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Adult craniocervical and pharyngeal changes—a longitudinal cephalometric study between 22 and 42 years of age. Part II: morphological uvulo-glossopharyngeal changes

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SUMMARY The purpose of this study was to investigate, by cephalometric means, longitudinal alterations in uvulo-glossopharyngeal morphology in adult males and females, at three different ages with 10-year intervals, and to compare the changes between the two genders. The material consisted of three series of cephalograms of 26 males and 24 females, with approximately a 10-year interval between each series.

Alterations with age in males and females included:

1 An increase in the length, thickness, and sagittal area of the soft palate, with a more upright position for both genders.
2 A more upright tongue position and caudally-extended tongue mass for both sexes was found, and the sagittal area of the tongue was significantly increased only in males.
3 There was a decrease in the sagittal dimension of the oropharynx, and at the minimal distance between the base of the tongue and the posterior pharyngeal wall in both males and females.

The overall significant inter-sex differences, over a 20-year period, were that males showed a more upright tongue position and more caudally-extended tongue mass, a greater reduction in sagittal dimension of the minimal pharyngeal airway space, a greater increase in the sagittal area of the soft palate, and an increase in the tongue area.

Introduction

Cephalometric radiography has been extensively used in the field of orthodontics as a diagnostic and follow-up technique in the study of craniofacial morphology. Lateral cephalometric analysis also provides important information about the soft and hard tissue of the upper airway (Bear and Priest, 1980; Andersson and Brattström, 1991; Taylor *et al*., 1996). Growth and development of the pharynx have been studied longitudinally by different investigators, as has the relationship between airway patency and craniofacial development (Handelman and Osborne, 1953; Linder-Aronson and Leighton, 1983; Ceylan and Oktay, 1995).

Recently, increasing interest has been focused on the soft tissue, and the structure of the oral and nasal pharynx. This increased interest has been derived from a potential relationship between size and structure of the upper airway, and sleep-induced breathing disturbances (Djupesland *et al*., 1987; Lyberg *et al*., 1989b; Bacon *et al*., 1990). Obstructive sleep apnoea (OSA) is characterized by the recurrent occlusion of the upper airways resulting from inspiratory collapse of the pharyngeal walls during sleep (Maltais *et al*., 1991). Aetiological or predisposing factors for OSA are still debated. An anatomically narrow airway, craniofacial deformity, muscular hypotrophy, sleep posture, fatty depositions in the tissues of the upper airway, gender, and age have been reported to be related to OSA (Miles *et al*., 1996).

Cephalometry has been recommended for OSA patients as an important tool in diagnosis and treatment planning (Tangugsorn *et al*., 1995b). It has been shown that OSA patients have aberrated skeletal and soft tissue morphology, when compared with a normal population (Riley *et al*., 1983; Lyberg *et al*., 1989a,b). Reduced sagittal linear dimensions of the cranial base, and mandibular micrognathia or retrognathia were reported to have strong relationships with OSA (Lowe *et al*., 1985). The hyoid bone is located more inferiorly, relative to the mandibular plane, sella point and Frankfort horizontal plane (Tangugsorn *et al*., 1995a). Other studies have demonstrated the enlargement of the soft palate in OSA patients, with an increase in both length and thickness, as well as a smaller minimal airway space (PASmin) than controls (Lyberg *et al*., 1989b).

The prevalence of OSA has been reported to range from 1 per cent in a working population up to 42 per cent in an elderly nursing home. Of course, the estimation of prevalence depends on the population selected and on the definition used to make a diagnosis of OSA (Bresnitz *et al*., 1994). However, it has been shown that the prevalence of OSA is increased with age in males (Burger *et al*., 1992). It is generally accepted that there is a gender predisposition to OSA, middle-aged men being more affected than women of a similar age, with male to female ratios ranging from 2:1 (Young *et al*., 1993), 3:1 (Johns, 1991) and 10 to 20:1 (Cisneros and Trieger, 1992) in the various reports.

Brown *et al*. (1986) utilized the acoustic reflection technique to measure the cross-sectional pharyngeal area in adult men. They concluded that, in males, the pharyngeal area reduces with age. Maltais *et al*. (1991) compared cephalometric measurements from snorers, non-snorers, and patients with sleep apnoea. They reported that cephalometric values were influenced by the subject's age. There is also evidence that the tongue, especially in men, increases in bulk until maturity and becomes larger in relation to the intermaxillary space with increasing age (Cohen and Vig, 1976).

