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Semi-longitudinal study of adenoid and jaw growth of normal occlusal children aged 6 to 17

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Reduced nasal breathing can influence the growth and development of facial structures. It may have many causes, and enlarged adenoid is the most frequent one. To investigate the effects of adenoids to jaw growth, we must first understand the normal growth of adenoids and jaws, and the relationship between size of adenoids and the values for the jaw variables. The purpose of this study is to present a more objective standard of nasopharyngeal size and jaw dimension at each bone age, by using Cervical Vertebrae Maturation Index(CVMI) of Hassel, from normal occlusion children aged 6 to 17. The results of this study suggests as follows :

1. At same bone age, female's chronologic age was about 2 year older than male.
2. There was a growth peak of nasopharyngeal(NP) height and depth between CVMI 1 to 2 in male, but in female NP height and depth gradually increase through CVMI 1 to 6.
3. Relative airway of nasopharynx increases the most between CVMI 1 to 2 period in both gender.
4. Among adenoid measurements, Ad2-related variables and upper pharynx, and among dentofacial measurements inter-canine width in both arch, maxillary intermolar width and palatal depth had high correlation coefficient with adenoid percentage.

Key words : nasopharynx, adenoid, jaw growth, bone age

Lymphoid tissue is normally present in the form of a nasopharyngeal tonsil at part of Waldeyer's tonsilar ring. If this lymphoid tissue becomes so hypertrophied that it produces clinical symptoms, it is denoted *'adenoid vegetation* or *adenoids'*. Adenoids are usually developed in childhood and marked symptoms are most common at 2-12 years of age. During adolescence, the adenoids decrease in size, concurrently with growth of the nasopharynx. In adults, it is rather rare to find adenoid tissue and it is usually in an atrophic condition.[1),8)]

There are many causes which raise mouth breathing. Enlarged turbinate, adenoid hyperplasia, deviation of the nasal septum, allergy and chronic inflammation with edematous nasal mucosa etc. are the known etiology and hypertrophied adenoids regard as one of the chief cause among them. [1),2)]

Reduced nasal breathing can influence the growth and development of facial structures. Tomes[3)] had first reported that mouth breather usually displayed contracted, V-shaped maxillary dental arch. This phenomenon caused by lowered tongue position of mouth

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Table 1. Grouping of the subjects by bone age (CVMI) and average age of each group

	Initial age	*CVMI 1*	*CVMI 2*	*CVMI 3*	*CVMI 4*
Male	Number	24	10	10	14
	chronologic age	9.9±1.0	12±0.8	14±1.1	14.5±0.6
Female	Number	21	15	10	15
	chronologic age	7.3±1.0	9.9±0.8	11.5±0.8	12.2±1.3

breather. Angle[4] and Ricketts[8),11)] termed the facial pattern of mouth breather as *"adenoid face"*. The characteristics of adenoid face are narrow face, lip incompetency, flatten nose, short upper lip, small nares, protrusion of upper incisors, V-shaped maxillary arch and high palatal vault etc. Nordlund[5] documented that inactivity of nasal cavity led high palatal vault(*inactivity theory*). Bloch[6] & Miche[7] have suggested that hypertrophied adenoids and mouth breathing increased intraoral air pressure. Increased pressure would compress the palate and brought high palatal vault(*air compression theory*). From Bernfeld's study[9], there were many reports about the relationship between nasopharyngeal dimension and airway. Leech[10] & Moyer[15] have suggested that enlarged adenoid causes growth imbalance between adenoid and nasopharyngeal structure and led mouth breathing.

To investigate the effects of adenoids to jaw growth, we must first understand the normal growth of adenoids and jaw, and the relationship between size of adenoids and the values for the jaw variables. Mouth breathing caused by hypertrophied adenoid usually appears around 9 year old and at 12~14 year old. Malocclusion can be occurred by mouth breathing. In previous studies, there was many done to reveal the relationship of breathing mode and dentofacial morphology[1),14)-18)]. But in all studies, the samples were all divided by its chronologic age, which include various individual variations. So, the purpose of this study is to present a more objective standard of nasopharyngeal space size and jaw dimension at its bone age by using CVMI from normal occlusion children aged 6 to 17, which may be useful for prevention and diagnosis the malocclusion, and for prediction of posttreatment changes.

SUBJECTS AND METHODS

1. Subjects

The experimental subjects were normal occlusion children aged 6 to 17(58 males and 61 females) with no systemic diseases and have no experience of orthodontic treatment. Lateral cephalograms of each samples were subgrouped by its bone age. Subjects were divided into 4 groups according to Hassel's Cervical Vertebrae Maturation Index(CVMI)[13)](Table 1)

2. Methods

1) Cephalometric Study

Lateral cephalograms were taken annually for 3 years. with the conventional method(75Kvp, 6mA, 0.8, 1.0 second exposure). Tracing were drawn by same person and if the landmarks on both sides were not coincided the midpoint of the two points were chosen.

2) Measurements (Table 4)

Image-Pro® PLUS (version 4.0 for Windows) was used for linear, area measurements. 4 times magnified images were used to input the points. Linear measurements were read to 0.01㎜, and areal measurements were read to 0.01㎟.

3) Cast study

Digital calliper (ABSOLUTE DIGIMATIC, Mitutoyo) was used and linear measurements were read to 0.01㎜.

4) Reference points, reference line and measurements.

The reference points, lines and measurements are summarized in Table 2-4, and Figure 1-7.

5) Statistical evaluation

① Averages and standard deviations of each measurements were taken from each group of age and gender.

② Student's t-test was carried out on each group for comparison of male and female.

