



Radiological comparison of inferior turbinate hypertrophy between allergic and non-allergic rhinitis: does allergy really augment turbinate hypertrophy?

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Abstract

Background Inferior turbinate hypertrophy could be a result of allergic rhinitis (AR) that leads to nasal congestion and nasal airway obstruction, which is the most bothersome complaint in patients with AR. However, evidence regarding whether patients with AR have a more hypertrophied inferior turbinate than do patients with non-AR is lacking.

Objective We aimed to evaluate the degree of inferior turbinate hypertrophy according to the presence of AR using radiological measurements of the inferior turbinate.

Methods For evaluating the inferior turbinate, which contributes to nasal obstruction in patients with AR, we enrolled 90 adult patients with septal deviation and divided them into two groups (AR group: $n=49$; non-AR group: $n=41$). Allergic rhinitis was diagnosed according to the presence of an allergic history, positive multiple allergen simultaneous test, and serological total immunoglobulin E level (≥ 100 kU/L). We analyzed the minimal cross-sectional area on acoustic rhinometry for both groups. The bilateral total width as well as medial mucosa and nasal cavity space in the anterior and posterior portions of the inferior turbinate were measured using computed tomography.

Results We could not find any significant differences in the anterior and posterior dimensions of the inferior turbinate, intranasal space, and choanal spaces between the AR and non-AR groups. Instead, the anterior part of the inferior turbinate in both the groups showed significant differences between the deviated and contralateral sides. The contralateral side had a larger width than did the deviated side, but no significant difference was noted in the posterior portion of the inferior turbinate.

Conclusion The degree of inferior turbinate hypertrophy showed no difference between patients with and without AR. Therefore, we suggest that surgical treatment for reducing the size of the inferior turbinate hypertrophy should be considered when performing septoplasty in patients with symptoms of nasal obstruction, regardless of the presence of AR.

Keywords Allergy · Inferior turbinate · Multiple allergen simultaneous test · IgE level · Radiology · Nasal obstruction · Septoplasty · Turbinoplasty

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Introduction

Septoplasty is generally the most effective surgical method to improve symptoms of nasal obstruction. However, the failure rate of septoplasty in patients with nasal obstruction is more than 30%, and the outcome of septoplasty could be influenced by the treatment of inferior turbinate hypertrophy [1]. Because inferior turbinate hypertrophy contributes to nasal obstruction, various surgical techniques, such as cauterization, coblation, radiofrequency reduction, microdebrider resection, and partial or total turbinate resection, have been introduced to achieve optimal volume reduction of the inferior turbinate. The mucosa of the inferior turbinate,

which is pivotal in hypertrophic changes, comprises the respiratory epithelium involved in immunological defense. Therefore, the inferior turbinate has an important role in protecting the nasal cavity against exogenous stimuli, such as allergens, chemical irritants, infectious agents, or temperature changes.

Several studies have investigated the septal deviation and compensatory change in inferior turbinate hypertrophy using radiological evaluations. However, no consensus exists about the relationship between inferior turbinate hypertrophy and allergic rhinitis (AR). Since the presence of AR may be closely associated with the pathophysiology of turbinate hypertrophy causing nasal obstruction, the degree of turbinate hypertrophy can be affected by the presence of AR. In this study, we attempted to demonstrate whether AR can affect the degree of inferior turbinate hypertrophy by performing radiological measurements of the inferior turbinate using computed tomography (CT).

Materials and methods

Study population

Ninety patients were enrolled between September 2016 and June 2017 from the Department of Otorhinolaryngology at Hospital. The inclusion criteria were age between 18 and 65 years, and symptoms of AR including nasal obstruction and septal deviation on paranasal CT requiring septoplasty. The exclusion criteria were a history of previous sinus or nose surgery, a Lund–MacKay CT score of more than two on both sides, or any underlying disease or nasopharyngeal pathologic findings. Physical and endoscopic examinations were performed by a trained rhinologist according to a standardized procedure. The patients were classified into the AR and non-AR groups according to their allergic history, specific immunoglobulin E (IgE) levels in multiple allergen simultaneous tests (MASTs), and total IgE serum level. Ethical approval was obtained from the institutional review board (IRB) of Hospital, and informed consent was obtained from all patients prior to their enrollment (4-2017-0645).

