Airflow and symptom outcomes between allergic and non-allergic rhinitis patients from turbinoplasty*

K. Parthasarathi[1,2], J.M. Christensen[1], R. Alvarado[1], H.P. Barham[1,3], R. Sacks[4], R.J. Harvey[1,2,4]

[1] Rhinology and Skull Base Research Group, St Vincent's Centre for Applied Medical Research, University of New South Wales, Sydney, Australia
[2] St Vincent's Clinical School, Faculty of Medicine, University of New South Wales, Sydney, Australia
[3] Department of Otolaryngology Head and Neck Surgery, Louisiana State University, New Orleans, Louisiana, United States.
[4] Faculty of Medicine and Health Sciences, Macquarie University, Sydney, Australia

Rhinology 55: 332-338, 2017
https://doi.org/10.4193/Rhino16.210

***Received for publication:**
July 6, 2016
Accepted: July 24, 2017

Abstract

Background: Inferior turbinate procedures are applied to relieve medically refractory nasal obstruction. However, the nature of congestion differs between allergic(AR) and non-allergic rhinitis(NAR). This study compares surgical outcomes between AR and NAR patients.

Methodology: A case-control study of patients undergoing turbinate ± septoplasty surgery for nasal obstruction was performed. Patient reported outcomes were: nasal obstruction, global nasal function(GNF), and sino-nasal outcome test(SNOT-22) with rhinitis, facial symptom, sleep and psychological sub-scores . Nasal peak inspiratory flow(NPIF) assessed nasal airflow. Measurements were obtained preoperatively and 3 months postoperatively.

Results:190 patients were assessed. AR had worse obstruction and worse GNF. All outcomes improved post-surgery; nasal obstruction, GNF, SNOT-22, rhinitis-symptoms, facial-symptoms, sleep-function, psychological-function and NPIF. GNF improvement was greater in AR. NPIF improvement was similar between groups.

Conclusions: Both AR and NAR patients gained benefit from surgery to relieve nasal obstruction. AR patients demonstrate greater improvement in GNF score but allergy management may contribute to this.

Key words: nasal obstruction, rhinitis, nasal surgical procedures, NPIF, treatment outcome

Introduction

Nasal obstruction is a common presenting symptom in rhinology practice and a common feature of both allergic rhinitis (AR) and non-allergic rhinitis (NAR)[(1)]. However the underlying pathophysiology of these two conditions is different. AR is an example of type I hypersensitivity reactions. This involves a complex sequence of events leading to excess production of IgE antibodies in response to an allergen[(2)]. Both turbinate hypertrophy and vasodilation are associated with allergic changes[(3)]. In contrast the mechanisms underlying non-allergic rhinitis are less clear. It is associated with nasal hyper-reactivity to non-immunologic stimuli[(4)] and abnormal autonomic regulation[(2, 5)]. Vascular congestion and loss of vasomotor tone are thought to be major contributors to obstruction in NAR.

Obstruction, and rhinitis cause significant morbidity, and are consistently associated with decreased quality of life and significant economic costs[(2)]. Conservative and medical therapies constitute first line treatment options. When the outcomes of these are unsatisfactory, surgical management is often recommended[(5, 6)]. Procedures on the nasal turbinates and septum are common surgical strategies to resolve nasal obstruction[(5)]. Despite evidence for surgical intervention, there is little evidence to suggest if improvements are dependent on the aetiology of that obstruction.

Objective measures have an important role in the assessment of nasal surgery outcomes given the potential placebo influence of surgery on patient reported outcomes[7, 8]. Nasal peak inspiratory flow (NPIF) is a low-cost, noninvasive, easy to perform clinical assessment of nasal patency. It is a physiologic measure indicating the highest airflow achieved through both nostrils during maximal forced nasal inspiration. It has shown to be reproducible in healthy and rhinitis patients[9, 10]. It has comparable diagnostic accuracy to anterior rhinomanometry[11] and correlates with acoustic rhinometry[12]. Minimal clinically important difference (MCID) has been validated for NPIF [13].

This study aims to define the benefit imparted from turbinate reduction in the care of rhinitis patients, and determine the influence of rhinitis eitiology on the effects of surgery. This information would be of benefit to provide patients and clinicians with expectations from surgery in these conditions.