③ Paired t-test was carried out on male and female

Table 2. Cephalometric landmarks

Na	The anterior point of the intersection between the nasal and frontal bone
S	The midpoint of the cavity of sella turcica
Ba	The lowest point on the anterior margin of the foramen magnum, at the base of the clivus
ANS	The tip of the anterior nasal spine
PNS	The tip of the posterior nasal spine of the palatine bone, at the junction of the hard and soft palate
AA	The most anterior point on the anterior arch of the atlas
Ho	Intersection of inferior surface of the clivus with a line perpendicular to S-Ba registered on PNS
Ho′	Intersection of S-Ba with a line perpendicular to S-Ba registered on PNS
Ad1	Intersection of adenoid contour with line from PNS to Ba
Ad2	Intersection of adenoid contour with line from PNS to Ho′
Ad3	Intersection of adenoid contour with line from PNS to S

Table 3. Cephalometric reference line

Na-Ba	Line from Na to Ba
S-PNS	Line from S to PNS
Palatal Line (PL)	Line from ANS to PNS
Anterior Atlas Line (AAL)	Line perpendicular to PL registered on AA

Table 4. Measurements

Distance between posterior cranial base and PNS (figure 3)
S-PNS
Ho′-PNS
Ba-PNS
Nasopharyngeal dimension (figure 4)
NP height
NP depth
Linear airway measurements (figure 5)
Ad1-PNS
Ad2-PNS
Ad3-PNS
Upper pharynx
Lower pharynx
Areal measurements (figure 6)
NP area
Air area
OP area
Relative size of nasopharyngeal airway
Ad1-PNS / Ba-PNS
Ad2-PNS / Ho′-PNS
Ad3-PNS / S-PNS
Air area / NP area
Cast measurements (figure 7)
Intercanine width (ICW)
Premolar basal arch width (BAW)
Intermolar width (IMW)
Palatal depth (PD)

