The Nasal Valve: A Review of the Anatomy, Imaging, and Physiology

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ABSTRACT

Background: *The nasal valve region has remained difficult to define in clinical practice in part because of lack of integration between physiological data and anatomic-surgical findings.*

Methods: *In this review, we summarize the anatomic, physiological, and imaging data regarding this complex area of airflow regulation.*

Results: *There is no singular resistive focus or singular valve structure to explain all of the reported findings.*

Conclusion: *We conclude that there is a nasal valve region that begins approximately at the limen nasi and continues for several millimeters within the nasal cavum beyond the piriform aperture. Intranasal pressure measurements reflect distributed resistance across this nasal valve region. The geometry and anatomic constitution of the nasal valve region change greatly from its entrance to its distal aspect. To refer consistently to the component portions of the nasal valve region, we suggest the terms cartilaginous valve segment and bony valve segment for use in reporting future studies.* (American Journal of Rhinology 18, 143–150, 2004)

All otolaryngologists have an intuitive impression of the nasal valve and recognize its importance in regulation of nasal airflow. Many would equate the nasal valve with the alar regions of the nose that are prone to "nasal valving," *i.e.*, inspiratory collapse of the lateral nasal walls if the inspiratory force is sufficiently large or if the alar structures are sufficiently weak. A review of the literature has revealed to us a range of interpretations, varying definitions, and some ambiguities regarding the nasal valve region. This complicates comparisons between studies and attempts to improve our understanding of nasal valve disorders and their treatment.

Recent reports have highlighted the importance of evaluating and treating nasal valve dysfunction as part of comprehensive nasal airway management.[1–6] Rhinoplastic surgeons tend to group problems of the nasal valve as being those of the external nasal valve or the internal nasal valve, with little or tangential reference to the structures at the bony, piriform aperture and the inferior turbinates. In these surgical reports, emphasis has been placed on configuration, stability, and support of the upper and lower lateral cartilages. Physiologists, in contrast, may define the valve region by measurements of intranasal resistance, resulting in identification of a "flow-limiting segment."[7,8] The importance of vasoactive or erectile intranasal soft tissues to nasal valve function has been emphasized.[9,10] Some authors discuss a singular nasal valve that extends a few millimeters,[11–13] and others distinguish two[14–16] or more[17] airflow-regulating valves.

Although now there is much literature describing nasal valve mucosal components and the alar or cartilaginous components, they often are not defined clearly and distinguished anatomically. In a recent review, Cole[9] has referred schematically to "structural" and "functional" components of the valve, reaching to the piriform aperture. This emphasizes the compartmental nature of the nasal valve area, and directs us toward clarification of nasal valve components. Many authors indicate the importance of the inferior turbinate anterior head to the nasal valve physiology, and others concentrate on the upper lateral cartilages. It seems that there is still uncertainty and unease of sorts in defining the nasal valve component regions as is needed for standardized diagno-

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sis and treatment. The purpose of this review is to examine structural and imaging studies of the nasal valve and associated airflow data, clarify the nomenclature, and produce an integrated model of the nasal valve region.

DEFINITIONS OF THE NASAL VALVE

Valve is cognate with the Latin word valva, which refers to one of a pair of folding doors (pl. valvae, folding doors). Mink[18] first applied the term nasal valve to refer to the area of intranasal narrowing in the nasal vestibule. Specifically, he considered the nasal valve to be the region bounded by the limen nasi (nasal threshold) laterally and the septum medially. Anatomically, the limen nasi is a ridge found a few millimeters within the nasal vestibule where the caudal border of the upper lateral cartilage is overlapped by the lateral crus of the lower lateral cartilage. Mink considered the limen nasi to be the narrowest portion of the nasal passage. Thereafter, it was long held to be the segment of highest flow restriction. Although this concept of localized anterior nasal narrowing has changed considerably over the past 10–20 years, the limen nasi is still equated with the nasal valve in a modern medical dictionary.[19]

Hinderer[20] described the nasal valve to be the region between the caudal end of the upper lateral cartilage and the septum. He also referred to this as the os internum of the nose, a term he stated dates to Bell in 1830 and for whom the region was known to some as "Bell's constriction." In his thorough anatomic reference on the nose and sinuses, Lang[21] clarified that the internal nasal ostium is bounded laterally by the limen nasi and medially by the medial crus of the lower lateral cartilage (also called the greater alar cartilage). This was considered the narrowest area of the nose, with an estimated cross-sectional area (CSA) of 20–60 mm^2, in contrast to the estimates of 100–300 mm^2 in the nasal cavum. Thus, the nasal valve was considered by some authorities to be equivalent or closely related to the limen nasi or associated os internum. However, Bachmann and Legler[22] challenged this traditional conception of the nasal valve. Based on measurements made from luminal impressions of the anterior nasal passages, they determined that the region of greatest anterior nasal resistance is the isthmus nasi, whereas that which they called the anatomic ostium internum (or internal nostril) was more important in directing the airflow to the cavum than in regulating nasal resistance.

