Nasal valve Surgery (Different Surgical Techniques)

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Abstract: Different surgical technique used for treatment of nasal valve collapse. 30 patients had been under surgical management divided into three groups according to surgical intervention; spreader graft, cartilage spanning graft and splay conchal graft. It evaluates the three techniques However, the small number of patients included in each group, especially the second and third groups represented a limiting step against globalization of results obtained in the present study. The spreader graft technique provided the better outcome.
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Key words: nasal valve collapse, spreader graft, splay conchal graft, cartilage spanning graft, acoustic rhinometry.

1. Introduction

Nasal valve region begins approximately at the limen nasi and continues for several millimeters within the nasal cavum beyond the piriform aperture **(Wexler and Davidson, 2004).**

The external nasal valve is a variable area dependent on the size, shape, and strength of the lower lateral cartilage. The internal nasal valve (INV) involves the area bounded by upper lateral cartilage, septum, nasal floor, and anterior head of the inferior turbinate **(Cole and Roithmann 1996).**

Nasal valve problems are common causes of nasal airway obstruction that occurs when the mechanical integrity of the nasal valve fails to resist negative inspiratory pressure and can be classified into congenital, traumatic, senile, mucosal, neurogenic, or idiopathic **(Mlynski et al., 2005).**

Often the problem is not even diagnosed until surgical treatment such as septoplasty or turbinate reduction has failed to correct the patient's symptoms of nasal airway obstruction **(Edward, 2011).**

A variety of approaches have been devised for lateralization of the valve to improve the airway and treat this problem such as Spreader grafts, flaring sutures, butterfly grafts, or a combination **(Thomas et al. 2011)**.

Narrowing of the piriform aperture secondary to osteotomy can be treated with revision osteotomy without fracture of the nasal bones to widen the valve angle **(Thomas et al. 2011)**.

Rhinomanometry is one of the most commonly used methods for objective pre and post operative assessment of the nasal air way with the simultaneous recording of the transnasal pressure and airflow **(Corey, 2006).**

Aim of the work

We aim from this work to describe and evaluate different surgical techniques used to correction nasal valve insufficiency.

Anatomy

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 review**, Cole (2003)** 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 diagnosis and treatment **(Wexler and Davidson, 2004).**

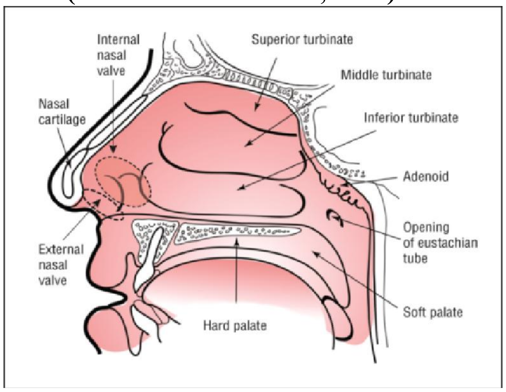

Figure (1): The internal nasal valve is the cephalic area between the upper and lower lateral cartilages and cartilaginous septum and the nasal floor inferiorly.

The external nasal valve is caudal in relation to the internal valve and formed by the nasal septum, the medial and lateral crura of the lower lateral cartilage, and the premaxilla. **(Sufyan et al 2012).**

Definition 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 (1920)** 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.

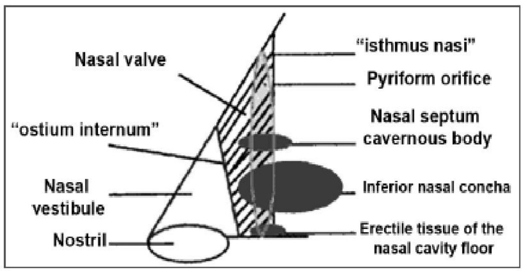

Figure (4): Drawing of nasal vale

External and internal nasal valves

Hinderer (1971) 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 *osinternum* 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 (1989)** clarified that the internal nasal ostium is bounded laterally by the limen nasi and medially by the medial crus of the lower lateral cartilage. This was considered the narrowest area of the nose, with an estimated cross-sectional area (CSA) of 20–60mm^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 limennasi or associated osinternum. However, **Bachmann and Legler (1972)** challenged this traditional conception of the nasalvalve. Based on measurements made from luminal impressions of the anterior nasal passages, they determined that the region of greatest anterior nasal resistance is the isthmusnasi, whereas that which they called the anatomic ostiuminternum (or internal nostril) was more important in directing the airflow to the cavum than in regulating nasal resistance.

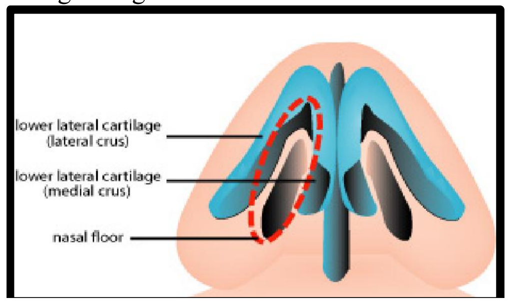

Figure (2): The external nasal valve consists essentially of the structures of the nostril of the nose **(Sam Lam 2017).**

The otorhinolaryngological and plastic surgical literatureoften differentiates between an external and an internal nasal valve. 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 **(Ghidini et al., 2002; Howard and Rohrich, 2002).**

Not all authors apply separate terms for these portions of thenose; some have used the term nasal valve singularly, without reference to internal and external valve components **(Boahene and Hilger, 2009).**

Important insights regarding anterior nasal resistance have been gained from physiological studies. **Bridger and Proctor (1970)** applied the term "flow-limiting segment" (FLS) in their airflow studies of the nasal valve. Their work and subsequent studies 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 **(Wexler and Davidson, 2004).**

OsInternum (Internal Ostium)

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 osinternum is the medial projection of the septum, i.e., the ridge on each side of the anteriorseptum caused by the projection of the medial crura of lower lateral cartilages **(Lang, 1989).**

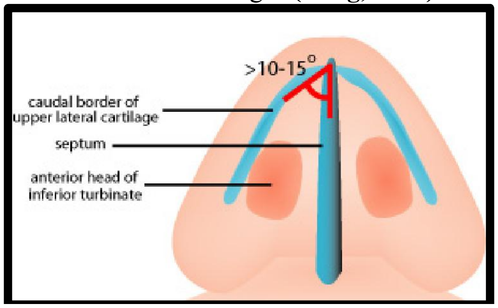

Figure (3): The Internal nasal valve (the angle that the septum makes with the upper lateral cartilage about 10 to 15 degree). **(Sam Lam 2017).**

This raised bony edge of the piriform floor may have aerodynamic significance for the nasal valve region **(Xiong et al., 2008).**

The nasal cavum is located posterior to the piriform aperture. Its overall contribution to total airway resistance is small. The component of nasal cavum resistance is determined by degree of vascular engorgement of tissues. Acoustic rhinometry demonstrates that the tip of the inferior turbinate narrows the airway immediately posterior to the nasal valve. The turbinated regions of the nasal passage have relatively large cross-sectional areas **(Kerr, 1997).**

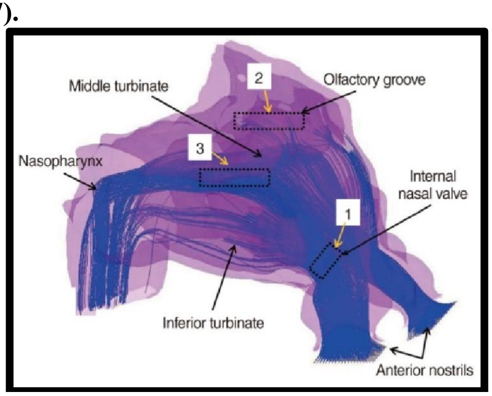

Figure (5): Three-dimensional (3D) model of inspiratory air streamlines (blue), with air velocity, pressure and wall shear stress measurements, at three points in both normal (healthy) and obstructed nose models. The flow rate used in computational fluid dynamics simulation is 34.8 L/minute.

Lateral Wall of the Cartilaginous Valve Region

Huret al. (2011) 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 muscle (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 thenasal bones at the piriform aperture.

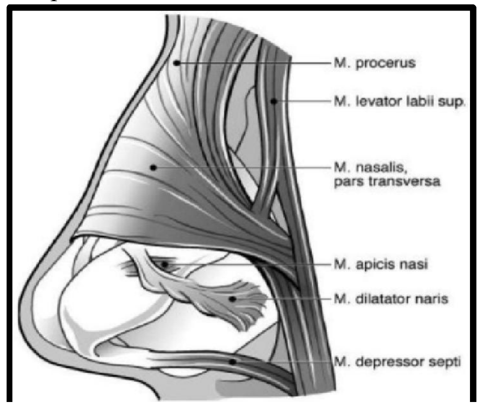

Figure (6): Presentation of the perinasal musculature: The internal nasal valve is widened by the M. dilatator naris originating from the lateral alar cartilage and the pars alaris of the M. nasalis. An excessively lateral preparation of the alar cartilage may damage the origin of the M. dilatator naris and destabilize the internal nasal valve.

In contrast to thisrelatively firm and well-supported area, the lateral “hinge”area contains only sesamoid cartilages embedded in softtissue and is the most structurally compliant portion of thelateral nasal wall **(Ghidini et al., 2002).**

Although the septal-lateral cartilage junction typical lyis described as a 10–15° angle, it is important to note that upper lateral cartilages may show an inward (medial) curling **(Huret al., 2011).** Thus, narrowing of the cartilaginous valve regionmay occur in its midlevel rather than simply at the septal-lateralcartilage junction. Narrowing at the septal-lateralcartilage junction has been treated with spreader grafts **(Aksoy et al., 2010).**

The epithelium between the limen nasi and the piriform is well vascularized though with thinner vascular plexuses than in other areas of nasal mucosa **(Lane, 2004).**

In magnetic resonance imaging (MRI) study the lateral wall of the cartilaginousnasal valve region appears to be relatively quiescent and nonvasoresponsive and, thus, unlikely to contribute to variable resistance on a mucovascular basis **(Ng et al., 1999).**

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 perpendicularplate.

The nasal swell body, also has been variously referred to under the designations septal intumescence, septal erectilebody, Kiessel bach's ridge (near but different from Kiesselbach'striangle), septal cavernous body, anterior septumtuberculum, and septal turbinate. The termnasal swell body is preferred as an intuitively suitable term, which makes no assumptions about the composition or function of the structure **(Costa et al., 2010).**

On computed tomography (CT) images, thickening of the mucosa as well as the cartilage and/or bone may be seen. 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 but may project across the plane of the piriform aperture into the cartilaginous portion of the valve **(Wexler and Davidson, 2004).**

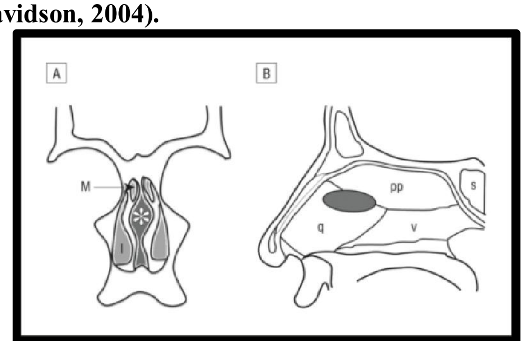

Figure (7): Schematic diagrams. A, Coronal diagram through the swell body (SB) (asterisk) demonstrating its location anterior to the middle turbinate (M) and superior to the inferior turbinate (I). B, Sagittal diagram through the nasal septum identifying the area of the nasal septal SB (shaded oval) along the anterior septum. The SB is approximately 2 × 3 cm and fusiform shaped, with its epicenter located 2.5 cm above the nasal floor. pp Indicates perpendicular plate of ethmoid; q, quadrangular cartilage; s, sphenoid sinus; v, vomer **(Costa et al., 2010).**

Gupta et al. (2003) found that this superior septal widening had a mean width of 1.15cm in contrast to 0.30 cm for the inferior portion of theanterior septum.

Lateral Wall of the Bony Valve Region

CT scans consistently show 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 histaminemoves the zone of swelling forward a few millimeters, and decongestion can cause the observable soft tissue bulge to recede a few millimeters.

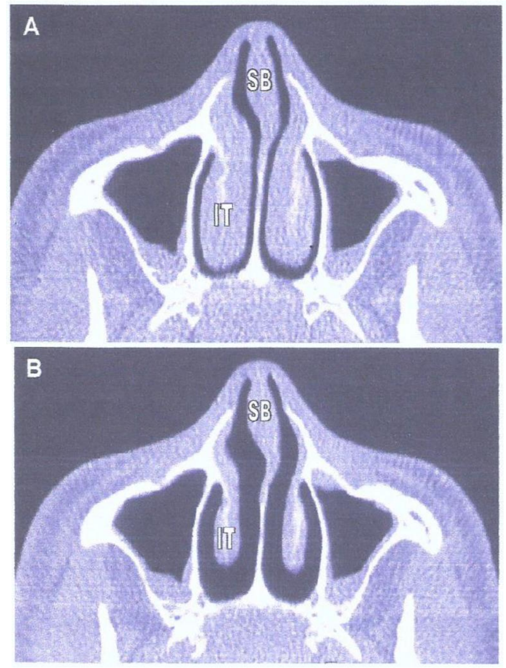

Figure (8): Modified axial CT reconstruction, angled up 30° anteriorly to show the nasl swell body (SB) and inferior turbinates (IT) in the same section. The SB straddles the piriform aperture at this level. (A) Undecongested nose showing thin relatively uniform air passages. (B) Decongested nose showing marked widening of the air passages; the SB is less vas oreactive 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 **(Wexler and Davidson, 2004).**

Jones et al. (1988) noted that the decongested inferior turbinate head was located at the level of the piriform aperture, at 2.15 cm within the nasal passage.

