Why RHINO-SYS

Comparison of pre- and postoperative findings

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otopront®

Why RHINO-SYS

For "evidence-based medicine", a meaningful objective diagnosis is required preoperatively for functional surgical interventions and an objective quality control postoperatively. In ear surgery this is already standard practice. For functional-aesthetic rhinosurgery this demand is long overdue. The rhinomanometry available so far only allows an objective statement about the extent of a nasal obstruction and distinguishes between swelling and non-swelling obstruction. Ultimately, this method has not been established in the diagnostics for functional aesthetic rhinosurgery, because the clinical statements possible are not very helpful for the rhinosurgeon due to low informative value.

RHINO-SYS was developed in order to have a meaningful diagnostic tool for rhinosurgery. RHINO-SYS objectifies the extent of a nasal obstruction and distinguishes between the four possible causes:

- Swelling
- Skeletal stenosis
- Narrowing due to a pathological collapse of the nasal valve
- Pathological turbulence

In addition, further clinically important diagnostic parameters are established:

- Localization of the skeletal stenosis causing an obstruction
- Increase in resistance caused by a collapse of the nasal valve during inspection
- Differentiation between physiological and pathological valve collapse
- Differentiation between the possible causes of pathological valve collapse: increased aspiration due to Bernoulli phenomenon and loss of stability in the valve area
- Identification of possible causes for pathologic turbulence behaviour
- Objectification of nasal breathing disorders over a full day under the patient´s everyday living conditions
- Disturbances of the nasal cycle, e.g. after rhinosurgery as a cause of postoperative complaints and before augmentation in case of empty nose syndrome
- Regulating mechanism for the nasal respiratory air flow under physical strain to provide sufficient oxygen and
- Objectification of chronic mouth-bypass respiration

With RHINO-SYS, a diagnostic system has been developed which, on the basis of decades of experience, research work and fluid dynamics laws, as well as with the help of the measurement and computing technology available today, fulfils the expectations of a modern diagnostic device for functional aesthetic rhinosurgery.

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FUNCTIONAL AND DIAGNOSTIC POSSIBILITIES OF RHINO-SYS

RHINO-SYS is a diagnostic system consisting of rhinomanometry, rhinoresistometry, acoustic rhinometry and long-term rhinometry.

RHINO-SYS combines all the measurement methods available today for nasal breathing. This combination is useful for the following reasons:

- Rhinomanometry is the measuring method for rhinoresistometry.
- Rhinoresistometry enables the acquisition of flow dynamic parameters of the nasal airflow.
- Acoustic rhinometry, which is always carried out in conjunction with rhinoresistometry, provides a representation of the geometry of the nasal flow channel and thus enables an insight into the relationship between changes in shape and functional disorders.
- With long-term rhinometry (analogy: long-term blood pressure measurement, long-term ECG), nasal breathing is recorded over 24 hours under the normal living conditions of a patient. It thus enables
  - diagnosis of nasal problems outside the doctor's consultation,
  - a recording of the nasal cycle important for respiratory function over 24 hours,
  - insight into how the nose works with increased oxygen demand during physical strain.

The 4 measuring methods are described below.

1 RHINOMANOMETRY

A rhinomanometric measuring system was developed for **RHINO-SYS** which meets the requirements of the "International committee on objective assessment of the upper airways". Due to high measuring accuracy and good measuring dynamic properties, reliable and precise measured values of the pressure-flow behaviour of nasal breathing are made available for further mathematical processing. The hardware and software is user-friendly.

RHINO-SYS also meets hygienic requirements due to a bacterial filter. In order to avoid wrong measurement results, an intelligent software at the end of a measurement procedure gives an indication to repeat the measurement in case of insufficient mask and pressure tube adaptation as well as other errors during the measurement.

The values required by the "International committee on objective assessment of the upper airways" for rhinomanometry are separated for both sides of the nose and made available for the whole nose:

- In- and expiratory flow and resistance at 75 Pa and 150 Pa to objectify the extent of obstruction,
- Inspiratory flow increase from 75 Pa to 150 Pa. With the flow increase, the curvature of the ΔP V-curve is used to maintain the turbulence and concludes the intake phenomenon in the valve area. This is incorrect because the curve curvature can be influenced simultaneously by turbulence and a dynamic flow path constriction (inspiratorial nasal valve collapse) and the respective proportion of turbulence and aspiration is not differentiated.

Since the rhinomanometric values have little significance for surgical indication and planning, the method was further developed while retaining the measuring principle of rhinoresistometry.

RHINO-SYS hygiene advice

The RHINO-SYS offers all prerequisites for diagnostics at a high hygienic level: the face mask is available as reusable item. The reusable face mask can be reprocessed using manual or automated reprocessing procedures commonly used in hospitals (incl. washer-disinfector 95°C and autoclave 134°).The bacteria-virus filter has a high cross-infection efficiancy (>99.999%) for viruses (incl. SARS-CoV-2) and bacteria.

2 RHINORESISTOMETRY

Rhinoresistometry uses rhinomanometrically measured pressure and flow values of the nasal airflow to calculate new, diagnostically significant parameters, which are calculated with special software on the basis of fluid dynamics laws.

The results are displayed graphically in red for the right side of the nose and blue for the left side, light colored before decongestion and dark colored after decongestion. This allows a quick recording and evaluation of the measurement results, since conspicuous values outside the range of the available reference values are highlighted in yellow.

Numerical values allow an exact diagnosis.

RHINO-SYS hygiene advice

All parts with direct patient contact are available as disposable items: the face mask is available as a single-use disposable item. The bacteria-virus filter has a high cross-infection efficiancy (>99.999%) for viruses (incl. SARS-CoV-2) and bacteria.

2.1 Graphical representations

2.1.1 Graphical representation of nasal flow resistance

Figures 1 to 3 show rhinoresistometric curves for nasal breathing resistance as a function of inspiratory and expiratory flow. Similar to an audiogram, the representation allows a diagnosis at a glance. The higher the course of a curve, the higher the breathing resistance, i.e. the nasal obstruction.

In addition to the extent of an obstruction, the resistance curves also allow a differentiation between swelling, skeletal stenosis and nasal valve collapse as possible causes of nasal airway obstruction. Characteristic for swelling is the distance between the curves before and after decongestion. On Fig. 1, a visual diagnosis of a swelling in both sides of the nose can be recognized by the large distance between the light and dark coloured curves.

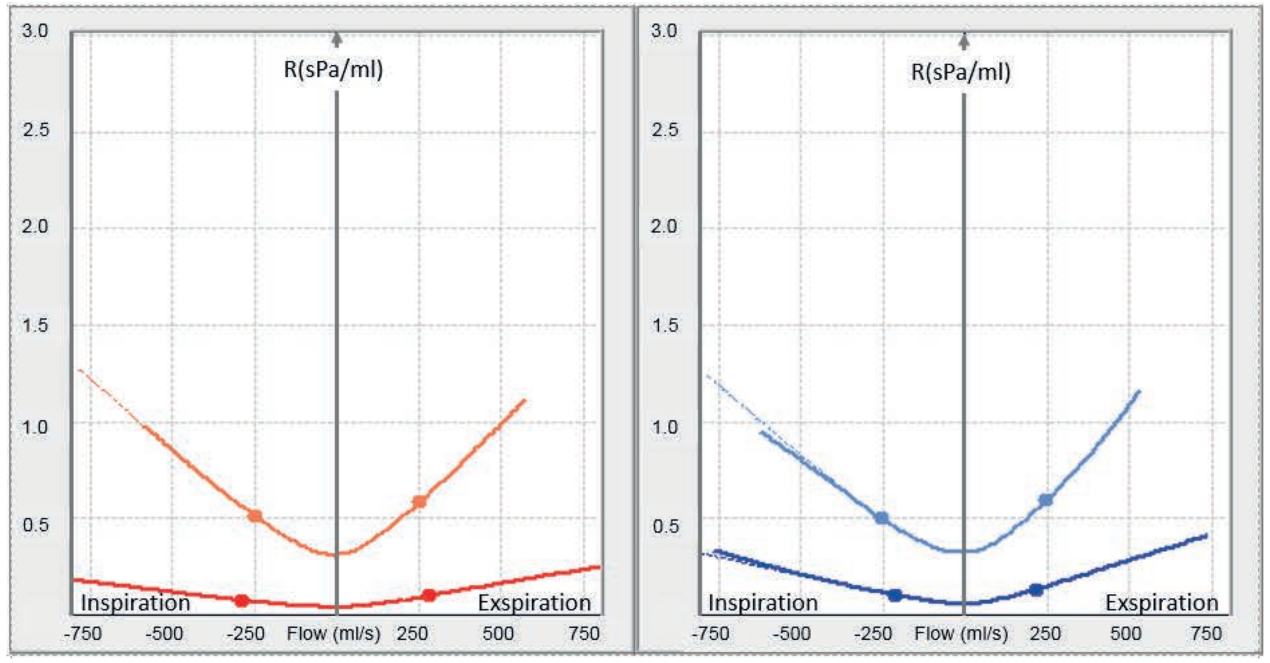


Fig. 1: Graphic representation of the inspiratory and expiratory nasal breathing resistance as a function of flow in a patient with a swelling of the mucous membrane in both sides of the nose.

In skeletal stenosis, the resistance remains high even after decongestion (Fig. 2 left side of the nose). For a gaze diagnosis the following applies: the higher the curve after decongestion, the narrower the skeletal stenosis.

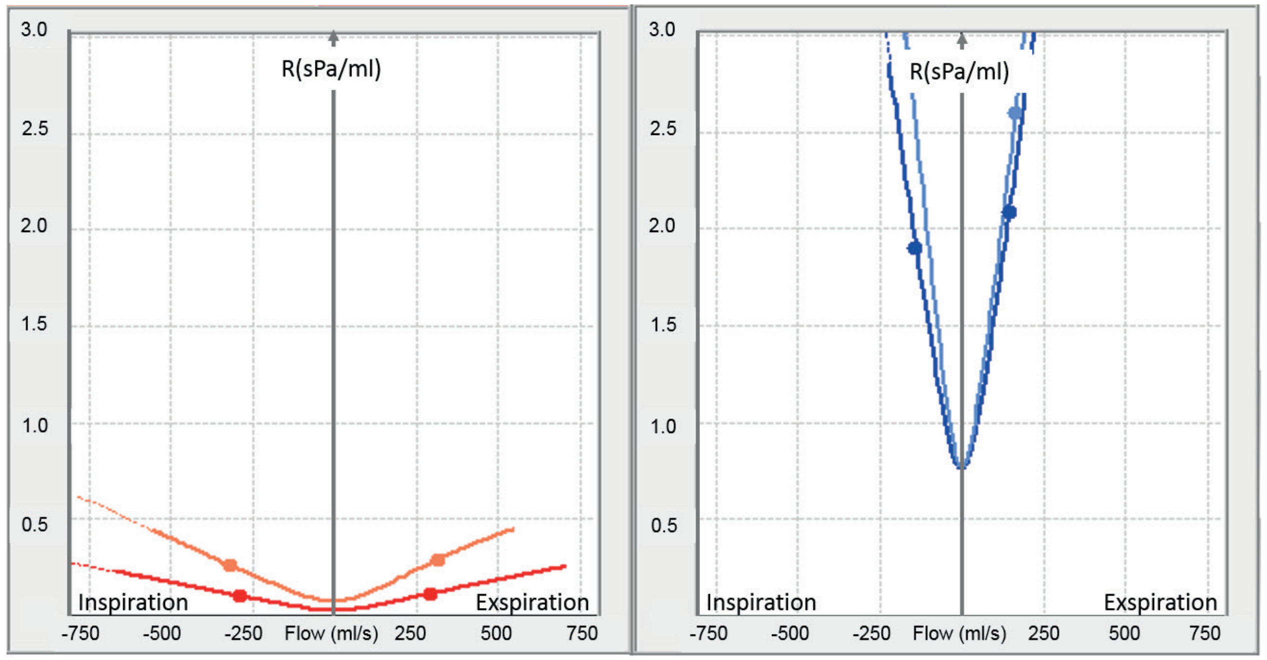


Fig. 2: Graphic representation of nasal breathing resistance as a function of inspiratory and expiratory flow in a patient with a skeletal stenosis on the left.

