Disorders of the nasal valve area

Abstract

The nasal valve area is not a singular structure, but a complex three-dimensional construct consisting of several morphological structures. From the physiologic point of view, it is the place of maximum nasal flow resistance ("flow limiting segment"). Therefore, according to Poiseuille's law, even minor constrictions of this area result in a clinically relevant impairment of nasal breathing for the patient. This narrow passage, also called "ostium internum nasi", is formed by the mobile lateral nasal wall, the anterior septum with the swell body, the head of the inferior turbinate and the osseous piriform aperture. Within the framework of aetiology, static and dynamic disorders of the nasal valve area have to be distinguished since they result in different therapeutic measures. In the context of diagnosis, the exploration of the case history for assessing the patient's extent of suffering and the clinical examination are very important. In addition to the presentation of the basics of disorders of the nasal valves, this paper focuses on the treatment of dynamic disorders that mainly constitute the more important therapeutic issue. In this context, we distinguish between stabilisation techniques through grafts or implants and stabilising suture techniques. Following a thorough analysis, the correction of static nasal valve disorders requires various plastic-reconstructive measures using transposition grafting and skin or composite grafts.

Keywords: nasal valve, disorders of nasal valve, nasal valve collapse, impairment of nasal breathing, rhinoplasty, functional nose correction, aging nose

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1 Definition of the nasal valve and the nasal valve area

2000 years ago, Galen described the anatomy of the nose and its functions for the first time. The term of nasal valve, however, has been coined by Mink (1903) not before the beginning of the 20th century and has been characterised in more detail by Bridger (1970) [1], [2].

There has been a controversy on the exact localisation and definition of the nasal valve in the past. Rhinoplasty surgeons prefer the division into an external and internal nasal valve (Figure 1). Physiologists rather speak of the nasal valve area as "flow limiting segment". This is the place of maximum flow resistance [3].

The elongated opening between the caudal end of the lateral cartilage and the medial nasal septum constitutes the actual internal (inner) nasal valve. It is also called "ostium internum nasi" [3]. According to Mink (1920), the included angle amounts to 10 to 20 degree in the Caucasian nose; in Afro-Americans and Asians, the angle is clearly increased [4], [5] (Figure 2). The internal nasal valve is the upper part of the nasal valve area that is completed in the caudal and lateral direction by the osseous frame of the piriform aperture and in the posterior direction by the head of the lower turbinate [6]. The nasal valve area is located at an angle in the sagittal plane [7].

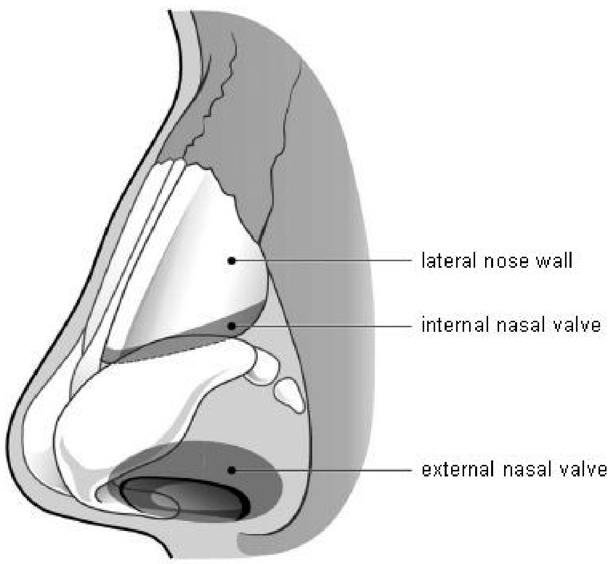

Figure 1: Presentation of the external and internal nasal valve: The external nasal valve is located in the area of the nostrils and is limited in the lateral direction by the caudal portion of the alar cartilage with the connected soft parts and in the medial direction by the columella. The internal nasal valve is an elongated opening. It is located in the upper area of the nasal valve area between the anterior septum and the caudal lateral cartilage.

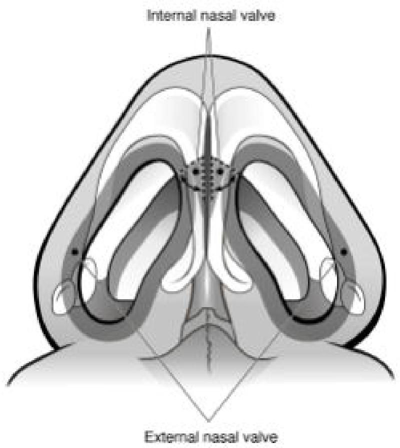

Figure 2: The angle of the internal nasal valve ranges between 10 and 50° in the different ethnic groups and often varies between the two sides (Miman 2006 [5]).

In plastic-surgical literature, the external (outer) nasal valve is limited in the lateral direction by the lower edge of the lateral crus of the alar cartilage with the associated fatty-connective tissue of the wing of the nose and in the medial direction by the columella with the medial crus of the alar cartilage and the septum [8].

2 Anatomy of the nasal valve area

Bruintjes et al. (1998) performed a large lumber of macroscopic and microscopic preparations of the nose. They divide the lateral nasal wall into three parts: (1) the bone-cartilage chain, (2) the hinge area and (3) the wing of the nose (Figure 3). Parts of the perinasal musculature examined as well are of such a small size that they can only be visualised using the microscope [9].

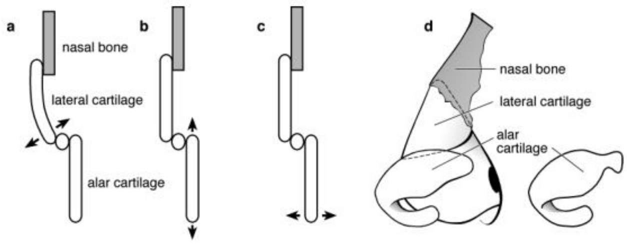

Figure 3: The lateral nasal wall is divided into three parts: the bone-cartilage chain, the mobile hinge area in the region of the nasal valve and the soft-tissue wings of the nose. The intercartilaginous region between the alar cartilage and the lateral cartilage can be seen as a diarthrosis with two degrees of freedom (translation and rotation).