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 nasalcavum rapidly increases its dimensions beyond the piriformaperture, from a mean width of 23.6 mm at the piriform toa~36-mm width at midcavum **(Lang, 1989).**

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. This may not be appreciated on routine anterior rhinoscopy because part of the nasal valve region is distorted or by passed by the speculum. Even with endoscopic visualization, the nasal valve region cannot be defined readily by reproducible and marks. This is because the valve is a region of complex anatomy and multiple contributory structures, rather than a solitary locus of resistance **(Cankurtaranet al., 2007).**

Physiology

The cross-sectional area of the nasal valve is between 55 to 83mm^2 and is the main site of greatest nasal resistance. It functions as the primary regulator of airflow and resistance, providing the sensation of normal airway patency. As described by Poiseuille's law, nasal resistance is inversely proportional to the radius of the nasal passages raised to the fourth power (resistance [viscosity*length]/radius). Small changes in the cross-sectional area of the nasal valve produce exponential effects on airflow and resistance **(Miman et al., 2006).**

The nasal valve functions as a Starling resistor, which consists of a semirigid tube with a collapsible segment anteriorly, and collapses with forceful inspiration to limit airflow. As described by the Bernoulli principle, the degree of lateral sidewall collapse depends on the intrinsic stability of the valve and on the transmural pressure changes during normal and forceful inspiration. As flow increases through a fixed space or volume, pressure in that fixed space decreases. As airflow velocity increases, the pressure inside the nasal valve decreases relative to atmospheric pressure, thus increasing the transmural pressure difference. As this transmural difference increases, the likelihood of nasal valve collapse increases. This may be a protective mechanism to prevent large volumes of unheated and unhumidified air from reaching the lower respiratory tract. In individuals with either acquired or congenital valve collapse, this mechanism functions at a transmural pressure that is too low and can lead to premature collapse and difficulty with nasal breathing. Partial collapse of the ULC normally occurs at a respiratory flow rate of 30 L/min, preventing further increases in intranasal pressure from increasing flow **(Lee et al., 2009).**

Nasal valve obstruction can be further divided into static and dynamic dysfunction. Static dysfunction is caused by continuous obstruction at the level of the nasal valve because of structural and skeletal deformities, such as inferior turbinate hypertrophy, deviated nasal septum, cicatricle stenosis, or medially displaced ULC. Static dysfunction requires more intranasal pressure to generate a given amount of nasal airflow **(Fraioli and Pearlman, 2013).**

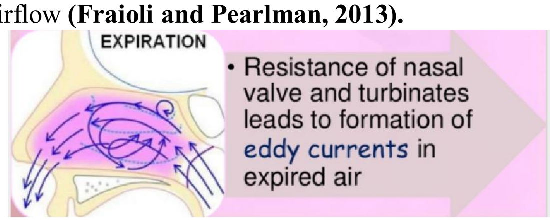

Figure (9): Role of nasal valve in control of airflow

Dynamic dysfunction, in contrast, is caused by collapsible or deficient structural support of the nasal sidewall, including the cartilaginous, fibro fatty, and muscular components, resulting in collapse of the nasal valve at low transmural pressures **(Lee et al., 2009).**

Pathophysiology

The nose serves a multitude of physiologic functions: immunologic, sensory, olfactory, and respiratory. As a respiratory organ it performs a prominent regulatory role. Air enters the nasal cavity, where it is warmed to a temperature of approximately 31^{o}C to 34^{o}C, regardless of outside temperature. It also humidifies the inspired air to a relative humidity of 90% to 95%. These functions prevent desiccation of the distal airways, which allows optimal gas exchange, and helps maintain temperature homeostasis **(Behrbohm, 2004).**

The physiologic role of the nasal valve is not as well defined. With forced inspiration by the nose, collapse of the valve occurs even in patients without nasal valve pathology. It is thought that nasal valve collapse dynamically regulates the cross sectional area of the nasal cavity preventing the influx of excessive air and ensures proper warming, humidification, and filtration before entering the lungs. The regulation might also assist in olfaction. As the nasal valve narrows, turbulent airflow is created that is redirected toward the olfactory epithelium **(Lee and Constantinides, 2008).**

The main factors that contribute to the airflow patterns are the nasal cavity geometry and the flow rate. As inspiration is initiated, airflow is directed in a laminar fashion toward the nasal valve region. This region has the smallest cross-sectional area and causes an acceleration of the flow. Poiseuille's law explains this phenomenon. This principle explains that the volume of a homogeneous fluid (air technically is a fluid) flowing through a tube per unit time (the definition of velocity) is directly proportional to the pressure difference between its ends and the fourth power of its internal radius. It is inversely proportional to the length of the tube and to the viscosity of the fluid. This equation predicts that even small changes in radius greatly affect the flow velocityby increasing it to the fourth power of the radius **(Kim and Rodriguez-Bruno, 2009).**

Changes in pressure (essentially inspiratory effort) increase velocity, but not to the extent that does a change in radius **(Sutera and Skalak, 1993).**

As flow velocity increases through constricted regions of the nasal airway, the Bernoulli the oremthenpredicts that air pressure decreases. This results ina negative pressure at the point of highest velocity, exerting a collapsing force on the surrounding tube. Whether or not this force leads to actual symptomatic collapse of the nasal airway depends on the magnitude of the force and the strength and geometry of the nasal valve areas. As described, the magnitude of the forcede pends on the pressure, which is determined by airflow velocity, which is determined by inspiratory effort and nasal airway dimension. The strength of the nasal airway depends on the anatomy of the nose, most notably the width and strength of the lateral nasal wall and the shape and stiffness of the ULCand LLC. The goals of functional rhinoplasty are twofold: to widen the nasal airway aperture and thereby reduce airflow velocity and the negative pressure created within the nose; andto strengthen the valve areas to become more resistant against collapsing pressure forces **(Wen et al., 2008).**

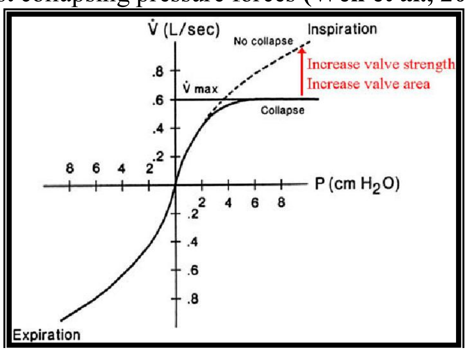

Figure (10): Flow-volume curve demonstrating normal functioning nose (dotted line) and nose with valvular collapse (solid line). In the pathologic state, at high pressure (inspiratory effort) the nose collapses and no further increase in flow occurs. The goal of surgery is to widen and strengthen the airway in the nasal valve areas, and shift the flow-volume curve from abnormal to normal **(Wen et al., 2008).**

Causes of nasal valve dysfunction

As described by **Kern and Wang (1993),** the etiologies of nasal valve dysfunction can be classified as mucocutaneous or structural/skeletal abnormalities. Conditions that can cause mucosal inflammation and edema, contributing to nasal valve obstruction, include sinusitis, nasal polyposis, and all forms of rhinitis ranging from allergic to vasomotor to infectious. Structural or skeletal causes of nasal valve obstruction include any deformities of individual components of the nasal valve complex. These may include the nasal septum, upper and lower lateral cartilages, fibrofatty sidewall tissue, piriform aperture, and floor of nose.

Static structural deformities of the internal nasal valve can be caused by inferomedially displaced ULC, narrowed pyriform aperture, scarring at the intercartilaginous junction, deviated nasal septum, and inferior turbinate hypertrophy. Dynamic deformities are often secondary to destabilization of the septum and LLC, resulting in ULC collapse. Static abnormalities of the external nasal valve can be caused by tip ptosis, cicatricle stenosis, or caudal septal deviations, whereas dynamic deformities include musculature deficiencies and either primary or postoperative LLC weaknesses **(Lee et al., 2009)**.

Previous nasal surgeries, namely reduction rhinoplasties, can contribute significantlyto nasal valve obstruction. **Celebi et al. (2014)** showed that the cross-sectional area at the nasal valve decreased by 25% and the pyriform aperture by 11% to 13% using acoustic rhinometry after reduction rhinoplasty. A more recent retrospective review of 53subjects by **Kosh and colleagues (2004)** showed that previous rhinoplasty was the cause of nasal valve obstruction in 79% of subjects, followed by nasal trauma (15%) and congenital anomaly (6%).

Several rhinoplasty techniques can contribute to postrhinoplasty nasal valvedys function. Overaggressive dorsal hump reductions that destabilize the ULC, and surgical over-resections of the LLC, may lead to collapse of the nasal sidewall. Scroll release with knuckling may also occur with overaggressive cephalic trims of the LLC and caudal trims of the ULC. Bossa formation at the nasal tip can occur with scroll release, tip-graft migration, or excessive postoperative scarring, especially in patients with preexisting bifidity or stiff LLC, all of which can lead to nasal valve obstruction postrhinoplasty **(Manickavasagam et al., 2014).**

Cannon and Rhee (2012) described that with resection of the middle vault roof, the flaccid ULC, once disarticulated from the nasal septum, tends to fall infer medially toward the nasal septum. These results in a narrowed middle vault characteristically described as the inverted-V deformity. This may lead to dynamic and static collapse of the ULC caused by their disarticulation from the septum medially, decreasing nasal valve areas, and more readily allowing dynamic collapse with inspiration. Traumatic displacement of the nasal bones, ULC, LLC, or nasal septum is a leading cause of acquired nasal valve dysfunction. When nasal fractures are being repaired, mobilizing and correcting the nasal bones and the attached cephalic border of the ULCs should be accomplished before correction of the internal nasal valve.

Other causes of nasal valve dysfunction include tip ptosis, cicatricial stenosis, facial paralysis, and paradoxical lateral crura. Tip ptosis can be from excess soft-tissue bulk causing narrowing of the nasal vestibule or structural ptosis secondary to saddle nose deformity or weakened LLC medial churapostrhinoplasty. Cicatricial stenosis isan uncommon cause of external nasal valve obstruction and is usually iatrogenic. Facial paralysis can result in collapse of the nasal sidewall caused by loss of muscular tone of the dilator naris and nasalis muscles.

Paradoxical lateral crura describe a rarephenomenon where the LLC lack normal external convexity in the lateral crura. These abnormal cartilages may project into the nasal vestibule causing static obstructionand dynamic obstruction with decreased resistance to collapse during inspiration **(Lee et al., 2009).**

Manickavasagam et al. (2014) reported that, anatomic abnormalities at the nasal valve could affect the skin, mucosa, submucosa, muscle, and/or cartilage. It is important to distinguish primary from secondary valve collapse because treating secondary collapse is usually not successful. **The primary causes** of nasal valve collapse are: excessive resection of the lower lateral cartilages; the shape of the lower lateral cartilages; inherently weak upper and lower lateral cartilages; an absence of overlap between the upper and lower lateral cartilages; long returning of the upper lateral cartilages; soft-tissue stenosis; facial nerve palsy; and a narrow piriform aperture.

Secondary causes are: a deviated nasal septum; a wide columella; turbinate hypertrophy; scarring of the vestibular skin; a slit-like inlet; and a wide Zuckerkandl tubercle.

Diagnosis

History and Physical Examination

The main symptom of nasal valve collapse (NVC) is decreased nasal airflow. However, there are a myriad of conditions that can present with nasal obstruction. These conditions include infectious, inflammatory, and neoplastic conditions, and the treatment varies depending on the underlying cause. Therefore, a detailed history should include the timing, onset, seasonal variation, laterality, prior history of nasal trauma or surgery, and exacerbating or alleviating factors of nasal obstruction. It is also important to determine the presence or absence of associated symptoms, such as epistaxis, anosmia, rhinorrhea, or postnasal drainage. This differentiation can help identify or rule out causes of nasal obstruction that are not attributable to pathologic conditions of the nasal valve **(Cannon and Rhee, 2012).**

There is currently no gold standard objective test to diagnose NVC; it remains a clinical diagnosis. A general assessment of the external appearance of the nose can identify problems with the potential to cause nasal obstruction, such as nasal tip ptosis, a narrow mid-vault, an inverted-V deformity, or narrowed nostrils. Additional physical examination techniques can identify abnormalities of the lateral nasal wall related to weak or malformed upper and/or lower lateral cartilages. Specifically, findings on physical examination suggestive of NVC include visible inspiratory collapse of the lateral nasal wall or alar rim. Also, subjective and audible improvement in nasal airflow during a Cottle maneuver (lateral retraction of the cheek) or modified Cottle maneuver (intranasal lateralization of the lateral nasal wall) is consistent with NVC **(Rhee et al., 2010).**

Anterior rhinoscopy is an adequate intranasal evaluation of the nasal valve region and will provide information about the position of the septum and size of the turbinates. Nasal endoscopy can be useful to rule out other causes of nasal obstruction not attributable to NVC if the diagnosis is uncertain but is not routinely indicated. If surgery is being planned or considered, preoperative photography can be helpful for patient counseling, preoperative planning, and documentation, even in cases when the surgical intent is purely functional, but this is especially true if surgery is being undertaken for both functional and cosmetic purposes **(Cannon and Rhee, 2012).**

In patients with NVC, it can be difficult to determine which components of the nasal valve to address because there are several anatomic structures that contribute. However, identifying the problematic area can help guide the surgeon in deciding which procedure is likely to provide the most benefit. In general, functional rhinoplasty techniques target a specific area or component of the nasal valve. Also, determining whether obstruction is resulting more from fixed or dynamic obstruction can help the surgeon decide between a procedure intended to increase the actual diameter of the nasal valve or one that aims to strengthen a weak lateral wall or alar rim **(Rhee et al., 2010).**

Subjective Measures of Nasal Obstruction

Traditionally, a common method of assessing nasal obstruction and reporting outcomes of functional nasal surgery is subjective patient-reported measures. For assessing the efficacy of a surgical intervention, a comparison of preoperative and postoperative results is often used. In addition, there has been a trend in medicine toward evaluating quality of life (QOL) in the assessment of disease processes and the efficacy of treatment **(Rhee and McMullin, 2008).**

Generic health-related QOL can be measured using scales, such as the Medical Outcomes Study Short Forms (SF-12 and SF-36). However, disease-specific QOL measures can be superior to generic QOL instruments because they may be more sensitive for the detection and quantification of small changes. There are validated QOL instruments specific for rhinologic disease, such as the Rhinosinusitis Disability Index **(Senior et al., 2001),** Rhinoconjunctivitis Quality of Life Questionnaire, and the Sinonasal Outcomes Test **(Hopkins et al., 2009),** each of which has beenused in the past for evaluating septal or nasal valve pathologic conditions.

