Research Article

Analysis of Internal Nasal Valve Shapes and Angle Due to Nasal Obstruction in Asian Nose

Tiara Melati,[1] Mirta H. Reksodiputro,[2]* Trimartani,[2] Sandi Iljanto[3]

[1]Department of Otorhinolaryngology-Head and Neck Surgery
Faculty of Medicine Trisakti University, Jakarta
[2]Department of Otorhinolaryngology-Head and Neck Surgery, Faculty of Medicine
Universitas Indonesia-dr. Cipto Mangunkusumo National Hospital, Jakarta
[3]Faculty of Public Health Universitas Indonesia

*Corresponding: citamirta@yahoo.com
Received 28 July 2022; Accepted 16 December 2022
https://doi.org/10.23886/ejki.10.203.212

Abstract

Caucasian has a rather acute angle of Internal nasal valve (INV) whilst Asian generally has broader, thicker, and bigger anthropometric proportion of nose than Caucasian. Asian INV may be differ in shape and larger in angles compare to Caucasian, due to the minimum publication addressing this issue. To report the anatomy of INV and its angle in obstructed Asian noses. A case control study was conducted at Cipto Mangunkusumo Hospital, December 2017 with 40 cases of nasal obstruction and 80 controls without nasal obstruction. Both groups were evaluated using nasal obstruction symptom evaluation (NOSE) questionnaire, rigid nasal endoscopy and active anterior rhinomanometry (AAR). Anatomy and angle of INV was later measured using digital image analysis. Six basic INV shapes were seen throughout both groups, many has different shape combinations. Most commonly (>60%) observed shape in both groups were the occupied by nasal septal body (NSB). The right INV angle in case group was 15.5º ± 10.1º (p = 0.123) and left INV angle was 17.2º ± 9.0º (p = 0.022). In control group, the right INV angle was 19.6º ± 11.8º (p = 0.123) and left INV angle was 23.2º ± 12.5º (p = 0.022). Most common shape of Asian INV in both groups, is the occupancy by NSB. INV angle in obstructed nose is narrower in comparison to those without nasal obstruction. This study also demonstrates Asian, particularly Indonesian, has wider angle of INV than Caucasian.
Keywords*: Internal Nasal Valve, anatomy INV, Asian INV, nasal obstruction, rhinomanometry.*

Analisis Bentuk dan Sudut Katup Hidung Internal Akibat Sumbatan Hidung pada Orang Asia

Abstrak

Ras kaukasia memiliki sudut Internal Nasal Valve (INV) yang agak lancip sedangkan orang Asia memiliki proporsi hidung lebih lebar, tebal, dan antropometrik lebih besar dari orang Kaukasia. INV Asia mungkin berbeda dalam bentuk dan sudut yang lebih besar dibandingkan Kaukasia karena minimnya publikasi yang membahas masalah ini. Untuk melaporkan anatomi INV dan sudutnya pada hidung orang Asia yang tersumbat dilakukan studi kasus kontrol dengan subjek 40 kasus sumbatan hidung dan 80 kontrol tanpa sumbatan hidung di RS Cipto Mangunkusumo, Desember 2017, Kedua kelompok dievaluasi dengan kuesioner nasal obstruction symptom evaluation (NOSE), rigid nasal endoscopy, dan active anterior rhinomanometry (AAR). Anatomi dan sudut INV diukur dengan analisis citra digital. Enam bentuk dasar INV terlihat pada kedua kelompok dengan kombinasi bentuk yang berbeda. Lebih dari 60% bentuk yang diamati pada kedua kelompok adalah yang ditempati nasal septal body (NSB). Sudut INV kanan pada kelompok kasus adalah 15,5º ± 10,1º (p = 0,123) dan sudut INV kiri 17,2º ± 9,0º (p = 0,022). Pada kelompok kontrol, sudut INV kanan adalah 19,6º ± 11,8º (p = 0,123) dan sudut INV kiri 23,2º ± 12,5º (p = 0,022). Bentuk INV Asia yang paling umum pada kedua kelompok, adalah hunian NSB. Sudut katup hidung internal pada hidung yang tersumbat lebih sempit dibandingkan dengan yang tidak mengalami obstruksi hidung. Kajian ini juga menunjukkan orang Asia, khususnya Indonesia, memiliki sudut INV lebih lebar dari orang Kaukasia.
Kata kunci: *Internal Nasal Valve, anatomi INV, Asian INV, sumbatan hidung, rinomanometri.*