The otorhinolaryngological and plastic surgical literature often differentiates between an external and an internal nasal valve.[1,2,4,23] The external nasal valve refers to the lateral crus of the lower lateral cartilage and surrounding soft tissues. It generally becomes of aerodynamic significance in postrhinoplasty alar rim pinching or lower lateral cartilage weakening. The internal nasal valve is more commonly problematic clinically. It is defined by the upper lateral cartilage, from its caudal border to its attachment at the piriform aperture, in relation to the septum medially. Not all authors apply separate terms for these portions of the nose; some[5,8,12,24,25] have used the term nasal valve singularly, without reference to internal and external nasal valve components. Confusion may arise in usage of the term "internal valve," which also has been used to refer to the vasoactive mucosal structures at the nasal isthmus.[15] Here, we will use the designation nasal valve region to refer collectively to the location of all components of anterior nasal airflow regulation in normal individuals, without any presumptions as to which components may dominate the resistance in a given individual.

Important insights regarding anterior nasal resistance have been gained from physiological studies. Bridger and Proctor[7] applied the term "flow-limiting segment"(FLS) in their airflow studies of the nasal valve. Their work and subsequent studies, outlined in the next section, showed that the FLS generally is beyond the limen nasi, in the region of the piriform aperture. The FLS is a useful physiological concept and fully consistent with the modern, fluid-hydraulic sense of the word valve; however, alone it is not a good basis for anatomic definition of the nasal valve because flow limitation can occur at various nasal locations depending on local constrictions. If the nasal valve should be defined as the FLS at the piriform inlet, *e.g.*, then "nasal valving" of the cartilaginous structures, which is described in the clinical exam would not be concordant with the FLS valve.

PHYSIOLOGICAL DATA

The strongest evidence that the nasal valve region is not synonymous with the limen nasi area or internal nasal os comes from intranasal fine-catheter pressure measurements. Bridger and Proctor[7] showed that there was little pressure drop across the limen nasi but there was a significant pressure gradient over the first 2 cm of the nose. They identified a region of maximum pressure change at 1.5–2.0 cm from the limen nasi and referred to this region as the FLS of the nose. In 1983 Haight and Cole[11] reported intranasal pressure measurements, finding on average that the pressure rise started at 1.90 cm from the naris and reached a near-maximal value at 2.60 cm, this site corresponding to the piriform aperture and head of the inferior turbinate. Jones *et al.*[8] subsequently made pressure measurements at 0.25-cm intervals within the nose. They found that only 7% of the pressure drop occurred at the ostium internum (at 1.0–1.5 cm); 43% of the pressure drop occurred over 1.5–2.8 cm; the locus from 0 to 1.0 cm accounted for another 29% of the pressure change. Thus, over the first 2.80 cm from the naris, some 79% of the total nasal pressure drop occurred. In our own laboratory exercise, serial intranasal pressure catheter measurements in two normal individuals confirmed that the main pressure gradient occurs in the first 3 cm of the nasal passage. We found that ~30% of the transnasal pressure drop occurred 1 cm from the naris and another 42% over the segment from 1.0 to 3.5 cm. This experience confirmed that the high-resistance part of the nose is situated in approximately the first 3 cm and most of it is between 1 and 3 cm beyond the naris. Jones *et al.*[8] noted that the mean distance to the piriform aperture was 2.15 cm, signifying that part of the pressure drop occurred over the cartilaginous portion of the nose and most of the remainder occurred in the first several millimeters of the bony nasal cavum starting at the piriform aperture.