It is logical to make the hypothesis that alterations of uvulo-glossopharyngeal morphology may appear later in life with increasing age. Apparently, no systematic longitudinal study has been reported that investigates the possible age-related changes of the upper airway, and the outline and position of the tongue during adulthood.

The purpose of this study was to determine, by cephalometric means, longitudinal alterations in uvulo-glossopharyngeal morphology in adult males and females, at three different age levels with a 10-year interval, and to compare the changes between the two genders.

Materials and methods

The materials and the methods used in this study have been reported previously (Kollias and Krogstad, 1999).

The reference points and lines used in this analysis are given in Figures 1 and 2. The definitions have been described in previous papers (Solow, 1966; Solow and Greve, 1979; Lyberg *et al*., 1989b). Some unfamiliar landmarks, plane, and measurements are described below.

Landmarks

- H — The most superior point of the tongue in relation to the line from V to T.
- LPW — Lower pharyngeal wall, intersection of a perpendicular line from V with the posterior pharyngeal wall.
- MPW — Middle pharyngeal wall, intersection of a perpendicular line from U with the posterior pharyngeal wall.
- T — The tip of the tongue.
- U — Tip of the uvula, the most postero-inferior point of the uvula.
- UPW — Upper pharyngeal wall, intersection of the pm–ba line and the posterior pharyngeal wall.
- V — Vallecula, the intersection of epiglottis and the base of the tongue.

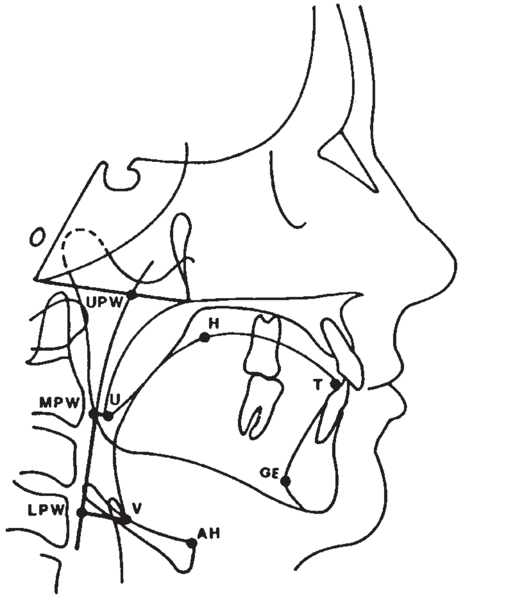

Figure 1 Uvulo-glossopharyngeal reference points used in this study: AH, anterior hyoid; GE, genial tubercle; H, highest dorsal point of the tongue; LPW, lower pharyngeal wall; MPW, middle pharyngeal wall; T, tip of the tongue; U, tip of the uvula; UPW, upper pharyngeal wall; V: vallecula (Lyberg *et al.*, 1989b, published with permission of the *Journal of Laryngology and Otology*).

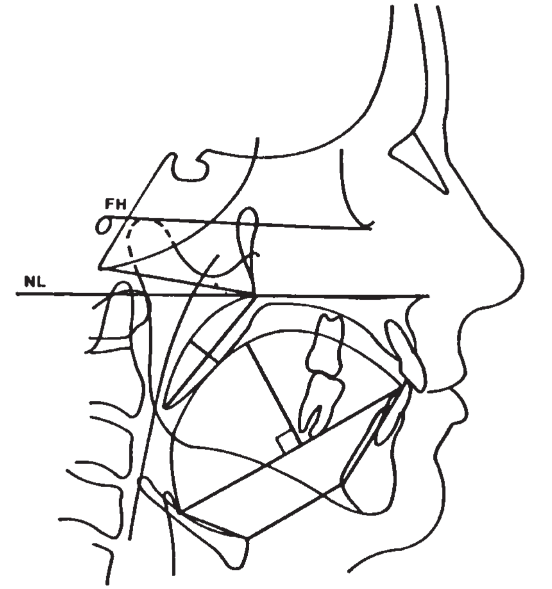

Figure 2 Reference lines used in this study: FH, Frankfort horizontal line; NL, nasal line. Tongue area: the outline of the tongue from V through H to T, and the lines to GE, AH, and back to V (Lyberg *et al.*, 1989b, published with permission of the *Journal of Laryngology and Otology*).