The back edge of the lateral cartilage is firmly connected to the nasal bone. Here, the cartilage partially lies under the bone and the perichondrium passes continuously into the periost. The lateral cartilages continuously pass into the cartilaginous septum and form a firm connection; they can be separated in the caudal portion only.
The intercartilaginous (IC) region is anatomically constant. The cephalic edge of the alar cartilage normally projects over the caudal edge of the lateral cartilages without touching them. In addition, in most cases, cartilaginous sesamoids of varying number and size are found in the IC region. The nasal cartilages are surrounded by perichondrium and are connected to each other through band-like firm cords of connective tissue.
Theoretically, the IC joint can be seen as diarthrosis with two degrees of freedom and is secured through taut connective tissue between lateral and alar cartilages. Sesamoid cartilages that might have some sort of ball bearing function are found between them. Translational and rotational movements are observed in this joint (Figure 3). Furthermore, the elastic properties of the alar cartilage make an inward and an outward deflection possible.
In addition to the elasticity of the cartilage, this depends on the free lower end of the lateral crus and the tough connection to the lateral cartilage. It has to be noted as well that any torsional forces in the area of the alar cartilage are associated with a deflection of the lateral cartilages. The bone-cartilage chain of the nose has to be seen as a functional unit made up of the individual components mentioned above.
The perinasal musculature mainly originates in the maxilla or in the alar cartilage and inserts at the skin, at the aponeurosis of the nasal dorsum or the crura of the alar cartilages. The lateral cartilage is free of any muscle attachments or origins of muscles. Only the nasalis muscle crosses it and thus keeps the nasal skeleton, the IC region and the nasal valve in place. The lateral crus of the alar cartilage is stabilised by the M. dilatator naris. The wings of the nose are mainly free of cartilage and are interspersed like a mesh with muscle fibres of the M. dilatator naris and the pars alaris m. nasalis (Figure 4). Concerning the nasal valve, there are only two important muscles with opening function. This is the M. dilatator naris that originates at the lateral crus of the alar cartilage and inserts into the skin of the wing of the nose. It has a stabilising function on the external nasal valve and widens the nasal aperture in case of innervation. It only has an indirect effect on the nasal valve through a consecutively caused outward deflection of the caudal end of the lateral cartilage and thus opening of the area of the nasal valve. The second important muscle is the pars alaris of the M. nasalis. It originates in the incisive fossa of the maxilla and inserts at the accessory cartilages and the skin in the region of the hinge area. This enables it to pull this structure in the lateral direction in case of innervation and thus to widen the internal nasal valve.

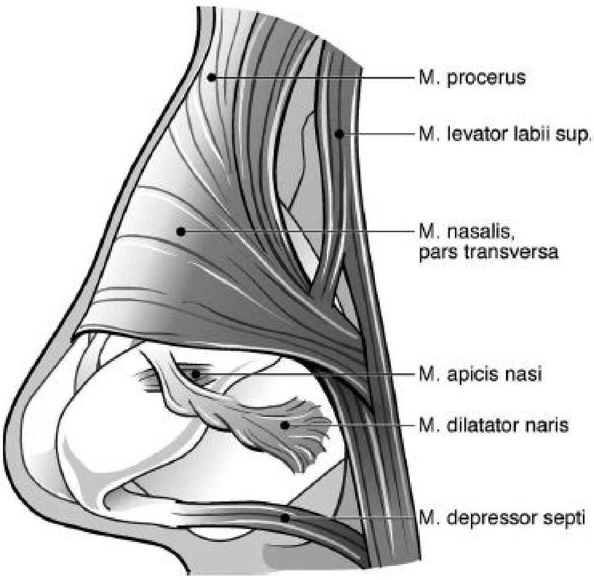

Figure 4: Presentation of the perinasal musculature: The internal nasal valve is widened by the M. dilatator naris originating from the lateral alar cartilage and the pars alaris of the M. nasalis. An excessively lateral preparation of the alar cartilage may damage the origin of the M. dilatator naris and destabilise the internal nasal valve.

The M. apicis nasi is very small and missing in some cases. Like the M. procerus and the M. levator labii superior alaeque nasi, this muscle does not have any functional importance regarding the nasal valve. The pars transversalis of the M. nasalis – as stated above – only has a stabilising function. The M. depressor septi widens the nasal aperture.

The “swell body at the nasal septum” described for the first time by Wustrow (1951) also is of functional importance in the area of the inner nasal valve. Macroscopically, this is a bloated area of the size of 1 to 5 mm of the cartilaginous-bony septum with thickened mucosa. This swell body is located above the lower and before the middle turbinate [10]. This structure is hardly taken note of clinically – although it can be visualised well in the CT – and is often misinterpreted as high septal deviation. Wexler et al. (2006) examined samples of the nasal mucosa from the area of the lower nasal turbinate, the septum and the swell body of the septum of healthy subject and compared them. In this region, the authors found mainly glands and clearly less venous sinusoids compared to the mucosa of the lower nasal turbinate. It seems that this region has a regulatory effect on the airflow and secretory functions [11].

Thus, the nasal valve area is not a singular structure, but a complex, three-dimensional construct consisting of various morphological structures. In this context, the term of "flow limiting segment" has been coined. The cross section areas of the passages through which air flows turn from asymmetrical-oval in the area of the nostrils to an upright-elongated and narrow shape in the nasal valve area [3].

Miman et al. (2006) studied the nasal valves of 124 subjects without obvious impairment of nasal breathing using endoscopy. Various shapes of the nasal valves were found and the angle between the nasal septum and the caudal edge of the lateral cartilage was determined in every case. The authors noticed that all of the angles exceeded the standard defined by Mink [4]. Inter-individual variations between 22 and 52 degrees were found. Furthermore, in 53% of the subjects, the shapes of the nasal valve were different on the two sides [5].

3 Physiology of the nasal valve area

The internal nasal valve constitutes the bottleneck of the nose. It is responsible for almost half of the total airway resistance [8]. A significant rise in pressure is recorded in particular within the first two centimetres of the air passage ("flow limiting segment") through the nose [3].

In this context, we absolutely have to elaborate on some underlying physical laws. The equations stated assume standardised parameters such as rigid pipes and ideal liquids or gases, but they are thoroughly useful for illustrating and are transmissible to the conditions of the nose in general.

Ohm’s law for flows says that the quantity of air or liquids flowing through a rigid vessel (I) is directly proportional to the pressure difference (Δp) and inversely proportional to the flow resistance (R).

$$I = \Delta p * 1/R$$

Applied to nasal breathing, this means that in case of increased flow resistance (e.g. due to a pathological septal deviation, turbinate hypertrophy or nasal valve stenosis) the flow quantity decreases and an impairment of nasal breathing results. Furthermore, an increased pressure difference between the aperture of the nose and the nasopharynx, e.g. in case of forced breathing, causes an increased flow quantity [8]. This also means that in case of a present (pathologically) increased nasal resistance increased pressure differences are required in order to reach a sufficient nasal breathing as a result. This condition may again cause disorders of the nasal valve, on which we will expand later.