In rhinomanometric studies, Haight and Cole[11] divided total nasal resistance into "alar" and "mucosal" components based on nasal splinting. They found that alar splinting lowered the nasal resistance by 26% in unmodified normal noses, by 30.8% in the histamine-congested nose, and by 38.9% in the decongested nose. This showed that the main part of the nasal resistance was located beyond the mobile, cartilaginous portion of the nasal valve region. Also of note, they found that decongestion affected both the alar and the mucosal components, suggesting that bony and extraosseous portions of the valve contain vasoreactive soft tissues.

From the physiological data it may be concluded that the main resistive segments in normal noses are found within 3 cm from the naris, and most of this was between ~1 and 3 cm. Because this straddles the piriform aperture, the airflow-regulating nasal valve region must have a cartilaginous portion, extending from about the limen nasi to the piriform, and a bony portion, containing the soft tissue elements within approximately the 1st cm of the nasal cavum. These two segments of the nasal valve region do not exhibit a distinct line of demarcation by physiological measurements. They are distinguished by anatomic and imaging means and have different implications for surgical management of anterior nasal airflow limitation.

ANATOMY AND IMAGING

Os Internum (Internal Ostium)

Lang's text[21] illustrates much regarding the structures pertinent to the nasal valve region. The lateral portion of the internal nasal ostium is the limen nasi, seen as a ridge ~10 mm long just beyond the nasal vestibule along the border between the upper lateral cartilage and the overlapping (by a mean of 2.9 mm) lower lateral cartilage. The medial border of the os internum is the medial intumescence of the septum, *i.e.*, the ridge on each side of the anterior septum caused by the projection of the medial crura of lower lateral cartilages. The medial crus and the limen nasi are not on the same horizontal plane; the limen nasi is higher and thus the internal ostium (which is essentially the nasal valve region inlet) is skewed laterally above the horizontal plane. The posterior limit of the os internum is the floor of the piriform aperture, which is a few millimeters higher than the level of the nares in Caucasians.[20,21] This raised bony edge of the piriform floor may have aerodynamic significance for the nasal valve region.[24]

Lateral Wall of the Cartilaginous Valve Region

Bruintjes *et al.*[26] have studied the relations of the nasal cartilages and muscles in the nasal valve area. The principal muscles acting to open and stabilize the nasal valve region are the M. dilatator naris and M. nasalis. The upper lateral cartilages are found to be in continuity with the nasal septal cartilage and are firmly attached beneath the nasal bones at the piriform aperture. In contrast to this relatively firm and well-supported area, the lateral "hinge" area contains only sesamoid cartilages embedded in soft tissue and is the most structurally compliant portion of the lateral nasal wall. Alar struts (alar batten grafts) and flaring sutures have been used to support this weak area of the ala.[5,16,23] Although the septal-lateral cartilage junction typically is described as a 10–15° angle, it is important to note that upper lateral cartilages may show an inward (medial) curling.[26] Thus, narrowing of the cartilaginous valve region may occur in its midlevel rather than simply at the septal-lateral cartilage junction. Narrowing at the septal-lateral cartilage junction has been treated with spreader grafts.[1,16] Combined valve region reconstruction techniques may offer the best outcomes.[1,14]

The epithelium between the limen nasi and the piriform is well vascularized though with thinner vascular plexuses than in other areas of nasal mucosa.[27] In magnetic resonance imaging (MRI) studies[28,29] the lateral wall of the cartilaginous nasal valve region appears to be relatively quiescent and nonvasoresponsive and, thus, unlikely to contribute to variable resistance on a mucovascular basis.

Medial Wall

The medial wall of the nasal valve region is comprised of the anterior septum. The septum may impact on the nasal valve region by its thickness, presence of spurs, accessory cartilages (Jacobson's cartilages), or deviations. Superiorly, a *nasal swell body* is found at or near the junction between the septal cartilage and the ethmoid perpendicular plate. The nasal swell body, a term that appears in the comparative literature[30] and a human cadaveric study ("Schwellkorper"),[31] also has been variously referred to under the designations septal intumescence,[21] septal erectile body,[9] Kiesselbach's ridge[32] (near but different from Kiesselbach's triangle), septal cavernous body,[32] anterior septum tuberculum,[33] and septal turbinate.[34] We prefer the term nasal swell body as an intuitively suitable term, which makes no assumptions about the composition or function of the structure. On computed tomography (CT) images, thickening of the mucosa as well as the cartilage and/or bone may be seen. In our septoplasty surgical specimens, cartilage up to 5 mm wide has been shown at the nasal swell body region. The septal swell body is located essentially under the nasal bones, anterior to the middle turbinates and superior to the inferior turbinates. It is primarily within the bony portion of the nasal valve region (Figs. 1 and 2) but may project across the plane of the piriform aperture into the cartilaginous portion of the valve. Gupta[35] *et al.* found that this superior septal widening had a mean width of 1.15 cm in contrast to 0.30 cm for the inferior portion of the anterior septum. Although shown to be vasoreactive by MRI[28] and CT,[36] there is no agreement on whether human nasal septal mucosa contains cavernous channels as seen in the inferior turbinates. Saunders *et al.*[33] found abundant vascular tissues and mucous glands but no true cavernous tissue in the swell body. Inferior turbinate mucosa may show a greater capacity for engorgement and vasoreactivity than the nasal swell body (Fig. 2, *A* and *B*). Despite the paucity of information on the nasal swell body, we recognize that it lies near or in a key region of the physiological FLS, *i.e.*, the piriform aperture, and its contribution to nasal valve region function deserves additional investigation.

