Surgical procedures of the nasal valve area

operative techniques and functional evaluation

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Printing and lay-out: drukkerij Mostert, Leiden

ISBN: 978-90-9025175-2

Surgical procedures of the nasal valve area

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Een wetenschappelijke proeve
op het gebied van de Medische Wetenschappen

PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. mr. S.C.J.J. Kortmann,
volgens besluit van het College van Decanen

in het openbaar te verdedigen op dinsdag 16 maart 2010

om 15.30 uur precies

door

Robert Francis André

geboren op 21 december 1967 te Londen

Promotores:

Prof. dr. K. Graamans
Prof. dr. G.J. Nolst Trenité, Universiteit Gent

Copromotor:

Dr. H.D. Vuyk, Tergooi ziekenhuizen, Blaricum

Manuscriptcommissie:

Prof. dr. P. H.M. Spauwen
Prof. dr. S. J. Bergé
Dr. K.J.A.O. Ingels
Prof. dr. A.M. Kuijpers-Jagtman
Prof. dr. ir. G.A. Zielhuis

To daddy,

for inspiring me to have at least
a few letters behind my name…

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Chapter 1

General introduction and outline of the thesis

Background

The seemingly simple complaint of a blocked nose is often a complex clinical problem involving mucosal, structural and even psychological factors. In individual patients more than one cause may be involved in nasal obstruction, and the relative contribution of the various mucosal and structural factors, let alone the psychological ones, may be difficult to assess. Although the sensation of nasal airflow is a subjective perception, it is closely related to airflow resistance, which in turn is related to the diameter of the segment of the nose through which the inhaled air passes.

Many conditions, diseases and environmental factors are known to negatively influence nasal patency through their effects on the mucosal lining of the nose. In such cases treatment is primarily conservative and can involve decongestants, steroids, antihistamines, and, if possible, avoidance of environmental pollutants or allergens. In nasal obstruction caused by inferior or middle turbinate hypertrophy, both the mucosal and the bony parts of the turbinate may be involved and medical as well as surgical treatment may be required.

Traditionally, nasal obstruction that was not responsive to conservative therapy was almost considered synonymous with a septal deviation and/or inferior turbinate hypertrophy. As a consequence, septoplasties and turbinate reduction procedures remain by far the most frequently performed operations aimed at improving nasal patency. These procedures however, even when technically correctly performed, do not always succeed in restoring normal nasal patency. This may explain a still often held opinion, both among the general public and medical practitioners, that the reliability of functional nasal surgery is at best questionable. This may be partially due to the fact that the importance of the nasal valve area concerning nasal patency has frequently been overlooked in the past. A variety of surgical techniques have been described to correct the anatomy of the nasal valve area in order to improve nasal functioning. There are still many uncertainties about their applicability in certain anatomical situations and their value in restoring nasal physiology. Moreover, the role of objective measurements of nasal patency in clinical practice is debatable. Therefore the main goal of this thesis is to evaluate aspects of nasal valve surgery, with emphasis on their usefulness in improving nasal functioning. Functional corrective nasal surgery brings about anatomical changes that are meant to improve nasal physiology. In the next section we

discuss the relevant aspects of the anatomy of the nasal valve area and their role in physiology and pathophysiology of the nose.

Nasal physiology and the nasal valve.

During inspiration air is drawn into the nose by the negative pressure in the lungs. About 50% of the total airway resistance is in the nose and the other half in the lower airways. According to Ohm's law, flow is directly proportional to the pressure differential and inversly proportional to the resistance. Unlike the septum, the lateral walls off the nose have a certain amount of flexibility. During inspiration the lateral walls are always partially sucked inwards due to the Venturi effect which causes a lowering of pressure as described by the law of Bernoulli. The extent to which this occurs depends on the velocity of the inspiratory airstream and on individual characteristics of the lateral walls, such as their stiffness and the configuration of the upper and lower lateral cartilages. This inward movement reduces the diameter of the nasal passages, increasing nasal airway resistance and causing a decrease of airflow. Up to a certain level this may be beneficial for the functioning of the nasal mucosa, facilitating heating, moisturizing and filtering of the inhaled air. However, if the resistance becomes too high, the flow will become too low for adequate ventilation of the lungs with nasal stuffiness and oral breathing as a consequence.

Over the last decades increasing attention has been given to the role of the nasal valve area in maintaining nasal patency. It is becoming clear that pathology in this area more frequently plays a role in causing nasal obstruction than was previously recognised. The term 'nasal valve' was first introduced by Mink[1-2] over a century ago and with it he referred to the dynamic properties of the lateral nasal wall, mainly the upper lateral cartilage, and the importance of this nasal segment in regulating airflow through the nasal cavities. Since then the term has evolved and nowadays in the most common definition an internal and external nasal valve is described, as well as a nasal valve area. This slit-like area, first described by Zuckerkandl [3], generally constitutes the narrowest part of the nasal airways and accounts for a large part of the inspiratory airway resistance. According to the law of Pouisseuille the flow through a tube is directly related to the difference in resistance between either end of the tube, multiplied with the radius to the fourth power. This means that flow is inhibited most by the narrowest part of a tube and

even a slight further decrease of the diameter at this site may disproportionately inhibite flow. Because of this, pathology in the nasal valve area may have a large negative influence on nasal breathing.

The shape of the nasal valve area also provides an important contribution to nasal physiology by causing turbulence in the inhaled airstream, which is necessary for optimal functioning of the nasal mucosa. Overall, the dynamic properties of the nasal valve area provide a control mechanism for regulating the flow of respiratory gasses during inspiration, thereby optimizing the influx of air during nasal breathing.

Anatomy of the nasal valve area

The nasal valve area consists of several structures that through their interdependence regulate nasal patency and resistance. Anatomically, a distinction can be made between the internal and external nasal valve (Figures 1.1 and 1.2). The internal nasal valve is further defined by its area and the nasal valve angle. Though the internal and external nasal valves may be strictly defined anatomically, there is considerable functional overlap.

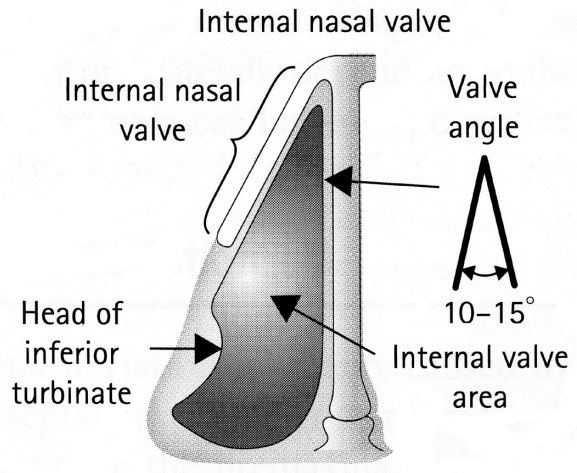

Figure 1.1 The internal nasal valve.

In the following segment the anatomical components making up the internal and external nasal valves are described, particularly in relation to their functional relevance are described.

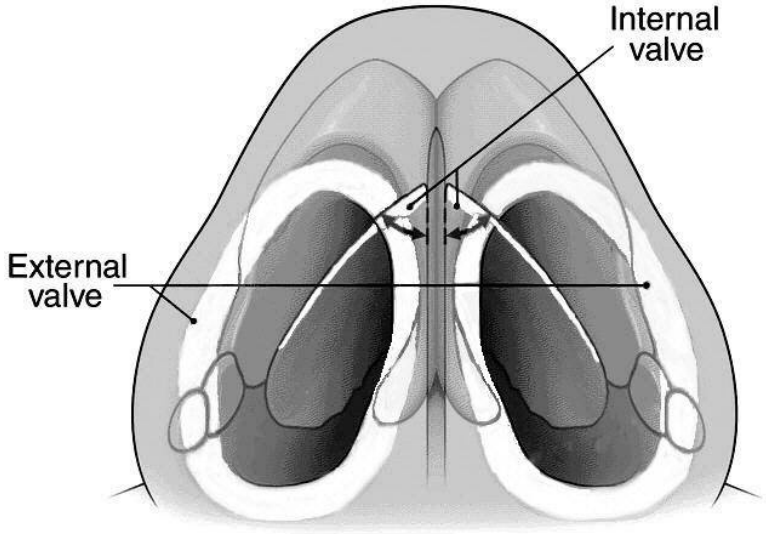

Figure 1.2 The internal and external nasal valves.

The internal nasal valve

The nasal valve proper is the slit-like relationship between the septum and the caudal margin of the upper lateral or triangular cartilages. This 'internal nasal valve' is located on an oblique plane between the nostril on a horizontal plane and the pyriform aperture on a vertical plane. The nasal valve area lies obliquely to the medial sagittal plane, from which it deviates slightly. The nasal valve area is generally the narrowest three-dimensional segment of the whole nasal passageway and is bounded as follows [4–10]:

- superolaterally, by the caudal margin of the upper lateral cartilage
- laterally, by the empty triangle, the triangular-shaped region devoid of cartilaginous support structures and made up of fibrofatty tissue extending down to the margin of the pyriform aperture
- infrolaterally, by the cephalic margin of the lateral crus of the lower lateral or alar cartilage
- medially, by the nasal septum

- inferomedially, by the inferior nasal spine and the premaxillary wings
- inferiorly, by the inferior rim of the pyriform aperture and the floor of the nose
- posteriorly, by the anterior tip of the inferior turbinate.

The nasal valve area extends not only in a vertical (coronal) plane, but also anteroposteriorly, being limited posteriorly by the head of the inferior turbinate. In the following section, the anatomy of the different subunits and bounderies of the internal nasal valve are reviewed in more detail.

Cartilaginous nasal septum and upper lateral cartilages (septolateral cartilage)

The cartilaginous component of the septum; the quadrangular cartilage, contributes significantly to the architecture of the nasal valve area. The septal cartilage is a flat cartilaginous lamina, unevenly square in shape and variable in size. The quadrangular cartilage and both upper lateral cartilages are connected and form one anatomic unit, sometimes referred to as the septolateral cartilage. The angle formed by the septal cartilage and its lateral extensions is approximately 90 degrees at the level of the fixed cephalic section, progressively decreasing in the caudal direction to 10–15 degrees at the level of the internal nasal valve. The caudal edge of the upper lateral cartilage separates at the bottom from the septal cartilage, thus forming a thin 'upside-down V' slit that adjusts to the respiratory excursions. The caudal edge of the upper lateral cartilage is bent upwards between 45 and 180 degrees and is referred to as 'returning' or 'curling' or 'scrolling'. This edge is joined to the lateral crus of the lower lateral cartilage (LLC) by a thin, flexible aponeurosis. The upper lateral cartilages are cephalically supported by the nasal bones. In cases of short nasal bones combined with relatively long upper lateral cartilages, the latter are less supported and prone to collapse. Deviations or other deformities of the nasal septum located in the nasal valve area are far more likely to cause obstructive symptoms, than deformities located posterior to this area.

Premaxilla and maxillary bone

The two wings that form the premaxilla rise above the nasal crest of the maxillary bone and are virtually joined together into a 'rail', which accommodates the septal cartilage. The anterior–inferior nasal spine extends forward from the two wings of the premaxilla forming its most frontal part. Deformities in the spine, the premaxillary wings, the pyriform crests and the anterior aspect of the floor of the nasal cavities may cause an altered shape and diminished cross-sectional area

of the bony aperture of the nasal valve area. Aerodynamic studies have shown the considerable importance of the lower portion of the internal nasal valve [11].

Empty triangle

This is the area of compliant fibrofatty tissue between the upper lateral cartilages and the pyriform aperture. Roughly triangular-shaped, this area is bordered anteriorly by the inferolateral margins of the upper lateral cartilages and the superior margin of the lateral crus, posteriorly by the osseous margin of the pyriform aperture, and inferiorly by the alar lobule. This triangular area represents the 'locus minoris resistentiae' of the external lateral nasal wall and is the site where inspiratory collapse may occur most frequently. At the junction of the upper and lower lateral cartilages, accessory cartilages are almost invariably found, either as a single large piece or as multiple smaller fragments [12].

Upper and lower lateral cartilages

The type of interdigitation between the upper and lower lateral cartilages is variable, the most frequent combination being end-to-end, [13] scroll formation [14] or overlapping [10, 15]. Functionally, the presence of two cartilaginous surfaces and their loose fibrous attachments provides support to the nasal valve. Although they lie below the level of the internal nasal valve, deformities or weakness of the lower lateral cartilages may indirectly contribute to internal nasal valve insufficiency.

Head of the inferior turbinate

The anterior tip of the inferior turbinate has a slightly oblique downward orientation and lies 2–3 mm posterior to the pyriform crest. It is covered by squamous epithelium, whereas the greatest part of the nasal passages is lined with ciliated columnar secretory epithelium. Its chorion houses the bodies of the nasal glands and cavernous erectile tissue. Erectile tissue is also found on the lateral wall of the nose, anterior to the insertion of the head of the inferior turbinate. This erectile tissue extends a few millimetres beyond the pyriform aperture, and in the congested nose will also intrude into the valve area. The bony part of the head of the inferior turbinate may also present structural alterations like hypertrophy or pneumatization. These anatomic variations must be borne in mind both at diagnosis and during surgery.

The external nasal valve

In the anatomical classification, the external nasal valve is divided into two main compartments. The medial compartment consists of the caudal septum, columella and premaxilla, while the lateral compartment is made up of (the caudal part of) the alar cartilage, alar lobule and dilator muscles. The ala is largely responsible for the collapsibility of the external nasal valve. The shape and structural strength of the external nasal valve depends on the size, shape, intrinsic resilience and orientation of the lower lateral cartilages, on the alar lobule architecture and thickness and texture of the skin/soft-tissue envelope and on the medial wall contour and position.

Lower lateral cartilage and medial wall

The external nasal valve may be conceptualized as a ring, with major contributions from the lower lateral cartilage and septum. More specifically, the following components further contribute to the external nasal valve:

- The medial crural footplates embrace the caudal septum with its fibrous articulation to the membranous septum.
- The quadrangular cartilage is anchored on the anterior-inferior nasal spine [(16)] extending from the perichondrial sheath of the septum as well as from the surrounding bone structures.
- The shape and resilience of the lower lateral cartilages add strength.
- The nasal hinge area comprises the most lateral aspect of the lower lateral cartilage where it attaches by way of ligaments, fibrous tissue, and the lateral chain of accessory cartilages to the pyriform aperture. At the hinge region, both accessory cartilages and lateral crus are enveloped in the same continuous perichondral sheath, which confers stability extending the support of the lateral crus to the piriform aperture.
- The two alar rings are reciprocally linked at their medial interfaces by the junction of dense connective tissue which thickens at the interdomal area and the region between the medial and intermediate crurae. This anatomical arrangement makes the two cartilaginous rings behave as a single structural and functional entity.
- The lateral crus may present in five morphologic types [(17)]:
  1. smooth convex crurae in which the entire lateral crus is convex
  2. crurae that are convex anteriorly and concave posteriorly

3. crurae that are concave
4. crurae that are concave anteriorly and convex posteriorly
5. crurae that are concave anteriorly, convex in the middle, and concave posteriorly.

Differences in conformation and orientation of the crurae may play a significant role in alar compliance. Generally speaking, the smooth convex type should give the smallest chance of valve insufficiency, while the concave type predispose to it most.

The medial components involved in the anatomical arrangement of the external nasal valve are made up of the medial crurae, the membranous septum and the cartilaginous septum. Each of these components may compromise nasal valve function. Deformities of components of the medial wall may result in a narrowing of the cross-sectional area of the external valve. Subsequent inspiratory retraction due to increased inspiratory negative pressure may cause collapse of the lateral nasal wall [18,19].

Muscular arrangement

Two nasal and paranasal muscles have a significant effect on lateral nasal wall mobility and valve function: the dilator naris and the alar part of the nasalis muscle. The dilator naris attaches to the lateral crus and the soft tissue just below the lateral crus, and increases the nostril cross-section on muscle contraction. A synergistic but smaller role is played by the alar part of the nasalis muscle which, being attached to the accessory cartilages at the hinge area, draws the hinge area (including the accessory cartilage and lateral crus) laterally. The transverse part of the nasalis muscle, acting on the skin overlying the nasal lateral wall, stabilizes the valve components (ULC, IC junction, hinge area) and thus stiffens the nasal lateral wall [10, 20].

Alar Lobule

The alar lobule consists of relatively stiff, fibrofatty muscular tissue whose dermis is interdigitated with muscle throughout and up to the alar rim on both the internal (vestibular) and external surfaces. Although deplete of cartilage, it still provides functional support of the alar side wall [21].

Skin/soft-tissue envelope

In general the skin/soft-tissue envelope of the nasal tip and ala is thicker and more sebaceous, while the skin of the columella and soft triangles is thinner and hardly contains any subcutaneous tissue. Thin skin is often associated with a paucity of subcutaneous fibrofatty tissue and strong, large alar cartilages, whereas weaker cartilages are a common finding in patients with thick skin and abundant subcutaneous fibrofatty tissue and sebaceous glands. Nasal valve evaluation may be facilitated by thin skin while thick skin may hide a narrow nasal valve.

Pathophysiology of the nasal valve area

During normal breathing, the internal nasal valve area alternately shrinks and opens following the inspiratory/expiratory cycle, with the upper lateral cartilages drawn inwards by the negative pressure in the nasal cavities by inspiratory airflow. Moreover, during inspiration the nostrils widen, because the lateral crura of the alar cartilages rotate on their major axis. This makes their upper border collapse inwards and their caudal margin open outwards. Since the upper margins of the lateral crura overlap the upper lateral cartilages by 1–2 mm, the latter are pushed further inwards. Dysfunction of this balanced mechanism may lead to increased inspiratory nasal resistance. Nasal valve incompetence (either internal or external) can be either static or dynamic. Static incompetence alludes to continuous nasal valve insufficiency, whereas dynamic incompetence occurs only upon more forceful inspiration such as during exercise.

Internal nasal valve incompetence is characterized by inspiratory collapse even at low negative pressures. It is the result of weakness of the supporting nasal sidewalls and/or a sharp nasal valve angle (smaller than 10–15 degrees). Such a narrow angle may have its cause medially by a septal deviation or laterally by (a part of) the sidewall. One may categorize nasal valve insufficiency as either primary or acquired. Primary causes encompass any congenital variation, resulting in a smaller nasal valve area, such as a narrow pyriform aperture or a deviated anterior septum. Mucosal swelling, specifically of the head of the turbinate, may also diminish the nasal valve area. Acquired nasal valve insufficiency may be due to loss of structural support after trauma or aggressive reduction rhinoplasty and/or narrowing based on scarring. Dysfunction of the ipsilateral facial nerve causing flaccid paralysis of the dilator naris and levator labii superioris alaequi

nasi muscles may induce nasal valve insufficiency. When the upper lateral cartilages are too weak and/or too thin (due to idiopathic or iatrogenic causes), the middle nasal vault may collapse during air inflow. In addition, the inward motion of the upper lateral cartilages during air inflow may be exacerbated by short nasal bones.

External valve incompetence may be due to a reduced size of the nares and nasal vestibule or weakness of the sidewall with subsequent collapse on inspiration. Deformities of the anatomy, either congenital or as a result of surgery or caused by facial nerve palsy [22], may alter the shape, strength and functioning of the external nasal valve. Scarring, specifically, may cause narrowing of the external nasal valve.

Diagnosis

The following paragraphs for the greatest part are true for both internal and external nasal valve dysfunction, specific points of attention concerning the external nasal valve will be addressed in the relevant section, without repeating the overlapping diagnostic considerations.

History

Sensation of nasal airflow is a complex subjective perception, which is only partly related to nasal airflow resistance and also involves affective and cognitive components [23]. Furthermore, in individual patients more than one cause may be involved in nasal obstruction and it can be difficult to assess the relative contribution of the various structural and mucosal factors, let alone the affective and cognitive ones. Consequently, a patient's history may not always correlate with anterior rhinoscopy or endoscopy [24, 25]. It is important to be aware of these possible discongruities between history and further diagnostic interventions and to discuss this with the patient.

Physical examination

External inspection is performed on frontal and basal views without any instrument. In cases of internal nasal valve insufficiency, upon external inspection, the nose may look narrow, especially in the middle third. The patient is observed during both normal and forced inspiration in order to identify areas of pathological

collapse [18]. Pulling the cheek laterally (Cottle's manoeuvre) as well as the superior tip rotation test are aspecific and not very reliable [26]. More valuable information may be obtained by intranasally supporting and/or lateralizing the collapsing segment with a fine instrument [27]. The insertion of a wax curette in different regions of the nasal sidewalls will help to locate the exact site of maximal collapse: the greatest subjective inspiratory improvement will occur when support is provided at the epicentre of the pathological area. The effect of a spreader graft may be mimicked by placing a small cotton tip in the apex of the internal nasal valve [28]. Endonasal inspection is classically performed with a nasal speculum to inspect and analyse the anterior segment of the nose. One should be aware that a speculum might distort the external as well as internal nasal valve. Further analysis may be performed using a 0-degree endoscope.

Although neither history nor inspection can be considered as objective evaluations, in most cases data collected from history and inspection provides the surgeon with sufficient information about the site and nature (static narrowing or dynamic collapse) of the valvular dysfunction. The role of rhinomanometry and acoustic rhinometry as objective measurements of nasal patency is discussed in chapter 2.

Surgery of the nasal valve

As was stated above, flow is inhibited most by the narrowest part of a tube and even a slight further decrease of the diameter greatly further inhibite flow. Because of this, pathology in the nasal valve area, often described as 'nasal valve insufficiency' may have a disproportionately large negative influence on nasal breathing. On the other hand, even a minor surgical widening of the of the narrowest section can greatly increase airflow, a fact that is put to use in the surgical treatment of nasal valve pathology.

Many surgical procedures and techniques have been developed for treating nasal valve insufficiency, and new ones are described frequently [28- 64]. What all nasal valve procedures have in common is that they aim at increasing the cross-surface nasal valve area, usually either by increasing the nasal valve angle and/or by reducing diminishment during inspiration. Often this is combined with a lateralisation and/or strengthening of the lateral nasal wall. Although surgery of the nasal valve area is increasingly frequently performed, there is still no consensus

on what surgical technique is most appropriate for the various causes of nasal valve insufficiency. Moreover the effect of nasal valve surgery, and of functional nasal surgery in general, is hard to express in terms of exactly measurable figures. While there may be a certain amount of overlap of the effectiveness of the techniques for specific areas, each technique has a particular region for which it is theoretically most suited. The selected technique should ideally be tailored to the exact site and nature of a deformity or malformation in any of the areas making up the boundaries of the internal or external nasal valves.

Deformities in six sites can be distinguished for which specific surgical techniques have been developed. (Table 1.1)

Table 1.1
Summary of techniques and sites for which they are most suited.

Site of deformity	**Technique**
Apex of internal nasal valve	(Endonasal) spreader grafts
(Bilateral) internal nasal valve/ caudal border of upper lateral cartilages and cephalic border of external nasal valve/ lateral crus	Butterfly graft
Lateral wall of internal and/or external nasal valve	Nasal valve suspension
Lateral wall of internal and/or external nasal valve	Sub-alar batten grafts
Caudal and/or dorsal nasal septum (deformity)	Septal Battens or major septal replacement
Caudal and/or dorsal nasal septum (perforation)	Nasal septum perforation repair

Objectives and study design

The main objective of this thesis is to discuss the current state of knowledge of conditions causing obstructive symptoms in the nasal valve area and to study the effectiveness of various surgical procedures aimed at treating those conditions. Although many procedures and techniques have been developed for this purpose, in this study we selected a limited number of techniques aimed a specific (sub)

sites surrounding the nasal valve area. The aim was to identify a select number of techniques with which it should be possible to treat the vast majority of causes leading to nasal valve insufficiency. The selection of the techniques described and evaluated, was based on previously described techniques in the literature, modified according to theoretical considerations that are discussed in the relevant chapters. The aim of this study was to evaluate the efficacy of each of these techniques in patient series ranging from 20 to 89 cases, combining clinical findings and subjective self-evaluation scores by the patients. As nasal patency is primarily a subjective sensation, albeit closely linked to nasal airflow resistance, the questions surrounding the means we currently have at our disposal to 'objectively' measure this sensation are also addressed. To this end, we analyzed the literature on objective rhinometry. It was our aim to draw conclusions concerning its relevance in clinical practice and its suitability for evaluating surgical results.

Outline of the thesis

Chapter 2 reviews the literature on the correlation between the subjective sense of nasal patency and 'objective' nasal testing with rhinomanometry and acoustic rhinometry. Based on these data, outcome measures for assessing functional nasal valve surgery are defined.