Another equation important for the physiology of the nose is the Bernoulli equation. In simple terms, it says that the sum of dynamic pressure and static pressure is constant.

$$P_{dyn} + P_{stat} = constant$$

To explain this we can say that liquids or gases are accelerated on the way from a place of high static pressure (large pipe diameter, nasal aperture) to a place of low static pressure (small pipe diameter, nasal valve area) and there have a higher flow rate (dynamic pressure). The cross-sectional area in the nasal valve area amounts to 20-60 mm² compared to 100-300 mm² in the downstream sections of the nose [3]. Thus, we can derive from the Bernoulli equation that the highest flow rates in the nose are found in the valve area. The lowest rate is found in the area of the olfactory region [12].

Finally, we would like to explain Poiseuille’s law that is particularly relevant in practice. It describes the fact that the flow (V/t, volume per unit of time) is directly proportional to the radius of the pipe (r) and the pressure difference ($p_1 - p_2 = \Delta p$) and inversely proportional to the length of the pipe (l) and the viscosity of the liquid (η).

$$V/t = (\pi * r4) / (8 * \eta * l) * (p_1 - p_2)$$

This shows that an insignificant constriction of the pipe radius results in a marked decrease in the flow rate since the radius of the narrow passage through which the liquid flows changes the flow in the power of four; i.e. if the cross-sectional area of the nasal valve is halved, the resistance will rise 16-fold, and if the pressure difference is unchanged, the volume flow rate will decrease to a sixteenth.

The flow of gases through a pipe constitutes a laminar flow under ideal conditions. In this case, the outermost air lamella nearly sticks to the pipe wall, whereas the central air masses move increasingly faster. In case of small flow rates, e.g. breathing in rest, and in case of examinations of healthy subjects, these conditions seem to be met largely and the flowing properties largely seem to be of the laminar type [12]. A purely laminar flow, however, cannot be reached in vivo due to the natural conditions [8].

Turbulent flows result from places of unevenness in the flow path. When air lamellas have to flow round these places of unevenness of the pipe wall, they are forced to deviate from the straight course. They have to change the direction and accelerating forces occur. When they become too strong, the accelerated lamellas mix and turbulences occur. This can also increase the flow resistance strongly and the flow rate is reduced. This means in practice that in case of anatomic variations (obstructions) of the nasal airway, turbulent flows that result in a drop in the flow rate can occur increasingly. If you want to reach the respiratory volumes that would occur without obstruction, either the radius of the pipe will have to be widened or the pressure difference will have to be increased.

The nasal valve seems to be involved in the occurrence of turbulent flows to a crucial extent. Seren (2006), for example, showed by means of loudness and spectral analyses of inspiratory sounds that clearly less turbulence occurs when Cottle’s manoeuvre is carried out than without this manoeuvre. He derives from this fact that the nasal valve essentially leads to a transformation from laminar to turbulent flows [13]. In general, his method can be compared to the blood pressure measurement according to Riva-Rocci where flow noise becomes audible due to the constriction of the vessels.

Another reason why the flow in the nose in vivo can never be purely laminar is the nature and the curvature of the pipe. In nasal breathing, the airflow does not follow any strictly straight course, but it is curved in the form of a parabola from the nostrils to the nasopharynx. After having passed the nasal valve area, the great majority of the breathing air flows through the lower turbinate towards the choanae [8].

4 Disorders of the nasal valve area and pathophysiologic particularities

In general, we have to distinguish between static and dynamic disorders of the nasal valve. However, both disorders can occur at the same time and/or be interdependent.

An impairment of the nasal breathing occurs when the nasal valve area is constricted through pathologies of any kind. In this context, causes of static disorders are hypertrophy of the head of the lower turbinate, nasal septal deviations, bony constrictions of the piriform aperture, anatomic variations of the cartilaginous lateral nasal wall or scarred stenoses of the nasal valves. Furthermore, neurogenic causes (facial nerve paralysis, stroke) can result in a symptomatic impairment of nasal breathing through distortion of the lateral nasal wall [9]. Although the function of the perinasal musculature is still not clear in its entirety, obstructive symptoms based on a nasal wing collapse with denervation of the mimic musculature are described. This can be provoked experimentally through a neural blockade of the facial nerve [14]. In case of a pre-existing narrow nasal valve, obstructive symptoms occur even after minor restrictions of the cross-sectional area of the nasal valve plane according to Poiseuille’s law [14].

Pathologies of the nasal valve can also be divided into primary and secondary disorders:

Primary disorders are narrowness or excessively weak lateral nasal walls with resulting collapse phenomenon that are congenital or are acquired in the course of life without surgical or traumatic changes. A typical example is the tension nose that often has elongated vertical nasal apertures (external nasal valve) and a narrow internal nasal valve tending to collapse phenomena [6]. Deformities of the nasal valve area are present in case of cleft malformations as well. In this case, alar cartilages of asymmetric configuration or additional scarred changes after repeated surgeries cause stenoses of the valve area. In case of broad or saddle noses, a drop of the tip of the nose with widening of the external and internal nasal valve (“ballooning” phenomenon) occurs. This often results in a change of the flow conditions (turbulences) with consecutive impairment of nasal breathing.

Age-related changes of the nasal valve area, that cause a change of the static conditions, constitute a problem that is often underrated. With increasing age, structural alteration processes occur in the cartilage involving a loss of the elastic properties. Furthermore, a loss of tone of the nasal musculature can be observed. This results in the drooping nose tip that can often be seen in elderly people and a weakening of the lateral cartilaginous nasal wall. This results in an impairment of nasal breathing through a collapse phenomenon even in case of non-forced breathing [9], [15].

Secondary causes in the context of aesthetic-plastic surgery concern in particular disorders of the nasal valve function after inappropriate resection of the cartilaginous supporting frame of the nose as well as a loss of function of the musculature in case of rhinoplasties that have been performed. They include extensive hump resections and reducing interventions in the area of the lateral and alar cartilages. Sheen (1984) estimates that 75-85% of all patients experience a narrowing of the nasal valve area after rhinoplasty [16]. Particular intraoperative caution is called for in case of patients having a long small tip of the nose where the lateral cartilage forms an acute angle with the nasal septum. Elderly patients with loss of elasticity of the soft parts are at risk as well. These properties increase the risk of a postoperative disorder of the nasal valve. Furthermore, it occurs primarily or secondarily that the lateral crus of the alar cartilage excessively projects over the lower edge of the lateral cartilage and thus constricts the nasal valve in a not physiological manner [6]. Scarring processes, traumatic influences or burn accidents in particular can also cause stenoses of the nasal valves [14].

