Some Observations on the Pharyngeal Airspace

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The morphology of the pharynx has attracted increasing interest from both static and dynamic viewpoints. This somewhat funnel-shaped tube is related to a changing framework of skeletal landmarks and to soft tissues of variable thickness and mobility. In addition, there is the complication of differing rates of growth and maturation of the contributing parts.

Early studies of the area were primarily concerned with skeletal relationships (*4, 11, 16*). This emphasis has since been broadened to include consideration of the soft tissue and the enclosed space (*15, 17*). More recent concepts have developed the importance of the airway-maintenance system (*2*) and the pharyngeal airspace itself as factors in growth and development (*14*). The growth of the soft palate has been studied and related to the cyclic and transient alterations of the adenoid tissue along the upper regions of the posterior pharyngeal wall (*17, 18*). The effects of certain disproportions in the velopharyngeal area have led to closer examination of the elements which provide the basis for functional activities (*1, 6, 13, 19*).

With this background, the present study on certain morphologic characteristics of the pharynx was conducted to provide information as a preliminary part of further study of the functional activity and interrelationship of various parts of the oropharyngeal system.

The aim of this work is twofold: a) to develop parametric guidelines which may be useful in assaying the anteroposterior depth of the pharynx and b) to evaluate, in terms of altering dimensions, some changes which occur during the growth period.

Procedure

The material, from the collection of the Burlington Orthodontic Research Centre, consisted of cephalograms taken longitudinally of a random sample of 96 children, of whom 55 were males and 41 females, at ages six, nine, and 12 years (*5, 7, 9, 10*).

Prints of the lateral cephalometric films were utilized to delineate

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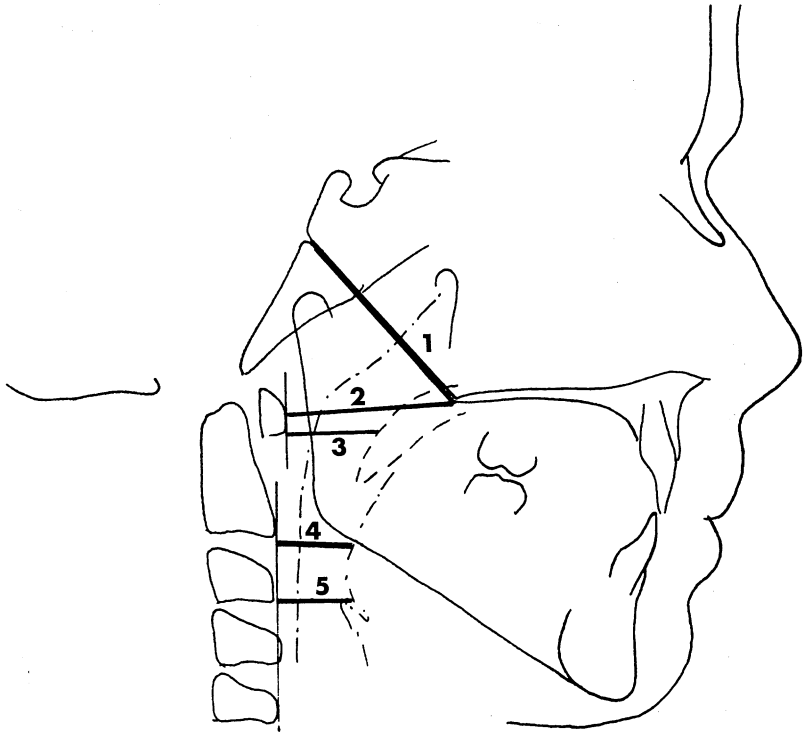

FIGURE 1. Tracing of cephalometric film. The numbered lines indicate the five areas surveyed.

sagittal dimensions (*8*). It is obvious that inconsistency in the relationship of the head position, with respect to the cervical vertebrae, would be reflected in the dimension of the pharynx. This has been pointed out by a number of workers who noted the increase in anteroposterior pharyngeal depth with extension and decrease with flexion (*11, 12*). However, gross alteration can be discarded in evaluation. For the most part, the relationship resulting from the orientation in the cephalostat was accepted for the purpose of this study. Selected measurements and easily reproducible landmarks were chosen to provide dimensions closely associated with functional activity.

