

Surgery of the nasal septum and turbinates

Abstract

The following article presents nasal septum and turbinate surgery. First an overview with special consideration of the anatomical and physiological background is given followed by indications for surgical procedures. Key steps of the gold standard procedure first described by Cottle and common variations are presented. Furthermore, some techniques dealing with special problems of the septoplasty are discussed followed by an overview on complications and long term results. However, it should be mentioned that studies on surgical procedures of the nasal septum are still not sufficient as higher evidence levels are very rare. Within a separated chapter techniques for closure of septum perforations are presented and indications particularly in the background of the standard procedure of bridge flaps forwarded by Schultz-Coulon are discussed. The second part focusses on turbinate surgery. Accordingly, anatomical and physiological basics are presented followed by indications for surgical procedures and the surgical steps of different procedures as well as postsurgical treatment and long term results.

Keywords: reduced nasal breathing, septoplasty, septum perforation, turbinate surgery

Christoph Matthias¹

1 ENT Department,
Grosshadern Medical Center,
Ludwig-Maximilians-
University, Munich, Germany

1 Introduction

The nose represents the entrance of the respiratory tract and has several functions: 1. the passageway for the air stream, 2. it harbours chemical sensory functions, 3. it warms and moistens the air and 4. it plays a role in the defence against foreign bodies of the surrounding environment [1], [2], [3], [4], [5], [6], [7].

The nose is comprised of a separated organ that harbours two passageways. However, as every nasal cavity has its own blood supply and innervation it can be seen as two organs that usually work together but in several situations can be regulated separately [2]. The most frequent symptom is obstructed nasal breathing. Problems with the other functions are less frequent. Since the beginning of modern rhinosurgery at the end of the 19th century several methods have been developed to objectively measure the nasal airstream. The first method was the cold mirror to measure the condensing dust during expiration, forwarded by Zwaardemaker. For a long time reliable surgical procedures to correct impaired nasal breathing were lacking. With the presentation of the submucous septum resection by Killian a reproducible procedure was described which could be evaluated in studies by different surgeons. Most of them were done during the 70s and 80s and are presented in the article by Mlynski for the congress 2005 [8]. During the 70s and 80s the septoplasty described by Cottle progressively took over and this procedure can be seen with its several variations as a gold standard nowadays.

The correction of a deviated nasal septum combined with reduction of the nasal turbinates is often seen as a beginners operation. Taking all the different techniques into

consideration that are necessary to solve all septum pathologies with reliable long term results it can be one of the most difficult procedures in rhinosurgery and be very demanding even for the experienced surgeon. It is nearly impossible to present all surgical techniques in this article. Accordingly, it is the authors intention to give an overview which techniques should be used in the common pathologies and to present some possible solutions for typical problems.

2 Septum surgery

2.1. Anatomical and physiological background

The nasal septum is separated into a bony and cartilaginous part. The bony part is comprised of the lamina perpendicularis as a part of the ethmoid of the vomer as well as bony processes of the maxilla and palate. The cartilaginous part is comprised of the lamina quadrangularis and its extensions to the lateral and alar cartilages. The lamina perpendicularis of the ethmoid forms the upper and anterior part of the septum is continuously connected to the lamina cribrosa. The vomer extends from below the sphenoid sinus anteriorly along the nasal floor. The cartilage of the lamina quadrangularis combines lamina perpendicularis, ethmoid, nasal dorsum and the vomer in the anterior part of the septum [9]. Frequently, a small sphenoid process is located between the ethmoidal part of the bony septum and the vomer which can particularly be seen in children and is a common cause for a consecutive development of a septum deviation. The upper

margin of the septum cartilage is closely connected to the upper lateral cartilages and usually forms an angle of 10 to 15°. Anteriorly to the upper lateral cartilages are the alar cartilages that lie close to the septum cartilage in the nasal tip and columellar area. The area between the upper lateral cartilages and the alar cartilages represents the anterior septum angle which can be seen as a supratip depression. The inferior (or posterior) septum angle is the structure where the septum is fixed to the anterior nasal spine. Anterior to that the medial crura of the alar cartilages are located which are separated from the cartilaginous septum by a small part of membranous septum, frequently named weak internal triangle. The embryological development of the cartilaginous septum and the cephalic two thirds of the upper lateral cartilages is one entity [9], [10], [11], [12].

The connection between septum cartilage and premaxilla or vomer has several peculiarities. While some fibers of the perichondrium and periosteum run parallel with the cartilage and bone many of them cross around the premaxilla to the opposite site. The fibers of the septum perichondrium have a similar crossing direction which results in a kind of pseudo-joint of the cartilaginous septum and the bony premaxilla allowing a slight lateral movement of the nasal septum. Accordingly, while it reduces the risk of fracturing under lateral compression it supports lateralisation of the lower septum during growth [12], [13], [14].

The submucosa of the inner nasal lining comprises of an intense venous plexus particularly in the area of the inferior turbinates and the posterior parts of the nasal septum. In the region of the anterior septum a vascular confluence of branches of the arteria ethmoidalis anterior, a. sphenopalatina and a. labialis superior is located. This area, also named Kiesselbachs plexus particularly plays a role in anterior nasal bleeding.

The nasal airstream can be regulated by filling the venous plexus [15]. 1932 Schaeffer described these venous sinus as corpora cavernosa, that are particularly located in the area of the nasal turbinates and the corresponding parts of the nasal septum. Meanwhile, the role of these venous sinus in the control of the nasal airstream is well investigated and its capability to intensively swell and completely obstruct the nasal cavity is well documented [15], [16]. The localisation of these venous swelling bodies in the anterior part of the nasal cavity is very important for the control of the nasal airstream as this is the narrowest part of the nasal cavity, therefore named nasal valve. Thus, it represents about 80% of the total nasal resistance [2], [9], [17]. The nasal resistance is regulated by three different components: the nasal entrance, the nasal valve and the passageway along the turbinates. The nasal airstream is regulated by the sympathetic nerve system. Further details are described in the literature [2], [3], [6], [7], [8], [9], [17], [18], [19].

2.2. Indications for septum surgery

Since the beginning of rhinosurgery at the end of the 19th century it is well known that the nasal septum very rarely lies absolutely straight within the skull but usually shows a more or less pronounced deviation that can be found in up to 90% of cases investigated. As this deviation can not be judged to be pathological several authors separate a physiological deviation from a pathological septum deviation. A physiological septum deviation is defined as a deviation without subjective or objective reduction of the nasal breathing. Accordingly, a pathological septum deviation has to be defined as a septum deviation with subjective reduction of nasal breathing. Thus, the problem of precisely defining the septum deviation is evident [17], [20]. To precisely evaluate the resistance of the nasal airway today several diagnostic procedures are available. First the rhinomanometry has to be mentioned, which allows the identification of a nasal obstruction but is not able to exactly identify the underlying anatomical structures. If this procedure is performed in advance and after sympathomimetic treatment it can reliably be used to separate between mucosal and bony or cartilaginous reasons for the reduced nasal airflow. Accordingly, this procedure is recommended in the guidelines by our society [21]. More intensive procedures like rhinoresistometry, acoustic rhinometry or long-term-rhinoflowmetry in their combination allow the precise anatomical identification of the obstruction but are rarely performed in clinical routine [2], [8], [16], [22]. Finally, the diagnosis of the underlying reasons for reduced nasal breathing is very much dependent on the clinical experience of the investigator. The above mentioned procedures are able to assist in identifying the anatomical structures that should be focussed on.

The identification of a deviated septum in a patient who complains reduced nasal breathing frequently results in the indication of a septoplasty that consecutively is performed using the procedure described by Cottle or in one of the variations [23]. It is assumed that this is one of the main reasons for the poor long term results of septoplasty as very commonly, the problems of the nose are far more complex. The septum deviation itself gives rise for compensatory changes in the nose [16], [20], [24]. Thus, usually the investigator can find an atrophy of the nasal turbinate on the convex side while the concave side presents enlarged. It is assumed that the turbinates regulate the nasal air stream in a way that further functions like warming up and moistening are fulfilled even in the deviated nose [2], [17], [22], [24].

To better compare and standardise the surgical procedures it often has been tried to establish a classification for septum deviation. Particularly, the classifications forwarded by Guyuron and coworkers 1999 and Sciuto and coworkers 1999 should be mentioned [25], [26]. Both are based on the differentiation between horizontal and vertical and combined deviations. The classification forwarded by Sciuto and coworkers is presented in Figure 1. If it is possible to clearly classify the septum deviation

it is recommended to adapt the surgical procedure. In example, in the presence of an isolated horizontal deviation a surgical procedure is recommended that only reduces the tension of the septum. In vertical-caudal deviations an excision of the deviation and consecutive reimplantation should be performed while high vertical or combined deviations frequently make a septum exchange necessary. The success rates for this diagnostic and therapeutic procedure given by the authors seem to be intensively improved, however, it is nearly impossible to find out whether this improvement is attributable to the classification system itself or due to the greater surgical experience of the investigators. As it is nearly impossible to investigate only one variable in the end the selection of the surgical procedure very much depends on the clinical experience of the surgeon. The complaints of the patient, all visible pathologies of the nose and, if possible, the results of further diagnostic procedures should be taken into consideration to plan the surgical procedure. Classification systems like the presented are helpful in this process.

