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# Cone-Beam Computed Tomography Measurement and Analysis of Upper Airway in Adult Patients of Han and Uygur Nationalities in Xinjiang

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## Abstract

To study the differences in the upper airway of adults in Xinjiang between Han and Uygur nationalities in terms of different sagittal skeletal types. Cone-beam computed tomography (CBCT) images of 228 adults with different sagittal skeletal types were investigated by SPSS 22.0. The sagittal depth of the upper airway and sagittal-sectional areas were compared among different skeletal types in patients of Han and Uygur nationalities. The anatomic characteristics of the upper airway, including volume, area, transverse, and sagittal diameter, were measured. Results showed the upper airway in males was larger than that in females, but there was no significant difference in gender. The upper airway lengths, sagittal-sectional areas, and volume increased from class II, class I, to class III group. There was a statistical difference in the Han and Uygur nationalities in terms of different sagittal skeletal types. There are statistical differences in the upper airway of adults of Han and Uygur nationalities. Hence, we should attach importance to these factors during clinical diagnosis and make appropriate individualized treatment plans. Furthermore, we can improve upper airway ventilation, minimize adverse factors affecting patient health, and reduce OSAHS especially in class II and III malocclusions.

***Keywords:*** *Cone-Beam Computed Tomography; Uygur Nationality; Upper Airway; Sagittal Skeletal Type; Obstructive Sleep Apnea*

## Introduction

The upper airway consists of three parts: nose, pharynx, and larynx. The hard tissue and soft tissue were combined to ensure unobstructed breathing and maintain many physiological functions, such as respiration or swallowing. In recent years, numerous studies on the upper airway have been conducted at home and abroad. Many scholars have found correlation between upper airway morphology and craniomaxillofacial structure in adult [1,2], some patients with upper airway stenosis are likely to have respiratory system problems. At the same time, it will have varying degrees of adverse effects on the development of craniomaxillofacial structure and lead to systemic multi-organ complications [3,4].

Obstructive sleep apnea hypopnea syndrome (OSAHS) is a breathing disorder during sleep with periodic apnea and hypopnea, which are related to many reasons such as upper airway stenosis, obesity, hypertension, and other adverse clinical diseases [1]. Some studies have also reported the relationship between upper airway and muscle function, craniofacial disharmonies or narrow dentition, which are predisposing factors leading to the occurrence and development of OSAHS, according to the influence of the upper airway and muscular function [5]. Over the past few decades, scholars have generally used lateral cephalometric radiographs or spiral computed tomography (CT) to study the upper airway [6,7]. Nevertheless, 2D radiographic evidence is affected by differences in magnification, the superimposition of bilateral structures and lack of cross-sectional area or volume information [8]. Moreover, the spiral CT radiation is larger than others and the cost is higher, then few patients can accept it. All these factors limit the use of these methods and tools in study of the upper airway researches. Recently, cone-beam computed tomography (CBCT) has been widely used in oral and maxillofacial diagnosis and treatment due to its advantages of lower radiation dose, accurate image and convenient operation [9,10].

At present, there are no related reports on the upper airway morphology analysis of Han and Uygur adults in Xinjiang. This study uses CBCT imaging to obtain the upper airway structure data of adult patients with different sagittal plane types. The structural characteristics were analyzed to provide clinical reference for the diagnosis and treatment of orthodontic and orthognathic patients in this area.

## Materials and Methods

In this study, a total of 228 patients from January 2018 to December 2020 came to the department of orthodontics. The sample consisted of 103 males and 125 women (124 Han, 104 Uyghur), aged 18 - 30, with an average age of (22.20 ± 2.57) years.

Inclusion criteria: (1) All adults were born in Xinjiang, and the three generations are Han or Uygur. (2) No missing teeth (except third molars), Mean angular type (27.3º ≤ GoGn-SN ≤ 37.7º; 23.5 ≤ MP-FH ≤ 30.5); (3) No cleft lip or palate, History of facial trauma, TMJ history, No history of orthodontic orthognathic and uvulopalatopharyngoplasty; (4) Good general health, No history of nocturnal snoring and apnea; (5) No asthma, chronic rhinitis and other respiratory diseases; (6) Body mass index (body mass index,); and BMI), 18.5 kg/$m^2$ ≤ BMI ≤ 24 kg/$m^2$.