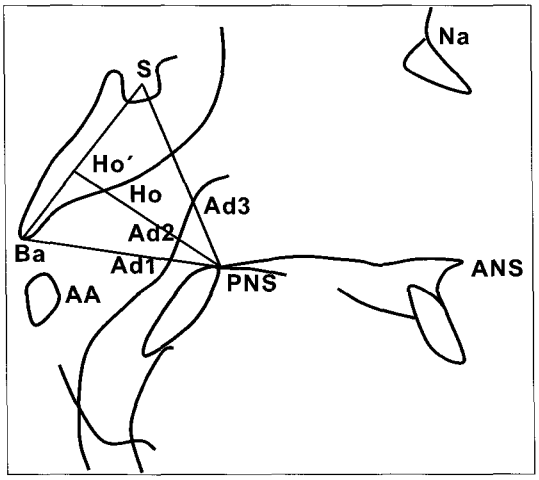


Figure 1. Cephalometric landmarks

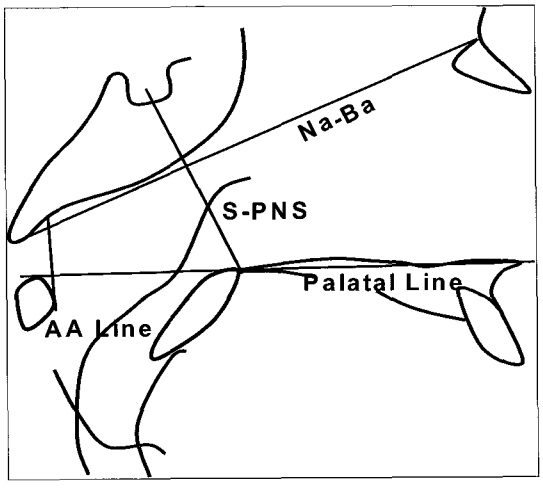


Figure 2. Cephalometric reference line

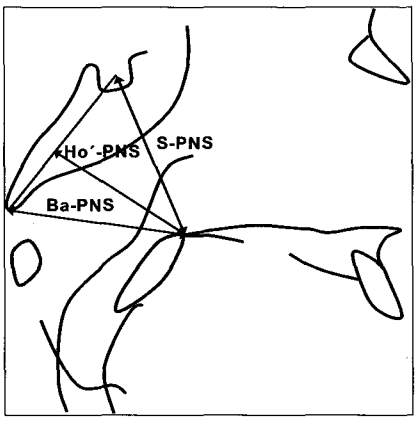


Figure 3. Measurements of distance between cranial base and PNS

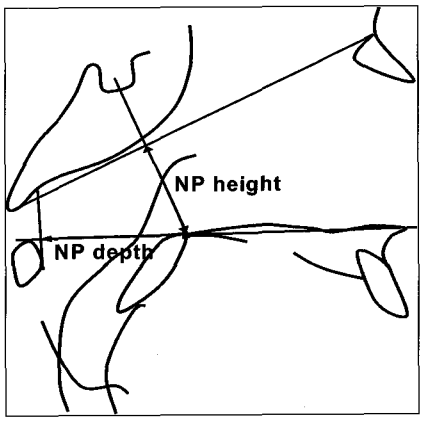


Figure 4. Measurements of nasopharyngeal dimension

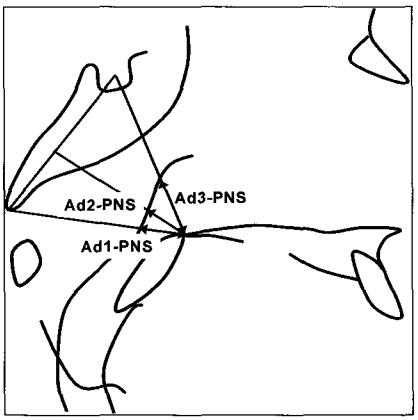


Figure 5. Measurements of linear airway dimension

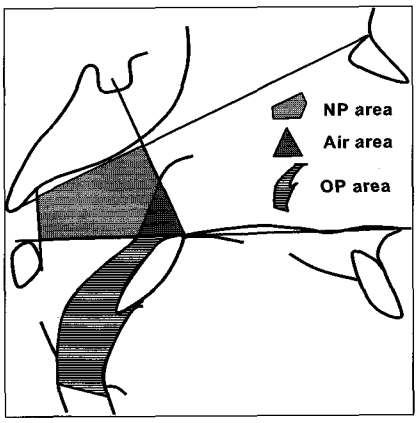
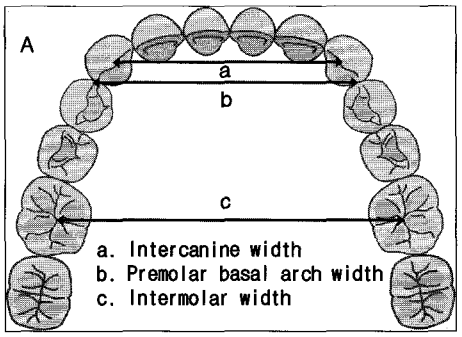
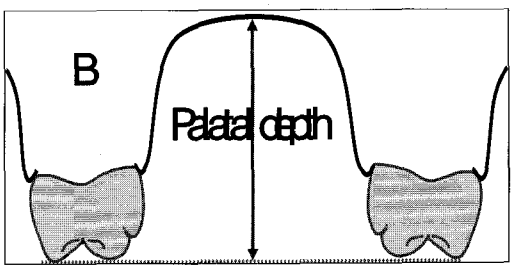


Figure 6. Measurements of pharyngeal area dimension. (* The lower border of OP area is corresponed with mandibular plane)





A. a. Intercanine width : distance between right and left canine tip
b. Premolar basal arch width(PMBAW)
c. Intermolar width : distance between right and left central fossa of first molar

B. Palatal depth : the longest distance from palatal and midpoint of the line which connects mesial side of right and left first upper molar

Figure 7. Cast measurements

Table 5. Growth changes for distances from posterior cranial base to PNS (㎜)

		CVMI 1		CVMI 2		CVMI 3		CVMI 4		CVMI 6	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
S-PNS	M	47.21	2.96	49.60	2.04	51.34	3.72	52.04	2.38	52.11	2.41
	F	42.20	2.52	45.61	2.29	46.57	3.05	46.63	3.95	48.84	2.54
	p-value	0.0004***		0.0005***		0.0439*		0.0097**		0.0470*	
Ho'-PNS	M	39.14	3.28	41.21	2.31	41.92	3.64	42.75	2.22	43.06	1.56
	F	37.45	2.05	38.79	3.00	39.14	3.01	39.23	2.62	39.70	2.88
	p-value	0.1233		0.0538		0.1984		0.0358*		0.0195*	
Ba-PNS	M	44.14	2.47	45.76	3.18	46.60	3.72	48.02	2.81	48.06	1.68
	F	43.70	2.41	44.26	3.60	44.35	3.32	44.37	4.72	44.42	6.45
	p-value	0.8551		0.3274		0.3177		0.6547		0.1024	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 6. Incremental changes for distances from posterior cranial base to PNS (㎜)

		CVMI 2-1			CVMI 3-2			CVMI 4-3			CVMI 6-4		
		Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value
S-PNS	M	2.39	1.57	0.0012**	1.74	0.16	0.1177	0.70	0.21	0.3369	0.07	0.02	0.0064**
	F	3.41	1.22	0.1453	0.96	0.71	0.0981	0.06	0.05	0.3369	2.21	1.32	0.1410
Ho'-PNS	M	2.07	1.02	0.0064**	0.71	0.42	0.1392	0.83	0.17	0.0044**	0.31	0.035	0.0303*
	F	1.34	0.68	0.0939	0.35	0.24	0.2728	0.09	0.02	0.0044**	0.47	0.24	0.1137
Ba-PNS	M	1.62	1.37	0.0388*	0.84	0.31	0.2592	1.42	1.1	0.1040	0.04	0.01	0.3121
	F	0.56	0.44	0.1599	0.09	0.04	0.1323	0.02	0.00	0.1040	0.05	0.01	0.0537

(* : p<0.05, ** : p<0.01, *** : p<0.001)

for comparison of growth change per bone age.

④ Pearson correlation coefficient was used to evaluate correlation between adenoid percentage(Air area/NP area) and other variables.

RESULTS

Growth changes of distance from posterior cranial base to PNS. When bone age increased, all variables indicating the distance between posterior cranial base to PNS increased. There was a sexual difference in S-PNS at all ages and Ho'-PNS at CVMI 4 and 6 (Table 5). At each group, there was no statistically significant difference in growth increment on both gender. In male, the growth increase was statistically significant from CVMI 1 to CVMI 2, and in female the increment was similar in all over the groups(Table 6).

Growth changes of nasopharyngeal dimension. By aging, height and depth of nasopharynx had increased. Nasopharyngeal height were more large in male than female in all groups(Table 7). In male, there was a significant growth of nasopharyngeal height and depth from CVMI 1 to CVMI 2 stage(Table 8).

Growth changes of pharyngeal airway. In male, there was significantly larger values in Ad3-PNS than in female(Table 9). Pharyngeal airway dimensions significantly increase between CVMI 1 to CVMI 2, especially in male(Table 10). But at same period, upper pharynx measurements had increased more in female than in male.