Theseinstruments all include nasal obstruction in their evaluation; however, their primarypurpose is the evaluation of inflammatory nasal disease, which may secondarily result in nasal obstructive symptoms **(Cannon and Rhee, 2012).**

Nasal obstruction symptom evaluation scale

The QOL measure most relevant to structurally based nasal valve pathologic conditionsis the Nasal Obstruction Symptom Evaluation scale, a disease-specific quality of-life instrument developed for the assessment of nasal obstruction with evidencein support of its validity, reliability, and sensitivity **(Stewart et al., 2004a).** With this instrument, patients are asked to rate the severity of several nasal symptoms and the results are summed and scaled. Its original use was in patients undergoing septoplasty who demonstrated an improvement in disease-specific QOL after surgery **(Stewart et al., 2004b).**

Subsequent studies usingthe NOSE scale in patients undergoing surgery for NVC also demonstrated statistically significant improvement in disease-specific QOL **(Rhee et al., 2005; Most, 2006).**

Visual analog scales

Visual analog scales (VAS) are a common method of subjectively measuring symptomsin various conditions that have also been used as an evaluation method and outcome measure in nasal obstruction. In VAS, patients are asked to rate their experience of symptoms on a linear scale ranging from no obstruction to complete obstruction **(Lam et al., 2006).** Multiple studies have shown improvement in VAS for nasal obstruction after nasalvalve repair **(Rhee et al., 2008; Spielmann et al., 2009).** One potential advantage of VAS over other objective tests is that, for patients with unilateral symptoms, VAS for each side of the nasal cavity can beassessed separately. Several studies show better correlation between VAS for nasalobstruction and objective measurement techniques when unilateral VAS is used **(Clarke et al., 2005).**

Objective Measures of Nasal Obstruction

Aside from subjective measures, there is also interest in the development and implementationof validated objective measures to assist in preoperative evaluation and tobetter assess surgical outcomes. Several techniques have been developed and validatedto date. Of these, rhinomanometry and acoustic rhinometry (AR) have beenused most frequently **(Rhee et al., 2008; Spielmann et al., 2009).**

Rhinomanometry allows the determination of nasal airwayresistance by simultaneously measuring transnasal pressure drop and nasal airflow **(Pawar et al., 2010).** This technique has been used to objectively document changes in nasal resistanceafter nasal valve surgery. However, it is not in widespread use because of several limitations. These drawbacks include the inability to precisely locate the area of obstructionand the need for specialized equipment and a well-trained operator **(Chandra et al., 2009).**

Acoustic rhinometry (AR) for nasal obstruction

The technology of AR was originally devised for oil investigation; however, it wasn't until the 1970s that it was first used in the field of medicine to perform measurements in the distal airway. The acoustic rhinometer consists of a sound source, wave tube, microphone, filter, amplifier, digital convertor, and a computer. A sound wave is transmitted into the nasal cavity, which is then reflected back from the nasal passages and converted into digital impulses, which are then constructed on a rhinogram.

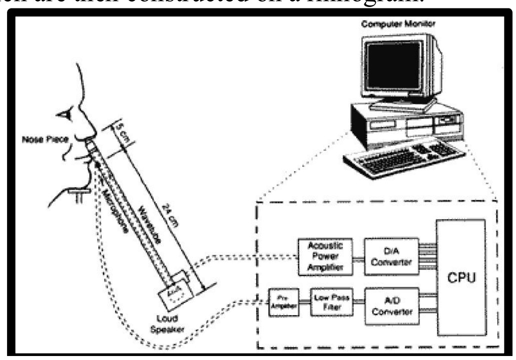

Figure (11): Diagram of the Acoustic rhinometry system

This rhinogram provides a two-dimensional anatomic assessment of the nasal airway. The cross-sectional area of the nose differs at different points from the nasal rim, and these variances are detected by changes in acoustic impedance. Each notch on the rhinogram represents a different anatomic constriction in the nasal cavity. The first notch represents the nasal valve and is usually the minimal cross-sectional area (MCV) in the normal nose. The second notch represents anterior portions of the inferior turbinate or middle turbinate, while the third notch is estimated to be in the area of the middle/posterior end of the middle turbinate. Each notch identifies a site of limitation of nasal airflow and can be used to locate the site of obstruction in the nose **(Lal and Corey, 2004).**

AR is a technique that uses the measurement of deflected sound waves to provide an estimate of the cross-sectional area (CSA) of the nasal cavity as a function of the distance from the nostrils. AR is relatively easy to perform and is quick and noninvasive. It too has limitations, however. Similar to rhinomanometry, it does require specialized equipment and an experienced operator. In addition, the results obtained are sensitive to variations in technique and testing conditions **(Clement et al., 2005).**

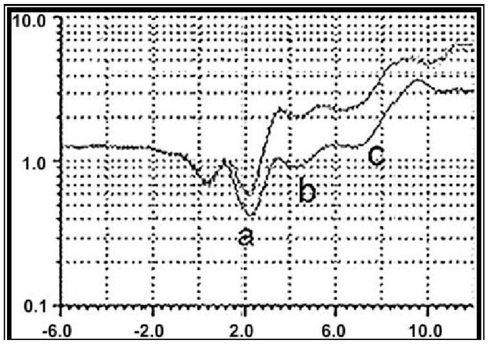

Figure (12): Acoustic rhinogram before (lower) and after (upper) nasal decongestion. The x-axis reflects the distance from the nostril and the y-axis is the cross-sectional area of the nasal airway. Note the increase in cross-sectional area after decongestion, most pronounced at notch (b) and (c). Notch (a) represents the MCA at the nasal valve. Notch (b) represents cross-sectional area at the anterior portions of the inferior turbinate and middle turbinate. Notch (c) reflects the area of the middle/posterior end of the middle turbinate **(Lal and Corey, 2004).**

Another known limitation of AR is that it overestimates CSA in areas beyond 5 cm from the nostrils **(Terheyden et al., 2000)** or after constricted regions or areas of drastic changes in nasal anatomy **(Cakmak et al., 2001).**

The advantagesof AR make it one of the most common objective methods used to evaluate nasalpatency. However, it has not achieved widespread clinical use because of the limitationsnoted previously **(Cannon and Rhee, 2012).**

Rhinomanometry

Rhinomanometry (RM) is a functional assessment of airflow and involves measurement of transnasal pressure and airflow. From these measurements one can assess the mean pressure, volume, work (pressure x flow) and resistance (pressure/flow) associated with each breath. Resistance from each side of the nose can be compared with each other and with total nasal resistance, enabling the physician to identify how each nasal passage is contributing to the patient's complaint. The resulting plot, with the x-axis representing the pressure differential and the y-axis representing flow, produces an S-shaped curve. The most common method of reporting results is with inspiratory airflow. The machine consists of a pressure transducer for measuring posterior nasal pressure, a pneumotachometer for measurement of flow, a mask for measurement of anterior nasal pressure and flow, and a computer for converting these measurements into digital signals **(Chandra et al., 2009).**

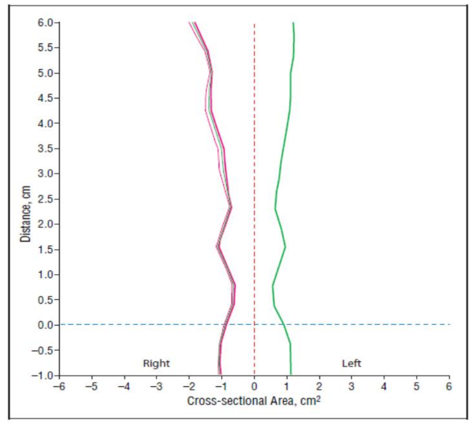

Figure (13): Acoustic rhinometry measures cross-sectional area vs distanceinto the nasal cavities. Note the two distinct minima, representing the externaland internal nasal valves.

In RM, posterior nasal pressure is measured in one of three ways. Anterior RM, introduced by Coutade in 1902, involves placement of a transducer in the nostril not being tested. Because there is no flow in this nostril, the pressure at the anterior end of this nostril is equal to the pressure in the posterior end of this nostril. Transnasal pressure differences and nasal airflow are recorded at the same time for each side and the dynamic changes of airway resistance are assessed.46 This is the most common method used because it is usually well tolerated and it is easier for the patient to cooperate. A limitation of anterior rhinomanometry includes the inability of accurate measurements with septal perforations. Another disadvantage is that a direct measurement of total nasal resistance cannot be made because each nostril is measured separately. Estimations of total nasal resistance can be obtained by calculations; however, these results are not as accurate as direct measurement **(Lund, 1989)**.

Another method of measuring the nasal pressure differential is with posterior (peroral) RM, introduced by Spiess in 1899. With this method, the pressure detector is in the posterior oropharynx by way of tubing passed through the mouth. It is only method which can accurately assess the contribution of adenoid hypertrophy to nasal airway obstruction, however it is not tolerated as well as anterior RM. The third method of measuring transnasal pressure is postnasal RM. This involves placement of a posterior nasopharyngeal tube by way of the test or non-test nostril. Postnasal RM is also not commonly used secondary to difficulties with patient tolerance. During RM, airflow can be generated by active or passive means. Active rhinomanometry, the most common technique used today, involves using the patient's own respiratory efforts as the source of airflow. Passive

RM involves pumping air through the nose at a known rate. This method does not imitate true nasal physiology and has been found to reflexively increase mucosal thickness, which could affect the accuracy of its measurements **(Zeiders et al., 2005).**

The measurement of airflow during RM can be accomplished by direct or indirect means. With direct methods, airflow is measured at the nasal outlet by way of a nozzle or mask. Masks are most commonly used today because the nozzle can alter the relationship of the nasal ala with airflow. Indirect methods of airflow measurement are slightly more complicated, using body plethysmography to measure changes in intrathoracic volume to extrapolate air flow **(Chandra et al., 2009).**

Odiosoft Rhino

Odiosoft rhino (OR) is a new objective technique that converts the frequency of sound generated by nasal airflow into cross-sectional area measurements. The theory behind the technology is that nasal airflow generates a higher frequency sound as turbulence increases. This noninvasive technique, developed by **Seren (2005),** involves a microphone, nasal probe, sound card, and a computer. The nasal probe is connected to a microphone situated 1 cm from the nostril, and the subject is asked to close the other nostril, avoiding any distortion of the test nostril. The sound created during breathing is directly measured with the odiosoft rhino technique, unlike acoustic rhinometry, which measures reflected sounds to calculate nasal cross sectional area.

A study published in 2006 shows this method provides a sensitive and specific assessment of nasal airway patency with better correlation to patient symptom scores when compared with AR. Although these findings are encouraging, the search continues for an ideal modality of objective testing **(Tahamiler et al., 2006).**

Imaging studies for nasal obstruction

Imaging studies, such as computed tomography (CT) or magnetic resonance imaging (MRI) scans, can have a role in the evaluation of nasal obstruction, with utility in evaluatinginfectious, inflammatory, or neoplastic disease, but have a limited role in theevaluation of nasal valve pathologic conditions specifically **(Rhee et al., 2010).**

CT imaging can beused as a method of measuring the nasal valve angle (between the septum and upperlateral cartilage). When used for this purpose, the most accurate measures are obtainedfrom views other than the traditional coronal view, which may underestimatethe true nasal valve angle. Specifically, a modified view known as the nasal baseview, which uses slices oriented perpendicular to the approximated acoustic axis ofthe nose, provides the most accurate information about the nasal valve angle **(Poetker et al., 2004).**

This technique has not been adopted for widespread use because there is subjectivityin the selection of the acoustic axis and the need to reformat CT images into a nonstandardview. There is also a lack of evidence in regard to its reproducibility, althoughstudies comparing this method with AR-derived data show good correlation in themeasurement of the nasal valve area **(Cakmak et al., 2003).**

Fiber-optic examination

Often, a fiber-optic examination gives additional information about the patient's nasal anatomy. Careful examination of the middle meatus and posterior nasal cavity in a patient with a longstanding history of sinusitis may augment a good anterior nasal examination. Patients may often have undetected purulence, indicating an active infection or significant nasal polyposis requiring treatment. Often, in patients who have had previous surgery, surgical scarring or synechiae between the nasal septum and turbinates may be present and difficult to appreciate without the use of a fiberoptic scope. Previous surgical septoplasty may reveal sites of resected cartilage, bent or malpositioned septal remnants, or a perforation. Several surgical maneuvers to repair internal and external nasal valve stenosis require cartilage grafting, and it is always a big disappointment to learn in the operating room that your primary donor site for nasal cartilage grafting has already been removed **(Moche and Palmer, 2012).**

Computational fluid dynamics for nasal obstruction

Computational fluid dynamics (CFD) is emerging as a new method to evaluate nasalairflow and resistance as well as other physiologic parameters important to the functionof the nose, including particle deposition and air conditioning. CFD is a technologyused widely in engineering as a way to model the motion of fluids. For this technique, anatomically accurate 3-dimensional computational models of patients' nasal cavitiesare generated from imaging data captured by CT or MRI **(Rhee et al., 2011).**

CFD softwareprograms can then be used to obtain computed measures of airflow, resistance, heat transfer, and air humidification. The ability to study multiple parameters of interest under different simulated conditionswith minimal cost or inconvenience to patients makes CFD an attractive methodto investigate nasal function. A further benefit of CFD over other objective measures ofnasal function is the ability to determine airflow and other factors of interest at preciseanatomic locations rather than in the nasal cavity as a whole as is done with other methods. Another exciting extension of CFD technology is the ability to do simulated surgery on the digital models. The computed nasal geometry can be virtually modified in a manner reflecting surgical techniques, and, subsequently, new patterns of airflow and heat and water vapor transport can be calculated **(Garcia et al., 2010).**

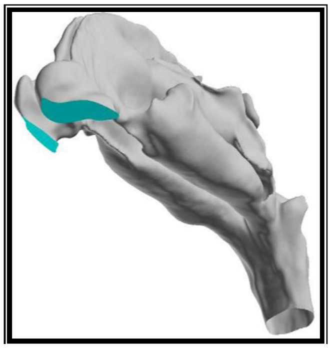

Figure (14): Digital nasal airway model for use in CFD analysis **(Rhee et al., 2011).**

There are also limitations with current CFD technology. There is additional cost to obtain the necessary imaging studies. Also, at present, the process of producing the digital models is time and labor intensive, although as technology has advanced, the cost and time to build models has declined and is expected to continue to do so. Further, although models can be built from either CT or MRI scans, the models basedon CT imaging give better results because of better resolution, thus subjecting patients to radiation exposure that they would otherwise not receive. CFD also makes assumptions that are reasonable in many cases but may not always hold true, such as laminar flow of air within the nasal cavity, fixed and rigid nasal cavity walls, and steady stateair flow **(Pawar et al., 2010).** CFD analysis with respect to nasal function is still in its early stages and most studies are limited in scope and number. Further studies are needed to fully validatethe method and elucidate the correlation between CFD-derived parameters and actualclinical and patient-reported data. However, this exciting technology holds greatpromise and may prove to be a valuable resource in objective preoperative evaluation, surgical planning, and analysis of surgical outcomes for surgeons performing functional rhinoplasty **(Cannon and Rhee, 2012).**