Chapters 3 to 6 each discuss a specific procedure (endonasal spreader grafts, butterfly graft, nasal valve suspension and sub-alar batten grafts) aimed at treating nasal valve insufficiency caused by a narrow nasal valve angle and/or weakness in (a part of) the lateral nasal wall. The results are presented of the clinical studies that were done to assess their effectiveness.

Chapter 7 describes and compares two surgical options for addressing deformities in the caudal and dorsal part of the cartilaginous nasal septum as these parts of the septum make up part of the medial wall of the nasal valve area.

Chapter 8 gives an overview of the management of nasal septum perforations as such perforations most frequently are (partially) located in the medial wall of the nasal valve area and can cause diminished nasal patency due to excessive turbulence of the inspiratory airflow. The results of one specific surgical technique regarding its effectiveness in closing such perforations are presented.

Chapter 9 summarizes and discusses the findings of the studies described in chapters 2 to 8. We discuss the conclusions drawn from our studies as well as their strengths and weaknesses. General issues surrounding 'evidence based surgery' are reflected upon and the relevance of these issues in regards to our studies is discussed. The studies are also compared to the literature on this subject. The objective of this thesis was to improve our knowledge of the influence of the nasal valve in causing nasal obstruction and to evaluate the therapeutic role of a selection of site-specific techniques. This chapter evaluates to what extent our findings have contributed to this aim, what the implications might be in clinical practice and gives recommendations for future research.

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Chapter 2

Objective and subjective testing of nasal patency

Based on:

The correlation between subjective and objective evaluation of the nasal airway. A systematic review of the highest level of evidence. Review.
Clin Otolaryngol. 2009 Dec; 34 (6): 518-25.

Robert F. André
Hadé D. Vuyk
Aftab Ahmed
Kees Graamans
Gilbert J. Nolst Trenité

Summary

Background: There is no consensus about the value of objective measurements of nasal patency.

Objective: To assess the correlation between the subjective sense of nasal patency and the outcomes found with rhinomanometry and acoustic rhinometry.

Type of review: Structured literature search.

Search strategy and evaluation method: Review of English-language articles in which correlations were sought between subjective nasal patency symptoms and objective scores as found with rhinomanometry (nasal airway resistance: NAR) and acoustic rhinometry (minimal cross-sectional area: MCA). Correlations were related to unilateral or combined assessment of nasal passages and to symptomatic nasal obstruction or unobstructed nasal breathing.

Results: Sixteen studies with a level of evidence II-a or II-b fit the inclusion criteria and were further analyzed. Almost every possible combination of correlations or lack thereof in relation to the variables included was found. However, when obstructive symptoms were present, a correlation between the patency symptoms with NAR and MCA was found more often than in the absence of symptoms. In cases of bilateral assessment a correlation was found almost as often as it was not between patency symptoms and total NAR or combined MCA's, while in the limited amount of studies in which unilateral assessment was done a correlation was found each time between patency symptoms and NAR.

Conclusion: The correlation between the outcomes found with rhinomanometry and acoustic rhinometry and an individual's subjective sensation of nasal patency remains uncertain. Based on this review, it seems that the chance of a correlation is greater when each nasal passage is assessed individually and when obstructive symptoms are present. There still seems to be only a limited argument for the use of rhinomanometry or acoustic rhinometry in routine rhinologic practice or for quantifying surgical results.

Key points:
-There is continuing divergence of opinion about the value of objective measurements of nasal patency in clinical practice.
-There is no consensus about the correlation between objective measurements and subjective nasal patency symptoms.
-Objective measurements of nasal patency are frequently used to validate the results of therapeutic interventions.
-No firm conclusions can be based on this review, as the questionnaires were non-validated and a true meta-analysis could not be done. However, no basis was found to elevate the value of objective outcomes above subjective patency symptoms, neither in routine rhinologic practice, nor for the evaluation of therapeutic interventions.

Introduction

The complaint of a blocked nose is often a complex clinical problem involving mucosal, structural, and even psychological factors. In clinical practice it is frequently difficult to assess the relative importance of individual factors contributing to nasal obstruction and to decide on the therapy most likely to be effective in restoring satisfactory nasal breathing. The perception of nasal airflow ultimately is a subjective sensation and therefore, by definition, difficult to quantify. Even so, efforts are continuously being made to improve our ability to 'objectively' measure nasal patency. The gold standard would be a quantifiable, reproducible, objective test with a strong correlation to the subjective perception of nasal airflow. Such a test would help us in diagnosing the degree, and sometimes even the location and the cause of nasal obstruction. It would also be useful for evaluating the results of medical and surgical interventions aimed at improving nasal patency. Considering the complexity and variability of the subjective sense of nasal patency, one may justifiably wonder if such a test will ever be available.

Since the late 1950s, over a thousand articles have been published in which rhinomanometry has been described or involved in one way or another. Since the late 1980s, more than 500 studies have used acoustic rhinometry. A relatively small number of these studies attempted to investigate the correlation between rhinomanometry and/or acoustic rhinometry and the subjective sensation of nasal patency. They showed conflicting results. In this article we discuss the current status of our ability to objectively measure nasal patency, and more specifically, we review the literature on how this relates to the subjective sensation of nasal airflow. From this we tentatively deduce what the role of objective measurements may be in clinical practice at the present time.

Measuring nasal patency

Rhinomanometry

Rhinomanometry is a dynamic test of nasal function that calculates nasal airway resistance (NAR) by measuring transnasal pressure and airflow in the nasal airway during respiration. Rhinomanometry yields flow-pressure curves. Laminar airflow increases with increased transnasal pressure, but higher pressures lead to turbulent flow. Turbulent flow results in an exponential limitation of flow generated despite

greater transnasal pressure differences. Collapsibility of the lateral nasal wall and irregularities in the lining of the nasal cavity may enhance the development of turbulences.

The following three kinds of rhinomanometry are used [1].

1. The most commonly used method is active anterior rhinomanometry, in which the patient actively breathes through one nasal cavity while the transnasal pressure, or difference in pressure from the naris to the nasopharynx, is measured with a pressure probe placed at the contralateral nostril.
2. In passive anterior rhinomanometry the pressure is also measured for each nasal cavity separately, but at a given airflow.
3. Active posterior rhinomanometry measures choanal pressure with a sensor placed at the back of the nasal cavity via the mouth.

Acoustic rhinometry

Acoustic rhinometry is based on the analysis of sound waves reflected from the nasal cavity. By sending a sound pulse into the nose and recording and analyzing the reflected sound, a two-dimensional picture of the nasal cavity is made, from which the volume and the geometry of the nasal cavity can be deduced. The main benefit of acoustic rhinometry is its capacity to identify the narrowest part of the nasal cavity or minimal cross-sectional area (MCA). This usually corresponds to the nasal valve area or to the head of the inferior turbinate [2].

To help distinguish between mucosal hypertrophy and structural deformity as a cause of nasal obstruction, it is advisable to make the measurements before as well as after decongestion. This applies to both rhinomanometry and acoustic rhinometry.

Material and methods

The main question we wished to address was if any conclusions could be made about the correlation between objective measurements and the subjective sensation of nasal patency. To this end, we conducted a systematic search of the literature published in English from 1980 in which this topic was addressed, either directly or indirectly. First we screened all studies in PubMed in which the word rhinomanometry and/or acoustic rhinometry was used. We also made

combined MeSH searches with the words rhinomanometry, acoustic rhinometry and nasal obstruction to minimize the chance that any relevant article might be overlooked. We then screened the abstracts and when they contained information that suggested the possibility of relevance for our study, the full text article was examined. The aim of this search was to trace those studies that looked for statistically significant correlations between objective outcomes and subjective patient assessments. The studies that fit this minimum requirement were rated according to their respective levels of evidence according to the guidelines of the 'Oxford Centre for Evidence- based Medicine'. The essential parameter included in every article reviewed was the subjective analysis of nasal patency ('patency symptoms'). The two other parameters, of which at least one was required for a study to be included, were minimal cross-sectional area (MCA) as measured by acoustic rhinometry and nasal airway resistance (NAR) as measured by rhinomanometry. Although we were primarily interested in correlations between patency symptoms and either NAR or MCA, correlations between NAR and MCA were also noted when addressed in a study. The correlations were related to the following variables (when reported in the study): unilateral or combined assessment of nasal passages and the absence or presence of sensations of nasal obstruction.

Results

We found 21 studies that met the criteria mentioned above. Four studies were rated as II-a (evidence obtained from a well designed controlled trial without randomisation), 12 studies as II-b (evidence obtained from a well designed cohort or case control analytic study), and 5 studies as III or lower (opinions of respected individuals based on clinical experience, descriptive studies, or reports of expert committees). None of the 21 studies were randomized controlled trials (level of evidence I). The 5 level III or lower studies were excluded. The remaining 16 papers are briefly described in Table 1 [3-18]. For each study we noted the correlations between parameters (Table 2). We attempted to batch the studies into rational subgroups, but because of the differences and the overlapping similarities between the studies we found no logical way to do this that would enhance our ability to analyze the outcomes. Because of differences in study design and other variables (e.g., different patient populations, unilateral or total nasal patency, use of different kinds of rhinomanometry, lack of uniform assessment of patency symptoms or use

	Study	Year	Level of evidence	Population characteristics	Method of Objective Rhinometry	Method of scoring subjective sympto ms	Use of vasocon-striction	Pharma-cologica inter-vention	Surg. ical inter-vention	Brief description of study and outcome
1	Gordon et al.3	1989	II-1	74 patients	AARM	Questionnaire	no	no	yes	Correlation between nasal obstruction symptoms and NAR before surgery, but not after surgery, overall NAR normalized after surgery
2	Jones et al.4	1989	II-2	250 volunteers +/- symptoms	AAMR	VAS	no	no	no	No correlation between subjective sensation of nasal airflow and NAR in patients attending a clinic
3	Grymer et al.5	1989	II-1	42 patients	AR	Questionnaire	Yes	No	Yes	Significant correlation between MCA and the subjective feeling of nasal patency both before and after septoplasty
4	Sipilä et al.6	1994	II-2	102 patients	AARM	Question: Which side of nose most obstructed?	Yes	No	Yes	The side of the nose indicated as being the narrowest, by patients referred for septoplasty, correlated with NAR roughly 75% of the time, compared to 50 % of the time in individuals without complaints
5	Marais et al.7	1994	II-2	16 patients	AR	VAS	no	no	yes	A correlation between patients' satisfaction after septal surgery and increase in MCA
6	Sipilä et al.8	1995	II-2	200 patients	AAMR	VAS	yes	no	no	A strong correlation between SA and NAR when evaluating unilateral obstruction compared to total nasal evaluation
7	Simola & Malmberg 9	1997	II-2	101 patients	AAMR	VAS	no	yes	no	Significant correlations between SA and NAR during changes in nasal patency caused by histamine challenge in patients with history of allergic or non-allergic rhinitis
8	Shemen & Hamburg10	1997	II-2	24 patients	AR	" patients reported improvement"	yes	no	yes	A significant correlation between MCA and SA both before and after septoplasty

9	Szücks & Clement 11	1998	II-1	50 patients	AAMR and AR	VAS	yes	no	no	Stronger correlation between the SA and NAR than between SA and MCA in patients with deviated nasal septum
10	Reber et al.12	1998	II-2	27 patients	AR	VAS	yes	no	yes	No correlation between SA and MCA pre and post septoplasty
11	Gungor et al.13	1999	II-2	10 volunteers without symptoms	AR	VAS	yes	no	no	No correlation between SA and MCA changes during the nasal cycle
12	Naito et al.14	2001	II-2	50 patients	AAMR and AR	Questionnaire	no	no	yes	Correlation between SA and MCA and SA and NAR, but no correlation between MCA and NAR before and after nasal and/or sinus surgery
13	Numminen et al.15	2003	II-2	69 patients	AAMR and AR	VAS	no	no	no	A significant correlatiom between patency symptoms, MCA and NAR in patients with acute viral rhinitis
14	Suzina et al.16	2003	II-1	200 patients	AAMR	“ with or without symproms”	no	no	no	A significantly higher mean NAR in patients with nasal disease compared to individuals without nasal disease, but no significant difference in total NAR between patients with obstructive symptoms and those without symptoms
15	Clarke et al.17	2005	II-2	60 volunteers with URTI	PR	VAS	no	no	no	A significant correlation between unilateral SA and NAR, but no correlation between total SA and total NAR in patients with URTI
16	Clarke et al.18	2006	II-2	60 patients with common cold	PR	VAS	no	no	no	The bigger the difference of the NAR between nasal passages, the more likely that the passage subjectively indicated as more obstructed concurred with NAR

Table 1. Studies in which the correlation between subjective analysis of nasal patency (SA) and nasal airway resistance (NAR) and/or minimum cross-sectional area (MCA) was addressed.

Subscript: AARM: Active anterior rhinomanometry, PR: posterior rhinomanometry, AR: Acoustic rhinometry, VAS: Visual analogue scales from 0 to 10 denoting the subjective sense of unilateral or total nasal obstruction. URTI: upper respiratory tract infections

of validated questionnaires, divergent reporting methods, involvement of surgery, inclusion of nasal cycle etc.), a direct, accurate and comprehensive comparison between outcomes is not possible and the data reported in the studies were not in the form to allow appropriate meta-analysis. In many of the studies more than one correlation, or lack thereof, between parameters was found, sometimes because more possible correlations were investigated, sometimes because the correlations depended on the inclusion of different variables, as mentioned above. We found almost every possible combination of correlations or lack thereof in conjunction with the variables included. In the 16 studies covered by this review, a correlation between the three main parameters was found on 19 occasions (10x patency symptoms/NAR, 8x patency symptoms/MCA, 1x NAR/MCA). No correlation was found between the parameters on 11 occasions (6x patency symptoms/NAR, 3x patency symptoms/MCA, 2x NAR/MCA). The finding of correlations or lack thereof was evenly distributed over the studies without showing a clear relationship to study design and the chance of finding a correlation did not depend on the level of evidence of the study under consideration.

Table 2. Correlation (+) or lack thereof (–) between parameters in relation to variables. This table refers to the 16 studies in table 1. The cell values indicate how often a correlation was (+) or was not (–) found between the parameters SA, NAR, and MCA in relation to the variables named in the column headings. The subscripts identify the articles in the reference list.

Correlation between parameters	Subjectively blocked nose/ unilateral assessment	Subjectively blocked nose/ bilateral or total assessment	Subjectively good-improved patency/ unilateral assessment	Subjectively good-improved patency/ bilateral or total assessment
Patency symptoms/NAR +	5(6,8,11,17,18)	4(3,9,14,15)	0	1(14)
Patency symptoms/MCA +	0	4(5,10,14,15)	0	4(5,7,10,14)
NAR/MCA +	0	1(15)	0	0
Patency symptoms/NAR –	0	4(4,8,16,17)	0	2(3,6)
Patency symptoms/MCA –	0	1(12)	0	2(12,13)
NAR/MCA –	0	1(14)	0	1(14)

Subscript: NAR= Nasal airway resistance, MCA= Minimal cross-sectional area

Discussion

Strengths/weaknesses of the review, methodological issues and validity of the scoring and reporting methods of the subjective outcomes.

While various objective methods to investigate nasal patency have been described, two of these are most commonly used: rhinomanometry and acoustic rhinometry. Rhinomanometry measures nasal airway resistance during breathing. Acoustic rhinometry provides a reflection of the anatomy of the nasal passages, from which the volume and the geometry of the nasal cavity can be deduced. Considering the amount of literature on these tests, and the increasing value that is attributed to them for validating surgical results, it is surprising that relatively little attention has been paid to how the outcomes of these tests relate to subjective symptoms. Subjective analysis of nasal patency is generally based on patient self-assessment with visual analogue scales and/or questionnaires. In relatively recent publications validated questionnaires such as the 'Sino-nasal outcome test' (SNOT-22) and the 'Nasal obstruction symptom evaluation test' (NOSE) have been described with the specific goal of evaluating nasal symptoms including subjective obstruction [19-20]. While the majority of the studies reviewed made use of visual analogue scales to quantify the subjective sensation of nasal obstruction, others made use of questionnaires querying various nasal symptoms with several scoring systems; none of which were referred to as being validated. The non-use of validated questionnaires may be explained by the fact that most of the studies pre-dated the publications of the SNOT-22 and NOSE tests. The use of these now available validated subjective scoring tools is strongly advised for future studies on this subject so as to enhance the reliability of conclusions concerning the correlation between objective and subjective outcomes. The point that no validated questionnaires were used in the studies in this review, in combination with the heterogeneity of the study designs and impossibility of rational pooling of the studies, without even taking into account some of the other shortcomings of the studies, precluded a proper meta-analysis. So strictly speaking, no firm deductions can be made from this review concerning the correlation between objective and subjective analysis of nasal patency. On the other hand, this is the first review that has attempted to map the literature on this subject and to see if conclusions can be drawn that are based on more than 'expert opinion'.

Relationship between pressure/resistance and flow

All types of rhinomanometry are supposed to determine a relationship between pressure and flow. In other words, this method can reveal how much pressure decay in the nasal cavity is needed to bring about the amount of flow that meets the demands of adequate nasal physiology and the needs for respiration and gas exchange. The flow in the nose is turbulent to a large extent. This is illustrated by the fact that nasal respiration is nearly always audible, even in resting conditions. The turbulence is responsible for the contact between the in- and expiratory gasses and the nasal mucosa, a prerequisite for nasal functioning. Thus, there is no linear relationship between pressure and flow. The amount of turbulence depends not only on the patency of the nasal airway; the shape of the nasal cavity is also an important factor. As a consequence, a low patency may be accompanied by a high as well as a low resistance, depending on the presence or absence of irregularities in the shape of the nasal cavity [21].

Subjective sensation of nasal patency and nasal resistance

Another question concerns the uncertain relation between nasal resistance and the subjective sense of nasal patency. This problem has been pondered over for decades [22-33]. Several studies have demonstrated that applying substances such as camphor, eucalyptus, L-menthol, vanilla, or lignocaine to the nasal or even palatal mucosa can cause a marked sensation of increased nasal airflow without any change in nasal resistance as measured by rhinomanometry [22-31]. Conversely, infiltration or topical application of local anesthetics in the nasal vestibule or damage of trigeminal sensory nerve endings may cause a sensation of decreased nasal patency, again without any measurable effect on nasal resistance [30-33]. It was postulated that specific nasal sensory nerve endings, most likely of the major palatine nerve, might be responsible for the subjective perception of nasal patency. It appears that the sensation of nasal airflow, at least under certain circumstances, can be entirely independent of any objectively measurable change in nasal resistance.

Clinical applicability

When used as part of the overall evaluation of a patient's complaints, 'objective tests' may provide additional information. However, considering the extra time, effort, and investment it takes to include these tests in a diagnostic work up, one would need to be confident that the information they might yield would make a meaningful contribution to the diagnostic and therapeutic process of patients

with symptoms of nasal obstruction. In our own past experience this did not seem to be the case, as we frequently found discrepancies between the objective measurements and a patient's complaints (or lack thereof).

Synopsis of key findings

We found just three studies that used rhinomanometry as well as acoustic rhinometry [11, 14, 15]. One of them demonstrated a correlation between the results from both methods in patients with a subjectively blocked nose [15], which is in line with methodologic considerations [21]. Twenty-one studies addressed the possible correlation between the results of objective measurements and patency symptoms. Only 16 of them had a level II-a or II-b of evidence. None one of the studies were randomized controlled trials (level of evidence I). It must be emphasized, however, that the very nature of the question would make such a study design difficult, if not impossible. It may seem that there were almost as many outcomes as there were studies. Nonetheless, a few tentative conclusions could be drawn by evaluating the number of times a correlation or lack thereof was found between the parameters in relation to the variables.

It seems that in the presence of obstructive symptoms, a correlation is more likely to be found with either NAR or MCA. Conversely, for individuals with no symptoms, it may be more difficult to find a correlation with objective measurements. In other words, when a patient has subjective complaints of obstruction, the likelihood that the measurements found with objective tests will concur with this subjective sensation may be greater. This has a few interesting implications. If the correlation between an objective test of the nasal airway and the subjective sensation of nasal patency is generally strong, one may wonder what its added value is in clinical practice. If the correlation is strong, the subjective sensation alone may reliably describe the 'objective' nasal airway, thereby decreasing the need for objective measurements. On the other hand, if the correlation is generally weak, one must be cautious about relying on objective tools in the therapeutic decision-making process. However, with a strong and reproducible correlation, objective tests could play a role in measuring the effect of therapeutic interventions or in challenge studies. Indeed, one of the main uses for which objective measurements are recommended is to evaluate the results of nasal surgery aimed at improving patency. The results of the studies considered here suggest an interesting paradox: the greater the improvement caused by nasal surgery, the more difficult it may be to measure it, because the range of outcomes is larger in the absence than in the presence of obstructive symptoms (Table 2).

Conclusion

The perception of nasal airflow is primarily a subjective sensation but is related to nasal resistance and to the anatomy of the nasal passages. Since many factors may be of influence, no single objective test, however qualitatively and technically reliable, will reproducibly correlate with this perception. On the other hand, the tools commonly used for rating the subjective sense of nasal patency are not without flaws and the questionnaires used in the studies in this review were not validated. Taking this point and the fact that a true-meta analysis could not be done into account, a cautious conclusion based on this review might be that when a sensation of obstruction is present, this is more likely to correlate with objective tests than in the absence of symptoms. There also seems to be a greater likelihood of a correlation between unilateral symptoms (or lack thereof) and unilateral objective measurements than between bilateral symptoms and total nasal resistance or combined mean cross-sectional areas. As these objective tests only relate to nasal airway resistance and cross-sectional areas, not all factors involved in nasal patency disturbances are included. To elevate 'objective measurements' above subjective symptoms on the basis of the currently available data is unfounded and is more likely to be based on a general philosophical viewpoint than on facts in the case of nasal obstruction. In light of these findings and considerations, it seems unlikely that further research or technical refinements of the methods to measure nasal patency will solve the problem. At this point in time, there seems to be a limited argument for the routine use of either rhinomanometry or acoustic rhinometry in routine rhinologic practice or for validating therapeutic outcomes. Even though lacking in objectivity, a patient's subjective sensation of nasal patency, preferably rated with validated questionnaires and on visual analogue scales, still seems to give the most valuable information concerning the degree of nasal obstruction.

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Chapter 3

Endonasal spreader grafts

Text and figures based on:

Endonasal Spreader Graft Placement as Treatment for Internal Nasal Valve Insufficiency; No Need to Divide the Upper Lateral Cartilages From the Septum. Arch Facial Plast Surg 2004;6:36–40

Robert F. André
Santdeep H. Paun
Hadé D. Vuyk

Summary

Objective: To describe and evaluate results of a surgical procedure to treat internal nasal valve insufficiency using spreader grafts placed via an endonasal approach without division of the upper lateral cartilages from the nasal septum.

Design: Eighty-nine patients with complaints of nasal obstruction, at least partially due to internal nasal valve insufficiency underwent this operation on 120 sides in a private practice setting. Only autologous material was used and three different techniques for fixating the grafts are discussed. All patients were prospectively evaluated and subjective self-assessment was used to quantify the result of the operation.

Results: On 53 sides (44 %) nasal breathing was described as 'optimal' and on 53 sides (44 %) the result was deemed 'improved'. On 13 sides (11 %) no change was noted and on 1 side (1%) the postoperative situation was judged to be worse.

Conclusions: When opting for spreader grafts to treat internal nasal valve insufficiency, one does not necessarily need to perform an external approach nor is separation of the upper lateral cartilages from the septum required. The endonasal technique presented herein is less invasive and can be used in conjunction with other procedures aimed at improving nasal patency.

