SPIROMETRY AS AN OBJECTIVE TOOL IN THE ASSESSMENT OF NASAL PATENCY

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ABSTRACT

Introduction: Spirometry can be used as an objective tool in the measurement of nasal patency. It can act as a simple screening tool in selecting the patients for surgical correction of deviated nasal septum.

Material and Methods: This prospective study was done in a span of 18 months in patients coming to ENT OPD of a tertiary care centre.

Method of collection of data: All patients coming to ENT OPD with history of unilateral/bilateral nasal obstruction and who are undergoing a surgical procedure for the same were included in the study.

Sample size was taken as 100.

Parameters measured were Forced expiratory volume (FEV1 and FEV3), Forced inspiratory nasal flow volume (FINFV) and Maximum breathing capacity (MVV).

Parameters measured were checked pre-operatively and post-operatively at 2 weeks & 3 months.

Results: Of the 100 patients, 41 cases underwent Septoplasty alone, 17 cases underwent FESS, 22 cases underwent Septoplasty with FESS and 20 cases underwent other surgeries.

Statistically, for all the parameters there was highly significant change seen for both the nostrils when compared pre-operatively & post-operatively.

Conclusion: Spirometry is a useful tool for the objective assessment of nasal airway patency which can be retained as a record. Spirometry is also a useful screening tool in selecting the suitability of patients for nasal surgery. The procedure is easy to perform, non-invasive and comfortable for the patient.

INTRODUCTION

The nose is the first structure in the airway. Nasal obstruction is a common symptom affecting 9.5 - 15% of the general population. Nasal septal deviation is one of the most frequent causes of nasal obstruction. Septoplasty is the conventional surgery for correcting the deviated nasal septum and improving the airway. However, the functional benefits of this procedure have often been questioned. Objective measures to quantify and establish the success of surgery for nasal obstruction have been a challenge.

Questionnaires are always subjective and may not give the accurate picture. Hence there is a need for an objective tool which may help to establish the efficacy of different procedures and can also be used as a screening tool in selecting the patients for the surgical procedure. This will also help in the proper documentation of the results. The two most commonly used methods for objective measurement of nasal airway are rhinomanometry and acoustic rhinometry. Most studies have shown that these methods do not always correlate with the patient's reported subjective improvement. Moreover, the size of the equipment, cost, training required are the disadvantages with rhinomanometry. Nasal spirometry has been used effectively to monitor the nasal cycle and thereby nasal airway. The procedure done using spirometry is non-invasive, simple, easy to perform and comfortable to the patient. In our study, we have tried spirometry as a tool to assess the nasal patency.

Many techniques have been designed to assess the nasal airflow and resistance. It started with a Glatzel mirror which used to be held under the nostrils and the resulting area of condensed breath measured. Rhinometry was first employed by Courtade (1903) and is being used now with modifications. Uddstromer (1940) used a face-mask divided into compartments so that spirometric measurements pertaining to both nose and mouth could be made.

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MATERIALS AND METHODS

This is a Prospective study done in a span of 18 months in patients coming to ENT OPD, of a tertiary care hospital. All patients above 12 years of age, coming to the ENT OPD with history of unilateral/bilateral nasal obstruction and who are undergoing a surgical procedure for the same were taken as the sample. Cases with medical contraindications and those under 12 years of age were excluded. Cases with acute infection were given appropriate treatment for adequate duration before taking up for the procedure. Clearance from the institutional ethical committee was obtained. After taking a detailed history, a detailed general physical and ENT examination was done on all the patients. All patients underwent routine preoperative investigations. Following this the patients were counselled for this study. A written informed consent was taken. Topical and systemic decongestants and antihistamines were stopped for 1 week prior to the procedure. A course of antibiotics is given for 5 days prior to surgery for patients presenting with upper respiratory tract infection. Sample size was taken as 100.

MATERIALS

Spirometry apparatus- RMS Helios 401 and Modified Endotracheal tube.