Linear measurements

pm–U The line between pterygomaxillare (pm) and tip of the uvula (U), representing the long axis and the length of the soft palate.

V–T The distance from V to T, representing the tongue length.

H⊥VT The perpendicular distance from H to the line connecting V and T, representing the tongue height.

pm–UPW The distance from pm to UPW, representing the nasopharyngeal airway space.

U–MPW The distance from U to MPW, representing the oropharyngeal airway space.

V–LPW The distance from V to LPW, representing the hypopharyngeal airway space.

PASmin The minimal distance between the base of the tongue and the posterior pharyngeal wall, representing the minimal pharyngeal airway space.

SPT The maximal thickness of the soft palate measured perpendicular to the pm–U line.

V⊥FH The perpendicular distance from V to FH, representing the vertical position of vallecula.

V–C3 The distance from V to the third cervical vertebra (C3), measured parallel to FH, representing the horizontal position of vallecula.

Angular measurements

pm–U/NL The inclination of the long axis of the soft palate relative to the nasal line (NL).

V–T/FH The inclination of the long axis of the tongue relative to the Frankfort horizontal (FH).

Area measurements

TA Tongue area, the upper outline was defined by the dorsal contour of the tongue from V through H to T. The lower outline was reduced to a geometric polygon of which the boundary was defined by line segments connecting the following points: V, AH, GE, and T.

SPA Soft palate area: the outline was defined along the anterior and posterior contour of the soft palate, the superior border was a line through pterygomaxillare (pm) perpendicular to the pm–U line.

OA Oral area, including the tongue area (TA) and extending superiorly to the outline of the soft and hard palate.

OPA Oropharyngeal area, including the oral area (OA), the soft palate area (SPA), and the area defined by the points pm, UPW, LPW, and V along the posterior pharyngeal wall, and the dorsal outline of the tongue.

Ratios

TA/OA A relationship between the tongue area (TA) and the oral area (OA).

(TA + SPA)/OPA
A relationship between the tongue (TA), the soft palate area (SPA), and the oropharyngeal area (OPA).

SPA/(OPA–OA)
A relationship between the soft palate area (SPA) and the residual pharyngeal area.

Reliability

All the lateral cephalograms were traced twice by hand on acetate tracing paper and digitized twice using the Dentofacial Planner computer program (Dentofacial Software Inc., Toronto, Canada) on an IBM 286/AT desktop computer. If the difference exceeded 1 mm or 1 degree, a third measurement was taken and the middle value of the two nearest measurements was used (Slagsvold, 1969).

Statistics

All the statistical procedures were performed by using the Minitab computer program. The comparison of the means was obtained with the level of significance by using a two-tailed paired Student's *t*-test, except for the comparison between sexes, in which an unpaired Student's *t*-test was used.

Results

Soft tissue morphology

Soft palate. The length (pm–U) and thickness (SPT) of the soft palate increased during the observation time for both sexes (Tables 1 and 3). The increase in length was highly significant when T0 was compared with T2 ($P < 0.001$) for both genders. Linear increase in thickness was significant between T0 and T1 ($P < 0.05$), and highly significant between T0 and T2 ($P < 0.001$) for both males and females (Tables 2 and 4). Consequently, due to increased length and thickness the sagittal area of the soft palate (SPA) was larger, and occupied more of the pharyngeal area (SPA/OPA–OA) in both genders, being significant at the 0.1 per cent level in men and at 1 per cent in females (Tables 2 and 4). In males, changes in SPA were found to be significant at all age levels (T0–T1, $P < 0.05$; T1–T2, $P < 0.05$; T0–T2, $P < 0.001$), but for the females the changes were significant only between T0 and T2 ($P < 0.01$; Tables 2 and 4). Another finding was that the posture of the soft palate (NL/pm–U) became significantly more upright with age between T0 and T2 in males ($P < 0.01$) and in females ($P < 0.05$; Tables 2 and 4).

