

The effect of adenotonsillectomy on changes of position during sleep in pediatric obstructive sleep apnea syndrome

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ABSTRACT

Background: It is unknown whether adenotonsillectomy influences changes of position during sleep in children with obstructive sleep apnea syndrome (OSAS). The aim of this study was to evaluate the effect of adenotonsillectomy on changes of position during sleep as determined by polysomnography in children with OSAS.

Methods: Forty-four polysomnograms from 22 children with OSAS were analyzed. We compared the frequency of positional changes during sleep and the distribution of sleep positions before and after adenotonsillectomy.

Results: Adenotonsillectomy significantly improved all respiratory parameters studied. The arousal index and sleep efficiency were improved among the sleep parameters. There was a significant decrease in the total number of positional changes during sleep ($p < 0.001$) and positional change index ($p < 0.001$). The proportion of sleep time spent in the supine position was significantly increased ($p = 0.001$), and the proportions spent in lateral ($p = 0.003$) and up ($p = 0.018$) positions were significantly decreased.

Conclusion: Significant changes were found in the frequency of positional changes during sleep and the distribution of sleep positions in children with OSAS after adenotonsillectomy.

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Key words: Adenoidectomy, arousal, child, obstructive sleep apnea syndrome, sleep, supine position, tonsillectomy

Obstructive sleep apnea syndrome (OSAS) is characterized by frequent episodes of partial or complete upper airway obstruction during sleep. The prevalence of OSAS in children is approximately 2% and OSAS is thought to peak in early childhood because of hypertrophy of the tonsils and adenoids.^{1,2}

The common clinical manifestations of OSAS include nocturnal snoring, observed apnea, restless sleep, adoption of abnormal positions during sleep, and behavioral and learning problems. If OSAS is left untreated, it may lead to severe complications such as cardiovascular and neurobehavioral problems.^{3,4}

The first-line and highly effective treatment for pediatric OSAS is adenotonsillectomy because it is associated with anatomic factors such as adenotonsillar hypertrophy leading to airway collapse during sleep. Respiratory disturbances and various other symptoms improved significantly after adenotonsillectomy in most children with OSAS.⁵

Currently, many studies have reported that adenotonsillectomy leads to changes in the common clinical manifestations, behavior, neurocognition, and quality of life related to pediatric OSAS.⁶ However, little is known about the influence of adenotonsillectomy on the changes of position during sleep in children with OSAS.

We hypothesized that respiratory disturbances and/or arousals are associated with the changes of position during sleep, such as frequency of positional changes and the distribution of sleep position in patients with OSAS. Therefore, the aim of this study was to evaluate the frequency of positional changes during sleep and the distribution of sleep positions as determined by polysomnography in children with OSAS before and after adenotonsillectomy.

MATERIALS AND METHODS

Subjects

The study population included children with symptoms suggestive of OSAS and adenotonsillar hypertrophy. Patients who were diagnosed with OSAS as a result of overnight polysomnographic studies and treated with adenotonsillectomy were enrolled in this study. We performed follow-up polysomnographic evaluations 3 months after surgery. Exclusion criteria included significant medical conditions, genetic or craniofacial syndromes, or neuromuscular disorders.

The diagnostic criterion for OSAS used in this study were obstructive sleep apnea-hypopnea index (AHI) of >1 /hour of total sleep time with symptoms suggestive of OSAS, including snoring and witnessed apnea. Obesity was defined as body mass index greater than the 95th percentile for gender and age.

Twenty-two children aged 3–13 years, with a mean age of 6.6 ± 2.7 years, were included in this study. There were 16 male and 6 female subjects. Mean body mass index was 17.9 ± 2.5 kg/m² and 5 subjects were obese. The study was reviewed and approved by the Institutional Review Board at Ansan Hospital, Korea University.