Differential Diagnosis

Allergic rhinitis, septal deviation, nasal polyposis, and rhinitis medicamentosa are all common causes of airway obstruction. Because the internal nasal valve (INV) represents the main site of resistance to airflow through the nose, any of these abnormalities will be most symptomatic if located within the INV area. In addition to these extrinsic causes of INV narrowing, intrinsic weakness of the ULC will cause the ULC to collapse inward, narrowing the INV angle and increasing nasal airway resistance. Patients with short nasal bones and/or weak upper lateral cartilages are at the highest risk for this; however, even in these patients, valve compromise is most commonly seen as a complication of surgery or trauma **(Fraioli and Pearlman, 2013).**

Collapse of the ENV may be caused by overzealous cephalic trim of the alar cartilages during aesthetic rhinoplasty. This causes a dynamic obstruction—the weakened nasal sidewall collapses when it can no longer counter the negative pressure of inspiration. To prevent this complication, it is now recommended that a minimum of 6mmof each lateral crus be left following cephalic trim. Facial paralysis, with dysfunction of the dilator muscles of the nose, is another potential cause of ENV compromise **(Oliaei et al., 2012).**

Non-surgical treatments of nasal valve obstruction

Non-surgical and medical interventions for the treatment of nasal valve dysfunction are appropriate for many patients with mild or mucosal etiologies for their dysfunction. Patients with mild-structural dysfunction or those that are poor surgical candidates may find relief with commercial nasal valve dilators, such as Breathe-Right strips (CNS Inc., Minneapolis, Minnesota) **(Lee et al., 2009).**

A newer non-surgical technique described by **Nyte (2007)** for correcting nasal valve collapse is a spreader graft like injection with calcium hydroxylapatite (Radiesse, Bio Form Medical, Franksville, Wisconsin) into the submucoperichondrial or submucosal plane at points on the ULC and at the junction between the dorsal septum and ULC. This may lateralize the ULC, making it less likely to collapse with inspiration. The author notes successful spreader graft injection in 23 subjects to date, with minimal adverse effects with follow-up ranging from 3 to 10 months, although percentages are not provided. All patients reported subjective improvement in nasal patency or alleviation of snoring. Patients with symptoms that improve significantly with nasal-decongestant therapy or those associated with inflammatory or infectious processes, should be treated medically, at least initially, but may require surgical intervention for refractory cases.

A retrospective review by **Inanli et al. (2008)** examining 45 subjects who underwent concurrent functional endoscopic sinus surgery and rhinoplasty demonstrated that combined surgery may be done safely without major complication, may be more cost-effective, and yield pleasing aesthetic and functional outcomes.

Surgical treatment

If a patient has exhausted medical management and the site of obstruction is identified, a surgical treatment plan specific to the dysfunctional element is determined. Nasal septal deviations and inferior turbinate hypertrophy can significantly contribute to obstruction of the nasal valve complex and should be addressed at the time of surgery, either alone or in conjunction with additional nasal surgery. Many authors will agree that septoplasty for anterior septal deviation is beneficial. Hypertrophic inferior turbinatescan be reduced in multiple ways, including submucous resection, KTP laser, coblation, and radiofrequency ablation, with or without out fracturing **(Lee et al., 2009).**

Internal nasal valve

The spreader graft as described by **Sheen in 1984** has been the most common approach to correct internal nasal valve collapse. Several adaptations to this technique have been reported in the literature. Each offers a varying twist of the standard that may accommodate specific circumstances pertaining to individual patients. An open approach is preferable as it allows superior visualization of anatomy **(Ozturan, 2000; Andre et al., 2004; Gupta et al., 2003; Boccieri, 2005).**

Techniques

1- Spreader graft

For an open approach: an 11 blade is used to make an inverted V transcolumellar incision. Marginal incisions are made in the nasal vestibule of each nostril. Soft tissue is elevated off the medial crus of the lower lateral cartilages with care taken not to disrupt this delicate cartilage. A converse scissors is used to create a subperiosteal plane that allows for a clean dissection. Tissue is elevated following each lower lateral cartilage laterally. By exposing the cartilages in this way, multiple problem areas can be corrected through the same approach.2. Dissection then follows at the septal edge and mucoperiosteal flaps are elevated from both sides of the septum. If septal cartilage is available this is the graft materialof choice as it is in the same operative field. Otherwise, auricular cartilage can be harvested. Leaving a 1 cmstrut to both the caudal septal edge as well as to the dorsal aspect of the septum, septal cartilage is harvested. The cartilage is then carved with either a 15 blade ora 64 beaver blade into two grafts 15 mm in length and2–3 mm in thickness **(Saedi et al., 2014).**

The grafts are placed on either side of the septum as highas possible. Try to place the grafts at the same height asthe septum so that they sit flush at the nasal dorsum. Theuse of a 25-gauge 1 inch straight needle helps to hold the grafts in place on each side of the septum while preparing to place sutures. At the caudal edge of the graft, a 5.0absorbable suture (Vicryl) is placed through the spreader graft, the septum, and the other spreader graft in a mattress fashion. Approximately 1 cm posterior another suture is placed from the upper lateral cartilage, through the spreader graft, septum spreader graft, and upper lateral cartilage in a mattress fashion **(Messina-Doucet, 2009).**

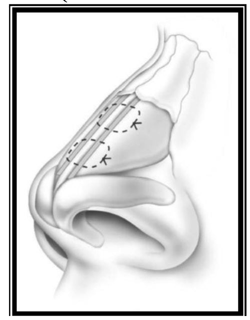

Figure (15): Spreader graft **(Messina-Doucet, 2009).**

The advantage of this technique is that it causes littlenasal deformity. It can widen the dorsum but this trade-offis usually acceptable as the function of the nose is improved as the obstruction may be alleviated **(Stacey et al., 2009).**

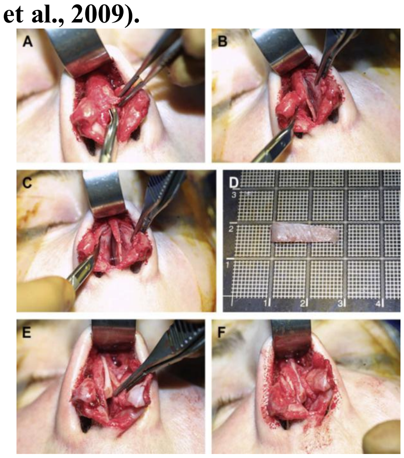

Figure (16): Spreader grafts. (A) In an open rhinoplasty, the tip scissors is placed in the submucoperichondrial pocket between the left ULC and the septum. (B) The left ULC has been cut away sharply from the dorsal septum. The forceps is holding the left ULC laterally. (C) Both ULC have been sharply cut away from the dorsal septum, leaving the overlying mucoperichondrium intact. (D) A typical spreader graft. Note the fine tapering at the end that will insert beneath the nasal bone cephalically. (E) The spreader graft has been inserted between the left ULC and the septum. (F) Bilateral spreader grafts have been placed **(Lee et al., 2009).**

Complications

Complications of spreader grafts include the cephalic edge rotating anteriorly and becoming visible at the bony-cartilaginous junction, under correction with continued visible middle third collapse, and poor lateralization of the ULC with continued internalnasal valve stenosis. Tapering the cephalic edge of the spreader graft and inserting itbeneath the nasal bone will lock it in place and prevent postoperative anterior rotation. Overcorrecting middle third depressions is often needed to adequately correct concavities there. Experienced surgeons are relying less on spreader grafts to correct internal nasal valve problems, adding batten grafts for greater stability and support ofthe internal nasal valve area posteriorly. Spreader grafts are most useful for correcting visible concavities and preventing unsightly inverted-V deformities and less useful for correcting internal nasal valve functional deficits **(Lee et al., 2009).**

Alternative to widen internal nasal valve

Flaring sutures, known as ‘‘Park sutures’’ after Dr. Stephen Park, are sometimes used to widen the internal nasal valve angle. A horizontal mattress suture extends from the caudal/lateral area of the ULC, across the septum dorsum, and fixed to the contra lateral ULC. The septum acts as a fulcrum when the suture is tightened, flaring the ULC laterally to increase the angle between the septum and ULC **(Ballert and Park, 2006).**

An alternative to the flaring suture is the suspension suture where a small incision, 1 cm anterior and inferior to the medial canthus, is made over the nasal bone to pass a suture under the superficial musculoaponeurotic system. A separate endonasalintercartilaginous incision is made so that the suture can be passed around the ULC and directed back to the external nasal incision. Tightening of this suture results in lateralization and suspension of the ULC and thus increasing the nasal valve area **(Nuara and Mobley, 2007).**

Butterfly grafts are additional alternatives to widen the internal nasal valve. These grafts use the intrinsic curvature of conchal cartilage and can be placed endonasally or by way of an open approach at the scroll area between the ULC and LLC to widen the internal nasal valve angle. Grafts are sutured in place with the caudal border of the graft deep to the cephalic border of the lateral crura. However, butterfly grafts have a higher tendency to alter cosmetic appearance by widening the nasal supratip region **(Clark and Cook, 2002).**

2-Cartilage spanning graft

Occasionally, spreader grafts alone are not sufficient especiallyin a patient with weak septal cartilages. Even ifauricular cartilage is used for spreader grafts, sometimes theseptum is very thin and another option must be considered. Cartilage placed over the area of internal valve collapsecan provide structural support and prevent collapse of the internal nasal valve **(Kucuker et al., 2014).**

Technique

Prior to anesthesia, the area on the external nose that corresponds to the internal nasal valve is observed. A Q-tip is used to view the internal valve area anda surgical marking pen is used to mark the surfaceof the skin on the lateral nose that sits above this weak area. An open approachis then used to expose the area of the septum and the upper lateralcartilage. Cartilage is harvested and a 64 beaver blade is used to configure a graft that is circular in fashion and large enough to cover the defect as determined bypreoperative markings. Tapering the edges improves cosmetic camouflage and makes the graft less visible postoperatively. The graft is placed spanning the upper lateral cartilage and the lower lateral cartilage, lateral to the septum. The graft is sutured percutaneously with a 4.0 PDS in order to coapt tissues, prevent graft migration, and prevent the accumulation of fluid between the graft and the skin. The PDS is removed in 7 days. This technique is advantageous in elderly patients with thin septal cartilages. It can also be used in patients with thick skin. The disadvantage of this method is that the tip is made to appear wider, and may not be acceptable to a cosmetic rhinoplasty patient or patients with thin skin **(Messina-Doucet, 2009).**

3-Splay conchal graft

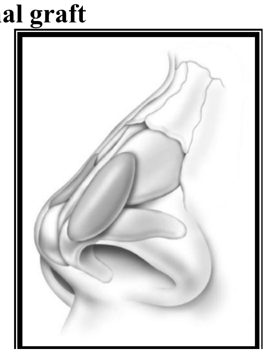

Figure (17): Cartilage spanning graft **(Messina-Doucet, 2009).**

The open technique is initiated. Conchal cartilage is harvested by making a postauricularincision. The perichondrium is left intact on the posteriorsurface. The entire concha is harvested. A 15 blade is used to sculpt the graft to fit over the anatomicdeformity that extends laterally to cover bothinternal nasal valve areas. The area of deformity usually its between the septum and upper lateral cartilage onboth sides, and cephalic to the lower lateral cartilage. The size of the graft ranges from 0.9 to 1.2 cm in length, by 2.2 to 2.5 cm in width **(Akcam et al., 2004).**

The edges of the concealed graft are beveled. The graft is placed on the nasal dorsum, over the upperlateral cartilages, with the concave side facing down and the periosteal covered side facing up. A 5.0 Vicrylisused to attach the graft to both upper lateral cartilages in a single interrupted fashion **(Deylamipour et al., 2005).**

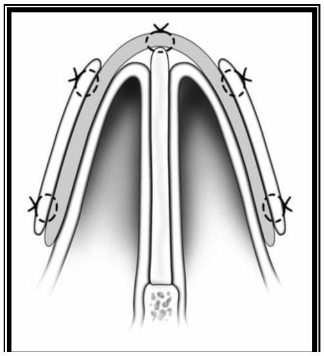

Figure (18): Splay conchal graft **(Deylamipour et al., 2005).**

The skin flap is then replaced and percutaneous sutureis placed in a mattress fashion to coapt the skin andendonasal lining to the graft using a 5.0 PDS suture. The suture is removed in 5 days. This is a very simple technique especially in a patientwith weak septal cartilage or in a patient in whom septalcartilage is unavailable for graft harvest. It can widen the nasal dorsum but if sculpted properly this widening is notperceived as a problem to the patient. It is most applicable for use on a patient with thick skin **(Stucker et al., 2002).**

External nasal valve

1- Alar batten graft

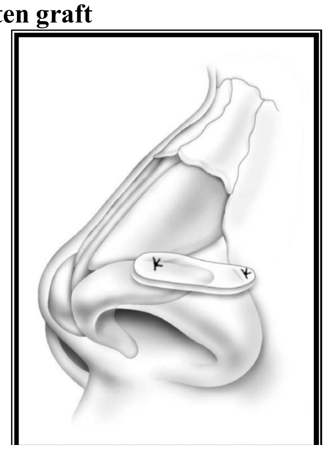

Figure (19): Alar batten graft **(Messina-Doucet, 2009).**

Prior to anesthesia, a surgical marking pen is used to mark the area of the lateral nasal sidewall corresponding to external valve or sidewall collapse. As the patient inhales, the area of maximum flaccidity is marked. An open rhinoplasty approach is recommended. Septalcartilage or auricular cartilage is harvested. The graft is fashioned to meet the required length per preoperative markings. Effective graft size is approximately 14 mm in length and 8 mm in width. The width of the graft should be 4–5 mm wider than the existing alar cartilage **(Messina-Doucet, 2009).**

The graft is placed anterior to the pyriform apertureand extends 2 mm superior to the rim. Using 5.0 Vicryl, the graft is sutured medially, centrally and laterally **(Kosh et al., 2004).**

Alar batten grafts augment weak or absent LLC, which may be congenital or secondary to prior rhinoplasty involving overaggressive cartilage resection during tip-modeling procedures. Septal or conchal cartilage can serve as sources for graft material. The graft should be long enough to be seated in the soft-tissue pocket starting at the level of the supra-alar crease, at the junction of the ULC and LLC, and extend over the bony pyriform aperture. For optimal cosmetic appearance, these grafts should be thin with beveled edges, and for maximal structural support, should be wider laterally along the pyriform aperture. The exact size and placement of the batten grafts depend on the specific individual deformities, but should primarily reinforce those areas of the alar lobule which collapse with inspiration, without changing the resting position of the valve. Battens may be fixed in place with either a transcutaneous or transmucosalresorbable suture to fix the batten graft in its pocket. If carefully placed and tapered, alar batten grafts need not create fullness at the site of the graft. If filling is desired, the graft can be contoured appropriately for optimal results **(Lee et al., 2009).**

Toriumi and colleagues (1997) described their experience with alar batten grafts in 46subjects and found that all but one had marked improvement in nasal airway obstruction. Postoperative examinations revealed significant increases in internal or external nasal valve with increased structural support and patency of the external valve upon moderate-to-deep inspiration. They concluded that alar batten grafts are effective techniques for long-term correction of nasal valve collapse in properly selected patients without intranasal scarring, loss of vestibular skin, or excessive narrowing of the pyriform aperture.