Introduction

Internal nasal valve (INV) is defined by caudal border of the upper lateral cartilage (ULC) and its relation to the nasal septum.[1] INV can be located approximately 1.3 cm from the nostril.[1,2] The average INV angle in a Caucasian is 9-15º. INV has a role in structural nasal obstruction separate from other anatomical pathologies, for example allergy. This is in accordance the Bernoulli's rule, hence the collapse of INV can cause nasal obstruction.[2]

Structural nasal obstruction is commonly caused by deviated nasal septum and incompetency of nasal valve (external or internal). Incompetency of the INV may present in static or dynamic form. Static form of INV regards to obstructions cause by the surrounding structures such as presence of nasal septal body, deviated septum, or hypertrophic inferior turbinate. Dynamic form of obstruction may present as the collapse of the nasal valve structures during inspiration secondary to the weak integrity of the ULC. Both forms may overlap in existence.[2]

There are 3 morphological types of noses, the leptorrhine (tall and thin) usually seen in Caucasian or Indo-European descent; the platyrrhine (broad and flat) mainly found in African origins; and the mesorrhine, a combination of the 2 types. Most common Asian nose is mesorrhine, associated with short radix, various anterior dorsal projection, rounded-under-projected tip and rounded nostrils.[3] Asian also features thicker skin, weaker cartilages, less dorsal projection, rounder tip and alae, a retrusive columella.[3] This basic difference between Caucasian and Asian noses, lead the assumption of different causes of structural nasal obstruction amongst the two population, thus distinctive strategy is required to manage it. The Asian noses have weaker ULC rather than more acute angle of INV, hence alar batten graft is commonly used to correct INV incompetency rather than spreader graft. There is little publication studying the anatomy of Asian INV, especially in Indonesia, therefore this study aims to report the anatomy of INV and its angle in obstructed Asian noses.

Methods

Forty cases (20 male, 20 female) of nasal obstructed patients and 80 controls (33 male, 47 female) without nasal obstruction in the outpatient clinic at Cipto Mangunkusumo Hospital, December 2017 were examined using nasal obstruction symptom evaluation (NOSE) questionnaire, rigid nasal endoscopy (nasoendoscopy) and active anterior rhinomanometry (AAR). Digital image analysis was done to identify the shape of INV and measurements of the angle. This study has obtained ethical clearance from the Medical Committee of a tertiary health care centre in Jakarta, Indonesia. This research was performed in the same examination room with the average room temperature of 23.[4] (±1.3º C) and humidity of 58.85% (± 4.365). All data was recorded accordingly. Exclusion criteria were nasal polyp, sinonasal tumor, intranasal decongestant, intranasal steroid, antihistamine consumption, uncontrolled comorbid (hypertension, diabetes mellitus), lung and/or heart problems.

Nasoendoscopy examinations were recorded using a 30º rigid nasal endoscope attached to an iPhone® 6 plus through an adapter, Clearscope (Clearwater Clinical Limited, Ottawa, Canada). A standardized technique was developed to achieve consistent image frame of nasal endoscopic view. Patients' sit upright, head parallel to the ground (horizontal Frankfort line). Endoscope was parallel to the ground, enters maximum 1 cm mark from the vestibule, on the nasal floor (Figure 1). All the examination videos were transfer into a computer in the format of .mp4 and then selected one frame (.jpg), which best described the INV, which includes all INV area anatomical landmark, such as nasal septum, most outer border mucosa of ULC, and head of inferior turbinate. Digital image analysis (INV tracing and angle) was evaluated using Adobe Photoshop® CS6.