Growth changes of areal measurements. Male presented larger NP area and Air area than female(Table

Table 7. Growth changes for nasopharyngeal dimension (㎜)

		CVMI 1		*CVMI 2*		*CVMI 3*		*CVMI 4*		*CVMI 6*	
		Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
NP height	M	24.56	2.64	26.74	1.55	28.06	1.96	29.19	1.64	29.88	1.01
	F	24.05	1.98	24.39	2.05	25.24	3.28	25.25	1.90	25.98	2.32
	p-value	0.5902		0.0056**		0.1257		0.0037**		0.0006***	
NP depth	M	32.24	1.65	33.73	2.71	33.74	2.57	35.37	3.44	35.38	1.94
	F	30.46	2.79	31.70	4.01	31.84	3.71	31.89	7.39	32.09	6.82
	p-value	0.1259		0.3406		0.3611		0.2430		0.2274	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 8. Incremental changes for nasopharyngeal dimension (㎜)

		CVMI 2-1			*CVMI 3-2*			*CVMI 4-3*			*CVMI 6-4*		
		Mean	*S.D.*	*p-value*	*Mean*	*S.D.*	*p-value*	*Mean*	*S.D.*	*p-value*	*Mean*	*S.D.*	*p-value*
NP height	M	2.18	1.67	0.0049**	1.32	0.33	0.2256	1.13	0.42	0.0159*	0.69	0.40	0.2166
	F	0.34	0.15	0.1451	0.85	0.19	0.2823	0.01	0.00	0.0159*	0.73	0.18	0.0049*
NP depth	M	1.49	0.60	0.0691	0.01	0.001	0.0061**	1.63	0.97	0.0151*	0.01	0.004	0.1705
	F	1.24	0.59	0.0168*	0.14	0.03	0.4275	0.05	0.02	0.0115*	0.20	0.16	0.0323*

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 9. Growth changes for pharyngeal airway (㎜)

		CVMI 1		*CVMI 2*		*CVMI 3*		*CVMI 4*		*CVMI 6*	
		Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
Ad1-PNS	M	21.74	3.92	23.58	3.45	24.08	3.11	24.66	3.57	24.70	3.25
	F	19.83	3.20	21.91	3.46	22.76	1.19	22.80	5.72	23.99	0.68
	p-value	0.2125		1.2851		0.3573		0.4899		0.2274	
Ad2-PNS	M	15.33	3.20	18.77	2.28	19.38	2.80	20.81	3.29	21.69	3.25
	F	14.17	2.19	16.04	3.50	17.36	2.76	17.68	5.87	18.54	2.74
	p-value	0.2943		0.0510		0.2594		0.2346		0.9684	
Ad3-PNS	M	17.35	3.23	21.48	2.39	22.16	3.14	22.19	1.58	22.71	1.26
	F	16.25	2.95	18.37	2.45	18.69	1.87	19.08	2.75	20.79	4.34
	p-value	0.4221		0.0084**		0.0486*		0.0226*		0.0772	
Upper Pharynx	M	9.90	1.95	12.80	2.68	12.98	2.68	13.05	2.80	14.79	3.53
	F	7.68	2.68	10.86	2.63	11.64	3.13	11.99	6.90	14.36	3.49
	p-value	0.0545		0.1120		0.4730		0.6775		0.2719	
Lower Pharynx	M	12.29	3.83	13.83	2.01	13.99	4.52	14.22	2.50	16.24	1.90
	F	13.45	3.93	14.14	3.86	14.68	3.12	14.93	2.20	15.04	2.47
	p-value	0.4631		0.8220		0.7501		0.6648		0.9486	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 10. Incremental changes for pharyngeal airway (㎜)

		CVMI 2-1			CVMI 3-2			CVMI 4-3			CVMI 6-4		
		Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p value	Mean	S.D.	p-value
Ad1-PNS	M	1.94	1.53	0.0005***	0.50	0.38	0.0568	0.58	0.24	0.2913	0.04	0.03	0.4202
	F	2.08	0.71	0.1316	0.85	0.56	0.0082**	0.04	0.00	0.2913	1.19	1.04	0.0502
Ad2-PNS	M	3.44	1.86	0.0088**	0.61	1.07	0.3131	1.43	0.64	0.0068**	0.88	0.42	0.1723
	F	1.87	0.96	0.1105	1.32	0.31	0.1141	0.32	0.04	0.0068**	0.86	0.05	0.0599
Ad3-PNS	M	4.13	2.68	0.0024**	0.68	0.057	0.0704	0.03	0.01	0.1827	0.52	0.22	0.5695
	F	2.12	0.13	0.1825	0.32	0.18	0.0632	0.39	0.23	0.1827	1.71	0.34	0.0477*
Upper Pharynx	M	2.90	1.39	0.0049**	0.18	0.09	0.2079	0.07	0.05	0.1498	1.74	0.51	0.0722
	F	3.18	0.54	0.0053**	0.78	0.10	0.3634	0.35	0.23	0.1498	2.37	0.87	0.1179
Lower Pharynx	M	1.54	1.22	0.0035**	0.16	0.09	0.4436	0.23	0.13	0.1424	2.02	1.06	0.3182
	F	0.69	0.05	0.1307	0.54	0.08	0.1785	0.25	0.03	0.1424	0.11	0.02	0.0006***

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 11. Growth changes for areal measurements (㎟)

		CVMI 1		CVMI 2		CVMI 3		CVMI 4		CVMI 6	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Air area	M	461.70	102.88	537.26	55.17	580.48	65.46	626.83	65.95	629.65	52.90
	F	467.27	43.37	471.56	67.00	483.53	124.61	488.11	134.96	493.11	142.82
	p-value	0.8421		0.0248*		0.1531		0.0228*		0.2354	
NP area	M	161.90	52.84	228.60	48.91	243.34	49.70	267.86	58.60	296.08	73.90
	F	139.42	43.59	182.34	49.52	196.11	77.37	197.01	160.79	240.76	97.47
	p-value	0.2761		0.0446*		0.2710		0.2231		0.0244*	
OP area	M	416.68	65.90	503.24	85.15	533.51	90.04	576.52	88.44	686.96	172.49
	F	362.11	80.94	411.13	106.62	458.50	97.84	460.87	71.10	484.06	172.67
	p-value	0.1216		0.0428*		0.2221		0.0607		0.3683	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 12. Incremental changes for areal measurements (㎟)