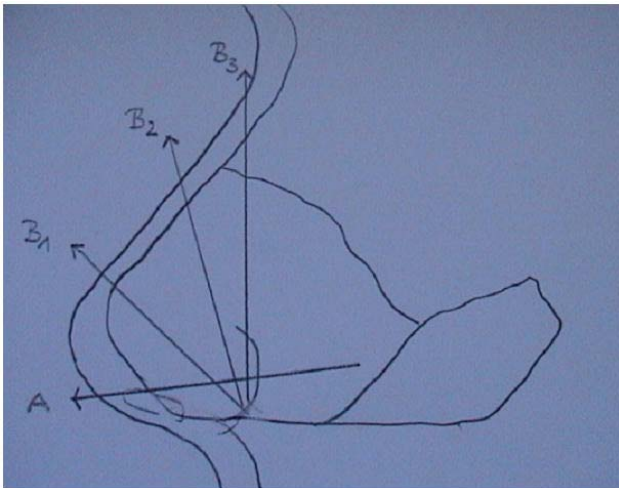


Figure 1: Classification of septum deviation (from Sciuto and coworkers): A: Horizontally, parallel to the premaxilla running deviation of the lamina quadrangularis. B: Vertically running deviation of the lamina quadrangularis. B₁: Caudal-vertically running deviation inferiorly to the insertion of the upper lateral cartilages. B₂: Mid-vertically running deviation with the axis in the area of the insertion of the upper lateral cartilages. B₃: High-vertically running deviation with the axis in the area of the bony nasal dorsum. C: Combined deviation of A and B.

2.3. Surgical procedures

Several surgical procedures have been described to correct a deviated nasal septum [23], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41]. The conservative, standard procedure today initially begins with a hemitransfexion incision, followed by a dissection of the caudal edge of the septal cartilage and the elevation of the mucosa of the opposite site of the hemitransfexion incision. If possible, it is recommended to leave the mucosa attached on one side of the septum to better support the mucosal bloodflow. Additionally, inferior tunnels should be prepared to reach the premaxilla

and the vomer region. Resection of cartilage and bone should be performed very conservatively in this technique, particularly in circumscribed deviations and in children. The complete caudal and inferior septum can be reached via the hemitransfexion incision after removing the mucoperichondrium and mucoperiosteum on both sides. Furthermore, the bony ridge of the premaxilla and vomer can be exposed and all bony and cartilaginous deviations can be corrected. In all resections it is important to leave an "L"-form to support the nasal dorsum at the anterior nasal spine. Depending on the stability of the cartilage the width of this columellar strut should be around 1 cm. When fractures of the anterior septum are present it is mandatory to reconstruct this "L"-frame using columellar struts or by performing a septum exchange or an extracorporeal septoplasty [29], [30]. In this procedure the complete cartilaginous septum is freed from the upper lateral cartilages and is straightened outside the nose. In most cases the surgeon will find sufficient cartilaginous structures in upper or posterior parts of the septum that allow functional reconstruction of the "L"-frame by rotating the remaining septum. Meticulous suturing of the reimplanted cartilage is particularly important in key areas like anterior nasal spine, columellar and K-region (cartilaginous-bony connection of the nasal dorsum).

Surgical steps

Hemitransfexion incision: After injection of 1 ml suprarenin containing local anaesthetics into the columellar anterior septum the hemitransfexion incision is placed to find the entrance between cartilage and perichondrium. The exact localisation of the hemitransfexion incision is much more important than the side of incision. While most surgeons prefer the right side for the incision nearly all pathologies can also be corrected from a left side incision. Only in cases with severe deviations of the anterior septum, i.e. in cleft nose deformities, the incision should be placed on the concave side of the deviation. Furthermore, it is important to place the incision into the vestibular skin and to avoid mucosal incisions as they predispose further injuries of the mucosal lining and heavier bleeding. The incision should be performed from cranial to caudal to avoid accidental injury of the alar cartilages and dome region. The next step includes the meticulous preparation of the subperichondreal lining. The entrance under the perichondrium should be located at the ventro-caudal septum as this area is much more stable than more cranial parts and accidental injuries of the caudal septum should be avoided. In cases of severe deviations it may be necessary to free the concave side first as the convex side might be accessible only after mobilisation of the corresponding cartilaginous area (Figure 2). Incisions on the cartilaginous surface should be avoided as they themselves can give rise to new deviations. The preparation of the anterior nasal spine is the next step and depending on the pathology the mobilisation of the cartilaginous septum from the anterior nasal spine. In cases of deviation of the bony septum particularly of the vomer

the preparation of both lower tunnels and consecutive mobilisation of the mucoperichondrium on both sides is necessary [34], [35], [42]. The attempt to resect in the caudal septum without preparation of both lower tunnels results in the commonly recognised longitudinal perforations of the inferior septum [43]. Depending on the individual pathology a vertical cartilaginous incision about 1 cm posterior the anterior septum margin is placed. The anterior septum is now freed and can be moved from side to side (swinging-door). Depending on the underlying pathology posterior vertical incisions should be placed to resect deviated cartilaginous areas (Figure 3). If it is possible to save the key areas for septum stability it is not necessary to reimplant resected cartilage. In selected cases, particularly when injuries of the mucosal lining are present it is advantageous to place cartilaginous or bony fragments between the mucosal linings. It might be necessary to suture these fragments to avoid dislocation. Additionally, larger one-sided mucosal defects and all corresponding mucosal defects should be sutured meticulously to avoid septumperforations [8], [42], [43], [44], [45]. Deviations of the lamina perpendicularis should be handled very carefully as the direct anatomical connection to the lamina cribrosa predisposes dural injuries with consecutive liquor flow [46]. Several authors favour the use of a microscope or endoscope during septoplasty [32]. Even though there are several advantages particularly in teaching, these techniques are not frequently used. In the authors personal experience the use of the endoscope is particularly helpful in far posterior located deviations and in teaching the surgical procedure.

