that the transverse part acts as a dilator. Paturet (1951) asserts that the myrtiform muscle is the actual compressor of the nose.

The alar part of the *M. nasalis* is said to have a dilator function by drawing the ala laterally (Sieglbauer, 1958; Hollinshead, 1968; Williams et al., 1989; Romanes, 1987; Lang, 1989). According to Schmalix (1968), the alar part should therefore be called an abductor. Griesman (1944), Letourneau and Daniel (1988) and Tardy (1990) attribute a depressor function to the alar part, lengthening the nose and dilating the nostril. Because of its supposed dilating effect, some believe the alar part in fact to be the *dilatator naris* (Williams et al., 1989; Romanes, 1987; Sieglbauer, 1958). Finally, to complicate matters even more, the alar part of the nasalis is also seen as a compressor of the nostril (Braus-Elze, 1929), whereas Eisler (1912) believes that the *M. nasalis* as a whole compresses the nostril.

M. dilatator naris

Not all textbooks agree as to the presence of a specific dilator muscle of the nose. Some consider the alar part of the *M. nasalis* to be the actual dilator (Williams et al., 1989; Romanes, 1987; Sieglbauer, 1958), only a few researchers mention the presence of one or two specific dilators. An early and precise description of a specific dilator muscle, based on meticulous dissection of cadaveric noses, was given by Sappey (1889). He describes the dilator muscle as the smallest muscle of the face, indeed often so small that it can only be detected by microscopical examination. The muscle arises from the alar skin and cartilage and inserts into the skin of the nasolabial groove (Figure 2b). This view has been adopted by other French authors (Rouvière, 1962; Paturet, 1951; Testut, 1928). In his review on nasal muscles, Eisler (1912) asserts that the presence of a dilator muscle has never actually been proven, but that its presence can only be assumed ("Das Vorhandensein eines Dilatator narium ist also ein Postulat."). In contrast to Sappey, Eisler describes the alleged dilator muscle or "(major) alar muscle" not as a small delicate muscle, but as a powerful muscle lying between the edge of the piriform aperture and the alar skin. This alar muscle of Eisler is seen as an inward rotator by Schmalix (1968).