		CVMI 2-1			CVMI 3-2			CVMI 4-3			CVMI 6-4		
		Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value
NP area	M	75.56	47.72	0.0022**	43.22	1.92	0.0812	46.35	10.47	0.0776	2.82	13.91	0.1703
	F	4.29	1.61	0.0627	11.98	5.33	0.1379	4.57	1.21	0.0776	7.00	5.78	0.0288*
Air area	M	66.70	27.20	0.0105*	14.74	3.69	0.4600	24.52	18.38	0.1592	28.22	10.53	0.0970
	F	42.92	24.27	0.0877	13.77	6.25	0.1623	0.90	0.44	0.1592	43.75	12.39	0.0631
OP area	M	86.56	55.96	0.0013**	30.27	12.75	0.4527	43.01	12.24	0.0183*	110.44	50.17	0.3353
	F	49.02	20.72	0.1006	47.37	17.61	0.1054	2.37	0.96	0.0183*	23.19	11.25	0.0277*

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 13. Growth changes for relative airway dimension

		CVMI 1		CVMI 2		CVMI 3		CVMI 4		CVMI 6	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Ad1-PNS Ba-PNS	M	0.49	0.07	0.51	0.06	0.52	0.05	0.52	0.06	0.52	0.08
	F	0.45	0.07	0.49	0.05	0.50	0.03	0.50	0.14	0.54	0.05
	p-value	0.2329		0.0683		0.6068		0.7839		0.3443	
Ad2-PNS Ho'-PNS	M	0.39	0.06	0.45	0.04	0.46	0.03	0.49	0.06	0.53	0.08
	F	0.38	0.09	0.41	0.06	0.45	0.05	0.46	0.13	0.47	0.10
	p-value	0.3867		0.0844		0.8337		0.3191		0.5542	
Ad3-PNS S-PNS	M	0.37	0.06	0.43	0.05	0.43	0.04	0.43	0.04	0.43	0.03
	F	0.38	0.05	0.40	0.05	0.40	0.02	0.41	0.04	0.43	0.06
	p-value	0.4112		0.0940		0.0457*		0.1297		0.9291	
Air area NP area	M	0.35	0.08	0.42	0.08	0.42	0.06	0.43	0.10	0.49	0.13
	F	0.29	0.08	0.38	0.09	0.40	0.09	0.40	0.22	0.48	0.18
	p-value	0.2180		0.2780		0.5992		0.6523		0.8926	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 14. Incremental changes for relative airway dimension

		CVMI 2-1			CVMI 3-2			CVMI 4-3			CVMI 6-4		
		Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value
Ad1-PNS	M	0.02	0.01	0.0321*	0.01	0.01	0.5000	0.00	0.00	0.5000	0.00	0.00	0.4365
Ba-PNS	F	0.04	0.02	0.1835	0.01	0.00	0.0034**	0.00	0.00	0.5000	0.04	0.03	0.2663
Ad2-PNS	M	0.06	0.03	0.0173*	0.01	0.01	0.5000	0.03	0.00	0.9296	0.04	0.00	0.0903
Ho'-PNS	F	0.03	0.01	0.1613	0.04	0.01	0.1181	0.01	0.00	0.9296	0.01	0.00	0.1561
Ad3-PNS	M	0.06	0.02	0.0129*	0.00	0.00	0.5000	0.00	0.00	0.1695	0.00	0.00	0.5000
S-PNS	F	0.02	0.00	0.2554	0.00	0.00	0.0351*	0.01	0.00	0.1695	0.02	0.01	0.0402*
Air area	M	0.07	0.04	0.0232*	0.00	0.00	0.5000	0.01	0.00	0.0335*	0.06	0.03	0.2338
NP area	F	0.09	0.05	0.1487	0.02	0.00	0.1181	0.00	0.00	0.0335*	0.08	0.01	0.1008

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 15. Growth changes for maxillary dimension (㎜)

Maxilla		CVMI 1		CVMI 2		CVMI 3		CVMI 4		CVMI 6	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Intercanine width	M	34.29	1.63	35.24	1.88	36.27	1.59	36.33	1.69	36.58	1.63
	F	31.10	2.63	33.69	1.88	34.24	2.30	34.51	0.99	35.43	1.77
	p-value	0.0063**		0.0754		0.1403		0.1050		0.2269	
Intermolar width	M	47.86	2.54	47.90	2.21	49.83	2.34	50.10	2.05	51.00	1.74
	F	44.46	2.80	46.24	1.66	46.30	1.98	47.19	1.18	48.07	1.32
	p-value	0.0092**		0.0647		0.0238*		0.0463*		0.0124*	
Palatal depth	M	16.60	1.41	17.49	1.40	17.88	1.10	19.87	1.74	20.10	1.80
	F	15.02	2.14	16.10	2.64	16.76	0.79	16.94	1.37	18.34	2.38
	p-value	0.1189		0.3689		0.0800		0.0210*		0.1675	
Basal arch width	M	45.41	2.50	46.56	2.31	47.87	3.55	48.20	0.53	48.30	0.54
	F	42.73	1.97	42.81	2.25	26.74	1.32	44.44	1.31	46.27	1.69
	p-value	0.0107*		0.0013**		0.0385*		0.0005***		0.0422*	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 16. Incremental changes for maxillary dimension (㎜)