Introduction

Nasal obstruction can be due to a variety of mucosal and anatomical factors, and in many patients both play a role. Numerous conditions, diseases and environmental factors are known to negatively influence nasal patency through their effects on the mucosal lining of the nose. On the whole, the treatment in such cases tends to be conservative and can involve decongestants, steroids, antihistamines, and, if possible, avoidance of environmental pollutants or allergens. The main anatomic causes of diminished nasal patency are deviations of the nasal septum and insufficiency of the internal or external nasal valves. In nasal obstruction caused by inferior or middle turbinate hypertrophy, both the mucosal and the bony parts of the turbinate may be involved and medical as well as surgical treatment may be required. In clinical practice, it is often difficult to make a clear distinction between mucosal and anatomic factors, let alone to assess the relative importance of individual anatomic variables. Never the less, numerous functional nasal operations have been developed and are in current use, all with the intent of improving nasal patency. Of these operations, septoplasty and inferior turbinate reduction are the most commonly performed. It is generally accepted that the nasal valve area constitutes the narrowest part of the nose and also poses the greatest resistance to nasal airflow. In the most common definition, its boundaries are the nasal septum medially, the floor of the nose inferiorly, and the caudal margin of the upper lateral cartilage and the head of the inferior turbinate laterally [1, 2, 3, 4, 5]. The *internal nasal valve* describes that part of the nasal valve area that lies between the caudal border of the upper lateral cartilage and the nasal septum. Although the exact function of the nasal valve has not been entirely elucidated, its main purpose is thought to be to regulate the inspiratory airflow by varying the degree of swelling in the inferior turbinate and the angle of the internal nasal valve. During the past 2 decades, increasing attention has been given to the role of the internal and, to a lesser degree, the external nasal valve in nasal obstruction. Some authors even state that in many cases an incompetent nasal valve may be the largest contributing factor to diminished nasal patency [6, 7], and it seems likely that many good results after septal corrections or turbinate reductions are largely due to an increased nasal valve area. There are numerous causes, both mucosal and anatomic, of obstruction in the nasal valve area. An example is nasal valve collapse due to previous surgery in which the cephalic edges of the lower lateral cartilages were over-resected; a good way to correct this is with alar batten grafts. The term *internal nasal valve insufficiency* is usually reserved for cases in which

reduction of the nasal valve area is caused by a narrowing of the angle between the nasal septum and the upper lateral cartilage and therefore can be due to the positioning of either. Several operations have been developed to tackle this problem and aim at widening the nasal valve angle and/or preventing it from narrowing during inspiration [6, 8-18]. The most widely used of these operations involves placing rectangular cartilage grafts, so called spreader grafts, subperichondrally between the septum and the upper lateral cartilage as described by Sheen in 1984 [19] (Figure 3.1). Although originally conceived to bridge the long middle vault in patients with short nasal bones, he soon found that the main advantage of spreader grafts lay in their ability to correct the lack of dorsal support to the lateral walls. More specifically he used this technique after hump resection to prevent the upper lateral cartilages from collapsing against the septum, thereby reducing the nasal valve angle and compromising nasal breathing. Since Sheen's original article, spreader grafts have become widely used for both functional and cosmetic purposes, in which the aim is to widen the middle third of the nose. Several variations of his original endonasal technique have been developed, and in most cases an external-approach rhinoplasty is used. The advantage of this approach is that it allows direct visualisation of the middle third of the nose, so that after division of the upper lateral cartilages from the septum, the grafts can be precisely positioned and secured in the apex of the nasal valve angle.

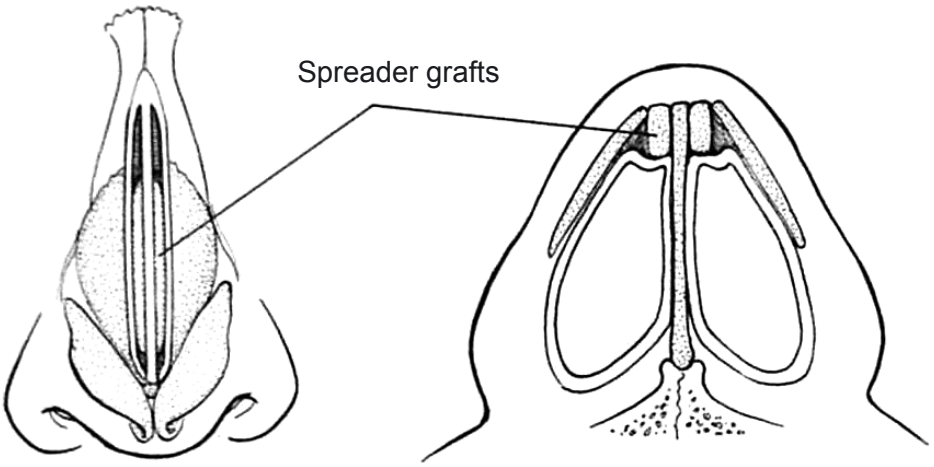


Figure 3.1 Spreader grafts as seen through an open approach in which the connection between the upper lateral cartilages and the septum has been severed.

The main disadvantage of this technique, apart from the relative invasiveness and the small postoperative columellar scar, is the possibility of compromising the integrity of the middle nasal vault when the upper lateral cartilages are divided from the septum. It is interesting that currently, even when an endonasal approach is used, in most cases the upper lateral cartilages are still divided from the septum before the grafts are placed. This is intriguing when one considers that, when Sheen originally started to use spreader grafts, it was precisely to avoid the sequellae caused by the loss of the connection between the upper lateral cartilages and the septum, as a consequence of the hump reduction.

Overall, the results of the above-mentioned procedures, with regard both to functional and cosmetic considerations, tend to be very good and complications are rare. Nevertheless, while surgeons strive to achieve satisfactory results, minimizing the risks of compromising the integrity of the middle third of the nose is important. With this in mind, we present herein a technique in which the spreader grafts are inserted endonasally and the upper lateral cartilages are not divided from the septum.

Methods

This series comprised a total of 111 patients who underwent functional nasal surgery including endonasal placement of subperichondral spreader grafts in the internal nasal valve. All where operated on by the same surgeon (H.D.V.) between February 1994 and January 2001. Of these 111 patients, 22 had a follow-up of less than 3 months and were excluded from the study, leaving 89 patients (60 men and 29 women) and 120 sides available for evaluation. The average age at operation was 38.6 years (range, 21-65 years), and the average follow-up was 12.2 months (range, 3-43 months). All patients had complaints of nasal obstruction due, in part at least, to an incompetent internal nasal valve. This was demonstrated by improvement in nasal patency with the use of a modified Cottle test in which an instrument with a diameter of 2 mm, such as a cotton gauze holder, was placed in the internal nasal valve, mimicking the desired postoperative situation (Figure 3.2). The further indication for surgery was determined after examination during quiet breathing in which patients were asked to indicate in which part of the nose (anterior, middle, or posterior third) they subjectively felt the most obstruction and after nasal endoscopy and computed tomographic scanning of the nasal passages.

(a) (b)

Figure 3.2 (a) The blunt side of a cotton gauze holder, approximating the diameter of a spreader graft. (b) Modified Cottle test, with the instrument placed in the apex of the internal nasal valve.

Thirty-four patients had previously undergone nasal surgery. Of these, 22 had had a septum correction, 7 had inferior turbinate reduction, 6 had ethmoid surgery, and 6 had a rhinoplasty; 7 had undergone more than one previous operation. This series did not include patients undergoing concomitant rhinoplastic procedures such as osteotomies or external nasal valve surgery. Of the 84 patients who underwent concomitant functional nasal surgery, 61 underwent a septum correction, 32 had inferior turbinate reduction, 49 had an ethmoidectomy. In cases in which the only septal work consisted of cartilage harvesting, this was classified as a septum correction. Forty-seven patients had a combination of these procedures. In 5 cases (8 sides) no additional procedure was performed. Only autogenous materials were used for grafting. Of the total of 120 spreader grafts used, 81 were harvested from the nasal septum and 39 from ear cartilage. All grafts were placed subperichondrally, as high as possible between the nasal septum and the upper lateral cartilage(s) in the middle third of the nose, i.e, the apex of the internal nasal valve. In no case were the upper lateral cartilages divided from the septum. Three different methods were used for fixation of the grafts (Figure 3.3): 59 grafts were secured in a tight-fitting tunnel, 12 were fixated with 2-cyanobutylacrylate tissue glue (Histo-Acryl; B. Braun Medical BV, Oss, the Netherlands), and 49 were fixated with transcutaneous and transseptal sutures.

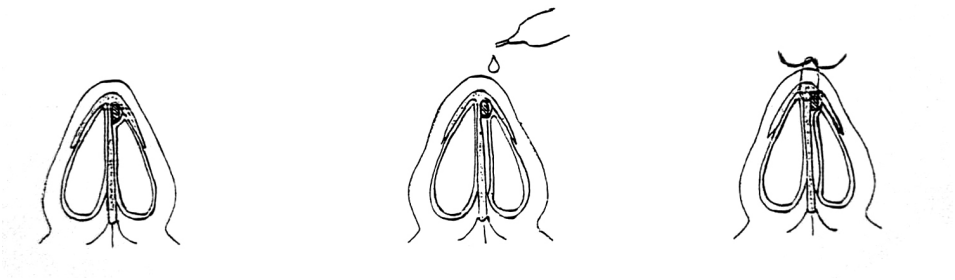
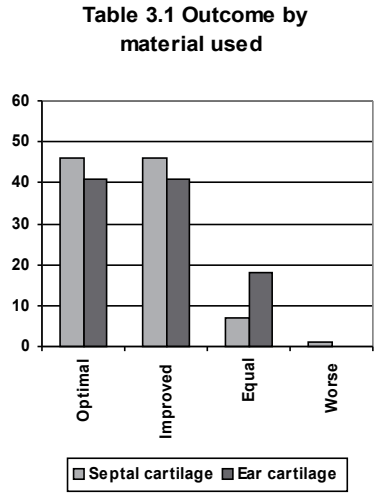


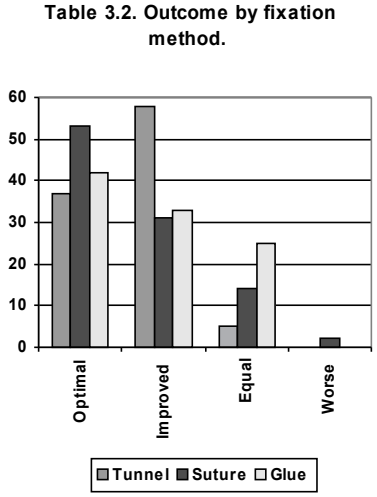
Figure 3.3 Fixation methods

Results

All patients included in this study had a follow up of at least three months and were re-examined several times within this period. They were asked to compare their nasal passage with their pre-operative situation and rate each side as worse, equal, better, or optimal. Therefore, the main criterion on which the result of the operation was judged was the patients' subjective sense of change in nasal patency. Of a total of 120 sides operated on, 53 sides (44%) were judged as optimal and 53 (44%), as improved. On 13 sides (11%) no change was noted. On 1 side (1%) the postoperative situation was judged as worse. In the 5 patients (8 sides) in whom no additional procedure was performed apart from endonasal spreader graft placement, 3 sides were rated as optimal, 4 as improved, and 1 as equal. Although these patients constitute a small subgroup, their outcomes are comparable to the entire study population in which the majority underwent 1 or several additional procedures. Overall, 106 sides (88%) had an outcome of improved or optimal. In the one patient in whom the postoperative result was deemed worse, this turned out to be due to a recurring septal deviation. Considering the many possible confounding factors, e.g., the concomitant operations, and the relatively small numbers and differences in outcome between the various techniques and graft materials, no realistic statistical analysis could be performed. Bearing these limitations in mind, we differentiated the results according to origin of donor material and fixation method and found no obvious differences (Table 3.1 and.3.2) In 5 patients a postoperative infection occurred that subsided after antibiotic treatment and left no permanent sequellae. In 3 of these 5 patients 2-cyanobutylacrylate glue had been used; in the other 2 patients a tunnel had been formed. No other complications were noted.

Table 3.1 and 3.2.





Discussion

In this study, we present the results of a modification and, we believe, a simplification of a procedure to treat nasal obstruction caused by an incompetent internal nasal valve. The most widely recommended solution for this problem is strengthening the nasal valve and widening the nasal valve angle by placing spreader grafts in between the upper lateral cartilages and the septum. This has proved to be especially useful after hump reduction, which may otherwise lead to a collapsed middle vault, causing both functional and aesthetic problems. This is particularly true if the hump reduction was not restricted to the midline septum and bony dorsum but included dorsal resection of the upper lateral cartilages. On the whole, the techniques as usually applied give very good results. The use of an external-approach rhinoplasty provides good visualization of the middle nasal vault and therefore allows secure fixation of the grafts in the appropriate place. In cases of internal valve incompetence in which the upper lateral cartilages are still attached to the septum, the necessity of separating them before the spreader grafts are placed may be questioned. When spreader grafts are used purely for functional reasons, ie, because of internal nasal valve insufficiency and not because of cosmetic considerations, an external approach can be avoided by placing the grafts endonasally. In our view, a big advantage of the endonasal route, besides its relative non-invasiveness, lies in its ease of use in combination with other

functional nasal operations such as a septum correction. The main reason for dividing the upper lateral cartilages from the septum in an open approach- namely, so that one can place and fixate the spreader grafts between them from above- loses its relevance in an endonasal approach. Leaving the connection intact minimizes the disruption of the integrity of the middle third of the nose and is less likely to result in loss of smoothness of the dorsum. As mentioned earlier, nasal obstruction that is bothersome enough for a patient to seek medical attention is often due to a combination of factors. It can be difficult to assess the relative importance of each contributing factor, and multiple procedures may be required. The most frequently performed example of this is the combination of a septum correction with some form of inferior turbinate reduction. For reasons of scientific clarity it would be preferable to carry out only one procedure at a time, but in clinical practice this would often increase the chance of a re-operation. In our series of 89 patients, 34 patients (38%) had previously undergone nasal surgery and 84 patients (94%) underwent 1 or several concomitant procedures aimed at improving nasal patency. The aforementioned considerations make it difficult to assess the value of the placement of spreader grafts alone. However, in a small subgroup of 5 patients (8 sides), no other reason for nasal obstruction was found and no other procedure was carried out. In these patients, the results (3 sides optimal, 4 improved and 1 equal) were comparable to those of the group as a whole. Although no significant differences in outcomes could be measured concerning graft material , we would advise the use of nasal cartilage, when available, for reasons of practicality and avoidance of unnecessary ear trauma. Likewise, although no conclusions can be made regarding which fixating technique gives the best outcome, transcutaneous suturing is the easiest technique to perform, especially in combination with a septum correction in which a submucoperichondral tunnel has already been formed. Considering that 2-cyanobutylacrylate glue was used in only 8 patients and that 3 out of a total of 5 postoperative infections occurred in this group we strongly recommend against the use of this fixation technique. There remains considerable controversy in the literature as to the value of objective testing of nasal patency for clinical purposes, especially in the region of the nasal valve [20-23]. In our previous experience there has been little correlation between a patient's subjective sense of nasal patency and the findings at rhinomanometry and acoustic rhinometry, and therefore these tests were not used in this study.

Conclusions

It is becoming increasingly clear that nasal obstruction is often partially caused at the internal nasal valve. Placement of spreader grafts between the septum and the upper lateral cartilages after division in the apex, using an external-approach rhinoplasty, gives good results but may be more invasive than necessary. When treating patients with nasal obstruction in whom internal nasal valve insufficiency is a major or contributing factor, one may consider the use of endonasal spreader grafts, alone or in conjunction with other procedures aimed at improving nasal patency. With this technique, the upper lateral cartilages need not be divided from the nasal septum, so that the risk of compromising the stability and integrity of the middle third of the nose is minimized.

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Chapter 4

The ‘Butterfly’ graft

Text and figures based on:

The ‘Butterfly’ graft as treatment for internal nasal valve incompetence. Plast Reconstr Surg. 2008 Aug;122(2):73e.

De ‘Butterfly’ graft procedure als behandeling van interne neusklepnsufficiëntie. Ned Tijdschrift voor Keel- Neus- en Oorheelkunde, juli 2008; 14 (3): 163-168.

Robert F. André
Hadé. D. Vuyk

Summary

Objective: In this article we describe and evaluate our experience with a surgical technique for treating nasal valve insufficiency using a so-called butterfly graft from ear cartilage.

Methods: Eighty-four patients with nasal valve insufficiency on 157 sides were operated on by two surgeons using this procedure. The patients were prospectively studied and their nasal patency was rated pre- and postoperatively, and per side, by subjective self-evaluation on a scale from 1 to 10.

Results: Post-operatively 11 sides (7 %) were rated as equal, on 68 sides (43%) the improvement was between 1 and 4 out of 10, and on 78 sides (50 %) 4 or more out of 10. Overall 93% of sides had improved compared to the pre-operative situation. The average post-operative improvement for all sides was 3.8 out of 10. Fifty-one patients had undergone previous nasal surgery. The average improvement in this group was 3.6 out of 10 compared to an average improvement of 4.3 out of 10 in the 33 patients without a history of previous nasal surgery.

Conclusions: Placement of a butterfly graft is generally a very effective treatment for nasal valve insufficiency, not only in patients with valve collapse due to previous rhinoplastic surgery, but also as a primary procedure.

Introduction

In this article we describe our experience with the so-called butterfly graft.
The main goal of this procedure is to widen the nasal valve angle and to increase the resilience of the nasal valve(s), by fixating a curved piece of ear cartilage over the caudal border of the upper lateral cartilages. A graft with this name was first described by Hage [(1)], but the technique we use is more similar to the procedure described by Clark and Cook [(2)] (Figure 4.1), in which they used this graft to treat nasal valve insufficiency due to previous rhinoplastic surgery. In our series we prospectively studied the effect of this graft not only in revision cases but also as primary treatment for nasal valve insufficiency.

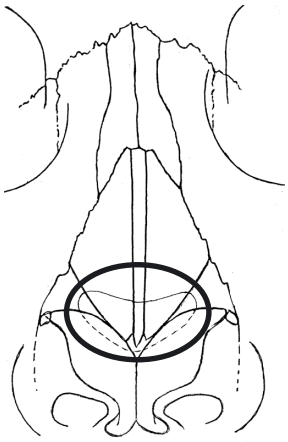

Figure 4.1 Shape and position of a butterfly graft; under the cephalic edge of the lower lateral cartilages and over the caudal edge of the upper lateral cartilages.

Patients and methods

Description of technique

First ear cartilage is harvested, either through an anterior or posterior incision. Our preference is the anterior approach, mainly because of superior exposition. The cartilage for the graft can be taken from the shoulder of the antihelix as described by Clark and Cook [(2)], although usually the cymba concha cartilage is adequate and its removal leaves practically no distortion at the donor site. The

(a)

(b)

(c)

Figures 4.2 (a), (b) and (c) Creation of a pocket under the cephalic portion of the lower lateral cartilages.

harvested cartilage is temporarily kept in a diluted gentamycine solution. The incision is closed with a continuous vicryl 5.0 suture. By placing the incision on the edge of the inferior antihelical crus, the scar eventually becomes all but invisible. A pressure dressing is applied for roughly 24 hours. A practical method is to use a sterile surgical sponge which is cut and remodelled after which both sides are sutured together through the pinna, or alternatively a mattress suture 4-0 vicryl rapid can be used, obliviating the need for any pressure dressing at all. The following step involves the exposure of the lower lateral cartilages and the caudal end of the upper lateral cartilages through an external approach. Although a butterfly graft can also be inserted through an endonasal approach, precise positioning is technically more difficult. The vestibular skin is partially freed from the under surface of the lateral crurae, frequently after a slight cephalic trim. In this manner a pocket is formed under the cephalic portion of the lateral crurae (Figures 4.2 a, b, c). Depending on the external shape of the nasal tip and the exact configuration of the lower lateral cartilages, they may be remodelled according to need.

The graft is then cut to size (Figure 4.3); depending on the shape of the nasal tip and the thickness of the skin, a wedge can be removed from the cranial part of the graft, this will result in more of a butterfly likeness and reduce supratip fullness, but is not always necessary.

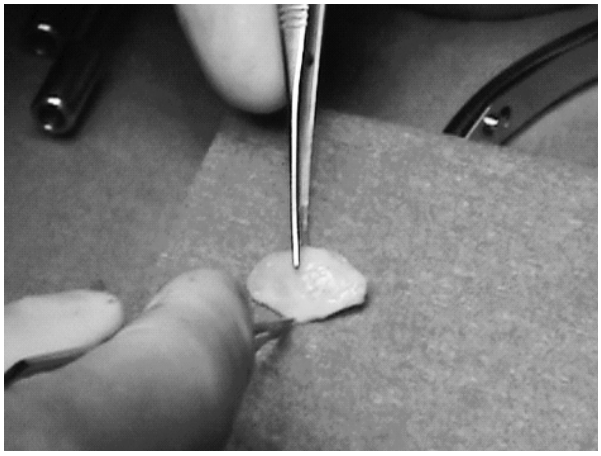

Figure 4.3 Sculpturing of the graft.

Another method to minimize fullness is to take a small slit from the ventral part of the septum into which the graft can be lowered. As this may also sever part of

Figure 4.4

(a) The graft is placed under the cephalic edge of the lower lateral cartilages...

(b) ... and over the caudal edge of the upper lateral cartilages.

(c) Fixation of the graft with pds 5.0. sutures.

the connection with the upper lateral cartilages, one must make sure the caudal edges are sutured to the graft or one risks worsening rather than improving the valve incompetence. Next the graft is placed under the cephalic edges of the lower lateral cartilages and over the lower border of the upper lateral cartilages, that is to say over the internal nasal valve, and fixated with pds 5.0. (Figure 4.4 a, b, c). The sutures are passed from the graft cartilage through the cartilage of the lateral crurae and the caudal borders of the upper lateral cartilages and the vestibular skin/mucosa, thereby ensuring maximal stability and a minimal possibility of dead space filling and swelling in the internal valve area. The graft eventually comes to lie for its greatest part under the lateral crurae, thereby minimising the risk of external visibility. The broken mid columella incision is closed with ethilon 6.0 interrupted sutures, antibiotic ointment is placed on the wound and light nasal packing is left in the vestibulum. The packing is removed 2 to 24 hours postoperatively and the sutures are removed after 5 to 7 days.

One hundred and two patients with complaints of reduced nasal patency, caused, at least in part, by nasal valve incompetence, were operated on by the two authors between April 2004 and June 2007 in their respective hospitals. Eighteen patients had a history of nasal cancer, cleft lip or had insufficient follow up data and were excluded from the study sample. This left 84 patients, with nasal valve incompetence on 157 sides (73 bilateral, 11 unilateral). Of these 84 patients, 51 were operated on by RFA and 33 by HDV. The average follow up period was 7, 9 months (range 3-31 months). There were 48 men and 36 women with an average age of 45, 4 years (range 19-71 years). Fifty-one patients (61%) had had at least one previous nasal operation, 33 patients (39%) had no prior history of nasal surgery. In sixty-seven patients the indication for surgery was purely functional while 17 patients also had a cosmetic reason for seeking nasal surgery. In fifty-eight patients (69%) additional procedures, such as septoplasties, turbinate reductions or rhinoplasties were performed for functional and/or cosmetic reasons. In twenty-six patients (31%) butterfly graft placement was the only procedure performed. The main criteria upon which the results were evaluated during follow up was subjective self-assessment by the patients. There are varying reports as to the value of objective nasal testing with acoustic rhinometry and rhinomanometry in clinical practice [3, 4, 5, 6]. Based on our past experience, we found that the correlation between these tests and patients' subjective sense of nasal patency was too low to warrant their use for evaluating surgical results. Although other objective measurement techniques are in development [7], at this point in time the

subjective opinion of a patient concerning his or her (change in) nasal patency remains our most relevant source of information.

Results

Pre- and postoperatively, (subjective) scores for nasal airflow per side were collected on a 10-point scale; 1 indicating total obstruction and 10 a perfect nasal airway. The average pre-operative score for the 157 sides involved was 3.6 out of 10 (range: 1– 7). The average post-operative score was 7.4 (range: 3-10). Post-operatively 11 sides (7 %) were rated as equal, on 68 sides (43 %) the improvement was between 1 and 4 out of 10, and on 78 sides (50 %) 4 or more. Overall, post-operatively 93% of sides operated on showed subjective improvement (Table 4.1). The average improvement was 3.8 points (range: 0-8). In the 51 patients who had undergone previous nasal surgery, the average improvement of the 94 sides involved was 3.6 out of 10 compared to 4.3 out of ten on the 63 sides in the 33 primary cases. Twenty-six patients (31%) underwent butterfly graft placement without any concomitant procedures. The average improvement of the 52 sides operated upon in this subgroup was 4 out of 10 compared to an average improvement of 3.7 out of 10 on the 105 involved sides in the 58 patients who underwent concomitant procedures (Table 4.2).

Table 4.1 Percentage of sides improved for total group.