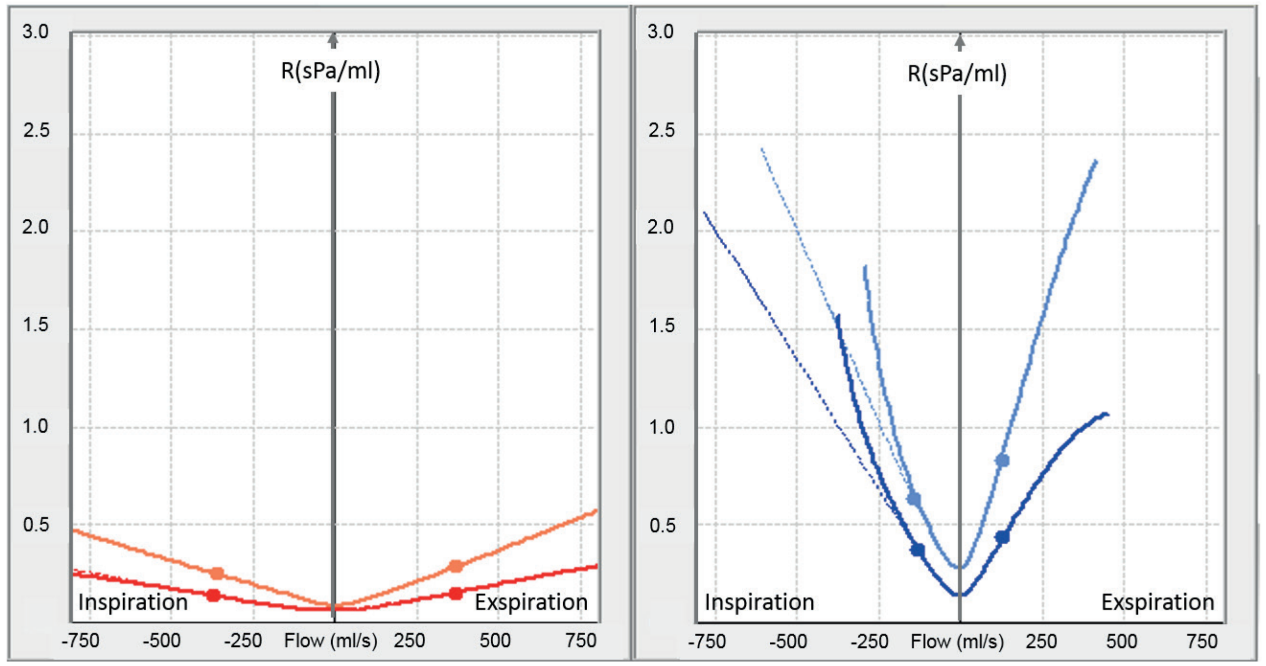


Fig. 3: Graphical representation of nasal breathing resistance as a function of inspiratory and expiratory flow in a patient with an inspiratory nasal valve collapse on the left.

An inspiratory nasal valve collapse can also be detected by gaze diagnosis. There are dotted lines on the inspiratory legs of the resistance curves (Fig. 1- 3). These are calculated and correspond to the course of the resistance curve with a stable nasal valve. The difference between the measured and calculated course of the curve corresponds to the extent of the suction due to the Bernoulli phenomenon.

Congruent calculated and measured curves can be seen on Fig. 1 and 2 for both sides of the nose and on Fig. 3 for the right side. Thus, it is objectified that these nasal valves are not sucked by inspiration. On Fig. 3 a considerable deviation of the measured curves from the calculated curves on the left side of the nose before and after decongestion and thus a suction of the nasal valve is verified.

When the patient puts on the face mask during a measurement, he/she breathes involun-tarily deeper than he/she would normally breathe at rest. Therefore, the curves are marked with a dot at the point where the flow in both sides of the nose amount to 500 ml/s. This is the maximum flow that is required for a sufficient oxygen supply during moderate physical exertion (climbing stairs).

Respiratory flows up to 500 ml/s should be guar-anteed by the nose without any problems, i.e. normal stair climbing should be possible without mouth bypass breathing. The points on the curves make it possible to see at a glance what proportion the sides of the nose contribute to the required overall flow under moderate physical exertion.

2.1.2 Graphical representation of turbulence behaviour in the nose as a function of flow

The graph in Fig. 4 allows a visual diagnosis of the flow behaviour with regard to the turbulence in the nose during inspiration and expiration, before and after decongestion.

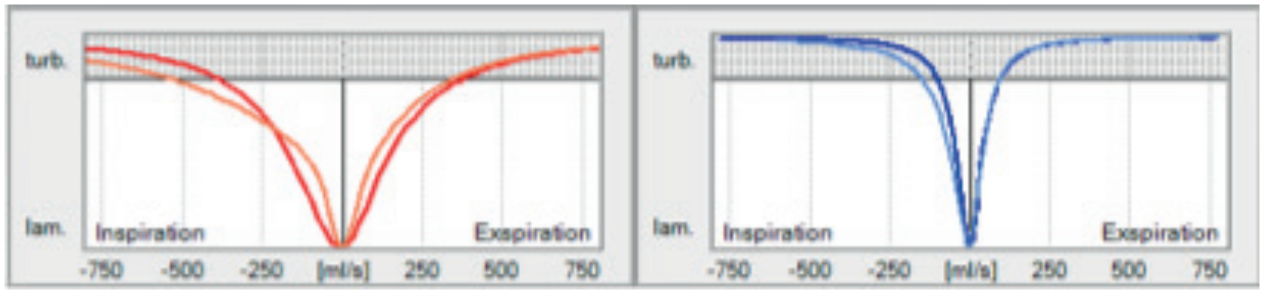


Fig. 4: Graphical representation of the inspiratory and expiratory turbulence behaviour of the same patient as the RRM resistance curves in Fig. 3.

A curve close to the x-axis ("lam." on left edge of the graph) speaks for predominantly laminar flow behaviour. If the curve lies in the grey-dotted area at the upper edge of the graph ("turb." at the left edge of the graph), the flow is completely turbulent. The transition from laminar to turbulent flow components can be seen in the rise of the curve with increasing flow velocity: the steeper, the faster the transition. This range should only be reached at a flow >250 ml/s.

This "physiological turbulence behaviour" is a prerequisite for sufficient air-mucosal contact and thus for the conditioning of the air in the nose (Fig. 4 right side of the nose). In case of "pathological turbulence retention" (Fig. 4 left side of nose), full turbulence is already achieved at low flow. This contributes to an increased breathing resistance and is the most frequent cause of sicca symptoms in the nose.

2.1.3 Numerical values

The following numerical values are calculated:

- The nasal breathing resistance [R250] is given at a flow of 250 ml/s. With equal flow resistance in both nasal sides, this breathing rate is required during moderate physical exertion (climbing stairs) in order to supply the organism with sufficient oxygen at a total rate of 500 ml/s without mouth bypass breathing. The extent of a nasal obstruction can be objectively evaluated with reference values (see appendix).
- The hydraulic diameter [Dh] is a common measure in engineering for the width of a flow channel with a non-circular cross-section. Since in the nose the cross-sectional areas deviate greatly from a round tube, the hydraulic diameter is a suitable width dimension for the nose. This dimension is diagnostically very important, because a nose that is too narrow leads to a high breathing resistance. A nose too wide causes pathological turbulence with the consequences described above.
- A collapse of the nasal valves is intended to limit the airflow at high flow rates and thus protect the nasal mucosa from excessive flow. A distinction must be made between this "physiological"and "pathological nasal valve collapse", which increases the nasal breathing resistance by more than 25 % even when the patient is at rest or under light physical stress and can thus contribute to an obstructive system. The percentage increase of the calculated resistance from the measured resistance [ΔR] as well as the flow rate at which the collapse begins [FNKK] are parameters with which a collapse of the nasal valve as a cause of obstructive symptoms can be distinguished with the following guide values (see appendix) can be assessed. When assessing a nasal obstruction, it is important to know how large the valve related resistance is. This can provide a reliable indication for a surgical therapy of the valve collapse.
- The turbulence behaviour in the nose is described with the flow velocity [FTurb], at which the flow is completely turbulent (see above).

For the numerical values, no normal values are given, but reference values. The reason for this are extranasal factors which influence the individual oxygen demand:

- Gender
- Age
- Body Mass Index
- Physical constitution
- Extranasal, particularly cardiopulmonary diseases

Accordingly, the nasal flow channel is individually adapted to different requirements.

For example, a flow resistance that is sufficient for a trained young man with a BMI<25 is not sufficient for an old, sick woman with a BMI >35. The reference values given by us are the average values of the measurements of 100 young, healthy female and male persons without rhinological complaints or operations. You will find these guide values in the appendix.

In order to facilitate the assessment of the rhinoresistometric findings, values which lie outside the guideline values are highlighted in yellow (Fig. 5).