Diagnosis of AR and group classification

Presence of allergic symptoms: patients with a history of the following allergic symptoms: (1) sneezing; (2) rhinorrhea; (3) itchy nose, palate, or throat; and (4) itchy, watery, or red eyes with nasal obstruction were included in the AR group; patients free of these symptoms formed the non-AR group.

Total serum IgE (TIgE): TIgE was measured using a 1470 WIZARD gamma counter (PerkinElmer, Turku, Finland) with Immuno CAP100 (Phadia, Uppsala, Sweden). The detection range of TIgE was ≥ 2.00 and ≤ 5000.00 kU/L.

The diagnosis of AR was considered positive when TIgE level was > 100 kU/L.

MAST: MASTs were used to measure specific IgE levels of 61 allergens, including food, pollen, and aeroallergens such as mites, dogs, cats, and molds. The results were graded into seven classes: 0 (< 0.35 kU/L), 1 (0.35–0.7 kU/L), 2 (0.7–3.5 kU/L), 3 (3.5–17.5 kU/L), 4 (17.5–50 kU/L), 5 (50–100 kU/L), and 6 (100 kU/L). Class 1 or higher was considered positive and class 0 was considered negative.

The diagnosis of AR was determined through the presence of an allergic history, positive MAST result, and serum total IgE level > 100 kU/L. Patients in the AR group had an allergic history, positive MAST result for at least one allergen, and TIgE level ≥ 100 kU/L, while those in the non-AR group showed no allergic history, negative MAST result for all allergens, and TIgE level < 100 kU/L.

We could hypothesize that most patients were under similar condition of AR because most of them suffered from severe nasal allergic symptoms for more than three months which had made them visit a tertiary hospital. All AR groups had persistent and severe nasal symptoms not responding to medical treatment such as intranasal topical steroid or oral antihistamines. We performed the acoustic rhinometry as an objective assessment of nasal cavity patency for all enrolled patients and evaluated the average minimum cross-sectional area (MCA).

Measurement of inferior turbinate and space

All included patients evaluated CT scans when they quit the medical treatment during at least 2 weeks. And all CT scans were performed during the daytime. All patients were evaluated using a 16-slice CT scanner (Siemens SOMATOM Sensation 16, Forchheim, Germany) in axial sections covering the region from the top of the frontal sinuses to the hard palate and from the tip of the nose to the region just posterior to the mastoid air cells. The scans were acquired in a cranio-caudal order. Our paranasal sinus protocol comprised 120-kVp tube voltage, 240-mA tube current, 3-mm slice thickness at a 0.55 pitch, and a 512×512 image matrix. From the raw volumetric data, the images of each patient were reconstructed in 1.0-mm slice thickness. None of the patients received a decongestant before CT. The measurements comprised (1) anterior and posterior total width of the inferior turbinates including the deviated and contralateral sides in the AR and non-AR; (2) medial mucosal thickness for both the anterior and posterior portions of the inferior turbinate; and (3) nasal cavity patency, measured as an intranasal space anteriorly and using the choanal space posteriorly. The intranasal space was measured anteriorly as the distance between the nasal septum medially and the inferior turbinate laterally, while the choanal space represented the posterior gap

between the inferior turbinate laterally and the posterior septum medially (Fig. 1). Accordingly, we analyzed the mean differences for the total width of the anterior and posterior portions of the bilateral inferior turbinate, medial mucosal thickness, intranasal space, choanal space, and posterior extension to the nasopharynx. All measurements were obtained using three-dimensional CT, and were compared between the AR and non-AR groups.