Figure 1 shows the areas surveyed. The first two areas were described as follows: level 1, defined by a line extending from the posterior nasal spine to the midpoint of the superior surface of the sphenooccipital synchondrosis; and level 2, defined by a posterior extension of the palatal plane passing through the posterior nasal spine. For the remaining three, a tangent was drawn to the antero-inferior angles of the second, third, and fourth cervical vertebrae. Three perpendiculars to this tangent provided level 4, the anteriormost point on the arch of the atlas; level 5, the base of the second cervical vertebra; and level 6, the base of the third cervical vertebra.

The mean error of measurement was calculated to be .73 mm, with a range from .28 mm for the soft tissue thickness of the pharyngeal wall at the level of the second cervical vertebra to 1.22 mm for the thickness of the soft tissue pharyngeal wall at the palatal plane.

Results

The data were treated by standard statistical techniques. Presented in Tables 1, 2, 3, and 4 are the minimum and maximum measurements, the mean, the standard error, and the standard deviation. Data developed from males and females were processed separately to provide standards for clinical use.

It is difficult to compare these results with those of other studies, inasmuch as some of the measurements used have not been employed in previous investigations of this area. However, measurements of comparable elements show general agreement. The slightly larger mean dimensions of the airspace may possibly be attributed to the dimension of the soft tissue over the posterior nasal spine, a factor which is not always considered, but which may reduce the airspace by an average of 2.6 mm.

As delineated in this study and other studies, the pharyngeal airspace appears to be a product of changing bony relationships and an alteration of soft tissue contours.

The contribution of these elements to the total dimension varies not only in each individual, but also with the area examined (see Figure 2).

In the upper pharynx, there is a highly significant increase in the depth of the airspace with growth. This dimension showed an average increase from about 12 to 17 mm in the six-year period studied, although the range varied from a decrease of 3 mm to a 16 mm increase. In the mid-portion, a mean 3 mm increase between six to nine years of age, and an additional 2 to 3 mm mean increase between nine to 12 years, may vary from a 7 mm decrease to a 22 mm increase in the six year period.

This wide gradation of change in the airspace measurements is similar for lower levels as well. However, the mean dimension itself shows no significant change at the second and third vertebral regions and remains at about 10 to 12 mm depth for both boys and girls.

The thickness of the soft tissue of the posterior pharyngeal wall also remains relatively constant in this area of the pharynx. The mean of approximately 4 mm, at the ages examined, ranges from half to almost twice that amount in the twelve year-old groups.

Above this region, the posterior soft tissue shows considerably greater variability so that, in the palatal plane area, the range is from 3 or 4 mm to 30 mm. However, in spite of this wide difference, the mean decrease in thickness of the posterior wall is significant. The average decrease is 3 mm, but there may be as much as 22 mm.

TABLE 1. Anteroposterior dimensions of the pharyngeal airspace at each of five levels for 55 males and 41 females. Data (in millimeters) include, for the group, the minimum, the mean and standard error, the maximum, and the standard deviation of the mean measurements for each of the three ages (6, 9, and 12) at which every child was x-rayed in this longitudinal study. Comparable data regarding the amount of change in the dimension of the airspace which occurred in three periods of time (6 to 9 years, 9 to 12 years, and 6 to 12 years) are also shown. Negative values indicate a decrease in dimension.