The exclusion criteria were (1) temporomandibular joint disorders; (2) congenital absence of permanent teeth; (3) history of upper airway surgery; (4) previous orthodontic treatment and/or orthognathic surgery; (5) self-reported snoring and/or obstructive sleep apnea; and (6) history of cleft lip or palate or any craniofacial syndrome impairment.

The CBCT imagings of these patients were obtained where they attended the Department of Orthodontics and Radiographs as part of the initial diagnosis. We told patients that the information may be used for clinical research, teaching, etc., and all patients have signed an informed consent. Institutional review board approval of our hospital was obtained for this study. Ethical approval was given by the medical ethics committee with the following reference number: 20200116-07. All imaging were taken by a fixed physician. When shooting, take the station, two eyes look straight ahead, the orbital ear plane is parallel to the ground, and the median sagittal plane coincides with the machine median reference line. The patient is told to bite in the middle, with the muscles around the mouth relaxed and the upper and lower lips closed naturally. Patient must breathe smoothly and evenly. Do not swallow and chew during examination.

The anatomic landmarks were identified, and airways were measured in the nasopharynx, oropharynx, laryngopharynx, and total airway regions as defined by other researchers [11-14] (Figure 1 and 2):

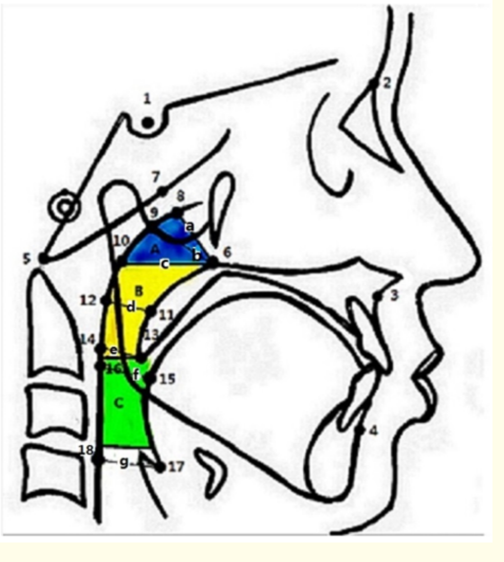


***Figure 1:*** *Landmarks and measurements of the upper airway.*

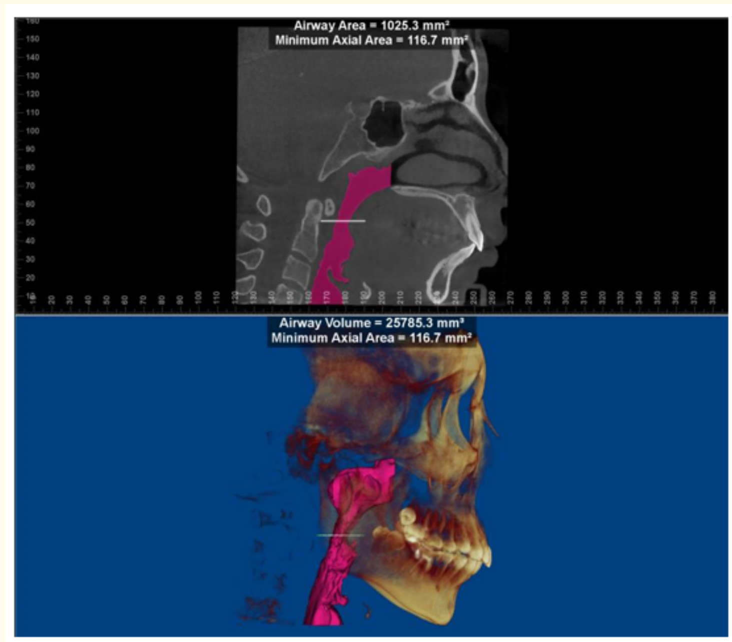


***Figure 2:*** *Volume measurements of the upper airway.*

1. S (Sella): The center of the sella.
2. N (Nasion): The most anterior point of the frontonasal suture in the midsagittal plane.
3. A (Subspinale): The most posterior point on the exterior ventral curve of the maxilla between the anterior nasal spine and supradentale.
4. B (Supraemental): The most posterior point on the bony curvature of the mandible between infradentale and pogonion.
5. Ba (Basion): The lower median point in the anterior margin of the foramen magnum.
6. PNS: The tip of the posterior nasal spine.
7. Hor (Hormion): The junction of the posterior border of the vomer with the sphenoid bone.
8. R: The intersection of the Hor and PNS line with the posterior pharyngeal wall.
9. Ad2: The intersection of the line between the PNS and base point of skull and the point of the sella.
10. UPW (point of the upper pharyngeal wall): The intersection of the PNA-Ba line and the posterior pharyngeal wall.