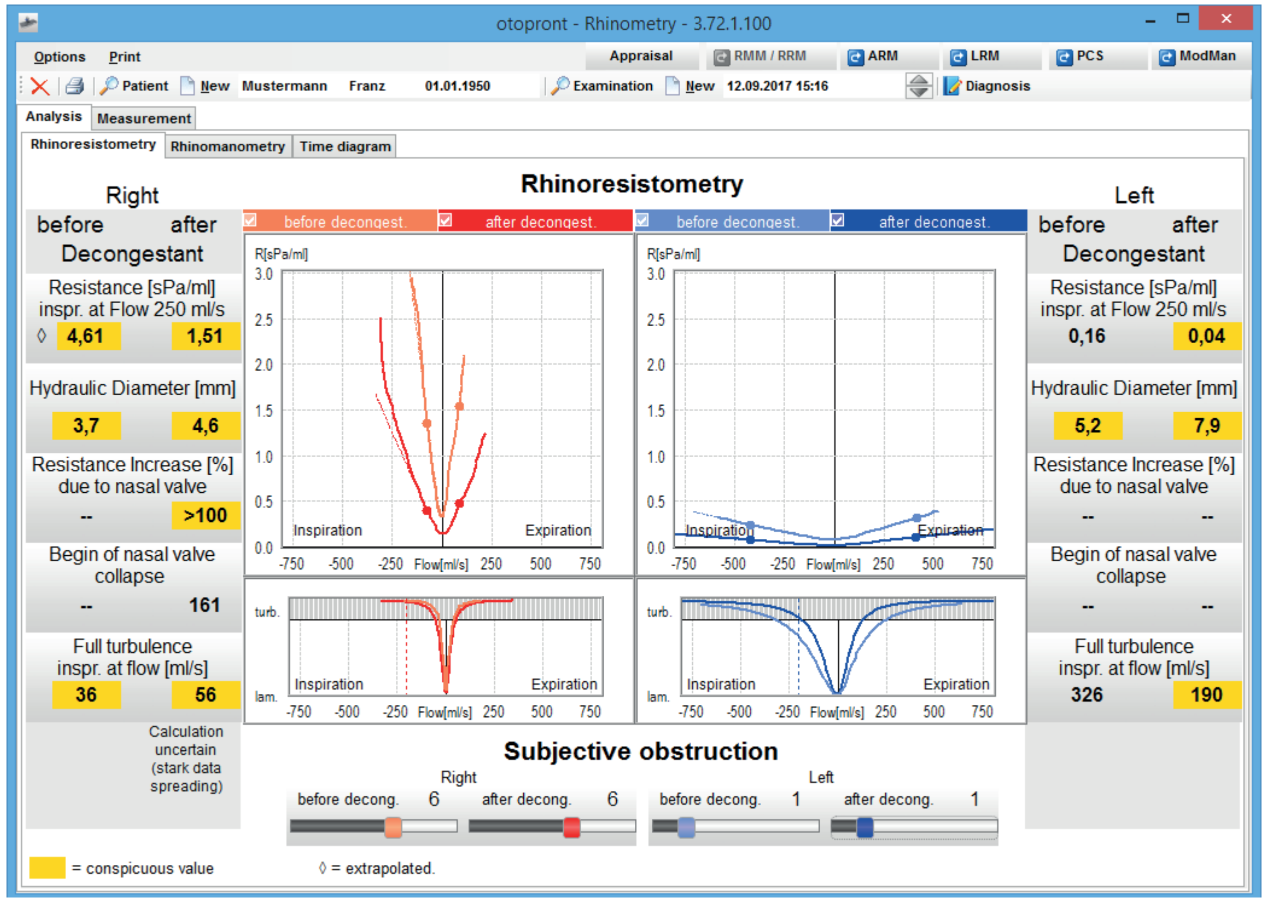
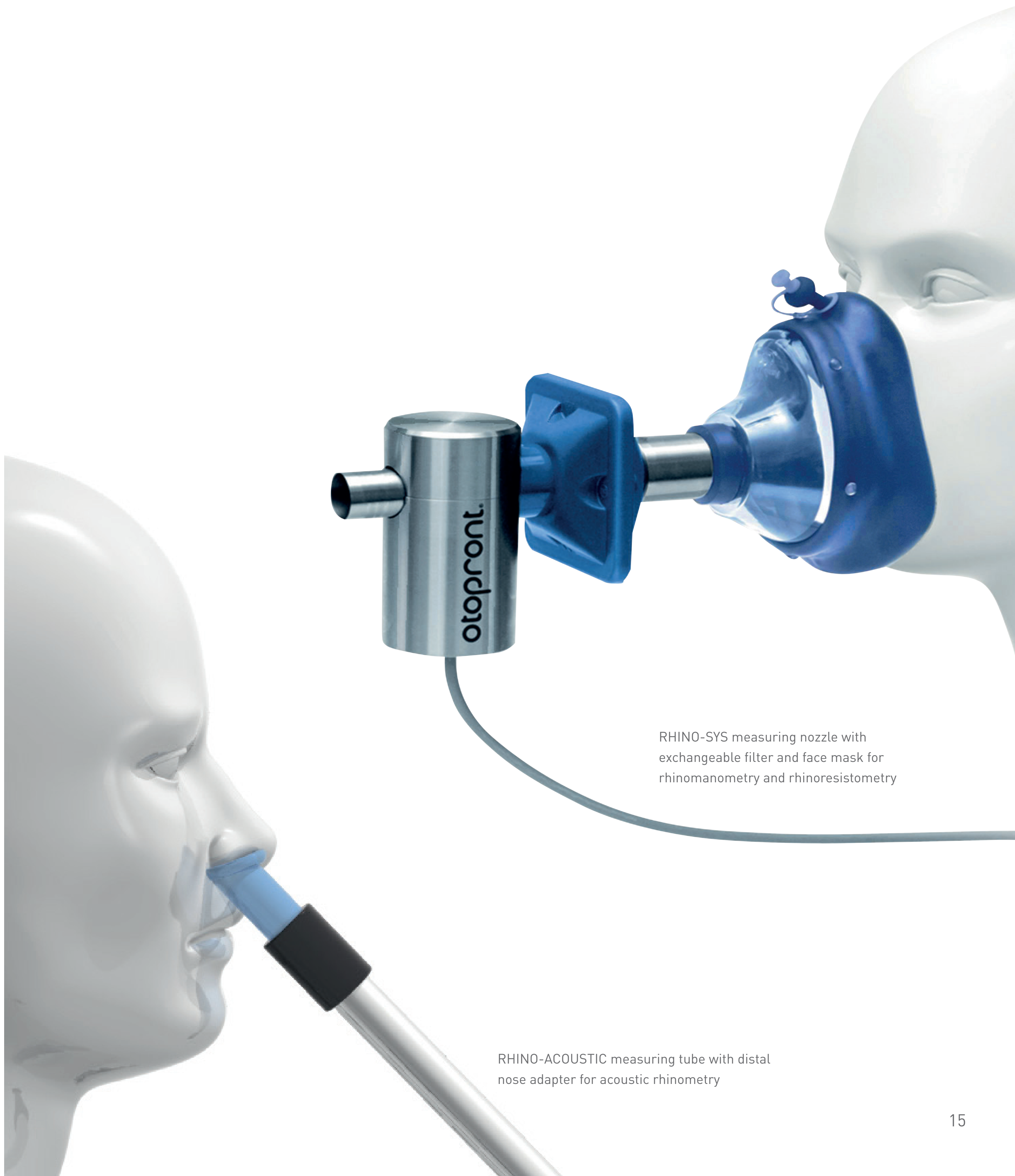


Fig. 5: Rhinoresistometric findings with yellow marking of the values outside the guideline values. Right side of the nose: Skeletal stenosis with pathological valve collapse and pathological turbulence. Left side of nose: After decongestion, unphysiologically low resistance if nose is too wide with pathological turbulence.



RHINO-SYS measuring nozzle with exchangeable filter and face mask for rhinomanometry and rhinoresistometry

RHINO-ACOUSTIC measuring tube with distal nose adapter for acoustic rhinometry

3 ACOUSTIC RHINOMETRY

Despite differentiation of the 4 causes of obstructions by means of rhinoresistometry, there are still open questions whose objective answer is necessary from a diagnostic point of view:

- Where is the skeletal constriction in the nose located?
- What is the cause for the pathological collapse of the nasal valve?
- What is the cause of the pathological turbulence?

To answer these questions, **RHINO-SYS** combines rhinoresistometry with acoustic rhinometry. Using sound waves in the nose, the geometry of the nasal interior can be measured. This is diagnostically important, since the flow in the nose depends crucially on the shape of the nasal flow channel.

3.1 Graphical representation

Fig. 6 shows the graphical representation of the cross-sectional areas in the nose measured by acoustic rhinometry as a function of their distance from the outer nostril. The physiological constrictions (MCA = Minimal Cross-sectional Area) are marked with red arrows:

- MCA0 = Ostium externum nasi (external nasal valve)
- MCA1: Ostium internum nasi (isthmus nasi, inner nasal valve)
- MCA2: head of the lower nose concha and septal swelling

ARM allows the objective localization of a rhinoresistometrically objectified constriction as the cause of obstruction. Fig. 6 shows a significant skeletal constriction at the level of the internal left orifice (blue arrow).

Possible causes for pathological turbulence formation can also be inferred from the acoustically and rhinometrically determined geometry of the inner nose.

The funnel-shaped expansion of the anterior nasal cavity in the inspiratory direction is important for the development of turbulence in the nose. Such an extension of the flow channel is called a diffuser in fluid dynamics.

The nasal diffuser begins at the narrowest point of the nose, the isthmus (inner nostril) and ends at the widest point in front of the head of the middle nose concha. With acoustic rhinometry, a "diffusor opening angle [ф]" can be calculated in this area before and after decay by means of regression (Fig. 7).

A large widening of the cross-section (large opening angle) causes strong turbulence, a small widening (small opening angle) causes small turbulence. In Fig. 7 the diffuser of the right side of the nose is marked yellow before decongestion and grey after decongestion.

A large opening angle [ф] in the swollen state corresponds to a working phase in the nasal cycle and causes predominantly turbulent flow. This is necessary for sufficient contact with the air and mucous membrane as a prerequisite for climatisation. The small opening angle [ф] in the swollen state corresponds to a rest phase in the nasal cycle with predominantly laminar flow.

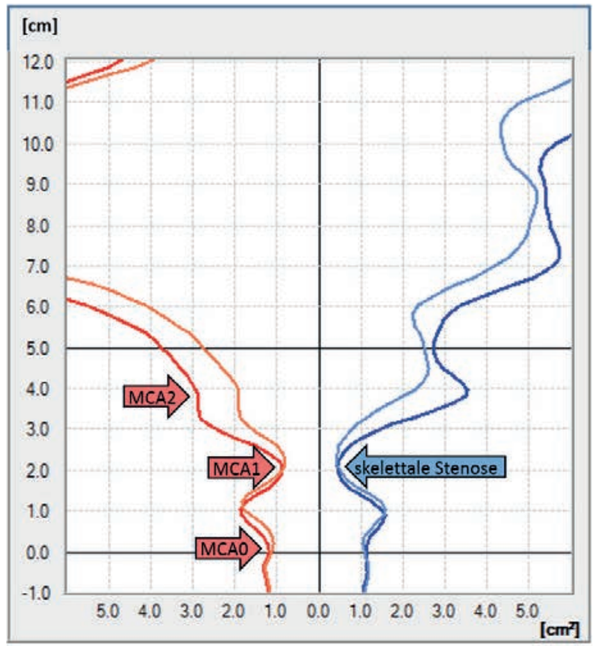


Fig. 6: ARM curves from the same patient as the RRM in Fig. 3: Objectification of the physiological constrictions in the right side of the nose (red arrows) and objectification of the location of a skeletal stenosis at the level of the internal left ostium (blue arrow).