The underlying pathogenetic mechanism of stenoses of the nasal valves is rooted in Poiseuille's law. When the nasal valve area is constricted, the flow volume increases clearly and a greater negative inspiratory pressure has to be developed in compensation which can consecutively result in a suction phenomenon of the wings of the nose. The actual collapse of the nasal wings is due to the mobile lateral nasal wall as a matter of principle. In case of pre-existing weakening of the lateral nasal wall and the alae – due to the above-mentioned causes, a suction phenomenon may occur even at rest due to Bernoulli's effect. The suction of the lateral wall of the vestibule, however, can be an absolutely physiological phenomenon in healthy subjects in case of forced respiration (>500 ml/sec) [17]. In this case, the necessary inspiratory pressure is higher than the transmural pressure of the nasal wall and thus causes the collapse of the wings of the nose [7].

5 Diagnosing disorders of the nasal valve area

In addition to septal deviations and turbinate hypertrophy, disorders of the nasal valve often result in an obstruction of nasal breathing and are frequently overlooked and/or not covered in a systematic examination for lack of knowledge. This results in false diagnoses and unsuccessful surgical treatments of impaired nasal breathing [18]. For the evaluation of the nasal respiratory function in the region of the nasal valve area, there is currently no singular examination method that reliably pictures the patient's symptoms on account of the complex physiological correlations and the multitude of subjective factors [5]. The knowledge of the physiological correlations and the physician's clinical experience are essential for making the correct diagnosis and selecting a promising therapy. Therefore, the development of reproducible diagnostic parameters is required for the purposes of evidence-based medicine.

The patient's history is very important in the diagnostic investigation of impairments of nasal breathing. It provides an indication of the presence of pathologies in the region of the nasal valve area and in particular of the subjective estimation of the severity of the symptoms. In this context, possible causes of a disorder of the nasal valve have to be explored as well.

Regarding the ENT findings, it has to be found out whether the inspiratory collapse of the nasal valve is a clinically relevant suction phenomenon or whether other pathologies are present as well. The common distinction between physiological and pathological suction phenomena is not always useful since the extent of suffering that varies from patient to patient is the decisive factor for the performance of any possible therapy. The inspection of the nose should be carried out both using instruments and without instruments. While doing so, the following details have to be paid attention to: size and shape of the isthmus nasi, septal deviation in the region II, nasal valve angles smaller than 15 degrees, deformities of the lateral or alar cartilages, elasticity of the cartilages, breadth of the columella, cicatricial stenoses, size of the body piriform aperture. In case of a positive suction phenomenon, it should be examined which parts of the lateral nasal wall are concerned. To this effect, the caudal edge of the lateral cartilage, the lateral crus of the alar cartilage and the lateral lower skinny-membranous portion of the wing of the nose have to be evaluated [16].

Rigid or flexible nasal endoscopy is the current standard for the exploration and assessment of the nasal valve area [5]. Video endoscopy with subsequent digital image analysis can also be used for documenting the angle of the nasal valve and the cross-sectional area of the internal nasal valve [19].

For making sure that a disorder of the nasal valve is present, the performance of the Cottle's manoeuvre is recommended. It was described for the first time by Heinberg and Kern in 1973. For doing so, the nasal valve area is widened by pulling it in lateral direction in the area of the nasolabial groove. An improvement of nasal breathing indicates an involvement of the valve [18], [20]. The findings made thanks to this manoeuvre, however, have to be assessed critically since nasal breathing is improved in patients having a physiologically configured nasal valve area as well and not all stenoses can be widened by lateral tension.

Bachman's manoeuvre has been suggested as another special examination. For this manoeuvre, the physician stabilises or widens the nasal valve using instruments (e.g. using a small tenaculum) [18]. This test excellently imitates the effect of a surgical intervention through the stabilisation of the internal or external nasal valve and the subjective influence on the patient's nasal breathing can be assessed. Furthermore, it is possible to select the method that is most suitable for the individual patient depending on the location of the disorder.

The application of decongesting nose drops can be useful for distinguishing between disorders of the nasal valve on account of a suction phenomenon and an impaired nasal breathing on account of enlarged nasal turbinates. In case of a collapse of the wings of the nose, we have to keep in mind that this often is not the only cause of an impairment of nasal breathing. Therefore, an objective functional diagnosis should be made in the individual case. In general, the following methods are possible:

Active anterior rhinomanometry before and after decongestion for measuring the nasal airflow is currently used widely for function diagnosis of impairments of nasal breathing. This method involves the objective measurement of the ratio of nasal airflow (V) and the developed pressure gradient (Δp). However, neither the location nor the number of bottlenecks can be determined, which is considered to be a disadvantage compared to anterior rhinometry [21]. A new development is 4-phase rhinomanometry (also called high-resolution rhinomanometry) that provides additional information on the stability of the lateral nasal wall [22]. In addition, Mlynski (2005) and Clement (2005) underline the advantages of rhinoresistometry [17], [22]. In this test, the flow rate at which the suction of the wings of the nose starts can be determined by means of a measurement of the nasal total resistance in correlation to the flow volume.

Acoustic rhinometry (AR) was described by Hilberg in 1989 [23]. This examination method is based on the comparison of emitted sound waves with the sound waves reflected on the walls of the nasal cavity. This makes it possible to objectify changes of the cross-sectional area of the nasal cavity. When the rate of the waves and the time until the reflected sound is recorded again is known, the distance from the place of the cross-sectional area to the nasal aperture can be calculated. In contrast to rhinomanometry, AR has the advantage that constrictions can be localised and quantified precisely. Reversible (swell bodies) and structural stenoses can be differentiated independently for both sides. Standard values have been defined up to present [21]. For purposes of quality assurance, evidence has been provided for the fact that data of AR correlate significantly with CT findings. To this effect, however, the CT has to be reconstructed in a way so that the layers are perpendicular to the acoustic axis (and not to the floor of the nose) [24]. Poetker et al. (2004) call this CT reconstruction the "nasal base view" and confirm the possible exact measurement of the angle of the nasal valve [25]. The disadvantage of acoustic rhinometry is that, in case of a severe constriction of the area of the nasal aperture, no valid findings regarding posterior regions can be made [26]. Furthermore, voluminous paranasal sinuses with large ostia seem to cause false results [27]. The tonus of the nasal musculature that varies from person to person may distort the findings as well. Although objective examination techniques are claimed in times of evidence-based medicine, this technique has not been used clinically to a large extent up to now [21].

