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Effects of Various Dentofacial Orthopedic and Orthognathic Treatment Modalities on Pharyngeal Airway

Tejashri Pradhan and Aarti Sethia

Abstract

The function of respiration is highly relevant to orthodontic diagnosis and treatment planning. Significant relationships between pharyngeal, craniofacial as well as dentofacial structures have been reported in several studies. Many authors have emphasized that mouth breathing is concomitantly associated with constricted airway causing obstructive sleep apnoea. Associated symptoms can be cured with correction of either skeletal or dental problems or both. Therefore it would be very intriguing to understand and interpret the airway during diagnosis and treatment planning for a clear view of changes in the airway dimensions during the course of orthodontic treatment using various treatment modalities. Therefore a complete understanding of the concept of airway should be considered as an important one. This chapter gives us an insight to the intricate detailing on how the various orthodontic and dentofacial orthopedic treatment signifies the changes in the dimensions of pharyngeal airway.

Keywords: pharyngeal airway, skeletal changes, dental changes, functional appliances, Orthognathic surgeries, expansion

1. Introduction

Orthodontia being one of its kind specialty has always aimed at correcting the dento-facial esthetics which involves achievement of: ideal jaw relationship, normal oral function, proximal and occlusal contact of teeth. But the core aspect of function and performance has been taken up by the function of respiration or breathing which in fact is the top most important function for humans. The synchrony of ideal health and facial development is based on accurate posture of tongue and nasal breathing. Therefore the recent protocols be it Preventive, interceptive or corrective orthodontics, factoring the dire need of pharyngeal airway space improvement in addition to improvement in smile and facial appearance [1].

Today Orthodontists play a very crucial and integral role in the interdisciplinary team management of airway and sleep related disorders. Commencement of Sleep

Figure 1.
Anatomy of the pharyngeal airway space.

Medicine as a speciality has brought about a very clear understanding of transformative or developmental biology, medicine; the jaw size and its spatial orientation has surfaced as the important factor of optimizing upper airway physiology. Airway passage, type of breathing and craniofacial formation are so interconnected during growth and development that form follows the function and function follows the form [2]. So the specialty of orthodontics, is well balanced to treat ideally form and function both in children and adults so that the function is optimized for life. The conventional treatment in orthodontics has always prioritised primarily on teeth esthetics. This method, seldom addresses symptoms and as a result the airway is ignored. Therefore it is necessary to focus more at physiologic adaptations and its muscle to resolve sleep disordered breathing [3].

The nasal airway analysis requires adequate anatomical dimensions for the overall pharyngeal airway space [4]. Oral breathing in relation to nasal obstruction is a well known entity among orthodontic patients [5]. Obstruction of nasopharyngeal pathway is associated with various craniofacial features, such as backward and upward growth of condyle, backward and downward rotation of mandible, divergent gonial angle, anterior open bite and spacing w.r.t mandibular anteriors [6]. The eradication of respiratory obstruction and acquiring adequate functional nasal breathing with precise patterns of swallowing boosts the stability and functional balance of orthodontic treatment (**Figure 1**) [7, 8].

2. Anatomy of airway

The airway, or respiratory tract, describes its organs that allow airflow during ventilation. They pass through the nares and buccal opening till the blind end of the alveolar sacs. This respiratory tract is subdivided into different regions and various organs and tissues to perform specific functions. The airway passage is subdivided into the upper and lower airway, each of which has numerous compartments.

The pharynx is the mucosal lined portion of the airway that is situated between the base of the skull and the esophagus. It is subdivided as follows:

- Nasopharynx [rhino-pharynx], is the muscular tubular structure from the nares, including the posterior nasal cavity, that divides from the oropharynx by the palate and lining the skull base superiorly.
- Oro-pharynx is the region that joins the nasopharynx and hypopharynx. It is the region situated between the palate and the hyoid bone, which anteriorly gets divided from the oral cavity by the tonsillar arch.
- Hypopharynx is the region which connects the oropharynx to the esophagus and the larynx, the region of pharynx below the hyoid bone.