Materials and methods

Study population

Consecutive patients from a single tertiary rhinology practice in Sydney, Australia were recruited. Data was gathered prospectively in patients undergoing turbinate surgery who presented with nasal obstruction as a primary complaint. Patients undergoing surgery had nasal obstruction that had not resolved satisfactorily with intranasal corticosteroids (at least 4 weeks), antihistamines, saline therapies and intranasal capsaicin where clinically appropriate.

Demographic details collected included date of birth, gender, smoking status and asthma status. A current smoker was defined as an individual who had been smoking cigarettes within 3 months of the assessment date. Asthma status was defined as a formal response to β-agonist of >15% FEV1 on spirometry, or decrease >15% from methacholine challenge or patients currently using inhaled therapy.

Patient consent was obtained and approval obtained from the local Human Research Ethics Committee (SVH 09/083)

Allergy status

At the time of surgery, the patient had a 10ml EDTA blood collection, which was analyzed for total and specific IgE (IU/mL) using an ImmunoCAP method. Serum specific IgE to four allergen mixes were evaluated (Dust mite, mould, animal and grass). House dust allergen mix tested for *Dermatophagoides pteronyssinus, Dermatophagoides farinae, Blatella germanica,* mould mix for *Penicillium chrysogenum, Cladosporium herbarum, Aspergillus fumigatus, Alternaria alternata* , epithelial mix for Cat dander, Horse dander, Cow dander, Dog dander and grass mix for *Cynodon dactylon, Lolium perenne, Phleum pratense, Poa pratensis, Sorghum halepense* and *Paspalum notatum*. Serum specific IgE (>0.35mU/L) for any four of mixed airborne antigens was considered positive or a total serum IgE greater than 100KU/L. Patients with neither were classified as NAR. No patients received oral corticosteroids for 4 weeks prior to surgery when the serum and tissue was taken for assessment.

Surgical technique

A medial flap turbinoplasty was performed by the same surgeon, using a surgical technique described previously[14, 15]. The procedure commences with the creation of a window to the inferior meatus, at the anterior inferior turbinate in the axilla between the inferior turbinate medially and the pyriform aperture laterally. This step allows access to the inferior meatus without destabilizing the turbinate and visualization of the valve of Hasner to prevent injury. The mucosa of the apex of the inferior meatus can be removed to prevent lateral stripping during the procedure. The posterior soft tissue tail is removed with the microdebrider, and a medial flap is created by removal of the inferior border a variable distance up the medial side depending of extent of reduction required. The remaining mucosal flap is elevated in a sub-periosteal plane using a cottle dissector. Any inferior attachments can be released with iris scissors. The turbinate bone and lateral mucosa are then removed along the vertex of the inferior meatus. Once the bone and lateral mucosa have been removed, the arterial supply, the medial and lateral branches of the inferior turbinate artery, are identified and exposure is maximized. With adequate exposure and visualization, precise cautery can be applied using a bayonetted bipolar. This is not a neurovascular pedicle as the posterolateral nasal nerves supply the medial mucosa. Attention is then directed at sculpting the anterior head undermining the soft tissue with microdebrider or ensure bone removal is flush to the pyriform. This will help to ensure the critical area at the internal valve is adequately reduced. The medial flap is then placed in its final position curving inferolaterally and surgicel dressing is dressed over the inferior cut edge. Because this procedure leaves minimal exposed mucosa and no bone exposure, the medial flap heals rapidly with minimal crusting [14, 15]. The technique is notable for its preservation of the medial mucosa and selective ablation of the inferior turbinate artery (Figure 1). The authors believe that this assists with removal of perceived nasal cycle, postural congestion and lower post-operative epistaxis. Procedures were performed alone or in conjunction with a septoplasty.

Outcome assessment

Patient reported outcome measures (PROMs) and NPIF were measured preoperatively and at least 3 months postoperatively. Nasal obstruction was measured using a 6-point Likert scale.