Lateral Wall of the Bony Valve Region

CT scans consistently show consistently that the soft tissue contour of the inferior turbinate begins to protrude into the airway at the level where lateral bony walls appear, *i.e.*, at the piriform aperture. Congestion with histamine moves the zone of swelling forward a few millimeters, and decongestion can cause the observable soft tissue bulge to recede a few millimeters.[8,11] Jones *et al.*[8] noted that the decongested inferior turbinate head was located at the level of the piriform aperture, at 2.15 cm within the nasal passage. We have confirmed this observation: in the decongested nose the soft tissue bulge of the inferior turbinate head is found approximately at the level of the piriform rim, whereas in the undecongested state the inferior turbinate head it is found 3 mm anterior to the piriform rim. Because much of the physiological evidence suggests that the valve region ends by ~3 cm from the nares, the end of the nasal valve region should be no more than a centimeter beyond the piriform aperture, within the bony cavum. The nasal cavum rapidly increases its dimensions beyond the piriform aperture, from a mean width of 23.6 mm at the piriform to an ~36-mm width at midcavum.[21]

Within the transition from limen nasi to piriform inlet, the cross-sectional shape of the nasal passage changes from asymmetric ovoid at the nostril inlet to an upright, elongated narrow passage at the distal valve segment (Fig. 3). This may not be appreciated on routine anterior rhinoscopy because part of the nasal valve region is distorted or bypassed by the speculum. Even with endoscopic visualization, the nasal valve region can not be defined readily by reproducible landmarks.[37] This is because the valve is a region of

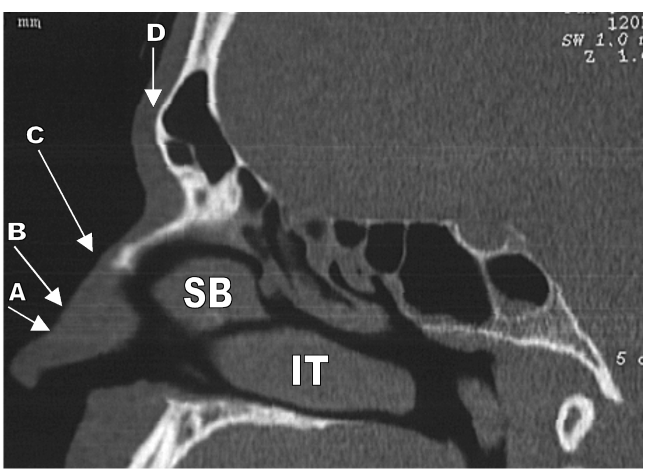

__Figure 1.__ Parasagittal CT reconstruction showing relation of the nasal swell body (SB) to the inferior turbinate (IT). In this section, the SB and IT are seen at the distal aspect of the nasal valve region. At different parasagittal planes these structures extend further anteriorly into the valve region. Arrows marked A, B, C, and D indicate angles of modified coronal CT reconstructions shown in Fig. 3.