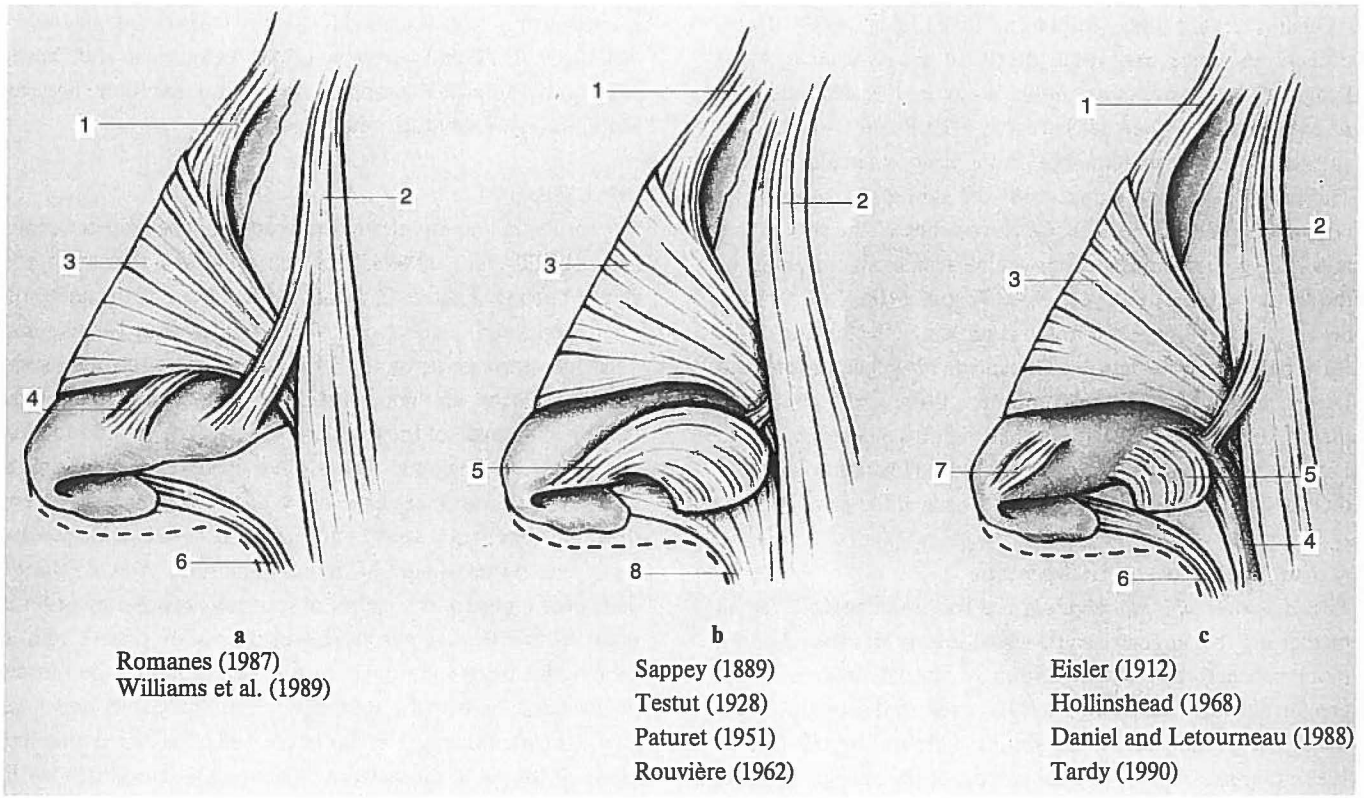

Figure 2. Nasal muscles as shown in established textbooks of anatomy. (1) M. procerus (M. pyramidalis); (2) M. levator labii superior alaeque nasi; (3) M. nasalis, pars transversa (M. transversus); (4) M. nasalis, pars alaris; (5) M. dilatator naris; (6) M. depressor septi; (7) M. apicis nasi; and (8) M. myrtiformis.

Letourneau and Daniel (1988) describe the dilator muscle as a small, fan-like muscle that originates from the lateral nasal cartilage and alar part of the nasalis and inserts into the caudal margin of the lateral crus and alar skin. Hollinshead (1968) describes two dilator muscles, an anterior and a posterior one, both consisting of a delicate muscle bundle. The posterior dilator is said to arise from minor alar cartilages, the anterior from the greater alar cartilage. They both pass downward, close to the border of the nasal aperture to insert into the skin near the margin. Lang (1989) considers the angular head of the *M. levator labii superioris alaeque nasi* to be the actual dilator of the nares.

M. apicis nasi

Eisler (1912) believes that the alar or dilatator muscle is assisted in its widening function by the very small "muscle of the nasal tip" or *M. apicis nasi*, lying on the lower half of the lateral crus (Figure 2c). This muscle is very often absent. It is said to widen the anterior part of the nostril (Eisler, 1912; Braus-Elze, 1929; Griesman, 1944; Lang, 1989). However, when the greater alar cartilage is thin, it may narrow the nasal aperture anteriorly and widen it posteriorly (Eisler, 1912; Schmalix, 1968; Lang, 1989). Some authors call this muscle the *M. compressor narium minor* (Letourneau and Daniel, 1988; Tardy, 1990), in the belief that the compressor function is more important than the dilator function.