Boundary between nasopharynx and oropharynx is known as soft palate, similarly the boundary between the oropharynx and laryngopharynx is the epiglottis. The soft palate is dangled at the posterior corner of the hard palate, and its top and bottom are comprises of the mucosal tissues. The centre portion of the soft palate includes muscles, aponeurosis, blood vessels, nerves, lymph and mucosal tissues. During the process of deglutition and injestion, the soft palate develops postero-superiorly and separates the nasopharynx and oropharynx. The mandible is interconnected to the hyoid bone, tongue, and soft palate by the strong musculature. Therefore, the location of the mandible can affect the size of the pharyngeal airway space.

3. Pharyngeal airway space (PAS)

Pharyngeal airway space is divided into three compartments: (Figure 2).

Upper pharyngeal width (UPW): Its is the smallest distance between the posterior border of the soft palate to the nearest point on the posterior pharyngeal wall.

Figure 2.
Various compartments of the pharyngeal airway space [9].

Middle pharyngeal width (MPW): It is the smallest distance between the posterior borders of the tongue to the nearest point on the posterior pharyngeal wall, through the tip of the soft palate.

Lower pharyngeal width (LPW): It is the smallest distance from the intersection of posterior border of tongue and inferior border of the mandible to the closest point on the posterior pharyngeal wall.

Normal upper pharyngeal airway space is 15–20 mm while middle and lower pharyngeal airway (LPA) space is 11–14 mm [9].

Literature supports the hypothesis that mandibular deficiency is analogous to a narrower PAS. It is generally observed that a retrognathic mandible and reduced space between the cranial column and the corpus of the mandible often leads to a posteriorly placed tongue and soft palate, which in turn increases the chances of impaired respiratory function and possibly causing nocturnal breathing problems. Alterations in PAS have been described with various sleeping disorders such as obstructive sleep apnea. Advancement and setback surgeries are standard procedures for the correction of mandibular position whether its retrognathism and prognathism, respectively. Operation for the mandibular deformity changes hard and soft tissue components, including the PAS [10].

4. Diagnosis

Malocclusion can be perceived in several ways which more likely includes patients with enlarged adenoids, obstructive sleep apnoea (OSA), snoring and clefts. The relation between respiratory pattern and form of malocclusion is still disputed. Patients with craniofacial disorders including a short cranial base, reduction in the cranial base angle, bimaxillary retrusion, and retrognathic mandibles show common finding of narrow airways [11].

5. Various methods for assessment

The methods described to assess the airway include: nasal endoscopy, rhinomanometry, acoustic rhinomanometry, cephalometry, computed tomography (CT), magnetic resonance imaging (MRI) and cone-beam computed tomography (CBCT).

6. Two dimensional versus three dimensional imaging

Lateral cephalograms can provide us with useful, credible and replicable airway measurements while minimizing patient costs and radiation exposure. Studies have shown that while cephalometric measurements provide two-dimensional data, cephalometry is a reliable method for airway assessment and adenoid size estimation [12]. Another comparative study to assess the linear measurements with lateral cephalograms and CBCT was carried out and the conclusions drawn: that airway linear measurements are reliable, with both lateral cephalograms and CBCT reconstruction, as there is a positive correlation with the respective area measurements on axial slices [13].

7. Changes in pharyngeal airway space using functional appliance therapy

In 1934, Pierre Robin proposed that use of an intraoral appliance helps in bringing the lower jaw forward in newborns with mandibular deficiency. This helps in preventing the posterior relocation of the tongue during sleep and the occurrence of oropharyngeal collapse [14]. This concept is now often used in adult obstructive sleep apnea (OSA) patients to avoid an upper airway collapse during sleep with the help of various myofunctional appliances [15]. Moreover, the idea to relocate the mandible anteriorly is applied in dentofacial orthopedics by the use of various myofunctional appliances which helps in stimulating mandibular growth in skeletal Class II growing patients with mandibular deficiency [16]. Several authors have hypothesized that the functional orthopedic treatment of growing patients with short mandibles may lead to increased oropharyngeal airway dimensions, and some have suggested a possible reduction in the risk of future respiratory problems (**Figures 3 and 4**) [17–20].