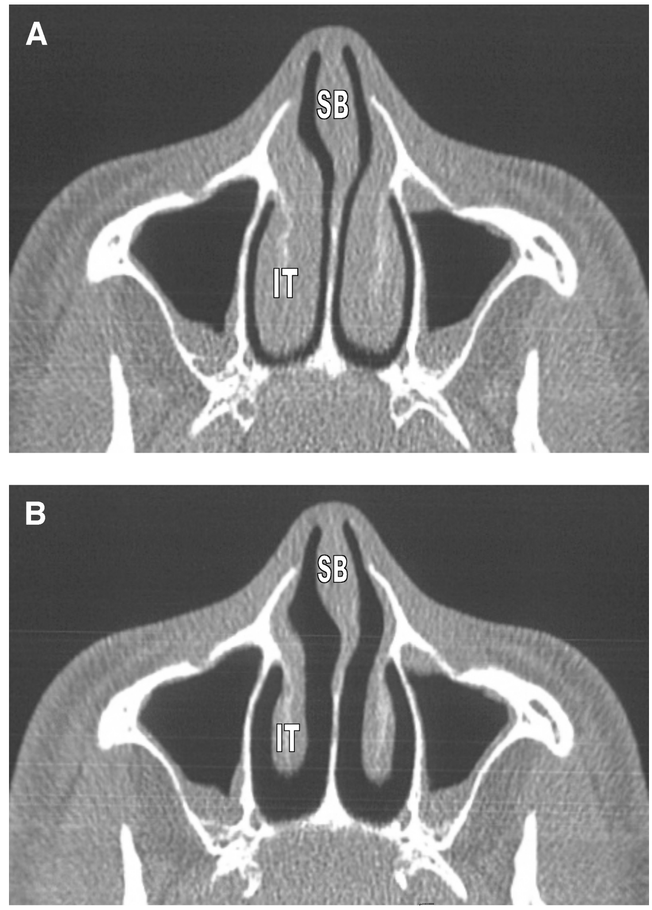

__Figure 2.__ Modified axial CT reconstruction, angled up 30° anteriorly to show the nasal swell body (SB) and inferior turbinates (IT) in the same section. The SB straddles the piriform aperture at this level. (A) Undecongested nose showing thin relatively uniform air passages. (B) Decongested nose showing marked widening of the air passages; the SB is less vasoreactive than the IT in this section. The bulge of the inferior turbinate anterior head is located a few millimeters more posteriorly in the decongested state.

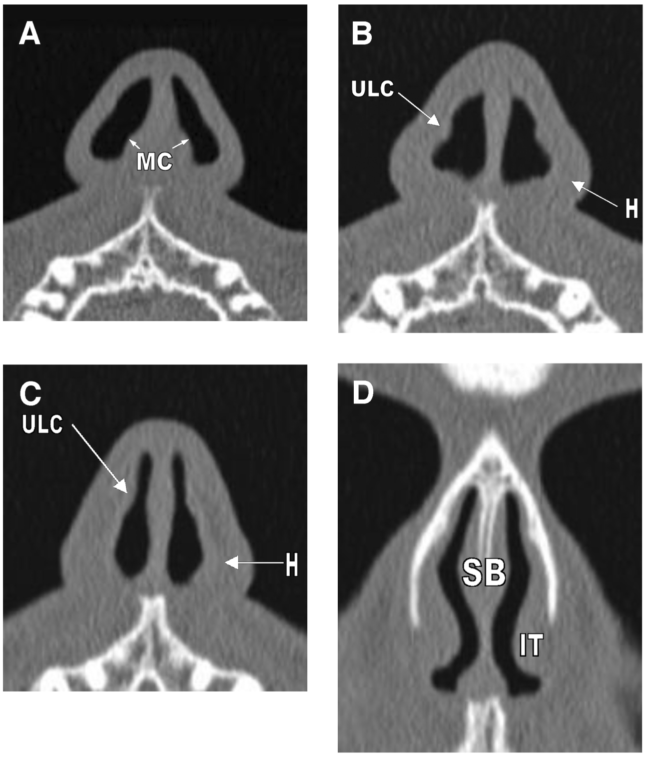

Figure 3. *Modified coronal CT reconstructions, at various angles to the horizontal, to approximate perpendicular orientation to direction of airflow. (A) Thirty degrees from horizontal plane, at the nasal valve inlet. The septocolumellar junction is widened by the medial crura (MC) of the lower lateral cartilages. (B) Forty-five degree angle from the horizontal plane, proximal cartilaginous valve segment, showing mild inward deflection of the upper lateral cartilage (ULC) and the hinge area (H), which contains sesamoid cartilages and poorly supported soft tissues. (C) Sixty-degree orientation from horizontal, distal cartilaginous valve region, anterior to piriform aperture. Inward curvature of ULC can significantly impinge on the airway at this level. H area has thick, poorly supported soft tissues. (D) Ninety degrees to the horizontal plane. Distal valve region—the bony segment. The nasal swell body (SB) is noted superomedially and the inferior turbinates (IT) are positioned inferolaterally.*

complex anatomy and multiple contributory structures, rather than a solitary locus of resistance.