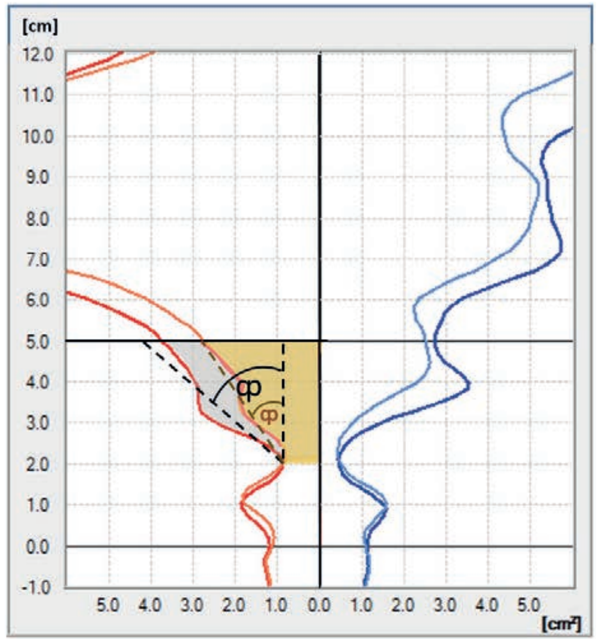


Fig. 7: ARM curves from the same patient as the RRM in Fig. 1. change in turbulence during the nasal cycle, illustrated by the change in the diffuser opening angle of the right side of the nose.
Yellow area: small opening angle in the swollen state (resting phase: mainly laminar flow).
Grey area: large opening angle after decongestion (working phase: mainly turbulent flow).

However, the size of the inlet opening also has an influence on the formation of turbulence: the smaller the opening, the stronger the turbulence (Fig. 8).

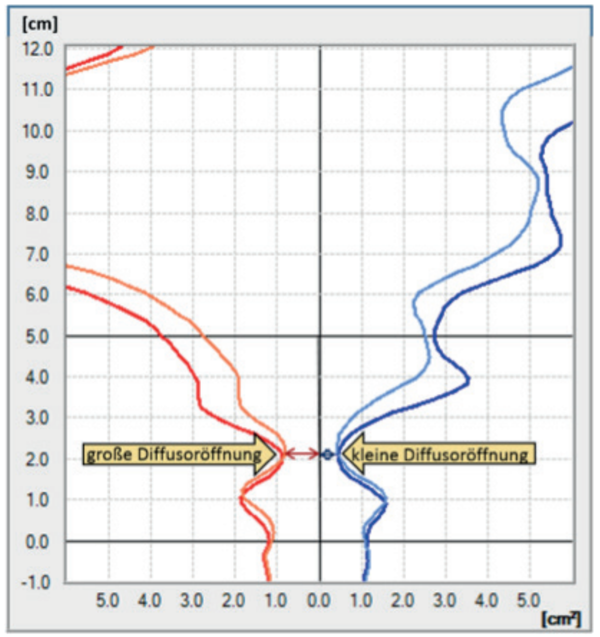


Fig. 8: ARM curves from the same patient as the RRM in Fig. 3. objectification of the possible causes of pathological turbulence in the nose.
Red area: right nasal diffuser with large entrance opening into the diffuser, blue area: left nasal diffuser with small diffuser opening.

The inflow opening is physiologically the MCA1. However, in the case of a "Ballooning phenomenon" it can also be MCA0, i.e. the outer nostril (Fig. 9).

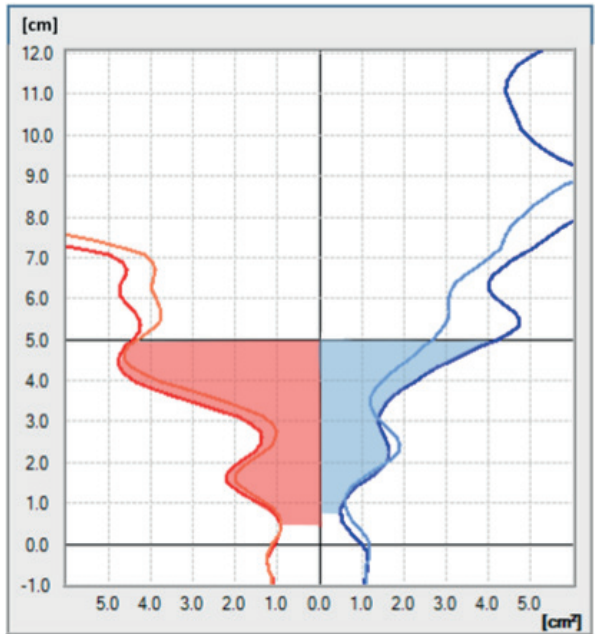


Fig. 9: Acoustic rhinometry in a patient with "ballooning phenomenon" in both sides of the nose.

RHINO-ACOUSTIC measuring tube with distal nose adapter

3.2 Numerical Values

The following numerical values are given in acoustic rhinometry for an exact diagnosis:

- Physiological constrictions MCA0, MCA1, and MCA2

  By comparing the current values of these constrictions after decongestion with the reference values (appendix), an exact evaluation of a skeletal stenosis is obtained. By comparing the MCA2 before and after decongestion, it is possible to objectify the swelling.
  The MCA1 is used to measure the diffuser input, which can contribute to the development of turbulence when constricted.

- Diffuser opening angle
  This angle provides information on the extent to which the front cavity promotes the formation of turbulent flows, due to its widened cross section, favours the formation of turbulent flow components. Orientation values see Appendix.

- Volumes in the front cavity nasi
  The acoustically rhinometrically determined volumes are particularly suitable for objectifying changes in swelling, because not only the change of a surface but also of a space volume is assessed. The following volumes are calculated:

  Volume 1: Volume between MCA1 and MCA2,

  Volume 2: Volume between MCA1 and a distance of 5 cm from the ostium externum.

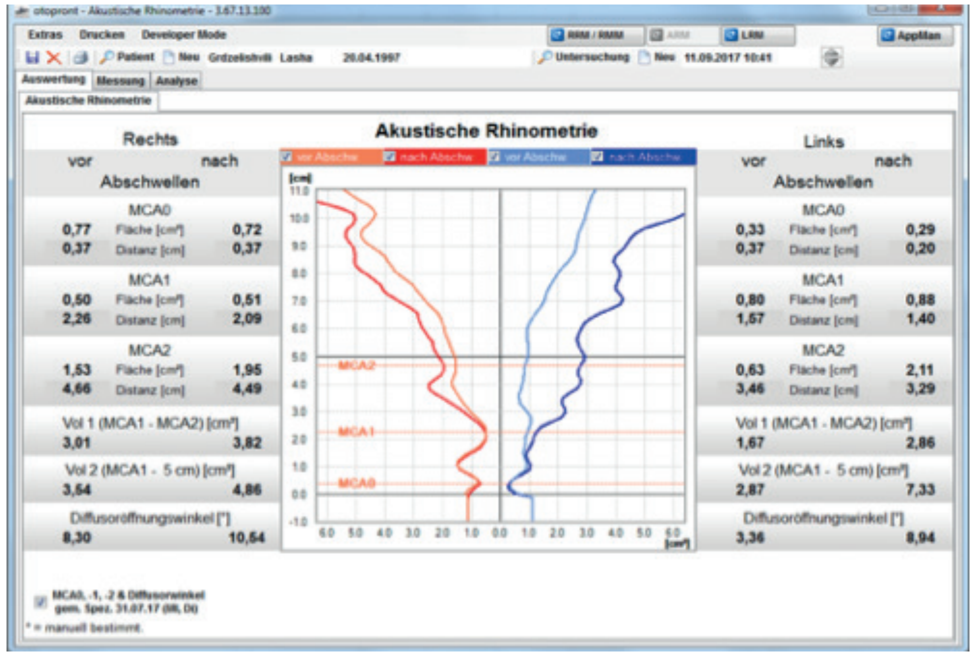


Fig. 10: Acoustic rhinometric findings from the same patient as in Fig. 5: On the right side the skeletal stenosis is localized in the isthmus region. The narrowing causes a high local flow velocity and thus a strong Bernoulli phenomenon with the consequence of a pathological nasal valve collapse. The strong cross-sectional expansion after constriction (large diffuser opening angle) causes the pathological turbulence. On the left side the wide cavity is visible after decongestion, causing pathological turbulence.

4 LONG-TERM RHINOMETRY

This method was developed to objectively represent the patient's complaints outside the time of a doctor's consultation during the course of his or her daily life, based on the long-term ECG or long-term blood pressure measurement. In long-term rhinometry, the nasal air flow is recorded and registered by means of a modified nasal cannula, separately for both sides of the nose over the course of a whole day. ECG electrodes are used to measure the heart rate as a measure of physical activity. The breathing rate and the nasal respiratory minute volumes are calculated. The results are displayed graphically.

Fig. 11 shows the results of a long-term measurement in a male person with unimpeded nasal breathing. The curves of the inspiratory flow maxima in the upper graph are coloured red for the right side of the nose and blue for the left side. In the lower graph, the orange curve corresponds to the heart rate, the green curve to the nasal respiratory minute volume and the purple curve to the respiratory rate.

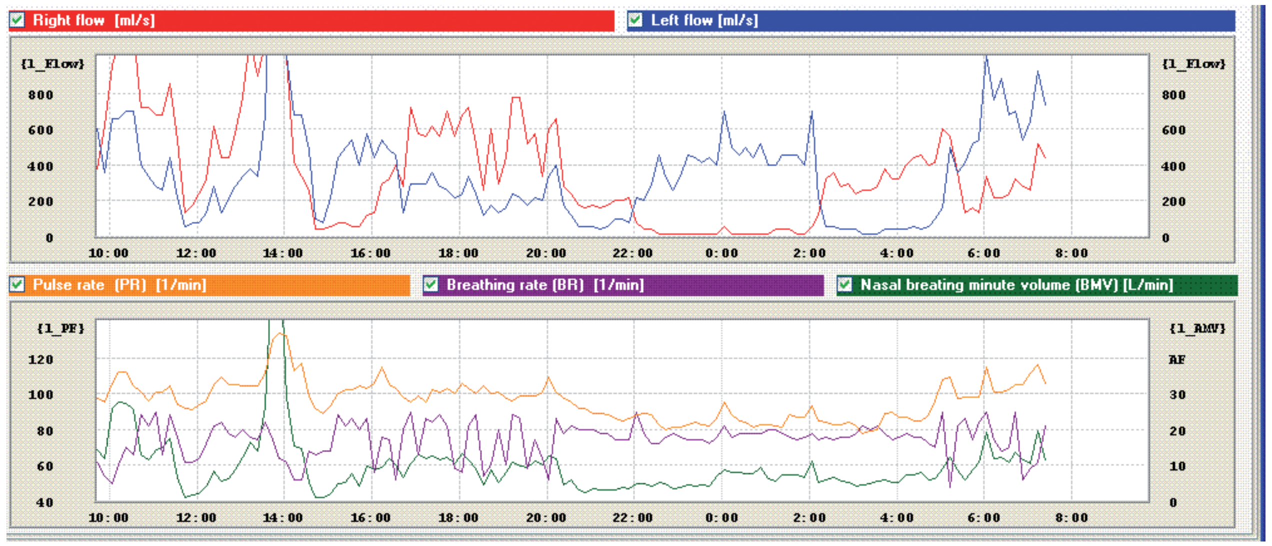


Fig. 11: Long-term rhinometry in a patient with unimpeded nasal breathing: normal nasal cycle, physiological reaction of the nose to increased oxygen demand due to physical exertion.
Upper graph:
X-axis: Time in hours
Y-axis: Nasal breathing volume velocity at the maximum of inspiration in ml/s.
Right side of nose (red), left side (blue). Lower graph: X-axis: Time in hours
Y-axis: heart rate = HR (orange), breathing rate = BR (purple), nasal breathing minute volume = BMV in L/min (green)

During the night's rest (22:00 to 05:00: resting heart rate), the flow curves show a classic nasal cycle with cyclical, reciprocal change of sides. During this time first the left side goes into working phase, then the right side. During the resting phase of the respective opposite side, the flow goes towards zero. The further course of the curves indicate that the person gets up around 05:00: The heart rate increases as does the nasal flow: the left side takes over a working phase with a higher flow than during rest and the right side goes into a non-complete resting phase; the right side must "help" to ensure a sufficient oxygen supply.

