A STATISTICAL STUDY ON THE CORRELATION BETWEEN THE NASOPHARYNGEAL SPACE AND THE DENTOFACIAL STRUCTURES

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INTRODUCTION

Since cephalometric analysis was introduced by Broadbent[1] into the field of orthodontics, research on the diagnosis of malocclusions and their growth and development has been actively performed Especially, the clarification of the morphological and spatial relationship between certain craniofacial structures has been done, and with the cephalometric method, attempts to predict the growth of the human facial skeleton have been made

The endeavor of finding the relationship of some structural deformity or functional insufficiency to a certain malocclusion is continued By virtue of the endeavor to clarify the etiology of a certain malocclusion, orthodontists can treat the patients more effectively than ever before

The space problem of nasopharyngeal space, which is one of the etiological factors of malocclusions, has been actively investigated by some research workers[3-23,28] They argued that the narrowed and/or obstructed nasopharyngeal space is one of the etiological factors of malocclusion They proposed that narrowed and/or obstructed nasopharyngeal space induces the change of oral muscle tonicity, and as a second effect, the morphological changes of facial skeleton occur[3-6, 8-10]

Some research workers did not agree to a certain pattern of malocclusion induced by nasopharyngeal space problem, and it was proved that the type of malocclusion induced by nasopharyngeal problem varies[9,10,17]

To this suggestion of nasopharyngeal space problems as etiological factors of malocclusion, some research workers disagreed because the correlation coefficients between malocclusions and mouth breathing are too low to be considered as an etiological factor[28]

By surveying the interrelationship between the dimension of the nasopharyngeal space and the facial structures with the statistical method, and by comparing the results with other reports, it could be possible to decide whether or not it is acceptable that the narrowed or occluded nasopharyngeal space be blamed as one of the etiological factors of a certain malocclusion

MATERIAL AND METHODS

156 Cephalometric roentgenograms were taken from healthy Korean adults (91 males and 65 females) who had a complete set of permanent teeth between the second molars on the upper and lower arches

Cephalometric analysis programs were developed for the NEC PC-9801 VM2 personal computer (640KB RAM) for analyzing various cephalometric parameters

Each cephalogram was traced on acetate films for digitizing, and 25 reference points were digitized by the Oscon GT-4000 digitizer All of the reference points are listed in Fig 1 and have been identified according to well-known accepted definitions and criteria For the points located apart from the midline, averages between the two points were used Reference lines are also listed in Fig 1

146 angular measurements (Fig 1), 66 linear measurements (Fig s 2-1 to 4-3), and 4 nasopharyngeal measurements (Fig 5) were calculated by cephalometric analysis programs Angular measurements are made by crossing of two reference lines and those are listed in Fig 1 In the measuring procedure of linear measurements, new reference planes such as S-vertical and S-horizontal were adopted Definitions of those new planes are as follows

1 S-vertical / FH (SV/FH) plane which is vertical to FH and passes point S
2 S-vertical / S-N (SV/S-N) plane which is vertical to S-N and passes point S
3 S-vertical / ANS-PNS (SV/ANS-PNS) plane which is vertical to ANS-PNS and passes point S
4 S-horizontal / FH (SH/FH) plane which is parallel to FH and passes point S
5 S-horizontal / ANS-PNS(SH/ANS-PNS) plane which is parallel to ANS-PNS and passes point S

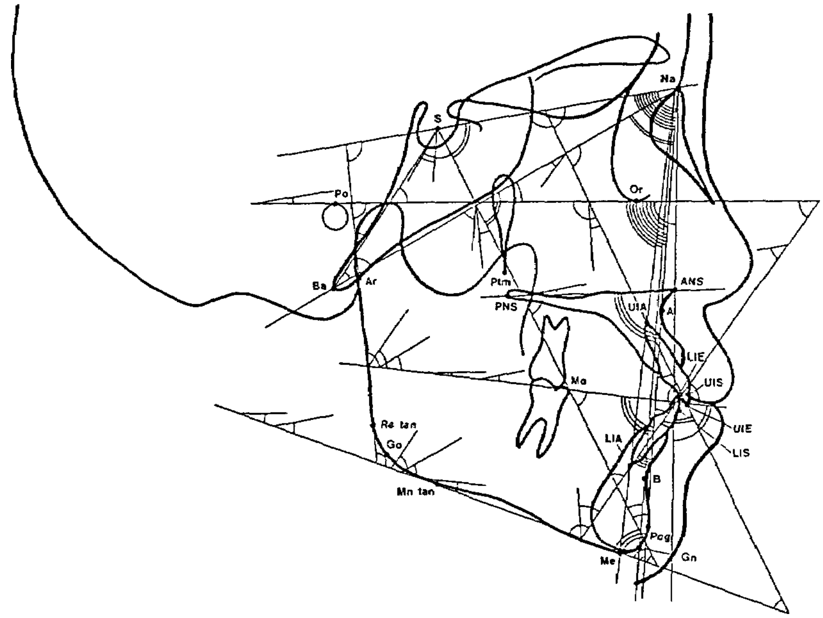


Fig. 1. Cephalometric landmarks, planes, and angles See opposite side for the items of angular measurements

Items for angular measurements

1.	N-ANS	to FH
2.	N-A	to FH
3.	N-B	to FH
4.	N-Pog	to FH
5.	N-Gn	to FH
6.	N-Me	to FH
7.	S-N	to FH
8.	N-Ba	to FH
9.	S-Ba	to FH
10.	Y-axis	to FH
11.	ANS-PNS	to FH
12.	Occl. pl.	to FH
13.	Mand. pl.	to FH
14.	Ramus pl.	to FH
15.	U-1	to FH
16.	L-1	to FH
17.	A-Pog	to FH
18.	A-B	to FH
19.	N-ANS	to SN
20.	N-A	to SN
21.	N-B	to SN
22.	N-Pog	to SN
23.	N-Gn	to SN
24.	N-Me	to SN
25.	N-Ba	to SN
26.	S-Ba	to SN
27.	Y-axis	to SN
28.	ANS-PNS	to SN
29.	Occl. pl.	to SN
30.	Mand. pl.	to SN
31.	Ramus pl.	to SN
32.	U-1	to SN
33.	L-1	to SN
34.	A-Pog	to SN
35.	A-B	to SN
36.	N-ANS	to N-A
37.	ANB	
38.	N-Pog	to N-A
39.	N-Gn	to N-A
40.	N-Me	to N-A
41.	N-Ba	to N-A
42.	S-Ba	to N-A
43.	Y-axis	to N-A
44.	ANS-PNS	to N-A
45.	Occl. pl.	to N-A
46.	Mand. pl.	to N-A
47.	Ramus pl.	to N-A
48.	U-1	to N-A
49.	L-1	to N-A
50.	A-Pog	to N-A
51.	A-B	to N-A
52.	N-ANS	to N-B
53.	N-Pog	to N-B
54.	N-Gn	to N-B
55.	N-Me	to N-B
56.	N-Ba	to N-B
57.	S-Ba	to N-B
58.	Y-axis	to N-B
59.	ANS-PNS	to N-B
60.	Occl. pl.	to N-B
61.	Mand. pl.	to N-B
62.	Ramus pl.	to N-B
63.	U-1	to N-B
64.	L-1	to N-B
65.	A-Pog	to N-B
66.	A-B	to N-B
67.	N-ANS	to N-Pog
68.	N-Gn	to N-Pog
69.	N-Me	to N-Pog
70.	N-Ba	to N-Pog
71.	S-Ba	to N-Pog
72.	Y-axis	to N-Pog
73.	ANS-PNS	to N-Pog
74.	Occl. pl.	to N-Pog
75.	Mand. pl.	to N-Pog
76.	Ramus pl.	to N-Pog
77.	U-1	to N-Pog
78.	L-1	to N-Pog
79.	A-Pog	to N-Pog
80.	A-B	to N-Pog
81.	N-Ba	to N-ANS
82.	S-Ba	to N-ANS
83.	Y-axis	to N-ANS
84.	ANS-PNS	to N-ANS
85.	Occl. pl.	to N-ANS
86.	Mand. pl.	to N-ANS
87.	Ramus pl.	to N-ANS
88.	U-1	to N-ANS
89.	L-1	to N-ANS
90.	A-Pog	to N-ANS
91.	A-B	to N-ANS
92.	N-Ba	to A-B
93.	S-Ba	to A-B
94.	Y-axis	to A-B
95.	ANS-PNS	to A-B
96.	Occl. pl.	to A-B
97.	Mand. pl.	to A-B
98.	Pamus pl.	to A-B
99.	U-1	to A-B
100.	L-1	to A-B
101.	A-Pog	to A-B
102.	N-Ba	to ANS-PNS
103.	S-Ba	to ANS-PNS
104.	Y-axis	to ANS-PNS
105.	Occl. pl.	to ANS-PNS
106.	Mand. pl.	to ANS-PNS
107.	Ramus pl.	to ANS-PNS
108.	U-1	to ANS-PNS
109.	L-1	to ANS-PNS
110.	A-Pog	to ANS-PNS
111.	N-Ba	to Occl. pl
112.	S-Ba	to Occl. pl
113.	Y-axis	to Occl. pl
114.	Mand. pl.	to Occl. pl
115.	Ramus pl.	to Occl. pl
116.	U-1	to Occl. pl
117.	L-1	to Occl. pl
118.	A-Pog	to Occl. pl
119.	N-Ba	to Mand. pl
120.	S-Ba	to Mand. pl
121.	Y-axis	to Mand. pl
122.	Ramus pl.	to Mand. pl
123.	U-1	to Mand. pl
124.	L-1	to Mand. pl
125.	A-Pog	to Mand. pl
126.	N-Ba	to Ramus pl
127.	S-Ba	to Ramus pl
128.	Y-axis	to Ramus pl
129.	U-1	to Ramus pl
130.	L-1	to Ramus pl
131.	A-Pog	to Ramus pl
132.	N-Ba	to S-Ba
133.	Y-axis	to S-Ba
134.	U-1	to S-Ba
135.	L-1	to S-Ba
136.	A-Pog	to S-Ba
137.	Y-axis	to N-Ba
138.	U-1	to N-Ba
139.	L-1	to N-Ba
140.	A-Pog	to N-Ba
141.	U-1	to Y-axis
142.	L-1	to Y-axis
143.	A-Pog	to Y-axis
144.	Interincisal angle	
145.	A-Pog	to U-1
146.	A-Pog	to L-1

