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Review Article

Role of airway in orthodontic treatment planning - A Literature Review

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ABSTRACT

Diagnosis and treatment planning of the orthodontic patient involves the evaluation of four areas: the TMJs and musculature, the airway, the face, the dentition and periodontal structures. The function of respiration is highly relevant to orthodontic diagnosis and treatment planning. For the normal growth of the craniofacial structures, the normal airway is one of the important factors. By understanding the normal growth of the skull, the significance of the growth and function of the nasal cavities, the nasopharynx, and the oropharynx have been interpreted. Surgical orthopaedic and fixed appliance therapy has been advocated by clinicians to treat patients wih airway dysfunctions. These treatment modalities differ from patien to patient and have to be considered based on lot of criterion. This review focused on the role of airway in orthodontic treatment planning.

INTRODUCTION

WHAT IS THE PROBLEM?

Significant relationships between the pharyngeal structures and both dentofacial and craniofacial structures have been reported in several studies.[1] The interaction between pharyngeal dimensions and various vertical and sagittal facial growth patterns at varying degrees have been reported by numerous researchers. In determining the size and shape of the human face and thus of the airway, the heredity plays an important role; however, the environment appears to play a major part in the etiology of nasal obstruction. Normal upper pharyngeal airway space is 15–20 mm while lower pharyngeal airway (LPA) space is 11–14 mm. Skeletal features such as retrusion of the maxilla and mandible and vertical maxillary excess in hyperdivergent patients

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may lead to narrower anteroposterior dimensions of the airway. On the other hand, the growth of craniofacial structures has been affected by the oropharyngeal airway, narrowing of the pharyngeal airway passage (PAP). The upper airway has long been an area of interest in orthodontics. A normal airway is an important factor in the physiologic growth of craniofacial structures. Differing methods of measurement of nasal airway dimensions and function have been proposed and utilized; each technique has its strengths and limitations. The imaging of the upper airway is an indispensable tool in the field of orthodontics. Upper airway imaging has allowed us to begin to understand the biomechanical bases for obstructive sleep apnea syndrome (OSA) and mouth breathing. Modern developments in imaging have produced many options and methodologies.[2]

The mutual interaction between the pharyngeal structures and the skeletal relationship is a subject of interest for the orthodontists and maxillofacial surgeon. Orthodontists believe that evaluation of soft tissues including facial contours, neuromuscular function, tongue, tonsil, adenoids and nasal polyps should be an integral part of orthodontic diagnosis and treatment planning. The pharyngeal airway is an intricate structure. In conjunction with its surrounding structures, it is responsible for the physiologic processes of swallowing, vocalization, and respiration.

HISTORICAL BACKGROUND

Renate[3] in (1982) reviewed a number of early studies demonstrating that nasal blockage leads to orofacial and dental deformities regardless of the cause for the obstructions. A number of authors during the 1960s and 1970s, including Ricketts, Subtelny and Quinn[6] concluded that nasal obstruction plays a significant role in an altered pattern of facial growth. Later studies evaluating a number of different etiologies leading to mouth breathing have reported similar results and the effects of allergic rhinitis and asthma have specifically been shown to be associated with divergent facial pattern and posterior crossbites. While it may appear that there is some disagreement on the conclusions of previous studies as to the exact facial abnormalities seen associated with allergies, there are, however, some very common observations that are reported, namely divergent facial pattern and posterior crossbites. It must be noted, however, that the development of malocclusion is multifactoral, having both genetic and epigenetic influences. Evidence has demonstrated that nasal obstruction, regardless of the cause, leads to mouth breathing, which in turn leads to altered function resulting in altered form of facial development. For these reasons, a young child presenting with predisposing factors to nasal obstruction should receive prompt attention before the adverse effects of nasal obstruction manifests.

BASIC SCIENCE

Airway Anatomy

The airway is divided into the upper and lower airway (Fig.1). The upper airway begins at the nares and mouth and extends to the glottis.[4] The lower airway extends from the glottis to the alveoli.