Polysomnography

All subjects arrived at the Sleep Laboratory around 8:30 P.M., and the sleep studies began between 9:30 and 11:30 P.M. The subjects underwent laboratory-based polysomnographic evaluation with a computerized polysomnographic device (Alice 4; Respironics, Atlanta, GA). Sixteen channels were used to document the following parameters: four channel electroencephalogram, electrooculogram, submental and leg electromyogram, electrocardiogram, airflow at the nose and mouth (thermistor and nasal pressure transducer), chest and abdominal respiratory movement, oxygen saturation (pulse oximetry), snoring microphone, and body position sensor. A sleep technician observed the behavior of the subjects and confirmed their sleep positions using an infrared camera inside the room. All of the sleep studies were manually interpreted by a sleep technician according to the standard pediatric criteria of The AASM Manual for the Scoring of Sleep and Associated Events and were reviewed by certified physicians.⁷

Apnea was defined as the absence of airflow for the duration of at

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Table 1 Sleep and respiratory parameters in children with obstructive sleep apnea syndrome before and after adenotonsillectomy (*n* = 22)

	Before	After	<i>p</i> Value
Sleep parameters			
TST, min	436.3 ± 34.5	445.0 ± 38.5	0.322
Sleep efficiency (%)	91.0 ± 5.2	92.8 ± 5.5	0.031*
Arousal index (events/hr of TST)	19.9 ± 8.6	10.0 ± 4.6	0.000*
Sleep-stage duration (as % of TST)			
Stage N1	9.4 ± 5.1	8.0 ± 6.9	0.381
Stage N2	43.3 ± 7.8	45.8 ± 8.4	0.168
Stage N3 (slow wave sleep)	28.4 ± 9.1	27.8 ± 9.7	0.709
Stage R (REM sleep)	18.0 ± 4.2	18.3 ± 4.3	0.889
Respiratory parameters			
AHI (events/hr of TST)	10.7 ± 11.0	1.1 ± 1.0	0.000*
Obstructive AHI (events/hr of TST)	9.9 ± 10.6	0.4 ± 0.6	0.000*
Apnea index (events/hr of TST)	5.4 ± 8.5	0.8 ± 1.0	0.019*
Obstructive apnea index (events/hr of TST)	4.8 ± 8.1	0.1 ± 0.1	0.000*
Minimal SaO ₂ (%)	81.9 ± 15.8	91.6 ± 2.8	0.004*
Snoring (%)	18.6 ± 18.6	9.3 ± 17.3	0.009*

Data are means ± SD.

**p* < 0.05.

AHI = apnea-hypopnea index; REM = rapid eye movement; TST = total sleep time.

least two breaths, and obstructive apnea was defined as the absence of airflow with continued chest wall and abdominal movement for the same length of time. Hypopnea was defined as a reduction in oronasal flow of ≥50% for the duration of at least two breaths, associated with an arousal, awakening, or desaturation of ≥3%.

The apnea index (AI) was defined as the number of apneas per hour of total sleep time and the AHI was defined as the number of apneas and hypopneas per hour of total sleep time. The obstructive AI was defined as the number of obstructive apneas per hour of total sleep time and the obstructive AHI was defined as the number of obstructive apneas and hypopneas per hour of total sleep time. Central and mixed apnea were included in the AHI and AI, but not in the obstructive AI and AHI. Body positions during sleep were classified into nine types, and these were identified by a body position sensor and technician. Eight sleep positions, *i.e.*, the supine, six lateral (right, supine right, prone right, left, supine left, and prone left), and prone, were classified by 45° ranges. The “up” position was defined as a position 30° above the horizontal plane. Positional changes were defined as changes between these nine body positions. The positional change index (PCI) was defined as the total number of positional changes during sleep per hour of total sleep time, and the proportions of time spent in each sleep position (supine, lateral, prone, and up position) were expressed as percentage of total sleep time.

Statistical Analysis

All of the data obtained in this study are summarized as means ± SD for continuous variables and as frequencies (percent) for categorical variables. The Wilcoxon’s signed-rank test was used to compare sleep, respiratory, and positional parameters before and after adenotonsillectomy. Statistical analysis was performed using SPSS Version 10.0 statistical software (SPSS, Inc., Chicago, IL), and *p* < 0.05 was considered statistically significant.