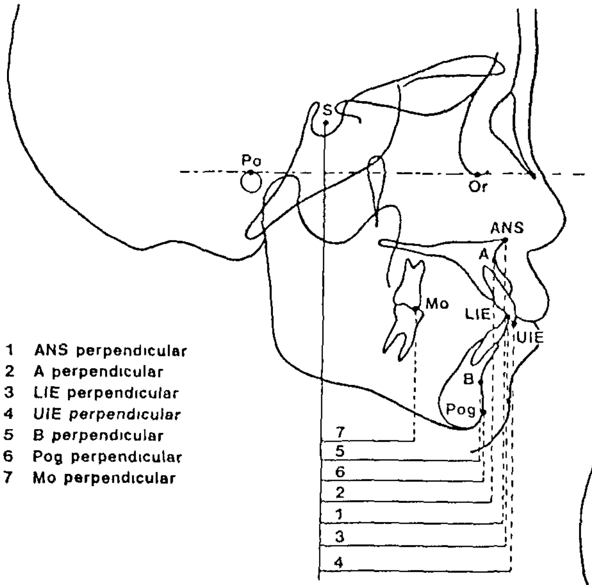


Fig. 2-1. Measurements from S-vertical/FH

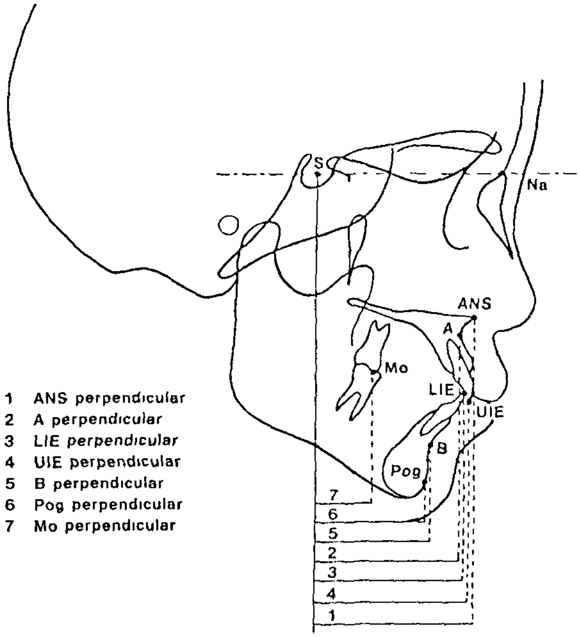


Fig. 2-2. Measurements from S-vertical/S-N

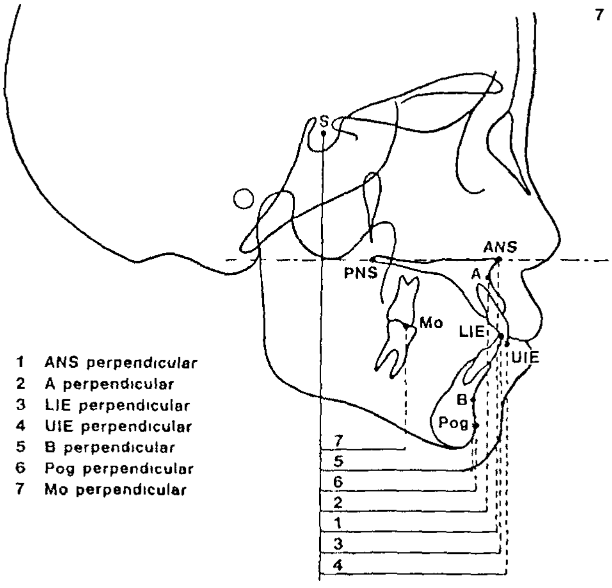
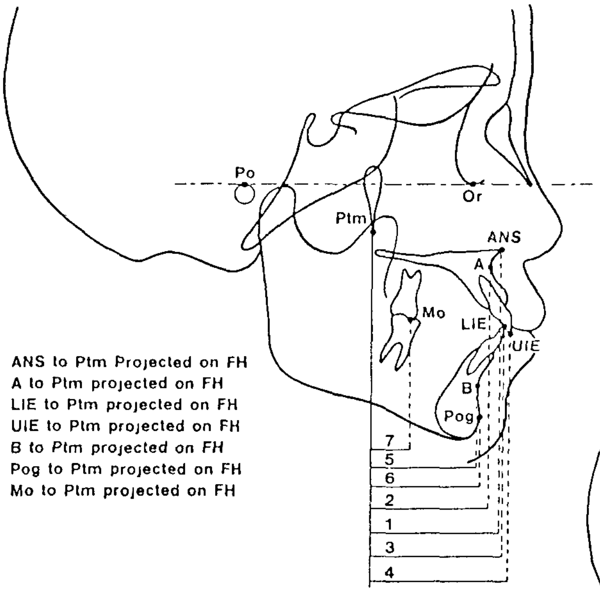
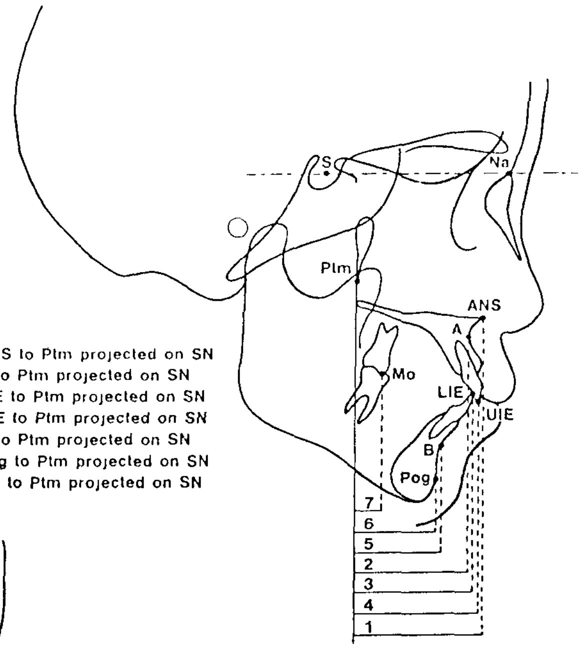


Fig. 2-3. Measurements from S-vertical/ANS-PNS



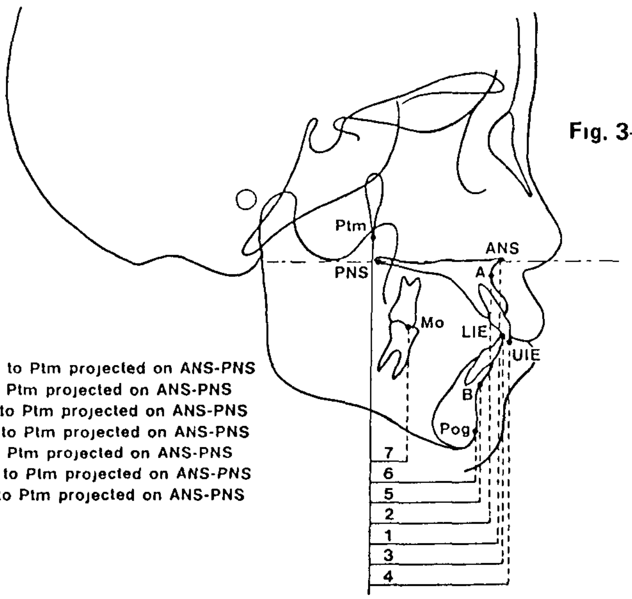
1 ANS to Ptm Projected on FH
2 A to Ptm projected on FH
3 LIE to Ptm projected on FH
4 UIE to Ptm projected on FH
5 B to Ptm projected on FH
6 Pog to Ptm projected on FH
7 Mo to Ptm projected on FH

Fig 3-1 Measurements from Ptm projected on FH



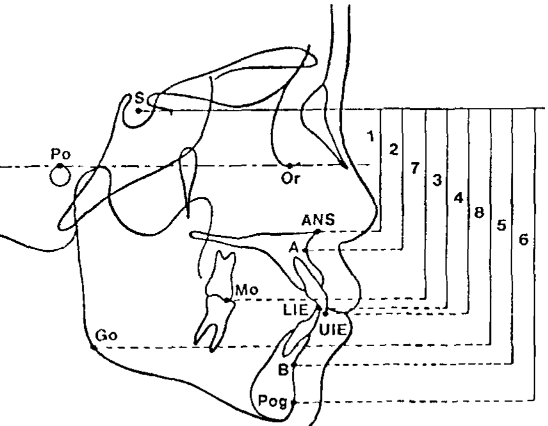
1 ANS to Ptm projected on SN
2 A to Ptm projected on SN
3 LIE to Ptm projected on SN
4 UIE to Ptm projected on SN
5 B to Ptm projected on SN
6 Pog to Ptm projected on SN
7 Mo to Ptm projected on SN

