# Clinical Characteristics of Positional Obstructive Sleep Apnea Among Asians

**Naricha Chirakalwasan**

Prior investigations have shown that when matched patients for age, gender, and body mass index, Asians were observed to have more severe OSA based on polysomnographic data [1]. The study comparing Asian and Caucasian OSA patients matching for age, gender, skeletal pattern, body mass index, and respiratory disturbance index revealed that the Chinese group, when compared with the Caucasian group, were found to have smaller maxillas and mandibles, more severe mandibular retrognathism, proclined lower incisors, increased total and upper facial heights, and steeper and shorter anterior cranial bases. Interestingly, the Chinese group was found to have a larger superior-posterior airway space, a larger nasopharynx and oropharynx cross-sectional area, and smaller tongue height [2]. A previous study which compared Far Eastern OSA with white men found that after matched for age, respiratory disturbance index (RDI), and the lowest oxygen desaturation, Asian OSA patients were observed to have more prominent SNA [angle measurement from sella (S) to nasion (N) to subspinate (A)], SNB [angle measurement from sella (S) to nasion (N) to supramental (B)], wider PAS (posterior airway space), and shorter MP-H (mandibular plane to hyoid bone) distance. However, they were noted to have a shorter anterior cranial base (NS) and narrower cranial base flexure (NSBa) than white men with OSA. The authors concluded that the nasopharyngeal and retropalatal regions may have a greater impact in the airway of Asian subjects because of the decreased cranial base dimensions, as opposed to the hypopharyngeal region, which may have a greater effect in the white subjects as reflected in the lower hyoid position [3] (Fig. 1). This notion is confirmed by a study using a videoendoscopic evaluation of the upper airway in Southeast Asian adults with OSA. They observed

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N. Chirakalwasan, M.D. (✉)
Division of Pulmonary and Critical Care Medicine, Department of Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Excellence Center for Sleep Disorders, King Chulalongkorn Memorial Hospital, Thai Red Cross Society, 1873 King Rama IV Road, Bangkok 10330, Thailand
e-mail: narichac@hotmail.com

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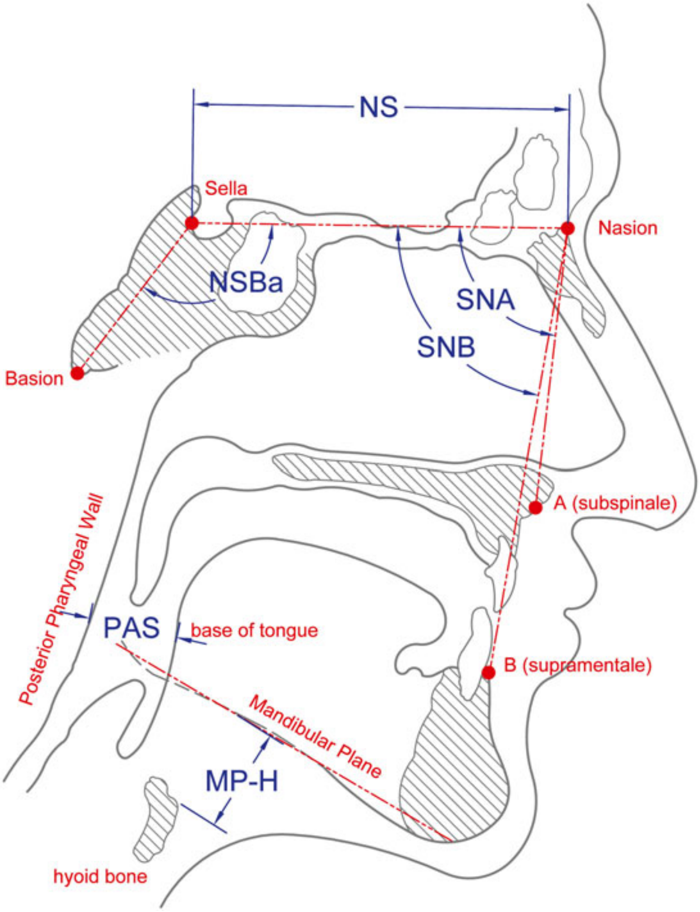