11. SPP: The intersection of the parallel line and the soft palate Go-B, which is the midpoint of the PNS-U line.
12. SPPW: The intersection of the parallel line of the Go-B line and the posterior wall of the pharynx through the midpoint of the PNS-U line.

13. U: The top or bottom of the uvula.
14. MPW (a point of the middle pharyngeal): A vertical foot point over the U point toward the back wall of the pharynx.
15. TB: The intersection of the Go-B line with the root of the tongue.
16. TPPW: Intersection of the extension line of the Go-B line with the posterior pharyngeal wall.
17. V (epiglottis valley): The intersection of the epiglottis and the root of the tongue.
18. LPW (lower pharynx wall): A vertical foot point over the V point toward the back wall of the pharynx:
    a. PNS-R: The distance between posterior nasal spine and pharynx apex.
    b. PNS-Ad2: The distance from posterior nasal spine to Ad2 point.
    c. PNS-UPW: The distance from the post nasal spine to the upper pharyngeal wall distance.
    d. SPP-SPPW: The distance of the pharyngeal wall behind the soft palate.
    e. U-MPW: Palatine tip-middle pharyngeal wall point distance.
    f. Posterior airway gap: TB-TPPW.
    g. V-LPW: The distance from epiglottis valley to a point of the lower pharyngeal wall:
        A. Np area (blue): Sagittal area of the nasopharyngeal airway.
        B. Op area (yellow): Sagittal area of the oropharynx airway.
        C. Lp area (green): Sagittal area of the laryngopharynx airway.

The airway volume was defined by two horizontal planes, which are parallel to the Frankfort horizontal plane. The upper limit was defined by the horizontal line connecting the posterior nasal spine and the posterior pharynx wall. The lower limit was a line parallel to the upper limit, crossing the anterior-posterior dimension of the airway and passing through the tip of the epiglottis (Figure 2). The airway volume was calculated in cubic millimeters.

To assess intra-observer variation, all the values were re-measured on 25 randomly selected patients, and intra-class correlation coefficient values were calculated. The measurements were made after two months had passed, and inter-observer observations were obtained by randomly taking another 20 images, which were examined once again by an orthodontist who would calculate the measurements.

All the data obtained by the software were input into the computer, and SPSS 22.0 statistical software was used to analyze the measured data. The independent sample t-test was carried out in this study, and single-factor ANOVA was performed on different sagittal plane types in the group. $P < 0.05$ was considered to be statistically significant for all analyses.