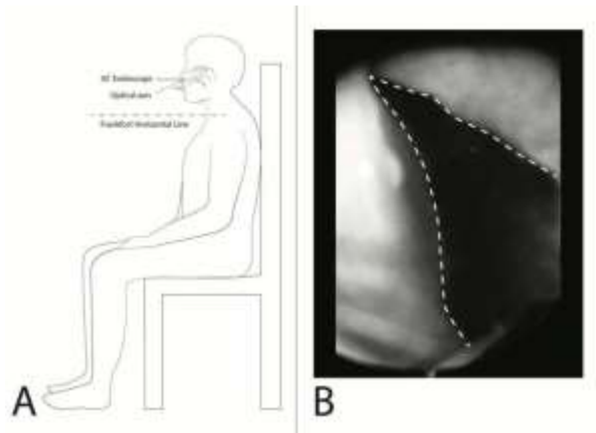

Figure 1. Endoscope measuring technique. Performing uniform rigid nasal endoscopy using a 30º telescope and a mark onthe probe ensure the reproducibility of INV digital image analysis. (A) Patients' sit upright, head parallel to the ground (horizontal Frankfort line). Endoscope was parallel to the ground, enters maximum 1 cm mark from the vestibule, on the nasal floor. (B) A frame was captured then trace using Adobe Photoshop® CS6.

AAR were performed to objectively measure the nasal obstruction, using ATMOS Rhino 31 (ATMOS Medizin Technik GmbH & Co. KG, Germany). Both nasal cavities were measured separately using disposable nasal probe mask. Upon each AAR measurement, patients were instructed to breathe as normal and effortlessly from the nose, thus generating a constant frequency and amplitude. Nasal resistance (R) was noted uni- and bilaterally at 75, 150 and 300 Pa, but in this study, calculation was made by R at 75 Pa. Using R = P/V formula, where P defined as average pressure difference and V as flow volume. Statistical analysis was calculated using SPSS® for Windows Version 20. Statistic was done by one-way ANOVA test. P value less than 0.05 was considered significant.

Results

Case group has a mean age of 30.75 ± 8.21 years, in the control group was 31.54 ± 9.73 years. NOSE score was performed in both groups, case has average NOSE score of 28.38 (± 23.0) and control group has average NOSE score of 3.8 (± 7.9) (Table 1).

Table 1. Characteristics of the Subjects

Characteristics	Case	Control	p value
Gender			0.367
Male	20 (50%)	33 (41.3%)	
Female	20 (50%)	47 (58.8%)	
Age	30.75 ± 8.21	31.54 ±9.73	0.661
NOSE Score			< 0.001
mean	28.38 (±23.0)	3.81 (±7.9)	
median	20	0	

The most common shape of INV in both groups were the angle occupied by NSB, followed by sharp and blunt angle (Figure 2). INV angle can only be measured in sharp angle, convex, concave caudal border and some occupied by NSB phenotypes. There were 74 right INV (32 cases, 42 controls) and 84 left INV (31 cases, 53 controls) to be calculated. The right INV angle in the case and control group were 15.5 ± 10.1 degree and 19.6 ± 11.8 degree, (p = 0.123) respectively (Table 2).