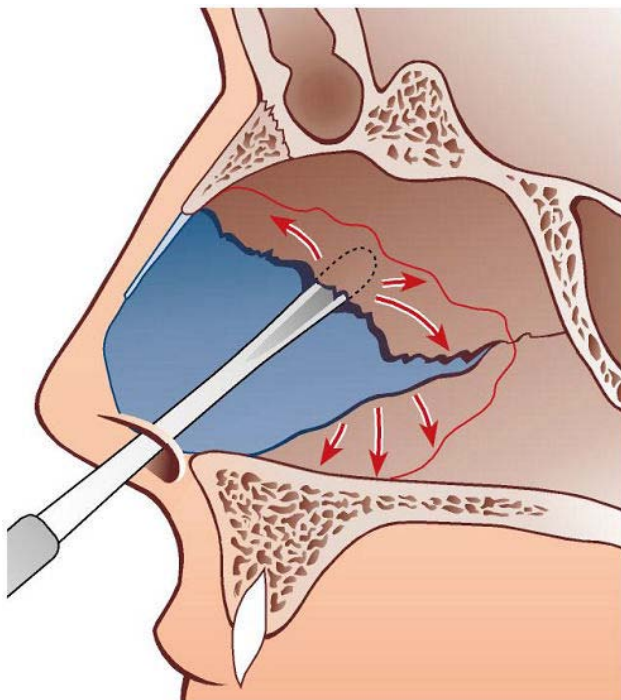


Figure 2: Preparation of upper and inferior tunnels

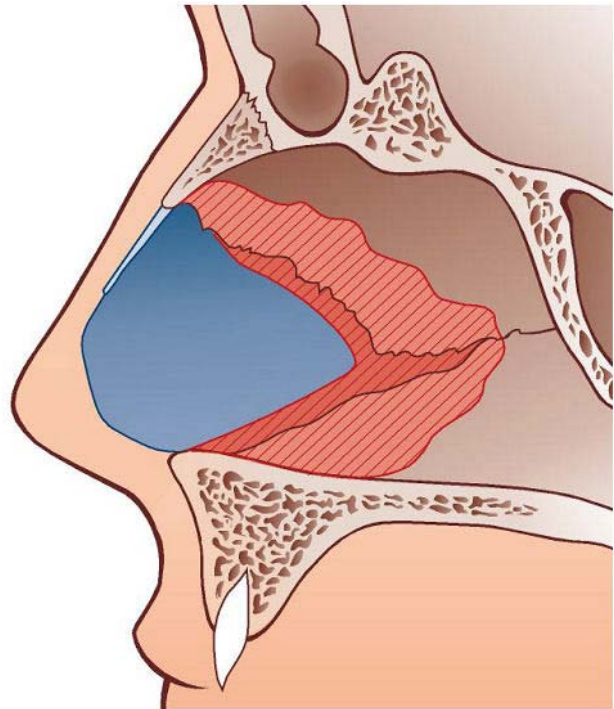


Figure 3: Deep-horizontal and posterior-vertical resections

2.4. Special procedures

In cases of severe destruction of the anterior septum due to trauma, infection of previous surgical procedures it may be necessary to perform a septum exchange [29], [30], [40]. This procedure is based on the common finding that cartilaginous material in the posterior parts of the nose often presents in much better shape and can be used to reconstruct the essential parts for septum stability. It is essential to reconstruct the „L“-frame out of a rotated septum and place it into a precise pocket between the medial parts of the alar cartilages. It has to be fixed in this position by meticulous suturing to avoid dislocation. Detailed descriptions of this procedure have been published by Gubisch 1994 and 2001. In cases of insufficient stability of the remaining cartilage PDS foil can be used to attach cartilaginous fragments [29], [30], [47]. Accordingly, meticulous fixation at the anterior nasal spine and the nasal dorsum is mandatory. In cases where no usable cartilaginous fragments can be found transplantation of autologous cartilage might be necessary [26], [35], [40], [42], [48]. This can be taken from ear cartilage or rip. Both donor sites harbour specific advantages and disadvantages. While ear cartilage is more flexible and allows better movement of the nasal tip it is not easy to get a straight fragment of ear cartilage that is about 3 cm long. In 2004 Pirsig described a technique to construct a straight cartilaginous transplant from cavum conchae by longitudinal incision and back to back suturing [40]. The resulting transplant can be thinned to gain more flexibility and to allow easier placement into the columellar pocket. If rip cartilage is used the surgeon has to take into consideration that only the middle part of the rip cartilage is free of tension. All other parts of the rip will gain new de-

viations due to their own tension. Even though getting enough cartilaginous material hardly ever is a problem the patient suffers from a painful additional surgical procedure and scar. Furthermore, while the higher stability of rip cartilage may be advantageous in several cases (i.e. saddle nose deformities) it results in a less flexible nasal tip. Additionally, the use of bony transplants from the bony septum or skull has been described but the use of these transplants imply an even more reduced flexibility. The use of foreign material inside the septum is usually associated with high extrusion rates over time, however, recent studies on porous polyethylene could show that this alloplastic material can be successfully used in the septum or nasal valve area in selected cases when the surgeon consequently follows several rules, i.e. to meticulously cover all the foreign material with healthy tissue.

Septoplasty in the cartilaginous deviated nose

With the exception of the congenitally deviated nose, i.e. in cleft nose deformities, trauma or previous surgery are the most common causes for the deviated nose. Due to the close correlation of the bony and cartilaginous framework of the nose a bony fracture often has an impact on cartilaginous structures like septum, upper lateral cartilages or alar cartilages. To achieve good results in the correction of deviated noses it is essential to analyse all anatomical components and correct them individually. Thus, during the development of modern rhinoplasty the conviction grew that the septoplasty plays an essential role in the management of the deviated nose [25], [26], [44], [49], [50], [51]. In many cases a high horizontal deviation requires a septum exchange. If an open approach is performed the total septum can easily be reached and fixed after correction. Several authors favour the implantation of a one sided spreader graft between the septum and the upper lateral cartilage on the concave side to achieve a long lasting straightening of the nose [41], [49], [50]. Foda even mentioned the use of an overlong bony spreader graft to achieve this effect [51].

The severe antero-caudal septum deviation (subluxatio septi)

Deviations of the anterior septum tend to give rise to a prolapsing anterior septum margin into one of the nostrils with a consecutive asymmetry of the nasal basis. The key part in correcting this pathology is, as Foda describes, the complete mobilisation of the ventro-caudal and cranial septum [51]. Most of the techniques described so far are based on the concept of separating septum cartilage from upper lateral cartilages and consecutive re-fixation with spreader grafts. This may be difficult in several cases of severe septum deviations particularly when a closed approach is used. Thus, Bocchieri and coworkers 2002 mentioned the possibility to correct the deviated nose using a „septal crossbar graft“ [50]. In this technique

a one sided spreader graft is placed under the high horizontal septum deviation on the concave side between three incisions of the cranial cartilaginous septum after preparation of the mucoperichondrium (Figure 4).

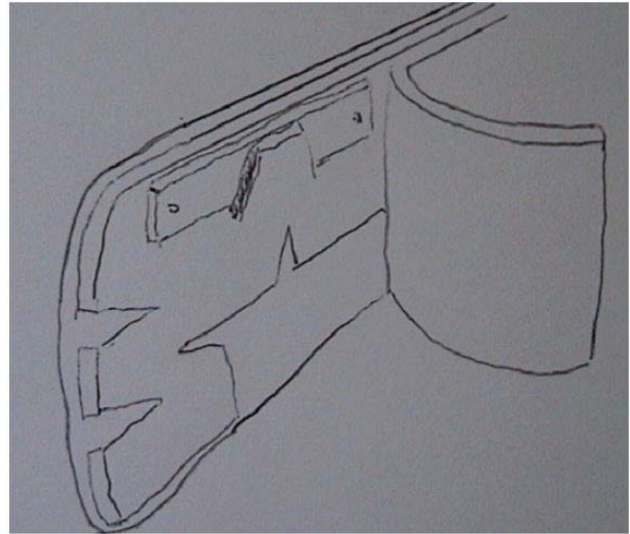


Figure 4: "Septal Crossbar Graft"

Visible changes of the nose induced by corrections of the nasal septum

While changes of the cosmetic aspect of the nose should generally be avoided during septoplasty the experienced surgeon can use corrections at the cartilaginous septum to achieve changes in the cosmetic aspect of the nose. Accordingly, a careful resection of a cartilaginous strip at the caudal septum can shorten the nose and reduce columellar show (Figure 5). The excision of a triangle at the caudal septum with its basis at the anterior septum angle results in a rotation of the nasal tip (Figure 6). Furthermore, the reduction of an overlong septum in the area of the inferior septum angle reduces the fullness of the nasolabial angle (Figure 7) [41]. It has to be mentioned at this point that corrections in these areas of the septum should only be made by an experienced rhinosurgeon who has a clear view about the extent of the corrections necessary to achieve the changes intended.