## Results

The results showed that the measured values of sagittal diameter of the upper airway were higher than those in women for both Han and Uygur groups. However, there was no significant difference (P > 0.05) (Table 1).

| | Han | | Uyghur | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| PNS-R (mm) | 13.41 ± 0.68 | 13.33 ± 0.42 | 13.74 ± 0.28 | 13.63 ± 0.46 |
| PNS-Ad2 (mm) | 14.66 ± 0.50 | 14.51 ± 0.48 | 14.72 ± 0.25 | 14.60 ± 0.49 |
| PNS-UPW (mm) | 16.53 ± 0.326 | 16.09 ± 0.27 | 16.51 ± 0.46 | 16.42 ± 0.32 |
| SPP-SPPW (mm) | 13.73 ± 2.36 | 12.91 ± 1.04 | 11.83 ± 2.55 | 10.65 ± 2.79 |
| U-MPW (mm) | 11.04 ± 2.69 | 9.82 ± 2.67 | 10.61 ± 2.20 | 10.56 ± 1.31 |
| TB-TPPW (mm) | 12.77 ± 2.62 | 11.10 ± 2.46 | 12.01 ± 1.78 | 10.78 ± 2.26 |
| V-LPW (mm) | 14.41 ± 1.81 | 14.03 ± 1.69 | 14.41 ± 1.34 | 14.37 ± 1.25 |
| Np area ($mm^2$) | 381.01 ± 33.34 | 327.47 ± 67.23 | 302.06 ± 54.56 | 294.68 ± 35.47 |
| Op area ($mm^2$) | 331.31 ± 29.49 | 283.06 ± 66.35 | 262.31 ± 53.46 | 239.54 ± 44.32 |
| Lp area ($mm^2$) | 259.42 ± 42.35 | 198.37 ± 62.12 | 167.31 ± 24.13 | 147.45 ± 36.09 |
| Np volume ($mm^3$) | 8047.19 ± 2389.71 | 7964.93 ± 2781.46 | 7745.38 ± 2199.79 | 7589.72 ± 2031.63 |
| Op area ($mm^3$) | 10938.64 ± 2971.45 | 9646.41 ± 2846.98 | 9789.57 ± 2691.41 | 9597.36 ± 1982.89 |
| Lp area ($mm^3$) | 7638.61 ± 2301.09 | 7371.12 ± 1972.91 | 7461.32 ± 2101.56 | 7401.13 ± 1892.09 |
| Total airway volume ($mm^3$) | 30137.71 ± 5171.91 | 29781.52 ± 5091.32 | 29989.37 ± 6119.62 | 27998.63 ± 5999.42 |

***Table 1:*** *Comparison of upper airway in different genders of Han and Urgur nationalities.*

The results in table 2 show that from class I, class II to class III, the measurement of the sagittal diameter of upper airway and the sagittal area of the nasopharynx, oropharynx, and laryngopharynx gradually increases. The PNS-R, PNS-Ad2, PNS-UPW, SPP-SPPW, U-MPW, TB-TPPW, V-LPW and the difference of the nasopharyngeal airway area and volume in patients with different sagittal types with Han was statistically significant (P < 0.05).

| | Class I | Class II | Class III | P value |
|---|---|---|---|---|
| PNS-R (mm) | 13.13 ± 0.41 | 12.92 ± 0.33 | 14.01 ± 0.36 | 0.000 |
| PNS-Ad2 (mm) | 14.64 ± 0.47 | 14.25 ± 0.45 | 14.91 ± 0.31 | 0.000 |
| PNS-UPW (mm) | 16.38 ± 0.26 | 16.07 ± 0.33 | 16.53 ± 0.41 | 0.000 |
| SPP-SPPW (mm) | 13.14 ± 1.86 | 12.10 ± 1.48 | 15.09 ± 0.52 | 0.000 |
| U-MPW (mm) | 9.04 ± 0.85 | 8.22 ± 0.91 | 13.25 ± 0.12 | 0.000 |
| TB-TPPW (mm) | 10.97 ± 1.73 | 10.56 ± 2.54 | 15.13 ± 0.59 | 0.000 |
| V-LPW (mm) | 14.95 ± 2.22 | 13.21 ± 1.75 | 15.09 ± 1.34 | 0.007 |
| Np area($mm^2$) | 336.17 ± 38.39 | 325.07 ± 62.34 | 359.13 ± 25.25 | 0.049 |
| Op area ($mm^2$) | 315.34 ± 65.13 | 288.26 ± 56.07 | 321.18 ± 29.47 | 0.089 |
| Lp area ($mm^2$) | 231.54 ± 50.30 | 226.29 ± 53.31 | 254.32 ± 49.08 | 0.159 |
| Np volume ($mm^3$) | 7995.61 ± 1998.11 | 7541.82 ± 1947.81 | 8531.86 ± 1919.51 | 0.049 |
| Op volume ($mm^3$) | 9683.57 ± 1874.80 | 8912.92 ± 1982.89 | 10899.84 ± 1962.35 | 0.000 |
| Lp volume ($mm^3$) | 7615.06 ± 1991.84 | 7491.70 ± 2031.12 | 7821.57 ± 1999.91 | 0.003 |
| Total airway volume ($mm^3$) | 28935.63 ± 6024.56 | 26735.91 ± 5909.82 | 31089.13 ± 6231.63 | 0.000 |