M. procerus

The procerus muscle (*Latin*: slim or slender) is usually seen as the downward continuation of the occipitofrontal muscle, leading into the transverse aponeurosis on the nasal dorsum (Williams et al., 1989; Romanes, 1987; Lang, 1989). Occasionally, its fibers may reach the nasal ala (Griesman, 1944; Lang, 1989). Because of its fan-like structure it is also called the *M. pyramidalis* (Sappey, 1889; Testut, 1928; Paturet, 1951). Most authors agree that its influence on the nose is actually limited. The procerus muscle draws down the skin at the root of the nose and thus produces transverse wrinkling of the skin in this area. The procerus muscle thus can be seen as an antagonist of the frontal muscles (Sappey, 1889; Testut, 1928). It is also believed to be an antagonist to the depressing effect of the transverse part of the *M. nasalis* (Griesman, 1944; Letourneau and Daniel, 1988), because in cases in which the fibers insert into the ala, the procerus elevates the ala and thus dilates the nostril. Letourneau and Daniel (1988) and Tardy (1990) have adopted this view of the procerus being an elevator of the nose.

M. levator labii superioris alaeque nasi

The *M. levator labii superioris alaeque nasi* is said to have a small medial slip (or "angular head") which inserts into the nasal ala, more precisely the perichondrium of the lateral crus of the greater alar cartilage (Lang, 1989), covering the origin of the transverse portion of the *M. nasalis* (Letourneau and Daniel, 1988). It arises from the frontal process of the maxilla. It would act as a dilator of the nostril (Williams et al., 1989; Lang, 1989) or as an elevator muscle, shortening the nose and dilating the nostril (Griesman, 1944; Letourneau and Daniel, 1988; Tardy, 1990). Sappey (1889) describes a superficial and a deep levator muscle which seems to be identical to the *M. levator labii alaeque nasi* and *M. levator labii superioris*. They act together in drawing the lip and nasal ala upwards.

M. depressor septi

The depressor septi muscle is attached to the maxilla above the incisor tooth, together with the fibers of the alar part of the *M. nasalis*. It is said to ascend to the medial crus of the greater alar cartilage (Lang, 1989, Letourneau and Daniel, 1988) or to (the mobile part of) the septum (Romanes, 1987; Letourneau and Daniel, 1988; Williams et al., 1989; Hollinshead, 1968). Some fibers may insert into the posterior part of the ala of the nose (Hollinshead, 1968). Contradictory functions are ascribed to it. The *M. depressor septi* draws the septum downwards and thus pulls down the lobule (Letourneau and Daniel, 1988). This movement is said to widen the nasal aperture (Griesman, 1944; Williams et al., 1989; Lang, 1989) and to enlarge the valve opening (Cottle, 1955) or to narrow the nostril (Romanes, 1987, Hollinshead, 1968). Converse (1964) stresses the importance to preserve the function of the *M. depressor septi*, because of its supposed role in tensing the membranous septum at the initiation of nasal inspiration.

M. anomalus nasi

The anomalus muscle lies on the lateral part of the bony nose, covering the area between the *M. orbicularis oculi* and procerus muscle. It is a very thin muscle, probably absent in the majority of cases. Origin and insertion are not uniformly described, but it seems as though both attachments are on the same bone. The anomalus muscle is described by Sappey (1889; as *M. innominatus*), Eisler (1912) and Griesman (1944). Letourneau and Daniel (1988) and Tardy (1990) attribute an elevator role to the muscle. More likely, it is of little or no importance.

DISCUSSION

The cartilages and muscles of the nose have been given various names by different authors. This lack of uniform terminology is very confusing. Therefore, we advocate the use of the anatomical nomenclature presented in *Nomina Anatomica*. Tables 1 and 4 list the terms given by the 1989 edition. The so-called sesamoid cartilages are not mentioned in *Nomina Anatomica*. However, because of their possible importance in the mobility of the intercartilaginous region, they do deserve mentioning. The sesamoid cartilages have to be differentiated clearly from the minor alar or accessory cartilages in the so-called hinge area. As to the nomenclature of the nasal muscles, *Nomina Anatomica* only indicates the names of four muscles. No mention is made of the *M. dilatator naris*, which possibly plays a role in keeping the nasal valve open. Furthermore, neither the muscle of the nasal tip nor the (probably insignificant) *M. anomalus nasi* are mentioned. The literature indicates three possible views of the nasal musculature. These views are illustrated in Figure 2. Modern anatomy textbooks - such as Williams et al. (1989) and Romanes (1987) - simply restrict themselves to three nasal muscles: the *M. nasalis*, *M. procerus*, and *M. depressor sep-*