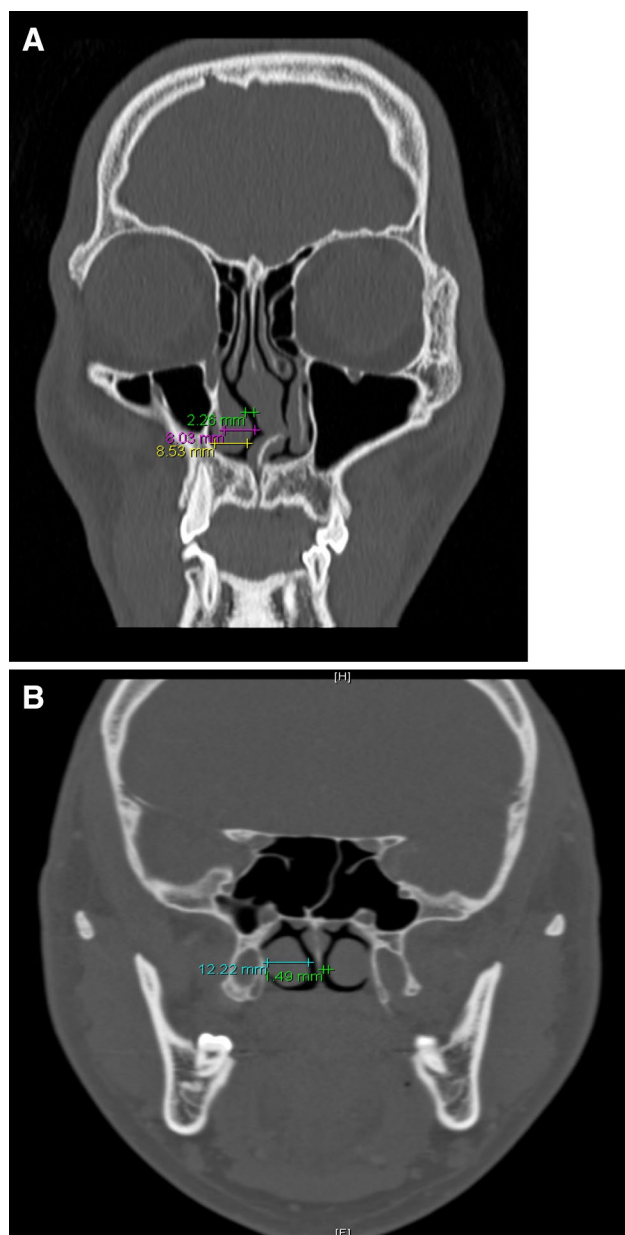


Fig. 1 Bilateral inferior turbinates are selected by the region of maximum volume. **a** Anterior portion of the turbinate shows the total width (yellow), medial mucosa (violet), and intranasal space (green). **b** Posterior portion showing the total width (blue) and choanal space (green)

Other variables

Demographic variables included sex, age, body mass index (BMI), cigarette smoking, alcohol history, and comorbidities. BMI (kg/m^2) was calculated as weight (kg)/height² (m^2). Patients were categorized as cigarette smokers (> 5 packs during lifetime) or non-smokers (never smoked or had smoked < 5 packs during lifetime) on the basis of their lifetime smoking history. Patients were evaluated for their alcohol history using the Alcohol Use Disorders Identification Test; a score above 8 indicated a positive alcohol history in men and a score of 4 was the cut-off for women. Past medical history was obtained from all patients, including chronic diseases such as diabetes or hypertension (Table 1).

Turbinoplasty

All included patients underwent radiofrequency turbinoplasty, which included the insertion of a handheld needle electrode into the anterior, middle, and posterior portions of the inferior turbinate via an inferomedial approach to deliver 350–500 Js, 2–13 Ws, and 70–80 Vs, with a target temperature of 80 °C per lesion. The activated system usually required 2 min per lesion. The depth of needle electrode insertion was 5 mm to reduce the risk of mucosal damage, and for preventing ulceration or sloughing. After radiofrequency application, the turbinate was out-fractured.

Statistical analysis

Measurements for both the deviated and contralateral sides were obtained; a Chi-square test was used to compare the inferior turbinate volume between the two groups.