**Fig. 1** SNA, angle measurement from sella (S) to nasion (N) to point A (subspinale); SNB, angle measurement from sella (S) to nasion (N) to point B (supramentale); MP-H, distance from mandibular plane (MP) to hyoid bone (H); PAS (posterior airway space), the distance between base of the tongue and the posterior pharyngeal wall; NSBa (cranial base flexure), angle formed by the intersection between lines drawn from nasion (N) to sella (S) to basion (Ba); NS (anterior cranial base), distance from nasion (N) to sella (S)

that the retropalatal region has more severe obstruction compared with retroglossal region in either erect or supine position [4]. A study comparing the differences in craniofacial structures and obesity between an Australian OSA and a Hong Kong OSA group found that at the same level of AHI, the Chinese OSA group was observed to be less obese with lower BMI and smaller neck circumference; however, they were observed to have more restricted cephalometric measurement [5]. It is believed that central obesity, which is generally more prevalent in Asians, may have predisposed them to develop OSA at a lower BMI compared to Caucasians [6–8]. Even though the clinical characteristics of Asian OSA patients appeared to be different, the prevalence of OSA was observed to be comparable to the other population. If OSA is defined as RDI ≥ 5, the prevalence of OSA was observed to be 8.8–27 % and 3.7–16 % in males and females, respectively. If OSA is defined as RDI ≥ 5 plus excessive daytime sleepiness, the prevalence of OSA was observed to be 4.1–7.5 % and 1.9–3.2 % in males and females, respectively [9–14].

Contrarily, positional OSA, which is a form of OSA noted predominantly during supine sleep, was reported with higher prevalence among Asians. The first data on positional OSA by Cartwright et al. using criteria for positional OSA as 50 % or more in apneic index between back and side sleep positions reported a prevalence of 58.3 % (14 in 24 subjects) [15]. Pevernagie et al. demonstrated overall positional OSA prevalence of 58.2 % using positional OSA criteria of apnea-hypopnea index (AHI)-O (off back)/AHI-B (back) ≤0.5 (similar to Cartwright criteria) [16]. Oksenberg et al. subsequently reported a prevalence of 55.9 % (321 in 574 subjects) for positional OSA using criteria for positional OSA as a ratio of supine RDI to the lateral RDI ≥2 and required sleep time more than 30 min in either supine or lateral position [17]. Mador et al. published a paper using a more rigid positional OSA criteria which was >50 % reduction in the AHI between the supine and non-supine position and the AHI in the non-supine position <5 with data of at least 15 minutes of both the supine and non-supine position [18]. They reported an overall prevalence of 27.4 % (68 in 248 subjects). For each severity of OSA, positional OSA prevalence was reported as 49.5 %, 19.4 %, and 6.5 % in mild, moderate, and severe OSA, respectively. Richard et al. reported overall positional OSA prevalence of 55.8 % using positional OSA criteria as at least two times higher AHI in supine position than the average AHI in the other positions (similar to Cartwright criteria) [19]. All these combined reports represent an overall prevalence of positional OSA in the Western population of approximately 27.4–58.3 %.

However, positional OSA among Asians was reported with higher prevalence ranging between 49 and 74.5 % [20–27] (Table 1). The prevalence of positional OSA was observed to be less as the severity of OSA increases [26, 27]. For clinical characteristics, most of the studies did not show differences in terms of age; however, two studies reported that the positional OSA group was older [23, 26]. Half of the studies with available information on BMI reported that positional OSA group was found to have lower BMI [23, 26, 27]. Two out of three studies with available information on neck circumference reported positional OSA to have smaller neck size [25, 27]. Excessive daytime sleepiness determined by Epworth Sleepiness Scale (ESS) was observed to be no different between the two groups. However, one study reported the positional OSA group to be less sleepy compared to the non-positional OSA group [23] (Table 2). For polysomnographic characteristics, all studies reported the AHI or RDI to be lower in the positional OSA group. Mean and nadir oxygen saturations were observed to be higher in positional OSA group [25, 26]. Only two papers on positional OSA in Asians described the details on sleep architecture. Both papers did not find a difference in sleep efficiency between the two groups. One study found less N1 and increase in REM sleep with no difference in NREM3 in the positional OSA group, compared to the non-positional OSA group [23]. Another study found the positional OSA group to have an increase in N3 with