The nasal respiratory minute volume increases synchronously with the heart rate, i.e. with the physical strain. On the previous day between 1:00 and 2:30 p.m., the heart rate (around 130 bpm) indicates strong physical activity. The nose shows a physiological reaction: the nasal flow increases on both sides to over 800 ml/s, so that the nasal respiratory minute volume can be increased up to ten times the resting respiration. These values indicate a physiological reaction of the nose to increased oxygen demand due to physical activity.

Fig. 12 shows curves of a patient with a high degree of obstruction on both sides due to a tension nose.

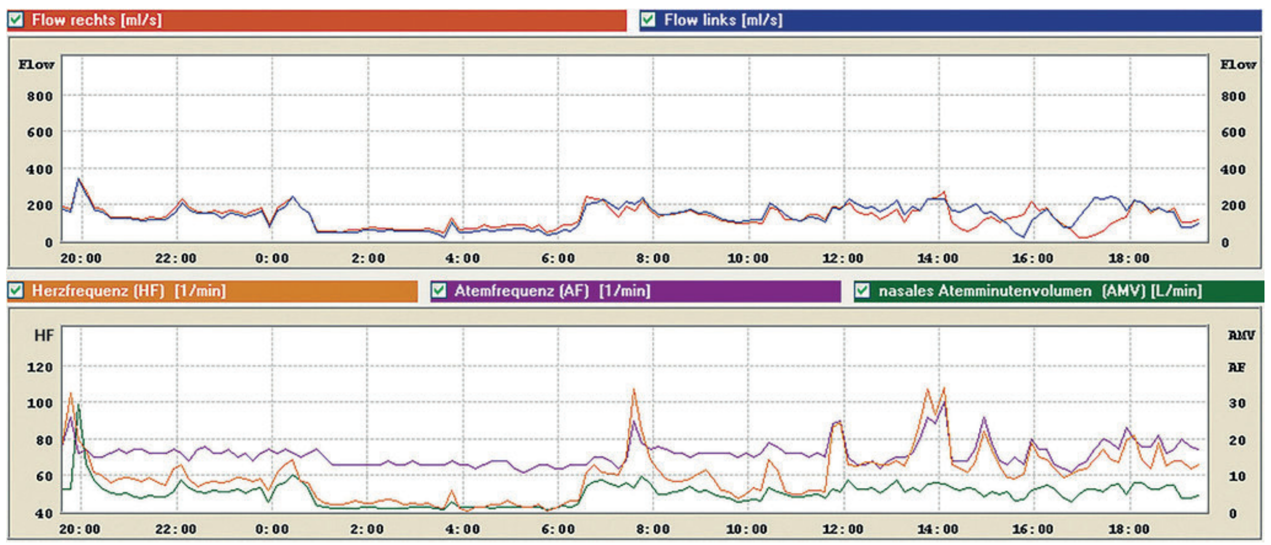


Fig. 12: Long-term rhinometry in a patient with obstructed nasal breathing on both sides due to tension nose: highly disturbed nasal cycle. In case of increased oxygen demand due to physical exertion, not sufficient physiological reaction of the nose, but mouth-bypass breathing.
Upper graph: X-axis: Time in hours.
Y-axis: Nasal breathing volume velocity at the maximum of inspiration in ml/s. Right side of nose (red), left side (blue).
Lower graph: X-axis: Time in hours
Y-axis: heart rate = HR (orange), breathing rate = BR (purple), nasal breathing minute volume = BMV in L/min (green)

In the patient, long-term rhinometry does not show a cyclical change with sufficient flow neither at night (20:30 to 06:30) nor during the day until 14:00. Because the nasal respiratory minute volume during the entire period of resting heart rate during the night is close to zero, it can be assumed that the patient sleeps with his mouth open. At 8:00 p.m. during a brief physical exertion (heart rate 100 bpm) an increase of the nasal respiratory minute volume can be seen by increasing the nasal flow. During the physical exertion at 07:30, 12:00 and 14:00 only an increase of the respiratory rate was registered, the flow in the nose and the nasal respiratory minute volume did not increase. This speaks in favour of mouthbypass breathing even during physical exertion.

The low flow values in the nose even during physical exertion, the largely missing classical change of the nasal cycle, as well as the mouth bypass breathing during the night and during physical exertion, are reliable signs of a high-grade nasal obstruction.

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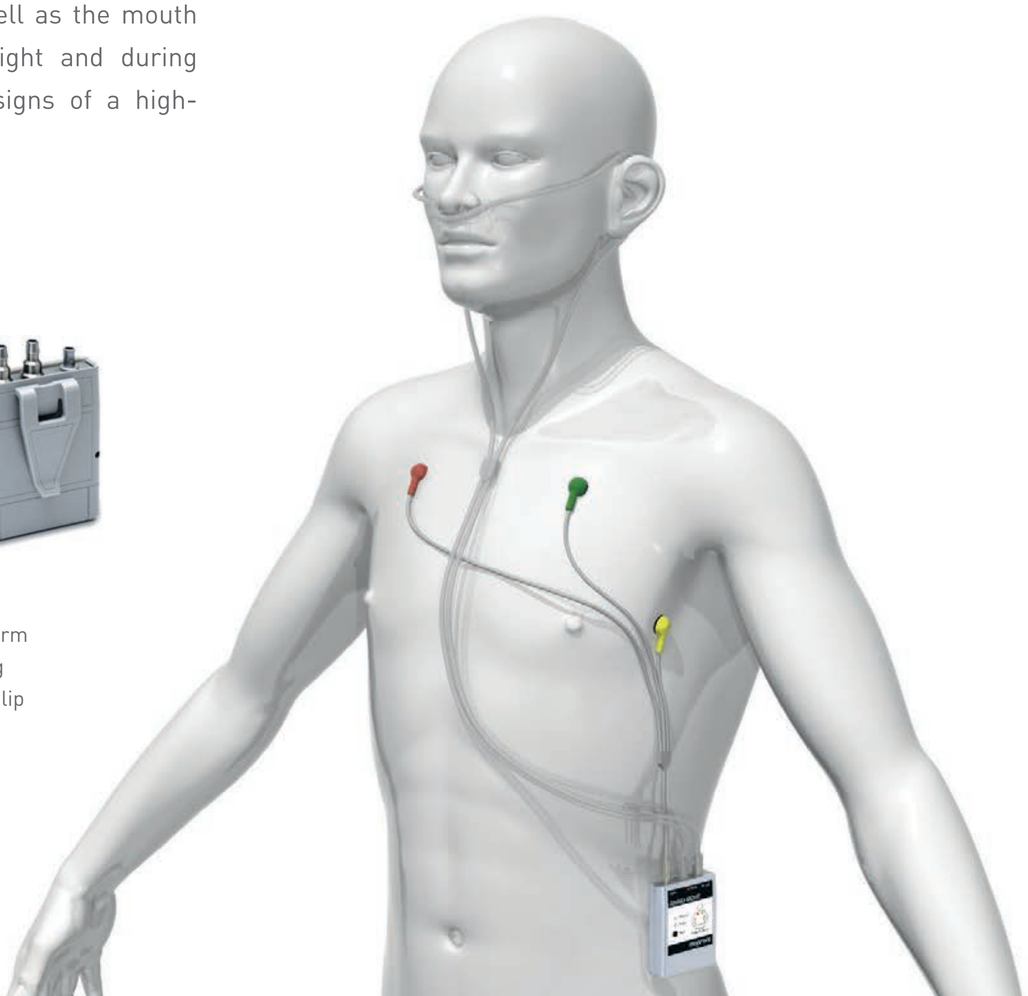
Source: Gunter Mlynski Wolfgang Pirsig, Functional-Aesthetic Rhinosurgery with special consideration of physiological aspects, 2018

RHINO-MOVE Long-term rhinometry measuring system with clothing clip



5 GUIDE VALUES FOR RHINORESISTOMETRY

Resistance at 250 ml/s	Degree of nasal obstruction of one side of the nose
< 0.17 sPa/ml	no obstruction
0.17 – 0.34 sPa/ml	moderate obstruction
0.35 – 0.70 sPa/ml	median obstruction
> 0.70 sPa/ml	heavy obstruction

Hydraulic diameter	Width of the nose
< 5.5 mm	too tight
5.5 – 6.5 mm	normal width
> 6.5 mm	too broad

Resistance increase ΔR	Inspiratory collapse
ΔR ≤ 25%	physiological
ΔR > 25%	pathological

Flow at full turbulence	Turbulence assessment
≤100 ml/s	highly pathological
>100 bis 200 ml/s	pathological
>200 ml/s	physiological

GUIDE VALUES FOR ACOUSTIC RHINOMETRY

Cross section area	Assessment of the width of the cross section
MCA0 > 0.9 cm²	physiological
MCA1 ~ 0.6 cm²	physiological
MCA2 > MCA1	physiological

Diffusor opening angle ϕ	Turbulence formation in the nose
<7°	low
7°- 9°	physiological
>9°	pathological