In summary, the anatomic and imaging data can be construed to define (1) a cartilaginous portion of the nasal valve region, extending from the limen nasi to the piriform aperture, with the shape and CSA of the passage highly dependent on the configuration of the upper lateral cartilages as well as the characteristics of the anterior septum and (2) A bony portion of the nasal valve region that starts at the piriform, contains most of the vasoreactive soft tissues including the head of the inferior turbinate and the nasal swell body. On intranasal exam, the exact transition between these portions cannot be identified by inspection. CT imaging and direct surgical approaches offer clearer definition.

ACOUSTIC RHINOMETRY

Since its introduction by Hilberg[38] in 1989, acoustic rhinometry (AR) has been used extensively to investigate nasal passage geometry and identify narrow intranasal segments. The method is rapid and reproducible. Despite certain technical limitations, it can estimate CSA minimums in the anterior nose with an accuracy of 5–10%.[39,40] Correlation coefficients between AR and CT estimates of CSA are reported to be between 0.83[39] and 0.94.[38] Although the CSA measurements are considered to be accurate through the anterior nasal airway,[39] CSA estimates are most closely to CT determination of area when the measurements are made perpendicular to the acoustic axis,[41] which approximates the geometric axis of the nasal cavity. The position of the CSA nadir may lag up to 8–10 mm distal to the level of actual obstruction[40]; the distance information is less accurate than the CSA information in AR measurements.

In several studies of normal subjects, AR shows a pattern of two local minimums in the anterior portion of the nose. The first minimum has been reported at distances of 1 cm,[42] 1.3 cm with a mean CSA of 0.73 cm^2,[43] and 1.18 cm with a mean CSA 0f 0.78 cm^2.[44] Lenders[43] referred to this as the I-notch (isthmus nasi) and designated the second minimum the C-notch (concha), to indicate the head of the inferior turbinate. He described this second minimum at a distance of 3.3 cm with a CSA of 1.1 cm^2. Hilberg's report placed this minimum at ~3 cm. Roitman *et al.*[44] labeled this MCA2 (minimum CSA no. 2), with CSA = 0.70 cm^2 at a distance of 2.86 cm. In two studies by Roitman *et al.*,[42,44] topical decongestant increased the local minimum CSA; in one of these studies the distance to local minimum decreased from 2.53 to2.0 cm,[42] whereas in the other study there was no significant change of minimum CSA position with the decongestant. Shaida[15] identified a minimum at 2.28 cm, which advanced slightly to 2.12 cm with vasoconstriction. An external splint increased this CSA minimum by 14%, in contrast to topical vasoconstriction, which produced a 54% increase at this site.

Corey *et al.*[37] reported a correlative study that compared AR findings with direct endoscopic measurements of intranasal landmarks. Although the first AR minimum CSA was found at a 1.4-cm distance, endoscopically the nasal valve was placed at 2.27–2.32 cm. A second CSA minimum was found at 3.3 cm, with close endoscopic correspondence to the head of the inferior turbinate. The authors noted the difficulty of defining the nasal valve endoscopically. Tomkinson and Eccles[45] also described the pattern of two minimums in the anterior nose but concluded that the first, found near the start of the acoustic trace, was in fact signaling the end of the nose piece, limen nasi, or rim of the nasal aperture, whereas the second minimum, found at ~2 cm, represented the nasal valve. In line with this interpretation, Cakmak *et al.*[41] described a CSA minimum attributed to the nasal valve at a distance of 1.38–2.1 cm. Following the estimated acoustic axis within the anterior nasal passage, this AR CSA minimum corresponds to the soft tissues anterior to or at the piriform aperture.

Thus, in normal individuals local CSA minimums of the anterior nose may be seen on AR examination anywhere from the limen nasi near the nasal inlet to the head of the inferior turbinate at 3.3 cm. The nasal valve region probably is bounded by these distances and may present as a single intermediate AR minimum. In our own experience, when nasal valve collapse is induced by gentle external pressure on the ala, the double-minimum waveform changes to a broad monophasic minimum situated between the two original minima. Roitman *et el.*[44] also found that a patient with a nasal valve problem exhibited a single AR minimum, located between the sites of the usual local minima. A given AR minimum in the anterior nose should not be automatically construed as indicating a solitary locus of valve function or dysfunction.