Alar-strut graft

An alternative to alar batten grafts that overlay the lateral crura are alar strut grafts that underlay the lateral crura. They provide support to the external nasal valve or the internal nasal valve, depending upon their positioning. The graft is placed by elevating the vestibular skin off the undersurface of the lateral crus. The graft is usually directed more caudally than the posterior portion of the lateral crus, essentially acting as an alar batten in the region of the external valve devoid of cartilage. Its medial portion, therefore, supports the lateral crus, lateral to the dome, while its lateral portion supports the hinge area, where ligaments course from the lateral crus toward the pyriform aperture. Indications for the alar strut graft include inward curvature of the lateral crus, doubleconvex lateral crus, and weak lateral crus. Alar strut grafts are also helpful when transposing cephalically-oriented lateral crura to help stabilize them once they have been translocated more caudally **(Lee et al., 2009).**

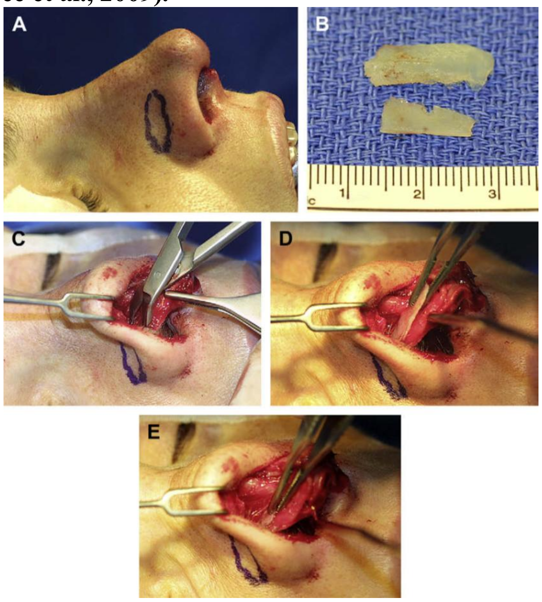

Figure (20): Alar batten grafts. (A) The area of maximal weakness has been marked preoperatively. (B) Typical size of a batten graft (top). The graft ideally extends laterally onto the pyriform aperture for maximal stabilization of the lateral-nasal wall. (C) Pocket to receive graft being dissected with the tip scissors. (D) Graft being inserted into pocket. (E) Graft in position, before being suture-secured to underlying lateral crus **(Lee et al., 2009).**

Lateral crus pull-up

Another technique for correcting a flaccid external nasal valve is the lateral crus pull-up described by **Menger (2006),** where the lateral crus of the LLC is rotated in a superolateral direction and held in place with a permanent spanning suture through the pyriform aperture. This technique involves dissection through an intercartilaginous incision toward the caudal border of the bony pyramid. Once the soft-tissue envelope, including the periosteum, is elevated, a small hole is drilled in the bony pyriform aperture at the desired location. Menger recommends using a Gore-Tex (WL Gore & Associates Inc., Newark, Delaware) suture given its strength and decreased chance of cutting through cartilage over time.

Columelloplasty

The width of the columella often plays an important rolein narrowing the nostril. Strengthening the columella andnarrowing the footplates can improve nasal airflow **(Ghidini et al., 2002).**

Using an open approach, the columellar footplates areexposed. Soft tissue is dissected from the caudal edgesof the medial alar crura. The basal third of the medial crural footplate is exposedand a 15 blade is used to transect the cartilage. A strut graft is then fashioned from septal cartilage andplaced between the footplates. The graft and footplatesare then sutured together using a 5.0 Vicryl. This procedure is not indicated on all patients. It is usefulto narrow the columella and widen the nostril sill. Sometimesthe bony nasal spine and pyriform crest contribute tonarrowing and need to be trimmed as well. This procedurecan also correct abnormalities at the base of the nostril dueto wide or asymmetric columellar footplates **(Messina-Doucet, 2009).**

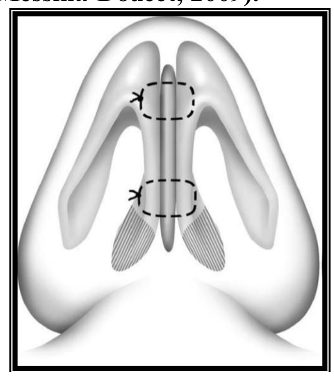

Figure (21): Columelloplasty **(Messina-Doucet, 2009).**

Nasal valve suspension technique

This technique is a simple approach, providing an internalsuspension suture to elevate the nasal valve. It is most beneficial for the treatment of internal nasal valve collapse but itprovided improvement in external valve collapse also. The technique involves anchoring sutures into the inferiororbital rim and guiding sutures to suspend the nasal valve. Cartilage harvesting is not involved. The technique wasoriginally described by **Paniello (1996)** and advancements in thistechnique have been described over the years **(Friedman et al., 2003).**

Technique

The area of nasal collapse is marked preoperatively. Specifically, the caudal and cephalad margins that representthe area of maximal collapse are marked. Thesetwo points should be about 5 mm apart. Under general anesthesia, orbital shields are placed. Access to the infraorbital rim can be through a standardtransconjunctival incision medially or a subcillaryincision. The incision should be medial to the infraorbitalnerve and lateral to the lacrimal punctae. Inpatients with thick skin or rhytids, a natural crease canbe used. An 11 blade is used to make a small 3 mm incision downto the periosteum. A periosteal elevator facilitates clearinga 3x3 mm area on the orbital rim. A Mitek Softtissue anchor system is optimal for anchoring sutures tothe orbital rim (1.3

mm Micro quick anchor; Ethicon) **(Manickavasagam et al., 2015).**

A drill is used to make a small hole in the orbital rim. The anchor is then placed into the hole and the suturesreleased. The bone anchor must sit flush with the bonein order to prevent a palpable foreign body sensation postoperatively. The end of one suture is threaded through a largecurved needle. The needle is then advanced through theincision toward the endonasal mucosa. The plane ofadvancement is deep to the facial muscles and superficial to the maxillary periosteum. The needle should exitat the cephalad point of nasal valve collapse first. Theneedle is then retrieved intranasally and passed from theinternal nasal mucosa back toward the orbital rim incision **(Messina-Doucet, 2009).**

The suture is then tied. Once the sutures are tightened, observe the area of collapse and adjust the tightness ofthe suture accordingly. Slight overcorrection may benecessary. If there is any skin dimpling, this indicatesthat the needle tract passed too superficially and willneed to be redirected in a deeper plane. The skin incision is closed with a 6.0 chromic. The advantage of this technique is that it is simple andeffective. It does not require cartilage harvesting. In myexperience the results have not caused widening of thenasal tip or dorsum. This is a good procedure to consider in cosmetic surgical patients **(André and Vuyk, 2008).**

Nasal valve stabilization

The nasal valve stabilization technique is a variation of thenasal valve suspension technique, but it offers some potentialadvantages. The stabilization technique easily allowsmultiple stabilization points. It does not require an extranasalincision, and it does not change the nasal appearance. Ittakes guesswork out of how tight to tie the sutures. Itanchors strongly to bone without any permanent foreignbody. It is a minor procedure requiring a simple intranasalincision. It can be performed in isolation or in combinationwith other nasal procedures. It can be employed as a primaryprocedure or as a secondary procedure after priornasal surgery. It can often be performed in patients whohave had multiple prior rhinoplastic procedures when othervalve procedures are risky or not possible. Since it leaves nopermanent foreign body and requires little dissection, long-term risks are minimal. However, the nasal valve stabilization is not perfect. Itonly addresses dynamic collapse and not anatomic narrowingof the nasal valve area. It often provides only partialvalve stabilization, just like every other nasal valve surgicaltechniques. Because no valve surgery is uniformly successful, minimization of morbidity is an important goal. Thisvalve stabilization technique achieves that important goalwhile providing a simple and often useful tool to managenasal valve collapse **(Weaver, 2012).**

Other conditions

Cicatricial stenosis of the external nasal valve can be corrected with a number of surgical techniques, including Z-plasty, skin grafts, alar interposition, and composite grafts. Small webs may be divided primarily and then stented. External nasal valve obstruction caused by tip ptosis is either caused by soft tissue ptosis, resulting from bulky excess tissue, or structural ptosis, resulting from cartilaginous, ligamentous, or muscular deficiencies in tip support **(Cannon and Rhee, 2012).**

Idiopathic tip soft- tissue bulk is usually associated with thick redundant skin and subcutaneous tissue in the supratip region, which can be excised to relieve soft-tissue bulk. Structural ptosis can result from weakened support from the medial crura or columella, and may require a tip-lifting maneuver where a horizontal mattress suture is placed from the LLC to the periosteum of the nasal bones. Dynamic external nasal valve dysfunction can also occur because of decreased nasal muscular tone secondary to facial paralysis or aging, resulting in cartilaginous and soft- tissue laxity. This may require a combination of a tip-lifting maneuver and soft-tissue excision. In cases of severe facial paralysis, patients who undergo nerve grafts, cranial nerve XII to VII anastomosis, or VII to VII crossover for facial reanimation, may regain little or some of their nasal valve tone. However, this does not occur in many cases, and these patients often benefit from additional nasal valve reconstruction **(Lee et al., 2009)**.

A retrospective review by **Soler and colleagues (2008)** examined 28 subjects undergoing facial nerve resection as part of their oncologic ablative surgery and found that those patients who received immediate nasal valve suspension reconstruction, using a suture-suspension technique to secure the nasal valve to the inferior orbital rim periosteum at the time of ablation, had significantly fewer symptoms of nasal obstruction than the control group who did not undergo immediate reconstruction. These authors suggest that the nasal valve should be addressed at the time of initial facial nerve resection for optimal outcomes. Paradoxical lateral crura are relatively uncommon phenomenon where the curvature of the lateral crus is reversed and concave rather than convex. A lateral crura flip-flop procedure can be beneficial in these patients, where the paradoxical portion of the lateral crurais resected, flipped over, and sutured back into place to resemble normal LLC curvature. If further external nasal valve support is needed to overcome collapse during inspiration, then alar batten or tip grafts may be needed.

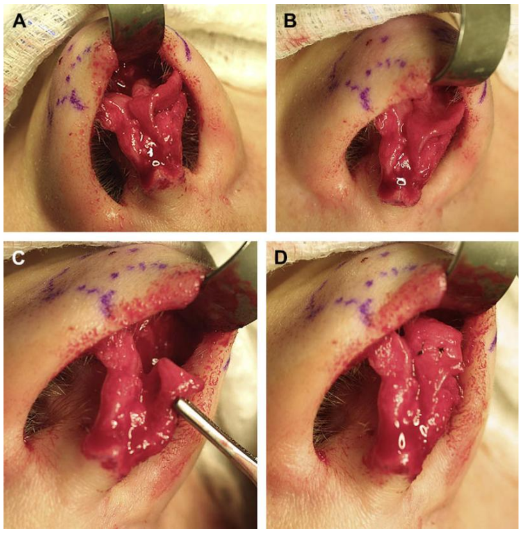

Figure (22): Paradoxical lateral crus. (A, B) Intraoperative views demonstrating a paradoxical left lateral crus. See the severe concavity in the longitudinal and transverse planes. (C) The lateral crus has been removed. All that remains is the left dome. (D) The lateral crus has been flipped over, replaced and sutured to the left dome. The previous concavity is now a convexity, symmetric with the contralateral side (not shown) **(Soler et al., 2008).**

Nasal valve problems secondary to rhinoplasty

Intraoperative injuries to the nasal tissues are uncommon and manageable when encountered. Fracture of the septum or the L-strut left after septoplasty is uncommon, but possible where extensive septal harvest has weakened its structural integrity. A review demonstrates that this occurs in about 1% of cases **(Gunter et al., 2006).**

Prolonged Swelling

Prolonged swelling can be seen in 2 ways. The firstis edema that refuses to subside over time. A greatdeal of handholding must be done for the patientwho has prolonged edema of this sort. Onceagain, preoperative education is a cornerstone tosuccessful patient management. If patients arecounseled preoperatively that they may haveswelling of 6 to 12 months' duration, and that theirfinal result will not be seen for at least 1 year, thenthese realistic expectations will go a long way inbuying time for resolution of edema. The patientshould understand that most often, the skin envelopeof the nose will shrink down to its frameworkover time, but that this is a long process. In addition, if the procedure is being performed concomitantlywith endoscopic nasal surgery, there will bea tendency for a greater time for resolution ofedema. Any patient undergoing combinedprocedures like this should be aware of this fact **(Sclafani and Schaefer, 2009).**

Scarring

Scarring can present in several forms. The columellarscar created during exposure in the opentechnique can notch when there is inordinatetension secondary to a large increase in tip projection/rotation. Percutaneous osteotomiescan also result in unsightly visible scars, causedby traumatic tattooing. This scarring is avoidedby carefully cleansing the osteotome before entryinto the skin. Patients with fair skin and thosewith very dark skin can be at greater risk for issueswith scarring. This factor should be taken intoconsideration when planning open rhinoplasty orexternal osteotomies. Internal scarring of the nasalsoft tissues can lead to thinning of the skin, discoloration, and an operated appearance. This internalscar tissue can complicate secondary attempts atcorrection, causing distortion of dissection planesand potentially jeopardizing nasal skin. Perhapsthe most dreaded scarring is internal scarring ofthe nasal mucosa. This can create problematicsynechiae. The avoidance and correction ofinternal scarring are further covered under thediscussion of nasal airway obstruction **(Gryskiewicz, 2005).**

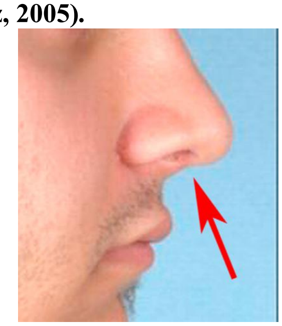

Figure (23): Notching of columellar scar after open rhinoplasty **(Gryskiewicz, 2005).**

Nasal Airway Obstruction

Nasal airway obstruction can present in one ormore of the three nasal vaults. External nasal valvecollapse secondary to cosmetic rhinoplasty canbe caused by excessive scoring or lower lateralcartilage overresection, specifically overtransectionduring a ''cephalic trim.'' An overly aggressivemaneuver can weaken the lower lateralcartilage, to the point where the middle crurabuckles into the airway on inspiration. Theexternal and internal nasal valves can be compromisedby stenosis secondary to synechiae **(Huret al., 2011).**

These trimsleft mucosal deficits, as mucosa was trimmedalong with cartilage. Any form of injury to thevestibular lining can create these types of scars. Such injury can be avoided by injection of saline/local anesthetic into the vestibular skin; thiselevates the skin from the undersurface of thecartilage through hydrodissection, and allows forroom to dissect and place sutures **(Shaida and Kenyon, 2000).**

Also, an ‘‘Mflap’’ or an ‘‘M alar wedge resection’’ can beused by carefully designing these intranasal incisions, with the goal of decreasing scar contractureand alar deformities. Intra-operative recognition ofthese types of tears is important, as they can besuture repaired at this stage. If a patient presentswith airway obstruction caused by synechiae formation, correction can be carried out using directexcision and scar revision; transposition flapsfrom the alar skin **(Aydogdu et al., 2006);** intranasal z-plasty withvestibular mucosa flaps, paranasal myocutaneousflaps **(Choudhury et al., 2014),** labial mucosal flaps **(Bozkurt et al., 2012);** or mucosal grafts.