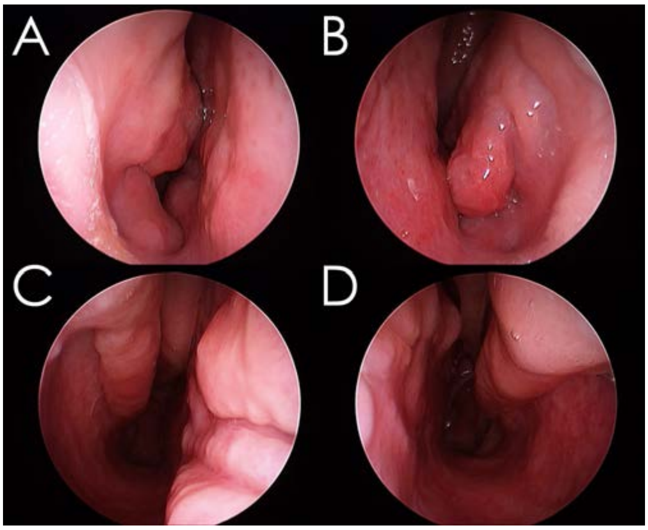

Figure 1. The medial flap turbinate reduction is demonstrated. The preoperative view of the right (A) and left (B) nasal cavity of a patient with persistent allergic rhinitis is shown. The post-turbinoplasty right (C) and left (D) airway demonstrates the expected change in this patient population. The medialization of the turbinate is key features as much as reduction in volume.

Grading of nasal obstruction as subjectively assessed by the patient ranged from "no problem" (0) to "problem as bad as it can be"(5). The sinonasal outcome test 22 (SNOT-22) was used to assess disease specific quality of life[14]. This tool has been used to assess rhinitis, septal and other non-sinus interventions [16, 17]. SNOT-22 Total (0-110) was derived by summation of all question scores. The SNOT-22 derived rhinitis symptom (0-25), facial symptom (0-20), sleep function (0-15), and psychological function scores (0-25) are validated subdomains [18, 19]. The global nasal function score (GNF) was measured using a 13-point Likert scale ranging from -6 (terrible function) to +6 (excellent function).

NPIF was measured using a mini-wright peak flow meter with an anaesthetic mask (Clement Clarke International, Australia) [13]. The patient's NPIF was measured in a seated position with a good seal ensured and the patient instructed to make a maximal inspiratory effort with the mouth closed. Patients were educated on technique. The best result of three attempts within 10% of repeated recordings was used [9]. The unit of measure was L/min.

Statistical analysis

The data was de-identified, and analysed with IBM® SPSS® Statistics Version 22 (SPSS, Inc., Chicago, IL, USA). Chi-squared analysis of proportions was used for gender, asthma and smoking status. Nasal obstruction and GNF scores were tested using a Kendall's tau-b analysis. Where possible, these ordinal scores were represented as % above or below a threshold for ease of interpretation but they were analysed as ordinal values. Age, NPIF and SNOT-22 domains were parametric in nature and expressed as mean ± standard deviations (SD). Independent sample t-tests were performed to compare means between AR and NAR groups. Paired sample t-tests were performed to compare pre-operative and post-operative outcomes. Values where $p<0.05$ were considered statistically significant.

Table 1. Patient haracteristics based on allergy status at the time of surgery.

Characteristic	Allergic	Non-allergic	p-value
n	45	145	
Age (years)	37.20±13.71	42.90±13.56	0.015
Female (%)	44%	44%	0.971
Asthmatics (%)	37%	16%	0.006
Smokers (%)	7%	6%	0.954
Septoplasty (%)	93%	81%	0.045

Results

Demographic data

190 patients (42±14years, range 19 to 74 years, 44% female) were assessed. Asthma was prevalent in 21.1% and smoking in 6.3%. Positive allergy status was defined in 23.7% (n=45). AR patients were younger than NAR (37.20±13.71yrs v 42.90±13.56yrs, p=0.017) and had a greater prevalence of asthma (37% v 16%, p=0.006). Concurrent septoplasty was performed more commonly in the AR group (93% v 81%, p=0.045) Patient characteristic comparison is shown in Table 1.

Baseline assessments

For the study population a nasal obstruction score of ≥3 was reported by 84% of patients. The total SNOT22 was 39.33±19.31, with subdomain findings: rhinitis symptom score 8.36±5.40, facial symptom score 3.86±3.95, sleep function score 7.26±4.14 and psychological function score 10.19±6.62. A GNF score of ≤-3 was reported by 66% of patients. NPIF for the whole group was 101±39L/Min.