Fig. 3-2. Measurements for Ptm projected on S-N



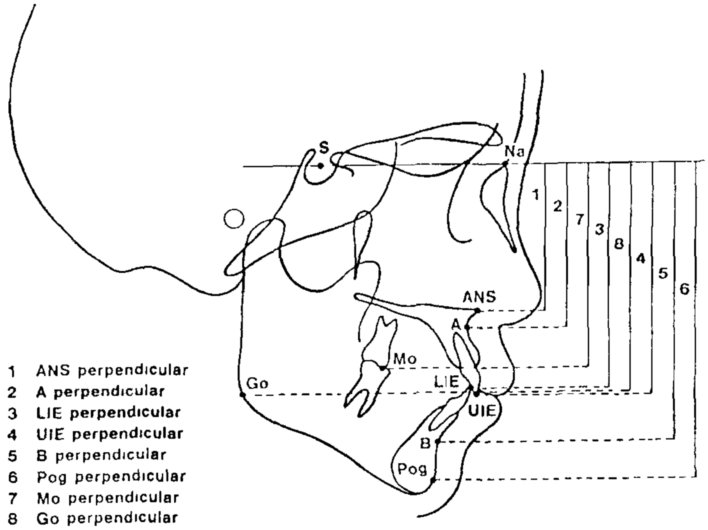
1 ANS to Ptm projected on ANS-PNS
2 A to Ptm projected on ANS-PNS
3 LIE to Ptm projected on ANS-PNS
4 UIE to Ptm projected on ANS-PNS
5 B to Ptm projected on ANS-PNS
6 Pog to Ptm projected on ANS-PNS
7 Mo to Ptm projected on ANS-PNS

Fig 3-3. Measurements from Ptm projected on ANS-PNS



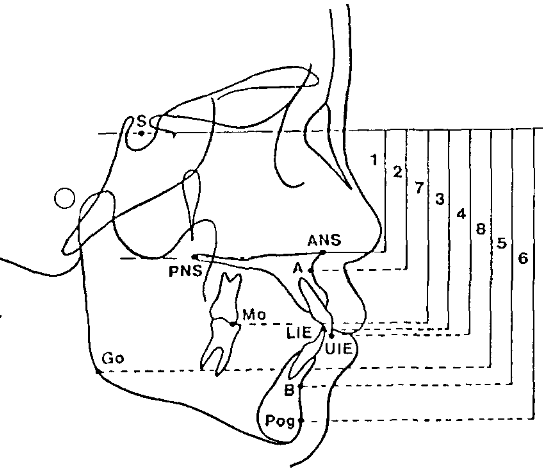
1 ANS perpendicular
2 A perpendicular
3 LIE perpendicular
4 UIE perpendicular
5 B perpendicular
6 Pog perpendicular
7 Mo perpendicular
8 Go perpendicular

Fig. 4-1. Measurements from S-horizontal/FH



1 ANS perpendicular
2 A perpendicular
3 LIE perpendicular
4 UIE perpendicular
5 B perpendicular
6 Pog perpendicular
7 Mo perpendicular
8 Go perpendicular

Fig. 4-2. Measurements from S-N



1 ANS perpendicular
2 A perpendicular
3 LIE perpendicular
4 UIE perpendicular
5 B perpendicular
6 Pog perpendicular
7 Mo perpendicular
8 Go perpendicular

Fig. 4-3. Measurements from S-horizontal/ANS-PNS

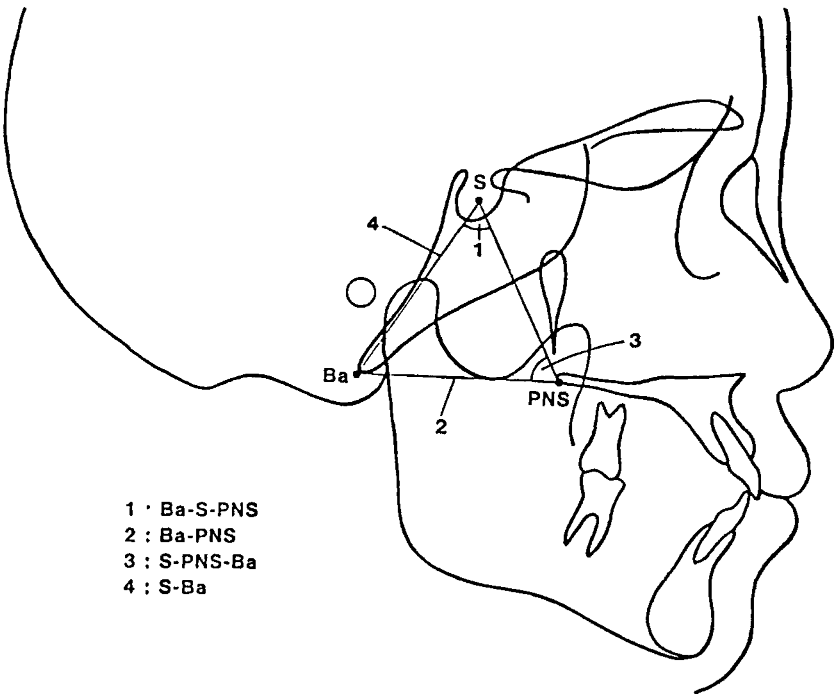


Fig. 5. Measurements for nasopharyngeal space

Table 1. Results of Student's t-test about nasopharyngeal measurements
(* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$)

	MALE MEAN	S.D.	FEMALE MEAN	S.D.	t
Ba-S-PNS	56.64	4.67	61.27	4.64	6.08 ***
S-PNS-Ba	64.78	4.56	62.55	4.47	3.01 *
Ba-PNS	50.37	3.72	49.76	3.38	
S-Ba	51.65	3.43	47.24	2.49	8.79 ***

Table 2. Correlation coefficients between nasopharyngeal measurements
(* $p < 0.05$ ** $p < 0.01$)

	MALE				FEMALE			
	Ba-S-PNS	S-PNS-Ba	Ba-PNS	S-Ba	Ba-S-PNS	S-PNS-Ba	Ba-PNS	S-Ba
Ba-S-PNS	1				1			
S-PNS-Ba	-0.71 **	1			-0.68 **	1		
Ba-PNS	0.71 **	-0.55 **	1		0.81 **	-0.53 **	1	
S-Ba	-0.25 *	-0.24 *	0.39 **	1		-0.39 **	0.29 *	1

Table 3. Results of Student's t-test about the angular measurements
(* $p < 0\ 05$ ** $p < 0.01$)

			MALE MEAN	S.D.	FEMALE MEAN	S D.	t
1.	N-ANS	to FH	92.81	3.59	94.10	2.46	2.48 *
2.	N-A	to FH	89.32	3.46	90.65	2.53	2.77 *
3.	N-B	to FH	87.62	3.29	88.02	2.57	
4.	N-Pog	to FH	88.52	3.31	88.51	2.64	
5.	N-Gn	to FH	87.02	3.26	87.00	2.62	
6.	N-Me	to FH	84.42	3.25	84.42	2.62	
7.	S-N	to FH	7.45	2.70	8.58	2.88	2.81 *
8.	N-Ba	to FH	27.85	1.95	27.17	2.34	
9.	S-Ba	to FH	56.99	3.74	55.21	4.06	
10.	Y-axis	to FH	62.82	3.33	61.59	3.22	
11.	ANS-PNS	to FH	2.13	3.15	1.33	3.78	
12.	Occl. pl.	to FH	5.47	3.86	5.98	4.08	
13.	Mand. pl.	to FH	23.86	5.41	25.03	5.15	
14.	Ramus pl.	to FH	87.54	5.19	86.45	3.81	
15.	U-1	to FH	116.25	7.06	116.26	5.71	
16.	L-1	to FH	60.16	6.91	57.53	5 48	
17.	A-Pog	to FH	87.57	5.22	86.20	4.55	
18.	A-B	to FH	95.03	5.60	95.91	4.66	
19.	N-ANS	to S-N	94.69	4.45	94.53	3.05	
20.	N-A	to S-N	81.91	4.37	82.12	2 87	
21.	N-B	to S-N	80.21	3.96	79.48	2.48	
22.	N-Pog	to S-N	81.11	3.98	79.98	2.56	
23.	N-Gn	to S-N	79.61	3.91	78.49	2.49	
24.	N-Me	to S-N	77.01	3.84	75.88	2.51	
25.	N-Ba	to S-N	20.44	2.56	18.64	2.24	4.53 **
26.	S-Ba	to S-N	130.58	5.37	133.42	5.11	3.30 **
27.	Y-axis	to S-N	70.23	3.68	70.12	2.73	
28.	ANS-PNS	to S-N	9.54	3.24	9.87	3.26	
29.	Occl. pl.	to S-N	12.87	4.16	14.51	3.54	
30.	Mand. pl.	to S-N	31.26	5.43	33.56	4.65	2.74 *
31.	Ramus pl.	to S-N	94.95	5.45	94.99	3.82	
32.	U-1	to S-N	108.85	7.64	107.73	5.23	
33.	L-1	to S-N	52.75	7.10	49.17	5.32	3.59 **
34.	A-Pog	to S-N	80.16	5.39	77.66	4.19	3.11 *
35.	A-B	to S-N	102.44	5.69	104.35	4.17	2.53 *
36.	N-ANS	to N-A	3.54	1.49	3.49	1.33	
37.	ANB		1.74	2.47	2.67	1.95	
38.	N-Pog	to N-A	0.75	2.70	2.09	2.32	3.22 *
39.	N-Gn	to N-A	2.25	2.74	3.59	2.34	3.16 *
40.	N-Me	to N-A	4.85	2.87	6.19	2.43	3.04 *
41.	N-Ba	to N-A	61.52	3.52	63.52	2.43	4.18 **
42.	S-Ba	to N-A	32.48	4.67	35.48	4.14	4.22 **
43.	Y-axis	to N-A	28.00	3.28	27.90	3.24	
44.	ANS-PNS	to N-A	88.69	4 24	88.15	3.67	
45.	Occl. pl.	to N-A	85.35	4.01	83.50	4.34	2.73 *
46.	Mand. pl.	to N-A	66.96	5.08	64.46	5.61	2.89 *
47.	Ramus pl.	to N-A	3.28	5.13	3.03	4.29	
48.	U-1	to N-A	26.98	7.08	25.66	5.88	
49.	L-1	to N-A	29.20	7.04	33 06	5.89	3.59 **
50.	A-Pog	to N-A	1.70	5.69	4.41	4.90	3.08 **
51.	A-B	to N-A	4.20	6.09	6.43	4.82	
52.	N-ANS	to N-B	5.24	2.74	6.12	2.23	
53.	N-Pog	to N-B	0.95	0.62	0.54	0.97	2.93 *
54.	N-Gn	to N-B	0.65	0.73	1.04	0.99	2.74 *
55.	N-Me	to N-B	3.24	0.99	3.65	1.16	
56.	N-Ba	to N-B	59.82	3.33	60.89	2.08	
57.	S-Ba	to N-B	30.80	4.84	32.86	4.21	2.75 *
58.	Y-axis	to N-B	29.70	1.97	30.52	2.19	
59.	ANS-PNS	to N-B	89.70	3.77	89.31	2.73	
60.	Occl. pl.	to N-B	87.05	2.99	56.13	3.38	
61.	Mand. pl.	to N-B	68.66	4.13	67.09	4.66	
62.	Ramus pl.	to N-B	4.98	4.60	5.66	3.87	
63.	U-1	to N-B	28.68	6.20	28.29	4.87	
64.	L-1	to N-B	27.50	5.60	30.33	5.04	3.02 *
65.	A-Pog	to N-B	0.09	3.33	1.87	3.22	3.31 **
66.	A-B	to N-B	2.51	3.64	3.80	2.88	
67.	N-ANS	to N-Pog	4.34	2.90	5.60	2.47	2.90 *
68.	N-Gn	to N-Pog	1.54	0.28	1.54	0.27	
69.	N-Me	to N-Pog	4.14	0.65	4.14	0 67	
70.	N-Ba	to N-Pog	60.72	3.45	61.39	2 23	
71.	S-Ba	to N-Pog	31.71	4.89	33.35	4.34	
72.	Y-axis	to N-Pog	28.79	1.71	30.03	1.78	4.36 **
73.	ANS-PNS	to N-Pog	89.49	3.75	90.28	2.75	
74.	Occl. pl.	to N-Pog	86.15	2.83	85.64	3.03	
75.	Mand. pl.	to N-Pog	67.75	3.98	66.59	4.23	