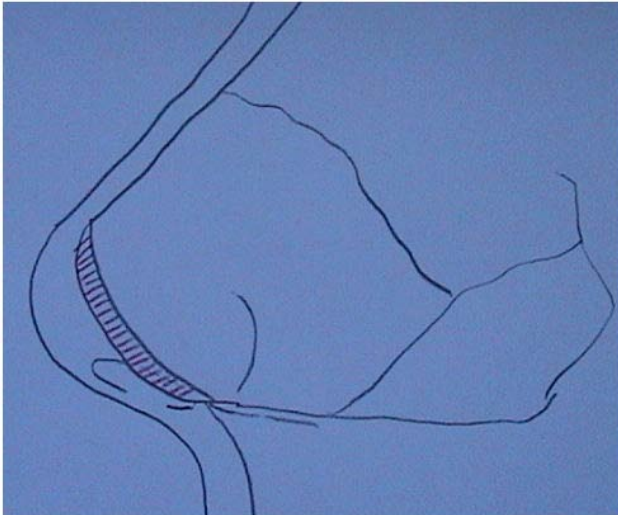


Figure 5: Resection of an overlong septum

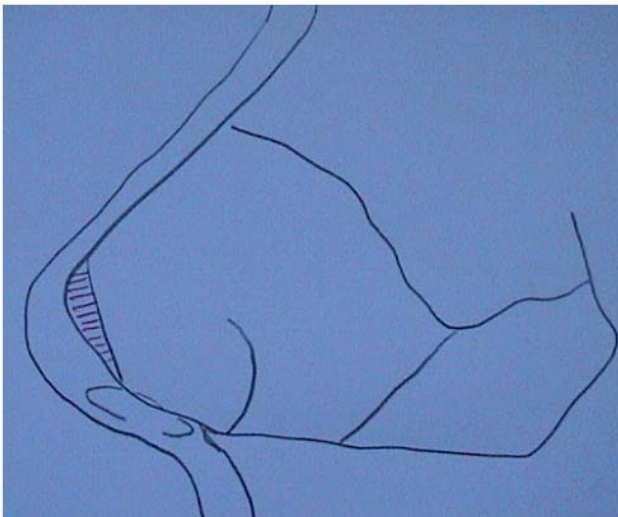


Figure 6: Resection of a triangle based at the anterior septum angle

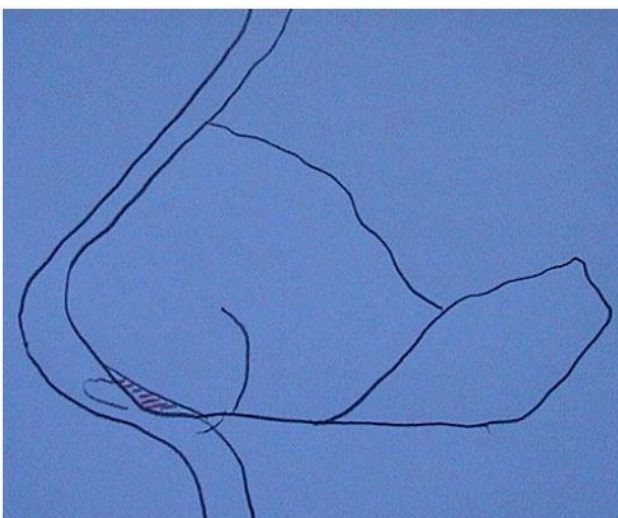


Figure 7: Resection at the posterior-inferior septum angle

2.5. Postsurgical treatment

The key role of meticulous fixation of all implanted material inside the nasal septum has already been mentioned. Accordingly, the reconstructed nasal septum itself can be fixed using mattress sutures. Some authors recommend to use fibrin glue, however, it has often been described that this fixation is not reliable. There is good evidence that in most reconstructed septums the use of splints (Doyle, Reuther) for about four days is sufficient, while there is no sufficient study material on the benefit of nasal packing. In the authors experience nasal packing is only necessary in turbinate resections or heavy bleeding during surgery. More details about various methods of nasal packing are described in the congress article by Mlynski [8]. Even though the postsurgical treatment after septoplasty usually is not very intensive the patient should be seen for about 14 days on a regular basis. Particularly a short time after removing the splints a septum hematoma is not uncommon. It can easily be seen by the typical ballooning of the septum. In most cases suctioning through the hemitransfexion incision is not sufficient, but reexploration of the complete septum and removing all blood clots is necessary. Immediate revision surgery is mandatory as infection and abscess formation with consecutive necrosis of cartilaginous material has to be avoided [42], [45], [52].

2.6. Complications after septoplasty

The critical role of the anterior margin of the septum with its possible influence on the cosmetic aspect of the nose has been mentioned above. Accordingly, many of the complications after septoplasty described in the literature are mainly due to mistakes in the indication or technical procedure itself. Unfortunately, good studies on the complications after septoplasty are lacking.

Infections

Infections after septoplasty or rhinoplasty are much less frequent than it could be expected from a surgical procedure that usually is performed in an unsterile environment. Even though potentially pathological bacteria like staphylococci or streptococci are present the infection rate usually lies under 3% [44], [52], [53], [54]. It will rise in revision surgery and more extensive procedures like septum exchange. In revision cases with the use of free transplants in 75% of cases Pirsig and Schäfer found minor infections in 25% and more severe infections in 6% of cases [53]. Taking these studies into consideration an antibiotic treatment can not be recommended for routine septoplasty. Even though there is no sufficient study based evidence most authors recommend the use of antibiotics in revision cases, in complications like hematomas and in cases where free transplants or alloplastic material has been used.

Hematomas

Postsurgical bleeding is the most frequent complication after septoplasty occurring in 2 to 7% of all cases [28], [43]. Superficial ulcer and bleeding from incisions particularly from branches of the palatal artery or the premaxilla are common causes. Even more frequent are bleedings from wounds after turbinate surgery, a surgical procedure frequently performed together with septoplasty. Thus, the use of nasal packing is recommended in cases in which resections of the turbinates have been performed.

Abscess

Usually, a septum abscess develops from hematoma after surgery or trauma. Commonly found bacteria are staphylococci, streptococci and haemophilus influenzae. Good studies on the frequency of abscess development after septoplasty are lacking. There is a strong necessity to immediately reoperate as there is the risk of necrosis of cartilaginous tissue. Intravenous antibiotics are usually applied additionally. If further cartilage is affected the typical changes are saddle nose deformities and retraction of the columella [35], [53].

Intranasal adhesions (synechia)

Intranasal adhesions are relatively common after septoplasty in combination with turbinate surgery [54], [55], [56], [57]. In retrospective studies in up to 36% of cases intranasal adhesions could be found, however not all of them were functionally relevant [57]. Investigations by Pirsig on more than 2000 patients could show that the use of nasal splinting for 4 to 7 days could avoid intranasal adhesions in almost all cases [45]. Crusting and mucosal atrophy which was a common complication after submucosal septum resection (Killian procedure) [39], [56] is very unusual after the above mentioned Cottle procedure [37], [42], [45], [58].

Septum perforation

Extensive submucosal resections are the most frequent reason for septum perforations after septoplasty. The exact frequency is very difficult to determine as long term studies are lacking and a clear differentiation of the severity or a classification of septum perforations are lacking. Described frequencies range from 3 und 25% [27], [38], [49], [54]. As a general rule all large one-sided perforations and all corresponding perforations should meticulously be sutured and cartilage should be positioned between the mucoperichondrial sheets to prevent septum perforations.

Changes of the outer form of the nose

Major changes of the outer form of the nose after septoplasty are less common with the Cottle procedure

compared to Killian`s septum resection [52]. Typical changes are saddle nose deformities or minor forms of these changes like cranial rotation of the nasal tip, widening of the nasolabial angle, shortening of the tip or retraction of the columella. These changes are mainly due to insufficient stability of the "L"-frame and thus insufficient protection of the nasal dorsum and nasal tip from the anterior nasal spine. The frequency of these changes varies in the literature from 5 und 60% [37], [45], [48], [59], reflecting the problem of clear definition of these changes. In most of these cases a rhinoplasty is necessary to correct all these changes [46], [47].

Smelling disorders

Swelling and scar formation in the area of the olfactory mucosa can result in a complete or incomplete loss of olfaction [60], [61], [62]. As patients are often unable to differentiate taste and smelling it is recommended to do a routine olfactometry prior to septum surgery. Additionally, olfactory dysfunction usually is not realised by the patient immediately after surgery with additional difficulties to attribute the dysfunction to the surgical procedure. Preliminary dysfunction of smelling is regularly found immediately after septum surgery and mainly due to mucosal swelling and crust formation. The risk of permanent hyposmia or anosmia should be under 1% [61], [62].

Rare complications

The possibility of dural injury at the anterior skull base with consecutive liquor leakage has already been mentioned. Other rare complications are impaired visual function up to blindness due to retrograde flow of local anaesthetics via the ethmoidal artery into the ophthalmic vessels. However, these are very rare complications and frequencies are not given in the literature.

2.7. Long term results

Septoplasty is one of the most frequent performed surgical procedures in otolaryngology. Accordingly, one would expect to have sufficient studies with high evidence levels to prove the benefit and long term results of this operation. By contrast, the study level is quite poor. Most follow up studies evaluate after 3 to 6 month. Several scores have been developed, however non achieved widespread acceptance [63], [64]. The few long term studies available give evidence that the benefit after septoplasty is not as long lasting as often supposed. Thus, Konstantinidis found out, that 2 to 3 years after surgery only 50% of the patients feel to benefit from surgery [59]. These patients predominantly had deviations of the anterior septum.

Septumperforation

In cases of typical symptoms like crusting, bleeding and reduced breathing small nasoseptal defects can effect-

ively be treated with the established surgical procedures. In contrast, the closure of large septum defects represents one of the most challenging rhinosurgical procedures [64], [65], [66]. Within the last decades more than 40 different techniques have been described. Surgical procedures are derived from six different strategies: free tissue transfer [67], [68], septal mucosa flaps [68], [69], inferior turbinate flaps [70], oral vestibular flaps [67], endonasal mucosa advancement [65], [66], [69], and the use of a fronto-temporal or paramedian forehead flap [71]. Most procedures, like free tissue transfer and septum mucosa flaps are only suitable in small defects. Other techniques carry specific risks like necrosis in oral vestibular flaps. Thus, the closure rate of septum perforation varies between 40% and 90% depending on the defect size and the technique used. Schultz-Coulon described a success rate of 92.5% in 403 patients suffering septum perforations using bipediced nasal mucosa flaps [66]. The author assesses the limitation of this technique in defects exceeding 50-60% of the vertical septum high. In this large defects a separation and mobilisation of the lower lateral cartilages is necessary in the technique forwarded, a procedure known to be functionally and aesthetically risky. Consequently, the author sees no surgical alternative for larger vertical septum perforations [66]. Established alternative procedures like obturator implantations give poor results [72] or necessitate external incisions with major aesthetic disturbance like alar base incisions or lateral rhinotomy [71], [73]. Another procedure uses the midfacial degloving advancement which is a time consuming procedure and resulted in the authors' series in nasal valve stenosis in 20% of the cases [74]. The use of a subcutaneous pericranial flap to close septum defects was first described by Paloma and coworkers but the authors used a bicoronal approach in combination with an open rhinoplasty [75]. We describe a new technique for the reconstruction of large septum defects using a galeo-periosteal forehead flap. This technique has been developed by Berghaus and the author within the last three years. The technique requires a 4 cm hairline incision combined with standard closed rhinoplasty procedures. The subcutaneous galeo-periosteal forehead flap consists of the cranial periosteum and loose connective tissue adjacent to the periosteum, the subgaleal fascia. The flap is strongly vascularized by the deep branches of the supraorbital and supratrochlear vessels. The forehead flap is harvested in the subdermal plane and is pedicled at the supratrochlear and supraorbital vessels. It is rotated through an open nasal roof into the septum. The flap is fashioned through a 4 cm paramedian hairline incision (Figure 8). Only skin, subdermal tissue and galea are incised to facilitate further preparation while the flap is still spanned in the donor region. The dissection runs in the subdermal layer down to the superior rim of the orbit. A small vertical skin incision can facilitate safe identification of the supratrochlear vessels during preparation of a small pedicle.