Table 1 Comparison of clinico-surgical characteristics between the allergic rhinitis and non-allergic rhinitis groups

	AR group (N=49)	Non-AR group (N=41)	p value
Age (years)	34.6 ± 15.3	33.5 ± 13.8	0.726
Sex			
Male	47 (95.9%)	37 (90.3%)	0.406
Female	2 (4%)	4 (9.8%)	
BMI (kg/m^2)	24 ± 4.7	24 ± 3.8	0.457
Serum IgE level	324 ± 281.3	37.7 ± 30	<0.001
Smoking	57 (63.3%)	33 (36.7%)	0.388
Alcohol	66 (73.3%)	24 (26.7%)	0.066
Nasal surgery history	0	0	<0.001
Comorbidities	1 (2%)	1 (2.4%)	0.362
	Pulmonary TB	Epilepsy	

AR allergic rhinitis, BMI body mass index, IgE immunoglobulin E, Non-AR non-allergic rhinitis, TB tuberculosis

SPSS Statistics for Windows/Macintosh, Version 17.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Statistical significance was determined as $p < 0.05$, and all p values were two tailed. The value of 0.90 (Beta = 0.10) was used for power.

Results

Demographic data of the study population

Among the 90 patients enrolled, 84 were men and 6 women (age range, 18–65 years; mean, 37 ± 15 years). The AR and non-AR groups included 49 (47 men; 2 women) and 41 (37 men; 4 women) patients, respectively. The data showed no statistically significant intergroup differences (Table 1).

Comparison of minimal cross-sectional area on acoustic rhinometry

We analyzed the MCA on acoustic rhinometry for both groups. For the right nasal cavity, the average MCA was $1.46 \pm 0.08 \text{ cm}^2$ in the AR group and $1.44 \pm 0.07 \text{ cm}^2$ in the non-AR group ($p = 0.912$). While for the left nasal cavity, the average MCA was $1.26 \pm 0.08 \text{ cm}^2$ in the AR group and $1.23 \pm 0.07 \text{ cm}^2$ in the non-AR group ($p = 0.632$). The comparison for the MCA between both sides of nasal cavities also showed no significant difference for both groups (Table 2).

Table 2 Minimal cross-sectional area on acoustic rhinometry

	AR group (N=49)	Non-AR group (N=41)	p value
Right side (cm ²)	1.46 ± 0.08	1.44 ± 0.07	0.912
Left side (cm ²)	1.26 ± 0.08	1.23 ± 0.07	0.632
p value	0.416	0.517	

AR allergic rhinitis, Non-AR non-allergic rhinitis

Table 3 Anterior and posterior dimensions of the inferior turbinate in relation to the deviated septum

	AR group (N=49)	Non-AR group (N=41)	p value
Anterior width (deviated side)	10.48 ± 2.59	10.73 ± 2.62	0.657
Anterior width (contralateral side)	8.59 ± 2.29	8.21 ± 1.98	0.350
Medial mucosa (deviated side)	4.19 ± 1.23	4.41 ± 1.46	0.410
Medial mucosa (contralateral side)	3.85 ± 1.28	3.45 ± 1.25	0.141
Posterior width (deviated side)	11.64 ± 1.92	11.72 ± 2.21	0.865
Posterior width (contralateral side)	10.57 ± 1.28	10.09 ± 1.51	0.172

Comparison of the inferior turbinate according to the presence of AR

We analyzed the mean intergroup difference in the anterior and posterior total widths of the inferior turbinate. In the AR group, the average anterior and posterior medial widths of the inferior turbinate were 10.48 ± 2.53 and 11.64 ± 1.9 mm, respectively, on the deviated side, and 8.6 ± 2.29 and 10.57 ± 1.78 mm, respectively, on the contralateral side. In the non-AR group, the average anterior and posterior medial widths of the inferior turbinate were 10.73 ± 2.7 and 11.72 ± 2.21 mm, respectively, on the deviated side, and 8.21 ± 1.98 and 10.09 ± 1.51 mm, respectively, on the contralateral side. Therefore, the mean widths of the inferior turbinate showed no significant intergroup differences (Table 3; Fig. 2). A comparison between the inferior turbinate total widths in deviated and contralateral for the anterior and posterior aspects revealed significant differences between anterior inferior turbinate width in deviated side and that in contralateral side for all groups ($p = 0.0004$ in the AR group; $p < 0.0005$ in the non-AR group). However, a comparison between posterior inferior turbinate width in deviated side and that in contralateral side showed no significant difference for all groups ($p = 0.701$ and $p = 0.649$ in the AR and non-AR groups, respectively) (Table 4; Fig. 3).

