ISSN 2706-6819 Vol.4, Issue 9: 6-11, DOI: 10.25236/IJFM.2022.040902

Advances in the Study of Upper Airway Characteristics in Children with Malocclusion

Yanli Mo[1,2,a], Jing Wang[1,2,b], Yishan Liu[1,2,*]

[1]Department of Pediatric Dentistry, The First Affiliated Hospital of Xinjiang Medical University (Affiliated Stomatological Hospital), Urumqi, Xinjiang, 830054, China
[2]Xinjiang Uygur Autonomous Region Institute of Stomatology, Urumqi, Xinjiang, 830054, China
[a]1391974573@qq. com, [b]604776839@qq. com
**Corresponding author: LYS-tree@126. com*

Abstract: *Malocclusion is the malformation of teeth, jaw and skull caused by congenital genetic factors or acquired environmental factors in the process of children's growth and development, such as diseases, bad oral habits, abnormal substitute teeth, such as irregular arrangement of teeth, abnormal relationship between upper and lower dental arch, abnormal jaw size and shape, etc. Malocclusion is also accompanied by respiratory diseases and dysfunction, such as obstructive sleep apnea (OSA). Conversely, abnormal occlusion also leads to respiratory tract developmental disorders and dysfunction. The cranio-maxillofacial morphology is closely related to the upper airway morphology. They are cause and effect each other. In recent years, it has been found that orthodontic treatment can not only improve the malocclusion, but also has a significant effect on the upper airway volume. The abnormal upper airway in childhood will affect children's breathing, cause children's sleep apnea, and affect children's growth and development. At the same time, with the development of society, we pay more attention to children's face. Therefore, at present, the upper airway morphological characteristics, influencing factors and correction methods of malocclusion have become the focus of research.*

Keywords: *Malocclusion deformity, Upper airway, Intervention, Principle of correction*

1. Introduction

Malocclusion is a variety of deformities caused by the irregular relationship between teeth, jaw and craniofacial region. The upper airway is an important physiological organ of the human body, which is closely related to breathing, swallowing, pronunciation and other functions. As the bony support of the upper airway, the cervical vertebra, upper mandible and hyoid bone, together with the soft palate, tongue, epiglottis and surrounding muscles, participate in the maintenance of respiratory function [1]. There are many factors affecting the upper airway, such as facial shape, hyoid bone, temporomandibular joint, soft tissue and so on. This article reviews the upper airway characteristics of different malocclusion deformities and the effects of different orthodontic methods on the morphology of upper airway.

2. Anatomy and physiology of upper airway and malocclusion

The length of human upper airway is about 12cm, including nasopharynx, oropharynx and laryngopharynx, in which oropharynx is the narrowest part of upper airway, tongue, soft palate and retropharynx are the main components of oropharynx. The hyoid bone, located at the lower rear of the neck mandible, is involved in maintaining the opening of the upper airway and assisting in mandibular movement [2]. The mechanism of malformation is caused by the disharmony between teeth and bone, teeth and jaw, upper and lower dental arch, upper and lower jaw, jaw and craniofacial bone. Because all kinds of malocclusion have different soft tissue function and different hard tissue morphology, different malocclusion deformities have different effects on the morphology of the upper airway. When we formulate the treatment plan, we should not only consider the patient's teeth, mandible, muscle and other factors, but also need to consider the airway shape of the patient. In order to prevent OSAS caused by aggravation of airway stenosis during the treatment process.

ISSN 2706-6819 Vol.4, Issue 9: 6-11, DOI: 10.25236/IJFM.2022.040902

3. The relationship between malocclusion and upper airway

3.1. Correlation between maxilla, temporomandibular joint and upper airway

The position and shape of the mandible and mandible have a certain influence on the shape and volume of the upper airway, which has been confirmed by many researchers. KimDooHwan et al compared children with mandibular hypoplasia and normal children, and found that there were significant differences in hyoid position, hyoid distance and mandibular measurement between patients with mandibular hypoplasia and healthy controls. The distance of anterior hyoid and mandibular angle may be the risk factors of airway stenosis in patients with mandibular hypoplasia [3].