Finally, compromise of the bony vault can resultfrom moving the nasal bones too far medially afteran osteotomy. Also, a poorly executed lateralnasal osteotomy can move too far medially andcause this compromise. This mistake can beavoided by using caution to preserve Webster'striangle (the inferior/posterior portion of the pyriformrim) **(Gryskiewicz et al., 2010).**

Some investigators report that the prevalence of airway impairment after aesthetic rhinoplasty may be as high as 10%. The etiology of nasal obstruction following rhinoplasty isoften multifactorial, but there are certain medical and surgicalerrors that commonly lead to this problem. Surgicalfailures affecting the nasal septum, nasal valve, inferiorturbinate, or other intranasal structureswill produce obstructivesymptoms. Failure to diagnose and address medicalissues such as rhinitis, polyposis, smoking, and sinusitismay also contribute to nasal obstruction after rhinoplasty. Furthermore, sequelae of nasal surgery, like synechiae andseptal perforation, can lead to nasal obstruction after rhinoplasty **(Winkler and Sokoya, 2016).**

Lateral Wall Insufficiency

Internal Nasal Valve

The INV is a "bottleneck" area of the upperrespiratory tract and is therefore susceptible to even minoraberrations in its cross-sectional area. Failure to correct staticor dynamic problems at the INV collapse is a common culpritof secondary obstruction. If dynamic nasal valve collapse isidentified preoperatively, the gold standard treatment at this time is the placement of spreader grafts. Furthermore, improvement in nasal airflow after correctionof a profoundly deviated septum can unmask anipsilateral weak INV, leading to postoperative INV collapse. Failure to consider this during surgery leads to secondaryobstruction and a return to the operating room for revisionsurgery **(Park, 1998).**

External nasal valve

Change to the integrity of external nasal valve is another potential source of secondary obstruction. Onemust avoid over-resection of the cephalic margin ofthe lower lateral cartilages, as this leads to weakening andcollapse of the external valve. The safe amount of completelateral crus that must be left intact varies between patientsbased on the strength and resiliency of their cartilage **(Wittkopf et al., 2008).**

Caudal Septal Failure

Caudal septal deviation (CSD) at the INV is an often-overlookedcause of nasal obstruction. Failure to recognize CSDand to correct it during surgery inevitably leads to secondaryobstruction. Furthermore, a CSD may persist or recur despiteone's best efforts at correction. The caudal septal attachmentto the maxillary crest is traditionally kept intact duringsurgery. If this attachment is dislocated, an attempt to securethe septum in the midline should be made. This may beaccomplishedwith sutures, grafts, or conservative removal ofthe deviated cartilage.1 The open septorhinoplasty approachis invaluable in obtaining complete visualization of the caudalseptum and maximizing the chances of success at this vitallocation **(Winkler and Sokoya, 2016).**

Septal Deflection

Incomplete correction of structural abnormalities of theseptum results in persistent nasal airway obstruction. Evenseemingly minor deviations can have a significant effect onthe patient's perception of breathing. Spurs along the maxillarycrest may be addressed with a parasagittal bony shaveusing an osteotome. Subtle deviations of the perpendicularplate of the ethmoid and vomer bone must be addressed asthese may "tent" the septal mucoperichondrium laterally, reducing the nasal patency. Additionally, a straighter nosetends to breathe better. Failure to perform medial and lateralosteotomies to obtain a truly straight dorsum can also be asource of secondary obstruction **(Guyuron, 1998).**

Inferior Turbinate

Unrecognized or poorly treated inferior turbinate hypertrophywill lead to persistent obstruction symptoms. Turbinatehypertrophy may result from a host of medical diseases, including allergic rhinitis, nonallergic rhinitis, sinusitis, andso on. Authors advocate performing inferior turbinate reductionwith submucosal debridement of erectile tissue whenever there is a clinical suspicion. The surgeon should also nothesitate to perform lateral outfracture of the inferior turbinateto provide additional improvement in nasal airwaycross-sectional area **(Winkler and Sokoya, 2016).**

Postoperative Healing

Septal Perforations

The frequency of nasal septal perforation following septoplastyhas been reported to be between 0.7 and 1.4%**(Topal et al., 2011).** Septalperforation causes secondary obstruction via excessive drynessand crusting of the nasal mucosa, which leads toepistaxis and debris accumulation. Surgical correction ofseptal perforation is a challenging procedure and should beattempted only by experienced surgeons. The external rhinoplastyapproach is advised for perforation repair, as thisprovides the exposure imperative to success. The combinationof bilateral mucosal advancement flaps together with atissue interposition graft has been associated with a successrate of 80 to 90%**(Foda and Magdy, 2006).**

Synechia

When performing nasal surgery, care should be taken to avoidviolation of nasal mucosa whenever possible. Violation of theapposing surfaces of the nasal mucosa creates the possibility of synechia formation. This most often occursbetween the inferior turbinate and septum during rhinoplasty, but may also occur between the lateral nasal wall and theseptum during osteotomy. Treatment of synechiae involvesdivision of the adhesion followed by interposition placementof Silastic sheeting until healing occurs **(Lee and Lee, 2007).**

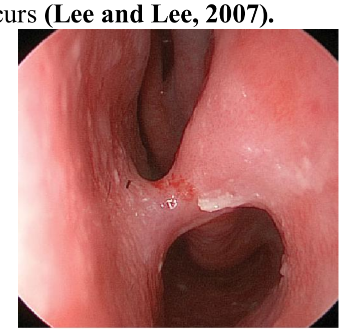

Figure (24): A synechia from the left inferior turbinate to the septum

Patients and methods

The present study was conducted at Al-Azhar faculty of Medicine.

Study design

Prospective, non-randomized study

Study populations

Thirty patients with nasal valve insufficiency underwent different surgical techniques for repair of nasal valve.

- **Inclusion criteria**

1- Patient aged 18 years or more.

2- The primary complaint was nasal obstruction.

- **Exclusion criteria:**

1- Patients required revision septoplasty or formal septorhinoplasty.

2- Concomitant diagnosis of other causes of nasal obstruction requiring additional adjunct procedures (e.g. nasal polyposis, nasal septum perforation, etc.).

The study protocol was approved by the local research and ethics committee of Rhinolaryngology department (Al-Azhar faculty of Medicine), and an informed consent was obtained from each patient before inclusion in the study.

Grouping:

According to surgical intervention for correction of nasal valve insufficiency, patients participated in this study were divided into three groups:

- Group (I): included 15 patients who were treated by spreader graft.
- Group (II): included 8 patients who were treated by Cartilage spanning graft
- Group (III): included 7 patients who were treated by splay conchal graft

Methods:

- Medical history and clinical examination established the cause of nasal obstruction with internal nasal valve dysfunction.
- Nasal endoscopy with a Storz telescope 00 (Karl Storz, Tuttlingen, Germany) was performed. Characteristics of nasal mucosa, presence and localization of septal deviation, situation of concha and septum, nasal discharge, and condition of the columellawere evaluated and collected data were recorded.

All patients had preoperative and postoperative evaluation (up to 3 months after surgery).

- Subjective evaluation wasdone with a questionnaire in which each patient ratedbreathing quality from 1 (poor) to 10 (excellent).
- The pre-operative nasal valve insufficiency or stenosis was diagnosed not only through visual examination and the Cottlemanoeuvre but also by testing with Breathe Right®Nasal Strips (Glaxo Smith Kline plc, Middlesex, UK) placed on the cartilaginous vault area. Reproducible conditions were achieved for these diagnostic procedures by first decongesting the mucosa using xylometazoline spray.
- The patients had to complete a self-assessment questionnaire to estimate the direct effect of the Breathe, judging their nasal breathing before and after surgery. This self-assessment test (SAT) was scored separately for each nasal side on a visual analogue scale with a point allocation of 0 (free nasal breathing) to 10 (complete blockage).

Endoscopic capture

- For evaluation of the internal nasal valve and patency of its angle.
- Digital pictures were taken with the inferior turbinate at the 7-o'clock position to ensure consistent magnification and photography of the internal nasal valve. The 0° endoscope, which was attached to a light

source, camera, and digital imaging capture device was then used to take a photograph of the internal nasal valve. Preoperative photographs of the left and right internal nasal valves were taken before surgery.

- The endoscope was then introduced to 1.3 cm, resulting in occlusion of the nostril opening and generating negative pressures inside the nose corresponding to the meaninspiratorypressures during a sniff.
- Preoperative photographs were taken of the left and right internal nasal valves under the stress of negative inspiratory pressures. Immediately after completion of the surgical procedure (s), photographswere taken again using the above-described techniques.

Skin Prick Tests

For the exclusion of allergic nasal diseases, skin prick tests were performed for all the patients. All the tests were performed by the same physician and at the same time of the day. Diameter of the induration resulting as skin reaction was measured. The cereal, grass, mold, tree, and house mite antigens were used as allergen groups in prick test panel.

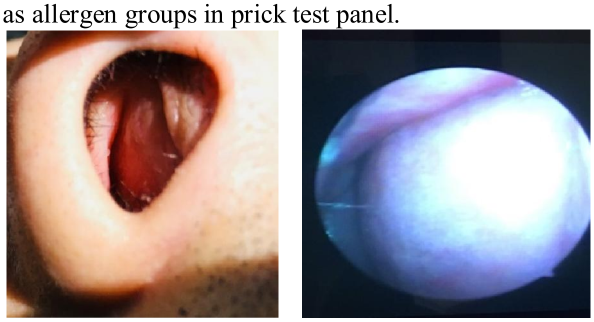

Figure (25): Endoscopic view of preoperative nasal valve obstruction

Acoustic Rhinometry

Measurements of the nasal cross-sectional area were performed by using an acoustic rhinometer (Rhino Scan, SRE 2000, Rhinometrics, Lynge, Denmark). With the patient seated, measurements were made before and after application of a nasal decongestant spray (oxymetazoline, 0.05%); however, to avoid potential errors associated with different degrees of congestion before and after surgery, only measurements after using the decongestant were analyzed. An external nasal adapter was used, and care was taken to avoid distortion of the nostrils. The first two measurements of minimal cross-sectional area on the acoustic rhinometry graphs were recorded by obtaining three curves (averaged) during cessation of breathing (patient holding their breath). Nasal patency was evaluated with the modified Glatzel mirror test, performed with a metal plate (scored in millimetres) placed under and along the patient's nostrils. Measurements were made with the patient seated and the head vertical. The area of condensation obtained on the metal plate after normal expiration (with mouth closed) was marked with a ballpoint pen and then transferred to a millimetre reference sheet. The markings were a measure of the area of nasal aeration; these markings were quantified in square cm (UTHSCSA Image Tool for Windows, version 3.0, San Antonio, TX, USA), and the left and right sides were recorded separately.

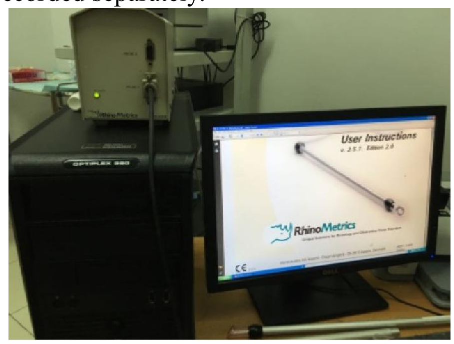

Figure (26): Acoustic rhinometry apparatus used in this study

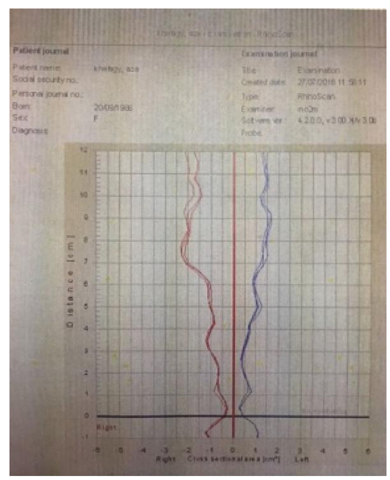

Figure (27): preoperative acoustic rhinometry showing narrowing of airway

Operative technique

Spreader graft

During endonasal rhinoplasty, cartilage is harvested, usually from the septum, using a limited Killian incision that stops 1.5 cm to 2 cm before reaching the dorsal septum to maintain the mucosa over the dorsal septum intact and attached to the septal cartilage. If a septoplasty is to be performed for functional reasons, the cartilage is resected at that time. Otherwise, a rectangular portion of quadrangular cartilage is resected when the procedure reaches the point of spreader graft placement, which, is usually before performing osteotomies. The spreader grafts are cut and shaped on a metal plate on a back table. The usual size is approximately 2 cm to 2.5 cm × 5mm with thickness being approximately 2 mm. If the dorsum is reduced, an incremental reduction of the cartilaginous dorsum is performed until the desired level is reached. The mucosa between the upper lateral cartilage (ULC) and septum is preserved intact. Attention is devoted to avoid violation ofmucosal attachment at the most dorsal aspect of septum during humpreduction maneuvers. Fixation of the grafts is dependent on thecreation of a tight submucoperichondrium pocket at the angle of the internal nasal valve (INV). Hence, maintaining the attachment of septal mucosa to thedorsal septum is paramount to the creation of such a closed pocket. If this attachment is disrupted, the pocket will 'open' dorsally andsuture fixation will be required. A stab incision of approximately 2 mm to 3 mm is made using a No. 15 scalpel blade through the mucosa and perichondrium, andplaced 2 mm caudal to the caudal edge of the ULC. The incision is approximately 3 mm to allow for the placement of the graft. A submucoperichondrial pocket is created using a 2 mm curved Lempert elevator (Instrumentarium, Terrebone, Canada) throughblunt dissection approximately 2 cm to 3 cm long to the cephalic marginof the ULC. Great care must be taken to ensure the proper angleof dissection as the pocket is advanced, and to maintain the attachmentof the mucoperichondrium to the dorsal septum.