Comparison of space distance between the AR and non-AR groups

No significant intergroup difference was observed in space distance measurements (Table 5).

Comparison of nasopharyngeal extension between the AR and non-AR groups

We considered the posterior extension of the inferior turbinate to the nasopharynx, which could worsen the nasal obstruction symptom. All patients with adenoid hypertrophy or nasopharyngeal pathology were excluded, and this guaranteed that nasopharyngeal narrowing would be exclusively due to the posterior extension of the inferior turbinate. Eight patients (16.3%) in the AR group and 2 (4.9%) in the non-AR group had nasopharyngeal extension. However, despite

Fig. 2 Anterior and posterior dimensions of the inferior turbinate in relation to the deviated septum according to the presence of allergic rhinitis

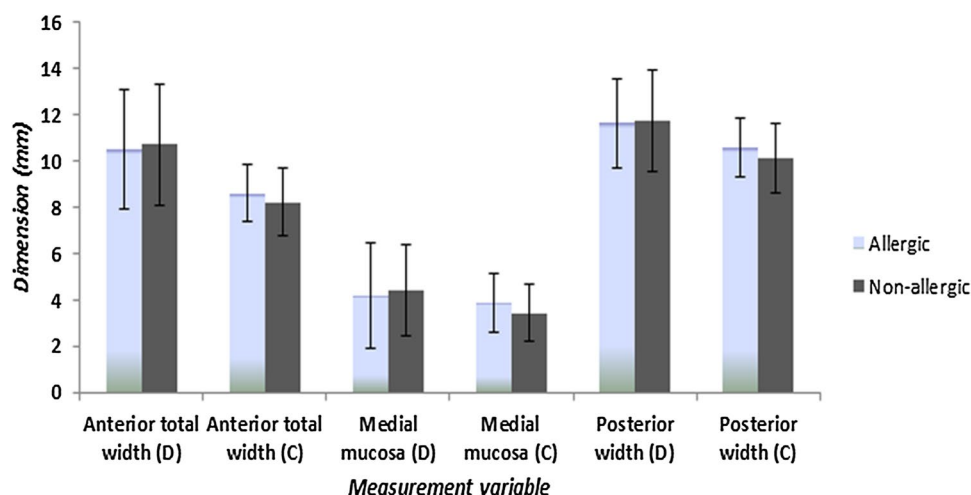


Table 4 Comparison of inferior turbinate width between the deviated and contralateral sides in the allergic rhinitis and non-allergic rhinitis groups

	Anterior allergic	Anterior non-allergic	Posterior allergic	Posterior non-allergic
Deviated side (mm)	7.57 ± 1.54	8.25 ± 1.82	10.29 ± 1.76	9.83 ± 1.57
Contralateral side (mm)	11.69 ± 2.10	11.63 ± 1.86	12.2 ± 1.59	12.16 ± 1.74
P value	0.0004	< 0.0005	0.701	0.649

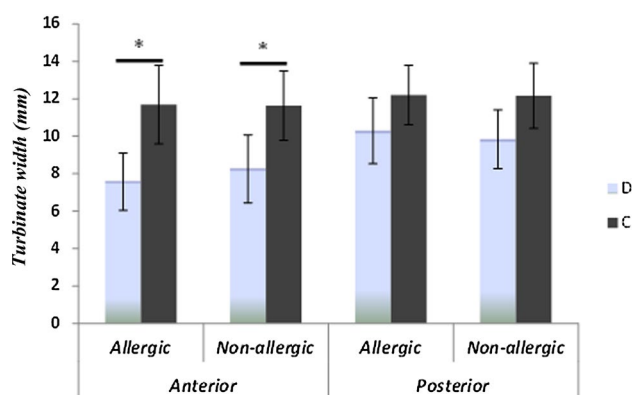


Fig. 3 Comparison of inferior turbinate width between the deviated and contralateral sides in the allergic rhinitis and non-allergic rhinitis groups. *Statistically significant

the higher number of patients in the AR group, the difference was not significant ($p = 0.09$).