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Table 3. (Continue)

76.	Ramus pl.	to N-Pog	4.08	4.50	5.16	3.77	
77.	U-1	to N-Pog	27.78	6.25	27.79	4.96	
78.	L-1	to N-Pog	28.41	5.37	30.83	4.46	2.98 *
79.	A-Pog	to N-Pog	-0.91	3.01	-2.28	2.59	2.96 *
80.	A-B	to N-Pog	-3.41	3.55	-4.30	2.89	
81.	N-Ba	to N-ANS	65.01	3.69	66.97	2.37	4.03 **
82.	S-Ba	to N-ANS	35.99	4.92	38.93	4.03	3.96 **
83.	Y-axis	to N-ANS	24.50	3.42	24.45	3.32	
84.	ANS-PNS	to N-ANS	85.20	4.10	84.70	3.74	
85.	Occl. pl.	to N-ANS	81.86	4.05	80.05	4.43	2.64 *
86.	Mand. pl.	to N-ANS	63.47	5.21	61.01	5.54	2.83 *
87.	Ramus pl.	to N-ANS	-0.22	5.28	-0.42	4.37	
88.	U-1	to N-ANS	23.49	7.28	22.21	5.94	
89.	L-1	to N-ANS	32.70	6.98	36.50	5.87	3.58 **
90.	A-Pog	to N-ANS	2.46	1.44	1.97	0.65	2.86 *
91.	A-B	to N-ANS	7.70	6.14	9.88	4.86	
92.	N-Ba	to A-B	57.26	5.61	57.05	4.05	
93.	S-Ba	to A-B	28.27	6.85	29.01	5.72	
94.	Y-axis	to A-B	32.25	3.99	34.37	3.24	3.52 **
95.	ANS-PNS	to A-B	87.14	5.52	85.47	3.47	
96.	Occl. pl.	to A-B	89.61	4.55	89.98	3.84	
97.	Mand. pl.	to A-B	71.22	5.21	70.93	4.70	
98.	Ramus pl.	to A-B	7.53	5.93	9.50	4.94	
99.	U-1	to A-B	31.23	6.58	32.13	4.68	
100.	L-1	to A-B	24.95	5.23	17.96	38.43	
101.	A-Pog	to A-B	2.55	1.44	2.06	2.03	
102.	N-Ba	to ANS-PNS	29.93	3.35	28.46	3.54	2.62 *
103.	S-Ba	to ANS-PNS	59.00	5.33	56.50	5.44	2.86 *
104.	Y-axis	to ANS-PNS	60.74	3.56	60.30	2.56	
105.	Occl. pl.	to ANS-PNS	3.38	3.29	4.69	2.89	
106.	Mand. pl.	to ANS-PNS	21.77	5.10	23.74	4.14	
107.	Ramus pl.	to ANS-PNS	85.46	5.27	85.17	4.27	
108.	U-1	to ANS-PNS	118.34	6.91	117.55	4.82	
109.	L-1	to ANS-PNS	62.24	7.02	58.86	5.49	3.23 *
110.	A-Pog	to ANS-PNS	90.44	5.13	92.61	3.62	
111.	N-Ba	to Occl. pl.	33.27	3.99	33.11	3.99	
112.	S-Ba	to Occl. pl.	62.37	5.40	61.15	5.94	
113.	Y-axis	to Occl. pl.	57.40	2.58	55.65	2.38	4.29 **
114.	Mand pl.	to Occl. pl.	18.43	3.91	19.09	3.14	
115.	Ramus pl.	to Occl. pl.	82.12	4.46	80.52	4.42	
116.	U-1	to Occl. pl.	58.42	5.60	57.89	4.68	
117.	L-1	to Occl. pl.	65.58	6.72	63.44	5.23	
118.	A-Pog	to Occl. pl.	87.01	4.00	87.96	3.32	
119.	N-Ba	to Mand. pl.	51.66	5.29	52.16	5.26	
120.	S-Ba	to Mand. pl.	80.66	6.53	80.19	7.16	
121.	Y-axis	to Mand. pl.	39.00	3.48	36.61	3.32	4.32 **
122.	Ramus pl.	to Mand. pl.	116.36	6.08	118.62	5.48	
123.	U-1	to Mand. pl.	40.03	7.62	38.85	6.04	
124.	L-1	to Mand. pl.	96.12	6.87	97.52	5.82	
125.	A-Pog	to Mand. pl.	68.71	4.66	68.91	3.97	
126.	N-Ba	to Ramus pl.	64.75	5.51	66.51	4.12	
127.	S-Ba	to Ramus pl.	35.72	6.48	38.47	5.87	2.71 *
128.	Y-axis	to Ramus pl.	24.76	3.93	24.91	3.33	
129.	U-1	to Ramus pl.	23.75	6.88	22.67	5.63	
130.	L-1	to Ramus pl.	32.44	7.42	35.99	6.01	3.18 *
131.	A-Pog	to Ramus pl.	5.03	5.48	7.84	4.73	2.91 *
132.	N-Ba	to S-Ba	29.15	3.19	28.08	3.09	
133.	Y-axis	to S-Ba	60.42	5.02	63.34	5.08	3.56 **
134.	U-1	to S-Ba	59.35	8.01	61.10	6.46	
135.	L-1	to S-Ba	3.46	7.92	2.61	0.80	
136.	A-Pog	to S-Ba	30.79	6.52	31.03	5.78	
137.	Y-axis	to N-Ba	-0.53	3.57	1.37	3.06	3.46 **
138.	U-1	to N-Ba	88.45	7.35	89.13	5.13	
139.	L-1	to N-Ba	32.36	6.89	30.61	5.12	
140.	A-Pog	to N-Ba	59.77	5.30	59.07	4.09	
141.	U-1	to Y-axis	-0.97	6.33	-2.19	4.80	
142.	L-1	to Y-axis	57.16	5.79	60.89	4.75	4.26 **
143.	A-Pog	to Y-axis	29.75	3.33	32.35	2.79	5.12 **
144.	Interincisal angle		123.95	9.81	121.49	7.85	
145.	A-Pog	to U-1	5.29	5.66	7.94	4.88	3.05 *
146.	A-Pog	to L-1	27 46	4.72	28.41	3.94	

Every measurement that was calculated by the programs was recorded in sequential order into a computer disk and statistical evaluation was performed by using the collected data By using a statistical analysis program package, calculation of mean and standard deviations, Student's t-tests, and simple linear regression analysis were performed to all of the parameters

The statistical evaluations were done in the following manner

First, basic statistics like the mean values and standard deviation for male and female samples were calculated

Second, Student's t-tests were performed between male and female

Third, correlation coefficients between nasopharyngeal parameters and facial structures were calculated

RESULTS

Results of Student's T-tests

Mean and standard deviation of each measurement and t-values are listed in Tables 1, 3, and 5 Most of the angular measurements did not exhibit notable significance of difference in sex. But in the parameters which represents the antero-posterior relationship of mandible to maxilla, male sample showed the protruded mandible to maxilla than female sample (Table 3) These parameters are N-Pog to N-A, N-Gn to N-A, N-Me to N-A, A-Pog to N-A ($p < 0.05$)

Most of the horizontal measurements from S-vertical exhibited the significance of difference ($p < 0.05$) Horizontal measurements from PTM // ANS-PNS (see Fig 3-3) to each point exhibited high significance ($p < 0.01$)

All of the measurements from SH/FH exhibited notable significance of the difference ($p < 0.001$)

Results of Correlation

Correlation between the Nasopharyngeal Variables

Results of correlation of nasopharyngeal measurements are listed in table 2

(Male Sample)