**Table 1** Prevalence of positional OSA

| Author/year | Country | Ethnicity | Population/*N* | Positional OSA criteria | Prevalence of positional OSA | Prevalence of positional OSA (subgroup analysis) |
|---|---|---|---|---|---|---|
| Itasaka Y et al. [20] | Japan | Japanese | OSA patients/257 | ≥50 % reduction in AHI in lateral position | 69.3 % (178 in 257 subjects) | 90.9 % in normal weight group (BMI < 24), 74 % in mild obese group (BMI 24–26.4), 57.4 % in obese group (BMI > 26.4) |
| Nakano H et al. [21] | Japan | Japanese | Habitual snoring diagnosed with OSA/51 | Lateral AHI/supine AHI < 0.5; ≥10 min of recorded lateral sleep | 49 % (25 in 51 subjects) | No data |
| Chang ET et al. [22] | Taiwan | Chinese | OSA, central sleep apnea or mixture of obstructive and central sleep apnea excluded/75 | Total AHI ≥ 5, <50 % reduction in the AHI between supine and non-supine postures, AHI < 5 in the non-supine posture | 57.3 % (43 in 75 subjects) | No data |
| Tanaka F et al. [23] | Japan | Japanese | OSA patients/462 | Supine AHI ≥2 times of lateral AHI | 74.5 % (344 in 462 subjects) | No data |
| Lee CH et al. [24] | Korea | Korean | OSA patients undergoing uvulopalatopharyngoplasty (UPPP)/74 | Supine AHI >2 times of lateral AHI; ≥5 % of sleep time in both supine and lateral position | 70.3 % (52 in 74 patients) | No data |
| Teerapraipruk B et al. [25] | Thailand | Thai | OSA patients/144 | Supine RDI/non-supine RDI ≥ 2, total RDI ≥ 5, supine and non-supine sleep time ≥30 min | 66.7 % (96 in 144 patients) | No data |
| Sunwoo WS et al. [26] | Korea | Korean | OSA patients undergoing sleep videofluoroscopy | Supine AHI >2 times of lateral AHI, ≥5 % of sleep time in supine and lateral position | 71.4 % (65 in 91 patients) | 91.3 % in mild OSA group, 82.6 % in moderate OSA group, 55.6 % in severe OSA group |
| Hu B et al. [27] | China | Chinese | OSA patients undergoing nasal surgery/79 | Supine AHI/non-supine AHI ≥ 2, supine and non-supine sleep time ≥30 min | 53.2 % (42 in 79 patients) | 70.4 % in mild OSA group, 61.5 % in moderate OSA group, 26.9 % in severe OSA group |