At baseline, the AR and NAR groups appeared similar in most outcomes. The AR group had a greater proportion of patients with greater Nasal Obstruction (91% v 82% % with score≥3, p=0.039), and worse GNF (84% v 60% % with score ≤-3, p=0.003) (Table 2).

Effects of surgical intervention

Improvements in all measures were observed for the entire

Table 2. Comparison between AR and NAR Group outcomes at baseline.

Characteristics	Allergic	Non-allergic	p-value
n	45	145	
Nasal obstruction (% ≥ 3 (Moderate problem))	91%	82%	0.039
SNOT22 total (0-110)	42.20±17.96	38.41±19.70	0.643
Rhinitis Symptom (0-25)	9.31±5.36	8.05±5.40	0.979
Facial Symptom (0-20)	4.04±3.55	3.81±4.076	0.111
Sleep Function (0-15)	7.58±4.20	7.16±4.12	0.479
Psychological Function (0-25)	10.49±6.32	10.09±6.74	0.654
Global nasal function (%≤-3 (Poor))	84%	60%	0.003
NPIF (L/min)	102±34	100±40	0.429

Table 3. Measured effect of surgical intervention for nasal obstruction.

Outcome	Preoperative	Postoperative	Change	p-value
SNOT22 total (0-110)	39.33±19.31	23.24±17.44	-15.32±19.69	<0.001
Rhinitis Symptom (0-25)	8.36±5.40	6.14±4.48	-2.04±5.73	<0.001
Facial Symptom (0-20)	3.86±3.95	2.79±3.11	-1.01±3.99	<0.001
Sleep Function(0-15)	7.26±4.14	3.69±3.76	-3.44±4.29	<0.001
Psychological Function (0-25)	10.19±6.62	6.02±6.31	-3.89±6.73	<0.001
NPIF (L/min)	101.04±38.96	167.91±42.80	65.58±39.07	<0.001

Table 4. Effect of surgical intervention based on allergy status.

Outcomes from surgery	Allergic	Non-allergic	p-value
n	45	145	
Nasal obstruction (% with improvement)	83%	81%	0.957
ΔSNOT22	-15.76±23.76	-15.17±18.28	0.883
ΔRhinitis	-1.57±7.00	-2.19±5.27	0.603
ΔFacial Symptoms	-0.76±4.17	-1.09±3.94	0.507
ΔSleep	-4.10±4.68	-3.23±4.15	0.291
ΔPsychological	-4.17±6.67	-3.81±6.42	0.764
ΔGlobal nasal function (% with improvement)	100%	90%	<0.001
ΔNPIF (L/min)	70.19±35.62	64.32±40.04	0.472

group post-operatively (Table 3).

An improvement in nasal obstruction score was observed, with fewer patients reporting the problem as moderate or worse (≤3) following surgery (84% v 22%, p<0.001). Overall 83% of patients reported an improvement. SNOT22 scores improved post-operatively (39.33±19.31 v 23.24±17.44, p<0.001), with similar improvements observed across all subdomains (Table 3). GNF improved with fewer % patients reporting poor or worse function (≤-3) compared to baseline (66% v 6%, p<0.001) and 93% reporting an improvement. Nasal airflow measured by NPIF also increased (101.04±38.96L/min v 167.91±42.80L/min, p<0.001).

Allergic v Non-allergic groups

AR and NAR groups demonstrated similar improvements from surgery (Table 4). Total nasal obstruction scores were similar, as were SNOT22 and subdomain score changes. The AR group had a higher percentage of patients with an improved GNF Score (100% v 90%, $p<0.001$). Changes in NPIF were similar between groups (AR Δ70.19±35.62L/min v NAR Δ64.32±40.04L/min, $p=0.472$).