level		*absolute dimensions*						*change in dimensions*					
		age	*min*	*M*	*se*	*max*	*SD*	*age period*	*min*	*M*	*se*	*max*	*SD*
1	M	6	5	12.60	.48	20	3.54	6–9	−5	2.52	.46	13	3.33
		9	7	15.11	.42	21	2.99	9–12	−4	2.08	.40	12	2.95
		12	9	16.96	.47	23	3.57	6–12	−3	4.51	.49	16	3.66
	F	6	6	11.48	.41	19	2.60	6–9	−4	2.78	.43	11	2.74
		9	8	14.34	.52	20	3.37	9–12	−4	2.13	.47	15	3.03
		12	10	16.36	.51	23	3.31	6–12	−1	5.20	.43	11	2.75
2	M	6	5	14.10	.52	25	3.89	6–9	−7	2.94	.66	15	4.81
		9	10	16.99	.56	26	4.11	9–12	−7	1.87	.45	10	3.28
		12	13	19.30	.47	29	3.68	6–12	−6	5.14	.59	15	4.35
	F	6	4	12.80	.82	22	5.16	6–9	−7	3.12	.83	18	5.48
		9	6	15.62	.50	22	3.19	9–12	−7	2.74	.70	14	4.32
		12	11	19.43	.56	32	3.63	6–12	−1	5.82	.80	22	5.16
3	M	6	5	12.04	.55	18	3.68	6–9	−6	.87	.61	9	3.83
		9	6	12.63	.47	19	3.19	9–12	−10	1.75	.62	11	4.09
		12	7	14.52	.52	22	3.78	6–12	−8	2.08	.69	14	4.33
	F	6	4	11.44	.51	17	3.00	6–9	−7	.54	.66	6	3.64
		9	6	11.30	.57	20	3.39	9–12	−7	1.20	.48	8	2.83
		12	6	13.47	.55	20	3.44	6–12	−7	1.60	.58	7	3.31
4	M	6	3	10.89	.49	19	3.56	6–9	−9	−.34	.66	10	4.67
		9	4	10.46	.50	19	3.67	9–12	−7	.65	.57	13	4.14
		12	2	10.91	.52	21	3.89	6–12	−8	.72	.66	13	4.82
	F	6	3	11.53	.62	19	3.87	6–9	−10	−.46	.65	7	3.74
		9	5	11.55	.58	20	3.50	9–12	−10	.13	.54	5	3.25
		12	4	11.82	.61	20	3.83	6–12	−8	.13	.66	10	4.07
5	M	6	2	9.40	.47	16	3.31	6–9	−8	.46	.61	12	4.27
		9	4	9.80	.59	20	4.21	9–12	−6	1.00	.38	9	2.96
		12	5	10.09	.49	19	3.33	6–12	−7	.82	.61	10	3.78
	F	6	5	9.91	.61	19	3.57	6–9	−10	.07	.80	7	4.17
		9	6	9.91	.49	18	2.82	9–12	−7	.74	.77	8	3.70
		12	6	10.84	.66	18	3.33	6–12	−5	1.05	1.0	9	4.66

TABLE 2. The thickness of the pharyngeal wall at each of five levels for 55 males and 41 females. Data (in millimeters) include, for the group, the minimum, the mean and standard error, the maximum, and the standard deviation of the mean measurements for each of the three ages (6, 9, and 12) at which every child was x-rayed in this longitudinal study. Comparable data regarding the amount of change in the dimension of the airspace which occurred in three periods of time (6 to 9 years, 9 to 12 years, and 6 to 12 years) are also shown. Negative values indicate a decrease in dimension.