Tongue. The cephalometric measurements for the tongue are shown for men in Table 1 and for females in Table 3. Tongue length (V–T) was found to remain almost unchanged, but the height of the tongue (H–VT) showed an increase at ages T1 and T2 (Tables 1 and 3). This increase was significant ($P < 0.05$) when T0 was compared with T2 (Tables 2 and 4) for both genders. An additional finding was that the sagittal area of the tongue (TA) did not increase between T0 and T1, but did so from T1 to T2 for both

Table 1 Males: cephalometric variables of uvulo-glossopharyngeal morphology and area measurements. Values are given in degrees, millimetres, and square centimetres.

	Initial (T0) (n = 26)		1st follow-up (T1) (n = 16)		2nd follow-up (T2) (n = 26)	
	Mean	SD	Mean	SD	Mean	SD
Soft palate						
pm–U (mm)	36.73	4.82	37.02	4.08	39.26	4.91
SPT (mm)	11.03	2.08	11.99	1.68	12.36	2.38
pm–U/NL (°)	123.41	5.84	121.87	5.73	119.94	5.31
Tongue						
V–T (mm)	77.33	5.13	77.48	5.01	77.62	5.15
H–VT (mm)	37.88	5.07	38.98	3.42	40.33	3.64
V⊥FH (mm)	94.37	4.85	97.38	4.85	99.77	4.55
V–C3 (mm)	26.81	5.28	26.31	4.08	25.4	3.37
VT/FH (°)	30.35	4.99	35.00	5.08	36.86	5.21
Pharynx						
pm–UPW (mm)	27.44	3.26	26.98	2.59	26.75	3.31
U–MPW (mm)	14.43	3.04	13.31	2.34	11.55	2.85
V–LPW (mm)	20.31	3.45	21.15	3.35	21.25	3.23
PASmin (mm)	14.80	4.38	12.76	3.70	10.34	3.02
Area measurements						
TA (cm^2)	34.47	3.34	34.45	3.00	35.75	3.29
SPA (cm^2)	2.78	0.51	2.85	0.59	3.30	0.74
OA (cm^2)	37.69	2.80	37.25	2.99	38.88	2.98
OPA (cm^2)	53.35	3.69	52.33	3.83	53.47	3.89
Ratios						
TA/OA	0.91	0.06	0.92	0.30	0.92	0.04
(TA + SPA)/OPA	1.35	0.08	1.37	0.04	1.39	0.06
SPA/(OPA–OA)	0.18	0.04	0.19	0.04	0.23	0.05

genders (Tables 1 and 3). The changes, however, reached a statistically significant level only in males from T0 to T2 ($P < 0.001$). In both sexes, the vallecula (V) was found to be located more inferiorly (V⊥FH) with age, implying that the mass of the tongue extends caudally towards the lower part of the pharynx, leading to a more upright position of the tongue (VT/FH) at T1 and T2 (Tables 1 and 3). These changes were highly significant ($P < 0.001$) in both genders (Tables 2 and 4).

Pharynx. The pharyngeal airway space was measured at the level of the nasopharynx (pm–UPW), oropharynx (U–MPW), and hypopharynx (V–LPW). At the nasopharyngeal and hypopharyngeal level no significant changes were observed, whereas the airway space at the oropharyngeal level decreased with increasing age for both males and females (Tables 1 and 3). The changes were significant for all age groups in males reaching the 0.1 per cent level between T0 and T2 (Table 2). In females, the differences were significant between T0–T1 ($P < 0.05$) and T0–T2 ($P < 0.001$; Table 4). In addition, the minimal distance between the base of the tongue and the posterior pharyngeal wall (PASmin) was shown to decrease, the difference being significant at the 5 per cent level, when T0 was compared with T1, and highly significant ($P < 0.001$) between T0 and T2 for both genders (Tables 2 and 4). Furthermore, due to the increased sagittal area of the tongue (TA) and soft palate (SPA), the ratio TA + SPA/OPA was increased ($P < 0.05$) from T0 to T2 in both genders (Tables 2 and 4). The ratio SPA/OPA–OA increased with age, and the differences were highly significant ($P < 0.001$) between T0 and T2 in males (Table 2), and significant ($P < 00.1$) in females (Table 4).