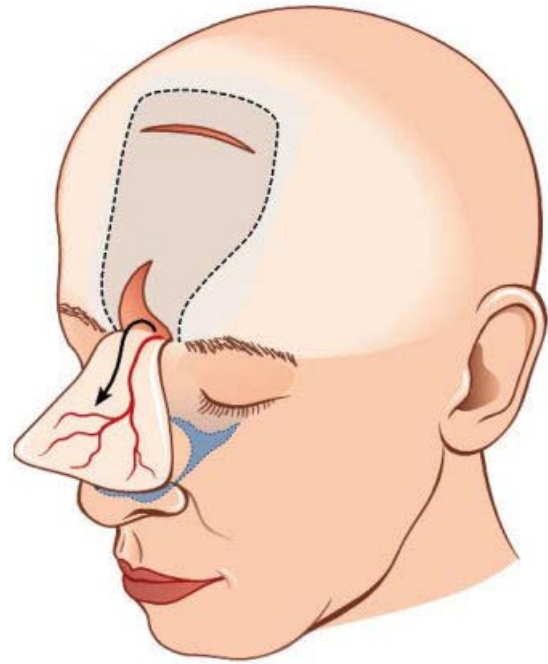


Figure 8: The subcutaneous galea-periosteal flap

The distal part of the flap should be adapted to the horizontal extension of the perforation while the axial length of the flap easily reaches 6-7 cm sufficient enough to reach the nasal floor. This allows the reconstruction of septum perforations without vertical limitations in size. After complete preparation of the subdermal layer the flap is cut down to the bone.

The further preparation involves standard procedures of closed rhinoplasty. A hemitransfection incision is used to advance the mucosal margins of the perforation while décollement of the nasal dorsum is performed through intercartilaginous incisions. After division of the upper lateral cartilages from their attachment to the dorsal septum paramedian osteotomies are performed to widen the nasal roof. Lateral osteotomies usually are necessary particularly if a dorsal hump is removed in the same procedure. After complete tunnelling between forehead and nasal dorsum the flap will be rotated 180° through the open nasal roof into the separated mucosal margins of the perforation (Figure 9 a)

The flap will meticulously be sutured to the defect margins using rapid Vicryl 4-0 (Figure 9 b). Nasal splinting for 5 days and additional cleaning of the nasal cavity over 3 weeks seems sufficient. Surgery resulted in complete closure of large septum defects in 8 out of 9 cases (Figure 9 c).

The galeo-periosteal forehead flap represents a safe procedure for the reconstruction of anterior skull base defects [76], [77]. Due to its good vascularisation the flap is widely used to cover free transplants like bone, cartilage or implants in poorly vascularized parts of the midface [77]. The donor region of the flap is easy to reach and the blood supply is very reliable provided by branches of the supratrochlear and supraorbital vessels. On the basis of this previous experience with the galeo-periosteal

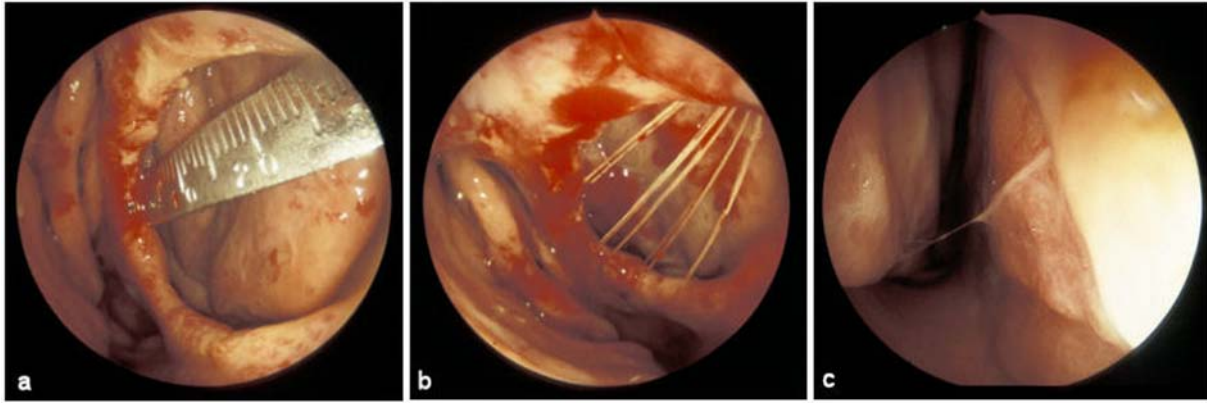


Figure 9: Closure of a septum perforation using the subcutaneous galea-periost flap. a: Preoperative perforation. b: During surgery with sutures positioned. c: 6 month after surgery.

forehead flap we have chosen it for septum reconstruction.

Due to lacking long term follow-up and large numbers of patients treated with the procedure described success rates can not be presented up to now. Clamping of the pedicle in the area of the open roof is a possible risk. Additionally, a second step may be necessary to close the open roof. In the cases treated by the authors aesthetic results made a second operation unnecessary. The technique presented here seems to be a very promising procedure to close large septum perforations particularly with large vertical extensions. The vertical high of the perforation is not important in determining the difficulty of the procedure and success rate of the closure as the flap is positioned into the defect from the nasal dorsum. This is a great advantage of the technique presented as the vertical extension of the perforation is the limiting factor in nearly all other procedures available.

3 Surgery of the nasal turbinates

3.1. Anatomical and physiological background

The inferior nasal turbinates are comprised of the turbinate bone with the mucoperiost above, a submucous cavernous plexus and the respiratory mucosa. The bone has its own ossification centre, that arises at the 5th month during development [9], [14]. The bony surface is very irregular, perforated and interspersed with numerous vessels. Therefore, the mucoperiost is very strongly attached to the bone. The bone has contact to the ethmoid, the palate and the lacrimal sac. The cavernous plexus is particularly well developed in the anterior part of the inferior turbinate and is regulated by autonome endocrine innervation. Thus, the nasal turbinate is able to regulate its expansion. The number of goblet cells is much higher in the mucosa of the inferior nasal turbinate compared to the middle turbinate [6], [9], [18]. The bone of the middle turbinate is part of the ethmoid sinus [9], [78]. In 30% of all cases the turbinate is pneumatized (concha bullosa). Its cavernous plexus is much less developed

compared to the inferior turbinate [6], [9], [18]. Similar to septum deviation enlarged turbinates are a very common finding in patients suffering from reduced nasal breathing. Underlying reasons are: allergic, vasomotoric or medication induced rhinitis, chronic sinusitis, hormone induced rhinitis, and compensatory hypertrophy on the concave side of a septum deviation [34].

3.2. Indication for nasal turbinate surgery

According to the indication for septum surgery, it has to be taken into consideration that the nose has to be seen as one system and the anatomical reasons for obstruction have meticulously to be evaluated. Therefore, it is important to keep in mind that numerous reasons for turbinate hypertrophy are systematic or reflect a reaction of the entire respiratory tract. Besides the clinical finding the rhinomanometry before and after a-mimetic reduction is very helpful [21]. It could be shown that the long term result after turbinate surgery is very poor if the underlying reason for hypertrophy is not meticulously evaluated [5]. Including techniques that are very rarely used today (i.e. neurectomy, kryosurgery, injection of steroids) more than 20 different techniques including the use of several laser systems have been described for turbinate surgery [79], [80], [81], [82], [83], [84], [85], [86], [87], [88]. These surgical procedures are based on three different principles: the lateralisation that only changes the position of the turbinate, resection and coagulation procedures. The indication for surgical resection is generally agreed in cases where septoplasty is performed under general anaesthesia, in cases with a hyperplastic turbinal bone or in recurrent hypertrophy after lasersurgery.