**Table 2** Baseline clinical characteristics (positional OSA/non-positional OSA)

| Author/year | Age (years) | Sex (%M) | BMI | Neck size (cm) | ESS |
|---|---|---|---|---|---|
| Itasaka Y et al. [20] | No data | No data | No data | No data | No data |
| Nakano H et al. [21] | No data | No data | No data | No data | No data |
| Chang ET et al. [22] | 54.8 ± 11.1/ 53.0 ± 14.6; $p = \text{ns}$ | No data | 26.9 ± 3.5/ 28.1 ± 4.5; $p = \text{ns}$ | 39.6 ± 3.7/ 39.9 ± 5.9; $p = \text{ns}$ | 9.1 ± 5.2/ 6.8 ± 4.6; $p = \text{ns}$ |
| Tanaka F et al. [23] | 49.5 ± 13.3/ 46.5 ± 11.7; $p = 0.0287$ | 91.6/87.3; $p =$ no data | 26.0 ± 3.5/ 29.6 ± 5.2; $p \leq 0.0001$ | No data | 10.6 ± 5.0/ 11.8 ± 5.5; $p = 0.0238$ |
| Lee CH et al. [24] | 47/47.2; $p = \text{ns}$ | No data | 26/26.5; $p = \text{ns}$ | No data | No data |
| Teerapraipruk B et al. [25] | 53.2 ± 11.5/ 50.8 ± 11.9; $p = 0.27$ | 76/81.3; $p = 0.53$ | 26.3 ± 4.8/ 27.9 ± 5.4; $p = 0.074$ | 14.9 ± 1.5/ 15.7 ± 1.4; $p = 0.001$ (in.) | 9.6 ± 4.8/ 10.5 ± 5.3; $p = 0.335$ |
| Sunwoo WS et al. [26] | 49.5 ± 11.9/ 43.8 ± 10.4; $p = 0.035$ | 83.1/88.5; $p = 0.520$ | 26.1 ± 3.2/ 28.1 ± 3.5; $p = 0.009$ | No data | 10.0 ± 3.7/ 12.0 ± 4.3; $p = 0.059$ |
| Hu B et al. [27] | 41.8 ± 11.8/ 43.2 ± 8; $p = \text{ns}$ | 78.6/81.1; $p = \text{ns}$ | 26.6 ± 2.6/ 29.8 ± 3.3; $p < 0.01$ | 42.4 ± 1.6/ 43.7 ± 1.5; $p < 0.01$ | No data |

Data displayed in mean ± SD or the median
*ns* nonsignificance

no difference in N1 or REM sleep [25]. Two studies reported information on sleep position duration [23, 26]. One out of these two papers reported that the patients with positional OSA spent less time in supine position when compared to the non-positional OSA patients [23] (Table 3). Tanaka et al. [23] reported that the lateral AHI but not the supine AHI significantly correlated with excessive daytime sleepiness using ESS ($r = 0.102$; $p < 0.05$). For cephalometric measure, Chang et al. found the MP-H to be correlated with ESS [22]. Predictors for positional OSA were studied by Teerapraipruk et al. [25]. Low snoring frequency (less than 20 % of total sleep time) was a significant predictor for positional OSA (odd ratio of 3.27; $p = 0.011$). Low mean oxygen saturation <95 % was found to be a negative predictor (odd ratio of 0.31; $p = 0.009$). Low RDI (<15) was a significant predictor for normalization of RDI to less than 5 in non-supine position (odd ratio of 8.77; $p < 0.001$). Furthermore, Nakano et al. also reported an interesting finding that positional dependency of snoring was observed in terms of snoring intensity but not in terms of % of snoring time [21]. Position change in snoring was significantly correlated with AHI, especially in supine position.

Anatomical characteristics of positional OSA among Asians have been previously reported in literature. Chang et al. published a paper on clinical and cephalometric characteristics of positional OSA compared to non-OSA and non-positional OSA [22]. They reported that positional OSA when compared to non-positional OSA was observed to have longer PAS measurement (9.8 ± 3.1 mm and 8.1 ± 2.6 mm,