ti (Figure 2a). The *M. levator labii superioris alaeque nasi* is also depicted, but is actually considered to be part of the group of labial muscles.

The second view is represented by Sappey (1889) and other French authors (Figure 2b). They distinguish a separate transverse muscle (i.e., the transverse part of the *M. nasalis*), a dilator muscle, a pyramid muscle (i.e., procerus muscle), and a myrtiform muscle. The myrtiform muscle more or less corresponds with the *M. depressor septi* and alar part of the *M. nasalis.*

The third view is that of the nasal muscular system being composed of the *M. nasalis*, *M. procerus*, *M. depressor septi*, *M. apicis nasi*, and *M. dilatator naris* (Figure 2c). Sometimes, the *M. anomalus nasi* is added to this description (not depicted in Figure 2c). This view is propagated by Daniel and Letourneau (1988), Hollinshead (1968) and Tardy (1990), but was first described by Eisler (1912). Although the outline of the nasal muscular system follows generally this scheme, the various authors do not agree as to the origin and insertion of the muscles. There is also no clarity regarding the function of the different muscles. Opposite functions have been ascribed to the same muscle. For instance, the alar part of the *M. nasalis* is seen as a dilator, but also as a compressor of the nostril. The division into dilator and compressor muscles is made by most authors, but a discussion on the actual mode of action of these muscles is lacking or very brief. A description of the dilatory action (whether dilation leads to a change in the form of the nostril or to an actual increase in diameter without change of form, such as the pupillary aperture) is never subject of discussion. Moreover, dilation of the nasal aperture probably does not lead to an actual decrease in nasal resistance (Haight and Cole, 1983). It seems likely however that a "dilatory" action of one or more nasal muscles is important in preventing nasal valve collapse (Bridger, 1970). As far as nasal compressor function is concerned (as supposed in case of the transverse part of the *M. nasalis*), one may speculate as to its significance. According to Griesman (1944) and Romanes (1987) compression of the nostril occurs in the production of certain sounds. Compression of the vestibule might also play a role in maintaining the air pressure within the oral cavity by blockage of the airway (Griesman, 1944) or in directing the air current when sniffing, by changing the form of the vestibule (Schmalix, 1968). Kern (1978) has stated that "the nasal constrictors are not as important phylogenetically in man as they are in other life forms, especially aquatic life."

Anatomical descriptions of the nasal cartilages and muscles do not provide sufficient insight into the mechanism of mobility of the lateral nasal wall and valve area, although they do form a framework from which to derive a basic model. For example, the articulations between the skeletal elements of the nose (nasal bone, lateral nasal cartilage, and greater alar cartilage) would suggest that the lateral nasal wall is composed of a polyarticular chain. Other contributing factors are the muscle action in the unsupported part of the lateral nasal wall (the nasal ala) and the resilience of the cartilages. Further studies are necessary to investigate these features, including the nature of the attachments of the cartilages and the location and function of the different muscles that may influence the valve area. This would facilitate the development of a model describing the mobility of the lateral nasal wall, and thus provide information on the dynamics of the valve area.

ACKNOWLEDGEMENTS

The authors thank Mrs. A. van den Berg for the illustrations.