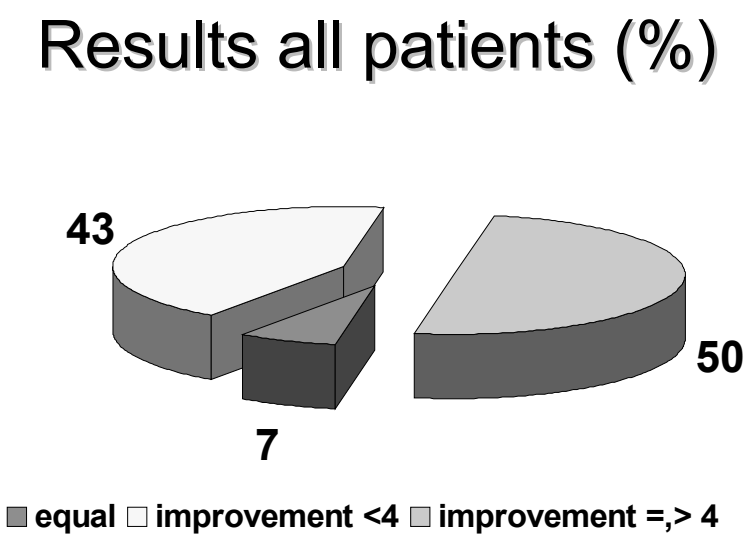

Table 4.2 Average improvement per subgroup.

Sides:	Average improvement:
Total: 157	3.8/10 (Average pre-op 3.6, post-op 7.4)
Primary procedure: 63	4.3/10 (Average pre-op 3.5, post-op 7.8)
Revision: 94	3.6/10 (Average pre-op 3.7, post-op 7.3)
Only butterfly graft: 52	4/10 (Average pre-op 3.8, post-op 7.8)
Additional procedures: 105	3.7/10 (Average pre-op 3.4, post-op 7.1)

Discussion

As mentioned in the introduction, many procedures have been developed to tackle the problem of nasal valve insufficiency. While all have their relative advantages and drawbacks, they all aim at widening the nasal valve area and/or strengthening (a part of) the lateral nasal wall. The butterfly graft, when successful, accomplishes both these aims. The nasal valve angle is opened from the outside, (without insertion of cartilage in the apex of the internal valve, such as in the case of a spreader graft) thereby avoiding any diminishment of the cross-surface area in the nasal valve area. The resilience and shape of the graft reinforce the area of the nasal wall overlying the internal and usually part of the external valve as well. In this series 93% of sides operated on had improved compared to the pre-operative situation, 7% remained unchanged and no sides were worse. Fifty percent of sides had improved by four points or more out of ten. We found a fairly marked difference in outcomes between primary and revision cases. In the 33 primary cases the average improvement of the 63 sides involved was 4.3 out of 10 compared to 3.6 out of 10 on the 94 sides in the 51 revision cases. In a majority of cases (69%) additional procedures aimed at improving nasal patency or cosmesis were performed. So obviously it was particularly interesting to look at the 26 patients (31%), all with bilateral complaints, who only had butterfly graft placement without any concomitant procedures. The average improvement in this group was 4 out of 10 compared to an average improvement of 3.7 out of 10 on the 105 involved sides in the 58 patients who underwent concomitant procedures. This shows the improvement possible with a butterfly graft alone. Because the average follow up in this series was only 7, 9 months, a degree of caution is advisable concerning longer term results. Despite good overall results, and the lack of complications in our series so far, this procedure does have a

few disadvantages. Partially these are linked to the open approach, such as the small columellar scar and longer post-operative tip swelling. Furthermore some patients experience pain in the ear from which cartilage was harvested or need a few weeks or even longer to get used to what they describe as a strange feeling in their nose. The graft itself always causes some swelling in the supratip area, especially in the early post-operative period, but generally diminishes in time to such an extent as to become barely noticeable. This must be discussed in advance with a potential candidate for this operation and might be a reason to be cautious in suggesting this procedure in a very thin skinned patient. In our series up until now 4 patients had relatively minor cosmetic complaints, but remained satisfied with the overall outcome because of the improvement in nasal breathing. One patient however, despite the functional improvement in nasal breathing, remained dissatisfied with the increased supra tip fullness and opted for a revision operation in which the size of the graft was reduced.

Conclusion

The increasing interest in surgical procedures for treating nasal valve incompetence can be seen as a reflection of the growing recognition of the role of the nasal valve area in maintaining nasal patency. In our experience so far, placement of a butterfly graft as treatment for internal valve insufficiency, both for revision and especially for primary cases, has generally been very effective. One must however be aware that a certain amount of post- operative supra-tip fullness is to be expected, although with proper pre-operative patient selection and counselling and selection this need rarely have cosmetic consequences.

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Chapter 5

Nasal valve suspension

Text and figures based on:

Nasal valve surgery; our experience with the valve suspension technique. Rhinology, 2008 Mar; 46(1): 66-9.

Robert F. André
Hadé D. Vuyk

Summary

Objective: To describe and evaluate our experience with the surgical technique of nasal valve suspension for treating nasal valve insufficiency.

Methods: Twenty patients with nasal valve insufficiency underwent nasal valve suspension (a total of 33 sides). The patients were prospectively studied and their nasal patency was rated per side pre-and postoperatively, by subjective self-evaluation on a scale from 1 to 10.

Results: Post-operatively 7 sides (21%) were rated as unchanged, on 17 sides (52%) the improvement was from 1 to 3 out of 10, and on 9 sides (27%) 4 or more out of 10. The average post-operative improvement for all sides was 2,3 out of 10. In five patients (25%) complications occurred, such as pain, inflammation and suborbital swelling and three eventually underwent a re-exploration of the surgical area, resulting in a permanent scar in one patient.

Conclusions: Although nasal valve suspension may be beneficial for some patients, based on our experience, we would not recommend this technique as first line treatment for nasal valve insufficiency. In this series we found relatively limited improvement in most patients and a far higher complication rate compared with other nasal valve procedures we have had experience with in the past.

Introduction

A multitude of surgical techniques have been described for dealing with nasal valve pathology and new ones are being described with increasing frequency [1-15]. All such techniques have in common that they aim at strengthening and/or lateralizing (a part of) the lateral nasal wall, thereby facilitating nasal airflow. Since 1996 several articles have been published describing treatment of nasal valve incompetence using valve suspension procedures [16-18]. In this article we describe the technique and present our results with it as carried out by the senior author.

Patients and Methods

Description of technique

As with all nasal valve surgery, the main goal of the procedure presented herein is to increase the diameter of the nasal valve area, and the resilience of the nasal valve(s). In this technique, sutures are used to lateralize (a section of) the lateral nasal wall by suspending the relevant part to the inferior orbital rim. In this series an infraorbital incision was made at the junction of the thin lower eyelid skin and the thicker cheek skin on the medial part of the inferior orbital rim. A permanent suture is then tunnelled below the facial soft tissue to the involved part of the lateral nasal wall. The needle is subcutaneously reversed endonasally within the subcutaneous fibro fatty tissue, usually slightly above the alar groove often encompassing the lateral part of the lateral crus and the sesamoid cartilages, and guided back towards the inferior orbital rim. At this point, the suture is tied to the periosteum of the inferior orbital rim, thereby opening and supporting the nasal valve.

Twenty patients with complaints of reduced nasal patency, caused at least in part, by nasal valve incompetence, were operated on by the senior author between August 2002 and January 2005. Nasal valve suspension was carried out on 33 sides; in thirteen patients the valve dysfunction was bi-lateral and in seven unilateral. There were 17 men and 3 women and the average age was 46 years (range: 25-68 years). The average follow-up in this series was 5 months (range: 3-27 months). Sixteen patients were revision cases having had at least one

previous nasal operation, and of these, 9 patients had undergone previous nasal valve procedures (5x spreader graft, 4x sub-alar batten graft). Only four patients had no prior history of nasal surgery.

In five patients nasal valve suspension was the only surgery performed, while 15 patients underwent one or more concomitant procedures such as septoplasties, turbinate reductions and ethmoidectomies. Eight patients had additional nasal valve procedures apart from the valve suspension (5x spreader graft, 2x composite alar grafts, and 1x sub-alar batten graft). On 19 sides goretex 3.0 was used as suture material and on 14 sides ethilon 3.0 was used. On all 33 sides an infraorbital incision was made. On 11 sides a single suture was used, on 20 sides a double and on 2 sides the suture was fixated at three separate points between the lateral nasal wall and the periosteum of the inferior orbital rim.

Results

The main criteria upon which the results were evaluated during follow up was subjective self analysis by the patients. There are varying reports as to the value of objective nasal testing with acoustic rhinometry and rhinomanometry in clinical practice [19-22]. Based on our past experience, we found that the correlation between these tests and patients' subjective sense of nasal patency was too low to warrant their use for evaluating surgical results. Pre-and postoperatively, (subjective) scores for nasal airflow per side were collected on a 10-point scale; 1 indicating total obstruction and 10 a perfect nasal airway. The average pre-operative score for the 33 sides involved was 4 out of 10 (range: 1, 5– 6). The average post-operative score was 6, 3 (range: 3-10). Post-operatively 7 sides (21%) were rated as equal, on 17 sides (52%) the improvement was from 1 to 3 out of 10, and on 9 sides (27%) 4 or more. Overall, post-operatively 79% of sides operated on showed subjective improvement. The average improvement was 2,3 points (range: 0-8). Five patients underwent nasal valve suspension without any concomitant procedures. The average improvement of the eight sides operated upon in this subgroup was only 1 point. In several patients it was observed that the initial results were better than later on during follow-up. At the time of this writing, three patients with insufficient improvement have elected to undergo revision valve surgery with butterfly graft implantation.

In five patients (25%) complications occurred: In three of these patients ethilon was used and in two goretex. One patient experienced temporary tenderness between the orbital rim and the nose. One patient had relatively mild complaints of a slight thickness under the eye for which no further action was considered necessary. Three patients experienced a painful swelling under the eye, which did not respond to antibiotic treatment. In two of these patients the area was explored and the sutures were removed (Figure 5.1). In the third patient no sutures were found during the first exploration. However, because the symptoms persisted a re-exploration was performed and the entire affected area was removed, resulting in a visible scar and an area of hypoesthesia (Figure 5.2).

Figure 5.1 (Sutures exposed through paranasal incision): Three patients underwent an exploration of the surgical area because of pain, inflammation and swelling and in two of those patients the sutures were removed.

Figure 5.2 (Paranasal scar):

In the third patient no sutures were found during the first exploration. Because the symptoms persisted a re-exploration was performed and the entire affected area was removed, resulting in a visible scar.

Discussion

As mentioned in the introduction, many procedures have been developed to tackle the problem of nasal valve insufficiency. While all have their relative advantages and drawbacks, they all aim at widening the nasal valve area and/or strengthening (a part of) the lateral nasal wall. What makes the technique of nasal valve suspension a seemingly attractive option, is the fact that it aims at achieving both those goals, while being relatively simple to perform and generally less time consuming than most other nasal valve procedures. In essence it mimics the Cottle manoeuvre in opening the nasal valve(s) by lateralizing and fixating a portion of the lateral nasal wall. In this series 79% of sides had improved post-operative scores, although the average improvement was fairly limited, especially when one takes into account that in a majority of cases one or more concomitant procedures aimed at improving nasal patency were performed. Not only did the functional outcomes as judged by the patients show limited improvement, but in several cases, the initial improvement diminished during a relatively short follow-up period. We are aware that this phenomenon occurs sometimes in other functional nasal surgery as well, but in our experience, not as frequently or rapidly. We also found a higher than average complication rate: inflammation, swelling or pain under the eye was evident in five patients (25%). Two of these patients had relatively mild and transient complaints, but three underwent an exploration of the affected area, and one of these three even needed a re-exploration resulting in a permanent scar and hypoesthesia.

Taking into account the small size of our patient group it would obviously be unwise to make a strong recommendation regarding this technique. However, because of the high complication rate in this series, as well as because of the relatively disappointing results and the availability of other, more reliable nasal valve techniques, we would not recommend this procedure as a first line treatment of nasal valve insufficiency.

Conclusion

Many surgical procedures for treating nasal valve incompetence have been described and new techniques are being developed with increasing frequency. This can be seen as a reflection of the growing recognition of the role of the nasal valve in maintaining nasal patency. Based on this (small) series, we conclude that nasal valve suspension as treatment for nasal valve incompetence may be beneficial in some patients. However, the overall results were disappointing and less reliable than with other nasal valve procedures. Moreover, the complication rate was higher than we consider acceptable, which has caused us to cease performing this procedure.

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Chapter 6

Sub-alar batten grafts

Text and figures based on:

Sub-alar batten grafts as treatment for nasal valve incompetence; description of technique and functional evaluation. Rhinology. 2006 Jun;44(2):118-22.

Robert F. André
Alwyn R D' Souza
Hendrik P. Kunst
Hadé D. Vuyk

Summary

Objective: To describe and evaluate the functional results of a surgical technique for treating nasal valve incompetence, in which a cartilage graft called a sub-alar batten graft, is placed along the undersurface of the lateral crus of the lower lateral cartilage.

Methods: The functional outcomes of 27 patients who had sub-alar batten grafts placed on 39 sides were evaluated by means of clinical examination and subjective self-assessment.

Results: Of a total of 39 sides operated upon, 10 (26%) were rated as optimal, 15 (38,5 %) as improved, 13 (33%) as equal and 1 (2,5%) as worse. Overall on 25 sides (64,5%) the post-operative situation was considered to be better than pre-operatively. In all cases in which there was a wish for cosmetic improvement, besides the functional indication, this was obtained, and in no case did the grafts give cause to cosmetic grievances or other complications.

Conclusion: Placement of sub-alar battens had a positive effect on nasal valve function in roughly two thirds of cases in this series. Although in our opinion this result was slightly disappointing from a purely functional point of view, they can improve the cosmetic result and continue to be considered in cases in which avoidance of surface irregularities is a primary concern or as a preventative measure in rhinoplasty patients at risk for post-operative valve collapse.

Introduction

Nasal obstruction, attributable in part or entirely to nasal valve aetiology, relates closely to the dynamics of movement of the lateral nasal wall during inspiration and to the cross-surface area, and therefore airflow resistance, of the nasal valve area. Although anatomically separated (Figures 6.1 and 6.2), in reality excessive inward movement of the lateral nasal wall during inspiration causing nasal valve insufficiency, usually involves elements of both the internal and external nasal valve to a varying degree. As was outlined in earlier chapters, various options are available to correct external valve collapse, and in many cases these techniques will also have an effect on the internal nasal valve.

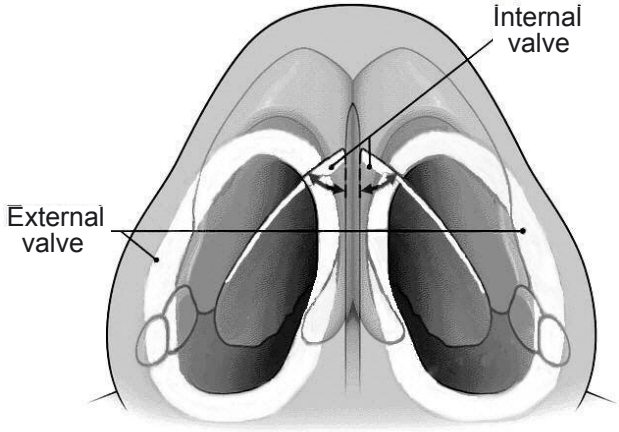

Figure 6.1 Internal and external nasal valves, basal view.

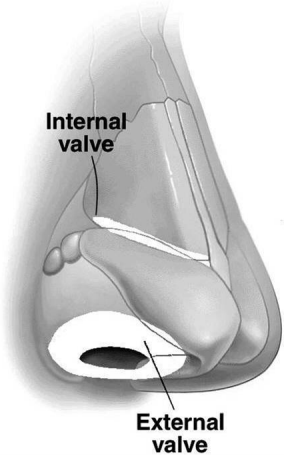

Figure 6.2 Internal and external nasal valves, lateral view.

The use of alar batten grafts to correct functional deficits and to lateralise the collapsed lateral wall was described by Toriumi [1]. Gunter described the lateral crural strut graft for treating alar rim collapse, concave lateral crura, and malpositioned lateral crura [2]. The graft described in this article can be seen as a combination of the techniques described by Toriumi and Gunter. In shape (convex) and main goal (to correct and prevent nasal valve collapse by strengthening and usually lateralising the ala and/or lateral crus of the lower lateral cartilage) it closely resembles an alar batten. In position (along the undersurface of the lateral crus, instead of caudal to it) and length (from the piriform aperture to the dome, rather than just to the lateral one third of the lateral crus) it is more like a lateral crural strut graft. The reasoning and goal behind the development of this graft was to obtain the same functional result as with an alar batten, while diminishing the chance of external visibility due to its position underneath the alar cartilage [3].

We refer to this graft as a sub-alar batten and present the results of a retrospective study evaluating its effectiveness.

Patients and Methods

Technique

Either an open or an endonasal approach may be used when placing sub-alar battens. In the open approach, after exposition of the nasal skeleton in the standard manner, the vestibular skin is meticulously dissected in a retrograde fashion off the under surface of the lateral crus. A small cephalic trim of the alar cartilage is usually done to aid in finding the correct plane of dissection. In this manner a small pocket is created into which the sub-alar grafted can be housed. Care is taken to leave a strip of vestibular skin attached along the caudal border of the lower lateral cartilage. Septal cartilage, conchal cartilage or rib cartilage grafts may all be used. An advantage of using conchal cartilage is its inherent convex shape. The size of the graft is approximately 5 mm wide and 25mm in length. The sub-alar batten graft is positioned on the deep surface of the lateral crus in the previously undermined pocket and extended to just beyond the piriform aperture (Figure 6.3). This requires vertical transsection of the junction between the lateral crus and the accessory cartilages and graft placement superficial to the accessory cartilages. Placement of the graft in this position helps to lengthen the distance

from the nasal tip to the rim of the piriform aperture and if sutured correctly results in gentle external bowing of the lateral crus.

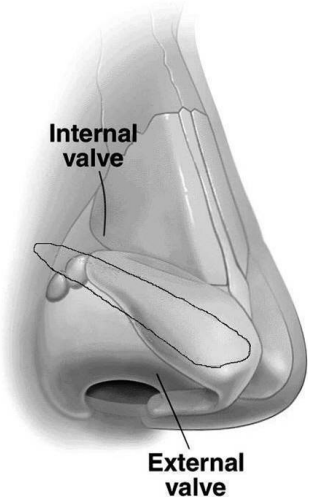

Figure 6.3 Right-sided sub-alar batten graft..

The graft is secured to the lateral crus with two or three 6.0 PDS sutures and the pocket is closed using a 5.0 fast absorbing vicryl suture. In the endonasal approach, the sub-alar pocket is created through a marginal or rim incision through which the graft can then be inserted. The graft is secured in the same way to the lateral crus with two or three PDS 6.0 sutures and the incision closed with 5.0 fast absorbing vicryl sutures. An endonasal approach, through a rim or marginal incision, is almost always used when no additional surgery besides sub-alar batten placement is necessary.

Between October 1996 and March 2004, 31 patients with a minimum follow-up of 3 months who had sub-alar batten grafts placed were retrospectively evaluated. Of these 31 patients, 4 were excluded (3 because of a history of cleft lip and one because he had lateral alar suspension sutures placed as well as sub-alar battens). This left a study group comprised of 27 patients who had sub-alar batten grafts placed on 39 sides (12 bilateral). There were 15 females and 12 males with an average age of 41 years (range 20 to 66 years). All patients had complaints of nasal obstruction caused in part at least by nasal valve incompetence and 8 of these patients also had a cosmetic indication for surgery. All patients who also had surgery for cosmetic reasons were female except one. Fourteen patients were

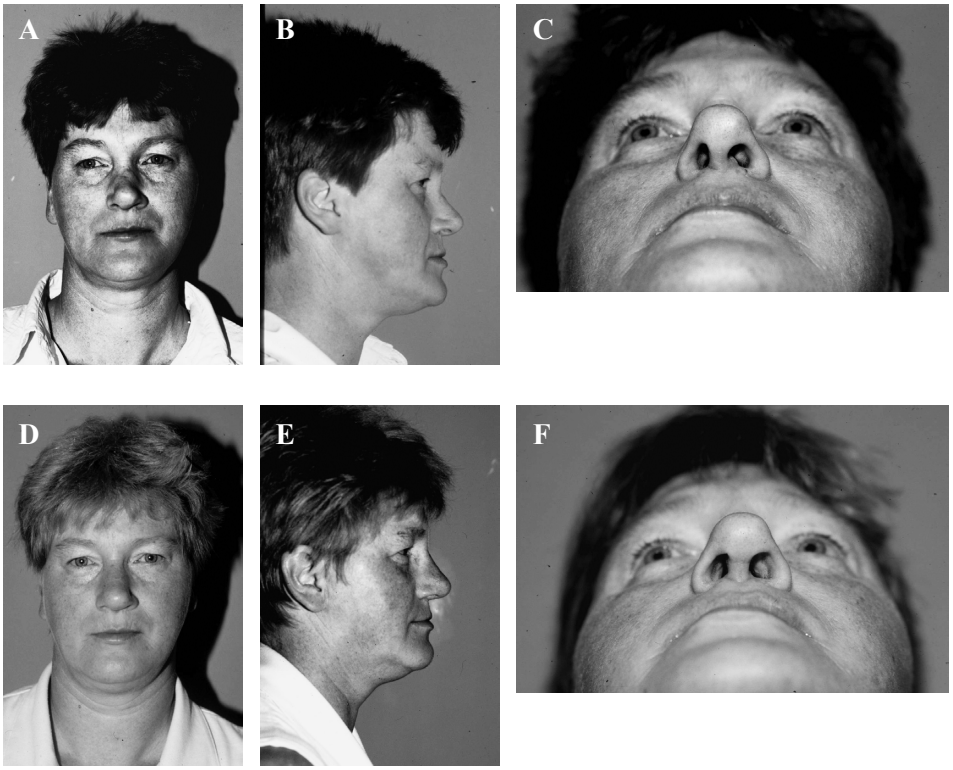

Figure 6.4 Illustrative case. A, B, C pre-operative, D, E, F 2 years post-operative.

operated on through an open approach, 13 through a closed approach. As graft material, autologous septal cartilage was utilised on 23 sides, ear cartilage on 11 sides, a combination of bone (perpendicular plate of the ethmoid) and septal cartilage on 3 sides and rib cartilage on 2 sides (in one patient). Nineteen patients had previously undergone cosmetic and/or functional nasal surgery. Additional procedures included a septum correction in 10 patients, spreader graft placement in 16 patients and turbinate reduction in 3 patients. In 3 patients (3 sides) no additional procedure was carried out. The minimal follow-up for this patient group was 3 months and the mean follow-up period at the time of this study was 14 months (range 3 to 53 months).

Results

All patients were examined several times during their follow-up period and were asked to rate the change in nasal patency per side comparing the post-operative to the pre-operative situation. Of a total of 39 sides operated upon, 10 (26%) were rated as optimal, 15 (38,5 %) as improved, 13 (33%) as equal and 1 (2,5%) as worse. Overall on 25 sides (64,5%) the post-operative situation was considered to be better than pre-operatively. The one patient in whom the post-operative situation on her only operated side was worse underwent revision surgery (the original septal cartilage graft was replaced by a larger and more convex ear cartilage graft) after which the result was improved. No differences in outcome were found concerning graft material or approach used. Apart from unsatisfactory functional outcomes no complications were noted. The patients in whom there was also an aesthetic reason for surgery were satisfied with the results and in none of the patients did the grafts cause an unsatisfactory cosmetic outcome (Figure 6.4).

A forty-seven year old woman with a history of two previous rhinoplasties and complaints of right sided nasal blockage due to internal and external nasal valve insufficiency. A sub-alar batten graft harvested from conchal cartilage was placed under the right lateral crus through an open approach. A spreader graft was also placed in the apex of the right internal nasal valve. Initially her complaints diminished. However, two years post-operatively she felt her nasal breathing through the right side of the nose was no better than pre-operatively. As alluded to in the text, this was probably due to sagging of the graft during the healing period.

Discussion

As with all nasal valve surgery, the primary goal of the technique presented herein is to increase the diameter and resilience of (a section of) the nasal valve. Sub-alar battens are placed along the under surface of the lateral crus, thereby supporting it and increasing its convexity. The lateral crus is located between and overlaps part of both the internal and external valve, and shows considerable variation in shape, size and strength. In this series, per- and postoperative physical examination showed that the goal of widening the cross-surface area at the level of the lateral crus had technically been obtained in a majority of patients. However the longer term overall functional improvement in this patient group (65%) was disappointing. In our opinion this probably relates partially to the fact that this technique does not, or not sufficiently, strengthen the internal valve or increase the (internal) nasal valve area. As mentioned previously, this is the area that contributes the most to nasal airway resistance. Furthermore an initial beneficial effect may be lost in the post-operative period due to sagging of the lateral nasal wall/graft complex. The second goal of this technique was to avoid un-aesthetic alar fullness or surface irregularities, and this was achieved in all patients. From a cosmetic point of view, the placement of the battens below the lateral crurae, may be preferred to more superficially placed grafts, as the latter carry an increased, if relatively unobjectionable, risk of external visibility.