**Table 3** Polysomnographic characteristics (positional OSA/non-positional OSA)

| Author/year | RDI or AHI | Sleep efficiency (%) | Mean oxygen saturation (%) | Nadir oxygen saturation (%) | %N1 or N1 (min) | %N3 or N3 (min) | %REM or REM (min) | %Supine sleep time or supine sleep time (min) | %Lateral sleep time |
|---|---|---|---|---|---|---|---|---|---|
| Itasaka Y et al. [20] | No data | No data | No data | No data | No data | No data | No data | No data | No data |
| Nakano H et al. [21] | No data | No data | No data | No data | No data | No data | No data | No data | No data |
| Chang ET et al. [22] | 36.4 ± 23.4/ 48.1 ± 25.4; $p<0.001$ (AHI) | No data | No data | No data | No data | No data | No data | No data | No data |
| Tanaka F et al. [23] | 22.4 (11.6–35.7)/ 63.2 (39.5–80.9); $p<0.0001$ (RDI) | 81.9 (71.6–88.4)/ 80.4 (71.8–86.0); $p=0.2943$ | No data | No data | 115.9 ± 57.7/ 160.5 ± 73.5; $p<0.0001$ (min) | 0.5 (0.0–7.7)/ 0.5 (0.0–3.3); $p=0.2095$ (min) | 58.7 ± 24.1/ 49.0 ± 10.1; $p=0.0002$ (min) | 200.4 ± 96.9/ 222.4 ± 97.6; $p=0.0344$ (min) | 156.1 ± 84.2/ 126.5 ± 77.8; $p=0.0008$ (min) |
| Lee CH et al. [24] | 30.9/50; $p<0.001$ (AHI) | No data | No data | No data | No data | No data | No data | No data | No data |
| Teerapraipruk B et al. [25] | 23.8 ± 14.2/ 43.0 ± 23.9; $p<0.001$ (RDI) | 89.5 ± 10.7/ 90.2 ± 7.6; $p=0.715$ | 95.1 ± 1.5/ 93.3 ± 2.7; $p<0.001$ | 81.2 ± 8.2/ 77.9 ± 9.3; $p=0.032$ | 13.2 ± 10.2/ 15.6 ± 14.4; $p=0.252$ (%) | 15.2 ± 10.1/ 10.2 ± 9.5; $p=0.005$ (%) | 16.0 ± 7.0/ 14.0 ± 6.9; $p=0.109$ (%) | No data | No data |
| Sunwoo WS et al. [26] | 25.4 ± 14.7/ 51.4 ± 23.8; $p<0.001$ (AHI) | No data | No data | 85.8 ± 5.6/ 76.7 ± 11.6; $p=0.033$ | No data | No data | No data | 61.8 ± 21.9/ 55.7 ± 21.9; $p=0.268$ (%) | No data |
| Hu B et al. [27] | No data | No data | No data | No data | No data | No data | No data | No data | No data |

Data displayed in mean ± SD or the median with interquartile ranges given in parentheses

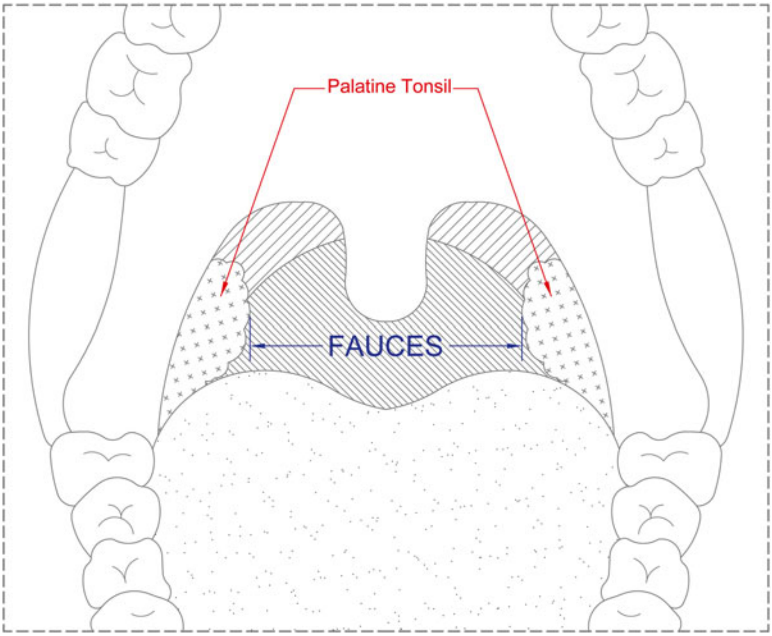

**Fig. 2** The width of the fauces. Grade 1: the palatopharyngeal arch intersects at the tongue's edge. Grade 2: the palatopharyngeal arch intersects at ≥25 % of the whole width of the tongue. Grade 3: the palatopharyngeal arch intersects at ≥50 % of the whole width of the tongue. Grade 4: the palatopharyngeal arch intersects at ≥75 % of the whole width of the tongue