3.3. Surgical procedures

The most aggressive procedure, total turbinectomy, is able to markedly increase nasal breathing, but this procedure should be avoided due to common severe complications like crusting and postoperative bleeding [8]. By contrast, several authors still recommend this procedure still as the most effective procedure to improve nasal

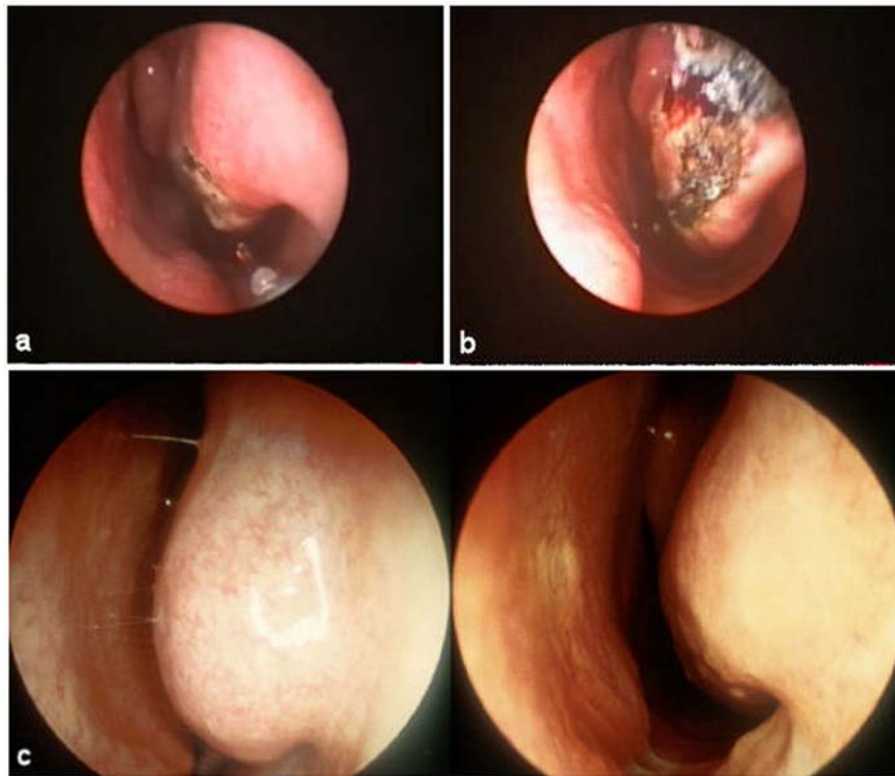


Figure 10: Laserturbinotomy (diode-laser). a: Beginning of the procedure. b: End of the procedure. c: Before and 1 year after treatment.

breathing even in areas of dry and hot climate [89]. Unfortunately, good data and high evidence level studies are not available. Partial turbinectomy, in which the head of the inferior turbinate is resected, is also very effective and associated with less complication rates. Due to scar formation the nasal cycle might severely be irritated as regulation from thermal stimuli is mainly induced by the anterior nasal turbinate [27]. Submucous resection, in which only parts of the turbinal bone and soft tissue will be resected is a very frequently performed procedure. Accordingly, a very low complication rate has been attributed to this procedure [8]. Turbinoplasty, in which resection of the lateral mucosa and parts of the turbinal bone is performed is of similar effectivity and low complication rate. Radiofrequency, a very mild procedure that can easily be performed as an outpatient procedure, represents a further effective alternative as progressively studies could prove long lasting effectivity [80], [85], [90]. Increasingly, the laser is used for turbinate surgery [81], [82], [83], [86], [87], [88], [90], [91], [92], [93]. It has some conceptual advantages but also implies some disadvantages. Thus, laserturbinotomy can be performed under general anaesthetics, postoperative bleeding is very rare and even if it occurs it usually is less severe so that nasal packing is generally not necessary [83], [92]. Conceptual disadvantage is the partial destruction of the mucosal surface that prolongs the healing process. Reduced energy can reduce the destruction of the mucosal surface but the volume effect is also reduced. However, submucous laser application has meanwhile been described to minimise this problem [92]. To support the in-

dication for laserturbinotomy, rhinomanometry in advance and after application of local a-mimetic medication should be performed to simulate the benefit of turbinate reduction. Laserturbinotomy should be avoided in cases with additional paranasal sinus infection, nasal polyposis, deviated septum or other anatomical variations like septum deviation or stenosis of the nasal valve [81], [82], [83], [86], [87], [88], [90], [91], [92], [93]. Particularly the severity of a septum deviation that still justifies laserturbinotomy is very much dependent on the investigators experience. In example, laserturbinotomy on the convex side of a septum deviation could be correlated with an increased risk for septum perforation [92], [93]. Numerous different laser systems have been used for laserturbinotomy. The most frequently available CO₂-laser is not ideal as it lacks the possibility for fiber transmission and applies only minor coagulation which increases the risk of postoperative bleeding and adhesions. The KTP-laser is fiber transmissible and has a high adsorption for blood making this system very attractive [89], [90]. The Holmium-YAG-laser is also usable for laserturbinoplasty. It is used in pulsed mode but the depth of the effect is only about 0.4 mm. With the application of several stripes a good volume effect can be achieved. Nd-YAG-laser is most frequently used in contact mode and multiple spots are applied. The effect can invade much deeper making this system better for reduction of turbinate hyperplasia [79]. In our experience the diode laser is the best system available as it applies the effect up to about 3 mm depth. We use this system in continu-

ous-wave-mode and apply longitudinal stripes on the turbinate surface (Figure 10) [81].

3.4. Postsurgical treatment

As mentioned above an intensive postsurgical treatment after laserturbinotomy in mandatory as crust formation occurs with nearly all laser systems used. Creams like Jellin-Neomycin or Bepanthen and additional ointment with NaCl are good choices. As the volume effect usually develops within 2 weeks local α -mimetics may be used.

4 Conclusions

Surgery of the nasal septum and turbinates are among the most frequently performed procedures in otolaryngology. They are performed in varying techniques for decades. By contrast, the study material for evaluation of the different techniques is still unsatisfactory. This is partially due to the fact that the indication for surgery is very subjective and mainly depends on the experience of the surgeon. Even though a variety of procedures to objectively measure nasal function are available today the effort to exactly evaluate the nasal pathology is very high and thus not applied in routine clinical work. Every otolaryngologist should have detailed anatomical and pathophysiological knowledge of the inner nose. The surgeon has to be experienced in the different techniques available today to be able to perform these procedures safely and effectively. The surgeon must be aware that the basic techniques are not sufficient to solve all septum problems. It is the author's intention to point out that it should be avoided that relatively inexperienced surgeons use aggressive surgical procedures and thus produce more harm than benefit. The procedure is particularly demanding if it is integrated into rhinoplasty as it itself can influence the outer aspect of the nose. In rhinoplasty, a good cosmetic result can be achieved by experienced colleagues from other specialisations, however, a good result that considers all cosmetic and functional aspects of the nose can only be achieved by the experienced otolaryngologist.

5 Acknowledgement

I particularly want to thank Alexander Berghaus, professor and chairman of our department for his very helpful criticism and supplement and for leaving some figures (Figure 2 and Figure 3). Additionally, I want to thank Andreas Leunig, consultant otolaryngologist of our department for his support and picture material (Figure 8). Dr. Miriam Havel assisted in literature search and Mr. Martin Müller in writing the manuscript.

