ORIGINAL ARTICLE

The influence of the lateral pharyngeal wall anatomy on snoring and sleep apnoea

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Abstract

Objectives: To elucidate the variations of the lateral pharyngeal wall anatomy on physical examination and to assess the clinical importance of the examination of the lateral pharyngeal wall on the presence and severity of obstructive sleep apnoea syndrome.

Methods: The cross-sectional study was conducted at Ege University Medical School, Izmir, Turkey, between May 2010 and April 2011. The patients were divided into four equal groups: Group 1 - snoring without apnoea (age 20-40); Group 2 - snoring without apnoea (age 40-60); Group 3 - apnoea-hypopnoea index <5/hr; Group 4: apnoea-hypopnoea index >30/hr. Calibrated oropharynx pictures were taken. Distance between palatoglossal and palatopharyngeal arches, height of palatoglossal and palatopharyngeal arches, uvula width, uvula length and distance between tonsils were measured. SPSS 17 was used for statistical analysis.

Results: Of the 80 patients in the study, 44(55%) were men. Mean distance between palatopharyngeal and palatoglossal arches were 1.55±0.34cm and 2.70±0.43cm respectively. Mean height of palatopharyngeal and palatoglossal arches were 0.60±0.21cm and 1.37±0.36cm respectively (p>0.05). Mean uvula width and uvula length were 0.80±0.12cm and 1.25±0.27cm respectively (p>0.05). Mean distance between tonsils was 2.24±0.56cm (p>0.05). Distance between palatopharyngeal arches was significantly different between groups 3 and 4 (p<0.05).

Conclusions: Palatopharyngeal arch anatomy was found to be significantly associated with obstructive sleep apnoea syndrome severity, especially in patients with normal or small tonsil size. Patients with the palatopharyngeal arches, which narrow the oropharyngeal inlet more than the tonsils, should further be investigated with polysomnography.

Keywords: Sleep apnoea, Oropharynx, Grading, Anatomy. (JPMA 65: 125; 2015)

Introduction

The importance of sleep disorders and related diseases have increased in the last 10 years. Obstructive sleep apnoea syndrome (OSAS) is by far the leading one.[1] It may predispose or worsen many major health problems.[2] OSAS is characterised by recurrent narrowing or obstruction of the upper airway and may cause cardiac and metabolic consequences as well as neurocognitive deterioration and decrease in life quality.[3] Positive airway pressure (PAP) is the most effective therapy for OSAS, but lifestyle alterations, intraoral devices and surgery are needed in most cases.[3]

Selection of the appropriate patient and the most suitable surgical procedure are the most important points in successful surgical management. Therefore, clinical evaluation of patients and examination of oropharynx and soft palate are very important before surgery.[4] There are some classifications for describing the individual anatomy of soft palate and oropharynx. Soft palate position was previously described, but it was found unsatisfactory in the management of OSAS and was subsequently revised.[5-8] The revised version has certain benefits and better predictive value, but it is far from being sufficient in most cases, especially for the selection of appropriate surgical procedure.[8,9]

There are other parameters not stressed in present classifications or scoring systems that might be used for better describing the three-dimensional (3D) anatomy of oropharynx and soft palate. There is very little information about the palatopharyngeal (PP) and palatoglossal (PG) arches, their relations with each other, with posterior wall of pharynx and with the opposite ones. In pre-operative evaluation, tonsil size, soft palate position, length of uvula and tongue base hypertrophy are stressed much more than the PP and PG arches which form significant part of the lateral pharyngeal wall. However, there are many surgical procedures which focus on the lateral pharyngeal wall.

The current study was planned to elucidate variations of the lateral pharyngeal wall anatomy on physical examination, and to assess the clinical importance of the examination of the lateral pharyngeal wall on OSAS presence and severity.

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Patients and Methods

The cross-sectional study was conducted at Ege University Medical School, Izmir, Turkey, between May 2010 and April 2011, after getting approval from the institutional review board and informed consent from all the subjects.

Patients referred to the Otolaryngology and Sleep Laboratory of the Chest Diseases Department were included in the study using stratified sampling technique. Those already on PAP therapy were excluded and so were those with previous tonsillectomy or soft palate surgery, those with grade 3-4 tonsil hypertrophy, patients using intraoral devices, and patients with significant pharyngeal (gag) reflex.