ShokriA [4] et al found that the position of the maxilla and mandible affects the size of the upper airway. The correlation between mandible and upper respiratory tract was the highest in III class malocclusion and the lowest in class I malocclusion [5]. Some studies also found that the upper airway area of bony III children in high-angle group was smaller than that in mean-angle group and low-angle group [6]. The volume of bony class II airway is smaller than that of bony III airway, and the height of mandibular angle may be related to airway condition [7]. At the same time, domestic researchers have found that the upper airway of patients with bony class II high angle is narrower than that of patients with uniform angle, and the volume of upper airway is closely related to the degree of mandibular retraction, and the position of mandible is also related to the retrograde displacement of condyle and anterior displacement of articular disc [8-9]. Mandibular retraction will make the condyle move backward, which proves that there is a close relationship among jaw, airway and joint, especially in sagittal direction [10]. The condyle is the center of mandibular development, so the change of condylar position may affect the size of the airway. TruongLaura et al. studied the correlation between temporomandibular joint position and airway volume in patients with SDB and non-SDB patients. It was found that there was a significant relationship between temporomandibular joint position and upper airway volume. Compared with the posterior condyle, the upper airway volume of the anterior and central condyle was larger, but not related to the cross-sectional area of the airway [11].

3.2. The position of tongue and hyoid bone is related to the upper airway

Wei Yonghua et al. [12] conducted a study on the upper airway of normal children and found that the size and position of the hyoid body were closely related to the patency of the upper airway, and the hyoid bone played an important role in maintaining the size of the upper airway. The lower hyoid bone can make the hyoid body position lower and backward, resulting in stenosis of the airway behind the root of the tongue. Scholars at home and abroad have found that for children, the tongue volume and hyoid position of class III patients are larger than those of class I and class II patients, and the tongue volume is positively correlated with pharynx and airway. It was closely related to the position of the mandible [13]. The children with Angle class III malocclusion had larger tongue volume, upward displacement of hyoid bone and smaller nasopharyngeal volume, while those with Angle class II malocclusion had smaller tongue volume, lower hyoid bone displacement and smaller oropharyngeal volume. There was a correlation among tongue volume, hyoid position, airway volume and maxillofacial morphology in children with malformation [14-16]. DaCostaElianaDantas et al found that the position of hyoid bone has a great influence on oropharynx and laryngopharynx, but has no significant effect on nasopharynx [17]. Hyoid position and obesity can lead to upper airway collapse [18]. In Chinese children, the variables of mandibular body length and craniocervical inclination were significantly correlated with most upper airway variables [19].

3.3. Other factors affecting the characteristics of the upper airway

In the upper airway measurement of male upper airway, the diameter of nasopharynx and the posterior airway space of soft palate and the space of laryngopharynx in male were significantly larger than those in female, and the length, area and thickness of soft palate and tongue in male were significantly larger than those in female[20-21]. The area of oral cavity and the area of oropharyngeal cavity in male were significantly larger than those in female, but there was no difference in the space occupied by soft palate and tongue between male and female. Some studies have found that there is also a correlation between different positions and airway size in cephalometric films [22]. There are differences in airway size between children and adolescents in obesity [23] and gender [24]. With age, the upper airway volume gradually increased [25-26]. The morphology of upper airway was different in different bone ages [27]. There are differences in upper airway among different races [28]. In childhood, the main cause of upper

ISSN 2706-6819 Vol.4, Issue 9: 6-11, DOI: 10.25236/IJFM.2022.040902

airway stenosis is adenoid and tonsil hypertrophy [29]. Oral breathing can lengthen the airway and make the oropharyngeal cavity smaller, while tonsillar hypertrophy can also narrow the airway [30]. Adenoid hypertrophy has obvious adverse effects on the morphology of cranio-maxillofacial and upper respiratory tract in children. Cervical posture also has an effect on the shape of upper airway, the size of oropharyngeal airway opening is closely related to cervical curvature, and cervical posture is related to pharyngeal airway [31].

4. Effects of different orthodontic methods on upper airway

Orthodontic methods are generally divided into functional correction, fixed correction and surgical correction. The structural stenosis of the upper airway is related to the abnormality of the airway itself and its surrounding structure. the function of the oral appliance is to try to change the abnormal size and position of the structure around the upper airway in order to expand or stabilize the airway [20]. At present, the orthodontic methods for children and adults are functional correction, fixed correction and surgical correction for patients with OSAS caused by severe airway stenosis.