Objective assessment of nasal patency was done using Spirometry apparatus in the pulmonary medicine department. Endotracheal tube was used to check the patency in each nostril of appropriate size (adults-8 & children-6) alternatively. The mouthpiece of the spirometer and the endotracheal tube were connected by using an air-tight seal light body condensation silicone prosthetic material.

Figure 1 Nasal Spirometry being performed

Figure 2 Spirometer mouthpiece with endotracheal tube. Spirometer mouthpiece with light body condensation silicone prosthetic material.

Figure 3 Flow-Volume Curve

Parameters Measured were

1. Forced expiratory volume (FEV1 and FEV3)
2. Forced inspiratory nasal flow volume (FINFV)
3. Maximum breathing capacity (MVV)

Parameters measured were checked pre-operatively and post-operatively at 2 weeks & 3 months.

FEV was measured by instructing the patient to first inspire maximally then expire as forcefully & rapidly as possible and finally the patient should again inspire maximally into the endotracheal tube. The patient should inspire completely. The inhalation should be rapid but not forced. There should be only a brief pause at maximal inspiration; a prolonged pause (4-6 sec) may decrease flow during the subsequent expiration. The manoeuver is displayed on a computer monitor screen & analyzes the signal from the spirometer, then calculates & displays the FEV1 and FEV3 i.e. at 1 sec and 3 sec respectively and the FINFV. When the parameters are being measured in one nostril, the opposite nostril was blocked. The procedure was similarly done for the opposite nostril and also for all the parameters. Graph obtained is a Flow-Volume curve – The FVC graphs the flow generated during an FVC maneuver against volume change. FVC maneuver is performed by inspiring fully & then exhaling as rapidly as possible. To complete the loop, the patient inspires as rapidly as possible from the maximal expiratory level back to maximal inspiration. Volume is plotted on the horizontal X-axis, & flow is plotted on the vertical Y-axis. Expiratory flow is plotted upward. Expired volume is usually plotted from left to right. FEV, as well as PEF & FINFV, can be directly calculated from the F-V loop.

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surgeries amounting to 20 cases. Turbinoplasty and septorhinoplasty were categorized as other purpose, septoplasty with other procedures like FESS, SMD & 4 patients underwent Septoplasty+FESS+PIT, 6 cases underwent FESS, 22 cases underwent Septoplasty alone, 17 cases underwent Septoplasty+PIT, 5 cases underwent Septoplasty+SMD & 4 patients underwent Septorhinoplasty. For Statistical purpose, septoplasty with other procedures like FESS, turbinoplasty and septorhinoplasty were categorized as other surgeries amounting to 20 cases. (Table no.1)

The graph obtained is shown below

**Figure 4** Maximum Voluntary Ventilation Curve

**Observations**

This is a prospective study which was conducted in the Department of Otorhinolaryngology of a tertiary care centre in patients who came to the OPD with complaints of nasal obstruction and underwent appropriate procedure for the same.

At Post-op 3months – Results are shown in table 4 and 5.

**Table 1 Procedures performed**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>FESS</td>
<td>17</td>
<td>17.0</td>
</tr>
<tr>
<td>SEPT</td>
<td>41</td>
<td>41.0</td>
</tr>
<tr>
<td>SEPT+FESS</td>
<td>22</td>
<td>22.0</td>
</tr>
<tr>
<td>SEPT+FESS+PIT</td>
<td>5</td>
<td>5.0</td>
</tr>
<tr>
<td>SEPT+PIT</td>
<td>6</td>
<td>6.0</td>
</tr>
<tr>
<td>SEPT+SMD</td>
<td>5</td>
<td>5.0</td>
</tr>
<tr>
<td>SEPT+PIT+PIT+SEPTRH</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