Ba-S-PNS, which is one of the horizontal measurements of nasopharyngeal space, exhibited significance of negative correlation with S-Ba ($r=-0.25$) and S-PNS-Ba ($r=-0.71$) which are vertical components of nasopharyngeal space It also exhibited high correlation with Ba-PNS ($r=0.71$) which is also a horizontal component of nasopharyngeal measurements

Ba-PNS exhibited significance of negative correlation with S-PNS-Ba ($r=-0.55$) and exhibited significant correlation with S-Ba ($r=0.39$) which is measured in the same unit

S-PNS-Ba, which is one of the vertical components of nasopharyngeal measurements, exhibited significance of negative correlation with S-Ba ($r=-0.24$)

Table 4 Correlation coefficients between angular measurements and nasopharyngeal measurements ($* p < 0.05$ $** p < 0.01$)

		MALE				FEMALE			
		BA-S-PNS	S-PNS-BA	BA-PNS	BA-S	BA-S-PNS	S-PNS-BA	BA-PNS	BA-S
1.	N-ANS to FH								
2.	N-A to FH								
3.	N-B to FH			0.25 *					
4.	N-Pog to FH			0.27 *			-0.26 *		
5.	N-Gn to FH			0.26 *			-0.27 *		
6.	N-Me to FH			0.25 *			-0.29 *		
7.	S-N to FH	0.48 **	-0.48 **			0.44 **	-0.47 **		
8.	N-Ba to FH	-0.32 *			0.36 **	-0.25 *		-0.36 **	
9.	S-Ba to FH	-0.65 **	0.56 **	-0.41 **		-0.70 **	0.55 **	-0.65 **	
10.	Y-axis to FH	-0.43 **	0.31 *	-0.35 **		-0.40 **	0.44 **		
11.	ANS-PNS to FH					-0.30 *	0.25 *		
12.	Occl. pl. to FH	-0.25 *				-0.36 **	0.44 **	-0.25 *	
13.	Mand. pl. to FH	-0.24 *	0.28 *	-0.26 *		-0.42 **	0.52 **	-0.33 *	
14.	Ramus pl. to FH	-0.31 *	0.25 *			-0.36 **	0.48 **		
15.	U-1 to FH						-0.28 *		
16.	L-1 to FH								
17.	A-Pog to FH						-0.29 *		
18.	A-B to FH								
19.	N-ANS to S-N		0.29 *			0.35 **	0.35 **		
20.	N-A to S-N		0.31 *			-0.28 *	0.41 **		
21.	N-B to S-N		0.26 *			-0.33 *	0.33 *		
22.	N-Pog to S-N		0.24 *			-0.33 *	0.26 *		
23.	N-Gn to S-N		0.25 *			-0.34 *	0.26 *		
24.	N-Me to S-N		0.26 *			-0.34 *	0.24 *		
25.	N-Ba to S-N	-0.75 **	0.49 **	-0.29 *	0.51 **	-0.83 **	0.55 **	-0.56 **	0.29 *
26.	S-Ba to S-N	0.66 **	-0.60 **	0.34 *		0.80 **	-0.70 **	0.60 **	
27.	Y-axis to S-N								
28.	ANS-PNS to S-N								
29.	Occl. pl. to S-N								
30.	Mand. pl. to S-N						0.29 *	-0.27 *	-0.27 *
31.	Ramus pl. to S-N								
32.	U-1 to S-N								
33.	L-1 to S-N					-0.31 *			
34.	A-Pog to S-N								0.31 *
35.	A-B to S-N								
36.	N-ANS to N-A								0.28 *
37.	ANB								
38.	N-Pog to N-A								0.29 *
39.	N-Gn to N-A								0.29 *
40.	N-Me to N-A						-0.24 *		0.28 *
41.	N-Ba to N-A	0.31 *		0.31 *		0.43 **		0.36 **	-0.32 *
42.	S-Ba to N-A			0.24 *		0.80 **	-0.58 **	0.65 **	
43.	Y-axis to N-A	0.30 *	-0.33 *			0.25 *	-0.39 **		
44.	ANS-PNS to N-A								
45.	Occl. pl. to N-A						-0.37 **		
46.	Mand. pl. to N-A					0.30 *	-0.45 **	0.29 *	
47.	Ramus pl. to N-A		-0.27 *				-0.39 **		
48.	U-1 to N-A						-0.25 *		
49.	L-1 to N-A								
50.	A-Pog to N-A								0.28 *
51.	A-B to N-A								
52.	N-ANS to N-B								
53.	N-Pog to N-B								
54.	N-Gn to N-B								
55.	N-Me to N-B								
56.	N-Ba to N-B	0.36 **		0.33 *		0.50 **		0.45 **	
57.	S-Ba to N-B	0.58 **	-0.46 **	0.45 **		0.78 **	-0.66 **	-0.66 **	
58.	Y-axis to N-B	0.44 **	-0.38 **			0.38 *	-0.40 **	0.26 *	
59.	ANS-PNS to N-B					-0.25 *		-0.25 *	
60.	Occl. pl. to N-B					0.30 *	-0.37 **	0.27 *	
61.	Mand. pl. to N-B		-0.30 *			0.37 *	-0.46 **	0.34 *	
62.	Ramus pl. to N-B					0.24 *	-0.33 *		
63.	U-1 to N-B								
64.	L-1 to N-B								
65.	A-Pog to N-B								0.29 *
66.	A-B to N-B								
67.	N-ANS to N-Pog								
68.	N-Gn to N-Pog								
69.	N-Me to N-Pog								
70.	N-Ba to N-Pog	0.38 **		0.34 *		0.45 **	-0.25 *	0.43 **	
71.	S-Ba to N-Pog	0.60 **	-0.46 **	0.46 **		0.75 **	-0.67 **	0.64 **	
72.	Y-axis to N-Pog	0.45 **	-0.42 **			0.49 **	-0.41 **	0.31 *	
73.	ANS-PNS to N-Pog					0.26 *		0.24 *	
74.	Occl. pl. to N-Pog					0.34 *	-0.36 **	0.30 *	
75.	Mand. pl. to N-Pog					0.41 **	-0.47 **	0.37 **	

continue to the next page

Table 4. (Continue)

76. Ramus pl. to N-Pog					0.25 *	-0.30 *		
77. U-1 to N-Pog								
78. L-1 to N-Pog								
79. A-Pog to N-Pog								0.28 *
80. A-B to N-Pog								
81. N-Ba to N-ANS	0.33 *		0.30 *		0.33 *		0.29 *	
82. S-Ba to N-ANS	0.57 **	-0.39 **	0.44 **		0.76 **	-0.63 **	0.63 **	
83. Y-axis to N-ANS	0.25 *	-0.30 *			0.33 *	-0.34 *	0.25 *	
84. ANS-PNS to N-ANS					0.25 *		0.25 *	
85. Occl. pl. to N-ANS					0.28 *	-0.34 *	0.27 *	
86. Mand. pl. to N-ANS		-0.29 *			0.35 **	-0.43 **	0.33 *	
87. Ramus pl. to N-ANS		-0.25 *			0.27 *	-0.35 **		
88. U-1 to N-ANS								
89. L-1 to N-ANS								
90. A-Pog to N-ANS								
91. A-B to N-ANS								
92. N-Ba to A-B	0.24 *				0.25 *		0.25 *	
93. S-Ba to A-B	0.44 **	-0.40 **	0.32 *		0.58 **	-0.58 **	0.49 **	
94. Y-axis to A-B					0.27 *			
95. ANS-PNS to A-B								
96. Occl. pl. to A-B					0.27 *			
97. Mand. pl. to A-B					0.37 **	-0.34 *	0.32 *	
98. Ramus pl. to A-B								
99. U-1 to A-B								
100. L-1 to A-B								
101. A-Pog to A-B								
102. N-Ba to ANS-PNS	-0.38 **			0.25 *	-0.49 **		-0.46 **	
103. S-Ba to ANS-PNS	-0.55 **	0.47 **	-0.35 **		-0.73 **	0.58 **	-0.63 **	
104. Y-axis to ANS-PNS								
105. Occl. pl. to ANS-PNS						0.29 *		
106. Mand. pl. to ANS-PNS					-0.24 *	0.42 **		
107. Ramus pl. to ANS-PNS								
108. U-1 to ANS-PNS								
109. L-1 to ANS-PNS					-0.27 *			
110. A-Pog to ANS-PNS								-0.28 *
111. N-Ba to Occl. pl.	-0.40 **		-0.28 *		-0.51 **	0.41 **	-0.47 **	
112. S-Ba to Occl. pl.	-0.62 **	0.51 **	-0.43 **		-0.72 **	0.67 **	-0.62 **	
113. Y-axis to Occl. pl.								
114. Mand. pl. to Occl. pl.						0.29 *		
115. Ramus pl. to Occl. pl.								
116. U-1 to Occl. pl.							0.26 *	
117. L-1 to Occl. pl.					-0.32 *	0.26 *	-0.26 *	
118. A-Pog to Occl. pl.					0.32 *		0.25 *	
119. N-Ba to Mand. pl.	-0.36 **	0.28 *	-0.32 *		-0.52 **	0.48 **	-0.48 **	
120. S-Ba to Mand. pl.	-0.56 **	0.54 **	-0.43 **		-0.70 **	0.68 **	-0.60 **	
121. Y-axis to Mand. pl.					0.26 *	-0.38 **	0.30 *	0.27 *
122. Ramus pl. to Mand. pl.								
123. U-1 to Mand. pl.					0.26 *		0.31 *	
124. L-1 to Mand. pl.					0.42 **	-0.38 **	0.35 **	
125. A-Pog to Mand. pl.					0.44 **	-0.35 **	0.38 **	
						-0.41 **	0.33 *	
126. N-Ba to Ramus pl.	0.41 **				0.47 **	-0.41 **	0.55 **	
127. S-Ba to Ramus pl.	0.61 **	-0.51 **	0.35 **		0.72 **	-0.69 **		
128. Y-axis to Ramus pl.								
129. U-1 to Ramus pl.								
130. L-1 to Ramus pl.					0.29 *			
131. A-Pog to Ramus pl.								
132. N-Ba to S-Ba	-0.56 **	0.66 **	-0.38 **		-0.73 **	0.76 **	-0.59 **	
133. Y-axis to S-Ba	0.74 **	-0.60 **	0.50 **		0.82 **	-0.72 **	0.66 **	
134. U-1 to S-Ba	0.40 **	-0.29 *	0.29 *		0.53 **	-0.59 **	0.38 **	
135. L-1 to S-Ba	0.34 **	-0.29 *	0.25 *		0.35 *	-0.39 **	0.30 *	
136. A-Pog to S-Ba	0.50 **	-0.42 **	0.36 **		0.56 **	-0.61 **	0.49 **	
137. Y-axis to N-Ba	0.58 **	-0.28 *	0.40 **	-0.26 *	0.61 **	-0.42 **	0.49 **	
138. U-1 to N-Ba						-0.29 *		
139. L-1 to N-Ba								
140. A-Pog to N-Ba	0.29 *				0.24 *	-0.28 *	0.25 *	
141. U-1 to Y-axis								
142. L-1 to Y-axis					0.35 **			
143. A-Pog to Y-axis					0.32 *			-0.33 *
144. Interincisal angle								
145. A-Pog to U-1								
146. A-Pog to L-1								