level	*absolute dimensions*						*change in dimensions*					
	age	*min*	*M*	*se*	*max*	*SD*	*age period*	*min*	*M*	*se*	*max*	*SD*
	6	5	10.82	.33	16	2.44	6–9	−5	−.73	.33	5	2.47
M	9	5	10.31	.38	17	2.87	9–12	−6	−.98	.31	4	2.29
	12	4	9.39	.36	15	2.69	6–12	−8	−1.68	.38	5	2.82
1												
	6	5	10.27	.44	16	2.80	6–9	−5	−.05	.36	6	2.29
F	9	5	10.23	.46	17	2.97	9–12	−7	−.66	.36	4	2.41
	12	4	9.48	.43	16	2.81	6–12	−8	−.93	.40	4	2.55
	6	4	15.68	.86	30	6.43	6–9	−13	−1.66	.66	11	4.72
M	9	6	13.68	.75	25	5.43	9–12	−10	−1.27	.52	7	3.76
	12	3	12.56	.69	29	5.18	6–12	−15	−3.12	.62	3	4.63
2												
	6	6	15.92	1.0	30	6.78	6–9	−21	−1.77	1.0	11	6.35
F	9	5	13.59	.9	28	6.19	9–12	−10	−.58	.6	6	3.75
	12	4	12.47	.9	30	6.22	6–12	−22	−2.50	1.0	7	6.41
	6	2	9.28	.65	20	4.74	6–9	−14	−1.65	.65	14	4.66
M	9	2	7.45	.54	22	4.09	9–12	−13	−.66	.43	5	3.20
	12	2	7.50	.39	19	2.81	6–12	−13	−2.48	.78	3	4.30
3												
	6	2	8.14	.85	24	5.46	6–9	−9	−1.69	.55	7	3.47
F	9	2	6.56	.49	15	3.09	9–12	−7	−.61	.37	5	2.34
	12	2	5.95	.43	12	2.75	6–12	−14	−2.35	.65	5	4.12
	6	2	3.97	.10	6	.76	6–9	−3	−.09	.10	2	.76
M	9	2	3.80	.11	6	.91	9–12	−2	.03	.10	2	.885
	12	2	3.80	.10	7	.79	6–12	−2	−.16	.11	2	.85
4												
	6	3	3.83	.21	5	1.40	6–9	−2	−.05	.13	3	.806
F	9	3	3.84	.11	6	.69	9–12	−1	−.13	.08	1	.54
	12	3	3.83	.10	5	.69	6–12	−2	−.15	.13	2	.84
	6	2	3.80	.02	5	.20	6–9	−2	−.10	.10	2	.75
M	9	2	3.74	.10	6	.74	9–12	−2	−.43	.10	2	.82
	12	2	3.50	.03	6	.25	6–12	−2	−.30	.11	2	.84
5												
	6	2	3.83	.09	5	.61	6–9	−2	−.33	.13	2	.81
F	9	3	3.45	.11	4	.68	9–12	−1	−.05	.01	1	.57
	12	3	3.62	.10	5	.63	6–12	−1	−.3	.11	1	.70

TABLE 3. The skeletal dimensions as measured at two levels for 55 males and 41 females. Data (in millimeters) include, for the group, the minimum, the mean and standard error, the maximum, and the standard deviation of the mean measurements for each of the three ages (6, 9, and 12) at which every child was x-rayed in this longitudinal study. Comparable data regarding the amount of change in the dimension of the airspace which occurred in three periods of time (6 to 9 years, 9 to 12 years, and 6 to 12 years) are also shown. Negative values indicate a decrease in dimension.

level	*absolute dimensions*						*change in dimensions*					
	age	*min*	*M*	*se*	*max*	*SD*	*age period*	*min*	*M*	*se*	*max*	*SD*
	6	40	44.43	.29	49	2.22	6–9	−2	2.09	.22	8	1.65
M	9	41	46.67	.36	52	2.66	9–12	0	2.49	.19	8	1.41
	12	43	49.04	.22	54	2.67	6–12	0	4.55	.22	10	1.64
1												
	6	38	42.25	.31	45	1.97	6–9	−1	2.61	.27	8	1.70
F	9	39	45.24	.32	49	2.05	9–12	−2	2.02	.24	4	1.59
	12	43	46.98	.36	51	2.21	6–12	−1	4.88	.42	11	2.67
	6	29	37.53	.60	48	4.52	6–9	−6	1.16	.52	12	3.75
M	9	25	38.86	.72	49	5.26	9–12	−7	.50	.37	8	2.73
	12	29	38.64	.70	49	5.19	6–12	−5	1.43	.39	9	2.92
2												
	6	29	36.86	.69	46	4.47	6–9	−9	.96	.56	7	3.62
F	9	31	37.82	.60	46	3.89	9–12	−4	1.58	.43	9	2.88
	12	32	38.95	.81	47	5.24	6–12	−9	.39	.75	10	4.86

Higher in the nasopharynx, the average thickness of the soft tissue remained relatively constant at about 10 mm, ranging from 5 to 17 mm.

Since the airspace in the upper region increases approximately 5 mm during the six-year period, the greater depth may be attributed to the vertical growth reflected along this skeletal dimension. In this study, the mean measurement between the skeletal landmarks on the hard palate and the base of the skull shows an increase of about 5 mm, but may be as much as 11 mm.