Table 2 Males: mean differences and *t*-values between T0, T1, and T2.

	T0–T1 (*n* = 16)		T1–T2 (*n* = 16)		T0–T2 (*n* = 26)	
	Diff. of means	*t*-value	Diff. of means	*t*-value	Diff. of means	*t*-value
Soft palate						
pm–U (mm)	–1.02	1.02	–2.05	1.69	–2.52	5.02***
SPT (mm)	–1.41	2.31*	–0.24	0.44	–1.33	3.24**
pm–U/NL (°)	2.54	1.60	1.78	1.31	3.46	2.80**
Tongue						
V–T (mm)	0.45	0.87	0.20	0.13	0.29	0.25
H–VT (mm)	–0.48	0.58	–0.85	0.90	–2.45	2.42*
V⊥FH (mm)	–3.25	2.07*	–2.61	3.02**	–5.4	6.55***
V–C3 (mm)	0.94	1.43	0.30	0.32	1.41	1.57
VT/FH (°)	–4.41	3.31**	–2.84	2.59*	–6.51	7.13***
Pharynx						
pm–UPW (mm)	0.97	1.57	0.09	0.14	0.68	1.21
U–MPW (mm)	1.44	2.66*	1.64	2.20*	2.88	4.24***
V–LPW (mm)	–0.93	0.72	–0.54	0.61	–0.94	1.13
PASmin (mm)	2.27	2.07*	2.05	1.93	4.46	4.40***
Area measurements						
TA (cm^2)	–0.01	0.01	–0.86	1.74	–1.28	4.27***
SPA (cm^2)	–0.25	2.38*	–0.28	2.59*	–0.58	4.39***
OA (cm^2)	–0.16	0.43	–1.19	3.77**	–1.19	3.70**
OPA (cm^2)	0.26	0.31	–0.94	1.30	–0.12	0.16
Ratios						
TA/OA	0.002	0.16	0.006	0.44	–0.0042	0.46
(TA + SPA)/OPA	–0.010	0.49	–0.015	1.21	–0.0414	2.34*
SPA/(OPA–OA)	–0.021	1.74	–0.0197	1.76	–0.0459	5.84***

Level of significance: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Inter-sex differences

Table 5 shows the statistically significant differences between males and females, when comparing the changes in the two genders between the initial observation (T0) with the second follow-up (T2). These differences were significant at the 5 per cent level and apply to the vertical position of vallecula (V⊥FH), the inclination of the tongue (V–T/FH), the minimal pharyngeal airway space (PASmin), tongue area (TA), and the soft palate area (SPA).

Discussion

Research of the upper airway frequently involves cephalometric measurements of soft tissue structures, such as the tongue and soft palate (Lyberg *et al.*, 1989b; Shen *et al.*, 1994). It is also known that the largest source of error of measurements on cephalograms is landmark identification (Houston, 1987), so it is logical that tracing of soft tissue landmarks should be questioned for reliability. Cohen and Vig (1974) demonstrated that the tongue area was not critically dependent on precise positional standardization, provided that the mandible lay between an envelope bounded by rest position, centric occlusion, and edge-to-edge position. More recently, Miles *et al.* (1995) investigated the reliability of landmarks and outlines of airway structures, which are commonly used in cephalometric airway research. They concluded that cephalometric measurements, such as the thickness of the soft palate (SPT), the minimal pharyngeal airway space (PASmin), and the hyoid bone position could be reliably identified, irrespective of the quality of the radiograph or of the individual tracing of the radiograph.

In this study, all precautions were taken to obtain a cephalogram of high quality. This

Table 3 Females: cephalometric variables of uvulo-glossopharyngeal morphology and area measurements. Values are given in degrees, millimetres, and square centimetres.