Table 5. Results of Student's t-test about the linear measurements ($* \, p < 0.05$ $** \, p < 0.01$ $*** \, p < 0.001$)

	Male Mean	S.D.	Female Mean	S.D.	t
ANS - SV/FH	74.68	4.37	72.73	2.98	3.11 *
A - SV/FH	70.90	4.48	69.40	3.23	
LIE - SV/FH	74.61	5.46	72.88	4.36	
UIE - SV/FH	78.13	5.76	76.40	4.52	
B - SV/FH	66.93	6.28	65.07	4.73	
POG - SV/FH	65.68	5.61	65.58	5.57	2.56 *
MO - SV/FH	45.37	5.16	43.67	4.23	
ANS - SV/S-N	67.44	5.07	65.18	3.48	3.10 *
A - SV/S-N	62.98	5.30	61.06	3.58	2.53 *
LIE - SV/S-N	63.78	6.57	61.20	4.34	2.65 *
UIE - SV/S-N	66.78	7.11	64.24	4.49	2.54 *
B - SV/S-N	53.34	7.64	50.51	4.77	2.64 *
POG - SV/S-N	52.78	8.71	49.00	5.65	3.05 *
MO - SV/S-N	34.87	6.64	32.56	4.13	2.67 *
ANS - SV/ANS-PNS	76.54	4.89	73.84	3.68	3.75 **
A - SV/ANS-PNS	72.94	5.27	70.60	3.84	3.03 *
LIE - SV/ANS-PNS	77.46	6.37	74.55	4.12	3.23 *
UIE - SV/ANS-PNS	81.09	6.49	78.13	4.28	3.20 *
B - SV/ANS-PNS	70.57	7.20	67.18	4.31	3.38 *
POG - SV/ANS-PNS	72.45	8.20	68.00	5.09	3.87 **
MO - SV/ANS-PNS	48.17	6.10	45.28	3.92	3.35 *
ANS - PTM // FH	53.38	3.15	51.27	2.44	4.48 **
A - PTM // FH	49.60	3.27	47.94	2.38	3.45 **
LIE - PTM // FH	5.31	4.23	51.42	3.10	3.04 *
UIE - PTM // FH	56.84	4.46	54.94	3.29	2.89 *
B - PTM // FH	45.63	5.16	43.61	3.80	2.66 *
POG - PTM // FH	47.02	6.01	44.12	4.85	3.19 *
MO - PTM // FH	24.07	4.11	22.22	2.97	3.09 *
ANS - PTM // S-N	51.94	3.30	49.77	2.53	4.42 **
A - PTM // S-N	47.48	3.47	45.65	2.47	3.61 **
LIE - PTM // S-N	48.18	4.68	45.79	2.99	3.59 **
UIE - PTM // S-N	51.29	5.13	48.82	3.22	3.39 *
B - PTM // S-N	37.84	5.87	35.10	3.78	3.28 *
POG - PTM // S-N	37.26	6.86	33.59	4.84	3.68 **
MO - PTM // S-N	19.37	3.76	17.15	2.78	3.62 **
ANS - PTM // ANS-PNS	53.68	3.15	51.50	2.57	4.57 **
A - PTM // ANS-PNS	50.07	3.35	48.27	2.54	3.63 **
LIE - PTM // ANS-PNS	54.60	4.39	52.21	2.80	3.83 **
UIE - PTM // ANS-PNS	58.22	4.49	55.80	2.95	3.79 **
B - PTM // ANS-PNS	47.71	5.29	44.85	3.29	3.84 **
POG - PTM // ANS-PNS	49.59	6.23	45.66	4.32	4.36 **
MO - PTM // ANS-PNS	25.30	4.24	22.94	2.59	3.97 **
ANS - SH/FH	51.90	4.86	46.18	5.17	7.02 ***
A - SH/FH	57.42	5.22	51.71	5.07	6.80 ***
LIE - SH/FH	80.42	5.81	73.84	5.66	7.03 ***
UIE - SH/FH	83.46	5.52	76.82	5.48	7.39 ***
B - SH/FH	101.69	6.52	93.79	5.97	7.71 ***
POG - SH/FH	116.74	7.12	107.34	6.67	8.32 ***
MO - SH/FH	79.00	4.71	72.13	4.12	9.45 ***
GO - SH/FH	92.42	5.63	81.87	4.21	13.56 ***
ANS - SH/S-N	61.04	3.73	56.45	3.37	7.83 ***
A - SH/S-N	66.02	4.32	61.43	3.45	7.05 ***
LIE - SH/S-N	89.29	5.07	83.35	4.33	6.97 ***
UIE - SH/S-N	92.75	4.65	87.32	4.00	7.57 ***
B - SH/S-N	109.40	5.63	102.42	4.91	8.00 ***
POG - SH/S-N	124.48	6.52	115.90	5.66	8.57 ***
MO - SH/S-N	84.13	4.23	77.82	3.28	9.97 ***
GO - SH/S-N	89.97	5.97	79.33	4.18	13.09 ***
ANS - SH/ANS-PNS	49.16	3.67	44.54	2.86	8.46 ***
A - SH/ANS-PNS	54.80	4.60	50.15	3.39	6.90 ***
LIE - SH/ANS-PNS	77.65	5.22	72.25	4.41	6.76 ***
UIE - SH/ANS-PNS	80.58	5.04	75.15	4.10	7.13 ***
B - SH/ANS-PNS	99.18	5.76	92.37	4.85	7.75 ***
POG - SH/ANS-PNS	114.17	6.84	105.91	5.53	8.02 ***
MO - SH/ANS-PNS	77.28	4.48	71.18	3.57	9.08 ***
GO - SH/ANS-PNS	92.76	5.64	82.03	4.39	12.81 ***

(Female Sample)

Ba-S-PNS exhibited negative correlation with S-PNS-Ba (r=-0 68) But its correlation with S-Ba was not significant, while its correlation with Ba-PNS was significant (r=0 81)

Ba-PNS exhibited negative correlation with S-PNS-Ba (r=-0 53), and positive correlation with S-Ba (4=0 29)

S-PNS-Ba exhibited significance of negative correlation with S-Ba (r=-0.39)

Correlation between Angular Measurements and Nasopharyngeal Measurements

Results of correlation of angular measurements are listed in table 4

In general, male sample exhibited higher significant correlation than female measurements

(Male Sample)

Ba-S-PNS exhibited negative correlation with FMA (r=-0 24), occl pl to FH (r=-0 25), ramus pl to FH (r=-0 31), Y-axis to FH (r=-0 43), Y-axis to N-A (r=0 30), Y-axis to N-B (r=0.44), Y-axis to N-pog (r=0 45), Y-axis to N-ANS (r=0 25)

Ba-PNS exhibited significance of correlation with N-B to FH, N-Pog to FH, N-Gn to FH, and N-Me to FH which represent relative horizontal position of mandible to cranial base (r=0 25 to 0 27) Moreover, Ba-PNS exhibited significance of negative correlation with Y-axis which also represent relative horizontal position of mandible to cranial base (r=-0 35)

Ba-PNS exhibited negative correlation with FMA (r=-0 26), which means that if Ba-PNS gains length, then the tendency of counter-clockwise rotation of the mandible increases

S-Ba, which is one of the vertical measurements of the nasopharynx, did not exhibit significance of correlation with most of the angular measurements

S-PNS-Ba, which is one of the vertical angular measurements of nasopharynx, exhibited significance of correlation with Y-axis (r=0 31), FMA (r=0 28), and ramus pl to FH (r=0 25), S-PNS-Ba also exhibited significance of correlation with SNA (r=0 31), SNB (r=0 26), N-Pog to S-N (0 24), N-Gn to S-N (r=0 25), N-Me to S-N (r=0 26), and N-ANS to S-N (r=0 29)

(Female Sample)

Ba-PNS exhibited significance of negative correlation with occl pl to FH (r=-0 25), and FMA (r=-0 33), Ba-PNS exhibitied significance of positive correlation with Y-axis to N-B (r=0 26), mand pl to N-Pog (r=0 37), Y-axis to N-Pog (r=0.31), mand. pl to N-ANS (r=0.33), and Y-axis to N-ANS (r=0 25)