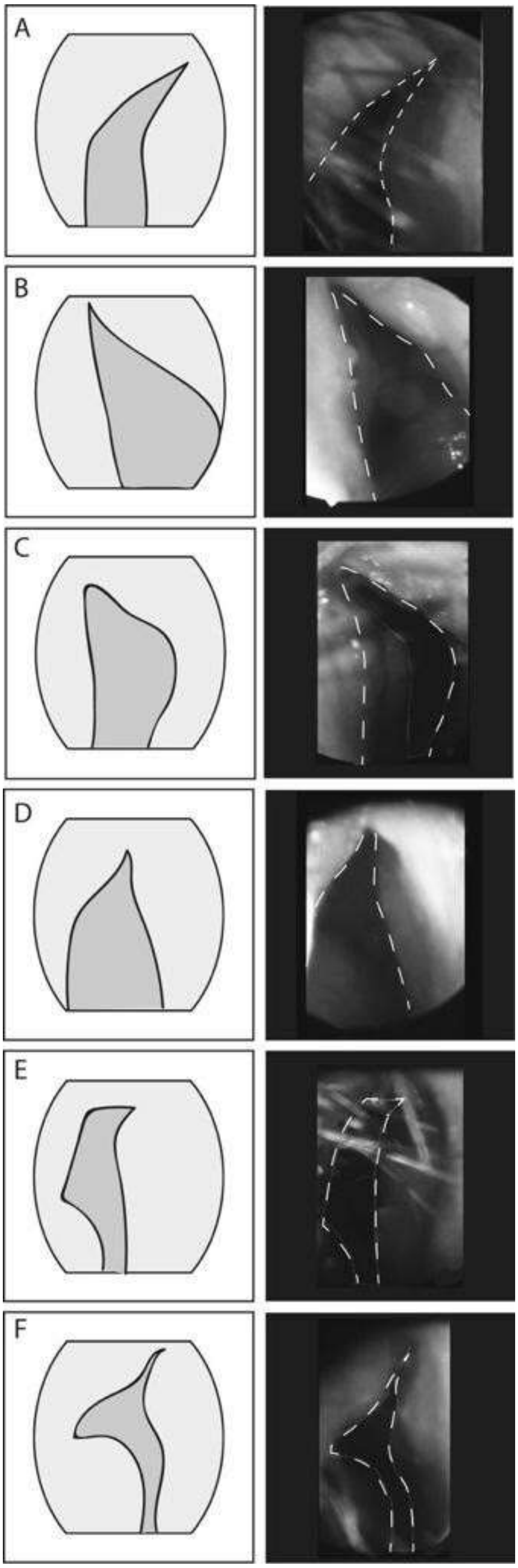

Figure 2. Six phenotypes of INV, in order from most to least commonly found in this study. (A) Occupancy by NSB, (B) sharp angle, (C) blunt angle, (D) convex, (E) concave, and (F) twisted caudal border.

Table 2. Right Internal Nasal Valve Angle in Relation to NOSE Questionnaire

Group	n	mean	SD	p value
Control	42	19.6	11.8	0.123
Case	32	15.5	10.1	

The left INV angle in the case and control group were 17.2 $\pm$ 9.0 degree and 23.2 $\pm$ 12.5 degree (p = 0.022) (Table 4).

Table 3. Left Internal Nasal Valve Angle in Relation to NOSE Questionnaire

Group	n	mean	SD	p value
Control	53	23.2	12.5	0.022
Case	31	17.2	9.0	

There were inconsistencies between the degree of nasal resistance to the degree of nasal obstruction based on NOSE score. These inconsistencies were found in both case or control group, either in bilateral and unilateral (Table 4) measurements.

Table 4. Nasal Resistance (R_{Right}, R_{Left}, R_{Total}) at 75 Pa in Relation to the Degree of Nasal Obstruction Based on NOSE Questionnaire

Degree of Obstruction	Case				Control			
	n	mean	SD	p value	n	mean	SD	p value
R_{Right}								
None	-	-	-	0.474	55	0.389	0.460	0.663
Mild	26	0.312	0.183		23	0.310	0.118	
Moderate	10	0.787	1.608		2	0.250	0.028	
Severe	2	0.355	0.092		-	-	-	
Extreme	2	0.245	0.021		-	-	-	
R_{Left}								
None	-	-	-	0.729	55	0.317	0.186	0.599
Mild	26	0.310	0.108		23	0.373	0.327	
Moderate	10	0.284	0.048		2	0.280	0.071	
Severe	2	0.310	0.071		-	-	-	
Extreme	2	0.365	0.134		-	-	-	
R_{Total}								
None	-	-	-	0.982	55	0.157	0.082	0.882
Mild	26	0.148	0.043		23	0.159	0.073	
Moderate	10	0.149	0.041		2	0.130	0.028	
Severe	2	0.160	-		-	-	-	
Extreme	2	0.145	0.035		-	-	-	

A slim difference of nasal resistance was noticed in the R_{Right} of the control over the case group, when compared to the disease specific question of NOSE questionnaire number 2. However, no significant difference in the R_{Left} and R_{Total} of both groups (Table 5).