Seren (2006) described the registration of frequency and loudness spectra during inspiration as an innovative method. In case of pathologies of the valves with occurrence of turbulent flows, this method shows significant changes of loudness and of the frequency spectrum that can be registered using a microphone. This method is currently in its experimental stage and cannot be recommended yet on account of the low specificity of the occurrence of turbulent flows [13].

Besides the examinations explained above, the function of the facial nerve has to be assessed regarding symptoms of denervation and paralysis. The physician also has to pay attention to the tonus and the integrity of the nasal musculature that can be trained by means of special exercise programmes [8]. Intranasal electromyography and surface myography of the perinasal musculature have been described as instrumental methods in this context [14]. CT and MRT examinations of the nasal valve area are reserved for scientific issues and do not form part of the clinical standard.

6 Therapy of disorders of the nasal valve area

The wish for improved nasal breathing is one of the most common causes stated by patients who see an otorhinolaryngologist. Main causes of an impaired nasal breathing are septal deviations and hypertrophy of the nasal turbinates. In the course of the last 20 years, however, the finding that disorders of the nasal valve area also play a relevant role in the set of causes of impaired nasal breathing has become more and more important. Identifying and treating disorders of the nasal valve, however, requires detailed anatomic and physiologic knowledge according to the explanations above. An exact analysis of the present disorder of the nasal valve area is at the beginning of the development of a patient-specific therapy. On account of the large number of different disorders, standard therapy approaches often do not achieve the success wished for and the patient's wish for improved nasal breathing remains unfulfilled.

In the following, the current approaches for the treatment of disorders of the nasal valve in the narrower sense will be presented. We deliberately refrain from describing correction methods of the anterior portions of the septum and the head of the lower turbinate that are at the beginning of the treatment although, strictly speaking, they belong to the nasal valve area. The treatment of disorders of the nasal valve area pursues the following aims:

- widening of the angle of the nasal valve,
- stabilising the mobile lateral wall,
- correcting stenoses of the soft tissues, the cartilage or bone.

6.1 Self-holding dilators

The widening of the nasal valve area has been carried out for a long time using self-holding dilators that are worn when not in public (in most cases at night). In the beginning, they were made out of wire, rubber, celluloid

or other materials [28]. In 1932, Noltenius described a rubber catheter that was used for the treatment of ozaena and for "ensuring good nasal breathing in case of suction of drooping wings of the nose" [29].
Currently, three different dilators are being used mainly. An external dilator (Breathe Right®) is stuck to the outer nose in the sense of a leaf spring and it significantly widens the nasal aperture and the cross section of the nasal valve area [30]. On account of its good fixation, this dilator is commonly used by athletes. Other commercial internal dilators of the nasal aperture are Nasanita® and Nozovent®. They are made of silicone and cause significantly increased inspiratory and expiratory nasal ventilation by widening the nasal aperture [31], [32]. The use of these dilators has been observed mainly in patients suffering from rhonchopathy and/or obstructive sleep apnoea syndrome who did not want to undergo a surgical therapy for improving nasal breathing. A study by Schönhofer et al. (2000), however, did not prove any effect of the nose dilator Nozovent® on the apnoea-hypopnoea index (AHI), snoring and oxygen saturation [33]. Therefore, the use of internal nose dilators for this indication has to be assessed critically.

6.2 Surgical techniques for stabilising and widening the nasal valve area

Stabilising the mobile lateral nasal wall is intended to prevent a clinically relevant suction phenomenon with resulting impairment of nasal breathing. In many cases, the stabilisation is accompanied with a widening of the nasal valve angle. According to Poiseuille's law, this results to a clear increase (power of four) in the nasal volume flow rate even in case of minor changes. The techniques used stabilise the internal nasal valve in the area of the lateral crus of the alar cartilage and the caudal lateral cartilage through grafts or implants, transposition of the lateral alar cartilage or suspension surgery. Disorders of the nasal valve are a complex problem with various causes. It is therefore necessary that the treating head-neck surgeons have experience regarding several surgical techniques in order to solve the present problems selectively. The most important methods are presented below.

6.2.1 Grafts and implants for stabilising and widening the nasal valve area

Alar batten graft

The "alar batten graft" (Figure 5) was described for the first time by Toriumi (1997) for stabilising the internal and external nasal valve [34]. They are used in case of congenital or acquired weakness and/or a subtotal loss of the lateral crus of the alar cartilage. Suitable autologous materials are the septal cartilage and the conchal cartilage [35]. The length of the grafts has to reach the piriform aperture in order to achieve a sufficiently stabilising effect. For avoiding cosmetic abnormalities, the grafts should be thin, bevelled and slightly rounded. The grafts are inserted into an exactly fitting pocket in the area of the maximal weakness of the valve and fixed using a thin, slowly absorbable suture (e.g. 5-0 polydioxanone) in order to prevent them from slipping out of place. A disadvantage of this technique is that these grafts need to be of a certain thickness for stabilising a weak alar cartilage, but then they can become visible [36].

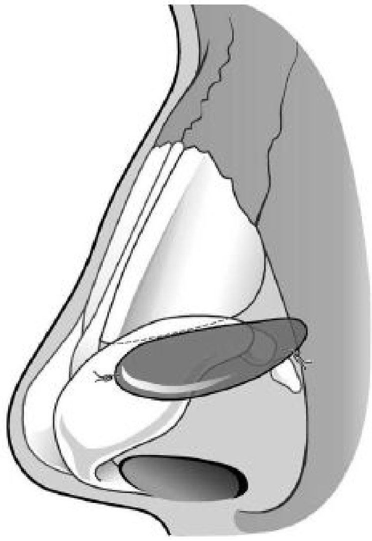

Figure 5: "Alar batten grafts" stabilise the internal and external nasal valve. Suitable materials are autologous cartilage grafts of the septum or the auricle that are placed in a fitting pocket onto the alar cartilage and fixed.