	Initial (T0) (*n* = 24)		1st follow-up (T1) (*n* = 13)		2nd follow-up (T2) (*n* = 24)	
	Mean	SD	Mean	SD	Mean	SD
Soft palate						
pm–U (mm)	34.54	4.27	36.48	4.54	37.12	3.37
SPT (mm)	9.47	0.85	10.20	1.25	10.86	1.76
pm–U/NL (°)	128.12	6.24	127.07	5.30	125.19	5.78
Tongue						
V–T (mm)	70.75	5.68	70.65	5.11	70.49	5.12
H–VT (mm)	34.66	3.28	35.18	2.77	36.15	2.86
V⊥FH (mm)	82.17	6.04	81.6	4.35	84.97	5.45
V–C3 (mm)	23.19	4.40	22.73	3.19	22.56	2.77
VT/FH (°)	27.01	4.76	27.81	3.21	31.43	5.59
Pharynx						
pm–UPW (mm)	28.12	2.66	28.10	1.53	27.27	2.09
U–MPW (mm)	12.65	2.62	10.94	2.25	9.95	1.99
V–LPW (mm)	18.06	2.95	17.94	2.65	17.85	2.73
PASmin (mm)	12.12	3.65	9.825	2.82	8.91	2.49
Area measurements						
TA (cm^2)	29.07	2.48	28.50	2.78	29.55	2.61
SPA (cm^2)	2.31	0.34	2.38	0.27	2.56	0.38
OA (cm^2)	30.92	2.64	30.69	2.49	31.66	2.85
OPA (cm^2)	42.83	4.11	41.44	3.42	42.72	3.90
Ratios						
TA/OA	0.94	0.03	0.92	0.04	0.93	0.05
(TA + SPA)/OPA	1.40	0.06	1.43	0.06	1.43	0.06
SPA/(OPA–OA)	0.19	0.04	0.22	0.04	0.23	0.04

included an optimal adjusted KVP (kilovoltage peak), as well as a high quality intensifying screen with grids. All the cephalograms were traced twice by hand and digitized twice using the Dentofacial planner. If the difference between two measurements exceeded 1 mm or 1 degree, a third measurement was taken and the middle value of the two nearest was used (Slagsvold, 1969). Few adjustments were necessary, indicating an adequate measure of reliability.

Clearly, there is an increasing trend throughout this 20-year period, in length (pm–U), width (SPT), and area (SPA) of the soft palate (Tables 1 and 3). This increase was found to be significant for both sexes when the initial observation (T0) was compared with the second follow-up (T2; Tables 2 and 4, Figure 3). Due to increased area, the soft palate occupied more of the pharyngeal area (SPA/OPA–OA) and, in addition, it was found to be in a more upright position (pm–U/NL) with increasing age in both genders. The only significant difference between sexes was the increase in soft palate area, which was found to be larger ($P < 0.05$) in the male group (Table 5, Figure 4).

Taylor *et al*. (1996) recorded changes in the soft tissues of the pharynx longitudinally in children every 3 years from 6 to 18 years of age. They found, not surprisingly, in this age span, an increase in thickness and length of the soft palate in all periods. According to the present study, this trend is likely to continue beyond the age of 18. Maltais *et al*. (1991) found that soft palate length was larger not only in snorers and patients with OSA, but also in the older in comparison to the younger control group. They therefore assumed that this measurement is likely to be influenced by age.

Similar changes are also demonstrated for most of the linear and angular tongue measurements

Table 4 Females: mean differences and *t*-values between T0, T1, and T2.

	T0–T1 (n = 13)		T1–T2 (n = 13)		T0–T2 (n = 24)	
	Diff. of means	*t*-value	Diff. of means	*t*-value	Diff. of means	*t*-value
Soft palate						
pm–U (mm)	–2.71	1.85	–1.22	0.95	–2.47	4.53***
SPT (mm)	–1.11	2.55*	0.12	0.53	–1.39	3.79***
pm–U/NL (°)	0.94	0.88	2.66	2.29*	2.93	2.69*
Tongue						
V–T (mm)	0.35	0.42	0.85	0.92	0.26	0.75
H–VT (mm)	–1.67	1.72	–1.63	1.93	–1.49	2.41*
V⊥FH (mm)	–2.01	1.86	–1.88	2.03*	–2.8	4.42***
V–C3 (mm)	0.83	1.45	0.13	0.15	0.62	0.79
VT/FH (mm)	–3.30	3.09**	–2.76	3.10**	–4.42	5.24***
Pharynx						
pm–UPW (mm)	–0.18	0.32	0.75	1.58	0.85	1.70
U–MPW (mm)	2.07	2.66*	1.19	1.78	2.70	5.22***
V–LPW (mm)	–0.21	0.22	0.32	1.58	0.21	0.33
PASmin (mm)	2.70	2.09*	1.68	1.98	3.20	4.01***
Area measurements						
TA (cm^2)	–0.02	0.04	–0.84	1.80	–0.48	1.48
SPA (cm^2)	–0.12	1.26	–0.10	1.15	–0.25	3.92***
OA (cm^2)	–0.24	0.79	–0.67	1.71	–0.74	2.52*
OPA (cm^2)	0.77	1.38	–0.46	0.74	0.11	0.24
Ratios						
TA/OA	0.007	0.77	–0.01	0.63	0.006	0.80
(TA + SPA)/OPA	–0.030	1.38	–0.02	1.35	–0.031	2.43*
SPA/(OPA–OA)	–0.027	1.61	–0.01	1.71	–0.036	3.59**