Table 5. Total Nasal Resistance (R_{total}) at 75 Pa in Relation to Disease-Specific Question Number2 of the NOSE Questionnaire

R	Group	n	Mean	SD	p value
Right	Control	80	0.358	0.39	0.465
	Case	40	0.439	0.81	
Left	Control	80	0.323	0.23	0.966
	Case	40	0.325	0.13	
Total	Control	80	0.154	0.08	1
	Case	40	0.154	0.04	

Discussion

The most common phenotype of INV found in the case and control group was the angle occupy by NSB (more than 60%). Miman et al[4] also discovered the most common type was occupancy by NSB. Murthy et al[5] studied 150 students and they were followed for 2 years. There were 32% of the sample population who has the shape of occupancy by NSB. It was the second most common type found in Murthy et al[5] description. In the 2-year follow-up, 26.6% of this population developed incidences of acute otitis media, sinusitis, and pharyngitis. Murthy et al[5] stated further narrowing of INV area will significantly give effect to ventilation of the sinuses, although he did not discuss the role and relationship INV to the disturbed ventilation in the sinuses and middle ear. Wexler[6] studied the histology of NSB and observed its highly glandular structure with a moderate proportion of venous sinusoids. E Gelera et al[7] noted NSB may change to hypertrophic state consequently interfere with nasal airflow in response to chronic inflammation. Wong[8] recognized NSB as a normal dynamic structure with a variety of width over time in close relation to inferior turbinate. Wong[8] also mentioned NSB may involve in facilitating laminar nasal airflow, humidification, and thermal regulation and particles filtration.

This study faced a challenge during observation of INV using nasoendoscopy and digital image analysis, which is defining the angle itself. Miman et al[4] considers there was no angular relation between ULC and septum when the INV angle is occupied by NSB type hence can't be measured. Therefore size, location, and state of NSB must be taken into considerations to establish the INV angle. Nasal septal body is a fusiform structure which varies in size and location. A hypertrophic NSB may extended high to the anterior septum, which obstruct the most caudal ULC and septum area, such type may not produce an angle. This study purposes a method to define a more precise INV angle in the presence of non-hypertrophic NSB. A non-hypertrophic NSB may be small and located in the middle of the anterior septum, which enable the definition of 3 points, A, B, C, hence an angle is to be calculated (Figure 3).

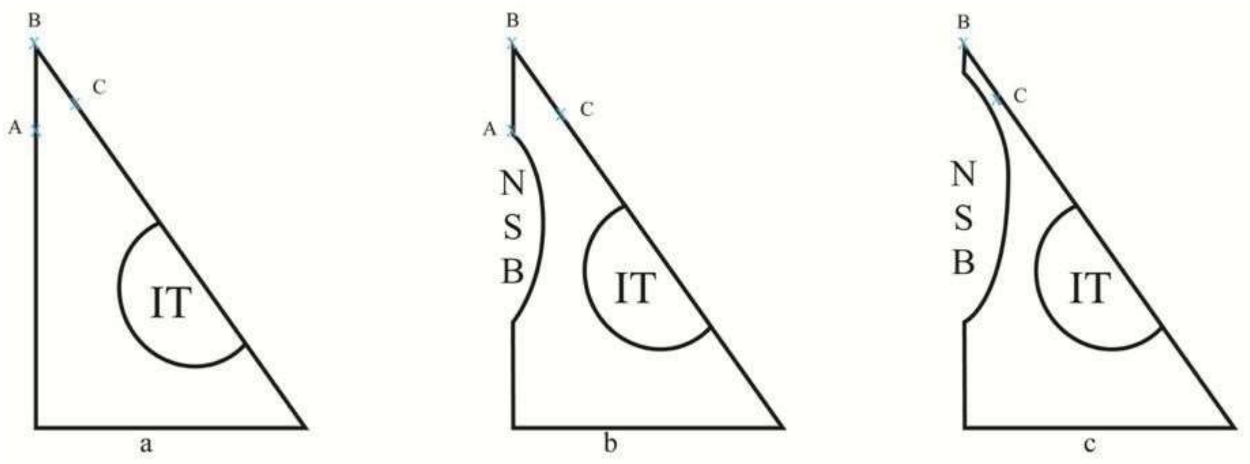

Figure 3. A proposal to define INV angle in relation to NSB. (A) When there is no NSB present, an angle is defined when point A is located of the outer part septal mucosa intersect with most outer caudal border of ULC. (B) When a non-hypertrophic NSB is present, an angle might still be able to define similarly to (A). (C) Hypertrophic NSB obstructing the INV, no angle is able to calculated.