***Table 2:*** *Measurement of upper airway in different sagittal types with Han nationality.*

Table 3 shows that in Class II, I, and III groups, the sagittal area of the upper airway of the Uygur group and volume of the nasopharynx, palatopharynx, and tongue pharynx, PNS-R, PNS-Ad2, TB-TPPW, and V-LPW gradually increased. The PNS-R, PNS-Ad2, TB-TPPW, V-LPW, sagittal area of the nasopharyngeal airway and volume were significantly difference in different sagittal types with Uyghur ($P < 0.05$).

| | Class I | Class II | Class III | P value |
|---|---|---|---|---|
| PNS-R (mm) | 13.64 ± 0.50 | 13.49 ± 0.25 | 13.96 ± 0.05 | 0.001 |
| PNS-Ad2 (mm) | 14.64 ± 0.38 | 14.36 ± 0.25 | 15.04 ± 0.05 | 0.000 |
| PNS-UPW (mm) | 16.34 ± 0.32 | 16.47 ± 0.58 | 16.63 ± 0.10 | 0.103 |
| SPP-SPPW (mm) | 12.00 ± 2.30 | 10.17 ± 3.21 | 11.58 ± 2.30 | 0.097 |
| U-MPW (mm) | 10.62 ± 1.52 | 10.37 ± 2.61 | 10.79 ± 0.95 | 0.803 |
| TB-TPPW (mm) | 12.18 ± 1.50 | 10.01 ± 2.81 | 12.06 ± 0.45 | 0.000 |
| V-LPW (mm) | 14.34 ± 0.98 | 13.56 ± 1.54 | 15.39 ± 0.15 | 0.000 |
| Np area($mm^2$) | 299.91 ± 30.42 | 290.36 ± 50.01 | 332.14 ± 30.28 | 0.006 |
| Op area ($mm^2$) | 261.14 ± 30.36 | 244.56 ± 80.71 | 245.45 ± 14.21 | 0.098 |
| Lp area ($mm^2$) | 151.09 ± 31.24 | 137.06 ± 23.38 | 189.51 ± 12.07 | 0.000 |
| Np volume (mm3) | 7795.61 ± 1901.17 | 7301. ± 2031.73 | 8331.86 ± 1819.51 | 0.007 |
| Op volume ($mm^3$) | 9534.71 ± 2008.78 | 9189.51 ± 2189.01 | 9899.84 ± 2067.50 | 0.000 |
| Lp volume ($mm^3$) | 7324.98 ± 2301.81 | 6981.07 ± 1931.71 | 7521.95 ± 2087.24 | 0.000 |
| Total airway volume ($mm^3$) | 28981.45 ± 6931.04 | 26931.89 ± 5983.48 | 30001.89 ± 6823.30 | 0.015 |