Maxilla		CVMI 2-1			CVMI 3-2			CVMI 4-3			CVMI 6-4		
		Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value
Intercanine width	M	1.32	0.14	0.0040**	1.03	0.14	0.1560	0.06	0.04	0.1112	0.25	0.15	0.6560
	F	2.59	0.28	0.0045**	0.55	0.19	0.0982	0.27	0.12	0.1112	0.92	0.15	0.0185*
Intermolar width	M	0.90	0.00	0.0037**	1.93	0.63	0.1916	0.27	0.06	0.1112	0.90	0.57	0.9423
	F	1.78	0.40	0.0572	0.06	0.00	0.0725	0.89	0.21	0.1112	1.67	0.52	0.0535
Palatal depth	M	1.49	0.35	0.0099**	0.39	0.14	0.2952	1.99	0.21	0.2151	0.23	0.12	0.4735
	F	1.08	0.75	0.1329	0.66	0.50	0.2151	0.18	0.02	0.2151	1.49	0.02	0.0356*
Basal arch width	M	1.15	0.64	0.0027**	1.31	0.20	0.4332	0.33	0.15	0.2422	0.10	0.03	0.2422
	F	0.08	0.00	0.0881	0.97	0.13	0.0373*	0.66	0.28	0.2422	1.47	0.82	0.0668

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 17. Growth changes for mandibular dimension (㎜)

Mandible		CVMI 1		CVMI 2		CVMI 3		CVMI 4		CVMI 6	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Intercanine width	M	27.21	1.93	27.81	1.49	28.53	2.2	28.53	0.58	28.58	0.30
	F	26.27	1.97	26.57	2.36	26.74	1.76	27.01	1.50	27.47	1.67
	p-value	0.2876		0.1615		0.2145		0.1182		0.2237	
Intermolar width	M	42.24	2.02	42.76	1.80	44.18	2.29	44.73	2.93	46.56	0.51
	F	40.70	1.45	41.34	1.57	41.66	2.14	42.15	1.72	42.77	2.56
	p-value	0.0765		0.0697		0.0938		0.0678		0.0152*	
Basal arch width	M	39.96	1.92	41.12	2.09	41.42	1.42	41.90	1.40	42.30	1.96
	F	36.99	2.30	37.09	2.77	38.24	0.90	38.91	2.39	40.29	2.79
	p-value	0.0625		0.0012**		0.0019**		0.0642		0.2234	

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 18. Incremental changes for mandibular dimension (㎜)

Mandible		CVMI 2-1			CVMI 3-2			CVMI 4-3			CVMI 6-4		
		Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value	Mean	S.D.	p-value
Intercanine width	M	0.60	0.27	0.0037**	0.72	0.07	0.1257	0.00	0.00	0.2048	0.05	0.03	0.8743
	F	0.30	0.08	0.1771	0.17	0.06	0.0080***	0.27	0.12	0.2048	0.75	0.224	0.0446*
Intermolar width	M	0.52	0.32	0.0001***	1.42	0.35	0.1821	0.55	0.28	0.2422	1.83	0.20	0.6413
	F	0.64	0.17	0.0955	0.32	0.01	0.0052**	0.49	0.07	0.1421	1.11	0.19	0.1279
Basal arch width	M	1.16	0.25	0.0343*	0.30	0.29	0.1257	0.48	0.27	0.2442	0.4	0.05	0.1625
	F	0.10	0.01	0.2086	1.15	0.00	0.2233	0.67	0.26	0.2442	1.02	0.29	0.1789

(* : p<0.05, ** : p<0.01, *** : p<0.001)

Table 19. Correlation coefficients between relative airway and nasopharyngeal measurements

		CVMI1	*CVMI2*	*CVMI3*	*CVMI4*	*CVMI6*
male	S-PNS	0.1750	0.6667**	0.0857	0.9607**	0.7023
	Ho'-PNS	0.0329	0.4868	0.3714	0.9390	0.8525
	Ba-PNS	0.1293	0.3804	0.4286	0.8930	0.9863**
female	S-PNS	0.9550***	0.7561**	0.9406	0.1913	0.0667
	Ho'-PNS	0.8829***	0.6868**	0.8860**	0.1731	0.1333
	Ba-PNS	0.5946	0.5329	0.6796	0.4966	0.3667
male	NP ht.	0.2185	0.5877*	0.0857	0.0772	0.4822
	NP dp.	0.0711	0.0810	0.6330	0.7407	0.9942**
female	NP ht.	0.8289**	0.4221	0.9000**	0.7419***	0.0389
	NP dp.	0.7940**	0.2439	0.5769	0.7472***	0.8167***
male	Ad1-PNS	0.5633**	0.6530**	0.8285**	0.9080***	0.9942***
	Ad2-PNS	0.7804***	0.8904***	0.5876	0.9106***	0.9610**
	Ad3-PNS	0.8643***	0.5553*	0.3314	0.8776***	0.6227
	U. Pharynx	0.8723***	0.9544***	0.8437**	0.8768***	0.9628**
	L. Pharynx	0.0567	0.4801	0.6378	0.8710***	0.9508**
female	Ad1-PNS	0.8108**	0.8415***	0.6943	0.6515**	0.9833***
	Ad2-PNS	0.9636***	0.8349***	0.9684***	0.9203***	0.9500***
	Ad3-PNS	0.9009***	0.8537***	0.8888**	0.4829	0.9740***
	U. Pharynx	0.9190***	0.6789**	0.8571*	0.8702***	0.9500***
male	NP Area	0.3289	0.5480*	0.0857	0.5000	0.6528
	Air Area	0.9376***	0.8379**	0.7829*	0.9289***	0.7532
	OP Area	0.5089**	0.9133**	0.5429	0.3367	0.7752
female	NP Area	0.7208*	0.4207	0.9000**	0.7198**	0.3975
	Air Area	0.9550***	0.8537***	0.9318***	0.8611***	0.9833***
	OP Area	0.5045	0.2561	0.7058	0.5467*	0.7500**
male	Ad1-PNS/Ba-PNS	0.6679***	0.5977*	0.5768	0.9464*	0.9407*
	Ad2-PNS/Ho'-PNS	0.6923***	0.9541***	0.8857**	0.9995**	0.9316*
	Ad3-PNS/S-PNS	0.2648	0.2461	0.4928	0.9599***	0.9132*
female	Ad1-PNS/Ba-PNS	0.8108**	0.7798***	0.4357	0.7300**	0.9161***
	Ad2-PNS/Ho'-PNS	0.9455***	0.8742***	0.4871	0.7300**	0.8946***
	Ad3-PNS/S-PNS	0.8636**	0.7454**	0.7498	0.9840**	0.9496***
male	MxC	0.0057	0.4077	0.5798	0.7366***	0.7914
	MxM	0.0226	0.4007	0.2319	0.9381***	0.9262*
	Mxp	0.0991	0.1683	0.8286**	0.5497	0.9859**
	Mxbaw	0.1659	0.2471	0.5429	0.6053	0.3162
female	MxC	0.1261	0.3395	0.8879**	0.5461*	0.0984*
	MxM	0.0364	0.0398	0.9487**	0.0273	0.7167**
	Mxp	0.0364	0.6159*	0.4039	0.2506	0.5811
	Mxbaw	0.7748**	0.3415	0.2000	0.1667	0.5942*
male	MnC	0.0449	0.1639	0.7714*	0.9503	0.9829**
	MnM	0.0405	0.0490	0.2171	0.6200	0.4750
	Mnbaw	0.0386	0.3455	0.3479	0.5000	0.5795
female	MnC	0.1752	0.4648	0.9000**	0.1913	0.1757
	MnM	0.0364	0.1866	0.8182*	0.2694	0.2427
	Mnbaw	0.0852	0.2561	0.7250	0.2877	0.7950**