Discussion

Septal deviation with turbinate hypertrophy is considered the main structural cause of chronic nasal obstruction, and underlying AR can aggravate the severity of nasal obstruction. Therefore, previous studies have recommended performing septoplasty in combination with inferior turbinate volume reduction [2]. However, no study has investigated the effect of AR on the degree of inferior turbinate hypertrophy. Although several studies have performed CT analysis of the inferior turbinate in patients with a deviated nasal septum, few studies have radiologically investigated the relationship

Table 5 Space distance within the nasal cavity in relation to the inferior turbinate in the allergic rhinitis and non-allergic rhinitis groups

	Intranasal space (deviated side)	Choanal space (deviated side)	Intranasal space (contralateral side)	Choanal space (contralateral side)
Allergic group (N=49) (mm)	1.57 ± 1.29	2.09 ± 1.06	1.45 ± 1.14	2.54 ± 1.35
Non-allergic group (N=41) (mm)	1.62 ± 0.53	2.21 ± 1.42	1.79 ± 0.99	2.71 ± 1.22
p value	0.819	0.684	0.136	0.553

between AR and turbinate hypertrophy. Therefore, we evaluated the inferior turbinate volume according to the presence of AR using CT to investigate the relationship between AR and inferior turbinate hypertrophy.

Inferior turbinate reduction has a beneficial effect in patients with persistent AR [3]. Mori et al. analyzed the long-term effect of submucous turbinectomy in patients with perennial AR and suggested submucous turbinectomy as a useful strategy for the long-term management of nasal allergic symptoms [4]. Furthermore, Mucci and Sismanis et al. showed an improvement in nasal obstruction in 90% of patients undergoing inferior turbinate surgery, as well as improvement in symptoms such as rhinorrhea, headache, and snoring [5]. Many recent studies have shown similar findings, i.e., AR exacerbates the degree of inferior turbinate hypertrophy and worsens nasal obstruction [6, 7]. However, distinguishing between allergy symptoms and turbinate hypertrophy can be difficult, especially in patients who have adapted to their symptoms. Moreover, the causes of turbinate hypertrophy are various, including upper respiratory infections, vasomotor rhinitis, drugs, hormones, and temperature changes, and not confined to allergy only.

If AR affects the degree of inferior turbinate hypertrophy, a significant difference in inferior turbinate volume would exist between the AR and non-AR groups. In our study, no significant intergroup difference was observed in the mean value of inferior turbinate dimension measurements. Our results showed that the presence of AR does not considerably change the degree of turbinate hypertrophy. This implies that turbinate surgery could be performed in a similar manner for all patients with nasal obstruction due to turbinate enlargement, regardless of the presence of AR. Hamerschmidt et al. compared the efficacy of inferior turbinoplasty in patients with and without AR, and confirmed the efficacy of inferior turbinoplasty not only for obstructive symptoms but also for non-obstructive symptoms [8]. This finding coincides with our result.

In patients with septal deviation, compensatory inferior turbinate hypertrophy is often found in the contralateral side to the major septal deviation. Berger et al. studied specimens from 19 patients undergoing nasal surgery for septal deviation contralateral inferior turbinate hypertrophy, and compared them with 10 inferior turbinates taken from autopsy controls. They found that inferior turbinate hypertrophy was caused by conchal bone hypertrophy rather than medial and lateral mucosal hypertrophy [2]. Egeli et al. found that compensatory turbinate hypertrophy was due to both conchal bone enlargement and medial and lateral mucosal hypertrophy [9]. Orhan et al. used CT to prove that compensatory hypertrophy of the inferior turbinate in patients with nasal septum deviation is caused not only by mucosal hypertrophy but also by inferior turbinate hypertrophy itself [10]. We compared the ratio of compensatory hypertrophy with