Upper lateral splay graft

This splay graft for supporting the lateral cartilage and correcting an "inverted v-deformity" was described for the first time by Guyuron (1998) in 9 patients and its functional and aesthetic effectiveness has been confirmed by other authors since then [37], [38], [39]. The principle of this graft is similar to the one of the Breathe Right® strip that, in contrast to the graft, stabilises the lateral cartilage from the outside. The graft can be inserted through an open or in rare cases through a closed access. It is located on the septum that has to be reduced carefully in case of need and pads the lateral cartilages on both sides in a submucous pocket. The spring effect of the cartilage stretches the mobile lateral nasal wall. Conchal cartilage is most suitable for this use on account of its material characteristics and convexity. The graft is fixed using slowly absorbable fine sutures (e.g. 5-0 polydiaxonane) firstly in the medial region in the area of the septum and then in the lateral area. A combination with "spreader grafts" in case of revision rhinoplasty with extensive medialisation of the lateral nasal wall is possible [38]. Disadvantages of the technique are the necessary large graft, a possible lifting defect in the area of the auricle and a possibly visible widening of the external nose.

Spreader grafts

“Spreader grafts” were described for the first time by Sheen in 1984 and are intended to avoid a functionally effective reduction of the cross section of the nasal valve after reduction rhinoplasty [16]. This problem can occur after resection of a cartilaginous-bony hump with paramedian and lateral osteotomies for closing the “open roof”. In this case, this medialisation of the lateral nasal wall causes a constriction of the internal nasal valve. For avoiding this medialisation, 1-2 mm broad pins of cartilage are inserted between the septum and the lateral cartilage into an intact mucosal pocket (Figure 6). Septal cartilage is most suitable in this case. According to Orten (1999) and our own experience, however, this results in an insignificant enlargement of the cross section of the internal nasal valve only since the angle of the nasal valve is changed only negligibly [40]. “Spreader grafts”, however, can harmonise the nasal dorsum after hump resection [41]. In the individual case, “spreader grafts” can also be used on one side only in order to compensate for minor asymmetries in the cartilaginous area of the nasal dorsum in case of high septal deviations that are difficult to correct. The fixation of the grafts is carried out using slowly absorbable fine mattress sutures (e.g. 5-0 polydioxanone). Acrylate-based tissue glues should not be used on account of the risk of inflammation despite their possible convenience [42]. Besides autologous materials, preshaped “spreader grafts” made of porous polyethylene are used today [43], [44]. The advantage offered is the shorter duration of the surgery. There are, however, characteristic disadvantages of foreign matter that are avoided by using autologous cartilage.

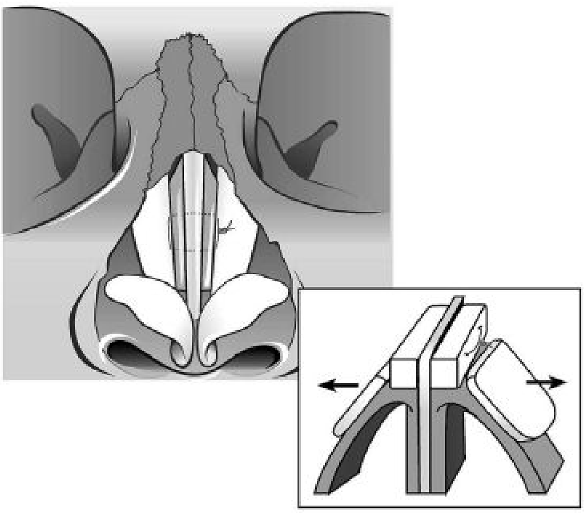

Figure 6: “Spreader grafts” were described for the first time by Sheen in 1984 for avoiding a functionally effective reduction of the cross section of the nasal valve after reduction rhinoplasty [16]. To this effect, 1-2 mm broad pins of cartilage are inserted between the septum and the lateral cartilage in an intact mucosal pocket and fixed using mattress sutures.

Butterfly graft

“Butterfly grafts” are placed on the septum and under the cranial border of the alar cartilage and expand the nasal valve through a spring effect (Figure 7). Cartilage grafts taken from the auricle that have a sufficient internal stress are particularly suitable. Akcam et al. (2004) describe a high effectiveness of this graft for improving nasal breathing and reducing obstruction-related sleep disorders [45]. On account of the required thickness of the grafts for achieving the desired effect, an aesthetically conspicuous accentuation of the supratip area may occur [15].

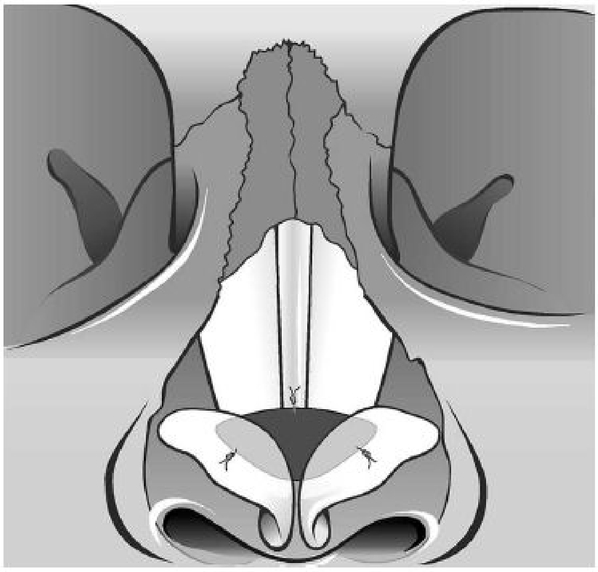

Figure 7: “Butterfly grafts” are placed on the septum and under the cranial border of the alar cartilage and expand the nasal valve through a spring effect. Cartilage grafts taken from the auricle that have a sufficient internal stress are particularly suitable.

Strut graft

Drooping nose tips can be due to weakness of the cartilaginous supporting structures and/or an increasing loss of elasticity of the soft parts with increasing age. This ptosis can cause a constriction of the internal and external nasal valve. Furthermore, the turbulent flow portions increase with rising airflow resistance. In this case, elevating the nose tip through reconstruction or supporting the cartilaginous structure leads to success. Sutures techniques that – placed between the alar cartilage and the nasal bone – elevate the nose tip can be used alternatively or in addition [46]. Skin resections also along the aesthetic units should be avoided on account of visible scars. The “strut graft” represents a part of the reconstructive measures [15]. However, it can also be used alone for elevating the nose tip. Autologous cartilage grafts or pre-shaped implants made of porous polyethylene are used. Our first own experiences show that alloplastic implants made of porous PE are suitable as “strut graft” on account of the good coverage of soft parts between the medial crura of the alar cartilage. The advantage is the high rigidity of the implants combined with small material thickness.