(* : $p<0.05$, ** : $p<0.01$, *** : $p<0.001$)

11). During CVMI 1 to CVMI 2, there was the largest growth in nasopharyngeal area in male(Table 12). Total increment of Air area was greater than that of NP area.

Growth changes of relative airway dimension. There was no statistically significant difference in relative ratios of airway from both male and female. All ratios increased from CVMI 1 to CVMI 3, and no more increase was observed after CVMI 3(Table 13). During CVMI 1 to CVMI 2 period, the increments were statistically significant(Table 14).

Growth changes for maxillary and mandibular dimension. Male's intercanine widths were larger than female's in all ages(Table 15). Maxillary intercanine width increased in a large amount from CVMI 1 to CVMI 2 period in both male and female(Table 16). Maxillary intercanine width increment was greater than mandibular intercanine width increment. Between male and female, there was a statistically significant difference in maxillary intercanine width at CVMI 1 stage and in palatal depth at CVMI 4 stage. Male had a large maxillary intermolar width than female in all age, except CVMI 2 stage. There was no increase in maxillary dimension after CVMI 2 stage in both arch.

Correlation with Adenoid percentage of nasopharynx(Air area/NP area) and other variables. There was intimate relationship between S-PNS and Ad2-PNS/Ho'-PNS with adenoid percentage in male. In female, Ho'-PNS and NP height had a close correlation with adenoid percentage. Linear measurements, especially upper pharynx, were closely related to adenoid percentage in both gender. In areal measurements, Air area was highly related to adenoid percentage. In maxillo-mandibular variables, all maxillary variables had closer relationship with adenoid percentage than in mandibular variables.

DISCUSSION

The pharynx can be divided into two parts : the nasopharynx and the oropharynx[9)1,9)]. The bony nasopharynx is cone-like shape, and during the growth process this structure increases its volume by about 80%[9)]. Transverse pharyngeal growth usually end of the second year of life[21)], and horizontally nasopharynx increase only 9%[19)-22)]. Handelman[23)] and King[24)] reported that NP depth showed early stabilization and NP height increased until late adolescent. Mature nasopharyngeal size was similar with male and female, but female had achieved about 4 years earlier than male. The nasopharynx grows vertically by downward growth of palate and spheno-occipital synchondrosis[9),23),24)]. The sagittal dimension of bony oropharynx is constant until puberty[24)-26)]. Oropharynx also grew vertically. The cervical vertebrae increase in height until adulthood and show two period of accelerated growth at preschool age and at around puberty[20)27)28)].Tongue and hyoid growth will compensate for this increase in bulk of vertebrae to maintain function during growth[29)].

There are characteristic lymphoid masses(*Waldeyer's ring*) placed at pharyngeal area. According to Scammon[30)], they usually increase rapidly in infancy and early childhood, and then gradually decline to adult size. But there were many controversy with general rule about the involution of Waldeyer's ring [31)-33)]. They suggested that there were no true growth curve for the pharyngeal lymphoid tissues but an individualized response to variable stresses.

It is commonly assumed that nasorespiratory function can exerts a dramatic effect upon the development of the dentofacial complex, such as *adenoid faces* or *long face syndrome*[1),3),16),34),35)]. Airway obstruction may have many causes and enlarged adenoid is the most common one. In this cases the absolute size of the adenoid would not be as important than the relative space the mass occupies within its nasopharyngeal dimensions[36),37)]. The sagittal depth of the nasopharynx can be evaluated on lateral skull radiographs, but only reflect the 2-dimension of the structure[38)]. Many previous studies reported that they can give us satisfactory informations in children[39)-42)]. Bergland[9)] used 3-anatomical points-pterygomaxillary line, basion and hormion- for illustrating the bony pharynx. But there was a difference in real adenoid position and the triangle, in general adenoid placed more anteriorly than the triangle. So, Handelman and Osborne[23)] modified the method by using 4 reference

lines ; pterygomaxillary line, palatal line, sphenoid line and anterior atlas plane.