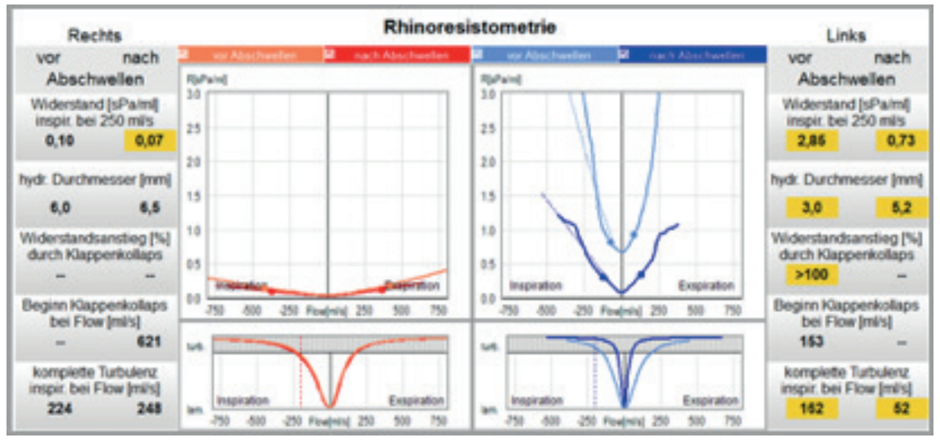
6 CASE STUDIES

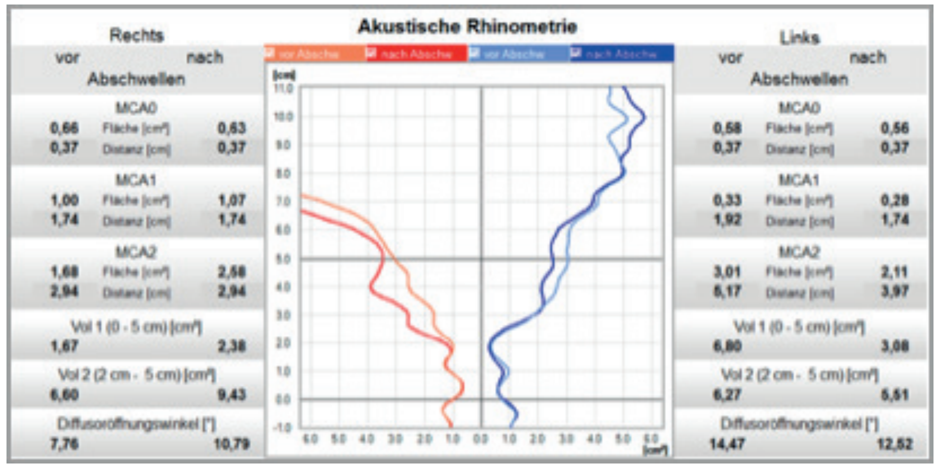
CASE 1: 41-year-old patient

PREOPERATIVE

Complaints: since childhood severely obstructed nasal breathing on the left, no complaints on the right.
Preoperative endonasal findings: septum deviation left in cottle region 2 and 3.

Results of preoperative functional diagnostics:





Evaluation of the preoperative functional findings: RRM: Right side of nose: Unphysiologically low nasal resistance with a wide cavity (hydraulic diameter 6.5 mm). Turbulence behaviour physiological.

Left side of nose: Respiratory resistance greatly increased after decongestion. The hydraulic diameter of 5.2 mm indicates skeletal stenosis as the cause of the pathological resistance. The turbulence behaviour is also pathological.

ARM: The skeletal stenosis on the left is located in the area of the inner nasal valve (MCA1 after decongestion: 0.28 cm²). The opposite side is very wide at the same height (MCA1 after decongestant: 1.07 cm²).

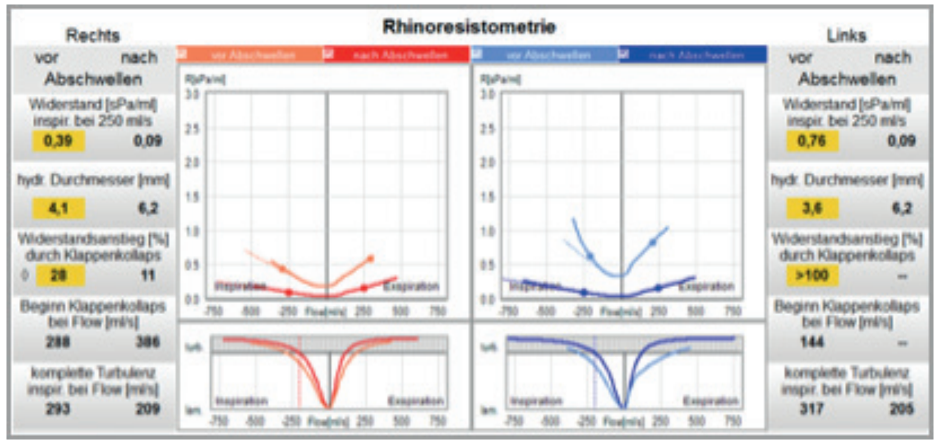
The pathological turbulence on the left is mainly due to a narrow entrance into the nasal diffuser (MCVA1: 0.28 mm).

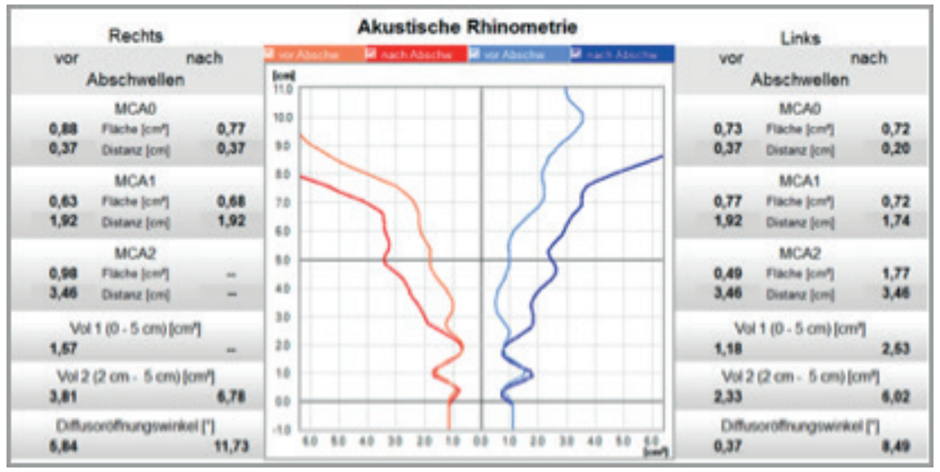
Diagnosis:
Septum deviation to the left. Operation planning: septoplasty, no concha surgery. Reason: Since the right side of the nose is very wide in the isthmus region and has a non-physiologically low flow resistance,a shifting of the septum to the right in the region of the inner nasal valve is not expected to cause postoperative obstruction of nasal breathing on the right side.

POSTOPERATIVE

Complaints: subjectively no nasal obstruction.
Postoperative endonasal findings: septum middling.

Results of the postoperative functional diagnostics:





Evaluation of the postoperative functional findings: RRM: Right side of the nose: The preoperative too little resistance has increased slightly postoperatively due to the septum gradient. It is now in the physiological range.

Left side of the nose: After decongestion, physiologically low resistance. Also the turbulence be-havior has normalized on the left side.

ARM: The skeletal stenosis on the left side in the area of the inner nasal valve has been corrected (MCA1 after decongestion: 0.72 cm²). The opposite side is still sufficiently wide at the same height (MCA1 after decongestion: 0.68 cm²).

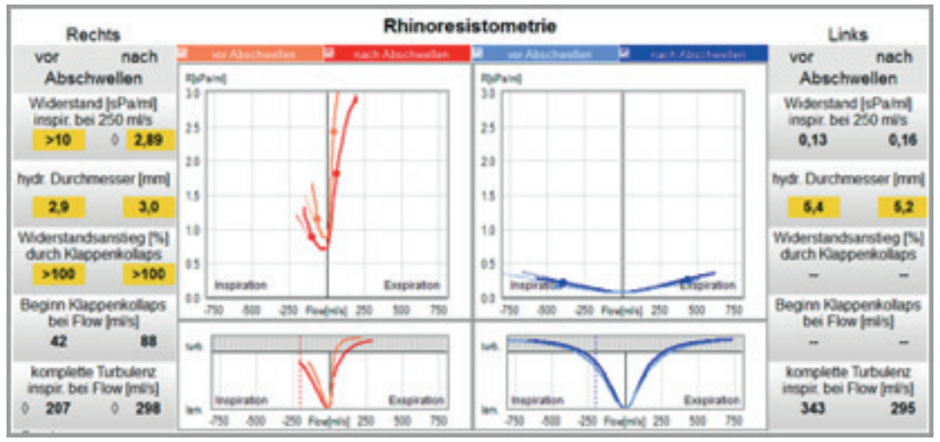
Assessment of the surgical result: By means of a septoplasty without conchoidal reduction the high breathing resistance and the pathological turbulence on the left side could be corrected. On the opposite side a physiological resistance was achieved.

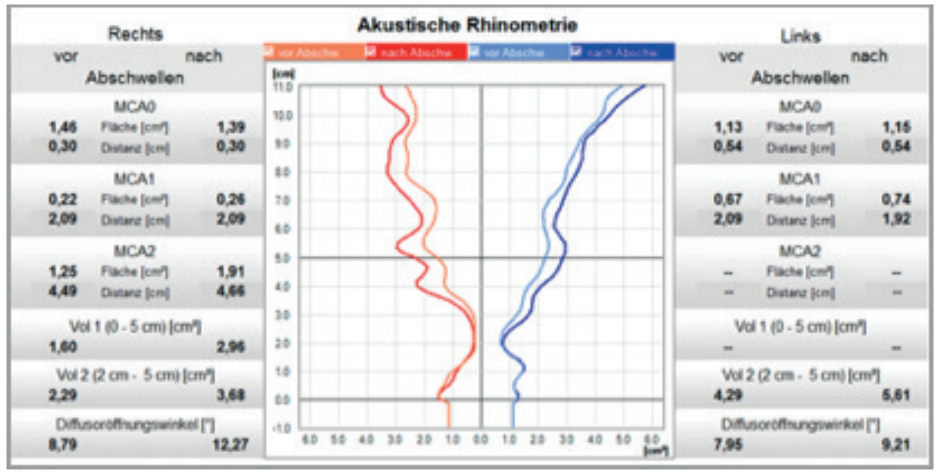
CASE 2: 51-year-old female,

PREOPERATIVE

Complaints: since childhood severely obstructed nasal breathing on the right, no complaints on the left.
Preoperative endonasal findings: septal deviation on the right in cottle region 2.