***Table 3:*** *Measurement of upper airway in different sagittal types with Uygur nationality.*

The results of this study showed that the volume measurements of the nasopharynx of the Han group in the three types of sagittal, sagittal area of the airway of the velopharyngeal, and lingual pharynx were larger than those of Uygur patients. Table 4 shows that the two groups of Han and Uygur patients had statistically significant differences in U-MPW, V-LPW, and velopharyngeal airway sagittal area. Table 5 shows that the Han and Uygur type II patients had statistically significant differences in PNS-Ad2, PNS-UPW, SPP-SPPW, U-MPW, and the sagittal areas of the nasopharyngeal airway and glossopharyngeal airway. Table 6 shows that there are three groups of Han and Uygur patients where the differences in PNS-R, PNS-Ad2, PNS-UPW, SPP-SPPW, U-MPW, V-LPW, and sagittal areas of the nasopharyngeal airway, velopharyngeal airway, and glossopharyngeal airway were statistically significant.

| | **Han** | **Uyghur** | **P value** |
|---|---|---|---|
| PNS-R (mm) | 13.13 ± 0.41 | 13.64 ± 0.50 | 0.191 |
| PNS-Ad2 (mm) | 14.64 ± 0.47 | 14.64 ± 0.38 | 0.711 |
| PNS-UPW (mm) | 16.38 ± 0.26 | 16.34 ± 0.32 | 0.076 |
| SPP-SPPW (mm) | 13.14 ± 1.86 | 12.00 ± 2.30 | 0.099 |
| U-MPW (mm) | 9.04 ± 0.85 | 10.62 ± 1.52 | 0.000 |
| TB-TPPW (mm) | 10.97 ± 1.73 | 12.18 ± 1.50 | 0.366 |
| V-LPW (mm) | 14.95 ± 2.22 | 14.34 ± 0.98 | 0.002 |
| Np area ($mm^2$) | 336.17 ± 38.39 | 299.91 ± 30.42 | 0.611 |
| Op area ($mm^2$) | 315.34 ± 65.13 | 261.14 ± 30.36 | 0.011 |
| Lp area ($mm^2$) | 231.54 ± 50.30 | 151.09 ± 31.24 | 0.049 |
| Np volume ($mm^3$) | 7691.01 ± 2013.62 | 7368.91 ± 1983.47 | 0.039 |
| Op volume ($mm^3$) | 9997.48 ± 2048.98 | 9601.79 ± 1997.56 | 0.000 |
| Lp area ($mm^3$) | 7481.00 ± 1899.91 | 7320.09 ± 2001.31 | 0.000 |
| Total airway volume ($mm^3$) | 29845.78 ± 5991.01 | 27810.01 ± 6034.56 | 0.000 |

***Table 4:*** *Comparison of the upper airway in class I patients between Han and Uyghur nationalities.*

| | Han | Uyghur | P value |
|---|---|---|---|
| PNS-R (mm) | 12.92 ± 0.33 | 13.49 ± 0.25 | 0.098 |
| PNS-Ad2 (mm) | 14.25 ± 0.45 | 14.36 ± 0.25 | 0.000 |
| PNS-UPW (mm) | 16.07 ± 0.33 | 16.47 ± 0.58 | 0.004 |
| SPP-SPPW (mm) | 12.10 ± 1.48 | 10.17 ± 3.21 | 0.001 |
| U-MPW (mm) | 8.22 ± 0.91 | 10.37 ± 2.61 | 0.000 |
| TB-TPPW (mm) | 10.56 ± 2.54 | 10.01 ± 2.81 | 0.414 |
| V-LPW (mm) | 13.21 ± 1.75 | 13.56 ± 1.54 | 0.666 |
| Np area ($mm^2$) | 325.07 ± 62.34 | 290.36 ± 50.01 | 0.046 |
| Op area ($mm^2$) | 288.26 ± 56.07 | 244.56 ± 80.71 | 0.155 |
| Lp area ($mm^2$) | 226.29 ± 53.31 | 137.06 ± 23.38 | 0.002 |
| Np volume ($mm^3$) | 7469.81 ± 1998.70 | 7199.09 ± 2102.04 | 0..000 |
| Op volume ($mm^3$) | 9105.73 ± 2401.68 | 8809.79 ± 2398.06 | 0.000 |
| Lp volume ($mm^3$) | 7135.68 ± 2003.56 | 6980.24 ± 1996.34 | 0.000 |
| Total airway volume ($mm^3$) | 27987.13 ± 6013.41 | 26107.96 ± 5698.41 | 0.000 |