Conclusions

Based on this series, sub-alar batten placement may have a positive effect on nasal valve function in roughly two thirds of patients. As the battens are placed below the lateral crurae, surface irregularities can be avoided and the cosmetic result can be improved. This technique may be especially useful for patients with thin skin and long and inwardly curved weak alar cartilages, either with functional complaints at the time of rhinoplasty, or who may be at risk of developing such complaints postoperatively.

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Chapter 7

Correction of deformities in the caudal and dorsal nasal septum

Text and figures based on:

Reconstruction of dorsal and/or caudal nasal septum deformities with septal battens or by septal replacement, an overview and comparison of techniques. Laryngoscope. 2006 Sep;116(9):1668-73.

Robert F. André
Hadé D. Vuyk

Summary

Objective: To describe and compare two techniques used to correct nasal septum deviations located in the dorsal and/or caudal septum. Study design: Retrospective clinical chart review.

Methods: Comparison of functional and technical results between surgery in the L-strut of the septum in 114 patients with septal battens or by septal replacement, by subjective self-evaluation and by examination of the position of the septum during follow-up.

Results: There was subjective improvement in nasal breathing in 86% of the septal batten group and in 94% of the septal replacement group. This difference was not statistically significant. The technical result was judged by examining the position of the septum during follow up as midline, slightly deviated or severely deviated. The septum was significantly more often located in the midline during follow-up in the septal replacement group than in the septal batten group.

Conclusions: Treatment of deformities located in the structurally important L-strut of the septum may be technically challenging and many functional, structural and aesthetic considerations must be taken into account. On the basis of this series both septal battens and septal replacement techniques may be considered for correction of deviations in this area. The functional improvement rates were not significantly different between the techniques, although during follow-up the septum appeared to be significantly more often located in the midline in the septal replacement group. The techniques are described and their respective advantages and potential drawbacks are discussed.

Introduction

Due to its central role in the anatomy of the nose, a deformity in the nasal septum often has obvious consequences both for the nasal airway and the external aspect of the nose. Many variables may play a role in the outcome of septal surgery. Partly this is due to the fact that it may be difficult to asses the exact influence of septal deformities on nasal patency, as other factors, such as mucosal swelling and in- and external nasal valve pathology may contribute to nasal obstruction [1]. Furthermore, despite developments in rhinomanometry and acoustic rhinometry, we still lack uniform, clinically relevant and reproducible objective tests for measuring nasal patency [2-4]. Although the extent of surgical manipulation largely determines the degree of possible correction, this may have consequences for the stability and shape of nasal structures [5,6]. In cases in which the dorsal or caudal parts of the septum are not involved, relatively straightforward septoplasty techniques may be successful in improving nasal breathing. As long as an L-shaped dorsal and caudal area of at least 1 cm is left intact, the entire underlying cartilaginous and bony septum may be repositioned and remodelled without structurally compromising or externally changing the nose [7]. The situation becomes more complicated however, when deviations or other deformities are located along the dorsal or caudal borders of the septum. The dorsal part of the cartilaginous septum is responsible for the anterior projection of the middle third of the nose, and deviations in this area are likely to be externally visible as asymmetries and/or deviation from the facial midline. Because of the connection of the dorsal part of the septum to the perpendicular plate of the ethmoid as well as to the upper lateral cartilages, surgical procedures in this area may affect the entire middle vault. This includes the function of the internal nasal valves, which are located at the angle between the septum and the lower border of the upper lateral cartilages. As the attachment between the upper lateral cartilages and the septum may exert tension on a repositioned septum, it is frequently necessary to sever this connection to obtain a tension free midline septal position. This in turn may cause internal nasal valve collapse if preventative measures, such as the placement of spreader grafts, are not taken [8-10]. A second important connection that is to be respected or restored to prevent post-operative loss of stability is found at the Keystone area where the cartilaginous septum and upper lateral cartilages are attached to the bony septum and nasal bones. The caudal part of the septum is intimately related to the premaxilla and anterior nasal spine and plays an important role in supporting the nasal tip, both directly and through its connections to the lower

lateral cartilages (Figure 7.1). These connections must be respected or restored if unwanted changes in the nasal tip are to be avoided after surgery.

Irregularities in this portion of the septum may cause columellar deformities and/or asymmetric nostrils with possible external nasal valve collapse [11].

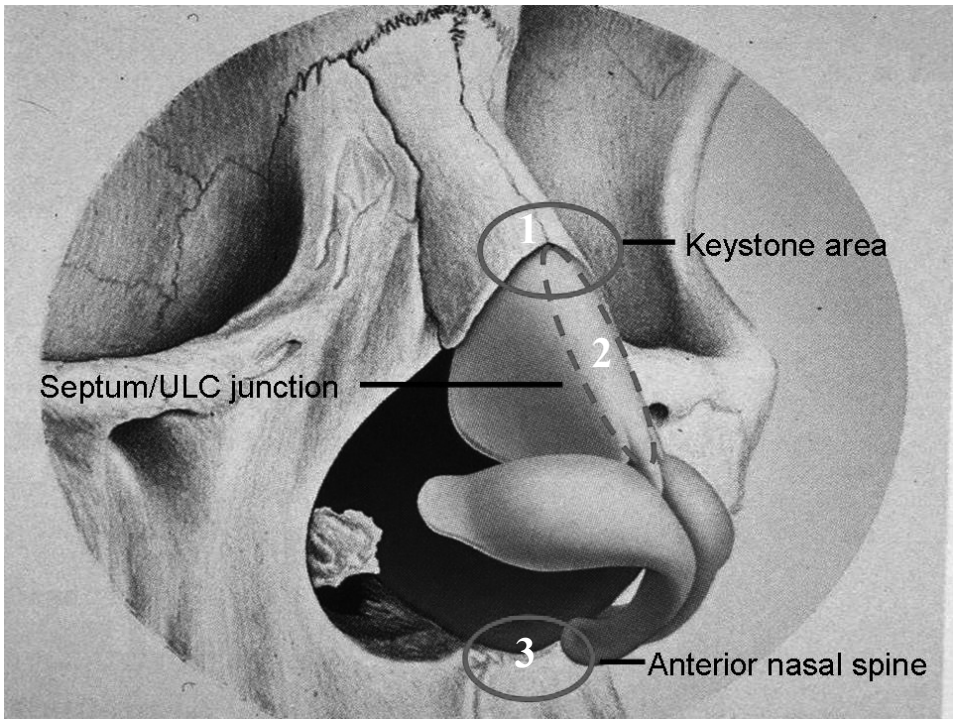

Figure 7.1 The cartilaginous and bony nasal skeleton showing the the Keystone area (1), the connection between the cartilaginous septum and the upper lateral cartilages (2) and the anterior nasal spine (3).

It may be clear from the above, that any surgery performed in the dorsal or caudal portion of the septum may have many structural, functional and aesthetic consequences that need to be anticipated if satisfactory outcomes are to be achieved. Although the techniques that have been described for straightening septal cartilage in general, can be applied to the dorsal and caudal septum, additional measures are necessary to maintain support and control the aesthetic outcome. The various techniques currently in use, which incorporate the above mentioned considerations, broadly fall into two categories The first aims at straightening and/or repositioning the relevant parts of the septum, by using

techniques such as scoring, transecting and thinning [7, 12], and maintaining the changes made with subsequent use of sutures and/or bone or cartilage battens [13-17]. The second approach, referred to in this article as septal replacement, is to remove the affected part of the septum and then either replace it after external remodelling, or replace it completely with an alternative material such as autogenous or banked rib cartilage or bone [18-26]. Both methods and their specific variations, have frequently been described, and can lead to good results but can be technically challenging and demand considerable experience to master. The varying success rates and descriptions we find in the literature are difficult to quantify or compare as many variables may play a role in individual patients and surgeons. A further difficulty in assessing the results of nasal surgery is the already mentioned lack of a uniform objective testing (and reporting) system, in other words; there will always be a certain subjective quality to statements regarding the effects of any given intervention.

Patients and methods

To evaluate the relative value of each method, we retrospectively compared the results between the two techniques, carried out by the same surgeon, in two groups of patients as described below. Although many of the reservations mentioned apply to our study as well, the amount of possible confounding factors was limited as the variables apart from the actual procedure were very similar in each patient group (Table 7.1). The main indication for surgery in each patient group was difficulty with nasal breathing, caused, in part a least, by a dorsal and/or caudal septal deformity. Besides the functional problem, many patients also had cosmetic considerations which needed addressing. For the purposes of this study, the comparison of the results between the two groups only concerned the functional results as subjectively indicated by the patients and the technical results with respect to the post-operative position of the septum as judged by the surgeon during follow-up.

Between 1995 and 2004, 154 patients with a deformity in the dorsal and/or caudal part of the septum where operated on by the senior author and underwent septal reconstruction, either with septal battens or by means of septal replacement. After exclusion of patients with a follow-up of less than 3 months, a history of cleft lip or for whom insufficient data for analysis was available, 114 patients remained for

Table 7.1 The distribution of variables in each patient group. Apart from the fact that (autogenous) rib cartilage was only used in the replacement group, and that there were more revision cases and more external approaches in the replacement group, the other variables were evenly distributed in both groups.

Technique	Number of patients	Ave age	Sex	Sides affected	Location of deformity	Additional procedures	Batten/ Replacement Material	Prev. Nasal Surgery	History Of Trauma	Approach
Septal Battens	69	32.8	64% male 36% female	26% unilateral 74% bilateral	77% caudal 2% dorsal 20% both	62% turb. reduct. 60% ethmoidect. 57% spreader gr. 16% none	65% sept. cart. 7% ear cart. 11% bone 0% rib 17% combination	68%	23%	65% external 35% closed
Septal replacement	45	32.6	71% male 29% female	29% unilateral 71% bilateral	74% caudal 2% dorsal 24% both	77% turb. reduct. 71% ethmoidect. 46% Spreader gr. 5% None	55% sept. cart. 2% ear cart. 5% bone 22% rib 16% combination	86%	22%	93% external 7% closed

evaluation. There were 76 men and 38 women and the average age was 32 years. The average follow up was 17 months (range 3- 129 months). 49 patients (42 %) only had functional complaints of difficulty with nasal breathing, while 65 patients (58 %) had both functional and cosmetic reasons for seeking surgery. There were 69 patients in the septal batten group and 45 patients in the septal replacement group. In a majority of patients, in both groups, concomitant procedures aimed at improving nasal patency, such as turbinate reductions, spreader graft placement and ethmoidectomies were done. Those procedures are likely to have influenced the outcomes in absolute terms, but because they were carried out in comparable numbers in both groups, a reasonable comparison between the two groups could still be made.

Description of Techniques

In the following each technique will be briefly discussed. Either an endonasal or an open approach can be used for either technique, although, because of the superior exposition, an open approach is especially helpful for septal replacement.

1. Septal Battens

A variety of techniques are available for straightening and/or repositioning septal cartilage. In most cases, after elevation of bilateral mucoperichondrial flaps from the septum, the cartilaginous septum is first freed from its attachment to the premaxilla and in a majority of cases a posterior chondrotomy between the cartilaginous and bony septum is made, as in a classic septoplasty. Where necessary basal and/or posterior strips of cartilage are resected, always leaving at least 1 cm of the dorsal and caudal L-strut intact. Any remaining deviations in the caudal or dorsal part of the septum can then be addressed. The main methods by which this is done involves either scoring or thinning of the cartilage on the concave side of the deformity, or by a series of complete cuts trough the cartilage. Both methods can result in cartilage moving from a curved to a straight plane. Next, septal battens are cut and shaped from excess septal cartilage, when available, otherwise from ear cartilage or from perpendicular plate bone. To maintain the straightening achieved, and also for structural support, the battens are then sutured to the septum (Figure 7.2). In patients in whom the battens need to be positioned at the apex of the dorsal septum, because the deviation had extended all the way there, they

take on a second function as spreader grafts. After addressing a caudal deformity, a caudal batten (or strut) is sutured to the septum. The caudal septum and batten are then fixated to the periosteum of the anterior nasal spine and usually also to the medial crurae of the lower lateral cartilages in a tongue in groove fashion. Apart from correcting caudal deformities, the main purpose of a caudal strut is to support the nasal tip, but by adjusting the size and shape of the caudal batten and the fixation points to the medial crurae, the projection and rotation of the nasal tip and the and the amount of columellar show can be greatly influenced [27]. At the end of the operation quilting sutures are placed through the redraped mucosal layers and septum, and the marginal and columellar, or hemitransfixion incisions are closed.

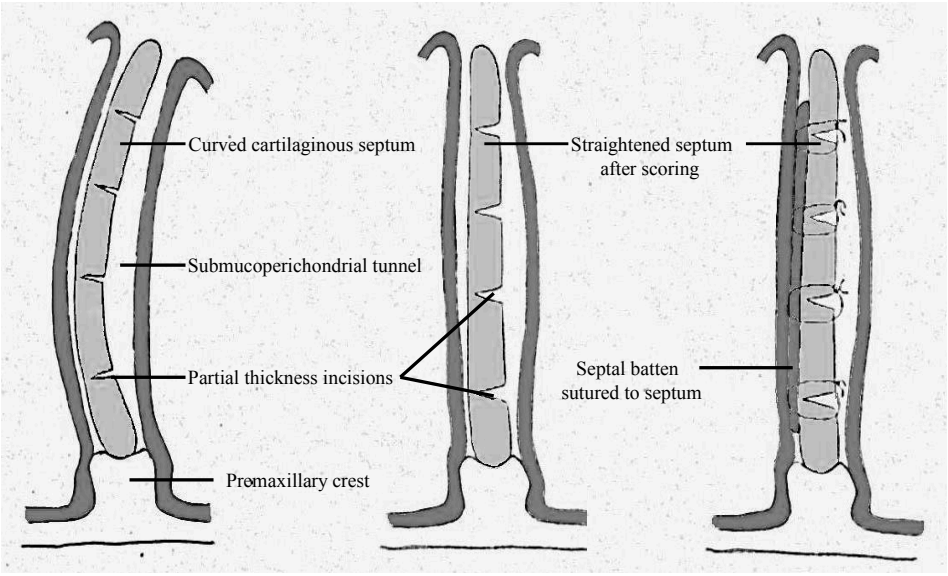

Figure 7.2 Schematic drawing of the principles of septal battens. In this example the septum is straightened by scoring the cartilage on the concave side of the deviation after which a batten is sutured to the septum to prevent a recurrent deviation.

2. Septal replacement

Septal replacement first involves the removal of the affected part of the cartilaginous septum after freeing it from all attachments holding it in place. More specifically, after dividing the connection with the upper lateral cartilages, developing complete submucoperichondrial tunnels on each side of the septum,

separating the basal fibrous connections to the maxillary crest and severing the posterior connection to the vomer and perpendicular plate of the ethmoid, the deformed part of the septum is lifted out of the nose. Depending on the situation the septum can then either be remodelled externally, were necessary making use of added autogenous ear or rib cartilage or bone, or more rarely replaced completely with rib cartilage. The most critical factor when deciding which option to choose when replacing a newly formed septum is the availability of a sufficiently large, robust and straight piece of cartilage for the L-shaped dorsal and caudal area (Figure 7.3a). Sometimes such a piece can be formed by turning the septum upside down and using the basal part of the septum as a new dorsum.

Figure 7.3a

Figure 7.3b

Figures 7.3a and 7.3b A large and straight piece of cartilage harvested from the posterior septum can serve as basis for the new dorsal area of the reconstructed septum.

Often however, mainly because of concomitant basal deformities, this alone will not solve the problem and added cartilage or bone is necessary to build a new septum. Although not used in this series, recent experience using PDS-foil as a template when reconstructing the septum, has proved useful [28]. Irrespective of the material used, the replaced cartilage must be securely fixated in position (Figure 7.3b). Posteriorly it is sutured to the bony septum or nasal bones through a burr hole. Caudally it is held in place by sutures through the periosteum of, or a burr hole through, the anterior nasal spine. Placing the septum in a pre-drilled groove in the pre-maxilla gives additional support and reduces the chance of (late) post-operative deformities [20] (Figure 7.4). The upper lateral cartilages are reattached to the septum, where necessary separated by spreader grafts (figure 7.5a), and the caudal cartilage is contoured and sutured to the medial crurae (figure 7.5b). A key feature of the technique described is that only the deformed part, and not the entire septum is removed. By leaving as much of the non-deformed septum intact as possible, a minimum amount of destabilisation occurs, and furthermore the replaced septum can be securely fixated to the remnants of the original septum.

Figure 7.4 A groove may be drilled in the pre-maxilla in which the new septum can be positioned for extra support and stability.

Figure 7.5a

Figure 7.5b

Figures 7.5a and 7.5b The upper lateral cartilages are reattached to the septum, usuaaly separated by spreader grafts, and the caudal cartilage is contoured, where necessary augmented with a caudal s strut, and sutured to the medial crurae.

Results

In the septal batten group there were 69 patients with functional complaints on 120 sides (18 unilateral, 51 bilateral). Post-operatively, 63% of sides were rated as optimal and 23 % as improved. 12% were equal and on 2 sides (≈2%) the postoperative situation was worse. In the septal replacement group there were 45 patients with obstructed airflow on 77 sides (13 unilateral, 32 bilateral). Post-operatively, on 69 % of sides the patients rated their nasal breathing as optimal, and on 25 % as improved. In 5 % no change was noted and on 1 side (≈1%) it was worse. So in the septal replacement group the overall improvement rate was 94% compared to 86% in the septal batten group. Statistical analysis using Pearson Chi-square cross tabulation tests, both for the unilateral and for the bilateral cases, was carried out. The differences in outcome between the two groups did not reach statistical significance (p-value: 0,634 for the unilateral cases and p-value: 0,092 for the bilateral cases). The technical result was rated during follow-up by judging the position of the septum as midline, slightly deviated or severely deviated. In the septal batten group, 54% of septums were midline, 44% slightly deviated, and 2% severely deviated. In some patients the septum was visibly widened because of the battens. In the septal replacement group 75% of septums were midline and 25% slightly deviated, without any obvious septal thickening. This difference in favour of the septal replacement group did reach statistical significance after Pearson Chi-square cross tabulation analysis (p-value: 0,018)

Discussion

Modern septal surgery has developed along the same lines as rhinoplasty. In modern rhinoplasty emphasis is now more on conservation, repositioning and restructuring rather than on resection. Ideally, any surgical step can be incrementally applied and is reversible. To a large extent batten grafting conforms to these prerequisites more than septal replacement which involves more resection and destabilisation. In the comparison we made, both from a functional and from a technical point of view (indicated by the position of the septum during follow-up) the results appeared better in the septal replacement group, although the functional differences did not reach statistical significance. When judging the post-operative position of the septum, it was (significantly) more often located in the midline in the septal replacement group than in the septal batten group. This

might be explained by several circumstances. In the first place, it is easier to form a completely straight plane externally, on a side table, than while the septum is still in the nose. And such a newly formed septum can probably also be reinserted more accurately than a septum which still has several attachments leaving less latitude for precise positioning. Furthermore, a septum which has been completely remodelled outside of the nose is probably less likely to contain residual inherent tensile forces or cartilage memory causing later distortion than a septum which has been remodelled internally. Of course the main purpose of septal battens is to counter those forces, but it is not hard to imagine that they might not always succeed in doing so during the healing process in the post-operative period. A further disadvantage of septal battens is that they always cause a certain extent of thickening and in some cases this may have a negative effect on nasal patency, especially in the caudal septum. A relative advantage of using battens, is that the surgery is less invasive and generally less time consuming as fewer supporting structures need to be severed, thereby reducing the risk of post-operative loss of stability of the middle and lower third of the nose compared to septal replacement. This risk can however be minimised when the remodelled septum is meticulously fixated after reinsertion, and was not an issue in this series.

Conclusion

Septal surgery for caudal and/or dorsal deformities can be a complex undertaking as many considerations, concerning form, stability and function of the nose, must be taken into account. This article describes and compares two techniques used to treat deformities of the L-shaped septal support structure. Both the use of septal battens and the technique of septal replacement may lead to good results as both respect or restore the structural integrity of the nose and each technique has its relative merits and disadvantages. On the basis of this series, we generally would advise (partial) septal replacement for the more pronounced cases as this is more likely to lead to a straight septum, especially when both the caudal and dorsal parts of the septum are involved. An isolated deformity can probably often be addressed with septal battens alone.

The authors gratefully acknowledge Ron Wolterbeek of the department of medical statistics of the Leiden University Medical Centre for the statistical analysis of the data.

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Chapter 8

Management of nasal septal perforations

Text and figures based on:

Management of nasal septal perforations. In Facial Plastic and Reconstructive Surgery, Vuyk and Lohuis, eds, Hodder Arnold 2006,
chapter 25, pp 319-327.

Nasal septum perforation repair using differently designed, bilateral intranasal flaps, with nonopposing suture lines. J Plast Reconstr Aesthet Surg. 2006;59(8):829-34. Epub 2006 Feb 23.

Robert F. André
Peter J.H.M. Lohuis
Hadé D. Vuyk

Summary

Objective: In this article, we briefly review the aetiology and symptoms of nasal septal perforations, and focus on a surgical reconstruction technique of which the results were retrospectively studied.

Methods: The technique described, involves the interposition of a connective tissue graft between differently designed local mucoperichondrial and/or mucoperiosteal flaps on each side of the perforation, thereby preventing opposing suture lines. On one side a rotation/advancement flap is derived from the septum, the nasal floor and lateral nasal wall while in the opposite nasal passage, bipedicled flaps from the septum and nasal floor and/or from the superior septum and under-surface of the upper lateral cartilage are created.

Results: Of the 43 patients included in this study, 40 had their perforation permanently closed, while three experienced a non-symptomatic recurrence.

Conclusions: The use of differently designed, mucoperichondrial or mucoperiosteal bilateral intranasal flaps with nonopposing suture lines, and interposition of Alloderm® or autogenous connective tissue with cartilage, especially with adequate exposure through an external approach, can lead to excellent results in the majority of cases.

Introduction

The successful management of septal perforations often poses a significant technical challenge. Many options, both surgical and non-surgical have been described, all with their respective advantages and drawbacks. By definition, a nasal septal perforation is a mucosal, cartilaginous and occasionally bony defect in the nasal septum, varying in aetiology, dimension and location. Sometimes a perforation may be a manifestation of an underlying systemic disease. Most perforations are asymptomatic, but some, particularly those that are anteriorly located in or near the nasal valve area, can cause pathophysiologic changes that may lead to crusting, epistaxis, nasal obstruction, whistling, pain and headaches. While nasal valve dysfunction is only rarely caused by a septal perforation, a septal perforation located in the nasal valve area may frequently lead to nasal valve dysfunction, either through turbulence, crusting or loss of structural support of the septum. Because of this, knowledge of and proficiency in the treatment of septal perforations should be part of the armamentarium of every nasal surgeon wishing to be able to treat all causes of nasal valve pathology.

This chapter reviews the aetiology, prevention and symptoms of nasal septal perforations and while discussing various treatment strategies focuses on surgical reconstruction techniques. One technique in particular, using differently designed bilateral intranasal flaps, with non-opposing suture lines is highlighted and the results of this technique as used in 43 patients are presented.

Aetiology

Although many causes exist, the vast majority of nasal septal perforations result from trauma with or without secondary infections [1] (Table 8.1). Surgical trauma during septoplasty is still one of the main offenders [2-4], although it has become less frequent since the technique of submucous resection has largely been abandoned [5]. Other traumatic causes include tight nasal packing or splinting, bilateral cauterisation of nosebleeds and repeated nose picking. Inadequately treated septal haematoma with subsequent septal abscess is another relatively frequent cause. Various diseases, such as Wegener's granulomatosis, autoimmune disorders with vasculitis, neoplasms and rare infections such as tuberculosis and syphilis, may lie at the origin of a perforation, sometimes as the sole manifestation

of such a disease. If the border of the perforation is inflamed, crusted or bleeds easily, or if granulation tissue is present, a sample and biopsy must be considered for bacteriological, fungal and histopathological examination before further treatment. Such a biopsy should preferentially be taken from the posterior end of the perforation as one wants to avoid enlarging the anterior aspect considering that this area is most likely to be responsible for symptoms and contributes most to structural support. When a patient's history and examination gives no clue as to the cause, extensive laboratory investigations may be indicated. As a minimum the erythrocyte sedimentation rate (ESR) should be checked, and depending on the index of suspicion this may followed by C-ANCA, FTA-ABS, VDRL and other serological anti-virus titre tests. The list of inhalant irritants that cause septal perforations is extensive, and even nasal steroids and nasal decongestive medications can occasionally be blamed when used injudiciously. Cocaine may cause septal perforations not only due to its vasoconstrictive properties but also because of irritant additives that are often added to non-medical grade cocaine [6-8].