Discussion

Although there is objective evidence to show that nasal surgery can result in improved airflow and patient reported outcomes [7, 20], few reports investigate whether allergy, or the nature of their turbinate pathology is an important factor in post-surgical nasal function. The population recruited for this study had comparable characteristics of age (42±14yrs) and gender distribution (44% female) to other studies assessing outcomes of turbinate and septal surgery [16, 21-24]. The outcome measures utilized were chosen based on their practicality and previous use in the assessment of rhinological conditions. The SNOT-22 questionnaire is a validated instrument previously used in the assessment of nasal surgery [16, 17].

The baseline NPIF found in this study was 101±38 L/Min and is below the normal range for healthy volunteers [24, 25]. Variations in NPIF are known to occur with gender, age, ethnicity and technique of measurement [9, 13, 25]. However, our findings appear comparable (102.10±21.39 L/min) to a similar study of a Turkish population presenting with nasal obstruction and nasal septal deviation.

The increase in Nasal Peak Inspiratory flow of 66±39L/min is above the minimal clinically important difference (MCID) of 20 L/min [13, 26]. This change in NPIF compares well to surgeries using only nasal septum modification (35L/min) [20, 27]; alternate turbinate surgery techniques (25L/min) [21], and patients with AR who underwent turbinate procedures 23L/min [28]. Along with this study, all these prior studies demonstrate improvement above the MCID. A prior laser turbinate study gave comparisons between NPIF in AR and NAR groups and although changes of 36L/Min versus 22L/min were reported, these were similarly found not to be statistically significant [21]. The higher overall change in NPIF reported here may be attributed to different population, measurement techniques, and differences in operative procedure.

Improvements were found in all PROMs in this study. Improvements have previously been reported using a variety of tools including visual analogue scales[21, 23, 24, 29], SNOT-22[16] and NOSE questionnaire[30, 31]. It is difficult to compare these with the current study given variations in measurement tools, patient cohorts and surgical procedures. It is interesting to note that patients in both groups reported improvement in all subdomains (rhinitis symptom, facial symptom, sleep functional and psychological function scores). A prior study comparing septoplasty outcomes in AR v NAR group showed PROM(NOSE) to be superior in NAR. This incongruence to the current study can be attributed to the different patient selection where in AR groups in the septoplasty study received no adjunctive treatments such as turbinate procedures or pharmacotherapy therapy. The nature of the nasal obstruction in the AR group was likely multifactorial and correction of the nasal septum deviation alone was perhaps insufficient to achieve equitable outcomes in the groups [32].

The GNF score improvement was found to be greater in the AR group greater compared with the NAR group.
Concomitant septoplasty is a potential confounding factor in this finding. The rate of septoplasty in the overall group was very high at 83%. A higher proportion of patients with what the author considered clinically important septal deviations where present in the AR group (93% v 81%, $p=0.045$). This may add to the higher GNF experience in this group. However, the authors rarely believe that non-traumatic, or development, septal deviation contributes to acquired adult nasal congestion. If there is the perception of normal nasal breathing after the second growth spurt and then acquired adult onset congestion occurs, then turbinate pathophysiology is usually a more important factor than septal abnormalities. A developmental septal deviation might lead to one side become congested prior to the other but is not per se the 'cause' of the acquired adult onset obstruction. Ancedotal experience is that post-turbinoplasty patient become aware of airflow asymmetry, post-operatively, if the septum is not addressed. In addition to the differing rate of septoplasty, the AR group was found to have poorer baseline function both in Nasal obstruction and GNF which may allow greater improvement in symptoms. Additionally ongoing pharmacotherapy such as intranasal steroids which provide greater efficacy in the AR patients may provide greater improvement in the post-operative AR group resulting in improved post-surgical nasal flow and PROMs. The efficacy of these medications post-surgery, and comparisons with AR and NAR to our knowledge has not previously been studied. Other therapies such as Immunotherapy may also provide some additional benefit in the AR group resulting in the noted greater improvement in GNF.

Assessment of the degree of turbinate hypertrophy was not collected. It has previously been studied in nasal obstruction and turbinate surgery and found to have high correlation with nasal obstruction score, and PNIF [18]. Anterior rhinoscopy assessment of the nasal airway has previously been assessed by the authors[14, 15] for assessment of outcomes in turbinate reduction The ordinal scale used did demonstrate improvement post-surgery in the total group, however was not predictive of outcome of turbinate reduction as measured by need for further intervention at twelve months. Studying turbinate size using new validated measures [34], comparing the size of turbinates pre and post-operatively in the two groups and their correlation effect with NPIF and PROMS may provide additional evidence to the impact of turbinate surgery. Within this study, allergic and non-allergic populations were assessed at a relatively short time point post-operatively. Although there were few differences observed in the outcomes between groups, different disease pathophysiology and medical treatments may affect nasal airflow at later time points. Thus, further long-term assessments would be of value in future studies.