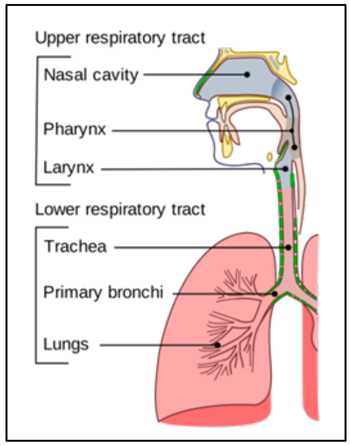

Fig. 1: Upper and Lower respiratory tract

The Upper Airway

Anatomically, the upper airway consists of the pharynx and nasal cavities (Fig 2).[4] However, functionally, the larynx and trachea may be included, and the oral cavity provides an alternate entrance to the respiratory passages.

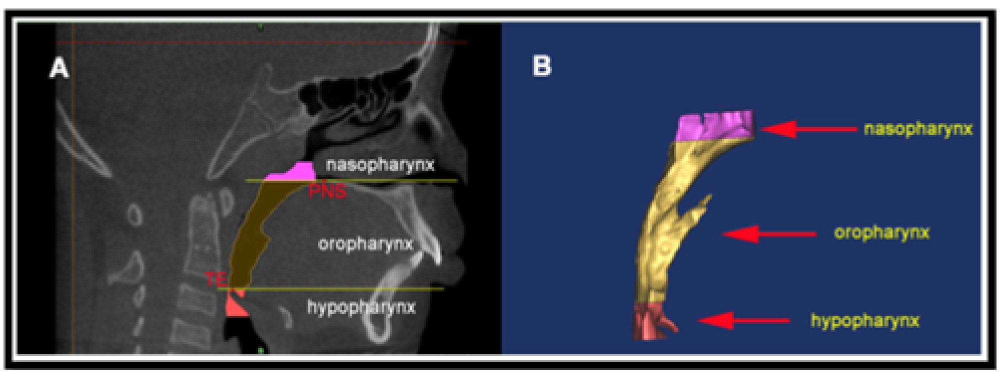

Fig. 2: 3D model of the upper airway was reconstructed. A) The upper airway was subdivided into three parts by two planes perpendicular to the sagittal plane and each region was highlighted in different colors. The landmarks used for defining the planes were: PNS, posterior nasal spine; SE, the superior border of the epiglottis. B) Each region of the upper airway was reconstructed respectively. The nasopharynx is the region from the top of the upper airway to PNS. Oropharynx region is between PNS and SE, and the hypopharynx is from SE to the level of the third cervical vertebra (C3)

The openings of the mouth and nose define the beginning of the airway. From a functional perspective, the nose is the primary structure for air entrance. The nose is a pyramidal structure composed of bone and cartilage attached to the facial skeleton, and is divided by a midline septum into the two nasal cavities The nose provides an immunologic barrier (mucus), warms and humidifies air, and serves as a food detection system (sense of smell). In times of high ventilatory demand or instances when the nares are blocked, a person can also utilize the mouth for ventilation.

The nasopharynx lies posterior to the turbinates and superior to the soft palate. It terminates into the oropharynx inferior-posteriorly. The pharynx is the area of the airway composed of the spaces behind the nose (nasopharynx) and the oral cavity (oropharynx).

The pharynx and hypopharynx are the areas of common passage for food and respiratory gasses. The pharynx is a U-shaped fibromuscular tube extending from the base of the skull to the cricoid cartilage at the entrance to the esophagus. The pharynx thus forms a common aerodigestive tract and is intimately involved with the act of swallowing. The hyoid bone, is the only bone in the body that does not directly articulate with another bone. Instead, it serves as a common point of attachment for a number of muscles and ligaments that function in swallowing and airway maintenance. Given its size, contents, and multiple functions, the pharynx is a very common area for airway obstruction to occur. However, imaging work by Shorten et al.[4] has demonstrated that, in fact, the soft palate and epiglottis make contact with the posterior wall of the oropharynx and pharynx before the tongue does and that these structures cause airway obstruction. Thus, the action for opening an airway actually depends on the anterior traction on the epiglottis. This is accomplished through the hyoepiglottic ligament by the anterior displacement of the hyoid bone. The hyoid is lifted by anterior mandibular displacement that occurs with a head-tilt chin-lift or jaw thrust.