Patients selected were divided into four equal groups. Group 1 had patients referred with snoring and without witnessed apnoea symptom and between ages 20-40; Group 2 had the same characteristics except the age range which was 40-60 years. Group 3 had patients with witnessed apnoea symptom and Apnoea-hypopnoea index (AHI) <5 per hour on polysomnography (PSG). Group 4 had patients with AHI>30/hr on PSG.

After taking detailed history from all patients, systemic and otorhinolaryngological physical examinations were performed. Body mass index (BMI) was calculated for all patients and 1cm-long paper strips were prepared and sterilised for application to the soft palate of patients for calibration. When tongue was in its normal anatomic position, strips were applied horizontally to the base of uvula on the soft palate. After application of the strips, video was captured with 0 degrees rigid endoscopes with an endoscope-compatible camera while patients were breathing through their mouths (Figure-1) in the normal sitting position. Multiple screenshots (more than 10) were taken from each patient's video, because soft palate has a very dynamic anatomy. One picture which had the least muscular tension and best reflected the sleep position was selected and used for metric measurements. All applications, video recordings, screenshot selections and measurements were performed by the same physician.

For metric measurements Universal Desktop Ruler version 3.5 software was used. Calibration was done with previously applied 1cm long strips. Since this region of oropharynx has many variations and asymmetries, measuring may be subjective and standardisation may be very difficult. In order to overcome the issue, we took three distinct measures for each parameter and averaged them to determine one measure. Distance between PG and PP arches, height of PG and PP arches, uvula width (UW), uvula length (UL) and distance between tonsils (DBT) were measured (Figure-2).

Distance between arches was measured on three different points from apex (minimum distance) to the widest part (maximum distance). One of the measured points was on the apex, one was on the widest part and one was on the middle. The three measures were averaged in all patients and distance between PG and PP arches were determined. Similarly, height of the arches was measured from these same three distinctly determined points from apex (maximum height) to the most lateral part (minimum height) and averaged. Height was determined as the distance from tongue to the measured point. DBT was also calculated by the same method. Distance was measured from three points and then averaged. One was the minimum distance point, one was the maximum distance point and one was on the middle of these two points.

UW was calculated likewise: at the base, at the tip and at the middle. Results were averaged and one value was determined.

Group 3 and group 4 patients underwent full overnight in-laboratory PSG (Compumedics E Series, Australia or Alice 5 Diagnostic Sleep System, Philips, Respironics, USA). Electroencephalography (EEG) electrodes were positioned according to the international 10-20 system. PSG consisted of monitoring of sleep by EEG, electrooculography (EOG), electromyography (EMG), airflow, and respiratory muscle effort, and included measures of electrocardiographic (ECG) rhythm and blood oxygen saturation. Thoracoabdominal plethysmograph, oro-nasal temperature thermistor and nasal-cannula-pressure transducer system were used to identify apnoeas and hypopnoeas. Transcutaneous finger pulse oximetre was used to measure oxygen saturation. Sleep was recorded and scored according to the standard method.[10] AHI was the sum of the number of apnoeas and hypopnoeas per hour of sleep. OSAS was defined as an AHI of 5 events/h and the presence of clinical symptoms e.g. excessive daytime sleepiness, loud snoring, witnessed apnoeas and nocturnal choking or AHI of 15 events/h without any OSAS symptoms.[11]

SPSS 17.0 was used for statistical analaysis. Independent samples t-test, one-way analysis of variance (ANOVA), Bonferroni and Dunnet T3 tests for post-hoc analysis, and Pearson correlation analysis were used. Measures were further analysed and adjusted for gender, age and BMI.

Results

Of the 80 patients in the study, 44(55%) were men. Overall mean age of patients was 45.5±11.6 years. Mean BMI was

Table-1: Measurements.