INV angle in this study was separated right and left, then recorded according to the group. The narrowest angle recorded was in the right INV angle of the case group, 15.5 $\pm$ 10.1 degree (p = 0.123). The widest INV angle was noted on the left INV control group 23.2 $\pm$ 12.5 degree (p = 0.022). Suh et al[9] used CT scan and nasoendoscopy to measure the INV angle, 21.6 ± 4.5 degree and 19.3 ± 3.6 degree, correspondingly. Kwun et al[10] uncovered the average INV angle in Asians were 21,4 ± 1,0 degree using CT scan and endoscopy. Hence verify Asians having wider INV angle, thus managing structural nasal obstruction in Asians requires different strategy compared to other races.

Suh et al[9] prefers CT scan as measuring tools compare to nasoendoscopy. The fisheye lens in nasal endoscopy causes a spherical distortion in the image that needed to be corrected in the image analysis. Moreover, the image of the endoscopy is merely a reflection of a 3-dimensional space in the nasal cavity. A perpendicular plane to the endoscope is easily changed due to any slight movement (tilt or rotation) (Figure 4). Therefore, it is beneficial to use a reference mark to achieve reproducibility when using nasoendoscopy.

The range of INV angle standard deviation (SD) in this study is remarkably wide, more than 10 to 12.5º. This may be due to the much diverse of ethnicity in Asian - Indonesia. Indonesia has 633 indigenous ethnicity group recognised in the public census 2010.[11] Although it is common to generalise Asian noses as mesorrhine, such diversity may contribute to the increased range of anthropometric measurements compare to other Asian countries with less diverse ethnicity groups.

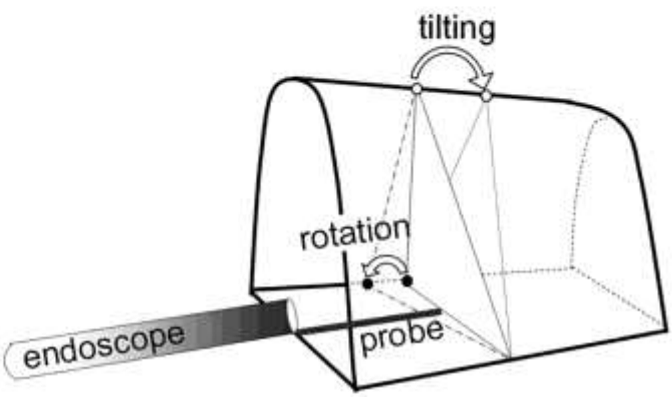

Figure 4. Pitfalls of measuring INV using rigid nasal endoscopy. Perpendicular plane to the endoscope is easily changed due to any slight movement (tilt or rotation). Reprinted with permission from Suh et al[9]

This study tried to measure objectively the subjective complaint using NOSE questionnaire and correlate the results to the objective finding from AAR. This has proven to be difficult due to the inconsistency throughout the data. Lipan et al[12] classified the degree of nasal obstruction to mild (range, 5-25), moderate (range, 30-50), severe (range, 55-75), or extreme (range, 80-100). Stewart[13] developed NOSE questionnaire to validate a subjective disease-specific tool to assess nasal obstruction. AAR was chosen because its records data through the dynamic of human breathing. However, this study found NOSE score contradict AAR outcome, those who had high NOSE score, presumably extreme nasal obstruction, does not necessarily followed by obstructive findings of the AAR or an increase nasal resistance.

This study contributed to the fact that, it is a challenge to validate subjective and objective assessments of nasal obstruction. Andrew et al[14] found no correlation of subjective quality of life and symptom measuring tools, such as visual analog scale (VAS), NOSE survey and sinonasal outcome test 22 (SNOT-22), to nasal inspiratory peak flow (NIPF). Despite this discrepancy, Andrew et al[14] emphasised the importance of minimally clinically important difference (MCID). Functional septorhinoplasty aim to restore and improve nasal airflow, while the two may not always correlates, rather the improvement in disease specific quality of life outcomes. For examples psychological, emotional, and aesthetic expectations, may outweighs the importance of post-operative measures.

AAR is expensive, not readily available in most centres, requires good communication between patient/operator. AAR measure nasal resistance in the effortless breathing dynamics, consequently, provide similarity to normal breathing. Andrew et al[14] noted NIPF is an effort dependent tool, but it is cheap, simple to use, requires minimal patient/staff education and it is one measuring device the nasal cavity airflow.