Figure 3.
Two dimensional lateral cephalometric evaluation versus three dimensional CBCT evaluation.

Figure 4.
Changes in the dimension of pharyngeal airway width using functional appliance therapy [9].

8. Effect of various functional appliances on pharyngeal airway

Twin block is considered to be one of the most patient compliant myofunctional appliance. Therefore prominent results can be drawn with this appliance [21]. According to Jena et al. [21] when twin block was compared with Mandibular protraction appliance MPA, the improvement of oropharynx dimension by twin-block appliance was significantly more. Another study showed significant increase in the dimensions of nasopharynx, oropharynx and hypopharynx following twin-block treatment [22]. Although the growth itself had very minor contribution in the improvement of oropharyngeal dimension, but the advancement of mandible through myofunctional orthopedic correction was evidently beneficial. The anterior relocation of mandible by the functional appliances places the tongue more forward and thus increases the overall dimension of oropharynx [23]. The improvement in the dimension of oropharynx was more with removable functional appliance (twin block) compared to fixed functional appliance [21, 24]. An increase in oropharyngeal volume was found after functional appliance treatment in Class II patients, leading to an increase in final volume of the upper airway.

Forsus Fatigue Resistance Device (FFRD) brought about improvement in the oropharyngeal airway significantly when compared the untreated subjects. Post treatment, the mean values of Superior Pharyngeal Space and Middle Pharyngeal Space increased by 1.06 mm and 1.28 mm respectively in the FFRD group. Aksu et al. [25] measured the airway space equivalent to the depth of hypopharynx and concluded that there was no significant improvement in the width of hypopharynx. Bavbek et al. [26] measured CV3 projection in FFRD group and control group and found that FFRD did not increase the hypopharyngeal width. Whereas the other three studies had not measured the hypopharyngeal airway dimension.

The following were the conclusions drawn from the systematic review [27]:

Functional appliances help in improving the pharyngeal airway dimensions in Class II malocclusion subjects with retrognathic mandibles. But it is also evident that minimum effect on nasopharyngeal airway passage and the minor improvement is mainly due to growth. Improvement of oropharyngeal airway passage dimensions is a very prominent effects of functional appliance treatment. Removable functional appliance prove to be more efficient than fixed functional appliance in the improvement of positive airway pressure (PAP) dimension.

9. Hyoid bone and tongue position with changes in pharyngeal airway space

The results obtained by treatment with functional appliances are mainly dento-alveolar in nature, there is however a significant modification of the oropharyngeal airway dimension is observed in most of the studies. Hypothesis could be presumed that, the dentoalveolar modifications occurring after functional appliance treatment, guides the tongue to a more forward position, enlarging the posterior airway space (PAS). Therefore, it can be said that forward positioning of the tongue is part of a planned surgical strategy when treatment of sleep disordered breathing is needed. Changes observed in the hyoid bone distance are more prominent horizontally than that in the vertical direction [27].

The conclusions drawn with respect to hyoid bone position are as follows:

Hyoid bone is found to be posteriorly and superiorly placed in patients with Class II skeletal malocclusion when compared to Class III and Class I skeletal cases. The hyoid bone position in males is found to be more inferiorly and anteriorly when compared to females. Also the anterior cranial base is very strongly related to the nasal fossa length and a moderately related to positive correlation with the hyoid bone vertical position and lower airway width. The hyoid bone vertical position had a strong positive correlation with the length of the nasal fossa [4].