Ba-S-PNS exhibited significance of negative correlation with Y-axis to FH (r=-0 40), ANS-PNS to FH (r=-0 30), occl pl to FH (r=-0 36), FMA (r=-0 42), and ramus pl. to FH (r=-0 36) Ba-S-PNS also exhibited negative correlation with SNA, SNB, N-Pog to S-N, N-GN to S-N, N-Me to S-N, and N-ANS to S-N (r=-0 28 to -0 35) Ba-S-PNS exhibited significance of correlation with Y-axis to N-A (r=0 25), Y-axis to N-B (r=0 38), mand pl to N-Pog (r=0 41), Y-axis to N-Pog (r=0 49), mand pl to N-ANS (r=0 34), ramus pl to N-ANS (r=0 27), and Y-axis to N-ANS (r=

0 33)

S-Ba exhibited significance of negative correlation with FMA (r=-0 27) S-Ba exhibited significance of correlation with A-Pog to S-N (r=0 31), A-Pog to N-A (r=0 28), A-Pog to N-B (r=0 29), A-Pog to N-Pog (r=0 28) S-Ba exhibited negative correlation with A-Pog to Y-axis (r=-0 33) S-Ba also exhibited correlation with N-Pog to N-A, N-Gn to N-A, N-Me to N-A (r= 0 28 to 0.29)

S-PNS-Ba exhibited significance of negative correlation with N-Pog to FH (r=-0 26), N-Gn to FH (r=-0 27), and N-Me to FH (r=-0 29) S-PNS-Ba also exhibited negative correlation with ramus pl to S-N (r=-0 39), Y-axis to S-N (r=-0 39), ramus pl to N-B (r=-0 33), Y-axis to N-B (r=-0 40) N-Pog to mand pl (r=-0 47), Y-axis to N-Pog (r=-0 41), N-ANS to mand pl (r=-0 43), ramus pl to N-ANS (r=-0 35), and Y-axis to N-ANS (r=-0 34)

S-PNS-Ba exhibited significance of positive correlation with Y-axis to FH (r=0 44), ANS-PNS to FH (0 25), occl pl to FH (r=0 44), FMA (r=0 52), ramus pl to FH (r=0 48), SNA (r=0 41), SNB (r=0 33), N-Pog to S-N (r=0 26), N-Gn to S-N (r=0 26), N-Me to S-N (r=0 24), and N-ANS to S-N (r=0 35)

Correlation between Linear Measurements and Nasopharyngeal Variables

Results of correlation of linear measurements are listed in table 6

(Male Sample)

Ba-S-PNS exhibited negative correlation with vertical measurements from SH/FH This means that the width of the nasopharynx being greater, the height of the anterior face is shorter Its correlations with all of the measurements from S-vertical were significant and positive (r=0 27 to 0 30)

The correlations of S-PNS-Ba with the measurements from S-vertical were not significant ($p < 0$ 05)

Ba-PNS length exhibited high significance of correlation with measurements from SH/FH (r=0 41 to 0 48) and exhibited moderate significance of correlation with measurements from SV/S-N and SV/ANS-PNS (r=0 24 to r=0 33), but S-Ba did not exhibit any significance of correlation with measurements from SV/FH ($p < 0$ 05)

Measurements of each point to PTM // SV did not exhibit significance of correlation with nasopharyngeal parameters

Ba-S-PNS angle exhibited high significance of negative correlation with measurements from SH/FH (r=-0 42 to -0 57) and as the reference planes changed to S-N, SH/ANS-PNS, coefficients of correlation decreased

S-PNS-Ba angle exhibited high significance of positive correlation with measurements from SH/FH (r=0 48 to 0 58) and as the reference planes changed to S-N, SH/ANS-PNS, coefficients of correlation decreased

S-Ba exhibited moderate significance of correlation with measurements from SH (r=0 24 to r=0 50)

Table 6. Correlation coefficients between linear measurements and nasopharyngeal measurements (* $p < 0.05$ ** $p < 0.01$)

	MALE				FEMALE			
	BA-S-PNS	S-PNS-BA	BA-PNS	BA-S	BA-S-PNS	S-PNS-BA	BA-PNS	BA-S
ANS - SV/FH	0.27 *		0.48 **		0.34 *		0.40 **	
A - SV/FH	0.27 *		0.47 **		0.41 **		0.42 **	
LIE - SV/FH	0.27 *		0.42 **		0.40 **		0.35 *	
UIE - SV/FH	0.30 *		0.44 **		0.42 **		0.37 *	
B - SV/FH	0.28 *		0.43 **		0.36 *	-0.28 *	0.33 *	
POG - SV/FH	0.29 *		0.43 **		0.32 *	-0.31 *	0.28 *	
MO - SV/FH	0.28 *		0.41 **		0.38 *		0.31 *	
ANS - SV/S-N			0.31 **					
A - SV/S-N			0.29 *				0.27 *	
LIE - SV/S-N			0.25 *					
UIE - SV/S-N			0.25 *					
B - SV/S-N			0.24 *					
POG - SV/S-N								
MO - SV/S-N								
ANS - SV/ANS-PNS			0.33 *					
A - SV/ANS-PNS			0.30 *					
LIE - SV/ANS-PNS			0.26 *					
UIE - SV/ANS-PNS			0.27 *					
B - SV/ANS-PNS			0.26 *					
POG - SV/ANS-PNS			0.25 *					
MO - SV/ANS-PNS								
ANS - PTM // FH								
A - PTM // FH								
LIE - PTM // FH					0.30 *	-0.28 *		
UIE - PTM // FH					0.32 *	-0.35 *		
B - PTM // FH						-0.37 *		
POG - PTM // FH						-0.38 *		
MO - PTM // FH					0.27 *	-0.28 *		
ANS - PTM // S-N								
A - PTM // S-N								
LIE - PTM // S-N								
UIE - PTM // S-N								
B - PTM // S-N								
POG - PTM // S-N								
MO - PTM // S-N								
ANS - PTM // ANS-PNS								
A - PTM // ANS-PNS								
LIE - PTM // ANS-PNS								
UIE - PTM // ANS-PNS								
B - PTM // ANS-PNS								
POG - PTM // ANS-PNS								
MO - PTM // ANS-PNS								
ANS - SH/FH	-0.57 **	0.54 **		0.42 **	-0.48 **	0.52 **		
A - SH/FH	-0.57 **	0.56 **		0.41 **	-0.48 **	0.49 **		
LIE - SH/FH	-0.55 **	0.55 **		0.34 *	-0.48 **	0.54 **		
UIE - SH/FH	-0.56 **	0.53 **		0.35 **	-0.45 **	0.53 **		
B - SH/FH	-0.51 **	0.54 **		0.29 *	-0.47 **	0.54 **		
POG - SH/FH	-0.42 **	0.48 **		0.33 *	-0.42 **	0.50 **		
MO - SH/FH	-0.57 **	0.58 **		0.41 **				
GO - SH/FH	-0.28 *			0.46 **				0.44 **
ANS - SH/S-N	-0.28 *	0.30 *		0.36 **		0.31 *		
A - SH/S-N	-0.31 *	0.35 **		0.33 *	-0.34 *	0.26 *		
LIE - SH/S-N	-0.30 *	0.34 *		0.26 *		0.33 *		
UIE - SH/S-N	-0.28 *	0.30 *		0.27 *		0.29 *		
B - SH/S-N	-0.32 *	0.40 **		0.24 *	-0.27 *	0.36 *		
POG - SH/S-N		0.33 *		0.28 *		0.33 *		
MO - SH/S-N	-0.39 **	0.45 **		0.36 **				
GO - SH/S-N	-0.32 *	0.29 *		0.45 **				0.44 **
ANS - SH/ANS-PNS	-0.53 **	0.53 **		0.50 **	-0.34 *	0.52 **		
A - SH/ANS-PNS	-0.48 **	0.50 **		0.42 **	-0.29 *	0.38 *		
LIE - SH/ANS-PNS	-0.45 **	0.48 **		0.35 **	-0.28 *	0.42 **		
UIE - SH/ANS-PNS	-0.45 **	0.45 **		0.35 **		0.39 *		
B - SH/ANS-PNS	-0.45 **	0.51 **		0.29 *	-0.30 *	0.44 **		
POG - SH/ANS-PNS	-0.33 *	0.42 **		0.32 *	-0.26 *	0.41 **		
MO - SH/ANS-PNS	-0.49 **	0.52 **		0.40 **	-0.25 *	0.35 *		
GO - SH/ANS-PNS	-0.31 *	0.26 *		0.46 **				0.43 *

(Female Sample)

Ba-S-PNS exhibited high significance of correlation with most of the measurements from SV/FH (r=0 27 to 0 30)

S-PNS-Ba exhibited moderate significance of negative correlation with B - SV/FH (r=-0 28), and Pog - SV/FH (r=-0 31)

Ba-PNS exhibited high significance of correlation with ANS - SV/FH (r=0 40), A - SV/FH (r=0 42) and exhibited moderate significance of correlation with LIE - SV/FH (r=0 35), UIE - SV/FH (r=0 37), B - SV/FH (r=0 330, Pog - SV/FH (r=0 28), and Mo - SV/FH (r=0 31)

Ba-S did not exhibit correlation with most of the linear measurements except the measurements of Go from SH (r=0 43 to 0 44)

Ba-S-PNS angle exhibited moderate correlation with LIE - PTM // FH (r=0 30), UIE - PTM // FH (r=0 32), and Mo - PTM // FH (r=0 27)

S-PNS-Ba exhibited moderate negative correlation with LIE - PTM // FH (r=-0 28), UIE - PTM // FH (r=-0 35), B - PTM // FH (r=-0 37), Pog - PTM // FH (r=-0 38), and Mo - PTM // FH (r=-0 28)

Ba-S-PNS exhibited rather high negative correlation with measurements from SH/FH (r=-0 42 to -0 48) except with Mo - SH/FH

S-PNS-Ba angle exhibited high correlation with measurements from SH (r=0 49 to 0 54) except with Mo - SH/FH