These changes, especially in the nose and posterior pharynx, will result in decreased airflow within the nasal passages and the development of mouth breathing depending on the age of onset may develop into malocclusion disorders. Throughout life, respiratory needs can alter the progression of developmental oral activities. Changes in the normal pattern of oral development can lead to alteration in the mandible and tongue. With the presence of mouth breathing the mandible is lowered and the lips are parted. This results in alteration on the forces affecting the facial skeleton, the tongue assumes a lower position in the oral cavity reducing the support of the palate and maxillary arch, the lower lip moves away from the labial surface of the maxillary incisors, the mandible may not contact the maxilla during swallowing, permitting unrestrained vertical alveolar development and posterior tooth eruption. These changes can impact the facial development with:

1. An elongated vertical development of the face (Fig. 3),
2. An increased open anterior bite,
3. Hyperplastic and inflamed gingival tissues,
4. A high palatal vault (Fig. 4),
5. Narrow maxilla (Fig. 4) leading to posterior crossbite,
6. A steep mandibular plane (Fig. 5), and
7. Class II malocclusion (Fig. 6).

Fig. 3: Patient displaying long face syndrome obstruction

Fig. 4: High palatal vault with nasal airway

Fig. 5: Lateral cephalogram displaying steep mandibular plane

Fig. 6: Class II malocclusion

This will result in the typical gaping expression and discomfort when the lips are brought together (lip incompetence). Mouth breathers have an increased incidence of malocclusion due to the clockwise rotation of the mandible secondary to elongation of the posterior alveolus and overeruption of the posterior dentition.

METHODOLOGY

Methods of assessing the airways

In the past, two dimensional (2D) cephalometric images were used to detect the anatomical limits of the airway. However, 2D images give poor representation of airway anatomy. To overcome this, other methods, such as MRI, conventional computed tomography (CT), rhinomanometry (RMN), acoustic rhinometry (AR) and CBCT have also been utilized.(Fig. 7)

Fig. 7: Cone beam computerized tomography for craniofacial imaging

Class II malocclusion is one of the risk factors for sleep-related disordered breathing (SDB) and obstructive sleep apnea (OSA), especially in cases with retrognathic mandibles. Many studies found a correlation between retrognathic mandibles and reduced upper airway volume. To improve airway obstruction in these patients, intervention involves forward mandibular positioning,

SLEEP-RELATED DISORDERED BREATHING (SDB)

Definition and Pathophysiology

Sleep-related disordered breathing (SDB) describes an abnormal breathing disorder,which includes snoring, apnea, hypopnea, and respiratory effort related arousals (RERAs). SDB also includes syndromes such as obstructive sleep apnea syndrome(OSAS), central sleep apnea syndrome (CSA) and Cheyne-Stokes respiration(CSR).[9] OSA has gained much attention in recent times due to the neurocognitive and cardiovascular sequelae. It was first described by Guilleminault[9] in the 1970s as a disease defined by the amount of apnea and hypopneas experienced during sleep with systemic effects. The disease is characterised by repetitive apnea, loud snoring, and excessive daytime sleepiness. An apnea is defined as the cessation of breathing for 10 or more seconds.[10] Hypopnea is the reduction of airflow where a total cessation is not observed. There are three forms of OSA, central, obstructive and mixed. Central apnea refers to cessation of nasal and oral airflow with cessation of respiratory effort. Obstructive apnea is defined as the absence or reduction of nasal and oral airflow despite continuing respiratory effort. Mixed apnea has both central and obstructive components.