Group		DPP* p<0.05±,3427	DPG* p>0.05±,4332	UW* p>0.05±,1296	PPH* p>0.05±,2185	PGH* p>0.05±,3627	UL* p>0.05±,2726	DBT* p>0.05±,5615
1	Mean	1.54	2.71	0.74	0.61	1.3	1.19	2.14
	Minimum	0.88	1.89	0.57	0.39	0.71	0.71	1.01
	Maximum	2.17	3.17	0.98	0.81	1.83	1.8	2.85
2	Mean	1.54	2.69	0.8	0.59	1.26	1.14	2.3
	Minimum	1.24	2.17	0.58	0.23	0.72	0.84	1.49
	Maximum	2.38	3.48	0.98	1.2	2.25	1.43	3.22
3	Mean	1.73	2.82	0.82	0.58	1.47	1.35	2.47
	Minimum	1.32	2.04	0.6	0.23	0.76	0.62	1.57
	Maximum	2.13	3.92	1.09	1	2.15	1.98	3.84
4	Mean	1.38	2.59	0.85	0.63	1.45	1.31	2.05
	Minimum	0.58	1.51	0.54	0.36	0.65	0.84	0.67
	Maximum	1.88	3.22	1.09	1.43	2.23	2.06	3.23
Overall	Mean	1.55	2.7	0.8	0.6	1.37	1.25	2.24
	Minimum	0.58	1.51	0.54	0.23	0.65	0.62	0.67
	Maximum	2.38	3.92	1.09	1.43	2.25	2.06	3.84

*DPP: Distance between palatopharyngeal arches, DPG: Distance between palatoglossal arches, UBW: Uvula width, PPH: Palatopharyngeal height, PGH: Palatoglossal height, UL: Uvula length, DBT: Distance between tonsils.

Table-2: Combined grading method.

Grade	Description
0	Previous tonsillectomy (fibrotic palatopharyngeal arches)
1	Tonsils or palatopharyngeal arches narrow the oropharyngeal inlet less than 25%
2	Tonsils or palatopharyngeal arches narrow the oropharyngeal inlet between 25% and 50%
3	Tonsils or palatopharyngeal arches narrow the oropharyngeal inlet between 50% and 75%
4	Tonsils or palatopharyngeal arches narrow the oropharyngeal inlet more than 75%

Table-3: Distribution of the groups according to the combined grading method.

Group		Grade 1	Grade 2	Grade 3
1	N	2	15	3
	%	2.5	18.8	3.8
2	N	1	15	4
	%	1.3	18.8	5
3	N	2	16	2
	%	2.5	20	2.5
4	N	0	13	7
	%	0	16.3	8.8
Overall	N	5	59	16
	%	6.3	73.8	20

28.69±5.98kg/m2. There wasn't any statistically significant difference among the groups (p>0.05), but apnoea-positive Groups 3 and 4 had significantly higher BMI scores than apnoea-negative Groups 1 and 2 (p<0.05). Mean AHI was 1.76±1.26/hour and 57.41±19.68/hr in groups 3 and 4 respectively. When comorbidities were taken into consideration, only hypertension incidence was found to be significantly higher in the groups 3 and 4 (p<0.002).

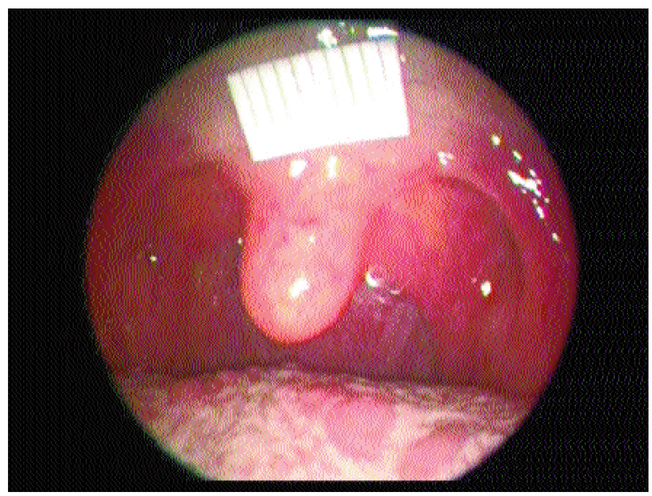

Figure-1: A screenshot from endoscopic video of a patient which shows the one cm long strip.