septal deviation and unexpected turbinate hypertrophy in patients with and without AR and found significant intergroup differences in anterior inferior turbinate volume, but not in posterior inferior turbinate volume. Most inferior turbinate enlargement is due to mucosal hypertrophy; however, in the case of septal deviation, it might include both bony and mucosal portions [11]. In this study, the bony portion of the inferior turbinate between the AR and non-AR groups showed no significant difference (data now shown). We did not consider including the precise turbinate bony structure in our analysis, because we believed that the effect of AR will be more on the mucosal portion of the inferior turbinate and that the surgical technique used, namely radiofrequency turbinoplasty, will address only mucosal portion. Our results only showed a significant intergroup difference between anterior inferior turbinate width between the deviated and contralateral sides for two groups. However, the significant intergroup difference between the two nasal cavities was not observed in the width of posterior turbinate portion. This significant difference in anterior turbinate width alone can occur because the anterior nasal mucosa acts as a barrier mainly facing the airflow. Accordingly, we emphasize that successful surgery for nasal obstruction depends on the surgeon's treatment of the anterior inferior turbinate [12].

Numerous surgical techniques have been introduced for inferior turbinate reduction, and these can be chosen on the basis of two basic criteria. First, the efficacy of the procedure in relieving rhinitis symptoms, and second, fewer complications such as epistaxis, synechiae, and crusting [12]. We preferred using radiofrequency reduction turbinoplasty (RFRT)—a minimally invasive surgical option—that can reduce tissue volume in a precise, targeted manner. RFRT delivers radiofrequency energy to the submucosal tissue of the turbinate, reducing tissue volume with minimal impact on surrounding tissues [13, 14]. Through a systematic literature review, Hytönen et al. found that RFRT is fast, effective, and well tolerated, and has low morbidity [15]. Many other studies have reported identical outcomes for both RFRT and power-assisted reduction surgeries, which improve nasal blockage by increasing the space in the nasal cavity [16, 17]. Because we focused on mucosal hypertrophic changes to consider the effect of AR, radiofrequency turbinoplasty would be a reasonable surgical technique in this study.

A limitation of our study relates to the dynamic feature of the inferior turbinate that undergo nasal cycle, which could change the inferior turbinate size during the time variation. To overcome this limitation, we included perennial allergic rhinitis patients with persistent and severe nasal symptoms not responded to medical treatment. Furthermore, Kim et al. studied the effects of allergen provocation on the nasal cycle and showed there was no significant difference in the changes of nasal cycle and the proportion of individuals exhibiting a nasal cycle between

the allergic patients group and control group [18]. Additionally, objective diagnostic endoscopic examination with decongested method showed almost no significant change of the inferior turbinate volume, accordingly we can assume that the inferior turbinate volume is relatively constant.

Another limitation of our study was the possible overlap between the infectious and allergic symptoms. Although a high possibility of enrolling patients with infectious rhinitis instead of AR exists, we overcame this issue via detailed history taking and by performing confirmative tests such as MAST and TIgE level measurements. Moreover, the patients usually presented with long-term symptoms; therefore, the possibility of mucosal thickening will be predominantly high. Further studies are needed to elucidate the effects of other factors on inferior turbinate hypertrophy.

Conclusion

The degree of turbinate hypertrophy causing nasal obstruction did not differ between patients with and without AR. Therefore, our conclusion supports the use of surgical treatment for inferior turbinate hypertrophy in patients who undergo septoplasty for nasal obstruction, regardless of the presence of AR.

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Author contributions Salma Saud Al Sharhan and Lee EJ: study concept and design; drafting of manuscript; manuscript revision. Hwang CS and Nam JS: acquisition, analysis and interpretation of data; Yoon J-H and Kim C-H: revision of manuscript, approval of final version of manuscript to be published; Cho H-J: study concept and design; revision of manuscript; interpretation of data; approval of the final version of the manuscript to be published.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval Ethical approval was obtained from the institutional review board (IRB) of Severance Hospital.

Informed consent Informed consent was obtained from all patients prior to their enrollment (4-2017-0645).

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