Breathe Implant®

The operating principle of the implant developed by àWengen in 2004 is similar to the butterfly graft and can be used for stabilising and widening the internal and – to a limited extent – the external nasal valve. For stabilising the nasal flap area through an open rhinoplasty, the formable, but stable titanium implant in the form of a clip is placed onto the caudal ends of the lateral cartilages in a way so that the larger portion of the implant is overlapped by the cranial end of the alar cartilage. Fixation is carried out through pre-shaped perforations of the titanium clip using thin, not absorbable suture material (Figure 8). Perforations of the nasal mucosa have to be avoided in order to reduce the risk of material rejection.

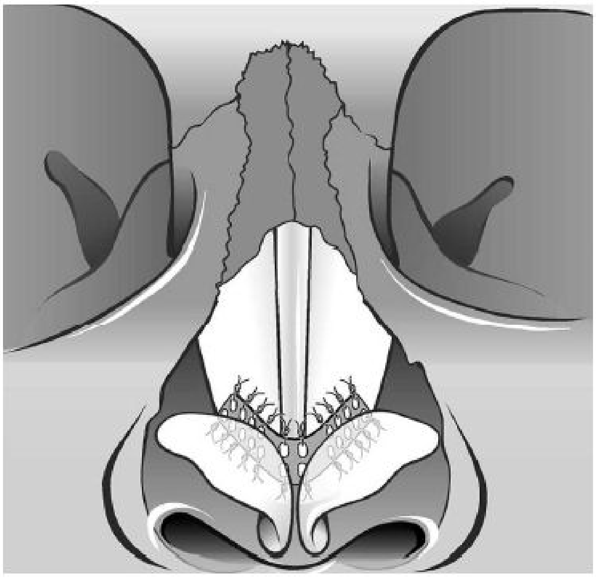

Figure 8: The titanium implant is placed on the caudal ends of the lateral cartilages for stabilising the nasal valve area so that the larger portion of the implant is overlapped by the cranial end of the alar cartilage. Fixation is carried out through pre-shaped perforations of the titanium clip. Damage to the nasal mucosa has to be avoided.

During the last 24 months, the implant has been used in 22 patients suffering from a functionally relevant dysfunction of the nasal valve area. All patients suffered from a moderate (n=4), severe (n=7) to very severe (n=11) impairment of nasal breathing before the surgery. The indication for the surgery was a clear improvement of nasal breathing during the Bachmann's manoeuvre as well as a positive Cottle's sign. 1 male patient with cleft nose deformity, 6 male/female patients with nasal valve disorder after rhinoplasty and 15 male/female patients with primary collapse phenomenon of the nasal valve were treated, in all 8 women and 14 men (age: 17-58 years). Follow-up examinations were performed by means of anterior rhinoscopy, nasal endoscopy, rhinomanometry, photo documentation and satisfaction score.

According to our own experience, the Breathe® implant according to àWengen is a method that is functionally very effective and cosmetically little conspicuous for treating disorders of the nasal valve and it can also be used in combination with a correction of the outer shape of the nose (Figure 9). Other methods of nasal valve stabilisation often result in a broadening of the wings of the nose visible from the outside. Unlike the nasal valve suspension surgery according to Paniello using titanium anchors, no infection or implant extrusion has been observed in our own patients up to now.

Figure 9: a: Preoperative situation before revision rhinoplasty with deformity of the tip of the nose, the supratip area and the nasal dorsum, as well as a constriction of the nasal valve area with collapse phenomenon. b: Postoperative situation after performance of an open revision rhinoplasty with implantation of a Breathe Implant®.

6.2.2 Suture techniques for stabilising and widening the nasal valve area

The principle of bone-anchored suture suspension has become more and more important in cosmetic facial surgery for many years. For example, suspension surgery is used in the surgical rehabilitation of patients suffering from facial paralysis in particular for elevating the eyebrow and the angle of the mouth [47]. Various suture techniques have been described for stabilising or widening the nasal valve area as well.

Nasal valve suspension surgery according to Paniello

The technique described here was published for the first time by Paniello (1996) and is based on a suspension of the cranial border of the alar cartilage upwards and outwards to the lower border of the orbita [48]. According to Paniello, fixation takes place either to the periost of the maxilla, to a screw inserted into the bone in the area of the lower border of the orbita or through a suture directly to the bone through boreholes (Figure 10). For the purposes of simplification, Friedman et al. (2003) suggested the bony fixation of the suture using a titanium bone anchor (Mitek® anchor) that is not palpable through the skin [49]. For the modified nasal valve suspension surgery according to Paniello, a titanium anchor with thread reinforcement is inserted into the bone through a stab incision in the area of the lower border of the orbita. Alternatively, a transconjunctival approach can be chosen in order to avoid an external scar. The reinforced threads are subsequently directed subcutaneously into the instable nasal valve area using slightly bent needles, stuck out into the nasal vestibule and returned in rostral direction in the sense of a mattress stitch and knotted. A simultaneous surgery of both sides of the nose is recommended in order to reach a symmetrical result.

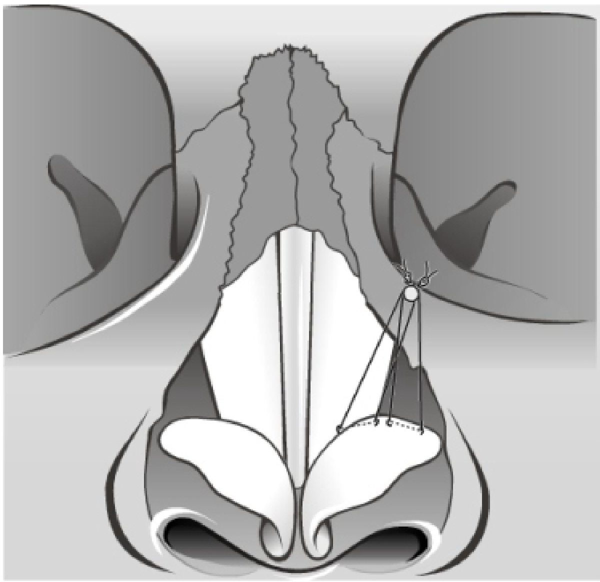

Figure 10: For the modified nasal valve suspension surgery according to Paniello, a titanium anchor with thread reinforcement is inserted into the bone through a stab incision in the area of the lower border of the orbita [52]. The reinforced threads are subsequently directed subcutaneously into the instable nasal valve area using slightly bent needles, stuck out into the nasal vestibule and returned in rostral direction in the sense of a mattress stitch and knotted.