Mean distance between PP and PG arches were 1.55±0.34cm ((range: 0.58-2.38cm) and 2.70±0.43cm (range: 1.51cm-3.92cm) respectively (p<0.05). Mean height of PP and PG arches were 0.60±0.21cm (range:

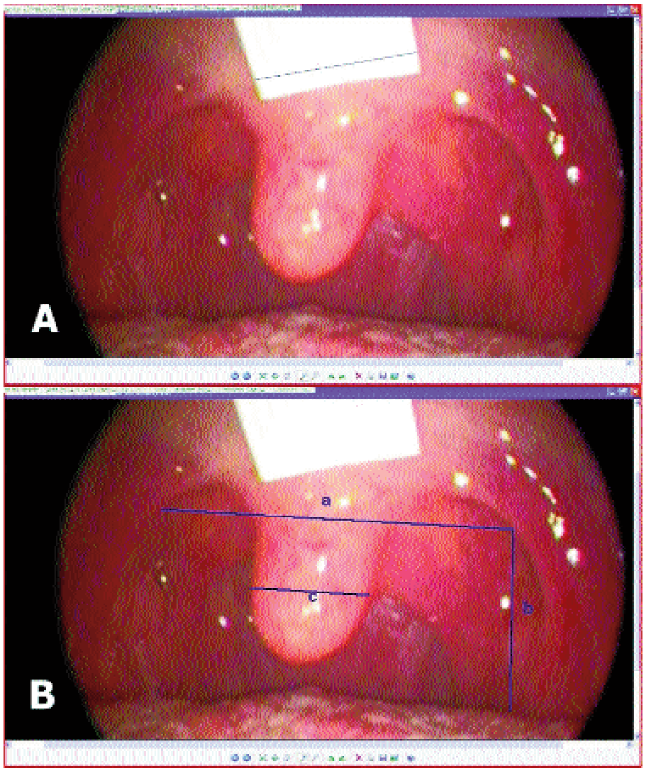

Figure-2: A) Measurement of the strip for calibration. B) A screenshot showing one of the measured points for distance between palatoglossal arches (a), the height of the palatoglossal arches (b), and the uvula width (c).

0.23cm-1.43cm) and 1.37±0.36cm (range: 0.65cm-2.25cm) respectively ($p>0.05$). Mean UW and UL were 0.80±0.12cm (range: 0.54cm-1.09cm) and 1.25±0.27cm (range: 0.62cm-2.06cm) ($p>0.05$). Mean DBT was 2.24±0.56cm (range: 0.67cm-3.84cm) ($p>0.05$). Distance between palatopharyngeal arches was significantly different between groups 3 and 4 ($p<0.05$) (Table-1).

There was no significant correlation between BMI and soft palate measurements ($p>0.05$). Similarly, there was no significant correlation between DPP and PPH, or between DPG and PGH ($p>0.05$).

Discussion

Sleep disorders together represent a spectrum of diseases which yields from mild and intermittent snoring to severe OSAS, affected by many parameters like weight, upper airway anatomy, sleep position, life habits and comorbids. There are many shortcomings in the management of sleep disorders, especially in the surgical management. There are many questions yet to be identified. For example, which patients should undergo PSG? Is witnessed apnoea enough to refer patients for PSG? What are the other clinical parameters that may help to predict OSAS severity or refer patients to PSG?

When oropharyngeal inlet is considered, it has distinct anatomical structures which are tonsils, PG and PP arches, uvula and tongue base. Lateral wall of pharyngeal inlet which was sometimes included in the surgical procedures was excluded in the current pre-operative classification or scoring systems. The question that inspired the current study was: Which anatomical properties of lateral pharyngeal wall in the physical examination might predict the presence or severity of OSAS or should be addressed in the surgical procedures?

Obesity was found to be more frequent among OSAS patients, similarly OSAS was frequent among obese people.[12,13] BMI was higher in the apnoea-positive Groups 3 and 4 than the apnoea-negative Groups 1 and 2. So, results of this study were not different from studies that have shown the effect of BMI on sleep disorders. There was no BMI difference between Groups 3 and 4. This finding might be due to the small sample size of the study.