The only other skeletal dimension considered was that along the palatal plane. Although the range was wide, the mean measurement was essentially in agreement with previous investigations of this area.

Summary

Essentially, the findings from this study are in agreement with those from other investigations. The variability of the pharyngeal airspace and the structures and tissues which contribute to its dimensions are well known. However, recognition of this fact does not vitiate the necessity for proper evaluation of the anteroposterior depth. In questions of velopharyngeal dysfunction, a description of the problem in morphologic terms can be a helpful adjunct to diagnosis. In order to provide a

TABLE 4. The amount of soft palate thickness interposed between the posterior nasal spine and the airspace along the upper two levels for 55 males and 41 females. Data (in millimeters) include, for the group, the minimum, the mean and standard error, the maximum, and the standard deviation of the mean measurements for each of the three ages (6, 9, and 12) at which every child was x-rayed in this longitudinal study. Comparable data regarding the amount of change in the dimension of the airspace which occurred in three periods of time (6 to 9 years, 9 to 12 years, and 6 to 12 years) are also shown. Negative values indicate a decrease in dimension.

level		*dimension in mm*						*change in mm*					
		Age	*min*	*mean*	*se*	*max*	*SD*	*age period*	*min*	*mean*	*se*	*max*	*SD*
1	M	6	1	2.69	.20	9	1.63	6–9	−4	−.19	.20	6	1.52
		9	1	2.45	.16	7	1.23	9–12	−2	.22	.15	4	1.12
		12	1	2.65	.17	6	1.33	6–12	−4	.02	.21	4	1.61
	F	6	1	2.65	.10	5	.98	6–9	−2	−.10	.19	3	1.20
		9	1	2.58	.18	5	1.14	9–12	−3	−.50	.19	3	1.23
		12	1	2.51	.17	5	1.12	6–12	−3	−.15	.18	3	1.19
2	M	6	1	8.12	.40	14	2.98	6–9	−7	.19	.41	8	2.97
		9	1	8.34	.43	15	3.15	9–12	−8	.19	.41	8	3.01
		12	2	8.94	.40	16	2.98	6–12	−7	.94	.45	10	3.39
	F	6	5	8.82	.38	16	2.41	6–9	−5	.25	.43	8	2.70
		9	4	8.62	.41	19	2.62	9–12	−11	−.62	.46	5	2.93
		12	3	8.00	.30	12	1.93	6–12	−9	−1.13	.46	3	2.88

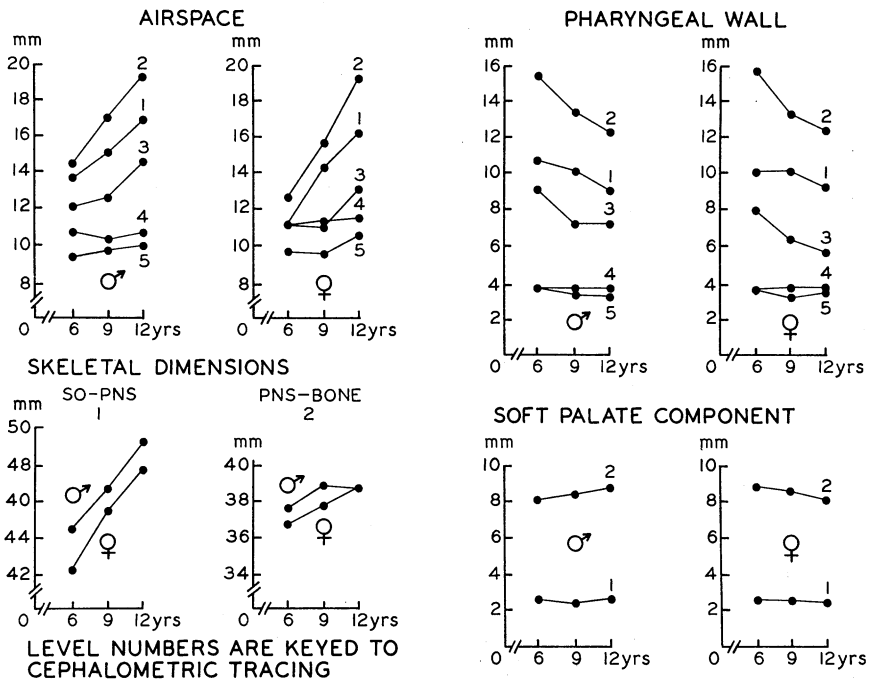

FIGURE 2. Representation of the sagittal dimensions and the contribution of the soft tissue and skeletal elements to the change in airspace depth.