References

1. Cole P. The Respiratory Role of the Upper Airways. A Selective Clinical and Pathological Review. Saint Louis, Mittelohr: Mosby Year Book 1993, 164-165.
2. Eccles R. Nasal Airflow in Health and Disease. *Acta Otolaryngol.* 2000; 120: 580-595.
3. Hanf G, Schierhorn K, Brunnée T, Matthias C, Kunkel G. Neuromodulation von Mastzellen in humaner Nasenschleimhaut. Histaminfreisetzung durch Neuropeptide in vitro. *Allergologie* 1997; 20: 121-127.
4. Kamani T, Yilmaz T, Surucus Turan E, Brent KA. Scanning Electron Microscopy of Ciliae and Saccharine Test for Ciliary Function in Septal Deviations. *Laryngoscope* 2006; 116: 586-590.
5. Mabry RL. Chronic Nasal Obstruction. In: Gates G, editor. *Current Therapy in Otorhinolaryngology, Head and Neck Surgery*. Toronto: BC Decker; 1987. p. 274.
6. Matthias C, de Suuza P, Merker HJ. Morphological Investigations on the Epithelium and Subepithelial Connective Tissue of the Human Paranasal Sinus Mucosa. *J Rhinol.* 1997; 4 (2): 129-138.
7. Wiesmiller K, Keck T, Rettinger G, Leiacker R, Dzida R, Lindemann I. Nasal Air Conditioning in Patients before and after Septoplasty with Bilateral Turbinoplasty. *Laryngoscope* 2006; 116 (6): 890-894.
8. Mlynski G. Wiederherstellende Verfahren bei gestörter Funktion der oberen Atemwege. *Nasale Atmung. Laryno-Rhino-Otologie* 2005; 84 Suppl.1: 101-117.
9. Maran AGD, Lund VJ. Nasal Anatomy. In: Maran AGD, Lund VJ, editors. *Clinical Rhinology*. Stuttgart: Thieme; 1990. p. 5.
10. McKinney P, Johnson P, Walloch J. Anatomy of the Nasal Hump. *Plast Reconstr Surg.* 1986; 77: 404-407.
11. Straatsma BR, Straatsma CR. The Anatomical Relationship of the Lateral Nasal Cartilage to the Nasal Bone and the Cartilaginous Nasal Septum. *Plast Reconstr Surg.* 1951; 8: 443-445.
12. Converse JM. The Cartilaginous Structures of the Nose. *Ann Otol Rhinol Laryngol.* 1955; 64: 220.
13. O'Neal RM, Beil RJ, Schlesinger J. Surgical Anatomy of the Nose. *Clin Plast Surg.* 1996; 23 (2): 195-222.
14. Dingman RO, Natvig P. Surgical Anatomy in Aesthetic and Corrective Rhinoplasty. *Plast Surg Clin.* 1977; 4: 111-114.
15. Cauna N. Blood and Nerve Supply of the Nasal Lining. In: Proctor DF, Andersen I, editors. *The Nose, Upper Airways Physiology and the Atmospheric Environment*. Amsterdam: Elsevier; 1982. p. 45-69.
16. Haight JSJ, Cole P. Site and Function of the Nasal Valve. *Laryngoscope* 1983; 93: 49-55.
17. Bridger GP. Physiology of the Nasal Valve. *Arch Otolaryngol.* 1970; 92: 543-553.
18. Matthias C, de Suuza P, Merker HJ. Electron Microscopic and Immunomorphological Investigations of the Mucosa of the Human Paranasal Sinuses. *Eur Arch Otorhinolaryngol.* 1997; 254: 230-235.
19. Schierhorn K, Zang M, Matthias C, Kunkel G. Influence of Ozone and Nitrogen Dioxide upon Histamine and Interleukin Formation in a Human Nasal Mucosa System. *Am J Respir Cell Mol Biol.* 1999; 20 (5): 1013-1019.
20. Yigit O, Akgul G, Alkan S, Uslu B, Dadas B. Changes Occurring in the Nasal Mucociliary Transport in Patients with One-Sided Septum Deviation. *Rhinology* 2005; 43: 257-260.

21. Ganzer U, Arnold W. Leitlinien: Septumplastik. <http://www.hno.org/publikationen/leitlinien.html>.
22. van Dishoek HAE, Leiden MD. The Part of the Valve and the Turbinates in Total Nasal Resistance. *Int Rhinol*. 1965; 3: 19-26.
23. Cottle JM. The Maxilla-Premaxillary Approach to Extensive Nasal Septum Surgery. *Arch Otolaryngol Head Neck Surg*. 1958; 68: 301-306.
24. Berger G, Gass S, Ophir B. The Histopathology of the Hypertrophic Inferior Turbinate. *Arch Otolaryngol Head Neck Surg*. 2006; 132 (6): 588-594.
25. Guyuron B, Uzzo CD, Scull H. A practical classification of septonasal deviation and an effective guide to septal surgery. *Plast Reconstr Surg* 1999; 104 (7): 2202-2212 .
26. Sciuto S, Bernadeschi D. Excision and Replacement of Nasal Septum in Aesthetic and Functional Nose Surgery: Setting Criteria and Establishing Indications. *Rhinology* 1999; 37: 74-79.
27. Carroll T, Ladner K, Meyers AD. Alternative Surgical Dissection Techniques. *Otolaryngol Clin North Am* 2005; 38 (2): 397-411.
28. Fjermedal O, Saunte C, Pedersen S. Septoplasty and / or Submucous Resection? 5 Years Nasal Septum Operation. *J Laryngol Otol*. 1988; 102: 796-798.
29. Gubisch W. The Extracorporeal Septumplasty: Technique to Correct Difficult Nasal Deformities. *Plast Reconstr Surg*. 1995; 95 (4): 672-681.
30. Gubisch W. 20 Jahre mit der extrakorporalen Septumkorrektur. *Laryngo-Rhino-Otol*. 2002; 81: 22-30.
31. Hellmich S. Septumplastik. *Laryngol-Rhinol-Otol*. 1997; 76: 663-666.
32. Hwang PH, McLaughlin RB, Lanza DC, Kennedy D. Endoscopic Septoplasty: Indications, Technique, and Results. *Otolaryngol Head Neck Surg*. 1999; 120 (5): 678-682.
33. Kastenbauer ER. Eingriffe an der Nasenscheidewand. *Laryngol-Rhinol-Otol*. 1997; 76: A 93 - A 103.
34. King HC, Mabry RL. Surgical Approaches to Correcting Nasal Obstruction. In: King HC, Mabry RL. *A Practical Guide to the Management of Nasal and Sinus Disorders*. Stuttgart: Thieme; 1993. p. 94.
35. Marschall HAH, Johnston MN, Jones NS. Principles of Septal Correction. *J Laryngol Otol*. 2004; 118: 129-134.
36. Masing H, Hellmich S. Erfahrungen mit konserviertem Knorpel bei Wiederaufbau der Nase. *Z Laryngol Rhinol*. 1968; 47: 904-914.
37. Mayer B, Henkes H. Mini-Septumplastik - für Funktion und Form. *Laryngo-Rhino-Otol*. 1990; 69: 303-307.
38. Newman MH. Surgery of the Nasal Septum. *Clin Plast Surg*. 1996; 23 (2): 271-279.
39. Peacock MR. Mucous Resection of the Nasal Septum. *J Laryngol Otol*. 1981; 95: 341-356.
40. Pirsig W, Kern EB, Ferser T. Reconstruction of Anterior Nasal Septum: Back-to-Back Autogenous Ear Cartilage Graft. *Laryngoscope* 2004; 114: 627-638.
41. Toriumi DM, Becker DG. Septoplasty. In: *Rhinoplasty: Dissection Manual*. Philadelphia: Lippincott; 1999. p. 31.
42. Schultz-Coulon HJ. Anmerkungen zur Septumplastik. *HNO* 2006; 54: 59-70.
43. Stockstead VP, Vase P. Perforations of the Nasal Septum Following Operative Procedures. *Rhinology* 1978; 16: 123-138.
44. Lawson W, Kessler S, Biller JF. Unusual and Fatal Complications of Rhinoplasty. *Arch Otolaryngol*. 1983; 109: 164-169.
45. Miller T. Immediate Postoperative Complications of Septoplasties and Septorhinoplasties. *Trans Pac Coast Ophthalmol Soc*. 1976; 57: 201-205.
46. Schwab JA, Pirsig W. Complications of Septal Surgery. *Facial Plast Surg*. 1997; 13 (1): 3-14.
47. Boenisch M, Tamas H, Nolst-Trenité GJ. Influence of Polydioxanone Foil on growing Septal Cartilage after Surgery in an Animal Model: New Aspects of Cartilage Healing and Regeneration. *Arch Facial Plast Surg* 2003; 5(4): 316-319.
48. Rettinger G. Autogene und allogene Knorpeltransplantate in der Kopf- und Halschirurgie. *Eur Arch Oto-Rhino-Laryngol. Suppl*. 1992; 1: 127-162.
49. Holt GR, Garner ET, McLarey D. Postoperative Sequelae and Complications of Rhinoplasty. *Otolaryngol Clin North Am*. 1987; 20: 853-876.
50. Boccieri A, Pascali M. Septal Crossbar Graft for the Correction of the Crooked Nose. *Plast Reconstr Surg*. 2003; 111 (2): 629-638.
51. Foda HMT. The Role of Septal Surgery in Management of the Deviated Nose. *Plast Reconstr Surg*. 2005; 406-415.
52. Tzadik A, Gilbert SE, Sade J. Complications of Submucous Resections of the Nasal Septum. *Arch Otorhinolaryngol*. 1988; 245: 74-76.
53. Pirsig W, Schäfer J. The Importance of Antibiotic Treatment in Functional and Aesthetic Rhinosurgery. *Rhinology Suppl*. 1998; 4: 3-11.
54. Weimert TA, Yoder MG. Antibiotics and Nasal Surgery. *Laryngoscope* 1980; 90: 667-672.
55. Eschelmann LT, Schleunig AJ, Brummett RE. Prophylactic Antibiotics and Otolaryngologic Surgery. A Double Blind Study. *Trans Am Acad Ophthalmol Otolaryngol*. 1971; 75: 387-394.
56. Huizing EH. The Management of Septal Abscesses. *Facial Plast Surg*. 1986; 3 (4): 243-252.
57. Bewarder S, Pirsig W. Long-Term Results of Submucous Septal Resection. *Laryngol Rhinol*. 1978; 57: 922-931.
58. White A, Murray JA. Intransal Adhesion Formation Following Surgery for Chronic Nasal Obstruction. *Clin Otolaryngol*. 1988; 13: 139-143.
59. Konstantinidis I, Triaridis S, Triaridis A, Karagianidis K, Kontzoglou G. Long-Term Results Following Nasal Septum Surgery: Focus on Patients' Satisfaction. *Auris Nasus Larynx* 2005; 32: 369-374.
60. Pfaar, O, Hüttenbrink KB, Hummel T. Assessment of Olfactory Function after Septoplasty: A Longitudinal Study. *Rhinology* 2004; 43: 195-199.
61. Stevens CN, Stevens MG. Quantitative Effects of Nasal Surgery on Olfaction. *Am J Otolaryngol*. 1985; 6: 264-267.
62. Kimmelman CP. The Risk of Olfaction from Nasal Surgery. *Laryngoscope* 1994; 104: 981-988.
63. Stewart MG, Smith TL, Weaver EM, Witsell, DL, Yueah B, Hannley MT, Johnson JT. Outcomes after Nasal Septoplasty: Results from the Nasal Obstruction Septoplasty Effectiveness (NOSE) Study. *Otolaryngol Head Neck Surg*. 2004; 130: 283-290.
64. Rowe-Jones, J. Nasal Surgery: Evidence of Efficacy. *Septal and Turbinate Surgery*. *Rhinology* 2004; 42 (4): 248-250.
65. Schultz-Coulon HJ. Experiences with the bridge-flap technique for the repair of large nasal septal perforations. *Rhinology* 1994;32: 25-33.
66. Schultz-Coulon HJ. Three layer repair of nasoseptal defects. *Otolaryngol Head Neck Surg* 2005;132(2): 213-217.
67. Kridel RWH. Septal perforation repair. *Otolaryngol Clin North Am* 1999;32(4): 695-724.