There were some new findings of the study which have not been mentioned before in the current English-language medical literature. Distance between PP arches was significantly lower in the severe OSAS Group 4. However, there was no difference between groups for the distance between PG arches. We believe that the difference of DPP was due to the individual anatomical properties of the patients rather than BMI, gender or age. BMI was not significantly different between Groups 3 and 4, but DPP difference was statistically significant. Furthermore, correlation between DPP and BMI was insignificant. The effect of gender and age on the measurements were taken into consideration during the statistical analysis. This is the first study to show that the PP arch anatomy might affect the severity of OSAS. Since grade 3 and 4 tonsil hypertrophy was excluded from the study, DPP should be taken into consideration, especially in patients with normal or small tonsil size. Further studies with bigger sample sizes are warranted to enlighten this association.

There was no significant difference in PPH and PGH between the groups. Although scoring systems and their modified versions are anatomically related to PPH and PGH, but the difference was not significant between the groups.[5,6] The tongue position is very important in these measurements. Scoring systems are relatively more subjective evaluation methods. In order to decrease the subjectivitiy of height measurements of PP and PG arches, we captured endoscopic video of soft palate while the tongue was in its anatomical position. Then we took a screenshot in which the soft palate and the lateral pharyngeal wall were relaxed and represented the best sleep position. The insignificant difference of heights of PP and PG arches between the groups might be attributed to our study design. The importance of the soft palate position was previously studied and found to be related with OSAS severity.[14-17]

Patient selection criteria (only grade 1 and 2 tonsils were included) were also important in the outcome of the study. The effect of UL and UW was insignificant. UW or UL might be important in snoring patients, but it had insignificant importance in the prediction of OSAS severity. Similarly, surgical procedures that focus only to uvula have shown to have limited effect in the management of OSAS.[18]

There are few studies that focus on the structural anatomy of lateral pharyngeal wall. One reported that oropharynx transverse diameter was narrower on both PG and PP arch levels in OSAS patients.[19] This study was performed under general anaesthesia unlike our study. Its clinical value was limited due to the application of general anaesthesia, but similar results were found in our study. Another study suggested a classification for lateral pharyngeal wall anatomy in OSAS patients. It found oropharynx inlet and lateral wall distance to be associated with OSAS.[20] This classification is good for PP arches, but it is unsatisfactory for all components of lateral pharyngeal wall.[21] It has been shown in our study that PP arch seemed to be associated with OSAS in normal tonsil size patients. We believe that combining Friedman's classification with posterior arch anatomy will yield better predictive results in OSAS patients (Table-2). Further studies are needed to investigate this hypothesis. A previous study described that increased volume of the lateral walls on magnetic resonance imaging (MRI) had increased the severity of OSAS.[22] Similarly other studies showed that pharyngeal wall anatomy has an influence on OSAS severity, but their classification was different from ours and relatively more general and subjective.[23-25] Another study found pharyngeal anatomy to be associated with apnoea.[26] We believe that the major difference of our study from the reports mentioned above is that our study is more objective and selective in the evaluation of the lateral pharyngeal wall.

Tonsil size of all patients included in our study was grade 1 or 2. When we re-assessed the patients according to combined grading method, some patients with grade 2 tonsils were upgraded to grade 3, especially in the severe OSAS group (Group 4) (Table-3). The percentage of higher grade patients was higher in Group 4, but this difference was not statistically significant (p>0.05). Though the aim of this study was not to evaluate the clinical value of the combined grading system, we believe that it may be helpful in the management of OSAS patients.

One of the shortcomings of this study might be that PSG was not applied to Groups 1 and 2. The patients in Group 1 and Group 2 did not undergo PSG as the waiting list of the sleep laboratory was quite long and it was very difficult to apply PSG even to patients with obvious OSAS symptoms. However, they were all questioned in detail and none of them had symptoms related to OSAS other than snoring. One may think that measurement method of this study was subjective and imperfect, so results were influenced by this imperfect method. However, physical examination is naturally subjective. Furthermore, soft palate and oropharynx has very dynamic anatomy. One more question that may arise was about the Groups 1 and 2: why they were separated according to age? We had hypothesised that young snoring patients would score better than elder ones in the physical examination of the lateral pharyngeal wall.

Conclusion

Lateral pharyngeal wall is one of the major parts of oropharynx inlet and addressed in most surgical procedures in the management of sleep disorders. Evaluation and grading of the lateral pharyngeal wall during the first visit might have benefits in the selection of the patients for further investigation with PSG or managing with surgery. Distance between PP arches was found to be significantly lower in severe OSAS patients with normal or small tonsil sizes.

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