Table 8.1 *Aetiology of nasal septal perforations*

Trauma

Intranasal trauma

- Nasal septal surgery
- Nasal packing
- Bilateral cauterisation
- Transnasal intubation
- Cryosurgery
- Nose picking

Extra-nasal trauma with septal haematoma.

Infection

- Septal abscess
- Tuberculosis
- Syphilis
- Wegener's granulomatosis
- Lupus erythematosis
- Sarcoidosis
- Rhinoscleroma

Inhalant irritants

- Cocaine abuse
- Nasal steroids
- Decongestants
- Caustic fumes

Neoplasm

- Carcinoma
- Midline granuloma

Prevention

Meticulous surgery and preservation of the structural integrity and mucoperichondrial layers of the septum is the mainstay to prevent nasal septal perforations. Intraoperative septal reconstruction with replaced autologous cartilage is essential to prevent loss of strength and support, and to enhance the rigidity of the septum as well as prevent the occurrence of a perforation. Bilateral corresponding mucosal tears should be repaired at the time of initial surgery. The use of haemostatic suture techniques and light non-adherent nasal packing (preferably removed within 24 hours) is advisable. It should be borne in mind that tight suturing of septal splints and tight nasal packing may cause septal damage. Septal haematoma should be treated aggressively. Electrocautery for nasal bleeding should not be performed bilaterally and simultaneously in corresponding septal areas.

Symptoms

An estimated two-thirds of perforations are either asymptomatic or cause minimal symptoms. The incidence of troublesome symptoms depends on the size and location of the perforation [(2)]. In general, the larger and the more anteriorly located a perforation is, the more likely it is to cause symptoms. A large anterior perforation may cause crusting, nasal obstruction, rhinorrhoea, epistaxis, uncomfortable sensations while inhaling cold air, and sometimes headache (Figure 8.1). Smaller perforations may lead to noisy breathing or whistling. Nasal obstruction can be caused by excessive turbulence in the inspiratory airflow, especially in the nasal

valve area. Crusting may also be a consequence of increased turbulence. Large perforations may seriously compromise structural support of the anterior and middle third of the nose leading to saddling which may further impede nasal airflow. Crusting and mucosal hypertrophy can be another important factor, worsened by chronic rhinosinusitis, atrophic rhinitis or the effects of previous radiotherapy as for a neoplasm.

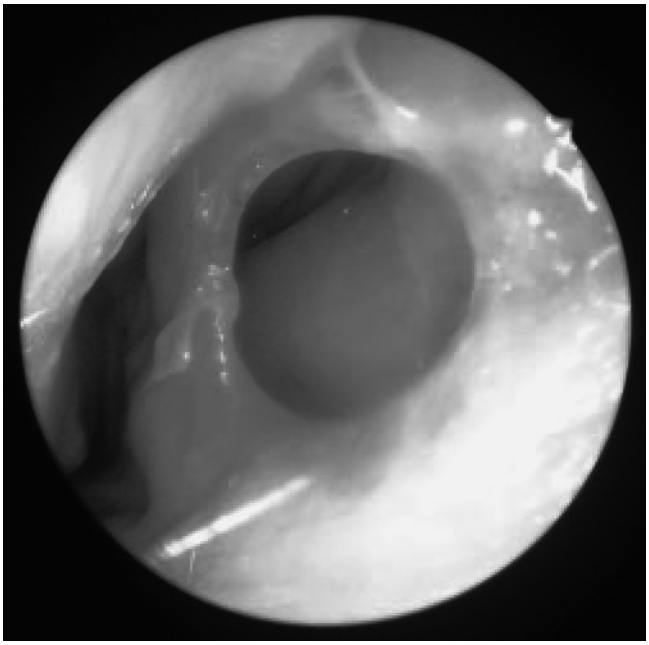


Figure 8.1 A large anterior septal perforation.

Treatment

Conservative options

After ruling out or treating systemic disease or a local infectious or malignant process only symptomatic perforations need to be treated. Treatment may be conservative, prosthetic or surgical. Repeated application of moistening, and when indicated, antibacterial ointments and nasal douching with saline, is sometimes all that is needed to reduce or cure symptoms of crusting and bleeding. Conservative treatment is always advisable, both as first treatment of choice and also to optimise the conditions of the mucoperichondrium if an operation is to

follow. Another option is to close the perforation by inserting a prosthetic device in the hole, thereby separating the right and left nasal passages [9]. Usually a preformed silicone or silastic button is used which can be individually tailored to fit a given perforation (Figure 8.2). This can easily be accomplished as an outpatient procedure under local anaesthesia. Ideally, this has several effects, although some symptoms are improved more by a prosthesis than others. Obviously nasal whistling will almost always disappear and nasal stuffiness is likely to improve, provided the perforation was its main cause. The reports of its effects on crusting and bleeding vary, but in general the goal is to create a moister environment at the perforation edges by reducing the drying effects of the pre-closure turbulent airstream. Unfortunately, sometimes the prosthesis may actually cause nasal obstruction, either because it may induce increased mucus secretion and mucosal swelling or simply because of the thickness of the prosthesis. A prosthesis generally needs to be cleaned regularly should be changed every three to five years, and is not tolerated well by all patients.

Figure 8.2 Silicone septal perforation interposition prostheses.

Pre-operative Considerations

Although high success rates for surgical septal perforation closure have been described, the most important predictor of successful surgical perforation closure is the size of the perforation; the larger the perforation, the more difficult the surgery and the less chance of complete closure. The vertical height of a perforation is more critical than the anteroposterior dimensions, as the approximation of the mucoperichondrial edges from the floor of the nose to the dorsum is causes the greatest tension [6]. If complete closure does not seem likely to be technically feasible, one may consider closing the anterior portion of the perforation only, as this is the area most likely to be responsible for symptoms. Obviously when choosing this rare option, ones considerations should be carefully discussed with the patient so as to avoid post-operative controversy. A nasal septal perforation caused by previous septal surgery may present with a cartilaginous perforation that is considerably larger than the apparent mucosal perforation. This may severely complicate dissection and mobilisation of mucosal flaps. Generally speaking smoking is associated with increased flap failure [10]. As in the case of facial reconstruction using flaps or grafts, and in facelift surgery, patients are advised to refrain from smoking for 3 months preoperatively and 4 weeks postoperatively. It is obviously unwise to attempt surgical closure in a patient whose underlying cause, be it a systemic illness or cocaine abuse, does not reliably belong to the past. An important surgical consideration in the case of cocaine abuse is that even when cartilage is present, its quality is usually poor.

Surgical treatment

The literature describes many methods of surgical closure of nasal septal perforations. This multitude of techniques may be a reflection of various factors adding to the complexity of any surgical undertaking aimed at closing an opening between the left and right nasal passages. To start with there is the problem of a relatively limited surgical exposure, especially through an endonasal approach. This complicates the already difficult task of separating and individually repairing each part of the three-layer architecture of the septum, necessary for the best chance of a lasting closure [1, 11]. According to Gillies' principle, missing tissue is ideally replaced with like tissue, so matters are further complicated by a relative paucity of suitable donor material, at least regarding the respective mucoperichondrial layers. The mainstay of treatment today involves the use

of local mucosal flaps with interposition of a connective tissue graft. Various techniques have been described using mucosal flaps derived from the septum [12, 13, 14], nasal floor, lateral wall [13, 15], inferior turbinate [4, 16], or even buccal mucosa [17]. The interposition grafts placed in-between the flaps also vary. Nowadays usually a combination of two layers of mucoperichondrium supported by autogenous fascia or cartilage graft is used [18 -22] or alternatively, interposition of a single layer of acellular human dermal allograft (Alloderm, Lifecell corporation, the Woodlands, USA) [23].

A variety of approaches have been described for nasal septal perforation closure. The endonasal approach using a hemi transfixion incision may offer enough exposure for smaller size perforations [19, 22], although technically it can be very difficult. Furthermore, theoretically the anterior vascular flap supply may be impeded by the hemi- transfixion incision. A lateral alotomy may be added [18] to increase exposure to the anterior septum and nasal floor. The transoral/ premaxillary approach [24] provides enhanced visibility of intranasal structures from a different perspective to the usual nasal approaches. A midface degloving procedure according to Romo [25] provides a good approach but does carry a significant risk of vestibular stenosis because of circular incisions. An external approach provides the best exposure, particularly of the dorsal and posterior septal portion [26, 30] (Figure 8.3). The access obtained after separating the upper lateral cartilages from the septum permits dissection around the perforation, enhancing mucosal flap mobilisation and precise graft interpositioning.

Figure 8.3 Exposure of a septal perforation through an external approach.

Complications

The most common and obviously disappointing complication is unsuccessful closure or recurrence, the stated rates for which vary between 5 and 50 percent. Although success rates of up to 95% have been reported, failures do occur because of poor exposure, inadequate mobilization of mucoperichondrial flaps, closure under tension and/or poor approximation of septal flaps [33]. As already alluded to, any success rate in septal perforation closure may reflect differences in patient selection criteria. Secondary intranasal donor defects usually heal without complication. Some patients develop minor synechia along the nasal floor or roof but these rarely have functional significance. In patients with large septal perforations that required mucosal mobilization from the inferior turbinate epiphora is a theoretical complication, but rarely occurs [8].

Septal perforation closure technique

It is clear that there are many ways to tackle the problem of a nasal septal perforation. The technique described in the following section combines several components of the aforementioned techniques. Although this technique may not be adequate for very large perforations, and is not always necessary for smaller ones, for the majority of septal perforations it is our procedure of choice. In most cases an external approach is used, the details of which will be described insofar as they pertain to this specific procedure.

General anaesthesia is supplemented with local infiltration of lidocaine 1% and adrenaline 1: 100.000. The first step of the operation is to incise the intranasal flap margins using a rigid 0^{o} nasendoscope and a specially bent and hooked (Beaver) knife. Subsequently a mid-columellar broken-line skin incision is connected with bilateral marginal incisions as for a standard external approach to obtain optimal exposure. The nasal skin is carefully elevated from the underlying nasal skeleton in the correct supraperichondrial plane. The caudal edge of the cartilaginous septum is exposed after complete division of the intermedial crural and interdomal ligaments. The upper lateral cartilages are dissected from the dorsal edge of the septum on both sides. Subsequently bilateral mucoperichondrial flaps are elevated from the septum and extended around the perforation. The goal of mucosal flap mobilisation is to close the defect completely on both sides, while avoiding opposing suture lines and maintaining adequate blood supply. Different

designs of mucoperichondrial flaps are used on each side of the perforation to prevent opposing suture lines (Figure 8.4). Usually on one side a rotation/ advancement flap is derived from the septum, the nasal floor and lateral nasal wall (Figure 8.5). Mucoperichondrium dissected from the septum is extended in continuity with the mucoperiosteum of the floor of the nose and up the lateral wall until the attachment of the inferior turbinate. In larger perforations

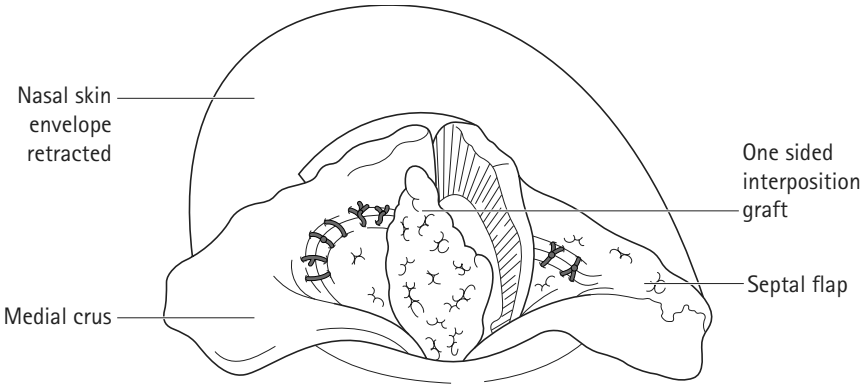
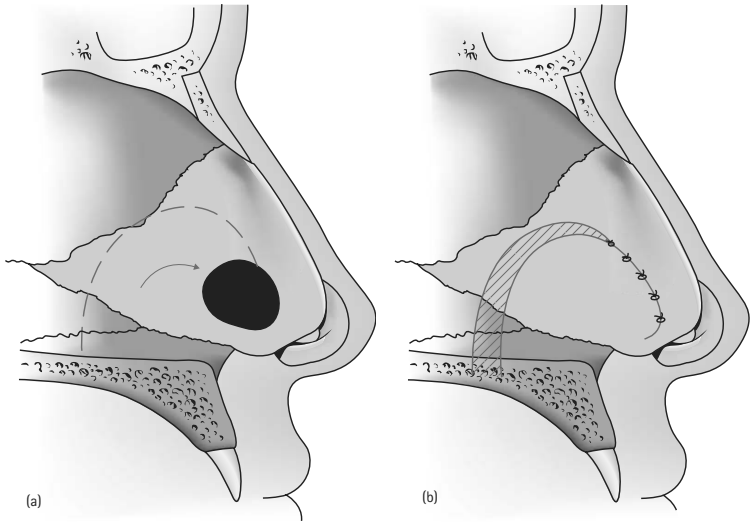


Figure 8.4 Non-opposing suture lines of an inferoanteriorly based rotation-advancement flap on the patient's right, and bipedicled, anteriorly and posteriorly based superior and inferior advancement flaps on the patients 's left.



Figures 8.5 a and b The inferoanteriorly based rotation-advancement mucoperichondrial flap.

(> 2.5 cm) the rotation flap is designed to include lateral and/or medial mucosa from the inferior turbinate. These rotation flaps are mostly based anteriorly on the branches of the superior labial artery [24]. This is preferable to posteriorly based mucoperiosteal flaps that are often too short to reach the anterior septal perforation [8]. In the opposite nasal passage, bi-pedicled flaps from the septum and nasal floor (Figure 8.6) are developed [6, 22]. A superior mucoperichondrial bi-pedicled septal flap may be created. Sometimes mucoperichondrium from the under-surface of the upper lateral cartilage is included, preserving all of its blood supply, or alternatively a cut may be made in the mucoperichondrium at the junction of the septal and the upper lateral cartilage, or slightly more lateral, creating a bi-pedicled flap to advance inferiorly [23, 27]. If a concomitant reduction rhinoplasty is indicated, lowering of the nasal dorsum will help to create a relative excess of mucoperichondrium to be used for perforation closure [28]. Occasionally a perforation cannot be closed completely on one or both sides and the connective tissue interpositional graft can serve as a template for migration of the overlying healing flaps [23, 29]. The mucosal flaps are approximated, using non-traumatic forceps and sutured without tension with multiple fast absorbable 5/0 vicryl sutures. Autogenous fascia and/or periosteum are obtained through a high postauricular temporal skin incision. The size of the graft is dictated by the size of the defect. Thickness depends on whether superficial temporalis fascia, loose areolar tissue or deep temporalis fascia is taken [31]. The connective tissue grafts are placed under the mucoperichondrial flaps on both sides of the septum and should ideally overlap the defect on all sides. Subsequently the cartilaginous and bony defect is reconstructed with autogenous auricular cartilage, which should fit precisely. Alternatively one layer of acellular human dermal allograft may be inserted, obviating the need for harvesting of additional autogenous temporalis fascia and/or ear cartilage. After insertion of the grafts, tissue adhesive (fibrin glue) may be used to secure and stabilize the reconstructed area. Nasal septal splints are secured with horizontal mattress sutures. The upper lateral cartilages are sutured back to the septum. After reconstruction of the nasal septal perforation, a rhinoplasty may be performed to correct concomitant deformities, such as loss of nasal tip support and projection and/or saddling of the middle nasal dorsum. The advice to refrain from alloplastic material insertion for dorsal augmentation, when possible, gains even more importance than usual because of the proximity and size of intranasal wounds [32].

Marginal and columellar incisions are closed with interrupted sutures. A non-adherent absorbing dressing is applied for 24 hours. The nose is taped and a cast applied for one week. The splints are usually left in place for 2-3 weeks. The nose is kept moist with nasal douches, using saline solution and ointment. Broad-spectrum antibiotics are administered one hour before the operation and continued for 7 days.

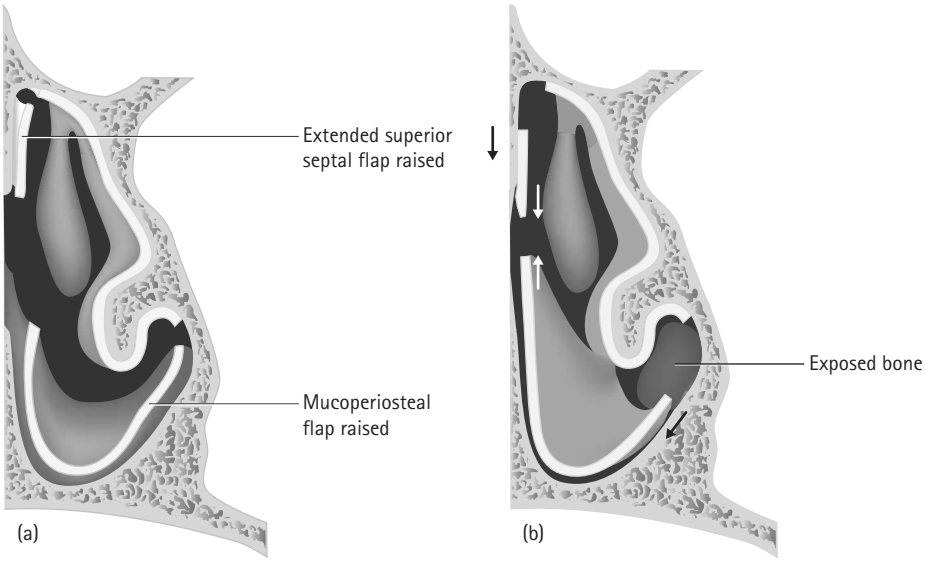


Figure 8.6 a and b Bipedicled, anteriorly and posteriorly based superior and inferior advancement flaps.

Patients and Methods

Between July 1991 and June 2002, 46 patients with a septum perforation were operated upon by the same surgeon (HDV) using bilateral mucoperichondrial rotation/advancement flaps as described above. Of these patients, three had a follow-up of less than 3 months and were excluded from the study. The average follow-up was 29 months (range 3–138 months). There were 10 women and 33 men and the average age was 36.6 years (range 16–68 years). In 14 cases the perforation was caused by previous septal surgery, in 12 cases it was due to nose picking, in three cases the cause was cocaine abuse, in two cases there had been a nasal trauma and in 12 cases no underlying cause was found. In six patients, the diameter of the perforation was smaller than 5 mm, in nine patients it was between

5 and 10 mm, in 26 patients it was between 10 and 20 mm and in two patients the diameter was larger than 20 mm. In 11 patients, a single layer of Alloderm was used as interposition graft while in the other 32 patients ear cartilage was sandwiched between two layers of temporalis fascia. An endonasal approach was used in seven patients; in the other 36 an external approach was used.

Results

At a minimum of 3 months all patients were re-examined although the majority had a much longer follow-up period. Of the 43 patients included in this study, 40 (93%) had their perforation permanently closed, while three (7%) had a recurrence. In two of these three patients, the size of the recurrence was less than 10% of the original perforation. In the third patient, the perforation was roughly half the original size. All three patients remained symptom free and did not need a second operation. In general, unsuccessful closure or a recurrence may occur because of poor exposure, inadequate mobilisation of mucoperichondrial flaps, closure under tension and/or because of poor approximation of septal flaps [33]. Except for age (all three patients with a recurrence were over 50), no common variable concerning the sex of the patient, the aetiology, the size of the perforation, the surgical approach or the type of interposition graft was found. A few patients developed minor synechia along the nasal floor or roof but these had no functional significance. In patients with large septal perforations that required mucosal mobilisation from the inferior turbinate, epiphora is a theoretical complication but did not occur in our study [8].

Discussion

Following suggestions made by Gollom [14] to optimize blood supply, the mucoperiosteal and perichondrial flaps described are broadly based random flaps (inferoanteriorly based septal rotation/advancement flaps as well as superior and inferior bipedicled flaps, anteriorly and posteriorly based), or axial flaps containing a named artery (anteriorly based, narrow pedicled, transposition or rotation flap based on a branch of the superior labial artery). The use of mucoperichondrial flaps conforms to Gillies' principle [34] that tissue loss should be replaced by the same kind of tissue. The non-juxta positioning of the flaps prevents opposing

suture lines and avoids jeopardizing the intervening septal cartilage/bone in case one of the flaps fails to heal. Dissection of flaps, especially out of the maxillary crest/ nasal floor transition zone should be done with care to prevent flap tears. A septal deviation or winged maxillary crest may make dissection particularly difficult. It is doubtful whether dissection of the flap out of the bony tunnel of the anterior palatine neuro-vascular bundle, which sacrifices the anterior palatine vascular supply, will increase flap mobility. It may, in fact, lead to a higher risk of flap necrosis. When unilateral failure occurs, this may not be detrimental to the reconstruction as the other vital mucosal flap supports the healing by secondary intention of the opposite failed flap. A previous report supports this notion by suggesting the use of a unilateral mucosal flap and temporalis fascia only [(29)]. The use of large intranasal mucosal flaps necessarily leads to large denuded areas. Non-epithelialised areas heal secondarily with proper treatment without long-term dryness or crusting, comparable to Caldwell Luc cavities. The three-week duration of splinting minimises synecchia formation and prevents drying and desiccation of healing grafts and flaps.

Other intranasal flaps used for nasal septal perforation closure often involve the inferior turbinate, either anteriorly [(16)] or posteriorly based [(4)]. The above-described intranasal flaps are preferred to tunnelled buccal mucosal flaps as these may lead to scarring and/or oronasal fistulas, sometimes needing repair [(12)]. However, for successful closure of very large perforations (over 2.5 cm) a three staged procedure using a cartilage reinforced buccal flap may be indicated [(17)]. Other methods that use skin grafts, skin flaps or buccal mucosa grafts leave the patient with a dry crusty nose, because respiratory nasal mucosa is deficient. Although tissue expansion is a theoretically attractive proposition, it is seldom used to increase the dimension of the intranasal flap [(35)].

Another key aspect is the utilization of low-metabolic fascia/periosteal interposition grafts as scaffolding for epithelialisation [(36)]. The graft maintains a barrier between the corresponding repaired flaps during healing and therefore decreases the risk of incision breakdown and re-perforation [(23)]. Application of these autogenous fascia grafts on both sides of the perforation [(37)] in combination with fibrin glue maintains a watertight closure enhancing successful reconstruction. The use of autogenous cartilage will lend strength and durability to the reconstructed septum. Only rarely does the width of the reconstructed septum appear to impair nasal breathing. Although a five-layer closure (Figure 8.7) might predispose to dead-

space formation or subsequent infection, in practice the use of fibrin glue and additional splinting prevents this. One advantage of a five-layer closure is that the strength of the reconstruction permits the future use of intranasal medication such as corticosteroid sprays for concomitant allergy.

The disadvantage of autogenous graft harvesting includes additional operative time and postoperative morbidity. Moreover, temporalis fascia is thin and technically difficult to manage. The grafts must be larger than the perforation in order to overlap the original deficient area. Kridel has championed the use of acellular human dermal allograft as an alternative interposition graft [23]. Acellular human dermal grafts (Alloderm, Lifecell Corp., Woodlands, Texas) have been used for several years for skin grafting in the management of acute burns [38]. Adequate screening, powerful antiviral agents and the removal of all living cells safeguards against transmission of viral or prion disease and avoids an immune response. A layer of 1-mm thickness Alloderm ® interposition graft seems to be a reasonable alternative to autogenous grafts in terms of cost effectiveness, patient friendliness and success rate [23].