4.1. Effect of functional correction on upper airway

Functional orthodontics is mainly aimed at children with growth and development potential of substitute dentition. Many studies have shown that functional orthodontics can significantly improve the upper airway volume of children with different malocclusion. Functional correction of FRIII had an effect on the airway space behind the soft tip of the upper airway, but there was no significant change in the rest of the upper airway space [32]. Wang Wei et al found that Twin-block significantly improved the airway volume and minimum cross-sectional area of oropharynx in patients with Class II mandibular retraction before and after treatment, and mandibular forward displacement was not positively correlated with airway improvement [33]. In this study, Angle class II bone type patients who complained of nocturnal snoring were selected for three-dimensional comparison of airway before and after treatment. After treatment with sagittal guided interresistance appliance (sagittal-guidanceTwin-blockappliance, SGTB) SGTB functional appliance, the upper airway volume, nasopharyngeal volume and oropharyngeal volume were all increased, and the study found that proper application of SGTB functional appliance can improve airway patency. Prevention of OSAS caused by structural stenosis of the upper airway [34]. Maxillary expansion and Twin-block appliance to guide the mandible forward can expand the horizontal plane of the airway and expand the nasopharynx, and the effect of Twin-block treatment is not affected by age, but also can be performed in the late stage of dental replacement [35]. After Twin-block treatment, the upper airway of Angle class II patients dilated, and the biggest change in volume and average cross-sectional area occurred in oropharynx [36]. It was found that Twin-block can increase airway volume and prevent the occurrence of OSAS [37]. The airway diameter increased after slow maxillary expansion [38]. FastucaR et al found that the upper airway volume increased significantly after using the maxillary expansion device for 12 months [39].

4.2. Effect of fixed orthodontics on upper airway

Domestic researchers have found that for 12-14 years old patients with bony II after orthodontic treatment, the condylar position is consistent with the upper airway volume, suggesting that there may be a certain correlation between the temporomandibular joint position and the upper airway volume [40]. Sun Jianwei and others have found that straight arch wire treatment after tooth extraction can change the shape of airway to a certain extent [41]. However, some studies have shown that fixed orthodontics has no significant effect on the airway, whether further treatment after extraction of premolars has an effect on the size of the airway [42].

4.3. Effect of surgical treatment on upper airway

The study found that if there is no early correction in childhood, it will aggravate the degree of malocclusion and lead to the occurrence of adult OSAS, while orthodontic treatment alone can not solve the bony malocclusion, which needs surgical treatment. The study found that maxillary forward movement less than 10mm is enough to increase TAV by at least 70% [43]. However, some studies have found that there is no change in the total pharyngeal volume after orthognathic surgery, but III double-jaw orthognathic surgery significantly reduces the pharyngeal airway volume and area [44]. Domestic researchers have found that in patients with bony II malocclusion, the total volume and each part of the upper airway volume increased after bimaxillary surgery, in which the glossopharyngeal volume increased most significantly, and the sagittal width of the upper airway increased significantly, but the length did not change significantly [45]. Meta analysis found that bimaxillary surgery still caused the risk of airway stenosis [46].

5. Summary

With the development of society, parents and doctors pay more and more attention to children's facial beauty, and malocclusion deformities will also affect airway size and children's breathing patterns, which will affect children's development. Many studies have found that upper and lower jaws, hyoid bone, tongue size, adenoid, tonsil hypertrophy and so on will cause airway stenosis, while cervical posture and the position of condyle in temporomandibular joint will also affect airway shape. The size of the airway is affected by many factors. in recent years, many researchers pay more attention to the influence of multiple factors of the airway. In the past, the research focused on the influence of the airway on the cranio-maxillofacial development, on the contrary, the study now turns to whether the cranio-maxillofacial development affects the airway, and there are few studies on the correction methods of different malocclusion and the influence of condylar position on the airway. We should pay more attention to the characteristics of the upper airway of different malocclusion, early detection and early treatment to avoid the aggravation of malocclusion, so as to avoid adverse effects on children's physical and mental health.

References

[1] Schwab RJ. Upper airway imaging. Clin Chest Med. 1998 Mar; 19(1): 33-54.