**Improvement: At Post-op 2 weeks**- Results are shown in table no.2 and 3

**Table 2: 2 weeks right side**

<table>
<thead>
<tr>
<th>FEV 1</th>
<th>FEV 3</th>
<th>FINFV</th>
<th>MVV</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.0%</td>
<td>72.0%</td>
<td>65.0%</td>
<td>62.0%</td>
</tr>
<tr>
<td>2.0%</td>
<td>1.0%</td>
<td>1.0%</td>
<td>7.0%</td>
</tr>
<tr>
<td>23.0%</td>
<td>27.0%</td>
<td>34.0%</td>
<td>31.0%</td>
</tr>
</tbody>
</table>

**Table 3: 2 weeks left side**

<table>
<thead>
<tr>
<th>FEV 1</th>
<th>FEV 3</th>
<th>FINFV</th>
<th>MVV</th>
</tr>
</thead>
<tbody>
<tr>
<td>65.0%</td>
<td>66.0%</td>
<td>65.0%</td>
<td>62.0%</td>
</tr>
<tr>
<td>3.0%</td>
<td>2.0%</td>
<td>3.0%</td>
<td>7.0%</td>
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<tr>
<td>32.0%</td>
<td>32.0%</td>
<td>32.0%</td>
<td>31.0%</td>
</tr>
</tbody>
</table>

**Table 4: 3 months right side**

<table>
<thead>
<tr>
<th>FEV 1</th>
<th>FEV 3</th>
<th>FINFV</th>
<th>MVV</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.0%</td>
<td>68.0%</td>
<td>71.0%</td>
<td>68.0%</td>
</tr>
<tr>
<td>1.0%</td>
<td>4.0%</td>
<td>2.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>24.0%</td>
<td>28.0%</td>
<td>27.0%</td>
<td>32.0%</td>
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**Table 5: 3 months left side**

<table>
<thead>
<tr>
<th>FEV 1</th>
<th>FEV 3</th>
<th>FINFV</th>
<th>MVV</th>
</tr>
</thead>
<tbody>
<tr>
<td>68.0%</td>
<td>70.0%</td>
<td>68.0%</td>
<td>72.0%</td>
</tr>
<tr>
<td>0.0%</td>
<td>0.0%</td>
<td>2.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>32.0%</td>
<td>30.0%</td>
<td>30.0%</td>
<td>26.0%</td>
</tr>
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</table>

Significance of the parameters: Was done by ANOVA F test

FEV1 – There was highly significant change seen for both the nostrils when compared pre-operatively & post-operatively. According to the Pair wise comparison done by BONFERRONI TEST. In Left Nostril – It’s highly significant Pre-op to Post-op 3 months and between post-op 2 weeks to post-op 3 months.

In Right nostril – It’s highly significant Pre-op to Post-op 2 weeks & Post-op 3 months and significant between post-op 2 weeks to post-op 3 months. (Figure no.1)

**Figure 4 Age distribution**
**Figure 1** Showing changes in FEV 1

FEV3- There was highly significant change seen for both the nostrils when compared pre- operatively & post-operatively. Pair wise comparison-In Left Nostril - It’s highly significant Pre-op to Post-op 3 months and between post-op 2 weeks to post-op 3 months.

In Right nostril – It’s highly significant Pre-op to Post-op 2 weeks & Post-op 3 months.(Figure no.2)

**Figure 2** Showing changes in FEV 3

FINFV- There was highly significant change seen for both the nostrils when compared pre- operatively & post-operatively. Pair wise comparison-In Left Nostril - It’s highly significant Pre-op to Post-op 3 months and between post-op 2 weeks to post-op 3 months. In Right nostril – It’s highly significant Pre-op to Post-op 2 weeks & Post-op 3 months and between post-op 2 weeks to post-op 3 months.(Figure no.3)

**Figure 3** Showing changes in FINFV

MVV- There was highly significant change seen for both the nostrils when compared pre- operatively & post-operatively. In Left Nostril - It’s significant Pre-op to Post-op 3 months and highly significant between post-op 2 weeks to post-op 3 months. In Right nostril – It’s significant Pre-op to Post-op 2 weeks & highly significant between pre-op to Post-op 3 months.(Figure no.4)

**Figure 4** Showing changes in MVV

Significance of the parameters according to the surgery: Was done by KRUSKAL WALLIS test.