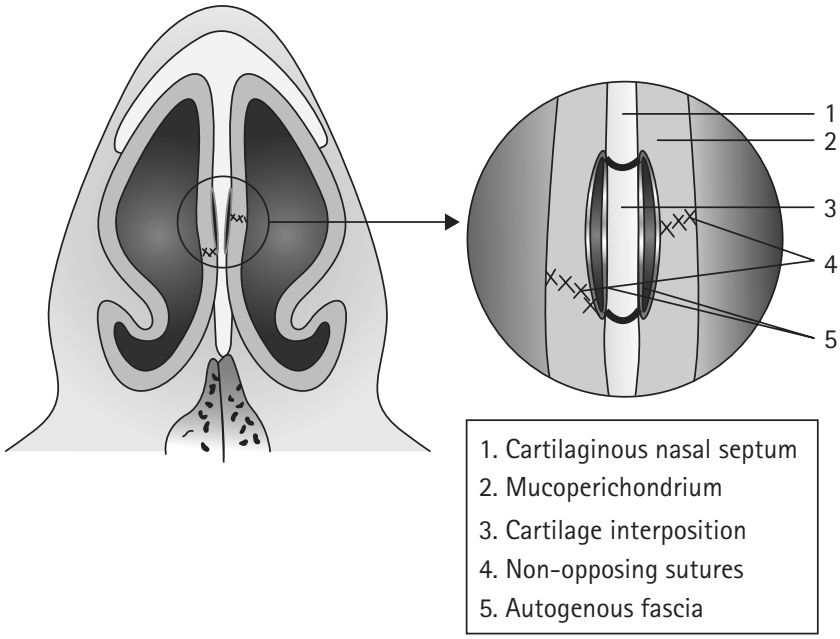


Figure 8.7 The five layers of tissue at the site of a repaired septal perforation; septal cartilage sandwiched between two layers of autogenous fascia and two layers of mucoperichondrium. Alternatively, one layer of Alloderm® may provide adequate long-term support for mucosal closure.

Conclusions

The technique described in this chapter for the surgical closure of nasal septal perforations using the external approach uses recognized surgical principles. The use of highly vascularised mucoperichondrial, periosteal and intranasal flaps with interposition of Alloderm ® or autogenous connective tissue for epithelialisation and cartilage for support aims at a complete anatomic closure. Though no method ensures success, the use of differently designed contralateral bilateral flaps with non-opposing suture lines, tension free closure and adequate exposure through an open approach greatly enhances surgical results. Finally, on should remember that for many patients non-surgical solutions may be adequate and should always be considered as an alternative to possible surgical disappointment. Thus, careful weighing of the various individual variables is necessary before one proceeds with this challenging surgery.

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Chapter 9

General Discussion

Goal of research and statement of the problem

The goal of the research underlying this thesis was to extend our knowledge of the role that the nasal valve area plays in nasal obstruction. The thesis evaluates a range of surgical techniques to identify which ones could help alleviate this complaint. The central problem explored here concerns the effectiveness of surgical procedures in treating pathology of the nasal valve area. We wanted to test the premise that most causes of nasal valve insufficiency should be treatable with a limited number of procedures. We proposed and evaluated seven [1-7] surgical techniques for correcting deformities at specific locations in the nasal valve area on both its medial and lateral boundaries. The effectiveness of these procedures was assessed with use of subjective self-evaluation by the patients [1-6] and in terms of clinical parameters [6,7] in prospective [1-4] and retrospective [5-7] studies.

A secondary problem explored here concerns the value of objective rhinometry instruments for measuring nasal patency. Specifically, we wanted to ascertain their value in quantifying surgical results. Opinion on this topic is still divided, but it has direct bearing on how our results are to be interpreted, as our studies are based on the patients' subjective self-analysis. After reviewing the literature on rhinomanometry and acoustic rhinometry, we focused on those studies that sought to assess the correlation between objective measurements and subjective sensations of nasal patency [8]. This correlation is of major importance, as the goal of functional nasal surgery is to improve the subjective perception of nasal patency, while the scientific method requires objective, quantifiable outcomes.

Methodological considerations, strengths and weaknesses

In our own prior experience – and in that of most of the clinical colleagues whom we queried on this subject through personal communication – we found poor correlation between objective rhinometry and patients' subjective sensations of nasal patency. Also, the vast majority of studies on functional nasal surgery use subjective scoring methods to judge the results. We recognize the importance of 'objective' and quantifiable outcomes. However, it seems that the objective tools at our disposal and the outcomes they measure are not always directly related to the symptoms we aim to treat surgically. Taking into account the ongoing controversy about the value of objective rhinometry, we reviewed the literature and found

little substantiation for a relevant, reliable and reproducible correlation between objective and subjective outcomes [8]. It should be noted that the design and quality of the studies analyzed in this review vary so widely that the controversy is not likely to be settled any time soon. Therefore, we conclude that for our studies the most useful tool to assess the effects of the procedures was subjective self-analysis. In our retrospective studies [5-7] the patients were asked to compare their subjective sense of nasal patency on each side, rating it as worse, equal, better or optimal compared to the pre-operative situation. In our prospective studies, the same method of evaluation was used in one study [1], whereas in the others [2-4] visual analogue scales were used pre- and postoperatively. With the latter design, the patients were asked to rate their sense of nasal patency on a scale of 1 to 10. In hindsight, it would have been better if all studies had been prospective and if we had used the same scoring system in each one, as consistency would have allowed better comparison of the results. Furthermore, in view of continuing developments in this field, it would be better for studies on this subject to use not only visual analogue scales but also validated questionnaires developed specifically for this purpose [9].

Generalization of the results; the clinical perspective

The goal of the studies we carried out, and indeed of nearly all clinical studies, is to present results of a particular intervention, as found in a limited number of patients and under certain circumstances, in such a way as to provide a reliable basis for extrapolation to patients with similar conditions outside the study population. Evidence-based medicine offers a number of criteria to determine the value of such studies. In that vein, one question that might be raised about this thesis is whether or not the results found and the conclusions drawn are relevant to patients presenting with complaints of nasal obstruction resulting from pathology in the nasal valve area.

In evidence-based medicine, a ranking system is used to rate the 'level of evidence' of the conclusions of clinical studies. The higher the level of evidence, the more likely it is that the conclusions are applicable to individual patients outside the study. According to the Oxford Centre for Evidence-Based Medicine, the highest level of evidence (1a) is afforded to systematic reviews (SR) of randomized controlled trials (RCTs). One step lower (1b) come well-designed RCTs themselves. Studies

with a level 1 level of evidence are given a recommendation of grade A, while grade B is given to studies with a level of evidence of 2 or 3. Level 2 comprises SRs of cohort studies (2a), individual cohort studies (2b) and outcomes research (2c). The next level (3a) is for SRs of case-control studies or (3b) case-control studies themselves. Level 4 (given grade C) is for case series and level 5 (grade D) for 'expert opinion' without critical appraisal.

While this rating system may also be used for 'evidence-based surgery', certain aspects relating to surgical studies require additional attention [10]. These aspects are mainly methodological. First of all, randomized trials are more difficult to perform in surgery than in other medical domains, which implies that most surgical studies have a lower level of evidence than medical studies. In surgical trials it is difficult to achieve the goals of randomization: to evenly distribute the determinants of outcome between the treatment and control groups; and to conceal both the randomization process and the treatment modality (double blind) from the investigators. Furthermore, in surgical studies, it is far less feasible, not to mention unethical, to form a control group that will be given placebo treatment. Most surgical publications are therefore based on retrospective case series and prospective non-randomized studies [11]. And indeed, these are the categories into which our surgical studies fall. Three were prospective [1-4], three retrospective [5-7] and none were randomized. According to the Oxford Centre for Evidence-Based Medicine rating system, this would give five studies [1-5, 7] a level of evidence 4 and grade of recommendation C and would give one study [6] a level of evidence 2b and grade of recommendation B.

The usefulness of such studies is also related to the limitations of data collection in retrospective studies. The information obtained is likely to be incomplete, and possibly less trustworthy, than when a fixed outcome protocol is used both before and after the intervention. While some of these drawbacks are overcome in prospective non-randomized controlled trials, these studies may be prone to bias. In studies without randomization between groups (such as our study comparing septal replacement to septal battens), difficulties may arise when comparing heterogeneous patient populations. Another problem concerns the outcome that is being investigated. Before accepting one treatment as superior to another, the clinical relevance of the main outcome measures must be examined. Most trials measure dichotomous outcomes or events such as death, cancer recurrence or the presence of surgical complications. These events either happen or they don't, so

the literature usually reports the proportion of patients having the event of interest. In this thesis only the study on nasal septum perforation repair [7] measured a dichotomous event (closure of perforation). All the other studies measured the amount of improvement the interventions made on subjective complaints. However, measuring relative outcomes makes comparison with other studies more difficult, especially when the literature uses different scoring methods.

Perhaps the key factor distinguishing surgical trials from medical ones is the skill of the surgeon who carries out the procedure. Without a doubt, the surgeon's proficiency is a very important but hard to measure component of the effectiveness of an operation [12]. The fact that the operations described in this thesis were carried out by experienced and highly specialized nasal surgeons (HDV and RFA) is likely to have led to more positive outcomes. Small details of the surgery may have a decisive influence. Not only is the matter of surgical proficiency responsible for a fundamental difference between medical and surgical trials [13, 14] but it may create a dilemma for practicing surgeons. If published evidence conclusively favors a surgical technique that a surgeon does not perform, or does not perform well, that surgeon is faced with three choices: proceed using another technique; refer the patient to a colleague; or seek additional training to master the operation [15, 16].

When interpreting the results of our studies, it should be noted that the majority of patients (except in the septal perforation repair study) underwent one or more concomitant procedures apart from the technique that was the object of the study. For the sake of scientific rigor it would have been better to perform only the specific procedure we wished to study. However, this was not feasible in many patients due to the multifactorial nature of nasal obstruction. In other words, when additional causes for nasal obstruction were discovered apart from the specific nasal valve disorder, they were treated as well. This meant that it was not always possible to judge which portion of the subjectively reported effect was caused by the technique under investigation and which portion by the concomitant procedures. Where possible we focused on the subgroups in whom only the technique of interest was used. The results found there were comparable to those for the whole population in which concomitant procedures were performed.

Taking all the above considerations into account, it should be obvious that the results we report here must be interpreted with some caution. At the very least, we can state that the techniques described seemed to have a positive effect on the

subjective sense of nasal patency in the majority of the patients. The indeterminate nature of our findings does not detract from their value, however. Surgical practice involves many uncertainties. As with all information that is used to make clinical decisions, the findings in this thesis should be judged on their relative merits. In the case of nasal valve surgery, there is a rapidly growing literature describing more and more (variations of) techniques. Therefore, the techniques and results we have presented are likely to be refined, altered and possibly substituted by more effective ones with advancing knowledge on the subject.

Comparison to the literature

An additional way to evaluate our studies is to compare them to the literature on this subject. To this end we considered the recently published first two systematic reviews of nasal valve surgery [17, 18]. These two reviews examined a combined total of 68 studies (24 overlapping) from 1970 to 2008. Many of the issues in our studies, such as the use of concomitant procedures apart from the technique under consideration and heterogeneous patient populations, appeared to be present in the other studies. Fifty-two studies relied on subjective assessment alone, with use of various scoring methods. Twelve studies included rhinomanometry besides the subjective assessment. In four studies only rhinomanometry was used to judge the results of the procedures and no studies used acoustic rhinometry. The share of patients with improved patency (when these figures were given) ranged from 53 to 100 percent. In our studies, 65 to 94 percent of the patients had improved patency. It has to be taken into account, however, that the outcomes of the various techniques cannot be directly compared due to differences in reporting methods and other considerations discussed above. Fifty percent of the studies were prospective and 50 percent were retrospective, which is the same distribution as in our studies. Four of the studies presented in this thesis [1, 4-6] were included in these reviews (our study on the butterfly graft was published more recently than the cut-off date of the reviews). Four other authors had two studies each discussed in the reviews. Only one of these authors, however, described two different techniques [19, 20]. In terms of number of patients per study, our studies stood in place 4 [6], 6 [1], 30 [5] and 45 [4] out of 68. The reviews ranked each publication according to its level of evidence. Only two studies had a grade 2b, one of which is part of this thesis [6]. One study was given a grade 3b in one review and a grade 4 in the other. The remaining 65 studies, including three of our publications, were rated as having a level of evidence of grade 4 in both reviews.

In light of these recent reviews, in terms of study designs, scoring methods and population sizes, the studies in this thesis can be considered to be at least at the same level as other studies on this subject. The fact that of the 68 studies reviewed only two had a level of evidence of 2b, one of which is part of this thesis, adds weight to this statement. Furthermore, only one other author described more than one technique for treating nasal valve disorders. That enhances the relevance and timeliness of this thesis in terms of insight into the indications, advantages and drawbacks of the techniques described.

Synopsis of key findings and conclusions

While being conscious of the limitations and shortcomings of the studies as explored in the above section on methodology, certain tentative conclusions can be drawn from this thesis. The reasoning as to how these conclusions were reached, as well as the specific results and conclusions themselves, are elaborated upon in detail in the relevant chapters. All of the techniques we studied seemed to have a positive functional effect, as subjectively indicated by the patients. However, one of the techniques [(4)] had a much higher complication rate than the others. We therefore advised against its continued use, especially as another technique [(5)] aimed at the same sub-site had comparable efficacy with far fewer complications. Although the results found using the butterfly graft seemed to be better than those of the other techniques, the difference in outcomes between the procedures cannot really be substantiated. This is due not only to the differences in scoring techniques, study designs and population sizes but also to the distinctive sub-sites for which the techniques are most appropriate. In the study on septal perforation repair we assessed the percentage of successfully closed perforations but did not evaluate the subjective improvement of nasal patency after surgery. The latter issue was not the main object of this retrospective study and was not always the main reason for which surgery was performed. Furthermore, data on subjective nasal patency were lacking in many patients. However, we decided to include this study in the thesis because septal perforations are often found in the medial wall of the nasal valve area and often lead to nasal valve incompetence. Therefore, the ability to repair septal perforations should be part of the armamentarium of a nasal surgeon wishing to be able to treat all deformities leading to nasal valve insufficiency.

The most important considerations and conclusions arising from this thesis can be summarized as follows:

1. Due to the central role of the nasal valve area in nasal physiology, pathology in this area may play a greater role in causing complaints of nasal obstruction than is generally realized.
2. It is possible to improve symptoms of nasal obstruction caused by deformities in the nasal valve area with relatively few targeted surgical techniques in a large majority of patients.
3. The complaint of nasal obstruction, although related to nasal airway resistance, is often due to multiple factors and is not fully understood.
4. The relatively poor reputation of functional nasal surgery among general practitioners and the public may be due to the fact that the appropriate technique for treating nasal obstruction is not always selected.
5. Objective rhinometry instruments have a limited correlation with the subjective perception of nasal patency and have little value in quantifying surgical results or in routine rhinologic practice. On the basis of currently available data it is unfounded to assign more value to objective measurements than to subjective outcomes in the case of nasal patency.
6. To judge the effect of nasal surgery on the subjective sense of nasal patency, the use of visual analogue scales and validated questionnaires is most appropriate.
7. Results of surgical studies are more difficult to interpret and extrapolate outside the study population than those of medical studies, due to additional issues in evidence-based surgery compared to evidence-based medicine. This is especially true for surgery in which the results can not be precisely quantified, as is the case in functional nasal surgery.

Recommendations for future research

Given the nature of surgical studies, particularly of those involving subjective outcomes such as used in functional nasal surgery, the level of evidence of future studies on this subject is likely to stay relatively low. It will remain difficult to accurately assess the outcomes of specific procedures or to compare results between techniques and surgeons. Considering the growing amount of literature on surgical techniques aimed at the nasal valve area, the balance is slowly tilting

away from septoplasties and turbinate reductions as the main surgical interventions for improving nasal breathing.

By designing future studies on functional nasal surgery techniques to be prospective, by consistently making use of visual analogue scales and validated questionnaires, and by pooling the results from a number of surgeons using the same techniques (multicentre studies), some of the possible shortcomings of such studies may be avoided. In this manner we should gain increasing insight into the specific causes of nasal obstruction and be better equipped to select the surgical techniques most likely to improve the subjective perception of nasal patency in our patients.

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Chapter 10

Summary and conclusions

The main objective of this thesis is to discuss the current state of knowledge of conditions causing obstructive symptoms in the nasal valve area and to study the effectiveness of various surgical procedures aimed at treating those conditions.

The aim was to identify a select number of techniques with which it should be possible to treat the vast majority of causes leading to nasal valve insufficiency.

In **chapter 1** the anatomy, physiology, diagnosis and pathology surrounding the nasal valve area are described and the general concepts of nasal valve surgery are discussed. Because the nasal valve area constitutes the narrowest part of the nose, pathology in this area can have a disproportionately large negative effect on nasal airflow. Many techniques have been developed for tackling the problem of internal and external nasal valve insufficiency. Each has its own theoretical background and specific deformity for which it is most suited. The selection of the techniques described and evaluated, was based on previously described techniques in the literature, modified according to theoretical considerations that are discussed in the relevant chapters. Deformities in six sites can be distinguished for which specific surgical techniques have been developed (Table 1.1). The aim of this study was to evaluate the efficacy of each of these techniques in patient series ranging from 20 to 89 cases, combining clinical findings and subjective self-evaluation scores by the patients.

Table 1.1
Summary of techniques and sites for which they are most suited.

Site of deformity	**Technique**
Apex of internal nasal valve	(Endonasal) spreader grafts
(Bilateral) internal nasal valve/ caudal border of upper lateral cartilages and cephalic border of external nasal valve/ lateral crus	Butterfly graft
Lateral wall of internal and/or external nasal valve	Nasal valve suspension
Lateral wall of internal and/or external nasal valve	Sub-alar batten grafts
Caudal and/or dorsal nasal septum (deformity)	Septal Battens or major septal replacement
Caudal and/or dorsal nasal septum (perforation)	Nasal septum perforation repair

As nasal patency is primarily a subjective sensation, albeit closely linked to nasal airflow resistance, the questions surrounding the means we currently have at our disposal to 'objectively' measure this sensation are addressed in **chapter 2**. We analyzed the literature on objective rhinometry with the aim of drawing conclusions concerning its relevance in clinical practice and its suitability for evaluating surgical results. We reviewed the English-language articles from 1980 in which correlations were sought between subjective nasal patency symptoms and objective scores as found with rhinomanometry and acoustic rhinometry. We found and analyzed sixteen studies with a level of evidence II-a or II-b that fit the inclusion criteria. Although almost every possible combination of correlations or lack thereof in relation to the variables included was found, when obstructive symptoms were present, a correlation between the patency symptoms with the objective measurements was found more often than in the absence of symptoms. In cases of bilateral assessment a correlation was found almost as often as it was not, while in the limited amount of studies in which unilateral assessment was done a correlation was found every time. We concluded that the correlation between the outcomes found with rhinomanometry and acoustic rhinometry and an individual's subjective sensation of nasal patency remains uncertain and that there is only a limited argument for the use of rhinomanometry or acoustic rhinometry in routine rhinologic practice or for quantifying surgical results.

In **chapter 3** a modification and simplification of a previously described procedure to treat nasal obstruction caused by an incompetent internal nasal valve is described. Placement of spreader grafts between the septum and the upper lateral cartilages aims at strengthening the nasal valve and widening the nasal valve angle. Usually an external approach is used. This allows good visualization of the middle nasal vault, but may be more invasive than necessary, as the upper lateral cartilages are divided from the septum before the grafts are placed. When an endonasal approach is used, the connection between the upper lateral cartilages and the septum may be left intact, thereby preserving the integrity of the middle third of the nose.

The series studied comprised 89 patients in whom spreader grafts were placed subperichondrally in the apex of the internal nasal valve, without dividing the upper lateral cartilages from the septum, through an endonasal approach. The patients were asked to compare their nasal passage with their pre-operative situation and rate each side as worse, equal, better, or optimal. Of a total of 120 sides operated

on, 53 sides (44%) were judged as optimal and 53 (44%), as improved. On 13 sides (11%) no change was noted. On 1 side (1%) the postoperative situation was judged as worse. In the 5 patients (8 sides) in whom no additional procedure was performed apart from endonasal spreader graft placement, 3 sides were rated as optimal, 4 as improved, and 1 as equal. Although these patients constitute a small subgroup, their outcomes are comparable to the entire study population in which the majority underwent 1 or several additional procedures.

In **chapter 4** we describe and evaluate our experience with a surgical technique for treating nasal valve insufficiency using a so-called butterfly graft from ear cartilage. The main goal of this procedure is to widen the nasal valve angle and to increase the resilience of the nasal valve(s), by fixating a curved piece of ear cartilage over the caudal border of the upper lateral cartilages and under the cephalic borders of the lower lateral cartilages. In all patients an external approach was used. We prospectively studied the effect of this graft not only in revision cases, as had previously been done, but also as primary treatment for nasal valve insufficiency. Eighty-four patients with nasal valve insufficiency on 157 sides were operated on by two surgeons using this procedure. The patients were prospectively studied and their nasal patency was rated pre- and postoperatively, and per side, by subjective self-evaluation on a scale from 1 to 10. Post-operatively 11 sides (7 %) were rated as equal, on 68 sides (43%) the improvement was between 1 and 4 out of 10, and on 78 sides (50 %) 4 or more out of 10. Overall 93% of sides had improved compared to the pre-operative situation. The average post-operative improvement for all sides was 3.8 out of 10. Fifty-one patients had undergone previous nasal surgery. The average improvement in this group was 3.6 out of 10 compared to an average improvement of 4.3 out of 10 in the 33 patients without a history of previous nasal surgery. We concluded that placement of a butterfly graft generally is a very effective treatment for nasal valve insufficiency, not only in patients with valve collapse due to previous rhinoplastic surgery, but also as a primary procedure.

In **chapter 5** we describe and evaluate our experience with the technique of nasal valve suspension for treating nasal valve insufficiency. This procedure uses sutures to lateralize (a section of) the lateral nasal wall by suspending the relevant part to the inferior orbital rim. In this series an infraorbital incision was made at the junction of the thin lower eyelid skin and the thicker cheek skin on the medial part of the inferior orbital rim. A permanent suture was tunnelled below the facial

soft tissue to the involved part of the lateral nasal wall and guided back towards and then tied to the periosteum of the inferior orbital rim.

Twenty patients with nasal valve insufficiency underwent nasal valve suspension on a total of 33 sides. The patients were prospectively studied and their nasal patency was rated per side pre-and postoperatively, by subjective self-evaluation on a scale from 1 to 10. Post-operatively 7 sides (21%) were rated as unchanged, on 17 sides (52%) the improvement was from 1 to 3 out of 10, and on 9 sides (27%) 4 or more out of 10. The average post-operative improvement for all sides was 2, 3 out of 10. In five patients (25%) complications occurred, such as pain, inflammation and suborbital swelling and three eventually underwent a re-exploration of the surgical area, resulting in a permanent scar in one patient. We concluded that although nasal valve suspension may be beneficial for some patients, we would not recommend this technique as first line treatment for nasal valve insufficiency. In this series we found relatively limited improvement in most patients and a far higher complication rate compared compared to the other techniques we described.

In **chapter 6** we describe and evaluate the functional results of a surgical technique for treating nasal valve incompetence, in which a cartilage graft called a sub-alar batten graft, is placed along the undersurface of the lateral crus of the lower lateral cartilage. This graft can be seen as a combination of the previously described alar batten, used for correcting functional deficits and lateralizing a collapsed lateral wall, and a lateral crural strut graft, used for treating alar rim collapse, concave lateral crura, and malpositioned lateral crura. The reasoning and goal behind the development of this graft was to obtain the same functional result as with an alar batten, while diminishing the chance of external visibility due to its position underneath the alar cartilage. The functional outcomes of 27 patients who had sub-alar batten grafts placed on 39 sides were evaluated by means of clinical examination and subjective self-assessment. Of a total of 39 sides operated upon, 10 (26%) were rated as optimal, 15 (38,5 %) as improved, 13 (33%) as equal and 1 (2,5%) as worse. Overall on 25 sides (64,5%) the post-operative situation was considered to be better than pre-operatively. In all cases in which there was a wish for cosmetic improvement, besides the functional indication, this was obtained, and in no case did the grafts give cause to cosmetic grievances or other complications. Although the results were slightly disappointing from a purely functional point of view, sub-alar batten grafts may have cosmetic advantages and

continue to be considered in cases in which avoidance of surface irregularities is a primary concern or as a preventative measure in rhinoplasty patients at risk for post-operative valve collapse.