After a secure and adequate pocket is created, the grafts are thenplaced using Adson-Brown forceps. If there was significantresistance while placing the graft, the graft wasremoved and the pocket enlarged slightly to accommodate the graft or the graftresized if appropriate. Because the pocket is made a few millimeterslonger than the graft (incision is made 2 mm caudal to the caudal edgeof ULC), once the graft is successfully placed, the edges of the stabincision will re-approximate easily. No suture closure is needed **(Samaha, and Rassouli, 2015).**

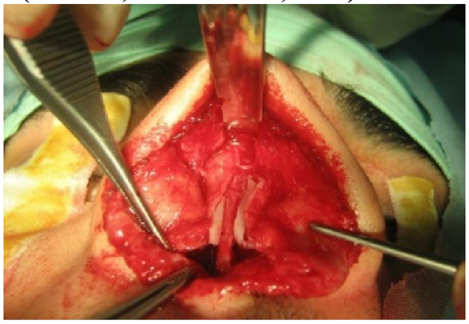

Figure (28): Spreader graft fixation into the internal nasal valve

Splay conchal graft technique

The open technique was used for rhinoplasty, and conchal cartilage was harvested through a postauricular incision and with the posterior perichondrium attached. The entire concha was removed to obtain the greatest length possible to ensure adequate lateral extension. The graft was shaved and trimmed to a uniform thickness. In this way, easily bending of the concha could achieved, shape it, and place it under the upper lateral cartilages. The upper lateral cartilages were freed from the underlying mucosa and the concha was placed between them bilaterally in such a way that perichondrium was placed over the septum, in contrast to the original operation. In this way, the lateral aspect of the cartilage is placed upward and below the upper lateral cartilage and skin, and the medial aspect of the concha with its perichondrium faces the dorsal septum.

This method produces a T-shaped configuration of the upper lateral cartilages and septum, and we can use most of its elastic force for opening of the internal nasal valve. In the previous method, the concha was placed like an upside-down U between the upper lateral cartilages, and especially in the most lateral sides, it cannot produce enough force for opening of the internal nasal valve. In the technique using the U-shaped configuration, the lateral part of the concha may protrude into the nasal mucosa. Also, placing the concha in the T configuration elevates the lateral side more effectively. Placing the concha in this way will produce and maintain more force for splaying (opening) of the upper lateral cartilages. After removal of the hump, there is enough space to place the concha, and it will never be seen from outside. There is no need to feather the lateral margins, because they are placed below the upper lateral cartilages and the concha is fixed in its place with one or two 4-0 nylon mattress sutures. Thus, we can use the maximal recoil potential of the cartilage, which is needed to splay or separate the upper lateral cartilages and will produce a good internal nasal valve for normal nasal breathing. The intrinsic recoil and strength of the concha supports the lateral wall. No suture is placed in the mucosa, and the skin is closed as for the standard external method. A splint was applied over the nose and removed as usual in 7 to 10 days. A lubricated packing was placed for just 12 to 24 hours. The external approach greatly facilitates dissection and reconstruction of the valve and endonasal lining. It does not require additional incisions, such as a mucosal incision, that can further compromise the valve region. With the open technique, graft placement and fixation are optimized and operation time is minimized. In this method, the nasal lining should be dissected from the underside of the upper lateral cartilage. This is a very time-consuming and technically demanding part of the operation, particularly because of the scars that are developed after previous surgery. Nasal lining dissection can more readily be performed with the open approach.

Figure (29): the auricle after harvesting the graft

Figure (30): Making tunnel to conchal cartilage

Cartilage spanning graft

Prior to anesthesia, the area on the external nose that corresponds to the internal nasal valve was observed. A Q-tip was used to view the internal valve area and a surgical marking pen was used to mark the surface of the skin on the lateral nose that sits above this weak area. An open approach was then used to expose the area of the septum and the upper lateral cartilage.

Cartilage is harvested and a 64 beaver blade is used to configure a graft that is circular in fashion and large enough to cover the defect as determined by preoperative markings. The graft was placed spanning the upper lateral cartilage and the lower lateral cartilage, lateral to the septum. The graft is sutured percutaneously with a 4.0 PDS in order to co-apt tissues, prevent graft migration, and prevent the accumulation of fluid between the graft and the skin. The PDS is removed in 7 days.

Figure (31): cartilage-spanning graft

Grading of nasal obstruction before and after surgery: it was divided into 5 categories as described below

Excellent airway: normal airway during regular and deep respiration during the day and night and during exercise.

Good airway: normal airway during regular respiration and during the day and night, but not during exercise.

Moderate airway: normal airway during regular respiration and during the day, but not during exercise and during the night.

Fair airway: normal airway during regular respiration but not during exercise and during the day and night.

Poor airway: bad and difficult respiration even during regular airway inspiration **(Deylamipour et al., 2005).**

Statistical analysis of data:

The collected data was organized, tabulated and statistically analyzed by the statistical package for social science (SPSS), version 18 (SPSS Inc., USA) running on IBM-compatible computer. Numerical data were expressed as arithmetic mean and standard deviation (SD); while qualitative data were expressed as relative frequency and percent. Comparison between groups was done by one-way analysis of variance with post Hoc least significant differences for numerical data and by Chi square test and Mann-Whitney test for qualitative data. For paired comparison, paired sample (t) test was used for numerical variables and Wilcoxon signed rank test was used for categorical data. P value < 0.05 was considered significant.

3. Results

As regard to age (years), it ranged from 23 to 61 years and there was no statistically significant difference between studied groups.

As regard to sex distribution, 18 patients (60.0%) were males and 12 (40.0%) were females; and there was no statistically significant difference between studied groups.

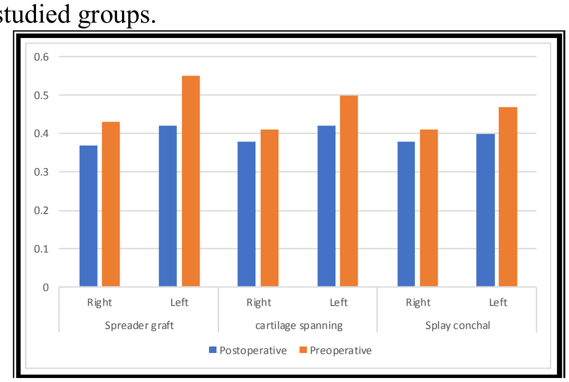

Figure (32): Paired comparison of nasal resistance on right and left sides in each of studied groups

In spreader graft group, the VAS was significantly decreased postoperatively when compared to preoperative corresponding values both on right and left sides and before and after decongestant use. On the other hand, in cartilage spanning group, VAS was significantly increased on both right and left sides after decongestants while values before decongestant were the same pre-and postoperatively. In splay conchal group, only right VAS after decongestant was significantly increased postoperatively.

Table (1): Paired comparison of nasal flow using acoustic rhinometryon right and left sides in each of studied groups

Group			Mean	S. D	Paired (t)	P value
Spreader	Right	Preoperative	359.3	38.4	***8.98***	***<0.001****
		Postoperative	386.4	44.9		
	Left	Preoperative	366.3	31.1	***11.83***	***<0.001****
		Postoperative	403.3	31.8		
Cartilage spanning	Right	Preoperative	363.7	38.0	***10.59***	***<0.001****
		Postoperative	379.3	37.8		
	Left	Preoperative	377.1	34.2	***7.98***	***<0.001****
		Postoperative	392.5	33.7		
Splay conchal	Right	Preoperative	375.4	38.0	***6.65***	***0.001****
		Postoperative	390.7	43.0		
	Left	Preoperative	389.5	28.37	***10.21***	***<0.001****
		Postoperative	405.7	29.08		

As regard to effect of treatment, each of spreader graft, cartilage spanning, and splay conchal graft provided statistically significant increase of nasal flow rate postoperatively when compared to corresponding preoperative value.

Table (2): Paired comparison of nasal resistance using acoustic rhinometryon right and left sides in each of studied groups

Group			Mean	S. D	Paired (t)	P value
Spreader	Right	Preoperative	0.43	0.063	***4.76***	***<0.001****
		Postoperative	0.37	0.024		
	Left	Preoperative	0.55	0.067	***15.87***	***<0.001****
		Postoperative	0.42	0.058		
Cartilage spanning	Right	Preoperative	0.41	0.053	***3.15***	***0.016****
		Postoperative	0.38	0.027		
	Left	Preoperative	0.50	0.084	***7.04***	***<0.001****
		Postoperative	0.42	0.057		
Splay conchal	Right	Preoperative	0.41	0.056	***2.70***	***0.036****
		Postoperative	0.38	0.026		
	Left	Preoperative	0.47	0.076	***4.49***	***0.004****
		Postoperative	0.40	0.042		

As regard to effect of treatment on the nasal resistance, there was statistically significant decrease of nasal resistance both on right and left sides at preoperative when compared to preoperative values in all three groups.

Table (3): Comparison between studied groups as regard paired comparison VAS (preoperative vs postoperative) by self-assessment questionnaire

			Preoperative		Postoperative		Paired (t)	P value
			Mean	SD	Mean	SD		
Spreader	Left VAS	Before dec.	4.7	1.4	2.6	0.7	4.5	***<0.001****
		After dec.	3.8	1.2	2.2	0.4	3.9	***0.001****
	Right VAS	Before dec.	5.2	0.9	2.5	0.6	9.1	***<0.001****
		After dec.	4.6	0.7	2.3	0.6	8.5	***<0.001****
Cartilage spanning	Left VAS	Before dec.	5.6	1.3	5.6	1.3	a	
		After dec.	4.5	1.1	5.0	1.0	2.6	***0.033****
	Right VAS	Before dec.	4.7	1.2	4.7	1.2	a	
		After dec.	3.3	1.3	4.5	0.9	3.8	***0.007****
Splay conchal	Left VAS	Before dec.	5.1	1.0	5.1	1.0	a	
		After dec.	3.7	1.2	4.5	0.9	1.6	0.14
	Right VAS	Before dec.	4.2	0.7	4.2	0.7	a	
		After dec.	3.4	0.9	4.2	0.7	***3.2***	***0.017****

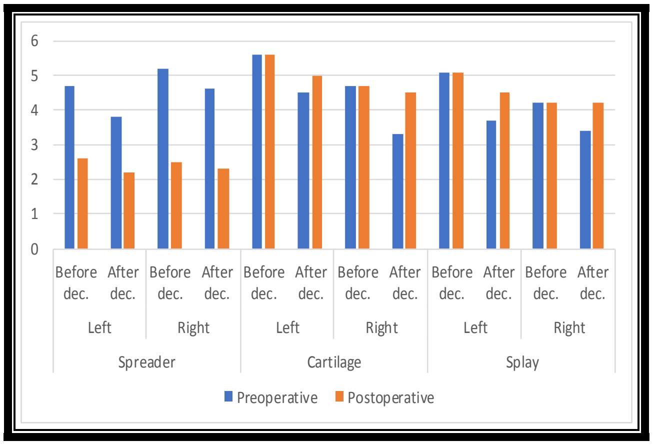

Figure (33): Comparison between studied groups as regard paired comparison VAS (preoperative vs postoperative)

Table (4): Paired comparison as regard to mean cross sectional area and volume by acoustic rhinometry in studied groups

			Preoperative		Postoperative		Paired	P
			Mean	SD	Mean	SD	(t)	value
Spreader	Left MCA1	Before dec.	0.416	0.021	0.506	0.026	***16.0***	***0.000****
		After dec.	0.505	0.026	0.538	0.021	***3.9***	***0.002****
	Right MCA1	Before dec.	0.463	0.043	0.606	0.026	***12.3***	***0.000****
		After dec.	0.524	0.026	0.682	0.030	***14.5***	***0.000****
	Left VOL1	Before dec.	1.819	0.032	2.166	0.243	***5.4***	***0.000****
		After dec.	1.920	0.023	2.241	0.242	***5.1***	***0.000****
	Right VOL1	Before dec.	1.776	0.049	1.996	0.094	***8.2***	***0.000****
		After dec.	1.816	0.047	2.253	0.130	***13.0***	***0.000****
	Left MCA2	Before dec.	0.519	0.024	0.711	0.017	***32.7***	***0.000****
		After dec.	0.583	0.027	0.776	0.028	***17.1***	***0.000****
	Right MCA2	Before dec.	0.434	0.032	0.604	0.021	***15.5***	***0.000****
		After dec.	0.563	0.024	0.756	0.030	***19.5***	***0.000****
	Right VOL2	Before dec.	3.554	0.048	5.000	0.169	***35.0***	***0.000****
		After dec.	4.393	0.201	5.380	0.193	***14.9***	***0.000****
	Left VOL2	Before dec.	3.980	0.189	4.440	0.261	***5.9***	***0.000****
		After dec.	4.700	0.285	5.893	0.198	***16.4***	***0.000****
Cartilage Spanning	Left MCA1	Before dec.	0.415	0.023	0.486	0.026	***7.33***	***0.000****
		After dec.	0.497	0.019	0.537	0.026	***3.15***	***0.016****
	Right MCA1	Before dec.	0.477	0.053	0.610	0.033	***7.16***	***0.000****
		After dec.	0.525	0.032	0.681	0.022	***19.52***	***0.000****
	Left VOL1	Before dec.	1.818	0.041	2.125	0.310	***2.70***	***0.030****
		After dec.	1.917	0.027	2.197	0.318	***2.47***	***0.043****
	Right VOL1	Before dec.	1.797	0.046	1.992	0.115	***4.29***	***0.004****
		After dec.	1.833	0.044	2.250	0.160	***7.12***	***0.000****
	Left MCA2	Before dec.	0.518	0.026	0.720	0.015	***25.50***	***0.000****
		After dec.	0.578	0.029	0.775	0.030	***10.44***	***0.000****
	Right MCA2	Before dec.	0.421	0.035	0.600	0.020	***9.73***	***0.000****
		After dec.	0.565	0.029	0.753	0.022	***13.79***	***0.000****
	Right VOL2	Before dec.	3.531	0.040	4.950	0.177	***20.95***	***0.000****
		After dec.	4.362	0.256	5.375	0.190	***10.83***	***0.000****
	Left VOL2	Before dec.	3.937	0.226	4.387	0.258	***4.08***	***0.005****
		After dec.	4.712	0.368	5.812	0.180	***9.32***	***0.000****
Splay Conchal	Left MCA1	Before dec.	0.421	0.024	0.485	0.037	***3.40***	***0.014****
		After dec.	0.505	0.036	0.532	0.017	***2.58***	***0.040****
	Right MCA1	Before dec.	0.487	0.024	0.555	0.052	***2.66***	***0.037****
		After dec.	0.532	0.024	0.604	0.084	***2.66***	***0.038****
	Left VOL1	Before dec.	1.760	0.079	2.008	0.330	***2.58***	***0.042****
		After dec.	1.814	0.142	2.040	0.354	***2.74***	***0.034****
	Right VOL1	Before dec.	1.880	0.159	2.012	0.100	***4.00***	***0.007****
		After dec.	1.818	0.038	2.061	0.230	***2.53***	***0.045****
	Left MCA2	Before dec.	0.470	0.057	0.572	0.155	***2.70***	***0.036****
		After dec.	0.53	0.064	0.634	0.164	***2.37***	***0.050****
	Right MCA2	Before dec.	0.48	0.045	0.567	0.050	***2.49***	***0.047****
		After dec.	0.58	0.043	0.710	0.036	***4.72***	***0.003****
	Right VOL2	Before dec.	3.68	0.204	4.700	0.571	***4.56***	***0.004****
		After dec.	4.24	0.335	4.800	0.503	***5.02***	***0.002****
	Left VOL2	Before dec.	3.67	0.564	3.885	0.805	***2.54***	***0.043****
		After dec.	4.55	0.237	5.35	0.828	***2.68***	***0.036****

