Rhinology, 20, 193-199, 1982

X-ray tomographical observations of the interrelationships among structures of the nasal airway

M. Okuda, Y. Sakaguchi, Y. Tanigaito, F. Sakaguchi, H. Machii and K. Yuge,
Tokyo, Japan

SUMMARY

In order to elucidate upon the interrelationships among the different structures in and around the nasal cavity, the noses of 95 adults without severe rhinitis, paranasal sinusitis, cysts or tumors were examined by means of X-ray tomography. The results indicate a close correlation between the width of the nasal cavity and 1) the width of the maxillary sinus, 2) the size, form and height of the inferior turbinate, 3) the size of the middle turbinate or 4) the nasal septal deviation; between the height of the nasal cavity and the length and height of the inferior turbinate or the length of the middle turbinate, and also between the degree of septal deviation and the width of the nasal cavity, the nasal meatus or olfactory slit or the form of the inferior turbinate.
In conclusion, it is recognized that correction of the abnormal interrelationships among the different structures is important for functional nasal surgery.

INTRODUCTION

Information on the structures composing the nasal airway space is extremely important for functional nasal surgery since the proper physiological activity of the nose can be attained only when the structures of the nasal cavity are normal. Many studies have been made on both normal and abnormal structures that it is not necessary to add anything further in this connection (Zuckerkandl, 1892; Leicher, 1928; Pesti, 1948; Terada, 1961). Nevertheless, tomographical observations on the different structures of the nasal cavity are made in this study for the following reasons: 1) previous studies generally concentrated on deformities of each seperate structure but not of the interrelationships among the sizes, shapes and positions of the many different structures from the point of view of harmonized structural growth, 2) recently developed X-ray equipments provide better visualization of the nasal structures than in the past, and 3) progress has been made in the field of electronic computers, facilitating statistical analysis of a large number of measured values.

MATERIALS AND METHODS

Ninety-five physiologically normal Japanese of both sexes and above the age of twenty are radiologically examined in this study. Patients with severe rhinitis, paranasal sinusitis, cysts or tumours, or with a history of nasal surgery are not included in this group. X-ray tomography of the sagittal projection is undertaken for all subjects in serial sections of 0.5 cm distance from the nasal tip to the posterior wall of the sphenoidal sinus. The X-ray machine used is a Tritome U (Philips, Holland) and the exposure factors are 65-60KV, 70 m As for 3 sec at a distance of 143 cm. The tomographic section taken at the middle of the nasal cavity, 3.5 or 4.0 cm deep from the nasal tip, is selected for measuring the sizes of the different nasal structures of each nose. In this section, the septum, the middle turbinates, the inferior turbinates, the ethmoidal sinuses and the maxillary sinuses, are clearly visualized as the structures of the nose (Figure 1) (The superior turbinates, the frontal sinuses and the sphenoidal sinuses are not clearly visualized in this section). The heights and widths of the nasal cavities, the sizes and shapes of the inferior and middle turbinates, and the sizes of the ethmoidal and maxillary sinuses are recorded. The bony and composite structures (composition of the bone and overlying mucosa) are separately measured, since the former are rather congenital, and the latter are affected by infection and air flow.

Each structure to be measured is named as shown in Figure 2. The nasal height, S_1, is the distance between the bony cranial basis and the nasal process of the palate. The nasal deviation, S_2, is the maximum distance from the straight line of the upper and lower limits of the septum. The length, i_1, and the height of the inferior turbinate, i_2, are the straight distances between the attached portion of the inferior turbinate and its free lower edge and between the attached portion and the surface of the nasal floor, respectively. The size of the inferior turbinate, i_5, is its