HUMAN STUDIES

The effects of functional appliance treatment, including the Herbst appliance, is a controversial topic.While many studies claim that functional appliances significantly enhance mandibular growth, some studies found that functional appliances did not promote significant changes in mandibular growth, and the improvement was due to dentoalveolar changes. These conflicting results could be due to inconsistencies in study and appliance design, not using functional appliances at the right age, patient compliance and individual patient variation. To answer the question of "Do functional appliances grow mandibles?", high level evidence such as meta-analysis, systematic reviews and randomized clinical trials (RCT) should be examined and should be interpreted according to the case.

There is evidence that functional appliances significantly reduce overjet by lower incisor proclination and maxillary incisor retraction, This was true for both removable and fixed functional appliances. A meta-analysis by Vaid et al. reported that fixed functional appliances create more labial displacement of mandibular incisors than removable appliances. There is also evidence for distal movement and intrusion of maxillary molars and mesial movement of the mandibular molars in Herbst and TB treatment.

DISCUSSION

Prevalence of obstructive sleep apnea syndrome

The prevalence of snoring ranges from 3% to 35% in young children, while 2% to 3.5% are presented with OSA.[11]

Risk factors

In children, adenotonsillar hypertrophy, allergies and asthma, obesity, and craniofacial abnormalities are the main causes of SDB.

Anatomic considerations

The pathophysiology of OSA is closely related to the anatomy of the upper airway, with features such as increased resistance and collapsibility of muscles of the upper airway. Narrowing of the upper airway frequently occurs at the level of soft palate and the base of the tongue. A constricted maxilla has been reported as a predisposing factor for SDB, and after maxillary expansion, increase in airway dimensions and decrease in nasal airway resistance have been found. Increased obesity and neck size, a forward and extended head posture, as well as increased soft palate and tongue dimensions, a small nasopharyngeal cross sectional area, a lower hyoid position, a smaller and retrognathic mandible, together with an overall reduction in sagittal craniofacial dimensions were reported to be predictors for OSA. A retropositioned maxilla as well as the mandible were also hypothesized as factors for pharyngeal airway reduction due to the more posterior position of the tongue.

Diagnosis

From a medical perspective, during a routine health check up, suspected OSA patients are questioned on sleep history such as snoring, witnessed apneas, gasping/choking episodes, excessive day sleepiness, headaches in the morning and sleep fragmentation/insomnia. Patients with signs of upper airway narrowing, obesity, increased neck circumference, elongated/enlarged uvula or high arched/narrow hard palate, may be at risk of OSA.[12]
Patients suspected to have OSA undergo a laboratory Polysomnography, as this is the gold standard in the diagnosis of sleep related breathing disorders. The apneahypopnea index (AHI) is the number of apneas plus hypopneas per hour of sleep. Another diagnostic method for OSA is the respiratory disturbance index (RDI).

DISCUSSION

Treatment of pediatric obstructive sleep apnea

There are many treatments option for snoring and OSA, such as weight loss, nasal continuous positive airway pressure (CPAP), mandibular advancement splint (MAS), maxillary expansion and other extensive surgical treatments like adenoidtonsillectomy (Removal of enlarged tonsils and/or adenoids).

Nasal continuous positive airway pressure (CPAP)

CPAP, which was introduced by Sullivan et al.,[13] is the gold standard in OSA treatment. Improvements in OSA symptoms have been attributed to prevention of pharyngeal airway collapse.

Rapid Maxillary Expansion

RME is claimed to reduce OSA symptoms in children and adolescents, as the constriction of maxillary arches is a feature of chronic nasorespiratory obstruction.[14] Many studies reported improvements in AHI, and in clinical signs of breathing disorders in children after RME treatment.
An increase in nasal cavity floor area adjacent to the midpalatal suture, and lateral movement of the outer walls of the nasal cavity after RME treatment, increases the capacity of nasal cavity and decreases the nasal airway resistance. Palaisa et al.[15] studied the anatomical changes in the nasal cavity after RME with conventional tomography on 19 children aged 8-15 years and followed up with the patients after 3 months. They found the anterior nasal cavity area to increase by 11.7% immediately after treatment, by 22.2% at the 3 month follow up, and an 35.7% overall increase. Middle and posterior nasal cavity areas also showed a similar increase, while the left and right sides of nasal cavity showed no significant change.
Pirelli et al.[16] evaluated the effect of RME in 42 children (average age 7.3 years) with OSA for 6-12 months. The results from PSG showed improvement of nasal airflow after RME treatment. Nasal fossa width and maxillary intermolar width were also increased. The authors suggested that RME might be one of the treatment

options in OSA patients, improving nasal airflow and reducing pharyngeal airway collapse.