REFERENCES

1. Bachmann W, Legler U (1972) Studies on the structure and function of the anterior section of the nose by means of luminal impressions. Acta Otolaryngol (Stockh) 73: 433-442.
2. Bernstein L (1975) Surgical anatomy in rhinoplasty. Otolaryngol Clin N Am 8: 549-558.
3. Braus H, Elze C (1929) Anatomie des Menschen. Band I. Springer Verlag, Berlin.
4. Bridger GP (1970) Physiology of the nasal valve. Arch Otolaryngol 92: 543-553.
5. Converse JM (1955) The cartilaginous structures of the nose. Ann Otolaryngol 64: 220-229.
6. Converse JM, Wood-Smith D, Wang MKH, Macomber WK, Guy CL (1964) Deformities of the nose. In: JM Converse (Ed.) Reconstructive Plastic Surgery. WB Saunders Company, Philadelphia, pp. 694-828.
7. Cottle MH (1955) The structure and function of the nasal vestibule. Arch Otolaryngol 62: 173-181.
8. Daley J (1948) Morphologic deformities of the lower lateral cartilages. Arch Otolaryngol 47: 49-63.
9. Daniel RK (1992) The nasal tip: Anatomy and aesthetics. Plast Reconstr Surg 89: 216-224.
10. Daniel RK, Lessard ML (1984) Rhinoplasty: A graded aesthetic-anatomical approach. Ann Plast Surg 13: 436-451.
11. Daniel RK, Letourneau A (1988) Rhinoplasty: Nasal anatomy. Ann Plast Surg 20: 5-13.
12. De Lara Galindo S, De Cuspinera G E, Cardenas Ramirez L (1977) Anatomical and functional account on the lateral nasal cartilages. Acta Anat 97: 393-399.
13. Dion MC, Jafek BW, Tobin CE (1978) The anatomy of the nose. Arch Otolaryngol 104: 145-150.
14. Drumheller GW (1973) Topology of the lateral nasal cartilages: The anatomical relationship of the lateral nasal to the greater alar cartilage, lateral crus. Anat Rec 176: 321-328.
15. Eisler P (1912) Muskeln des Stammes. Handbuch der Anatomie des Menschen. Fischer Verlag, Jena.
16. Gilbert JG, Feit LJ (1955) The nasal aponeurosis and its role in rhinoplasty. Arch Otolaryngol 61: 433-436.
17. Griesman B (1944) Muscles and cartilages of the nose from a standpoint of a typical rhinoplasty. Arch Otolaryngol 39: 334-341.
18. Gunter JP (1969) Anatomical observations of the lower lateral cartilages. Arch Otolaryngol 89: 61:63.
19. Haight JSJ, Cole PH (1983) The site and function of the nasal valve. Laryngoscope 93: 49-55.
20. Hinderer KH (1971) Fundamentals of Anatomy and Surgery of the Nose. Aesculapius Publishing Company, Birmingham.
21. Hollinshead WH (1968) Anatomy for Surgeons, Volume I. Harper & Row, New York.
22. Janeke JB, Wright WK (1971) Studies on the support of the nasal tip. Arch Otolaryngol 93: 458-464.
23. Jones AS, Wight RG, Stevens JC, Beckingham E (1988) The nasal valve: A physiological and clinical study. J Laryngol Otol 102: 1089-1094.
24. Jost G, Meresse B, Torossian F (1973) Etude de la jonction entre les cartilages lateraux du nez. Ann Chir Plast 18: 175-182.
25. Kern EB (1978) Surgical approaches to abnormalities of the nasal valve. Rhinology 16: 165-189.
26. Krmpotic-Nemanic J, Kostovic I, Rudan P, Nemanic G (1971) Morphological and histological changes responsible for the droop of the nasal tip in advanced age. Acta Otolaryngol (Stockh) 71: 271-281.
27. Lang J (1989) Clinical Anatomy of the Nose and Paranasal Sinuses. Thieme Medical Publishers, New York.