RESULTS

Sleep and Respiratory Parameters

The sleep parameters before and after adenotonsillectomy are given in Table 1. There was a significant reduction in the arousal index and a significant increase in sleep efficiency after adenotonsillectomy. However, no significant changes were found in total sleep time and the percentages of time spent in stage N1, stage N2, stage N3 (slow

Total number of positional changes

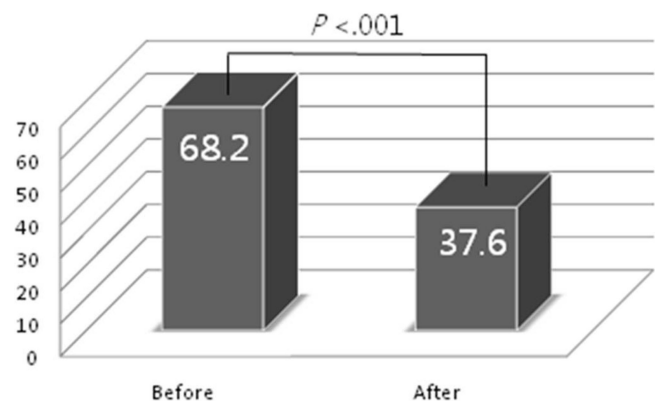


Figure 1. Total number of positional changes during sleep in children with obstructive sleep apnea syndrome before and after adenotonsillectomy (*n* = 22). Total number of positional changes during sleep fell significantly after adenotonsillectomy.

wave sleep), and stage R (rapid eye movement sleep). The respiratory parameters are also presented in Table 1. All of the respiratory parameters (AHI, obstructive AHI, AI, obstructive AI, minimal SaO₂, and snoring) improved significantly after adenotonsillectomy.

Frequency of Positional Changes during Sleep

The frequencies of positional changes during sleep before and after adenotonsillectomy are shown in Figs. 1 and 2. Both total number of positional changes during sleep (from 68.2 ± 41.4 to 37.6 ± 17.5; *p* < 0.001) and PCI (from 9.3 ± 5.4 to 5.1 ± 2.4; *p* < 0.001) declined significantly after adenotonsillectomy.

Distribution of Sleep Positions

The distributions of sleep positions before and after adenotonsillectomy are shown in Table 2. The proportion of sleep time spent in the supine position increased significantly after adenotonsillectomy (from 42.0 ± 12.2% to 56.6 ± 21.7%; *p* = 0.001), whereas the propor-

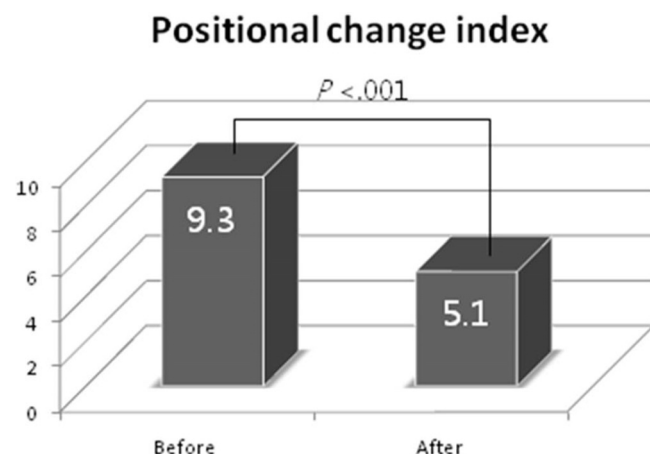


Figure 2. Positional change indices during sleep in children with obstructive sleep apnea syndrome before and after adenotonsillectomy ($n = 22$). The positional change index fell significantly after adenotonsillectomy.

tion of sleep time spent in the lateral (from $53.1 \pm 14.2\%$ to $39.8 \pm 21.6\%$; $p = 0.003$) and up (from $0.3 \pm 1.0\%$ to $0.0 \pm 0.2\%$; $p = 0.018$) positions decreased significantly after adenotonsillectomy. However, the proportion of sleep time spent in the prone position ($4.6 \pm 10.4\%$ before and $3.5 \pm 8.1\%$ after; $p = 0.139$) did not change significantly.