FEV1- In Left nostril -There is a highly significant change for all the surgeries Pre-op to Post – op 2 week and Post-op 3 months.In Right nostril - There is a highly significant change for all the surgeries Pre-op to Post – op 2 week & significant change between pre-op to Post-op 3 months.

FEV3- In Left nostril –There is a highly significant change for all the surgeries Pre-op to Post – op 2 week and Post-op 3 months & significant change between post-op 2 weeks to post-op 3 months. In Right nostril - There is a highly significant change for all the surgeries Pre-op to Post – op 2 week.

FINV- In Left nostril –There is a highly significant change for all the surgeries Pre-op to Post – op 2 week and Post-op 3 months & significant change between post-op 2 weeks to post-op 3 months. In Right nostril - There is a highly significant change for all the surgeries Pre-op to Post – op 2 week.

MVV- In Left nostril –There is a highly significant change for all the surgeries Pre-op to Post – op 2 week and Post-op 3 months. In Right nostril – There is a highly significant change for all the surgeries Pre-op to Post – op 2 week and Post-op 3 months.(Figure no.5)
Multiple comparisons: This was done between different surgeries for all the parameters in both the nostrils by MANN WHITNEY test:

In Left nostril-FEV1- On comparing Septoplasty+FESS with Other surgeries was found to be significant for pre-op to post-op 2 weeks.FEV3- On comparing FESS with Other surgeries was found to be significant for pre-op to post-op 2 weeks & highly significant on comparing FESS with Septoplasty & FESS with Other surgeries and also when Septoplasty +FESS was compared with Other surgeries for pre-op to post-op 3 months.

Also significant change was found when FESS was compared with other surgeries for post-op 2 weeks to post-op 3 months.

FINFV- On comparing FESS with Septoplasty and FESS with Other surgeries was found to be highly significant for pre-op to post-op 2 weeks & highly significant on comparing FESS with SEPT & FESS with Other surgeries for pre-op to post-op 3 months.

MVFV- On comparing FESS with Septoplasty was found to be highly significant and FESS with Other surgeries was significant for pre-op to post-op 2 weeks.

In Right nostril-FEV1- On comparing FESS with Septoplasty it was found to be significant and FESS with Other surgeries was found to be highly significant for pre-op to post-op 2 weeks.

Also significant on comparing FESS with Septoplasty and highly significant on comparing FESS with Other surgeries for pre-op to post-op 3 months.

FEV3- On comparing FESS with Septoplasty and FESS with Other surgeries was found to be highly significant for pre-op to post-op 2 weeks. For pre-op to post-op 3 months on comparing FESS with other surgeries was found to be significant.

FINFV- On comparing FESS with Septoplasty and FESS with Other surgeries was found to be highly significant and FESS with Septoplasty +FESS was found to significant for pre-op to post-op 2 weeks. MVFV- FESS compared with Septoplasty, Septoplasty+FESS and other surgeries were highly significant for pre-op to post-op 2 weeks. For pre-op to post-op 3 months FESS when compared with other surgeries was found to significant.

DISCUSSION

Nasal obstruction is one of the most common complaints presenting to ENT surgeons and could be secondary to a variety of causes. It’s affecting around 9.5 - 15% of the general population. Nasal septal deviation is one of its most frequent causes. Other causative conditions are Inferior turbinate hypertrophy, nasal tumours and nasal polyps.