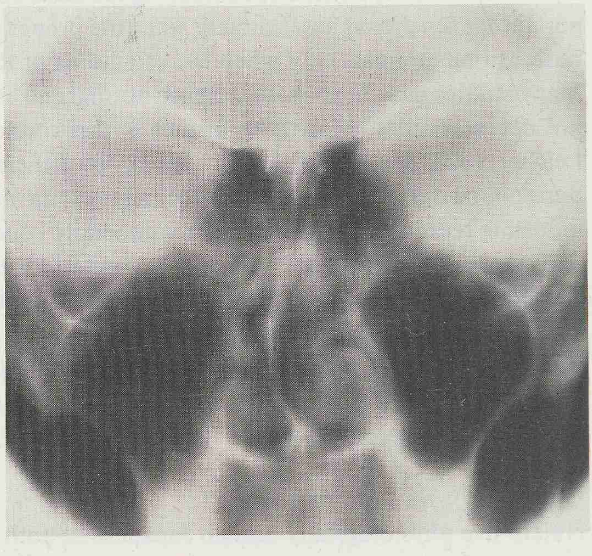

Figure 1. A section of X-ray tomography in the sagittal projection at 4.5 cm deep from the nasal tip. The septum, middle and inferior turbinates, maxillary and ethmoidal sinuses are clearly visualized. The septum shows C-type deviation, the right inferior turbinate is V-type and the left is H-type in shape. The left inferior turbinate is relatively wide.

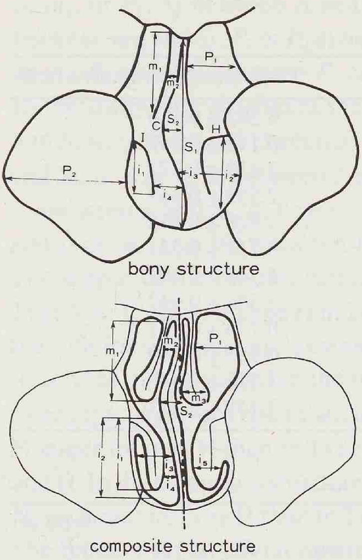

Figure 2. Measurement of nasal airway structures.

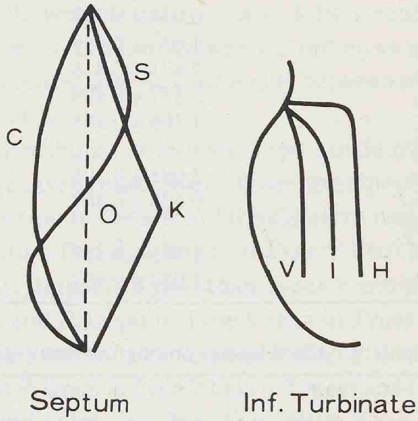

Figure 3. Types of septum and inferior turbinate forms.

maximum width. The width of the nasal cavity, i_3, and the width of the common nasal meatus, i_4, are the maximum distances between the nasal septum and the lateral wall of the inferior meatus and between the nasal and inferior turbinate, respectively. The width of the olfactory slit, m_3, is the distance between the middle turbinate and the septum. The size of the ethmoidal sinus, P_1, is the minimum distance between the middle turbinate and the medial wall of the orbit, and the size of the maxillary sinus, P_2, is its maximum width.

The shapes of nasal septal deviation are classified into four types (Types O, C, K and S) as shown in Figure 3. The shapes of inferior turbinate are also divided into three types (Type V-vertical, H-horizontal, and I-intermediate) according to the angles of projection toward the horizontal line (Figure 3).

The measured values are compared with each other and statistically analyzed by Pearson's method (comparison of the correlation coefficient) or by the student t-test according to the point of view of the interrelationships among the different structures.

RESULTS

The mean values and standard deviations measured in each structure are listed in Table 1.

In the bony structures, there is a significant correlation 1) between S_1 and i_2 or m_1, 2) between S_2 and m_2, i_3 or i_4, 3) between i_1 and i_2 or i_3, 4) between i_2 and S_1, i_1,

Table 1. Sizes of the nasal structures.

	bony structures (cm)	composite structures (cm)
S_1	6.215 ± 0.554	6.202 ± 0.550
S_2	0.036 ± 0.378	0.110 ± 0.645
i_1	1.637 ± 0.469	2.419 ± 0.372
i_2	2.471 ± 0.416	2.553 ± 0.367
i_3	2.377 ± 0.498	1.928 ± 0.415
i_4	1.306 ± 0.395	0.217 ± 0.231
i_5		1.544 ± 0.402
m_1	3.095 ± 0.505	3.584 ± 0.547
m_2	0.420 ± 0.407	0.136 ± 0.281
m_3		0.955 ± 0.439
P_1	1.795 ± 0.397	1.526 ± 0.476
P_2	3.083 ± 0.992	3.147 ± 0.883

Table 2. Correlations among the bony structures.