Conclusion

Both allergic and non-allergic rhinitis patients benefit from surgery, with improvements in nasal flow, sense of nasal obstruction and disease specific quality of life following turbinate surgery.

Authorship contribution

KP and RJH developed the idea. KP, JMC, HPB, RJH contributed to study design, data acquisition, and data interpretation. All authors contributed to writing of the paper with senior review of the paper by RJH and RS.

Conflict of interest

No conflicts of interest.

References

1. Chandra RK, Patadia MO, Raviv J. Diagnosis of nasal airway obstruction. Otolaryngologic clinics of North America. 2009;42(2):207-25, vii.
2. Skoner DP. Allergic rhinitis: definition, epidemiology, pathophysiology, detection, and diagnosis. J Allergy Clin Immunol. 2001;108(1 Suppl):S2-8.
3. Berger G, Gass S, Ophir D. The histopathology of the hypertrophic inferior turbinate. Arch Otolaryngol Head Neck Surg. 2006;132(6):588-94.
4. Settipane RA, Lieberman P. Update on nonallergic rhinitis. Ann Allergy Asthma Immunol. 2001;86(5):494-507; quiz -8.
5. Shah SB, Emanuel IA, Lalwani AK. Chapter 14. Nonallergic & Allergic Rhinitis. CURRENT Diagnosis & Treatment in Otolaryngology—Head & Neck Surgery, 3e. New York: The McGraw-Hill Companies; 2012.
6. Fraser L, Kelly G. An evidence-based approach to the management of the adult with nasal obstruction. Clin Otolaryngol. 2009;34(2):151-5.
7. Leong SC, Eccles R. Inferior turbinate surgery and nasal airflow: evidence-based management. Current opinion in otolaryngology & head and neck surgery. 2010;18(1):54-9.
8. Nease CJ, Krempl GA. Radiofrequency treatment of turbinate hypertrophy: a randomized, blinded, placebo-controlled clinical trial. Otolaryngology--head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck Surgery. 2004;130(3):291-9.
9. Starling-Schwanz R, Peake HL, Salome CM, Toelle BG, Ng KW, Marks GB, et al. Repeatability of peak nasal inspiratory flow measurements and utility for assessing the severity of rhinitis. Allergy. 2005;60(6):795-800.
10. Cho S-I, Hauser R, Christiani DC. Reproducibility of Nasal Peak Inspiratory Flow Among Healthy Adults Assessment of Epidemiologic Utility. CHEST Journal. 1997;112(6):1547-53 %@ 0012-3692.
11. Bermuller C, Kirsche H, Rettinger G, Riechelmann H. Diagnostic accuracy of peak nasal inspiratory flow and rhinomanometry in functional rhinosurgery. The Laryngoscope. 2008;118(4):605-10.
12. Yepes-Nunez JJ, Bartra J, Munoz-Cano R, Sanchez-Lopez J, Serrano C, Mullol J, et al. Assessment of nasal obstruction: correlation between subjective and objective techniques. Allergologia et immunopathologia. 2013;41(6):397-401.
13. Timperley D, Srubisky A, Stow N, Marcells GN, Harvey RJ. Minimal clinically important differences in nasal peak inspiratory flow. Rhinology. 2011;49(1):37-40.
14. Barham HR, Knisley A, Harvey RJ, Sacks R. How I Do It: Medial Flap Inferior Turbinoplasty. Americal Journal of Allergy and Rhinology. 2015;29(4):314 - 5.
15. Barham HP, Thornton MA, Knisely A, Marcells GN, Harvey RJ, Sacks R. Long-term outcomes in medial flap inferior turbinoplasty are superior to submucosal electrocautery and submucosal powered turbinate reduction. International forum of allergy & rhinology. 2016;6(2):143-7.
16. Phillips PS, Stow N, Timperley DG, Sacks R, Srubiski A, Harvey RJ, et al. Functional and cosmetic outcomes of external approach septoplasty. American journal of rhinology & allergy. 2011;25(5):351-7.