A Study by Moore M & Eccles R has classified nasal patency as physiological and anatomical nasal patency. Physiological nasal patency is unstable as it is related to factors such as the nasal cycle & also external environment. Anatomical nasal patency is stable, decongestion of the nose can stabilise anatomical nasal patency & measurements of patency is done in this state. Currently there are no standard reference values for nasal function. Factors such as age, height, sex, weight and race influence the anatomical nasal patency. Because of the great variation associated with nasal cycle, normal physiological nasal patency is also difficult to define. Subjective assessment of improvement in the nasal airway can always be done using questionnaires after the surgical procedures on the nose.

The ability of the clinician to differentiate between the contribution of mucosal and structural factors in producing airflow asymmetry and hence symptoms of nasal blockage can be difficult without objective measurement. An objective tool is required for the documentation and to establish the efficacy of different procedures.

Objective measures to quantify and establish the success of surgery for nasal obstruction have been a challenge. Several methods have been proposed; the two most common are rhinomanometry and acoustic rhinometry. Rhinomanometry measures nasal flow resistance during breathing. Acoustic rhinometry measures nasal permeability and quantifies the cross-sectional area of the nostrils up to the nasopharynx, as well as the nasal cavity volume between any two chosen cross-sections. Most studies have shown that these methods do not correlate with the patient’s reported subjective improvement. A few studies have shown, however, that septoplasty is generally effective for treating nasal obstruction and those most patient show improvements in nasal symptoms. Other methods to assess the nasal patency are by peak nasal inspiratory flow, nasalance, spirometry and laser Doppler velocimetry.

Hanif et al first described the use of nasal spirometry as an objective measure of the nasal partitioning of airflow in 2001. The spirometry has the potential to overcome many of the disadvantages of the more conventional objective measurements of the nasal passages such as rhinomanometry. It is a small, portable, hand-held machine that is easy to use, both by the investigator and subject, after only minimal training. The spirometer measures volume of air, and has been adapted to measure airflow through the nasal passages via a nosepiece. Measuring each nasal passage separately allows recording of the distribution or nasal partitioning of airflow. Few studies have reported that nasal spirometry is accurate, reliable and reproducible. It has been shown that nasal partitioning of airflow as measured by spirometry was directly comparable with the results as measured by the rhinomanometer.
Smita K. Nagle & Rajendra S. Kelkar in March 2007 stated that nasal patency can be measured with the help of Spirometer in order to evaluate patient’s complaints and confirming the pathology leading to nasal obstruction. They measured the ventilation in the form of maximum breathing capacity as a parameter to assess the functional average patency of nasal passage. The only limitation is that it only can be done only in an institution.\[5]\In our study MVV was one of the parameters that was used and it showed significant improvement when compared preoperative to postoperative results for both the nostril.

In Cuddihy PJ & Eccles R study, the usefulness of nasal spirometry in studying nasal airflow was demonstrated. Nasal spirometry was used to measure the effect of acute rhinitis associated with upper respiratory tract infection (URTI) on the changes in nasal airflow that occur with postural change. They concluded that nasal spirometry is useful in studying nasal airflow partitioning in health and disease.\[7]\h

Roblin DG & Eccles R, in their study used a portable nasal spirometry to determine the normal range of nasal partitioning ratio in 100 healthy subjects. They came to a conclusion that nasal spirometry may prove useful in assessing patients complaining of nasal obstruction and also assessing the degree of nasal septal deviation. They also emphasized the point that the presence of a deviated septum does not necessarily relate to symptoms or pathology. This study showed that men were more likely to have a deviated septum than women. They concluded that spirometry is a useful test for nasal respiratory function and provides objective assessment of nasal airway patency, which can be retained as record, the method is easy to handle and sensitive, the method is clinically applicable and recordable.\[9]\h

In Hooper RC study, individuals with and without nasal symptoms underwent forced inspiratory nasal flow–volume (FINFV) curve measurements. Definitions of normal and abnormal were established, Normal curves were defined as those from participants who had no nasal symptoms and a peak inspiratory nasal flow greater than 2.5 L/s. Abnormal curves were defined as those from participants who had 1 or more nasal symptoms, a peak inspiratory nasal flow lower than 2.5 L/s, and normal oral inspiratory flow. He concluded that Forced inspiratory nasal flow–volume curves are a potentially useful clinical tool to evaluate the nasal airway for obstruction. It is easy to perform and well- tolerated.\[10]\h