[2] Lin YC, Lin HC, Tsai HH. Changes in the pharyngeal airway and position of the hyoid bone after treatment with amodified bionator in growing patients with retrognathia [J]. J Exp Clin Med, 2011, 3(2): 93 – 98

[3] Kim DooHwan, Gwon Eunseo, Ock Junheok, Choi JongWoo, Lee Jee Ho, Kim SungHoon, Kim Namkug. Developmental features and predicting airway failure risk in critically ill children with mandibular hypoplasia using 3D computational tomographic analysis. [J]. Scientific reports, 2021, 11(1).

[4] Truong Laura, Reher Peter, Doan Nghiem. Correlation between upper airway dimension and TMJ position in patients with sleep disordered breathing. [J]. Cranio: the journal of craniomandibular practice, 2020.

[5] Ehsan Golchini, Homa Rasoolijazi, Farzaneh Momeni, Pedram Shafaat, Reza Ahadi, Mohammad Asghari Jafarabadi, Saba Rahimian. Investigation of the Relationship Between Mandibular Morphology and Upper Airway Dimensions[J]. Journal of Craniofacial Surgery, 2020.

[6] Zhang Jingjing, Liu Weitao, Li Weiran, Gao Xuemei. Three-Dimensional Evaluation of the Upper Airway in Children of Skeletal Class III. [J]. The Journal of craniofacial surgery, 2017, 28(2).

[7] Ravelo Víctor, Olate Gabriela, Muñoz Gonzalo, de Moraes Márcio, Olate Sergio, Nota Alessandro. The Airway Volume Related to the Maxillo-Mandibular Position Using 3D Analysis[J]. BioMed Research International, 2021.

[8] Ying Fang, Wen Sun, Jiefang Shi, Shifang Zhao. Study on the relationship between the structure of temporomandibular joint and vertical bone shape and coverage of Angle II ~ 1 mandibular retraction [J]. Journal of practical Stomatology, 2008, (06): 886, 889.

[9] Tingting Liu. Comparative three-dimensional analysis of adult bony class II uniform angle and high angle upper airway [D]. Guangxi Medical University, 2017.

[10] Jieli Ni, Wen Wu, Li Meng, Mengru Fang, Jie, Yang Zhang. Study on the relationship between three-dimensional airway structure and sagittal position of condyle in adult skeletal class II orthodontic patients [J]. Biomedicine of Stomatology, 2019. 10 (02): 83-87.

[11] Truong Laura, Reher Peter, Doan Nghiem. Correlation between upper airway dimension and TMJ position in patients with sleep disordered breathing. [J]. Cranio: the journal of craniomandibular practice, 2020.

[12] Yonghua Wei, Zhong Cai, Yufen Qian. X-ray cephalometric study of upper airway and surrounding structures in normal children [J]. Orthodontics, 2001, (01): 17-20.

[13] Wasaki Tomonori, Suga Hokuto, Yanagisawa-Minami Ayaka, Sato Hideo, Sato-Hashiguchi Makiko, Shirazawa Yoshito, Tsujii Toshiya, Yamamoto Yuushi, Kanomi Ryuzo, Yamasaki Youichi. Relationships among tongue volume, hyoid position, airway volume and maxillofacial form in paediatric patients with Class-I, Class-II and Class-III malocclusions. [J]. Orthodontics & craniofacial research, 2019, 22(1).

[14] Yin Zou, Qiaomei Fu, Xianyin Xu. The relationship between tongue volume, hyoid position, airway volume and maxillofacial morphology in children with Angle class I, II and III malocclusion [J]. Shanghai Stomatology, 2020 and 29 (06): 632-637.

[15] S. S. Rana, O. P. Kharbanda, B. Agarwal. Influence of tongue volume, oral cavity volume and their ratio on upper airway: A cone beam computed tomography study [J]. Journal of Oral Biology and Craniofacial Research, 2020, 10(2).

[16] Maris Mieke, Verhulst Stijn, Wojciechowski Marek, Van de Heyning Paul, Boudewyns An. Prevalence of Obstructive Sleep Apnea in Children with Down Syndrome. [J]. Sleep, 2016, 39(3).

[17] da Costa Eliana Dantas, Roque-Torres Gina Delia, Brasil Danieli Moura, Bóscolo Frab Noberto, de Almeida Solange Maria, Ambrosano Glaucia Maria Bovi. Correlation between the position of hyoid bone and subregions of the pharyngeal airway space in lateral cephalometry and cone beam computed tomography. [J]. The Angle orthodontist, 2017, 87(5).