***Table 5:*** *Comparison of the upper airway in class II patients between Han and Uyghur nationalities.*

| | Han | Uyghur | P value |
|---|---|---|---|
| PNS-R (mm) | 14.01 ± 0.36 | 13.96 ± 0.05 | 0.000 |
| PNS-Ad2 (mm) | 14.91 ± 0.31 | 15.04 ± 0.05 | 0.000 |
| PNS-UPW (mm) | 16.53 ± 0.41 | 16.63 ± 0.10 | 0.000 |
| SPP-SPPW (mm) | 15.09 ± 0.52 | 11.58 ± 2.30 | 0.000 |
| U-MPW (mm) | 13.25 ± 0.12 | 10.79 ± 0.95 | 0.000 |
| TB-TPPW (mm) | 15.13 ± 0.59 | 12.06 ± 0.45 | 0.283 |
| V-LPW (mm) | 15.09 ± 1.34 | 15.39 ± 0.15 | 0.000 |
| Np area ($mm^2$) | 359.13 ± 25.25 | 332.14 ± 30.28 | 0.043 |
| Op area ($mm^2$) | 321.18 ± 29.47 | 245.45 ± 14.21 | 0.002 |
| Lp area ($mm^2$) | 254.32 ± 49.08 | 189.51 ± 12.07 | 0.000 |
| Np volume ($mm^3$) | 8301.97 ± 2159.04 | 7903.67 ± 2391.32 | 0.005 |
| Op volume ($mm^3$) | 11673.18 ± 2108.01 | 10972.68 ± 2387.01 | 0.001 |
| Lp volume ($mm^3$) | 7869.08 ± 1997.09 | 7659.83 ± 2006.98 | 0.000 |
| Total airway volume ($mm^3$) | 30879.67 ± 6582.46 | 28979.01 ± 5984.09 | 0.000 |

***Table 6:*** *Comparison of the upper airway in class III patients between Han and Uyghur nationalities.*

## Discussion

The upper airway is vital to life, it affects individuals breathing, pronunciation, swallowing, and other functions as its normal structure is directly related to the growth and development of them [8]. In recent years, the relationship between upper airway morphology, surrounding soft and hard tissues, and craniomaxillofacial structure has attracted the attention of many scholars [11,15]. The results of their research showed that the upper airway morphology is closely related to the craniofacial structure; in particular, the abnormal structure of the upper airway will also cause adverse effects on craniomaxillofacial growth and development [8,16], sagittal and vertical osseous patterns, and the degree of obesity, all of which have an influence on the size and shape of the upper airway [17-19].

To better explore the difference of upper airway morphology in patients with different sagittal bone types, patients with the same vertical bone profile and normal body mass index were selected in this study. The accuracy and credibility of the research results were thus improved. The results of the study showed that the measured values of sagittal diameter in the upper airway of males were higher than those in females, and the results were consistent with those of previous studies [20,21].

Patients with OSAHS lack ventilation and develop apnea caused by upper airway collapse and even obstruction during night sleep, which can lead to hypercapnia and other problems, long-term hypertension, cerebrovascular accidents, other systemic complications, or even sudden death. A large number of studies have confirmed that most patients with OSAHS have varying degrees of upper airway stenosis [22-24]. Meanwhile, a large number of studies show that OSAHS often occur in patients with class II malocclusion [19,25]. The results of the present study also show that the sagittal diameter of the upper airway and the sagittal area of the pharyngeal airway of Han and Uygur groups of the class II malocclusion are smaller than class I malocclusion patients, and most of the upper airways of the patients with class II were narrow. The results indicated that the airway morphology in class III patients were greater than those in class I and II patients. In addition, the results are similar to those of foreign scholars' research [26-29].