	S_1	S_2	i_1	i_2	i_3	i_4	m_1	m_2	P_1	P_2	type of I.F.
S_1				***			***				
S_2					***(-)	***(-)		**			**
i_1				***	***						**
i_2	***		***		***			**		***(-)	
i_3		***(-)	**	***		**				***(-)	**
i_4		***(-)			***						
m_1	***								*	*	
m_2		**		**					**(-)		
P_1	*						*	**(-)		***	*
P_2				***(-)	***(-)		*		***		**

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, (-) negative correlation

Table 3. Correlations among the composite structures.

	S_1	S_2	i_1	i_2	i_3	i_4	i_5	m_1	m_2	m_3	P_1	P_2	type of I.F.	type of septum
S_1			***	***			*	**						*
S_2					***(-)									
i_1	***			***			***						*	*
i_2	***		***		**		**							*
i_3		***(-)		**			***	***				***(-)	**	*
i_4							*(-)		*					
i_5	*		***	**	***	*(-)							**	
m_1	**				***				*(-)					**
m_2						*		*(-)					*	*
m_3														
P_1												*		
P_2					***(-)						12		*	*

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, (-) negative correlation

i_3, m_2, or P_2, 5) between i_3 and i_1, i_2, i_4, S_2 or P_2, 6) between i_4 and i_3 or S_2, 7) between m_1, and S_1, P_1 or P_2 8) between m_2 and i_2, S_2 or P_1, 9) between P_1 and S_1, m_1 or m_2, P_2 and 10) between P_2 and m_1, P_1, i_2 or i_3.

In the composite structures there also is a significant correlation 1) between S_1 and i_1, i_5, i_2 or m_1, 2) between S_2 and i_3, 3) between i_1 and S_1, i_2 or i_5, 4) between i_2 and S_1, i_1, i_3 or i_5, 5) between i_3 and i_2, i_5, m_1, S_2 or P_2, 6) between i_4 and m_2 or i_5, 7) between i_5 and S_1, i_1, i_2, i_3 or i_4, 8) between m_1 and S_1, i_2 or m_2, 9) between m_2 and i_4 or m_1, and 10) between P_2 and P_1 or i_3.

The shapes of the inferior turbinate are distributed as follows: Type I in 54.6%, Type V in 17.2% and Type H in 28.2% of the cases, respectively. When the types of the inferior turbinate are examined in relation to the sizes of the different nasal structures, it is revealed in the bony structure that S_2 is larger in Type V than in Type H; i_1 larger in Type I than in Type H; i_3 larger in Type I than Types V and H; P_1 larger in Type H than in Types I and V, and P_2 larger in Type V than in Types I and H. In the composite structure, i_1 and i_3 are larger in Types I and V than in Type H; m_2 larger in Type H than in Type V, and P_2 larger in Type V than in Types I and H.

The types of septal deviation are distributed as follows: Type O in 28.1%, Type S in 17.9%, Type C in 31.5% and Type K in 22.4% of the cases, respectively. Significant correlations are observed only between the types of nasal septum and the sizes of different nasal composite structures: S_1 is larger in Type C than in Type K; i_1 larger in Type O than in Type C, and i_3 larger in Type O than in Type S; m_1 larger in Types C and O than in Type S; m_2 larger in Type S than in Type K, and P_2 larger in Types K, C and S than in Type O.

DISCUSSION

The interrelationships among the different structures of the nose are developed and established during the natal and postnatal periods. Among these relationships, the facts that the width of the nasal cavity is correlated with the pneumatization of the maxillary sinus (Pesti, 1948) and that the inferior turbinate is enlarged on the concave side of the septal deviation (Takahashi, 1971) have been the main interests of many investigators. As additional findings, we clearly demonstrated that a wider nasal cavity is also compensated by a longer, higher-positioned Type H or I inferior turbinate, a longer middle turbinate and septum deviation as well, while a narrower cavity is made up for a shorter, lower-positioned, Type V inferior turbinate as well as a shorter middle turbinate. When the inferior turbinate is shorter and thinner in the wider nasal cavity, the nose becomes dry due to the rush of air flow and a condition resembling atrophic rhinitis appears. However, when the inferior turbinate is H-type and wider or the middle turbinate is longer in the narrower cavity, the airway is obstructed. These observations are very important for functional nasal surgery. If the airway is wider, a longer inferior turbinate (H type) should be made by subperiostal implantation of autoginous bone or artificial material. Whereas, if it is narrower, a shorter inferior turbinate (V type) and a smaller, shorter middle turbinate should be constructed by fracture or submucosal resection of their bony structures or by partial resection of the thick overlining nasal mucosa.