[18] Genta Pedro R, Schorr Fabiola, Eckert Danny J, Gebrim Eloisa, Kayamori Fabiane, Moriya Henrique T, Malhotra Atul, Lorenzi-Filho Geraldo. Upper airway collapsibility is associated with obesity and hyoid position. [J]. Sleep, 2014, 37(10).

[19] Gu Min, McGrath Colman P J, Wong Ricky W K, Hägg Urban, Yang Yanqi. Cephalometric norms for the upper airway of 12-year-old Chinese children. [J]. Head & face medicine, 2014, 10.

[20] Yuehua Liu, Xianglong Zeng, Minku Fui, Xizhen Huang. X-ray cephalometric study of upper airway structure in normal population [J]. Orthodontics, 1997, (01): 10-14.

[21] Haiyan Lu, Minying Liang, Fusheng Dong, Wensheng Ma, Meiqing Yu. X-ray cephalometric study of upper airway and surrounding structures in normal bony adults [J]. Journal of Modern Stomatology, 2007, (05): 5415442.

[22] Wun Eng Hsu, Tzu Ying Wu. Comparison of upper airway measurement by lateral cephalogram in upright position and CBCT in supine position[J]. Journal of Dental Sciences, 2019, 14(2).

[23] Genta Pedro R, Schorr Fabiola, Eckert Danny J, Gebrim Eloisa, Kayamori Fabiane, Moriya Henrique T, Malhotra Atul, Lorenzi-Filho Geraldo. Upper airway collapsibility is associated with obesity and hyoid position. [J]. Sleep, 2014, 37(10).

[24] Jiang Ying-Ying, Xu Xin, Su Hong-Li, Liu Dong-Xu. Gender-related difference in the upper airway dimensions and hyoid bone position in Chinese Han children and adolescents aged 6-18 years using cone beam computed tomography. [J]. Acta odontologica Scandinavica, 2015, 73(5).

[25] Guo Tao, Ding Yin. X-ray cephalometric analysis of upper airway morphology in normal children and adults [J]. Beijing Stomatology, 2006, (04): 247250.

[26] Romain Luscan, Nicolas Leboulanger, Pierre Fayoux, Gaspard Kerner, Kahina Belhous, Vincent Couloigner, Erea-Noël Garabedian, François Simon, Françoise Denoyelle, Briac Thierry. Developmental changes of upper airway dimensions in children [J]. Pediatric Anesthesia, 2020, 30(4).

[27] Yang Yannan, Li Hongfa. A comparative study of upper airway morphology and hyoid position in adolescents of different bone ages [A]. Professional Committee of Orthodontics of Chinese Orthodontic Association, China International Science and Technology Exchange Center. 2017 International Orthodontic Conference and 16th National Orthodontic academic Conference papers compilation [C]. Professional Committee of Orthodontics of Chinese Stomatological Association, China International Science and Technology Exchange Center: Chinese Stomatological Association, 2017.

[28] Gu Min, McGrath Colman P J, Wong Ricky W K, Hägg Urban, Yang Yanqi. Cephalometric norms for the upper airway of 12-year-old Chinese children. [J]. Head & face medicine, 2014, 10.

[29] Celik O, Yalin S, Nan E, et al. Adenoid hipertrofisinin maksillofasial geliim üzerine etkileri/Effects of Adenoid Hyperprophy on Maxillofacial Growth[J]. kulak burun boğaz ve baş boyun cerrahisi dergisi, 1995, 3:222.

[30] Bin Hu MD, Jingying Ye MD, PhD, Guoping Yin MD, Yuhuan Zhang BS. The influential factors on the morphological changes of upper airway associated with mouth opening [J]. The Laryngoscope, 2018, 128(12).

[31] Fu Qiang, Ding Yin, Wang Yanqing, Chen Lin. Analysis of the correlation between the airway morphology of maxillofacial and pharyngeal cavity and cervical posture [J]. Journal of practical Stomatology, 2002, (03): 259, 262.

[32] Lu Haiyan, Ma Wensheng, Dong Fusheng, Hu Xiaoying, Ren Guiyun. Effect of FR III functional correction on upper airway space in patients with early bony Class III malocclusion [J]. Journal of Modern Stomatology, 2007, (04): 354, 356.