Mandibular advancement splint and functional appliances

The mandibular advancement splint (MAS) is an oral device worn during sleep by OSA patients to enlarge the upper airway and/or decrease the upper airway collapsibility by keeping the mandible and the tongue base forward. Patients with mild to moderate OSA symptoms or patients who are intolerant to Continuous positive airway pressure (CPAP) are suggested to use MAS.

The forward and downward movement of the mandible with MAS increases the superior airway space between the soft palate and posterior nasopharynx as well as the posterior airway space between the base of the tongue and posterior oropharynx. Johnson et al.[17] reported a 56% increase of posterior airway space with protrusion of the mandible with MAS in situ in patients with OSA.

Most studies, investigating the effect of MAS in patients with OSA have shown improvement in AHI with treatment. MAS is used in adults and has to be worn every night, similar to CPAP, as long as patients want improvements in their symptoms. In growing children the same effects are created using functional appliances, with the added benefit of improving maxillomandibular relationships.

Cozza et al.[18] investigated the effect of modified RME with modified monobloc (MM) in 20 OSA, retrognathic mandible children (mean age 5.91 years, treatment time 6 months). After treatment the PSG results showed significant reduction in AHI. Moreover, MM had a significant positive effect in the reduction of daytime sleepiness and there was a subjective improvement in the quality of sleep.

CONCLUSION

Most of the literature suggests a direct and positive co-relation between various treatment modalities like Rapid maxillary expansion, Functional appliances etc on airway, still further studies are mandatory regarding the same.

RECOMMENDATIONS FOR FUTURE

Airway-focused orthodontics is a protocol which factors upper airway dimensions and inputs when instituting orthodontic treatment. Impact assessment of orthodontic treatment on upper airway dimensions is considered a key aspect of decision-making. The protocol encourages mimicking what the nature intended, i.e., by □nding room for all the teeth early enough by promoting breastfeeding, habit-breaking therapy, RME, and functional jaw orthopedics. Maxillomandibular advancement surgeries are known to enhance the upper Airway-focused orthodontics is a protocol which factors upper airway dimensions and inputs when instituting orthodontic treatment. Impact assessment of orthodontic treatment on upper airway dimensions is considered a key aspect of decision-making. The protocol encourages mimicking what the nature intended, i.e., by □nding room for all the teeth early enough by promoting breastfeeding, habit-breaking therapy, RME, and functional jaw orthopedics. Maxillomandibular advancement surgeries are known to enhance the upper Airway-focused orthodontics is a protocol which factors upper airway dimensions and inputs when instituting orthodontic treatment. Impact assessment of orthodontic treatment on upper airway dimensions is considered a key aspect of decision-making. The protocol encourages mimicking what the nature intended, i.e., by finding room for all the teeth early enough by promoting breastfeeding, habit-breaking therapy, RME, and

functional jaw orthopedics. Maxillomandibular advancement surgeries are known to enhance the upper airway dimensions in addition to improving dentofacial esthetics drastically. Moreover, the percentage of cases who are undergoing this beneficial modality is far less in view of the need felt. This equation has to change and more capacity to provide this treatment modality must be built in our health-care system. Prof Christian Guilleminault of Stanford University, a leading light in the field of neurobiology and sleep medicine, has aptly summarized the emerging role of orthodontia; "although orthodontia recognizes the importance of evaluating and treating upper airway sleep disorders, they are yet to realize how well positioned they are for prevention of sleep-disordered breathing.

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