17. Buckland JR, thomas S, Harries PG. Can the Sino-nasal Outcome Test (SNOT-22) be used as a reliable outcome measure for successful septal surgery? Clin Otolaryngol. 2003;38:43-7.
18. Pynnonen MA, Kim HM, Terrell JE. Validation of the Sino-Nasal Outcome Test 20 (SNOT-20) domains in nonsurgical patients. American journal of rhinology & allergy. 2009;23(1):40-5.
19. Browne JP, Hopkins C, Slack R, Cano SJ. The Sino-Nasal Outcome Test (SNOT): can we make it more clinically meaningful? Otolaryngology--head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck Surgery. 2007;136(5):736-41.
20. Moore M, Eccles R. Objective evidence for the efficacy of surgical management of the deviated septum as a treatment for chronic nasal obstruction: a systematic review. Clinical Otolaryngology. 2011;36:106-13.
21. Sandhu AS, Temple RH, Timms MS. Partial laser turbinectomy: two year outcomes in patients with allergic and non-allergic rhinitis. Rhinology. 2004;42(2):81-4.
22. Zoumalan RA, Constantinides M. Subjective and objective improvement in breathing after rhinoplasty. Arch Facial Plast Surg. 2012;14(6):423-8.
23. Lee JY. Efficacy of intra- and extraturbinal microdebrider turbinoplasty in perennial allergic rhinitis. The Laryngoscope. 2013;123(12):2945-9.
24. Ozkul HM, Balikci HH, Gurdal MM, Celebi S, Yasar H, Karakas M, et al. Normal range of peak nasal inspiratory flow and its role in nasal septal surgery. J Craniofac Surg. 2013;24(3):900-2.
25. Ottaviano G, Scadding GK, Coles S, Lund VJ. Peak nasal inspiratory flow; normal range in adult population. Rhinology. 2006;44(1):32-5.
26. Barnes ML, Vaidyanathan S, Williamson PA, Lipworth BJ. The minimal clinically important difference in allergic rhinitis. Clin Exp Allergy. 2010;40(2):242-50.
27. Low WK. Can snoring relief after nasal septal surgery be predicted. Clinical Otolaryngology. 1994;19:142-4.
28. Koleli H, Paltura C, Sahin-Yilmaz A, Topak M, Develioglu ON, Kulekci M. Peak nasal inspiratory flowmetry for selection of patients for radiofrequency ablation of turbinates. Ann Otol Rhinol Laryngol. 2014;123(7):457-60.
29. Leong SC, Farmer SEJ, Eccles R. Coblation® inferior turbinate reduction: a long-term follow-up with subjective and objective assessment. Rhinology. 2010;48(1):108-12.
30. Gandomi B, Bayat A, Kazemei T. Outcomes of septoplasty in young adults: the Nasal

Obstruction Septoplasty Effectiveness study. Am J Otolaryngol. 2010;31(3):189-92.
31. Murrell GL. Correlation between subjective and objective results in nasal surgery. Aesthetic surgery journal / the American Society for Aesthetic Plastic surgery. 2014;34(2):249-57.
32. Karatzanis AD, Fragiadakis G, Moshandrea J, Zenk J, Iro H, Velegrakis GA. Septoplasty outcome in patients with and without allergic rhinitis. Rhinology. 2009;47(4):444 - 9.
33. Lieberman P, Pattanaik D. Nonallergic rhinitis. Curr Allergy Asthma Rep. 2014;14(6):439.
34. Camacho M, Zaghi S, Certal V, Abdullatif J, Means C, Acevedo J, et al. Inferior turbinate classification system, grades 1 to 4: development and validation study. The Laryngoscope. 2015;125(2):296-302.

Dr Krishnan Parthasarathi
Division of Surgery
The Canberra Hospital Yamba Drive
Garran ACT
Australia 2605

Mobile: +612-6244 2222
Fax: +612-6244 4107
E-mail: krishnanpartha@hotmail.com