[33] Wang Wei, Mo Shicheng, Wang Lin. airway changes before and after mandibular retraction treated with Twin-block [J]. Shanghai Stomatology, 2018. 27 (06): 607-611.

[34] Chen Nan, Xiong Bin, Zhang Ting, Xia Wenqian, Lu Jianfeng, Gao Meiqin. Changes of upper airway before and after SGTB treatment in nocturnal snoring adolescents with Angle Class II malocclusion [J]. Shanghai Stomatology, 2021 Journal 30 (03): 273-277.

ISSN 2706-6819 Vol.4, Issue 9: 6-11, DOI: 10.25236/IJFM.2022.040902

[35] Li Changtao, Liu Shanshan, Gao Xuemei, Wang Xueling, Meng Xianmin, Zou Jiajing, Wang Na, Wu Jing. Effects of maxillary arch expansion and mandibular anterior guide on upper airway in children with mixed dentition [J]. Chinese Journal of Orthodontics, 2019, (01): 7-11.

[36] Li Liang, Liu Hong, Cheng Huijuan, Han Yanzhao, Wang Chunling, Chen Yu, Song Jinlin, Liu Dongxu. CBCT evaluation of the upper airway morphological changes in growing patients of class II division 1 malocclusion with mandibular retrusion using twin block appliance: a comparative research. [J]. PloS one, 2014, 9(4).

[37] Yıldırım Ersin, Karaçay Şeniz. Volumetric Evaluation of Pharyngeal Airway after Functional Therapy. [J]. Scanning, 2021.

[38] Wanhong Tang, Qiao Liu, Juhong Lin, Huan Zeng. A preliminary study on the changes of palate and airway after slow expansion of maxilla in the early stage of substitute dentition [J]. Journal of practical Stomatology, 2020. 36 (03): 533-535.

[39] Fastuca R, Meneghel M, Zecca P A, Mangano F, Antonello M, Nucera R, Caprioglio A. Multimodal airway evaluation in growing patients after rapid maxillary expansion. [J]. European journal of paediatric dentistry: official journal of European Academy of Paediatric Dentistry, 2015, 16(2).

[40] Lei Jie, Xiao Yao, Luo Maoxuan, Xu Xiaomei. Changes of condylar position and upper airway structure before and after tooth extraction in 12-14-year-old skeletal class II high-angle female. Shanghai Stomatology, 2020 and 29 (03): 281-286.

[41] Sun Jianwei, Tang Rui, Gao Jie, Li Yongming. Cone beam CT analysis of oropharyngeal airway changes in adolescents with bony class I malocclusion after reduction correction [J]. Chinese Journal of Stomatology, 2021 Journal 56 (03): 256-262.

[42] Al Senani Yara, Al Shammery Al Jouharah, Al Nafea Abeer, Al Absi Nisreen, Al Kadhi Omar, AlShammery Deema. Influence of Fixed Orthodontic Therapy on Pharyngeal Airway Dimensions after Correction of Class-I, -II and -III Skeletal Profiles in Adolescents. [J]. International journal of environmental research and public health, 2021, 18(2).

[43] Kongsong W., Waite P. D., Sittitavornwong S., Schibler M., Alshahrani F. . The correlation of maxillomandibular advancement and airway volume change in obstructive sleep apnea using cone beam computed tomography [J]. International Journal of Oral and Maxillofacial Surgery, 2020, (prepublish).

[44] Tahsin Tepecik, Ümit Ertaş, Metin Akgün. Effects of bimaxillary orthognathic surgery on pharyngeal airway and respiratory function at sleep in patients with class III skeletal relationship[J]. Journal of Cranio-Maxillo-Facial Surgery, 2018, 46(4).

[45] Wen Xinglong, Li Yang, Yi Biao. Study on three-dimensional structural changes of upper airway in patients with bony class II malformation after bimaxillary surgery [J]. Chinese Journal of Orthodontics, 20119, 26 (01): 27-32.

[46] Chen Deyu, Guo Wanlu, Wang Yurong. Meta analysis of upper airway changes before and after orthodontic treatment combined with bimaxillary surgery for bony class III malocclusion [J]. Journal of practical Stomatology, 2017. 33 (04): 475-480.