Orthodontic doctors found that mandibular anterior movement could increase the mean sagittal diameter of the glossopharynx and laryngopharynx as well as obviously widen the transverse diameter of the upper airway [30-32]. After mandibular anterior migration, orthognathic surgeons found that the upper airway space were widened [33,34]. Contrary to the above findings, some researchers observed that after the extraction of premolars in orthodontic treatments, the pharyngeal airway behind the soft palate have been found dimensional changes, it have became narrower than before [35,36]. It may be due to changes in the craniofacial structure and the surrounding soft tissues generated by orthodontic treatment, which increase the volume of the nasopharynx and oropharynx [37]. These variations among the results of previous studies could be attributed to the differences in parameters selected for measurement and variety diagnostic methods [38,39]. A study on the correlation between upper airway size and different vertical growth patterns has found that the glossopharyngeal segment is the narrowest volume of each segment of the upper airway, which is consistent with the experimental results of the author [40-42]. During the orthodontic treatment of class II, we have to prevent the upper airway stenosis from becoming more serious, attention should be paid to avoiding the posterior and inferior rotations of the mandible and promoting the anterior and upper rotations of the mandible as far as possible, thereby improving or preventing the occurrence of OSAHS.

Therefore, these findings suggest that we should pay attention to these kinds of patients in the course of clinical diagnosis and treatment and carefully inquire about their health status, especially whether there are respiratory diseases. For class II patients with upper airway stenosis, we should attach great importance to their condition, perform timely screening of high-risk groups, and take timely and effective prevention and treatment for different individuals [41,42]. Mandibular retrogression and clockwise rotation should be avoided as these can lead to further reduction of the upper airway sagittal diameter [43].

There are some differences in the morphology of the upper airway in different growth periods. It is very necessary to evaluate the upper airway in orthodontic diagnosis and correction plan, which is helpful to the stability of treatment effect [44]. For example, when orthognathic surgery is needed for class III malocclusion, airway factors must be considered to prevent iatrogenic OSAHS [45,46]. If we need to obtain stable treatment goals, the shape of the airway needs to be considered together with the craniomaxillofacial structure and the soft tissue around the airway, and we need to further analyze the soft tissue around the airway.

There is a close link between OSAHS and obesity. Fat around the upper airway, pharynx, and neck will compress the airway, leading to a narrow pharyngeal cavity or an abnormal upper airway morphology, which in turn can lead to a higher risk of OSAHS [47]. The study found that the volume of soft tissue around the airway is related to body weight, and the size of the tongue and the volume of the soft palate are positively correlated with body weight and BMI. The fatter the patient, the larger the tongue and soft palate and the thicker the anterior pharyngeal wall. Many studies have confirmed that the morphology of the upper airway has a great correlation with body weight [48,49]. Therefore, when we study upper airway morphology, the effect of weight on the upper airway must be considered in the selection of subjects. Those with normal BMI should be chosen to avoid the effects of the BMI on the airway and obtained more accurate experimental results.

Initial investigations on the effects of orthodontic treatment, researchers often used lateral cephalometrics to study the impact of the pharyngeal airway space. Therefore, only the sagittal and vertical dimensions of the airway were evaluated with the advent of CBCT imaging. Our understanding of airway morphology has been expanded to three dimensions to include the overall volume. CBCT has been proven to be an accurate and reliable method of assessing the upper airway because it can accurately define the boundaries between the airway spaces and soft tissues with easily identifiable landmarks and negligible magnification. In our study, we use CBCT imagings to improve the accuracy of values.

## Conclusion

Xinjiang Uygur Autonomous Region is a multi-ethnic place mainly inhabited by Han and Uygur nationalities. The results of this study show that the sagittal diameter of the upper airway and the volume of the nasopharynx, palatopharynx, and glossopharynx are different in Han and Uygur patients. Therefore, in clinical practice, we should carefully examine and evaluate each patient's upper airway and craniomaxillofacial system so as to give a correct diagnosis and make appropriate individualized treatment plans according to the characteristics of each nationality and its normal reference value range. Furthermore, we can improve upper airway ventilation, minimize adverse factors affecting patient health, and reduce OSAHS.

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## Conflict of Interest

Authors declare no conflicts of interest.

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