10. Changes in pharyngeal airway space with various surgical procedures

Orthognathic surgery is a common method to treat dentofacial deformities. It changes the position of facial skeletal structures and also affects the morphology of the pharynx drastically. Structures such as soft palate, tongue, hyoid bone and some surrounding tissues are attached directly or indirectly to the maxilla and mandible, therefore any desired movement of the jaws by orthognathic surgery affects these tissues, causing changes in the dimensions of the pharyngeal area [28].

11. Mandibular set back surgery

In a thesis by Jain et al. [29], statistically significant increase in the nasopharyngeal airway dimension was observed. This finding has also been reported by Kitagawara et al. [30] and has been explained as a biological adaptation against postoperative swelling and edema, and for airway maintenance. It is a compensatory mechanism after the hypopharyngeal airway collapses. According to Susarla et al. [31], the upper airway length (UAL) contributes to resistance to airflow. Longer airways have more resistance to airflow than shorter airways [31].

12. Bimaxillary surgeries

Chen et al. [32] found that patients undergoing bimaxillary surgery had changes at the three levels, with increase at the nasopharynx and decreases at the oropharynx and hypopharynx. Bimaxillary operations mostly decrease the narrowing effect of the mandibular setback operations [33]. This indicates that Upper Airway Length increases along with narrowing of the airway, in patients who undergo bimaxillary surgery.

13. Mandibular advancement

Statistically significant increase in the oropharyngeal and hypopharyngeal airway dimension was observed according to Jain et al. [29] and Turnbull et al. [34].

14. Pharyngeal airway in cleft lip and palate patients

Cleft patient presents more frequently with large adenoids than do the non-cleft population. This has been regarded as a compensatory phenomenon to decrease the

pharyngeal depth and make velopharyngeal competence possible. After palatal operation, soft tissue is sometime short and scarred and frequently the uvula is missing, tissue deficit results in incompetence to velopharyngeal sphincter mechanism.

Gohilot et al. [35] in a study noted that adenoidal tissue size was larger in the juvenile and adolescent cleft group as compared to the adolescent cleft group and airway passage was decreased in juvenile subjects. The thickness of adenoidal tissues decreases with age in both subjects with and without CLP. Conversely, the upper airway dimensions increase in those with and without CLP.

15. Effect of expansion on pharyngeal airway

Iwasaki et al. [36] evaluated the effect of rapid maxillary expansion (RME) on nasal airway ventilation condition, tongue posture, and pharyngeal airway volume. They found that RME enlarges the pharyngeal airway both ways with and without improvement in nasal obstruction. Another study by Malkoç et al. [37] derived that expansion does not cause any significant change in the dimension of pharyngeal airway.

16. Cervical spine posture

Various researchers have been taking prime interest in finding the correlation between the cervical spine posture, head position and pharyngeal airway space, but significant evidence still needs to be procured through proper research.

17. Effect of different growth patterns on pharyngeal airway

A study by Kocakara et al. [38] showed that, the pharyngeal airway dimensions and hyoid bone position are similar in individuals in the sagittal direction. The vertical airway length is significantly shorter in Class III patients with hypodivergent patterns. Another study by Ucar et al. [39] concluded that the nasopharyngeal airway space and upper pharyngeal airway space in Class I subjects is larger in low angle cases than in high angle cases.

18. Conclusions

Impactful evaluation of orthodontic treatment on the pharyngeal airway dimensions is considered one of the prime aspects of orthodontic diagnosis and treatment planning. The protocol helps in emboldening the impersonation of what the nature had planned i.e. by fitting all the teeth early enough through various habit breaking appliances, expansion appliances, and functional jaw orthopedics. Although maxillo-mandibular advancement surgeries are very well known to improve the airway dimensions along with improvement in dento-facial esthetics. But the hypothetical percentage of cases undergoing this beneficial modality is far less due to its invasive nature. Although Orthodontia at the present juncture, recognizes the importance of evaluating and treating airway, sleep disorders, there are yet tremendous scope untouched.

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