Little consideration has been paid to the significance of nasal height in the structural formation of the nasal cavity. The present study demonstrates that a higher nasal cavity is compensated by a longer, higher-positioned inferior turbinate and a longer middle turbinate, while a lower nasal cavity is associated with a shorter, lower-positioned inferior turbinate and a shorter middle turbinate. When the inferior turbinate is shorter and lower-positioned in the higher nasal cavity, it appears to be atrophic rhinitis. While, if it is longer and higher-positioned in the lower cavity, the nasal airway is blocked. Therefore, correction of the size and shape of the inferior and middle turbinates is necessary depending on the conditions involved.

Septal deviation is the most common and important deformity of the nasal structures. The degree of deviation is found to be correlated with the width of the nasal cavity, nasal meatus and olfactory slit. Septal deviation also affects the shape of the inferior turbinate. The H-type inferior turbinate is frequently observed on the concave side of the deviation, and the V-type on the convex side. The correction of septal deviation, therefore, should be combined with the correction of the shape of the inferior turbinate by submucous resection of the bony structure, if necessary.

In clinical practice, however, more comprehensive considerations may be required, since the present observations were limited to only one tomographic section selected from the serial sections of the nose. Furthermore, the correlations among the nasal structures can vary from section to section as well as according to the quality of the nose.

CONCLUSION

It should be emphasized that correction of the abnormal correlations among the different structures in and around the nasal cavity is important for functional nasal surgery. The nasal airway space is constructed and formed during the foetal and postnatal periods by the continuous development and growth of the different structures. This work of construction is carried out according to provisions of nature, namely harmonization of growth among the structures. When the harmonization is disrupted and a subsequent pathological condition is established in the nasal cavity, we should try to improve the disparity in the correlations among the different structures of the nasal cavity, but not to correct the deformity of a single structure.

RÉSUMÉ

Dans le but d'éclaircir les relations existant entre les différentes structures se trouvant dans la cavité nasale et en autour, nous avons examiné au moyen d'une tomographie aux rayons X, les nez de 95 adultes non souffrant de rhinite grave, ni de sinusite paranasal, de kystes ou de tumeurs. Les résultats manifestent une corrélation étroite entre la largeur de la cavité nasale et 1) la largeur du sinus maxillaire, 2) les dimensions, forme et hauteur du cornet inférieur, 3) les dimensions du cornet moyen ou 4) la déviation du septum nasal; entre la hauteur de la cavité nasale et la longueur et la hauteur du cornet inférieur ou la longueur du cornet moyen; de même, entre le degré de déviation du septum et la largeur de la cavité nasale, le méatus nasal ou la fente olfactive ou la forme du cornet inférieur. En conclusion, il est admis que la correction de relations anormales existant entre les différentes structures est importante pour la chirurgie nasale fonctionnelle.

REFERENCES

1. Leicher, H., 1928: Vererbung anatomischer Variation der Nase, Ihrer Nebenhöhlen und des Gehörganes. J. F. Bergman, München.
2. Pesti, L., 1948: Die Pathogenese der Rhinitis atrophicans von Standpunkte der Pneumatisations-frage. Mschr. f. Ohrenhk. 82, 151–158.
3. Takahashi, R., 1971: Malformation of the nasal septum. A collection of ear, nose and throat studies. Dept. of Otorhinolaryngology. Jikei University School of Medicine. Tokyo.
4. Terada, K., 1961: A tomographical study of the correlation between nasal septal deviation and the lateral nasal wall. Jap. J. ORL. 64, 1105–1126.
5. Zukerkandl, E., 1892: Normal und Pathologische Anatomie der Nasenhöhle und ihrer pneumatischen Anhänge. W. Braumüller, Wien. Vol. 2.

M. Okuda, M.D.
Dept. of Otolaryngology
Nippon Medical School
Sendagi, Bunkyo-ku
Tokyo, Japan