Results of preoperative functional diagnostics:





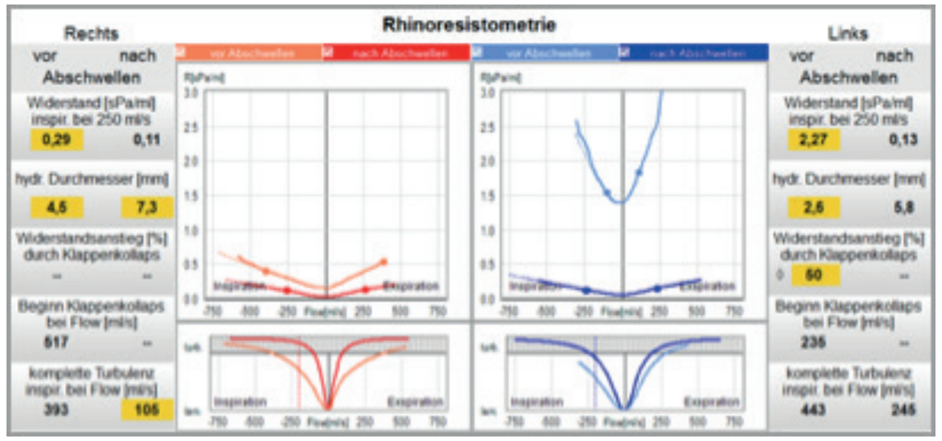
Assessment of the preoperative functional findings: RRM: Right nasal side: Even after decongestion severe obstruction due to skeletal stenosis (hydraulic diameter 3.0 mm), pathological inspiratory nasal valve collapse and pathological turbulence. Left side of the nose: Slightly constricted cavity (hydraulic diameter 5.2 mm). As a result, the resistance is at the border of a slight obstruction. ARM: The skeletal stenosis on the right is located in the area of the inner nasal valve (MCA1 after decongestion: 0.26 cm²). This causes the high resistance as well as an increased Bernoulli phenomenon (cause of valve collapse) due to constriction of the current path and pathological turbulence due to constriction of the diffuser entrance. Although the area of MCA1 on the opposite side is still sufficiently large at the same height (after decongestion: 0.74 cm²), the hydraulic diameter after decongestion (5.2 mm) already indicates a slight skeletal constriction. (Note: The flow resistance does not only depend on the size of a cross-sectional area, but also on its shape!)

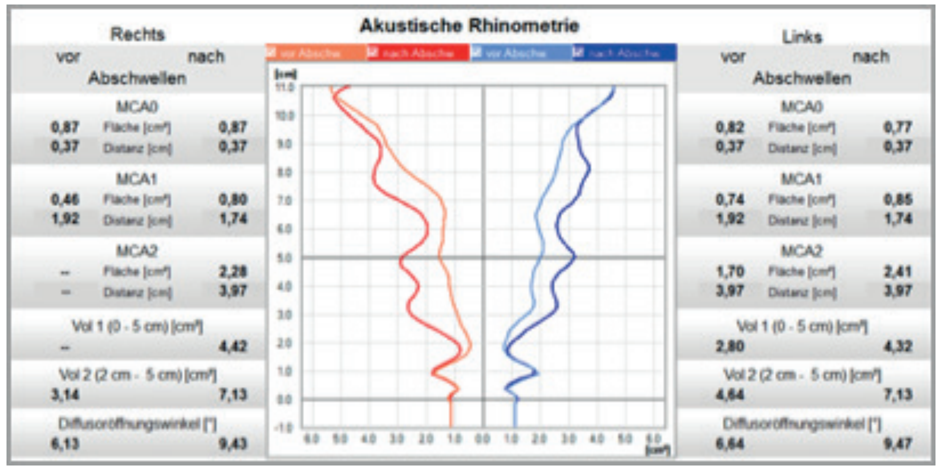
Diagnosis:
Septum deviation on the left side in cottle region 2 with insufficient width of the opposite side. Surgical planning: Septoplasty and dilatation of the isthmus region on both sides, no conchoidal reduction. Reason: To sufficiently relieve the high resistance on the right, a significant shift of the septum to the left is necessary. This would increase the slight skeletal constriction on the left side and the already borderline resistance would increase pathologically. Therefore, apart from a septoplasty, an overall widening of the isthmus region is necessary.

POSTOPERATIVE

Complaints: since childhood severely obstructed nasal breathing on the right, no complaints on the left.
Postoperative endonasal findings: septal deviation on the right in cottle region 2.

Results of the postoperative functional diagnostics:





Evaluation of the postoperative functional findings: RRM: Right side of the nose: The resistance has completely normalized postoperatively after decongestion, the pathological collapse of the nasal valve has been corrected and the pathological turbulence has improved.

Left nasal side: Slight decrease of the resistance compared to preoperative.

ARM: The skeletal stenosis in the area of the inner nasal valve on the right side is corrected (MCA1 after decongestion: 0.80 cm²). The opposite side is also sufficiently wide at the same height (MCA1 after decongestion: 0.85 cm²).

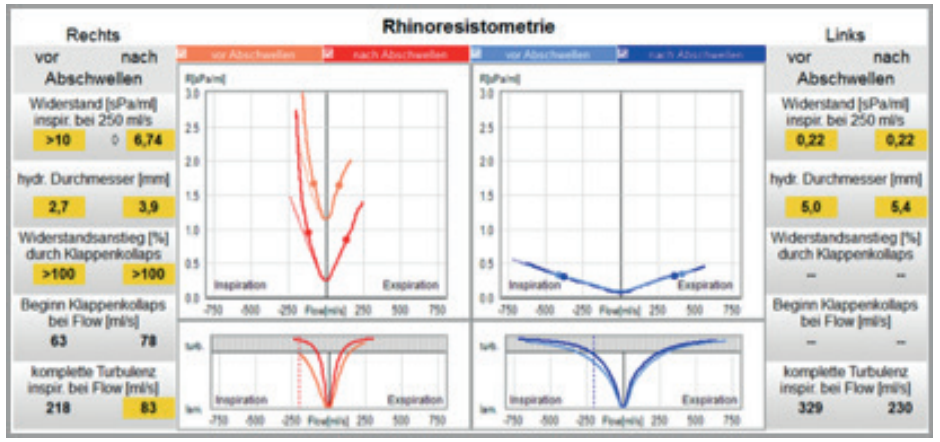
Assessment of the surgical result:
By an overall widening of the isthmus region combined with a septoplasty without nasal concha reduction, the obstruction on the right side and the valve collapse could be corrected and the pathological turbulence improved. The patient would not be satisfied with a septoplasty alone: "My nasal breathing is better on the right side now, but the left side is worse!

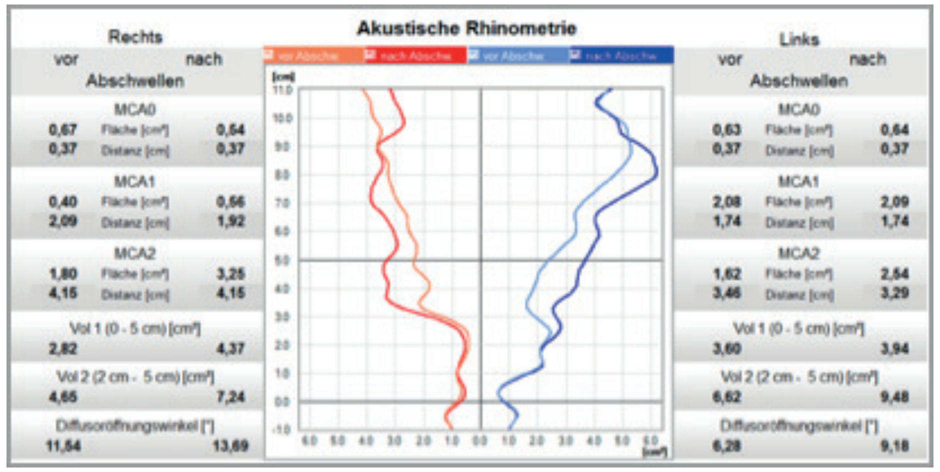
CASE 3: 19-year-old female,

PREOPERATIVE

Complaints: since trauma three years ago, obstructed nasal breathing on the left, no complaints on the right.
Preoperative endonasal findings: septal deviation on the right in cottle region 2, wide columella.

Results of preoperative functional diagnostics:





Assessment of the preoperative functional findings: RRM: Right side of nose: Even after decongestion, severe obstruction due to considerable skeletal stenosis (hydraulic diameter 3.9 mm). In addition, there is a pathological inspiratory nasal valve collapse and severe pathological turbulence. Left side of the nose: Before and after decongestion slight skeletal constriction (hydraulic diameter: 5.4 mm). ARM: The skeletal stenoses on the right side in the area of the inner nasal valve (septal deviation) and outer nostril (wide columella) cause the small hydraulic diameter.

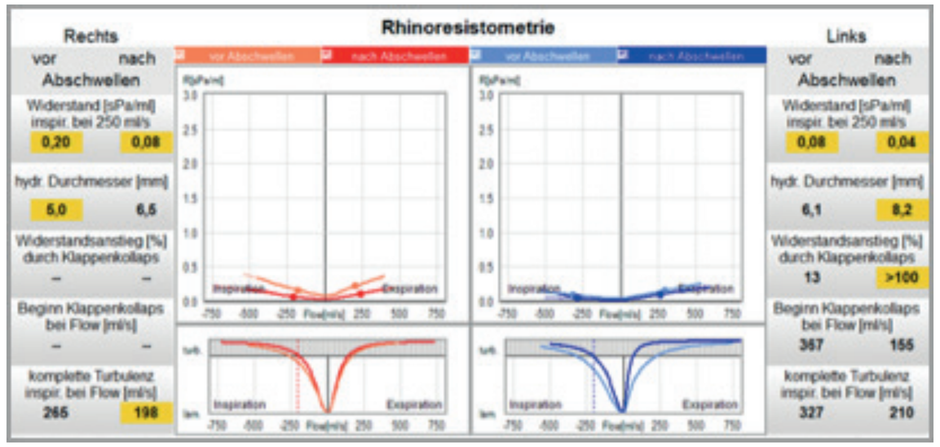
The slightly increased resistance on the left is only caused by the wide columella.

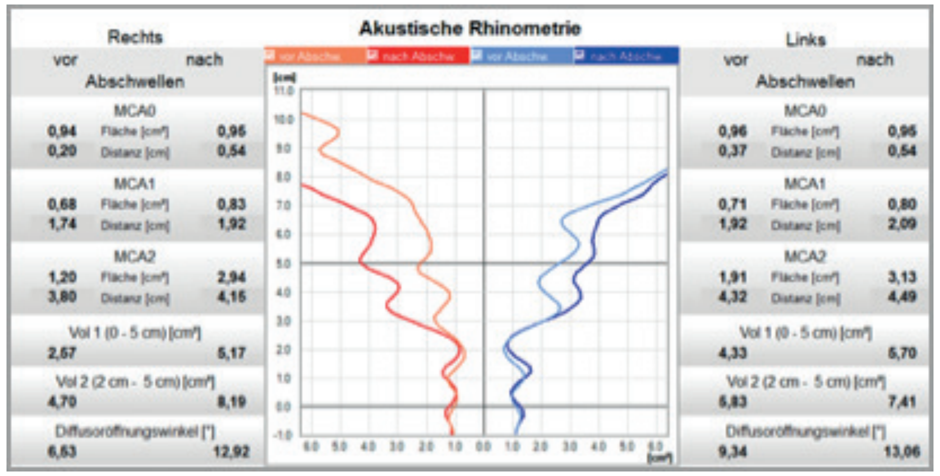
Surgical planning:
Septoplasty and columella narrowing. Reason: For sufficient improvement of the high resistance right > left septoplasty is planned. The septum can be shifted to the left in region 2 because the opposite side is very wide here. A columella narrowing to enlarge both nostrils is functionally important. A columella reduction is not necessary.

POSTOPERATIVE

Complaints: subjectively no nasal breathing impediment.
Postoperative endonasal findings: septum middling, ostium externum and isthmus on both sides sufficiently wide.