68. Woolford TJ, Jones NS. Repair of nasal septal perforations using local mucosal flaps and a composite cartilage graft. *J Laryngol Otol* 2001;115: 22-25.
69. Newton JR, White PS, Lee MSW. Nasal septal perforation repair using open septoplasty and unilateral bipedicled flaps. *J Laryngol Otol* 2003;117: 52-55.
70. Stoor P, Grenman R. Bioactive glass and turbinate flaps in the repair of nasal septal perforations. *Ann Otol Rhinol Laryngol* 2004;113: 655-661.
71. Meyer R, Berghaus A. Closure of perforations of the septum including a single session method for large defects. *Head Neck Surg* 1983;8: 390-400.
72. Osma Ü, Cüreoglu S, Akbulut N. The results of septal botton insertion in the management of nasal septal perforation. *J Laryngol Otol* 1999;113: 823-824.
73. Kastenbauer ER, Masing H. Chirurgie der inneren Nase, Versorgung von Nasenverletzungen. In: Naumann HH, editor. *Kopf- und Halschirurgie, Band 1, Teil 1*. 1985. p. 403-408.
74. Romo 3rd T, Foster CA, Korovin GS. Repair of nasal septal perforation utilizing the midface degloving technique. *Arch Otolaryngol* 1988;114: 739-742.
75. Paloma V, Samper A, Cervera-Pas F J. Surgical technique for reconstruction of the nasal septum: the pericranial flap. *Head and Neck*. 2000: 90-94.
76. Fukuta K, Avery C, Jachson YT. Long term complications of the galea-frontalis myofascial flap in craniofacial surgery. *Eur J Plast Surg* 1993; 16: 174-176.
77. Argenta LC, Friedman RJ, Dingman RO, Duus EC. The versatility of pericranial flaps. *Plast Reconstr Surg* 1985; 76(5): 695-702.
78. Cook PR, Begegni A, Cullen Bryant W, Davis WE. Effect of Partial Middle Turbinectomy on Nasal Airflow and Resistance. *Otolaryngol Head Neck Surg*. 1995; 113 (4): 413-419.
79. Chang CW, Ries WR. Surgical Treatment of the Inferior Turbinate: New Techniques. *Current Opin Otolaryngol Head Neck Surg*. 2004; 12 (1): 53-57.
80. Cavaliere M, Mottola G, Imma M. Comparison of the Effectiveness and Safety of Radiofrequency Turbinoplasty and Traditional Surgical Technique in Treatment of Inferior Turbinate Hypertrophy. *Otolaryngol Head Neck Surg*. 2005; 133 (6): 972-978.
81. Hoffmann P, Rudert H. CO₂- und Nd-YAG-Laser: Vergleich zweier Verfahren zur Nasenmuschelreduktion. *Arch Otorhinolaryngol. Suppl*. 1992; 2: 116-117.
82. Hopf JUG, Hopf M, Koffroth-Becker C. Minimal invasive Chirurgie obstruktiver Erkrankungen der Nase mit dem Diodenlaser. *Laser Med*. 1999; 14 (4): 106-115.
83. Janda P, Sroka R, Baumgartner R, Grevers G, Leunig A. Laser Treatment of Hyperplastic Inferior Nasal Turbinates: A Review. *Lasers Surg Med*. 2001; 28 (5): 404-413.
84. Jovanovic S, Dokic D. Nd:YAG-Laserchirurgie in der Behandlung der allergischen Rhinitis. *Laryngol Rhinol Otol*. 1995; 74: 419-422.
85. Kezirian J, Powell NB, Riley RW, Hester IE. Incidence of Complications of Radiofrequency Treatment of the Upper Airway. *Laryngoscope* 2005; 115 (7): 1298-1304.
86. Krespi YP, Slatkine M. Nd:YAG-Fiber Delivery System for Submucosal Interstitial Coagulation of Nasal Turbinates. *Laser Surg Med*. 1994; 15: 217-248.
87. Lippert BM, Werner JA. Behandlung der hyperplastischen unteren Nasenmuscheln. *HNO* 2000; 48 (4): 267-274.
88. Lippert BM, Werner JA. Long-Term Results after Laser Turbinectomy. *Laser Surg Med* 1998; 22: 126-134.
89. Talmon Y, Samet A, Gilbey P. Total inferior Turbinectomy: Operative Results and Technique. *Ann Otol Rhinol Laryngol* 2000; 109:1117-1119.
90. Porter MW, Hales NW, Nease CI, Krempel GA. Long-Term Results of Inferior Turbinate Hypertrophy with Radiofrequency Treatment. A New Standard of Care? *Laryngoscope* 2006; 116 (4): 554-557.
91. De la Chaux R, Dreher A, Clemens C, Rasp G, Leunig A. Respiratory Sleep Disorders: Benefit from Laser-Surgery. *MMW* 2004; 146 (47): 49-50.
92. Oswal V, Hopf JUG, Hopf M, Scherer H. Endonasal Laser Applications. In: Oswal V, Remacle M, editors. *Principles and Practice of Lasers in Otorhinolaryngology and Head and Neck Surgery*. The Hague, Holland; 2002. p. 163.
93. Oswal V, Krespi YJ, Kacker A. Nasal Turbinate Surgery. In: Oswal V, Remacle M, editors. *Principles and Practice of Lasers in Otorhinolaryngology and Head and Neck Surgery*. The Hague, Holland; 2002. p. 221.
94. Raynor EM. Powered endoscopic septoplasty for septal deviations and isolated spurs. *Arch Facial Plast Surg*. 2005; 7(6): 410-412.
95. Campbell JB, Watson MG, Shenoi PM. The Role of Intranasal Splints in the Prevention of Postoperative Adhesions. *J Laryngol Otol*. 1987; 101: 1140-1143.
96. Shone GR, Clegg RT. Nasal Adhesions. *J Laryngol Otol*. 198; 101: 555-557.
97. Fairbanks DN. Closure of nasal septal perforations. *Arch Otolaryngol* 1980;106(8): 509-513.
98. Federspil PA, Schneider M. Der individuell angepasste Nasenscheidewandobturator. *Laryngo-Rhino-Otol*. 2006; 85: 323-325.
99. Berghaus A, Jovanovic S. Technique and indications of extended sublabial rhinotomy ("midfacial degloving"). *Rhinology* 1991; 29 (2):105-110.

Corresponding author:

Prof. Dr. med. Christoph Matthias
ENT-Dept., Grosshadern Medical Center, Marchioninistr.
15, 81377 Munich, Phone: 089/7095-2990, Fax:
089/7095-88 91
Christoph.Matthias@med.uni-muenchen.de

Please cite as

Matthias C. *Surgery of the nasal septum and turbinates*. *GMS Curr Top Otorhinolaryngol Head Neck Surg*. 2007;6:Doc10.

This article is freely available from

<http://www.egms.de/en/journals/cto/2008-6/cto000044.shtml>

Copyright

©2008 Matthias. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en>). You are free: to Share – to copy, distribute and transmit the work, provided the original author and source are credited.