28. LePesteur J, Firmin F (1977) Réflexions sur l'auvent cartilagineux nasal. Ann Chir Plast 22: 1-9.
29. Lessard ML, Daniel RK (1985) Surgical anatomy of septorhinoplasty. Arch Otolaryngol 111: 25-29.
30. Letourneau A, Daniel RK (1988) The superficial musculoaponeurotic system of the nose. Plast Reconstr Surg 82: 48-55.
31. McKinney P, Johnson P, Walloch J (1986) Anatomy of the nasal hump. Plast Reconstr Surg 77: 404-405.
32. Mink JP (1902) De neus als luchtweg. Geneeskundige Bladen, Negende Reeks, No. IV: 75-115.
33. Mink JP (1903) Le nez comme voie respiratoire. Presse Otolaryngologique Belge, Bruxelles, pp. 481-496.
34. Mink PJ (1920) Physiologie der Oberen Luftwegen. Verlag FCW Vogel, Leipzig.
35. Natvig P, Sether LA, Gingrass RP, Gardner WD (1971) Anatomical details of the osseous-cartilaginous framework of the nose. Plast Reconstr Surg 48: 528-532.
36. Nomina Anatomica (1939) Nomina Anatomica. Fischer Verlag, Jena.
37. Nomina Anatomica (1989) Nomina Anatomica, 6th Edition. Churchill Livingstone, Edinburgh.
38. Parkes ML, Kanodia R. (1981) Avulsion of the upper lateral cartilages; Etiology, diagnosis, surgical anatomy and management. The Laryngoscope 91: 758-764.
39. Paturet G (1951) Traité d'Anatomie Humaine, Tôme 1. Masson, Paris.
40. Romanes GJ (1987) Cunningham's Textbook of Anatomy, 12th Edition. Oxford University Press, Oxford.
41. Rouvière H (1962) Anatomie Humaine, Tôme 1. Masson, Paris.
42. Sappey PC (1889) Traité d'Anatomie Descriptive. Delahaye, Paris.
43. Schmalix J (1968) Die eigentliche Nasenmuskulatur und ihre Bedeutung für den Nasenplastiker (zugleich ein Beitrag zur Physiologie der Nasenatmung). Arch klin exp Ohr Nas Kehlheilk 191: 683-688.
44. Sheen JH, Sheen AP (1987) Aesthetic Rhinoplasty. Mosby, St. Louis.
45. Sieglbauer F (1958) Lehrbuch der Normalen Anatomie des Menschen. Urban & Schwarzenberg, München.
46. Straatsma BR, Straatsma CR (1951) The anatomical relationship of the lateral nasal cartilage to the nasal bone and the cartilaginous nasal septum. Plast Reconstr Surg 8: 443-455.
47. Tardy ME, Brown RJ (1990) Surgical Anatomy of the Nose. Raven Press, New York.
48. Testut L (1928) Traité d'Anatomie Humaine, Tôme I. Doin, Paris.
49. Uddströmer M (1940) Nasal inspiration. Acta Otolaryngol (Stockh) Suppl 42: 3-146.
50. Van Dishoeck HAE (1942) Inspiratory nasal resistance. Acta Otolaryngol (Stockh) 30: 431-439.
51. Williams PL, Warwick R, Dyson M, Bannister LH (1989) Gray's Anatomy, 37th Edition. Churchill Livingstone, Edinburgh.
52. Zelnik J, Gingrass RP (1979) Anatomy of the alar cartilage. Plast Reconstr Surg 64: 650-653.
53. Zide BM (1985) Nasal anatomy: The muscles and tip sensation. Aesth Plast Surg 9: 193-196.
54. Zuckerkandl E (1882) Normale und Pathologische Anatomie der Nasenhöhle und ihrer Pneumatischen Anhänge. Braumüller, Wien.

Tj.D. Bruintjes, MD
Department of Otorhinolaryngology
University Hospital Utrecht
P.O. Box 85.500
NL-3508 GA Utrecht
The Netherlands