In our study nasal flow volume curve was used to calculate the FEV1 & 3 (forced expiratory volume at 1 sec and 3 sec) and also the FINFV (forced inspiratory nasal flow volume). All the parameters were easy to perform and also showed a significant change when compared pre-operative results to post-operative results. All the parameters showed a significant change when compared from pre- operative to post-operative 2weeks and 3 months. Hence, nasal surgery had improved the airway when assessed objectively and also patients had improvement in their symptoms. The improvement was seen more significant at post-op 3 months as compared to post-op 2 weeks due to reasons such as postoperative oedema and crusting at post-operative 2weeks. At post-op 3 months patients had better improvement in the nasal airway as nasal cavity is completely healed. The causes of deterioration in the objective measurements at post-op 3 months were due to persistent deviated nasal septum, crusting, synchiae formation and recurrent sinonasal polyposis.

In another study by Moore M & Eccles, they reviewed the efficacy of surgical management of the deviated septum as a treatment for chronic nasal obstruction. Functional benefit of septal surgeries was done by any evidence of a change in patency of the nasal airway, as assessed by objective methods such as rhinomanometry, acoustic rhinometry and peak nasal inspiratory flow. They reviewed seven studies to assess the efficacy of septoplasty where rhinomanometry was used to measure nasal patency, six studies where acoustic rhinomanometry was used, here there was statistically significant increase from pre-op to post-op.\[11]\h

In a similar study, Fyrmpas G, Kymizakis D, Vital V & Constantinidis J showed the role of bilateral simultaneous nasal spirometry (BSNS) in the preoperative selection of patients for septoplasty. In this study a modification of the nasal spirometry was used where bilateral simultaneous nasal spirometry measurement was done. The results were BSNS correlated well with rhinomanometry. They concluded that BSNS is a simple, quick, non-invasive and reproducible technique, which is easy to interpret and requires minimal training. This test offers valuable information along with clinical assessment of the nasal airway in the preoperative assessment of candidates for septoplasty.\[12]\h

In another study by Cuddihy PJ & Eccles R, nasal spirometry was used as an objective measure of nasal deviation and also to know the effectiveness of septal surgery. Nasal spirometry was performed preoperatively and postoperatively at the first visit. Subjective assessment of nasal airway was also done using the visual analogue score. They concluded that spirometry is a useful screening tool in selecting the suitability of patients for septoplasty. In our study the parameters showed significant changes for the septal surgeries in both the nostrils. Hence, nasal surgery has improved the nasal airway therefore showing improved objective measures in the nasal patency.

The procedures done using spirometer are sensitive, easy to perform and comfortable to the patient. Spirometry is a useful tool for the assessment of nasal respiratory function and provides an objective assessment of nasal airway patency which can be retained as a record. The procedure is simple to perform and also comfortable to the patient. Another advantage is the spirometer is portable and a non-invasive procedure.

The disadvantage being, as the subject breaths in, the nasal apparatus flattens and faster the air flow inward the more the alar cartilage and upper lateral cartilage are drawn inwards, increasing nasal resistance. Breathing outward through nose the opposite will happen causing a decrease in nasal resistance and also another common error that can occur is the air leak around the nostril while expiring.

CONCLUSION

This prospective study of “Spirometry as an objective tool for the assessment of nasal patency” was conducted in the Department of Otorhinolaryngology of a tertiary care centre. We draw the following conclusions from this study:

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1. Spirometry is a useful tool for the objective assessment of nasal airway patency which can be retained as a record.

2. Spirometry is also a useful screening tool in selecting the suitability of patients for nasal surgery.

3. The procedure is easy to perform, non-invasive and comfortable for the patient.

References