respectively). Saigura et al. revealed that patients with positional OSA when compared to non-positional OSA patients were noted to have a larger angle of the maxilla–nasion–mandible (the angle between A-N and N-B in Fig. 1) and smaller lower facial height (LFH) from cephalometric parameters and smaller volume of the pharyngeal lateral wall soft tissues from three-dimensional MRI reconstruction [28]. Soga et al. demonstrated that patients with positional OSA when compared with non-positional OSA patients were noted to have a lower grade of fauces width (50 % grade 2 compared to 8 % grade 2 in non-positional sleep apnea group) when a designated otolaryngologist performed an oral examination with the patient sitting in the upright position [29] (Fig. 2). Different risk factors for developing OSA in various ethnicities may have implications for OSA treatment. Asian OSA patients may be more beneficial from treatment options aiming to reposition the craniofacial structure such as maxillomandibular advancement surgery (MMA) or mandibular advancement device (MAD) [30]. A tongue-retaining device (TRD) which prevents a flaccid tongue from retrolapsing during supine sleep was also previously shown to be selectively effective in the group with positional OSA [31] as well as those patients with positional OSA who were unable to avoid supine sleep [32]. However, data for the effectiveness of palatal surgery for positional OSA treatment is controversial. A prior study performed in Korea utilizing sleep videofluoroscopy (SVF) demonstrated that patients with soft palate obstruction (SP type) were observed to have more positional OSA than the patients with tongue base obstruction (TB). The authors concluded that positional OSA may have higher success rates with palatal surgery alone [26]. A follow-up study from Korea by Kwon et al. also revealed similar findings. They demonstrated that in the responsive UPPP group—which was defined by reduction in postoperative AHI to less than 20 % and reduction of more than 50 % compared to the preoperative value—significant reduction in AHI was observed in supine AHI (40.5 ± 4.3 to 10.6 ± 9.3; $p < 0.001$). However, reduction in non-supine AHI did not reach statistically significant difference (13.5 ± 25 to 2.5 ± 4; $p = 0.25$) [33]. Another study also from Korea demonstrated a contradicting result; UPPP was more successful when events occurred in lateral position specifically in patients with non-positional OSA. They indicated that the improvement in lateral sleep-specific AHI may convert non-positional OSA to positional OSA [24]. The same group also concluded in another study that due to high positional dependency observed among Asians, effectiveness of surgical outcome should be interpreted with caution. They suggested using postoperative position-corrected AHI (P-AHI). P-AHI can be calculated from simple equation [(postoperative supine AHI × preoperative supine sleep time %) + (postoperative lateral AHI × preoperative lateral sleep time %)/100]. This P-AHI may be a more precise method of determining the success of OSA surgical treatment outcome [34]. Lastly, positional therapy, which can reposition the mandible by means of preventing the mandible from moving posteriorly, should obviously be theoretically beneficial among OSA. A previous study demonstrated a combination of lateral position (LP), cervical vertebrae support with head tilting (CVSHT), and scapula support (SS) to be effective treatment in Asian positional OSA patients. They demonstrated that in order to achieve at least 80 % reduction of AHI, LP and SS should be >30° and/or 20 mm, respectively [35]. Even prone position also was previously shown to be effective in ameliorating AHI in a case report from Japan which demonstrated that most dilated upper airway was observed in prone position according to an MRI study [36]. Recent meta-analysis of randomized trials comparing effectiveness of positional therapy versus continuous positive airway pressure (CPAP) demonstrated the superior efficacy of CPAP over positional therapy [37]. However, all three trials which were included in this meta-analysis were conducted in non-Asians. Further future randomized controlled studies on the effectiveness of positional therapy specifically performed among Asians are strongly encouraged.

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