Since October 2003, we have gained own experiences regarding a Mitek® anchor suspension in 18 patients. Nasal breathing was significantly improved. Infections regarding some of the implants inserted constituted a problem. They may be due to the wick effect of the twisted thread used and/or an immediate contact of the titanium anchor with the maxillary sinus. Besides the use of monofilament threads, a peri-operative antibiotic therapy should be performed. The technique is particularly suitable for latero-caudal constrictions of the internal nasal valve which is difficult to treat using the methods described above.

Lateral rhinopexy

By analogy with the described technique by Paniello, Hommerich developed the lateral rhinopexy. For this method, the piriform aperture is accessed through an incision of the oral vestibule and the lateral end of the alar cartilage is fixed in a new position located further outside by means of a borehole. To this effect, the thread is directed across a silicone film in the area of the nasal valve that can be removed after approx. 6 weeks [50]. In case of a bony constriction of the piriform aperture, it can additionally be expanded using a drill. On account of the large access, lateral rhinopexie should only be used in selected cases only despite its good functional and aesthetic results.

Flaring suture

The “flaring suture” leads to the expansion of the internal nasal valve angle and, as a result, to an increase in the cross section of the nasal valve. A mattress suture is directed from the lateral portion of the lateral cartilage across the nasal dorsum to the opposite side. When the suture is tightened, the lateral cartilages are lateralised, the nasal dorsum acting as a “hypomochlion” (Figure 11). Combinations with “spreader grafts” can be useful in order to avoid a functionally effective medialisation of the lateral nasal wall in reduction rhinoplasty [15], [51]. The “flaring suture” is ideally positioned through an open access. Polydioxanone 4-0 is used as suture material.

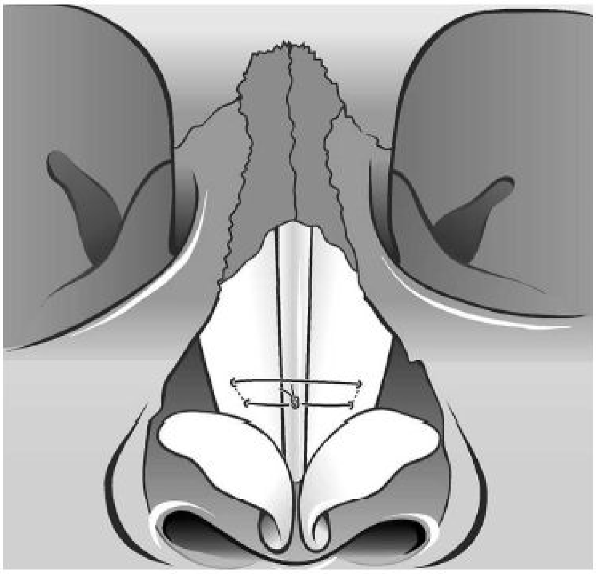

Figure 11: The “flaring suture” is a mattress suture that is directed from the lateral portion of the lateral cartilage across the nasal dorsum to the opposite side. When the suture is tightened, the lateral cartilages are lateralised, the nasal dorsum acting as a “hypomochlion”.

Horizontal mattress bending suture

The "horizontal mattress bending suture" was described for the first time by Ozturan [52]. This technique stabilises and widens the internal nasal valve through a mattress suture of the two lateral cartilages. For doing so, a not absorbable thread (5-0) is stuck in lateral direction into the lateral cartilage, directed in medial direction under the mucosa, stuck out and then again directed to the outside in caudal direction under the mucosa and knotted under tension. This folds the respective lateral cartilage convexly outwards and stiffens it; at the same time, the nasal valve area is widened (Figure 12). This technique can be induced for patients having a tension nose who do not wish a correction of the outer nose despite functional problems.

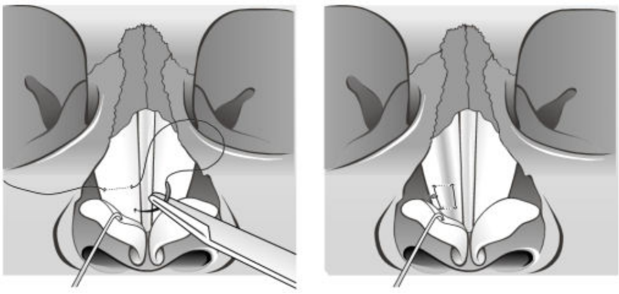

Figure 12: The "horizontal mattress bending suture" stabilises and widens the internal nasal valve through a mattress suture of the two lateral cartilages independently for both sides. As presented above, a not absorbable thread (5-0) is stuck into the lateral cartilage and knotted under tension.

6.2.3 Correction of stenoses of the soft parts, the cartilage and the bone in the region of the nasal valve area

Structural stenoses of the nasal valve area on account of pathological changes of the soft parts, the cartilage and the bone occur clearly more rarely than functional disorders that result in a nasal valve collapse. Causes are cleft lip, jaw and palate, scars after previous surgeries or burn traumata, facial paralysis, lateral crura of the alar cartilage paradoxically bent inwards or a state after reconstructive surgery after the resection of skin tumours. Cicatricial stenoses mainly concern the internal nasal valve. Formations of small veils can be corrected by means of a simple section using the following spacer therapy. The correction of rather large scars or veils is carried out using Z or V-Y-plasty, as the case may be, in combination with free whole-thickness skin grafts or mucosal flaps from the septum or the lip. Composite grafts can be used for broadening the base of the nose.

The surgical rehabilitation of permanent facial paralyses should be carried out for improving the affected patients' quality of life taking into account the labile lateral nasal wall. This paper will not expand on the principles and indications of dynamic and static rehabilitation methods.

Lateral crura of the alar cartilage paradoxically bent inwards result in a constriction of the external and internal nasal valve. In case of this mild malformation, a rotation-plasty of the cartilage is indicated. The cartilage bent inwards is removed for a short time and then re-implanted with outward bend. Care has to be taken in order to make sure that the internal mucosal cover remains intact in order to avoid infections [28].

Bony stenoses in the area of the piriform aperture can be resected carefully by means of a drill through an incision of the oral vestibule. Damage to the endonasal mucosa should be avoided in order to avoid subsequent stenosing of the nasal aperture in the context of wound healing. The soft parts can be put against and fixed to the bones by means of boreholes.

6.2.4 Postoperative treatment

After the surgery, all patients should use decongesting nasal emulsions for mucosa care in order to avoid incrustation, oedema and wound infections in the sense of local wound care. 5-7 days of antibiotic therapy are indicated for patients with cartilage grafts or alloplastic implants.

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