firmer basis for judgment, the components defining this area can be compared separately to a sample group of individuals of like age. Comparisons of this nature may also be of value in disclosing masked disproportions in pharyngeal dimensions prior to proposed alterations of existing relationships. While the data derived from this study are useful in assessing this area, it is obvious that a static, point-in-time, film has limited value. Because the pharynx is an area of movement and function, further investigation of the sites, direction, and dimensions of activity is being conducted to relate these movements to each other and to other oral events. From this, a clearer understanding of the role of the pharyngeal airspace may emerge.

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References

1. Blackfield, H., Miller, E., Owsley, J., and Lawson, Lucie, Cinefluorographic evaluation of patients with velopharyngeal dysfunction in the absence of overt cleft palate. *Plastic reconstr. Surg., 30,* 411–451, 1962.
2. Bosma, J., Oral and pharyngeal development and function. *J. dent Res., 42,* 375–380, 1963.
3. Brader, A., A cephalometric x-ray appraisal of variation on the cranial base and associated pharyngeal structures. Implications in cleft palate therapy. *Angle Orthod., 27,* 179–195, 1957.
4. Brodie, A., On the growth pattern of the human head from the third month to the eighth year of life. *Amer. J. Anat., 68,* 209–262, 1941.
5. Burlington Orthodontic Research Centre, Progress Report Series 1–6, 1952–1961.
6. Calnan, J., Movements of the soft palate. *Brit. J. plastic Surg., 5,* 286–296, 1952.
7. Cartwright, L. and Harvold, E., Improved radiographic results in cephalometry through the use of high kilovoltage. *J. Canad. dent. Assoc., 20,* 261–263, 1954.
8. Harvold, E. and Poynton, H., An improved tracing technique for radiographic cranimetry. *J. Canad. dent. Assoc., 27,* 145–147, 1961.
9. Harvold, E. and Hatton, M., The Burlington orthodontic research centre: A measure of its role in dental public health. *J. Canad. dent. Assoc., 28,* 6–17, 1962.
10. Hatton, M. and Grainger, R., Reliability of measurements from cephalograms at the Burlington orthodontic research centre. *J. dent. Res., 37,* 835–859, 1958.
11. King, E., A roentgenographic study of pharyngeal growth. *Angle Orthod., 22,* 23–37, 1952.
12. Mazaheri, M., Millard, R., and Erickson, D., Cineradiographic comparison of normal to noncleft subjects with velopharyngeal inadequacy. *Cleft Palate J., 1,* 199–209, 1965.
13. Moll, K., A cinefluorographic study of velopharyngeal function in normals during activities. *Cleft Palate J., 2,* 112–122, 1965.
14. Moss, M., Vertical growth of the human face, *Amer. J. Orthod., 50,* 359–376, 1964.
15. Ricketts, R., The cranial base and soft structure in cleft palate speech and breathing. *Plastic reconstr. Surg., 14,* 47–61, 1954.
16. Rosenberger, H., Growth and development of the nasorespiratory area in childhood. *Ann. Oto., 43,* 495–522, 1934.
17. Subtelny, J., A cephalometric study of the growth of the soft palate. *Plastic reconstr. Surg., 19,* 49–62, 1957.
18. Subtelny, J., and Koepp-Baker, H., The significance of adenoid tissue in velopharyngeal function. *Plastic reconstr. Surg., 17,* 235–250, 1956.
19. Warren, D. and Hofmann, F., A cineradiographic study of velopharyngeal closure. *Plastic reconstr. Surg., 28,* 656–669, 1961.