Ba-PNS did not exhibit significance of correlation with measurements from S-horizontal ($p < 0\ 05$)

DISCUSSION

Most of the research workers classify their samples with the method of subjective classification, i e , classification with molar relation or type of breathing, and they try to justify their theories Inadequacy of subjective differentiation about the definition of pathology and function in defining the relationship between shape and function is acknowledged.[6,28]

There are a lot of unknown factors influencing the development of craniofacial structures Hence, it is inadequate to classify samples with subjective classification if we make our goal to discover the tendency of growth patterns or facial deformities For that reason, the subjective classification of samples is excluded from this study Present study adopted random sampling method and tried to investigate the relationship of facial structures and related structures to the nasopharyngeal space

Adequacy of the adoption of Ba-PNS length and Ba-S-PNS angle as nasopharyngeal depth parameters is confirmed by Schulhof,[29] Linder-Aronson,[4] Holmberg and Linder-Aronson,[8] and Preston [30]

Linder-Aronson argued that the malocclusion occurs due to the narrowing of nasopharyngeal space, and that if the etiology is removed, the direction of the growth of mandible is redirected from downward to forward and thus malocclusion is relieved According to Linder-Aronson,[4-6] the narrowing of nasopharyngeal space induces lingual inclination of upper central incisors, lowered positioning of tongue, and clockwise rotation of the mandible, i e , it induces the characteristics of the class II type malocclusion. And if adenoid removal is performed, improvement of clinical conditions can be achieved Other studies are focused on the morphological deformation resulting from the functional problems or functional derangement [2,11,12,14,20]

The craniofacial structure is a complex set of 23 bones and the shape of this structure is decided by the shape of each component It is expected that if a part of this structure changes its morphology or function, then another part of the structure changes its form and/or function It is reported that there is a significant correlation between cervical angle to cranial base and craniofacial morphology,[11,14] and that there is a close relationship between cervical angle and dimension of nasopharyngeal space [14] Experimental opening of the jaw induced the increase of cervical angulation [31]

Facial height is determined by respiratory demands, and facial height is obviously longer in the mouth breathing patients than in the normal group [12]

There is a strong tendency to maintain the original facial type with age, and growth curves of different measurements exhibited parallelism regardless of facial type [36] Therefore, if we select and evaluate an adult, we can estimate the skeletal pattern in the early year of life If we evaluate the adult's skeleton, it is expected to decide the etiology of certain craniofacial deformities

Subtelny[35] argued that, "Form changes function" In reverse, it is possible to infer that the function changes the form This hypothesis has been insisted on by many research workers [2,9,11,12,14,19,30] "What are the causal factors?" and "What are the results?" are hard questions to be answered At least, we can say that the two groups of parameters are intermingled with each other At any rate, if we can find the causal factor of malocclusion, it is very helpful in treating orthodontic patients

In this study, parameters of nasopharyngeal space show notable significance of correlation to the parameters of facial height, especially with the depth parameter of nasopharyngeal space Ba-S-PNS angle, which is one of the depth indicators of nasopharyngeal space, generally exhibited significant negative correlation coefficients

Angular Measurement

Sex Difference

Angular measurements of the dentofacial structure is an index of its proportion rather than its absolute size So if it can be shown that the significance of difference between male and female angular measurements exists, it can be regarded as a morphological difference

In angular measurement, the differences in sex were not observed in most cases ($p < 0.05$) But parameters which represents antero-posterior relationship between the maxilla and the mandible showed moderate significance of difference

Correlation

Angular Measurements

Ba-S-PNS exhibited significance of correlation with the horizontal position of the mandible to cranial base ($p < 0\ 05$) That is, if Ba-S-PNS becomes larger, then the mandible moves forward in relation to cranial base

Ba-PNS exhibited significance of correlation with Y-axis to FH ($p < 0\ 05$), which means that if Ba-PNS gains length, then the tendency of counter-clockwise rotation of mandible occurs Both male and female samples exhibited the same tendency, but the female samples exhibited lower correlation coefficients In conclusion for angular measurements, nasopharyngeal space is related to the anteroposterior position of the mandible

Linear Measurements

Among the measurements, Ba-S-PNS angle and Ba-S length exhibited significant correlation with facial depth Ba-S-PNS angle exhibited a lower correlation coefficient with facial depth ($p < 0\ 05$) than did Ba-PNS ($p < 0\ 01$) Especially in the female sample, Ba-S-PNS angle and Ba-PNS length exhibited almost the same significance level with facial depth ($p < 0\ 05$)

If the reference plane is changed from FH to S-N or to ANS-PNS, the value of the correlation coefficient drops down The difference of inclination between FH and ANS-PNS is especially slight, but the correlation coefficients of measurements parallel to ANS-PNS are significantly lower than measurements parallel to FH

It should be mentioned that the horizontal measurements (facial depths) contains fractions of Ba-S-PNS angle and Ba-PNS length And the measurements from PTM to each reference point located on the surface of the facial structures exhibited a low correlation coefficient, therefore, it is considered that the nasopharyngeal dimension does not have a close relationship to the horizontal dimension of anterior facial structures

The correlation between nasopharyngeal variables and facial height exhibited notable significance of correlation, especially between Ba-S-PNS angle and facial height But according to Brodie[26] and King[22], skeleton of nasopharyngeal space attains its stability in the early year of life, it should be reconsidered whether it is right that the correlation between the dimension of soft-tissue nasopharyngeal space and facial structures exists which is argued by some research workers

Many of the reports showed the variability of its dimension of nasopharyngeal soft-tissue. Adenoids are usually developed in childhood and marked symptoms are most common at 2-12 years of age, and during adolescence, the adenoids decrease in size, concurrently with growth of the nasopharynx, so that the lymphoid tissue also becomes relatively smaller[4] So it could be deduced that the dimension of facial structures would be changed if the dimension of soft-tissue nasopharyngeal space changes Therefore, if the dimension of soft-tissue nasopharynx decreases due to the increased volume of adenoids in the nasopharyngeal space, the tendency of decreasing of facial height occurs And facial height expresses tendency of decrease if the dimension of soft-tissue nasopharyngeal space increases, vice versa If it is right, then the final result of facial height would not express the correlation with the dimension of hard tissue nasopharynx, because, as mentioned above, Brodie[26] and King[22] argued that the skeleton of nasopharyngeal space attains its stability in the early year of life (about 3 months after birth) Of course, this is only a deductive theory and it is very hard to corroborate this theory with the results of the present study which deals with the hard tissue dimension of nasopharyngeal space only

Results of this study showed the high significance of correlation between the depth of hard tissue nasopharyngeal space and facial height It is supposed that the facial height in consequent of growth is almost determined at the time when the hard-tissue dimension of nasopharyngeal space determined As mentioned above, each segments of craniofacial structures have interdependence, it could be suspected that the phenomenon which is expressed on the facial region by the effect of dimension of nasopharynx feed back to nasopharyngeal structure Because of this reason, it is hard task to define the interrelationship between each structure not only in the field of nasopharyngeal structure but all field of craniofacial structures

Correlation means the interrelationship between some structures or some phenomena as the word itself means It cannot define what the causal factor is and what the result is by resolving the correlation coefficients Only we can estimate is what the causal factor is and what the result is

According to the results of the present study, person who has small dimension of nasopharyngeal space has a tendency of high facial height It is hard to determine what the normal range is

CONCLUSION

Cross-sectional cephalometric study on the relationship of the nasopharyngeal space to dentofacial structures was conducted with healthy Korean adults (91 male and 65 female) The results are as follows

1 As to the difference between males and females, the males have a more protruded mandible to maxilla and mandible and longer facial height than do the females
2 The significance of negative correlation was seen between Ba-S-PNS and S-PNS-Ba Therefore, it is assumed that the two measurements have an interactive relation with each other.
3 Depth of the nasopharyngeal space showed the significance of correlation with antero-posterior position of the mandible
4 It is assumed that the depth of the nasopharyngeal space and facial depth are unrelated to each other
5 A high negative correlation between depth of nasopharyngeal space and anterior facial height

was noted

6 Correlation between height of nasopharyngeal space and facial height was significant.

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=국 문 초 록=

鼻咽頭腔과 顔面骨格間의 相關關係에 對한 統計學的 硏究

大阪齒科大學 矯正學敎室

吳聖辰 · 木下善之介

不正交合의 發生要因의 하나로서 鼻咽頭腔의 狹窄이 擧論되어 왔다 本 硏究는 顔面骨格의 形態決定에 鼻咽頭腔의 寄與程度를 把握하고자 함에 있다

硏究資料 및 方法安

韓國人 成人 男女 156名의 側貌頭部X線規格寫眞을 使用하여 NEC PC－9801 VM2 Personal Computer와 Oscon GT－4000 Digitizer에 의한 data 入力을 行한 후 統計處理를 行하였다 統計處理로서는 各計測値에 대하여 男女別로 平均値, 標準偏差値를 算出, Student's t－test를 行하고, 鼻咽頭腔 計測項目과 顔面骨格의 各 計測値間의 相關關係의 檢討를 行하였다

結　果

1 男女의 性差로서, 女子보다 男子가 上顎骨에 대해 下顎骨이 突出되어 있었으며, 顔面高가 컸다

2 Ba－S－PNS와 S－PNS－Ba間에 負의 相關이 認定되어, 이 두 計測値間에 相互作用이 있는 것으로 판단 되었다

3 鼻咽頭腔의 깊이는 下顎의 前後位置關係와 留意한 相關關係를 보였다

4 鼻咽頭腔의 깊이와 顔面의 깊이와는 關聯性이 없는 것으로 판단 되었다

5 鼻咽頭腔의 깊이와 顔面高間에 有意한 負의 相關이 示唆되었다

6 鼻咽頭腔의 高経과 顔面高間에 有意한 相關關係가 認定되었다