Level of significance: *P < 0.05; **P < 0.01; ***P < 0.001.

Table 5 Statistically significant inter-sex differences. The means are in millimetres, degrees, and square centimetres for linear, angular, and area measurements, respectively.

	Mean females (n = 24) (T0–T2)	Mean males (n = 26) (T0–T2)	Mean difference	*t*-value
V⊥FH (mm)	–2.80	–5.40	2.60	2.63*
VT/FH (°)	–4.42	–6.51	2.09	2.23*
PASmin (mm)	3.20	4.46	1.25	2.15*
TA (cm^2)	–0.48	–1.28	0.80	2.35*
SPA (cm^2)	–0.25	–0.58	0.33	2.17*

Level of significance: *P < 0.05.

(Tables 2 and 4) both in males and females. The mass of the tongue seems to extend caudally towards the lower part of the pharynx expressed by a lower level of the vallecula (V⊥FH) with increasing age (Figure 5). The caudally-extended tongue corresponds to the lower position of the hyoid bone reported previously (Kollias and Krogstad, 1999). The tongue in both sexes assumed a significantly more upright position (V–T/FH) in the older groups. It is interesting to note that, despite the similar trends for both genders, the magnitude of the changes is larger in men when the changes between sexes are compared (Table 5). Another interesting point is that

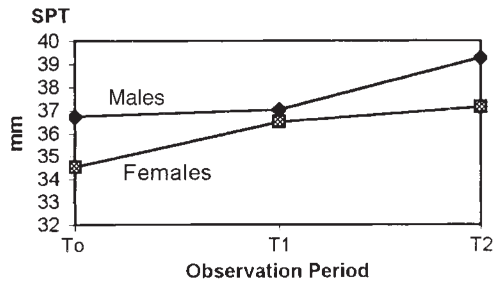

Figure 3 Soft palate length (SPT) for males and females.

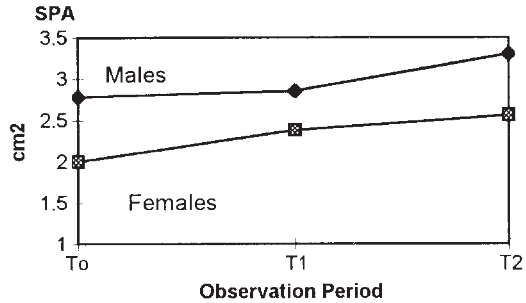

Figure 4 Soft palate area (SPA) for males and females.

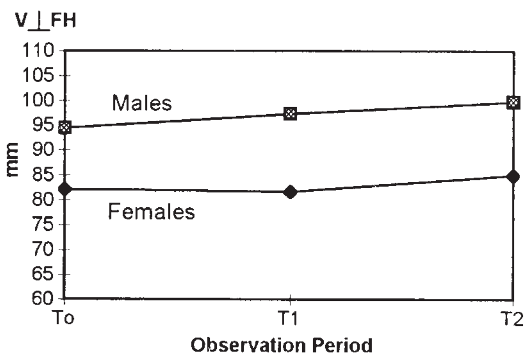

Figure 5 Vertical position of vallecula (V⊥FH) for males and females.