DISCUSSION

This study showed that the frequency of position changes during sleep decreased after adenotonsillectomy in a large percentage of the children (81.8%) with OSAS. The distribution of sleep positions was also changed after adenotonsillectomy. To our knowledge, this is the first study of this aspect of pediatric OSAS.

The exact clinical implications of and the basis for the positional changes during sleep in children with OSAS are unclear. In view of the beneficial effect of adenotonsillectomy on respiratory disturbance and the arousal index of children with OSAS, these results suggest that the respiratory disturbances and/or arousals may be associated with the frequency of positional changes during sleep. It is presumed that respiratory disturbance and/or arousal may lead to discomfort of the patient, which in turn induces positional change to alleviate the discomfort.

At the same time, it seems likely that restless sleep is associated with the frequent positional changes during sleep. Although restless sleep is one of the most common nocturnal manifestations in children with OSAS, it has not been defined or evaluated objectively. Therefore, we propose the PCI (or restless sleep index), *i.e.*, the total number of positional change during sleep per hour of total sleep time, as an objective measure of the frequency of positional changes during sleep, in subjects undergoing polysomnographic examination.

In this study, we also found that the proportion of time spent in the supine position was increased, and the proportion of time spent in lateral and up positions was decreased after adenotonsillectomy in children with OSAS. The reduction in frequency of positional changes during sleep shows that the sleep position is stabilized after adenotonsillectomy, and the increased time sleeping in the supine position suggests that the supine position may be a more comfortable and/or favorable position for breathing.

There were no significant changes in sleep parameters after adenotonsillectomy apart from the arousal index and sleep efficiency; total sleep time and sleep architecture in terms of time spent in stages N1, N2, N3 (slow wave sleep), and R (REM sleep) were unaltered. It has been shown previously that sleep architecture, including slow wave sleep, is well preserved before adenotonsillectomy in children with OSAS.^{8,9}

Most workers have reported that adenotonsillectomy is a highly effective treatment for children with OSAS. We confirmed that there

Table 2 The distribution of sleep position in children with obstructive sleep apnea syndrome before and after adenotonsillectomy ($n = 22$)

Sleep Position	Before	After	<i>p</i> Value
Supine (% of TST)	42.0 ± 12.2	56.6 ± 21.7	0.001*
Lateral (% of TST)	53.1 ± 14.2	39.8 ± 21.6	0.003*
Prone (% of TST)	4.6 ± 10.4	3.5 ± 8.1	0.139
Up (% of TST)	0.3 ± 1.0	0.0 ± 0.2	0.018*

Data are means $\pm$ SD.

* $p < 0.05$.

TST = total sleep time.

was a substantial improvement in all respiratory parameters, including AHI, obstructive AHI, AI, obstructive AI, minimal SaO_2 , and snoring. In the present study the overall cure rate (obstructive AHI of <1) was 90.9% (20/22). The obstructive AHI of one obese subject (from 25.7 to 1.7) and one nonobese subject (from 3.7 to 2.0) improved after adenotonsillectomy, but were not cured. Brietzke *et al.*⁵ reported in the meta-analysis of 14 articles that pediatric adenotonsillectomy was successful in normalizing polysomnographic measurements in the majority of patients, and the summary success rate was 82.9%.

There are a few limitations to this study. There is a possibility of night-to-night variation of positional changes because polysomnographic evaluation was performed for only one night. Factors associated with the frequency of positional changes and of the distribution of sleep positions, such as age, gender, and obesity, were not considered because of the small sample size. Also, the normal range and the severity of the frequency of positional changes during sleep were not defined, because we are not aware of any published English literature that have compared these parameters in normal children and in children with OSAS. Additional study of positional changes during sleep in children is required.

In conclusion, the results of this study suggest that positional changes during sleep may occur after adenotonsillectomy in children with OSAS. We hope that our findings contribute to understanding the effect of adenotonsillectomy on the changes of position during sleep in children with OSAS.

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