Results of the postoperative functional diagnostics:





Assessment of the postoperative functional findings: RRM: Resistance to swelling has normalized on both sides of the nose. The pathological collapse of the right nasal valve has been corrected.

ARM: The skeletal stenoses (right: MCA0 and MCA1, left MCA0) are extended to physiological values. Due to septal straightening, MCA1 on the left side is not constricted.

Evaluation of the surgical result:

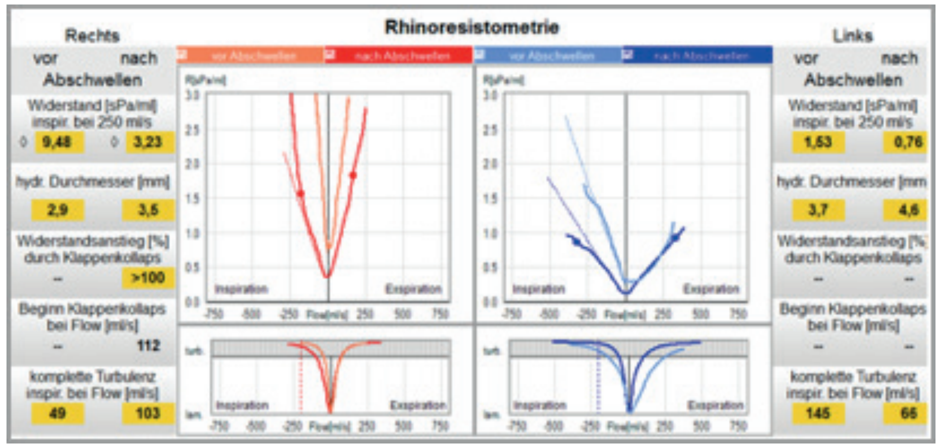
Through septoplasty and columella narrowing all constrictions could be widened and thus the resistances on both sides normalized. The pathological valve collapse and the strong turbulence on the right side were also corrected. A conchoidal reduction was not necessary.

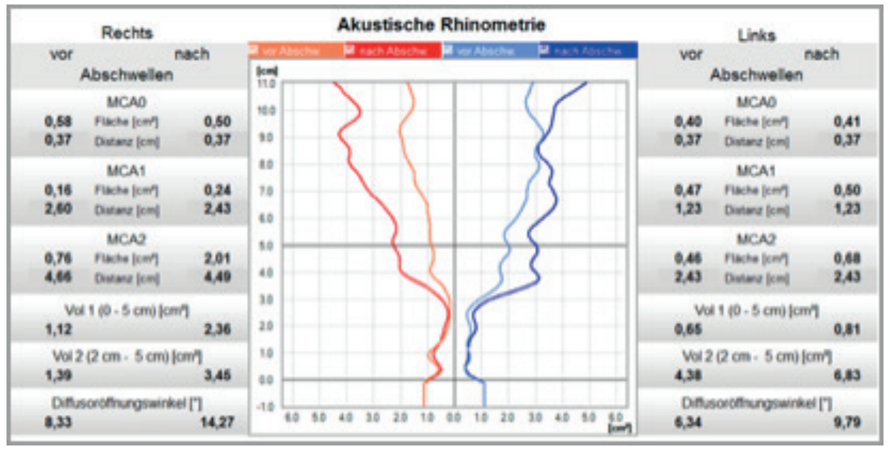
CASE 4: 21-year-old male,

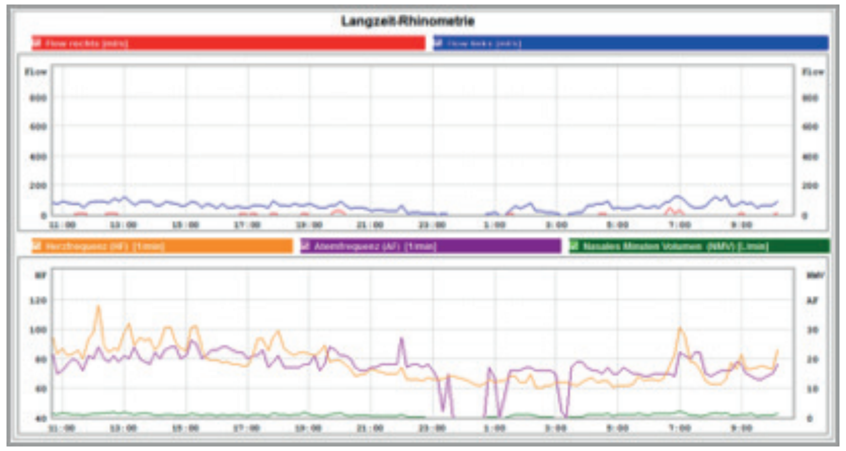
PREOPERATIVE

Complaints: nasal breathing severely impaired since childhood, more on the right than on the left.
Preoperative endonasal findings: septum deviation on the right side in cottle region 2 and 3, considerable isthmus stenosis, wide columella.

Results of preoperative functional diagnostics:







Assessment of the preoperative functional findings: RRM: Right nose side: Even after decongestion, severe obstruction due to skeletal stenosis (hydraulic diameter 3.5 mm). Severe pathological turbulence. Left side of the nose: Skeletal stenosis slightly reduced after decongestion (hydraulic diameter 4.5 mm). Strong pathological turbulence.

ARM: The entire nasal entrance is considerably constricted up to and including the inner nasal valve. The septum is deviated to the right in cottle region 2 and 3. LRM: Right side of nose none, left side very little flow. The low nasal minute volume speaks for almost complete mouth breathing over 24 hours. Even with high oxygen demand due to heavy physical exertion (heart rate up to 116/min) it is not increased. There is no nasal cycle.

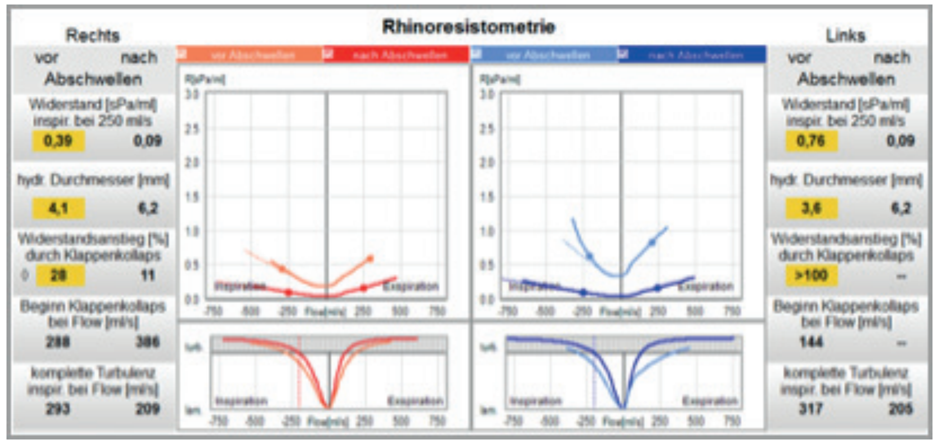
Diagnosis: Septum deviation to the right in cottle region 2 with narrow nasal entrance on both sides and wide columella with the consequences of severe obstruction right > left, pathological nasal valve collapse on the right side and pathological turbulence on both sides.
Surgical planning: septoplasty, widening of the isthmus region on both sides and narrowing of the columella. No reduction of the columella.

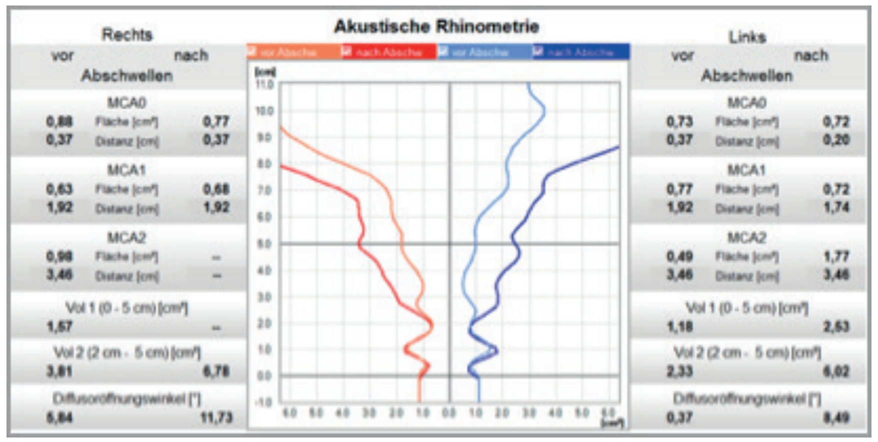
Explanation: To sufficiently improve the high resistance right > left, a widening of the entire nasal passage is planned. Afterwards the septum will be adjusted in the middle. Since the external ostia are constricted by a broad columella on both sides, a columella narrowing is also carried out.

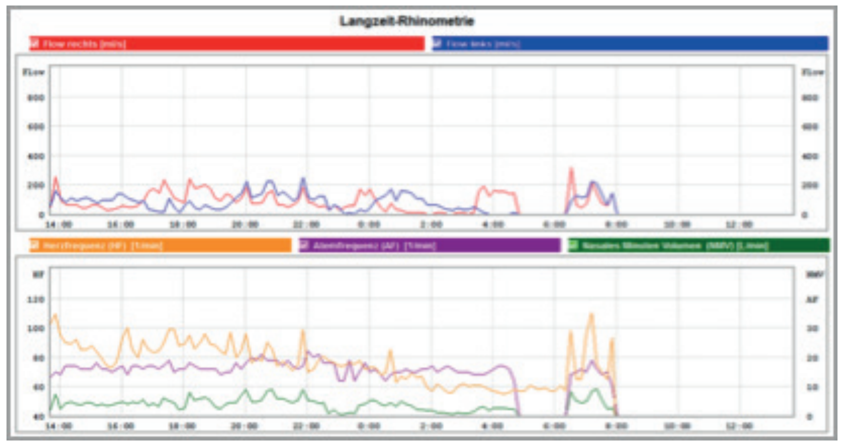
POSTOPERATIVE

Complaints: subjectively no nasal obstruction.
Postoperative endonasal findings: septum middling, nasal entrance sufficiently wide.

Results of the postoperative functional diagnostics:







Assessment of the postoperative functional findings: RRM: Resistance to swelling has improved significantly on both sides of the nose. The pathological collapse of the right nasal valve has been corrected. On both sides there is a physiological turbulence behaviour. ARM: The stenoses in the area of the nasal entrance are repaired on both sides. The MCA0 were normalized with 0.77 mm and 0.72 mm and the MCA1 with 0.68 mm and 0.72 mm.

LRM: During an 18-hour measurement, nasal breathing with cyclical changes is registered. During physical exertion, the nasal respiratory minute volume is increased.

Assessment of the surgical result: The patient's problems were resolved by an overall widening of the isthmus region combined with septoplasty and columella narrowing. Without functional findings, the required reduction of the columella would probably have been overlooked.

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