In spreader graft group, there was statistically significant increase of MCA1, MCA2, VOL1 and VOl2 postoperatively when compared to corresponding preoperative values both on right and left sides and before and after decongestants. Similar results were found in cartilage spanning and splay conchal groups.

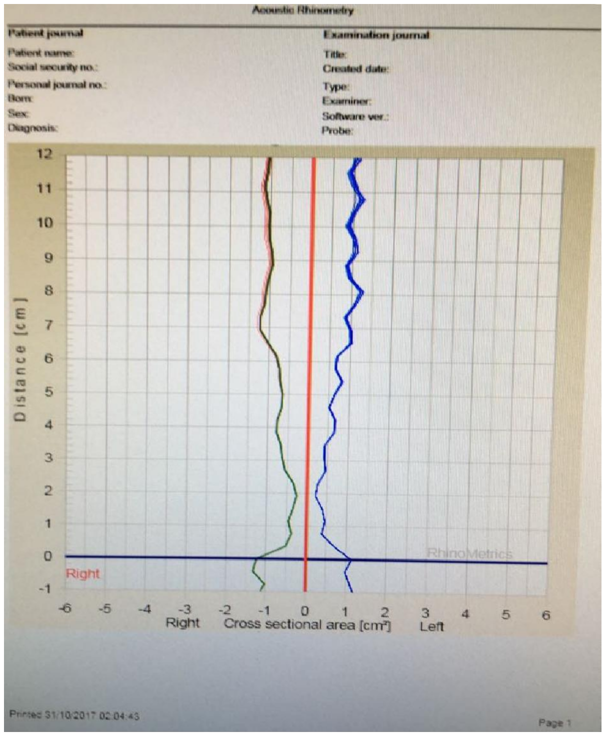

Figure (34): Postoperative acoustic rhinometry showing improvement of nasal airway

Figure (35): Endoscopic view of postoperative nasal valve showing improvement of airway

4. Discussion

Subjects may be candidate for a rhinoplasty for several reasons. The most common reasons are the anatomic deformity or deviation of the nasal septum which can be congenital or the result of trauma. Such abnormalities are often associated with functional impairments that require combined operation of cosmetic and functional septorhinoplasty **(Hassanpour et al., 2016).**

The internal nasal valve area is an important part of the airway resistance **(Kovacevic and Wurm, 2015).**

The hump removal and osteotomies that are commonly used techniques in rhinoplasty can lead to narrowing of the nasal valve area **(Pade and Hummel, 2008; Philpott et al., 2008).**

Grymer (1995) reported that cross-sectional area that was evaluated with acoustic rhinometery (AR) had decreased by 25% at nasal valve area and by 13% at pyriform aperture area after septorhinoplasty.

To avoid this situation and restore nasal dorsum all over some techniques have been developed such as spreader graft technique **(Teymoortash et al., 2012).**

The main principle ofspreader graft is to push the upper-lateral cartilages in the lateraldirection, thus increasing the cross-sectional area of the internal nasalvalve **(Teymoortash et al., 2012; Rohrich et al., 2004).**

Although themost frequent donor for spreader grafts is thenasal septal cartilage, the grafts could be obtained fromaural cartilageor rib cartilage as well **(Deylamipour et al., 2005).**

Acoustic rhinometry provides objectiveevaluation of nasal obstruction, whichwas used first by Hilberg in1989. It provides an estimate of cross-sectional area of nasal cavityand volume measurements at a specific distance from the nostril. This method has been used in clinical investigation for assessingchanges in the cross-sectional area of the nasal cavity following SRP **(Pawar et al., 2010).**

Mengi et al. (2011) used AR for evaluating the success of the SRPoperations with objective values. When comparing theresults of the ARand computed tomography, results revealed that ARisa valuable method for the evaluation of the anterior nasal space andnasal valve region.

The present study was designed to evaluate different surgical technique used for treatment of nasal valve collapse. It included 30 patients, who divided into three groups according to surgical intervention. The first included 15 in spreader graft group, the second included 8 in cartilage spanning graft and the third included 7 in splay conchal graft group. The present work – according to researcher best of knowledge- is unique in its design as it evaluates three surgical graft techniques. However, the small number of patients included in each group, especially the second and third groups represented a limiting step against globalization of results obtained in the present study.

Results of the present work revealed that, all groups were comparable as regard to demographic data with male sex predominance in all three groups. This preponderance is seen in the study by **Haavisto et al. (2013)** addressing surgical correction of nasal obstruction but has not been noted elsewhere. Further review of patient populations may reveal that male patients either exhibit more nasal obstruction or seek surgical correction of this obstruction more often than their female counterparts **(Erickson et al., 2016).**

The assessment of nasal flow revealed that, postoperatively the nasal flow values were significantly increased when compared to the preoperative values in each of studied groups. The highest increased values were in spreader graft group. In addition, in all groups, there was significant decrease of nasal resistance values after surgical intervention when compared to corresponding values before surgery. The highest decrease was in spreader graft group on the left side. These results are in agreement to **Okhovat et al. (2007)** study, in which rhinometrywas performed on 48 patients before and after septoplasty. The findings indicated that in addition to reduction in symptoms of obstruction, rhinometry showed an increase in flow rate and the total flow on both sides of the nose and a reduction in resistance to objective results. It can be recommended as a way to evaluate the results of septoplasty and to predict structural reforms.

On the other hand, results of the present study are in contradiction to those reported by **Hassanpour et al. (2016)** who reported that, subjects in their study were more satisfied about the functional than aesthetic outcome, the rhinometric measurements revealed that the air-ways resistance increased and air flow decreased after surgery. The changes were statistically significant before and after the surgery in each group, but the difference was not significant between groups.

In one study, **Teymoortash et al. (2012)** showed that the value of total nasalairflow was 761.82±267.87 before the surgery, which is higher than the value in the present study. The reason may be exclusion of subjects withany structural problem such as nasal obstructionin their study.

In the present work, VAS assessment revealed significant difference between groups postoperatively on right and left sides before and after use of decongestant drug. In addition, VAS was significantly decreased in spreader graft group after surgery when compared to values before surgery. However, in cartilage spanning and splay conchal groups, it remains constant or even increased.

Authors used AR for the objective evaluation ofthe nasal cavity and the effect of the operation for nasal airway and VAS scores for subjective evaluation. Nasal valve area was demonstratedwith MCA1 and pyriform aperture area with MCA2.

In the present study and in spreader graft group, postoperative and preoperative MCA1 and MCA2 changes of both sides of the nasal cavity were compared and it was demonstrated that both before and after topical decongestion these values significantly increased postoperatively on both the sides of the nasal cavity. These results are comparable to those reported by **Mamanov et al. (2017).** They reported that, in groupof patients who had septorhinoplasty with performing spreader grafts, postoperativeand preoperative MCA1 and MCA2 changes of both sidesof the nasal cavity were compared and it was demonstrated that bothbefore and after topical decongestion these values increased postoperativelyon both the sides of the nasal cavity and these findingswere found statistically significant. Similarly, **de Pochat et al. (2012)** reported that statistical significance wasfound on the left side of the nasal cavity but not on the right side. **Gomes et al. (2008)** reported the average MCA1 value 0.54±0.13cm^2 and MCA2 value 0.54±0.13 cm^2 for healthy population. **Roithmannet al. (1995)** reported that the average normal value for MCA1 is 0.62cm^2. In the present study, the postoperative values comes near to the reference normal values.

In the present work, the increase of the VOL1 and VOL2 values was statisticallysignificant postoperatively for studied groups. Visualanalogue scales scores of the cartilage spanning or splay conchal patients increased, whereasstatistically significant reduction was revealed for spreader graft postoperatively. These results are comparable to those reported by **Mamanov et al. (2017).**

Several studies have previously investigated objective measures of improvement with spreader graft surgery using cadaver models. **Huang et al., in 2006,** studied an endoscopic approach to spreader grafts on cadaveric heads using eight specimens. They found significantly improved nasal valve area (mean change 0.28 cm^2) using acoustic rhinometry measurements. **Craig et al., in 2014**, also performed spreader graft placement on 6 cadaveric heads and also found a significant improvement in INV area (mean change 0.10 cm^2).

Few studies have examined both the objective and subjectiveoutcomes of surgery for nasal obstruction. **Haavistoet al.,** in their **2012** paper, examined the use of acousticrhinometry as well as a visualanalogue scale to evaluate improvement in unilateral nasalobstruction in 30 patients undergoing septoplasty. Objectivemeasure of patients improved significantly and atrend toward improvement in patient satisfaction was alsofound, though not statistically significant. **Mengi et al., in2011,** however did show a significant improvement in NOSE scores, minimal cross-sectional area measured byacoustic rhinometry, and nasal resistance values after septoplasty in 44 patients.

Edizer et al. (2013) evaluated 26 patients undergoing septorhinoplastyfor objective improvement in nasal airwayusing acoustic rhinometry and subjective improvementsusing a 10-point visual analog scale. Although all patients underwent septorhinoplasty, not all had preoperativecomplaints of nasal obstruction. The study found significant improvement in symptom scoring butnot in cross-sectional area. **Zoumalan et al., in 2012,** alsoevaluated objective and subjective measurements of 31septorhinoplasty patients. This study also used acousticrhinometry and a 10-point rating scale for the measurements.

Finally, general agreement exists about the positive effect of spreader graft on nasal patency. Improvement rates in nasal patency range from 81% to 100% **(Cheng et al., 2014). Ingels et al. (2008)** went one-step further, demonstrating that spreader grafts do not only improve nasal airway, but also widen the middle third of the nose by 6%. This was measured using Adobe Photoshop pre- and post-operatively. Reassuringly in their study of 15 patients, none of them noticed this widening.

Splay graft, which was described by **Guyuron et al. (1998),** is a quiet efficient, physiological, and esthetic technique that does not disturb the anatomy of the nasal vault. In this technique, preferablyconchal cartilage of the auricular is prepared at suitable size, ULC are separated from the septum cartilage, and a pocket is opened between ULCand mucosa below them. The prepared graft is placed overthe septal cartilage in the pocket between mucosa and ULC. The formation of this T figure widens internal valveangle and prevents collapse.

In addition, **Deylamipour et al. (2005)** reported that, during the follow-up period, nearly all of the patientshad experienced much better breathingand stable relief of nasal obstruction. All of the patients were satisfiedwith the result of their surgery; only onepatient (3.2 percent) was not satisfied, and thispatient had a very compressed airway after surgery. At follow-up, it appeared that he had ahistory of allergic rhinitis, and he was treatedmedically and has a better airway. Result of reliefof obstruction was stable and did not deterioratewith time. Other authors found that cartilage willnot undergo absorption or atrophy. No complicationor morbidity was noticed at the donor site. They concluded that, allergic rhinitis is a relative contraindication for splay grafting. They placed the concha with its concave side facing upward, and we recommend this modification to achieve a much better result.

Furthermore, **Islam et al. (2008)** reported that, splay graft technique is quiet effective in deficiency of INV. As graft material, septum cartilage is preferred because it is in the surgical field and provides strong support when pericondriumis left intact on one side. Cosmetic deformity or morbidity is minimal because natural structure between ULC and septum cartilage is not impaired. This technique can easily be implemented with local anesthesia and endonasal approach. Moreover, operation period is short.

A potential limitation of this study is the reliability ofacoustic rhinometry. Various studies have shown varyingdegrees of reliability of acoustic rhinometry as comparedto computed tomography scans and magnetic resonanceimaging, assessing both cross-sectional area and volume of the nasal cavity. These studies have shownsignificant correlation between acoustic rhinometry andimaging for the anterior portion of the nose but not theposterior. This finding was confirmed in a study using high-resolution computed tomography scanningby **Numminen et al. (2003).** A statistically significantcorrelation was found between the minimum crosssectionalareas in the first 10 mm and 11–40 mm of thenasal cavity. There was a weaker correlation in the posteriorportion of the nose.

In short, according to results of the present study, the studied surgical techniques proved to be effective. However, the spreader graft technique provided the better outcome from the functional and aesthetic points of view.

One limiting step of the present study is the small number of included subjects. Thus, future studies are recommended before globalization of the results.

Conclusion and recommendation

The studied surgical techniques proved to be effective. However, the spreader graft technique provided the better outcome from the functional and aesthetic points of view. Thus, it is recommended to be the first choice in nasal obstruction and choice of other techniques must be individualized according to the clinical situation.

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