The bony pharynx. S-PNS and NP height have sexual difference among other variables representing the growth of the bony pharynx. Male has a greater values than female meaning that male growth is more vertical than female(Table 5,7). There was a statistically significant growth increase during CVMI 1 to 2 period and after CVMI 2 stage the growth seems to be stable. In male, there was a signigicant increase at NP height and in female, at NP depth. It means that vertical growth tendency of the palate in male, and forward-downward growth tendency of the palate in female seem to be a major factor of nasopharynx growth. Although there was a more increment on NP depth than NP height, NP height has a high correlation with adenoid percentage than NP depth. During growth, physiologic adaptation of nasopharyngeal structure for maintain the patency seems to be done in vertical direction.

The adenoids tissue. All variables representing adenoid tissue have its maximum growth at CVMI 1 to 2 period. But there were large variations in growth increment among individuals which support the previous studies done by Pruzansky[32] and Hollender[33]. Upper pharynx dimension and Air area have statistically signigicant relationships with adenoid percentage in both gender among other variables. In male, Ad2-related variables have close correlation with adenoid percentage and in female, all the variables seem to have similar effect. Adenoid of male grew in Ad2 direction predominately, while in female the growth was become similarly in all direction. According to areal measurements, the total increment in Air area was larger than total NP area increment. So the airway patency could be increased naturally by aging, and it would be helpful to reduce the possibility of mouth breathing. High correlation with adenoid-related variables than bony pharynx-related variables implies that relative airway dimension is affected more by the size of adenoid tissue than by the size of bony pharynx. Relative airway dimensions have increased the most at CVMI 1 to 2 period until CVMI 3 and then become stable. We can suppose that at early childhood there are downward-forward displacement of maxilla and nasopharyngeal growth so if there were decreased airway patency in childhood, it may be reduced after CVMI 3 period.

The maxillo-mandibular dimension. All maxillary variables grows until CVMI 2, and mandibular variables grows until CVMI 3. In male, maxillary basal arch width was significantly larger than in female all over ages. Maxilla and mandible grow a large amount between CVMI 1 and CVMI 2 period. This period coincide with the adenoidal growth period. If there is enlarged adenoid at infant or early childhood, the influence to the growth of the jaws may be great than any other period. Maxillary basal arch width was the closest variables relating with adenoid percentage in early age and after CVMI 3 maxillary intercanine width, maxillary intermolar width and mandibular intercanine have some correlation with adenoid percentage($p<0.01$).

To make a precise diagnosis, we must fully used the data taken from the patients. To check the airway problem, not only lateral cephalogram but also other several methods should be used; clinical evaluation(lip incompetency in rest position, mouthgaping, nares), mode of breathing (nasal vs oral respired tidal volume, duration), swallowing pattern, facial type. This study sets a standard for pharyngeal and maxillo-mandibular size of normal occlusion children based on bone age. And for the better standard values, there must be an evaluation of head and neck position, and different diagnosis between adenoid and pharyngeal musculatures[42)-47)].

CONCLUSIONS

1. At same bone age, female's chronologic age was about 2 year older than male.
2. There was a growth peak of NP height and depth between CVMI 1 to 2 in male, but in female NP height and depth gradually increase through CVMI 1 to 6.
3. Relative airway of nasopharynx increases the most between CVMI 1 to 2 period in male.
4. Among adenoid measurements Ad2-related variab-

les and upper pharynx, and among dentofacial measurements intercanine width in both arch, maxillary intermolar width and palatal depth had high correlation coefficient with adenoid percentage.

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국문초록

6세에서 17세 사이의 정상 교합 아동의 아데노이드와 악골의 성장에 관한 준종단적 연구

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림프조직은 비인두 부위에서 Waldeyer's ring의 일부조직으로 tonsil을 이루며 정상적으로 존재한다. 이러한 림프조직이 임상적인 증상을 나타낼 정도로 과증식한 것을 '*Adenoid vegetation* or *Adenoids*'라고 이른다. 아데노이드는 일반적으로 유년기에 발생하며 2~12세때 특징적인 증상을 보인다. 사춘기시기에 이르면 절대적인 아데노이드 크기 감소와 주변의 비인두의 성장으로 인한 상대적 크기 감소가 나타난다. 그리하여 성인이 되면 아데노이드는 퇴화된 상태로 변하게 된다. 아데노이드는 구호흡의 주요한 원인 중 하나이며, '아데노이드 얼굴'이라는 특징적인 안면형태를 야기한다고 알려져 있다. 아데노이드에 의한 구호흡이 안면 형태와 치열에 영향을 미칠 수 있다는 주장은 오래 전부터 제기되고 있으나, 여러 가지 복합적인 원인으로 이들간의 상호연관정도를 정확히 알기가 어려웠다. 이에 본 연구에서는 정상 교합 아동에서의 골 연령에 따라 아데노이드와 악골 크기의 정상치와 성장변화량을 제시하고 이들간의 상관관계를 알아보았으며 다음과 같은 결과를 얻었다.

1. 골 연령에 따른 남녀별 계측항목의 평균과 표준편차를 얻었다.
2. 같은 골연령을 비교시 남자는 여자보다 약 2년 가량 성장속도가 느렸다.
3. 비인두의 height과 depth는 남자에서는 CVMI 1과 2 때 많은 성장을 보이고, CVMI 4 이후에서는 성장을 보이지 않았으며, 여자에서는 모든 골 연령에서 유사한 정도의 성장이 나타났다.
4. 비인두의 상대적 면적은 남자에서 CVMI 1에서 2로 이행되는 시기에 유의한 증가를 보였다.r
5. 비기도의 상대적 면적과의 상관분석에서 남녀 모두에서 아데노이드 항목중에서는 Ad2와 관련된 항목과 uppe pharynx가 높은 상관관계를 보였으며, 치열궁과 관련된 항목중에는 상 · 하악의 견치간 너비, 상악의 대구치간 너비, 구개정 높이가 상관관계가 있었다.

주요 단어 : 비인두, 아데노이드, 악골성장, 골연령