In **chapter 7** we describe and compare two techniques used to correct nasal septum deviations located in the dorsal and/or caudal septum which form part of the medial wall of the nasal valve area. Treatment of deformities located in the structurally important L-strut of the septum can be technically challenging and many functional, structural and aesthetic considerations must be taken into account. The various techniques currently in use broadly fall into two categories. The first (septal battens) aims at straightening and/or repositioning the relevant parts of the septum and maintaining the changes made with subsequent use of sutures and/or bone or cartilage battens. The second procedure, referred to as septal replacement, is to remove the affected part of the septum and then either replace it after external remodelling, or replace it completely with an alternative material such as autogenous or banked rib cartilage or bone. The functional and technical results were compared between the septal batten and septal replacement techniques in 114 patients who underwent surgery of the L-strut of the septum. This was done by subjective self-evaluation and by examination of the position of the septum during follow-up. There was subjective improvement in nasal breathing in 86% of the septal batten group and in 94% of the septal replacement group. This difference was not statistically significant. The technical result was judged by examining the position of the septum during follow up as midline, slightly deviated or severely deviated. The septum was significantly more often located in the midline during follow-up in the septal replacement group than in the septal batten group. We concluded that both techniques may be considered for correction of deviations in this area as the functional improvement rates were not significantly different between the groups, although during follow-up the septum appeared to be significantly more often located in the midline in the septal replacement group.

In **chapter 8** we review the aetiology, symptoms and treatment options of nasal septal perforations and focus on a surgical reconstruction technique of which the results were retrospectively studied. While nasal valve dysfunction is only rarely caused by a septal perforation, a septal perforation located in the nasal valve area may frequently lead to nasal valve dysfunction, either through turbulence, crusting or loss of structural support of the septum. Because of this, knowledge

of and proficiency in the treatment of septal perforations should be part of the armamentarium of a nasal surgeon wishing to be able to treat all causes of nasal valve pathology. The technique of which the results were retrospectively studied, involves the interposition of a connective tissue graft between differently designed local mucoperichondrial and/or mucoperiosteal flaps on each side of the perforation, thereby preventing opposing suture lines. On one side a rotation/advancement flap is derived from the septum, the nasal floor and lateral nasal wall while in the opposite nasal passage, bipedicled flaps from the septum and nasal floor and/or from the superior septum and under-surface of the upper lateral cartilage are created. Of the 43 patients included in this study, 40 had their perforation permanently closed, while three experienced a non-symptomatic recurrence.

Chapter 9 reviews the findings of the studies described in chapters 2 to 8. The conclusions drawn from our studies as well as their strengths and weaknesses are described. General issues surrounding 'evidence based surgery' are reflected upon and the relevance of these issues in regards to our studies is discussed. The studies are also compared to the literature on this subject. The objective of this thesis was to improve our knowledge of the influence of the nasal valve in causing nasal obstruction and to evaluate the therapeutic role of a selection of site-specific techniques. This chapter evaluates to what extent our findings have contributed to this aim, what the implications might be in clinical practice and gives recommendations for future research.

The most important considerations and conclusions arising from this thesis can be summarized as follows:

1. Due to the central role of the nasal valve area in nasal physiology, pathology in this area may play a greater role in causing complaints of nasal obstruction than is generally realized.
2. It is possible to improve symptoms of nasal obstruction caused by deformities in the nasal valve area with relatively few targeted surgical techniques in a large majority of patients.
3. The complaint of nasal obstruction, although related to nasal airway resistance, is often due to multiple factors and is not fully understood.
4. The relatively poor reputation of functional nasal surgery among general practitioners and the public may be due to the fact that the appropriate

technique for treating nasal obstruction is not always selected.

5. Objective rhinometry instruments have a limited correlation with the subjective perception of nasal patency and have little value in quantifying surgical results or in routine rhinologic practice. On the basis of currently available data it is unfounded to assign more value to objective measurements than to subjective outcomes in the case of nasal patency.
6. To judge the effect of nasal surgery on the subjective sense of nasal patency, the use of visual analogue scales and validated questionnaires is most appropriate.
7. Results of surgical studies are more difficult to interpret and extrapolate outside the study population than those of medical studies, due to additional issues in evidence-based surgery compared to evidence-based medicine.
   This is especially true for surgery in which the results can not be precisely quantified, as is the case in functional nasal surgery.

Samenvatting en conclusies

Het doel van het in dit proefschrift beschreven onderzoek is om de huidige staat van kennis betreffende het neusklepgebied te beschrijven en om de effectiviteit van chirurgische procedures, gericht op behandeling van afwijkingen in dit gebied, te bestuderen. De opzet is om een beperkt aantal technieken aan te wijzen, waarmee behandeling van de overgrote meerderheid van oorzaken van neusklepinsufficiëntie mogelijk moet zijn.

In **hoofdstuk 1** worden de anatomie, de fysiologie, de diagnostiek en de pathologie van het neusklepgebied beschreven en worden algemene concepten van neusklepchirurgie besproken. Omdat het neusklepgebied het smalste deel van de neuspassage is, kunnen afwijkingen in dit gebied een aanzienlijk negatief effect hebben op de luchtstroom door de neus. Vele technieken zijn ontwikkeld om het probleem van interne en externe neusklepinsufficiëntie te behandelen. Elk van deze technieken heeft haar eigen theoretische achtergrond en specifiek toepassinggebied. De selectie van de technieken die in dit proefschrift beschreven staat, komt voort uit eerder beschreven operaties. Deze zijn gemodificeerd op basis van theoretische overwegingen, die worden beschreven in de betreffende hoofdstukken. Er kunnen zes plaatsen in het neusklepgebied onderscheiden worden, waarvoor specifieke chirurgische technieken zijn ontwikkeld (Tabel 1.1). Het doel van deze studie is om de effectiviteit van elk van deze technieken te evalueren door middel van retrospectief en prospectief patiëntenonderzoek, aan de hand van klinische parameters en zelfevaluatie door de patiënten .

Tabel 1.1
Overzicht van technieken en plaatsen waarvoor ze het meest geëigend zijn.

Plaats van de afwijking	**Techniek**
Apex van de interne neusklep	(Endonasale) “spreader grafts”
(Bilaterale) interne neusklep/ caudale rand van triangulaire kraakbeentjes en cefale rand van externe neusklep/ lateral crus	“Butterfly graft”
Laterale wand van interne en/of externe neusklep	“Nasal valve suspension”
Laterale wand van interne en/of externe neusklep	“Sub-alar batten grafts”
Caudale en/of dorsale neusseptum (deformiteit)	“Septal battens” of “major septal replacement”
Caudale en/of dorsale neusseptum (perforatie)	Septumperforatiesluiting

Hoewel de beleving van een belemmerde neuspassage primair een subjectieve sensatie betreft, kan deze gerelateerd zijn aan de mate van weerstand die de luchtstroom in de neus ondervindt. In **hoofdstuk 2** worden de twee meest gebruikte 'objectieve' meetmethoden beschreven. Hiermee wordt getracht om deze subjectieve sensatie weer te geven en in een getal uit te drukken. De literatuur over objectieve meetmethoden werd geanalyseerd met het doel om inzicht te verwerven omtrent de relevantie ervan in de klinische praktijk. Met name werd ook gekeken naar de mogelijkheid om hiermee chirurgische resultaten te evalueren. In de vorm van een systematische review werd de Engelstalige literatuur vanaf 1980 bestudeerd. Hierbij werd gezocht naar correlaties tussen (subjectieve) sensaties van neusdoorgankelijkheid en objectieve scores zoals gevonden met rhinomanometrie en acoustische rhinometrie. Zestien studies die voldeden aan de inclusiecriteria en die tevens een level of evidence van minstens II-a of II-b hadden, werden nader geanalyseerd. Vrijwel alle mogelijke combinaties van correlaties, of gebrek daaraan, betreffende de relevante variabelen werden gevonden. Het bleek echter, dat bij obstructieve klachten, een correlatie tussen de meetuitkomsten en de sensatie van neusdoorgankelijkheid vaker werd gevonden dan wanneer deze klachten ontbraken. Wanneer de neuspassage van beide zijden samen werd gemeten, werd een correlatie bijna net zo vaak wel als niet gevonden. Bij enkelzijdige metingen werd telkens wel een correlatie gevonden. Onze conclusie is dat de correlatie tussen de subjectieve waardering van de neusdoorgankelijkheid en de uitkomsten zoals gevonden met rhinomanometrie en acoustische rhinometrie zo onzeker is, dat er onvoldoende reden is rhinomanometrie of acoustische rhinometrie in de dagelijkse rhinologische praktijk te gebruiken. Dit geldt evenzeer voor het kwantificeren van chirurgische resultaten.

In **hoofdstuk 3** wordt een simplificatie besproken van een eerder beschreven operatie voor de behandeling van neuspassageklachten ten gevolge van een insufficiënte interne neusklep. Het plaatsen van zogenaamde "spreader grafts" tussen het tussenschot en de triangulaire kraakbeentjes heeft tot doel de interne neusklep te verstevigen en de interne neusklephoek te vergroten. Meestal wordt hiervoor een externe benadering gebruikt. Deze benadering vergemakkelijkt weliswaar de visualisatie van het middelste 1/3 deel van de neus, maar is mogelijk invasiever dan nodig is. Dit komt doordat hierbij de triangulaire kraakbeentjes gescheiden worden van het tussenschot voorafgaand aan de plaatsing van de grafts. Wanneer een endonasale benadering wordt gebruikt kan de verbinding tussen de triangulaire kraakbeentje en het septum intact gelaten worden. Hierdoor blijft de anatomische integriteit van dit deel van de neus onaangetast.

De bestudeerde serie betreft 89 patiënten bij wie spreader grafts submucoperichondraal geplaatst werden in de apex van de interne neusklep via een endonasale benadering. De triangulaire kraakbeentjes werden hierbij niet gescheiden van het septum. Aan de patiënten werd tijdens de postoperatieve periode gevraagd om de beleving van de neusdoorgankelijkheid te vergelijken met die tijdens de preoperatieve periode. Gevraagd werd om deze per zijde te beoordelen als verslechterd, gelijk, verbeterd of optimaal. Van in totaal 120 geopereerde zijden werden 53 zijden (44%) beoordeeld als optimaal en 53 zijden (44%) als verbeterd. Aan 13 zijden (11%) werd geen verandering bemerkt en aan 1 zijde (1%) werd de postoperatieve situatie als verslechterd ervaren. Bij de 5 patiënten (8 zijden) bij wie naast de spreader grafts geen additionele ingrepen werden verricht, werden 3 zijden beoordeeld als optimaal, 4 als verbeterd en 1 als onveranderd. Hoewel deze patiënten een kleine subgroep vertegenwoordigden, waren deze uitkomsten in lijn met die van de gehele studiepopulatie, waarin de meerderheid van de patiënten één of meer additionele ingrepen ondergingen.

Hoofdstuk 4 beschrijft en evalueert de ervaring met een chirurgische techniek om neusklepinsufficiëntie te behandelen met een zogenaamde " butterfly graft" uit oorschelpkraakbeen. Het doel van deze operatie is om de neusklephoek te vergroten en de laterale neuswand te verstevigen. Dit wordt bereikt door plaatsing van een gebogen stuk oorschelpkraakbeen boven de caudale rand van de triangulaire kraakbeentjes en onder de cefale rand van de alaire kraakbeentjes. Bij alle patiënten werd een externe benadering gebruikt. Het effect van deze graft werd prospectief bestudeerd, niet alleen bij revisies zoals eerder was gedaan, maar ook als primaire behandeling van neusklepinsufficiëntie. Twee operateurs voerden deze ingreep uit bij 84 patiënten met neuspassageklachten aan 157 zijden. De subjectieve waardering van de neusdoorgankelijkheid werd pre- en postoperatief, en per zijde vastgesteld door middel van zelfevaluatie op een schaal van 1 tot 10. Postoperatief werd aan 11 zijden (7%) geen verandering bemerkt, aan 68 zijden (43%) werd de verbetering gewaardeerd tussen 1 en 4 en aan 78 zijden (50%) als 4 of meer. In totaal werd 93% van de gevallen beoordeeld als verbeterd. De gemiddelde verbetering voor alle zijden was 3-,8 op de schaal van 1 tot 10. Eenenvijftig patiënten hadden eerder neuschirurgie ondergaan. De gemiddelde verbetering in deze groep was 3.6. Bij de 33 patiënten die eerder geen neusoperatie hadden ondergaan, was deze score 4. Concluderend wordt gesteld dat plaatsing van een butterfly graft in het algemeen een effectieve behandeling van neusklepinsuffiëntie is, zowel als primaire ingreep, als bij patiënten die eerder neuschirurgie hebben ondergaan.

In **hoofdstuk 5** wordt de ervaring met de neusklepsuspensie-operatie als behandeling van neusklepinsufficiëntie beschreven en geëvalueerd. Bij deze techniek worden hechtingen gebruikt om een deel van de laterale neuswand te lateraliseren. Dit geschiedt door het betreffende deel te fixeren aan de margo infra-orbitalis. Bij de in dit hoofdstuk beschreven patiëntenserie werd een incisie gemaakt aan de mediale zijde van de margo infraorbitalis, ter plaatse van de overgang van de dunne onderooglidhuid en de dikkere wanghuid. Een onoplosbare hechting werd getunneld onder de weke delen van het aangezicht naar en door het betreffende deel van de laterale neuswand en vervolgens teruggeleid en gefixeerd aan het periost ter plaatse van de margo infraorbitalis.

Twintig patiënten met neusklepinsufficiëntie ondergingen neusklepsuspensie aan in totaal 33 zijden. De patiënten werden prospectief bestudeerd en hun subjectieve waardering van neusdoorgankelijkheid werd pre- en postoperatief vastgesteld door zelfevaluatie op een schaal van 1 tot 10. Postoperatief werden 7 zijden (21%) beoordeeld als onveranderd, aan 17 zijden (52%) was de verbetering tussen 1 en 4 en aan 9 zijden (27%) 4 of meer. De gemiddelde postoperatieve verbetering voor alle zijden was 2,3. Bij vijf patiënten (25%) traden complicaties op, zoals pijn, ontsteking en infraorbitale zwelling. Drie van deze patiënten ondergingen uiteindelijk een re-exploratie. Bij één patiënt heeft dit zelfs geresulteerd in een ontsierend litteken. Onze voorlopige conclusie is dat, hoewel neusklepsuspensie effectief kan zijn bij sommige patiënten, deze techniek niet is aan te raden als behandeling van eerste keus. In deze serie was sprake van een relatief beperkte verbetering bij de meeste patiënten en een aanzienlijk groter aantal complicaties vergeleken met andere in dit proefschrift beschreven technieken.

In **hoofdstuk 6** worden de functionele resultaten beschreven en geëvalueerd van een chirurgische techniek, waarbij kraakbeen in de vorm van een “sub-alar batten graft” langs de onderzijde van het laterale crus van het alaire kraakbeen wordt geplaatst. Deze graft kan gezien worden als een combinatie een “alar batten”, die gebruikt wordt ter versteviging van een slappe laterale neuswand en een “lateral crural strut graft”, die gebruikt kan worden bij collaps van de externe neusklep, of bij concave of anderszins afwijkende laterale crura. Het doel van de ontwikkeling van deze graft was het zelfde functionele resultaat te bereiken als dat van een alar batten, maar met minder kans op uitwendige zichtbaarheid van de graft. Dit zou bereikt kunnen worden door plaatsing van de graft onder het alaire kraakbeen. De functionele resultaten bij 27 patiënten, bij wie sub-alar batten grafts aan 39 zijden

werden geplaatst, werden geëvalueerd door middel van klinische beoordeling en zelfevaluatie. Van het totaal van de 39 geopereerde zijden, werden er 10 (26%) beoordeeld als optimaal, 15 (38,5%) als verbeterd, 13 (33%) als onveranderd en 1 (2,5%) als verslechterd. Aan in totaal 25 zijden (64,5%) werd de postoperatieve situatie als verbeterd ervaren. Dit werd bereikt in alle gevallen waarin er naast de functionele indicatie tevens een wens tot esthetische verbetering was. In geen geval gaf de graft aanleiding tot complicaties. Hoewel de resultaten iets teleurstellend waren vanuit functioneel perspectief, kunnen sub-alar batten grafts toch esthetische voordelen hebben. Dit is bijvoorbeeld geval wanneer het vermijden van uitwendige onregelmatigheden een belangrijke overweging is bij planning van de operatie. Ook kunnen deze grafts preventief worden toegepast bij rhinoplastieken met een verhoogd risico op postoperatieve collaps van de laterale neuswand.

In **hoofdstuk 7** worden twee technieken beschreven en vergeleken, die gebruikt kunnen worden om afwijkingen te behandelen in het dorsale en/of caudale deel van het septum. Dit deel van het septum vormt de mediale wand van het neusklepgebied. Behandeling van afwijkingen in het structureel belangrijke "L-strut" gebied van het septum kunnen technisch moeilijk zijn en hierbij moeten functionele, anatomische en esthetische aspecten meegewogen worden. De hierbij gebruikte technieken kunnen globaal in twee categorieën worden opgesplitst. In de eerste categorie wordt getracht om eerst het afwijkende deel van het septum rechter te maken en/of te repositioneren en vervolgens de bereikte verandering te consolideren met hechtingen en/of rechte stukken bot of kraakbeen ("septal battens"). In de tweede categorie ("septal replacement") wordt het afwijkende deel van het septum verwijderd en, ofwel teruggeplaatst na remodelleren, ofwel geheel vervangen door materiaal van buiten de neus, zoals autoloog of homoloog ribkraakbeen of bot. De functionele en anatomische resultaten van de septal batten en de septal replacement techniek werden vergeleken bij 114 patiënten, die een operatie ondergingen in het L-strut gebied van het neustussenschot. Dit werd gedaan door zelfevaluatie en door beoordeling van de positie van het septum tijdens de follow-up. Er werd een subjectieve verbetering van de neusdoorgankelijkheid vastgesteld in 86% van de septal batten groep en in 94% van de septal replacement groep. Dit verschil was niet statistisch relevant. Het anatomisch resultaat werd geëvalueerd door beoordeling van de positie van het septum in de periode na de operatie. Deze positie werd ingedeeld in drie groepen: mediaan, licht gedevieerd of sterk gedevieerd. Het septum was significant vaker mediaan gelocaliseerd

in de septal replacement groep dan in de septal batten groep. De conclusie is dat beide technieken gebruikt kunnen worden om afwijkingen in dit gebied te behandelen. Hoewel het septum postoperatief vaker mediaan gelegen bleek in de septal replacement groep verschilden de functionele resultaten niet significant van elkaar.

In **hoofdstuk 8** worden de etiologie, de symptomen en behandelingsmogelijkheden van neusseptumperforaties besproken, dit laatste met nadruk op een chirurgisch reconstructieve techniek. Hiervan werden de resultaten retrospectief bestudeerd. Hoewel neusklepinsufficiëntie slechts zelden wordt veroorzaakt door een septumperforatie, kan een perforatie wel degelijk leiden tot functionele stoornissen door turbulentie, korstvorming of verlies van anatomische integriteit van het septum. Om deze reden is kennis van en vaardigheid in de sluiting van septumperforaties een vereiste indien men de oorzaken van neuskleppathologie wil kunnen behandelen. De techniek, waarvan de resultaten retrospectief werden bestudeerd, betreft de interpositie van autoloog kraakbeen of homologe huid tussen mucoperichondrale en/of mucoperiostale schuif- en zwaai/rotatielappen. Deze lappen worden aan elke kant verschillend ontworpen, waardoor voorkomen wordt dat er tegenover elkaar liggende hechtlijnen ontstaan. Aan één kant wordt een zwaai/rotatielap gebruikt van het septum, de neusbodem en de laterale neuswand, terwijl aan de andere kant dubbelgesteelde schuiflappen van het septum en de neusbodem, en/of van het dorsale septum en de onderzijde van de triangulaire kraakbeentjes worden toegepast. Bij 40 van de 43 patiënten in deze studie bleef de perforatie na de operatie permanent gesloten; bij drie patiënten trad een (asymptomatisch) recidief op.

In **Hoofstuk 9** worden de bevindingen besproken van het onderzoek beschreven in de hoofdstukken 2 tot en met 8. De sterktes en zwaktes van de studies worden behandeld, alsook de validiteit, toepasbaarheid en generaliseerbaarheid van de bereikte conclusies. Algemene overwegingen betreffende “evidence based surgery” worden beschreven en de relevantie van deze overwegingen met betrekking tot onze studies wordt nader toegelicht. De studies worden ook in de context van de betreffende literatuur geplaatst. Het doel van het in dit proefschrift beschreven onderzoek was de kennis te vergroten omtrent de invloed van het neusklepgebied bij het veroorzaken van neusobstructieklachten. In dit verband werd gestreefd naar een beoordeling van het therapeutisch effect van een aantal localisatie specifieke chirurgische technieken. In dit hoofdstuk wordt geëvalueerd

in hoeverre onze bevindingen aan deze doelstellingen hebben bijgedragen, wat de implicaties voor de klinische praktijk kunnen zijn, en welke aanbevelingen voor verder onderzoek over dit onderwerp relevant lijken te zijn.

De belangrijkste bevindingen en conclusies voortkomend uit dit proefschrift kunnen als volgt worden samengevat:

1. Door de belangrijke rol van het neusklepgebied in de fysiologie van de neusademhaling kunnen afwijkingen in dit gebied een grotere invloed hebben bij het veroorzaken van neuspassageklachten dan gewoonlijk wordt aangenomen.
2. In de overgrote meerderheid van gevallen is het mogelijk om de symptomen veroorzaakt door neusklepinsufficiëntie met een beperkt aantal specifieke technieken te verhelpen.
3. De oorzaak van klachten van een verminderde neuspassage hangt weliswaar samen met de luchtweerstand in de neus, maar is tevens van andere factoren afhankelijk. Deze zijn nog niet volledig bekend.
4. De relatief slechte reputatie van functionele neuschirurgie, zowel bij huisartsen als bij het publiek, is mogelijk ten dele het gevolg van het feit dat niet altijd de meest geschikte operatieve techniek gebruikt wordt.
5. De resultaten van metingen van de neusdoorgankelijkheid komen slechts in beperkte mate overeen met de perceptie van deze doorgankelijkheid door de patiënt. Deze metingen hebben dus weinig toegevoegde waarde in de algemene rhinologische praktijk en bij de evaluatie van chirurgische resultaten. Op basis van de thans beschikbare kennis is het bij de diagnostiek en behandeling van neuspassagestoornissen niet zinvol meer waarde toe te kennen aan objectieve metingen dan aan subjectieve uitkomsten.
6. Om het effect van neuschirurgie op de subjectieve perceptie van neusdoorgankelijkheid te beoordelen zijn visueel analoge schalen en gevalideerde vragenlijsten het meest geschikt.
7. De “evidence” bij “evidence-based surgery” is anders dan die bij “evidence-based medicine”. Daarom zijn de resultaten van chirurgische studies moeilijker te interpreteren en te generaliseren, dit in vergelijking tot die van niet-chirurgisch medisch onderzoek. Dit geldt a fortiori voor die chirurgie waarbij het resultaat niet met maat en getal is vast te leggen , zoals bijvoorbeeld bij de functionele neuschirurgie.

Acknowledgements

First of all my thanks to Hadé Vuyk without whose inspiration, enthousiasm and drive this thesis would never have left the starting blocks.

To Gilbert Nolst Trenité whose encouragement and constructive criticism took it to the next level.

And finally to Kees Graamans for all his time, support and expertise in seeing it through to its conclusion.

About the author

Robert André was born on December 21st 1967 in London, England. He received his secondary school education at the Royal Atheneum Tervuren, Belgium. He entered medical school at the University of Leiden in 1986. During his training he participated in clinical and scientific exchange programmes at the University of Hawaii, USA, the University of Siena, Italy, the University of London, England and the University of Heidelberg, Germany. In 1994 he obtained his Dutch Medical degree and in 1995 he passed the exams for the Educational Commission for Foreign Medical Graduates (ECFMG) of the United States of America. In 1995 he was junior house officer in general surgery at the Inverclyde Royal Hospital in Greenock, Scotland and senior house officer in Ear, nose and throat surgery at the Royal Alexandra Hospital in Paisley, Scotland. In 1996 he was resident at the department of Head and Neck Surgery at the Netherlands Cancer Institute in Amsterdam and in 1997 he started his specialist training in Ear, nose and throat surgery at the Leiden University Medical Centre. Part of this training was followed at the Westeinde Hospital in The Hague and the Rijnland Hospital in Leiderdorp. He received his specialist degree in 2002. He then completed a fellowship of the European Academy of Facial Plastic Surgery, based in Amsterdam and Blaricum, with clinical observerships in Houston, Portland and Seattle, USA and Sydney, Australia. He passed the exam of the International Federation of Facial Plastic Surgery Societies in Washington D.C. in 2003. Since 2003 he practices as an otolaryngologist and facial plastic surgeon at the Rijnland Hospital in Leiderdorp and Alphen aan den Rijn. In 2008 he opened his practice 'Kliniek Oud Zuid' in Amsterdam in which he focuses exclusively on functional and aesthetic nasal surgery. He is married to Martine van Rijn and they have three children: Jasper, Thomas and Hannah.

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