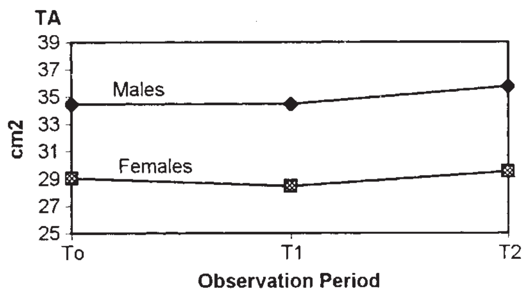

Figure 6 Tongue area (TA) for males and females.

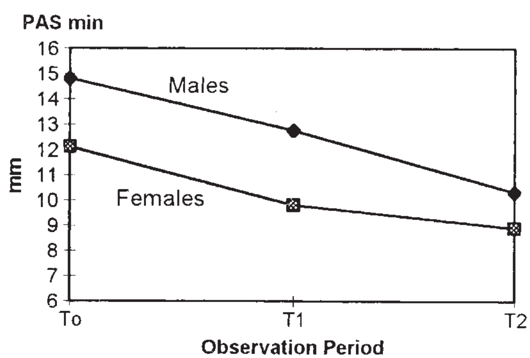

Figure 7 Minimal pharyngeal space (PAS min) for males and females.

tongue area (TA) increased with age at a significant level only in the male group (Figure 6). These findings are in agreement with Cohen and Vig (1976), who found that there is an increase in tongue size, especially in males, and that the tongue assumes a lower position with age.

The nasopharyngeal space (pm–UPW) remains almost unchanged throughout the period of this study for both males and females. This is in accordance with Tourne (1991), who concluded that adult nasopharyngeal depth dimensions are established early in life and that there is little change until maturity. Taylor *et al.* (1996) in their retrospective longitudinal cephalometric study found that nasopharyngeal airway space increased during the periods 6–9 and 12–15 years of age, but thereafter remains rather stable. Another interesting finding in the present study is that for both sexes there was a significant decrease with age in the oropharyngeal airway space (U–MPW), as well as in the minimal pharyngeal airway space (PASmin). For the latter variable, the difference between sexes was significant (Figure 7). This finding is in agreement with Bench (1963), who investigated pharyngeal cross-sectional area in men and women. He utilized the acoustic reflection technique and found that, in males, pharyngeal area reduces with age.

Cephalometric analysis is one of the most commonly accepted techniques for the evaluation of the upper airway in normal individuals and also in OSA patients during the awake period (Zucconi *et al*., 1993). Cephalometry is a relatively inexpensive method and permits a good assessment of soft tissue elements that define the upper airway (Shepard *et al*., 1991). Strelzow *et al*. (1988) found that measurements of soft palate length, width, and area, as well tongue area, were the best discriminants of apnoea severity. Djupesland *et al*. (1987) reported similar findings, suggesting that changes in the soft tissues may be more important than those in the skeletal structures in the majority of OSA patients. It has also been shown that the prevalence of sleep-disordered breathing events increases in adult males (Carskadon and Dement, 1981; Smallwood *et al*., 1983; Bliwise *et al*., 1984). One possible explanation could be age-related changes in upper airway size, a hypothesis that is confirmed in the present study regarding uvulo-glossopharyngeal morphology. Despite similar trends of morphological changes, both in males and females, more pronounced alterations were found in the male group. These findings cannot explain the occurrence of OSA, but may help in a better understanding, both in the age-related changes and the gender difference.

Another implication of the present findings may be that future comparative studies between OSA and normal individuals should validate the control group selected in order to match it with patient group for age and sex. This is because a control group is of major importance in the interpretation of the results especially in this field of research.

Conclusions

The findings in this study support the hypothesis that there are alterations in uvulo-glossopharyngeal morphology during adulthood. The main conclusions are:

1. An increase in soft palate length, thickness, and sagittal area were common findings for both genders with increasing age. The increase in soft palate area was significantly higher in men.
2. A more upright tongue position and caudally-extended tongue mass toward the lower part of the pharynx was found in both sexes with age. This trend was significantly more pronounced in men. In addition, the sagittal area of the tongue was found to increase only in men.
3. A decrease in sagittal dimension of oropharynx, and at the minimal distance between the base of the tongue and the posterior pharyngeal wall was found in both males and females. For the latter measurement, the decrease was significantly higher in men.

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