Conclusion

The most common shape of INV in Asian, predominantly Indonesian, is the occupancy by NSB. This study also demonstrates Indonesian has a wider angle than Caucasian. Diverse indigenous ethnicity may contribute the widespread range of Indonesia INV angle. It is difficult to correlate the subjective and objective findings of nasal obstructions, thus further studies are warranted in

Indonesian population or specific ethnicity group to improve the management of structural nasal obstruction.

Acknowledgements

Study was performed by the first author as part of thesis study during her residency at Department of Otorhinolaryngology Head and Neck Surgery, Faculty of Medicine, University Indonesia, dr. Ciptomangunkusumo Hospital, Jakarta, Indonesia; under supervision of both co-authors.

References

1. Tripathi PB, Elghobashi S, Wong BJF. The myth of the internal nasal valve. JAMA Facial Plast Surg. 2017;19:253-4. doi: 10.1001/jamafacial.2017.0039.
2. Patel B, Virk JS, Randhawa PS, Andrews PJ. The internal nasal valve: a validated grading system and operative guide. Eur Arch Otorhinolaryngol. 2018;275:2739-44. doi: 10.1007/s00405-018-5142-x.
3. Park J, Suhk J, Nguyen AH. Nasal analysis and anatomy: anthropometric proportional assessment in Asians-aesthetic balance from forehead to chin, Part II. Semin Plast Surg. 2015;29:226-31. doi: 10.1055/s-0035-1564817.
4. Miman MC, Deliktas H, Ozturan O, Toplu Y, Akarcay M. Internal nasal valve: revisited with objective facts. Otolaryngol Head Neck Surg. 2006;134:41-7. doi: 10.1016/j.otohns.2005.08.027
5. Murthy VA, Reddy RR, Pragadeeswaran K. Internal nasal valve and its significance. Indian J Otolaryngol Head Neck Surg. 2013;65:400-1. doi: 10.1007/s12070-013-0618-x
6. Wexler D, Braverman I, Amar M. Histology of the nasal septal swell body (septal turbinate). Otolaryngol Head Neck Surg. 2006;134:596-600. doi: 10.1016/j.otohns.2005.10.058
7. E Gelera J, Ojar D, Lim JH, Wee JH, Kim J-W, Rhee C-S. Radiographic changes of the nasal septal body among patients with sinonasal diseases. Clin Exp Otorhinolaryngol. 2017;10:338-43. doi: 10.21053/ceo.2017.00080.
8. Wong EH, Noussair M, Hasan Z, Duvnjak M, Singh N. Physiological changes in the size of the septal swell body correlate with changes in inferior turbinate size. J Laryngol Otol. 2020;134:323-7. doi: 10.1017/S0022215120000675
9. Suh MW, Jin HR, Kim JH. Computed tomography versus nasal endoscopy for the measurement of the internal nasal valve angle in Asians. Acta Otolaryngol. 2008;128:675-9. doi: 10.1080/00016480701663391
10. Kwun C, Yang CW, Kim SW, Lee KH. Evaluation of functional rhinoplasty using the Modified Cottle test in Asian patients. Acta Otolaryngol. 2016;136:330-2. doi: 10.3109/00016489.2015.1108523
11. Mengulik data suku di Indonesia. Statistics Indonesia. https://www.bps.go.id/news/2015/11/18/127/mengulik-data-suku-di-indonesia.html. Published 2010. Accessed June 30th, 2020. Indonesian.
12. Lipan MJ, Most SP. Development of a severity classification system for subjective nasal obstruction. JAMA Facial Plastic Surgery. 2013;15:358-61. doi: 10.1001/jamafacial.2013.344
13. Stewart MG, Witsell DL, Smith TL, Weaver EM, Yueh B, Hannley MT. Development and validation of the Nasal Obstruction Symptom Evaluation (NOSE) scale. Otolaryngol Head Neck Surg. 2004;130:157-63. doi: 10.1016/j.otohns.2003.09.016
14. Andrews PJ, Choudhury N, Takhar A, Poirrier AL, Jacques T, Randhawa PS. The need for an objective measure in septorhinoplasty surgery: are we any closer to finding an answer? Clin Otolaryngol. 2015;40:698-703. doi: 10.1111/coa.12455