AR is especially well suited to intraindividual repeated measurements, before and after treatment. For example, Grymer[46] found that reduction rhinoplasty decreased AR minimum CSA by 22–25% and CSA at the piriform aperture by 11–13%. Interestingly, less than 10% of these patients complained of decreased nasal patency postoperatively.

AR should be considered an adjunct to careful rhinoscopy, rhinomanometry, and conventional imaging. It is important to recall that locations of the CSA minimums may not correspond exactly to structural landmarks, and configurational information is lacking in the AR trace. AR results are highly technique sensitive and may vary considerably between laboratories; guidelines[47] should lead to standardization of results and interpretation. Despite its limitations, AR does seem to be worthy of further investigation as a tool for rapid, noninvasive assessment of nasal valve region CSAs.

DISCUSSION

In consolidating the anatomic parameters with the physiological data, it is apparent that there is no single structure or focal narrowing to be called the nasal valve. Instead, we view the nasal valve region as a set of interrelated structures extending from approximately the limen nasi, at ~1 cm from the naris, to about a centimeter within the nasal bony cavum, beyond the piriform aperture. A large portion of the total nasal resistance is distributed across this nasal valve region. There is great transformation of nasal passage geometry and functioning from the entrance to the exit of this region. The front half of the valve region primarily has cartilaginous support, with some additional stabilization from alar dilator muscle. Airflow regulation within the cartilaginous portion appears to be largely because of the configuration and stability of the cartilage and surrounding soft tissues. Some individuals may be prone to airflow-induced collapse of the cartilaginous segment, a consequence of the Bernoulli effect. The posterior portion of the nasal valve region functions within bony encasement and regulates the airstream by changes in mucosal congestion. We suggest that these two nasal valve region components be referred to as the cartilaginous valve segment and the piriform or bony valve segment. The terms external and internal valve, already extensively used in reference to parts of the cartilaginous valve segment, must not be confused with the bony valve segment that lies at and internal to the piriform aperture. The potential for blurring the interpretation of "internal valve" already has appeared in the literature.[15]

The transition between the cartilaginous and bony portions of the nasal valve region is not distinct by clinical or endoscopic examination of the nose. Also, the transition may not be abrupt on physiological measurements of intranasal pressure or acoustic rhinometry imaging. However, the crossover points are well defined during rhinoplastic surgery and on CT imaging, allowing for more precise localization and description of nasal valve treatments. Much needs to be learned about the transitional zone, regarding, *e.g.*, the nasal swell body, which may straddle the transition zone and affect the resistance of bony and cartilaginous nasal valve components.

Because the mechanisms of resistance are for the most part different between the cartilaginous and bony segments of the nasal valve region, treatments for each region must be designed and reported separately. Accordingly, selection criteria and outcome measures will need to be specific for cartilaginous valve problems in contrast to those of the bony portion of the nasal valve region. Of course, there may be overlap in the mechanisms, *e.g.*, mucosal swelling influence on both bony and cartilaginous (to a lesser extent) valve segments. Nevertheless, by distinguishing these two anatomic segments of the nasal valve, we can determine more consistently which indications and procedures are most suitable for a given patient's nasal airflow problem.

One new modern analytic approach, which may be helpful to the nasal valve problem, is mathematical modeling of the nasal airways. Recently, the numerical methods for complex computational fluid dynamics (CFD) models have been developed[48,49]. CFD models provide realistic estimations of nasal airflow velocity vectors and local flow rates, based on a computational mesh generated from CT or MRI images. The outputs can be used to shoe the local airstream patterns and velocities within the various nasal regions. This may potentially be very important for studies of the nasal valve region. Tarabichi and Fanous,[24] using a two-dimensional model of the nasal valve region, found that the projection of the inferior piriform bony rim may substantially influence airflow through the nasal valve region. Once fully developed and validated, the three-dimensional CFD models could be used to predict the aerodynamic effects of proposed surgical interventions. Last, with the direction of the airstream lines known, the CT scan can be specially reconstructed perpendicular to the direction of mean flow through the valve region. This would give an "aerodynamically accurate" image of the nasal valve region anatomy. Such special CT reconstructions should be of value in clarifying which structures are contributory to nasal valve obstruction in the bony and cartilaginous valve segments.

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