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Research Article

A COMPARATIVE MORPHOMETRIC ANALYSIS OF PHARYNGEAL AIRWAY SPACES AMONG SUBJECTS WITH DIFFERENT SAGITTAL CRANIOFACIAL PATTERNS

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Abstract

Aim: The aim of the present study was to investigate the inter-relationship between pharyngeal airway widths, velum morphology and hyoid bone position in patients with different skeletal sagittal craniofacial pattern. **Material and methods:** The sample comprised of 75 digital lateral cephalograms of adult individuals in age range of 16-25 years. Sagittally the total sample was divided into three Groups i.e Group Ia with normal anteroposterior positioning of maxilla and mandible, Group Ib with Skeletal class II malocclusion with Prognathic maxilla and retrognathic mandible i.e. SNA angle >840 SNB angle <780 and Group Ic with Skeletal class II malocclusion with Normal maxilla and retrognathic mandible i.e.SNA angle 80-840 SNB angle <780. The groups were compared for each of the 9 factors i.e width of nasopharynx, width of oropharynx, width of hypopharynx , width of the deep pharynx, PNS-UT, U-Ang, U-max, H-A,H-B,H-C3,H-MP. Since the data was normal, one way ANOVA test was used followed by complementary Tukey test. **Results:** The groups were compared for pharyngeal dimensions at various levels, velum morphological parameters and position of hyoid bone with respect to craniofacial structures. It was found that nasopharyngeal and oropharyngeal spaces were more in class II malocclusion subjects with prognathic maxilla and retrognathic mandible and smallest in class II malocclusion subjects with normal maxilla and retrognathic mandible., Soft palate / velum length and thickness was found to be more in class II malocclusion subjects. **Conclusion:** It was concluded that evaluation of maxillo-mandibular sagittal positioning plays an important role especially in determining morphology of pharyngeal airway space widths and soft palate and also positioning of hyoid bone.

Keywords: Pharyngeal Airway, Sagittal.

INTRODUCTION

The effects of respiratory function on craniofacial growth and development has increased interest in pharyngeal airway research in last few decades. A normal upper airway is important for nasal breathing, swallowing and phonation[1]. The human respiratory system can be divided into the upper and lower respiratory systems. The upper respiratory system consists of the nasal cavity, nasopharynx, oropharynx, and larynx[2]. Due to close relationship between the pharynx and the dentofacial structures, a mutual interaction is expected to occur between the pharyngeal structures and dentofacial pattern which is in interest of orthodontist[3]. An obstructive upper airway is present when obstructive processes of a morphological, physiological, or pathological nature occur, such as hypertrophy of adenoids and tonsils, chronic and allergic rhinitis, irritant environmental factors, infections, congenital nasal deformities, nasal traumas, polyps, and tumors cause functional imbalance and result in oral breathing patterns[4]. Thus, the aim of the present study was to investigate the inter-relationship between pharyngeal airway morphology, velum morphology and hyoid bone position in patients with different skeletal sagittal craniofacial pattern.

MATERIALS AND METHODS

Sample characteristics and data collection

Ethical clearance for the present study was obtained from institutional ethical committee. The sample size calculation was made considering the test power of 80 and 95% confidence coefficient.

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The sample was composed of 75 digital lateral cephalograms of adult individuals, with permanent dentition. The sample was divided sagitally into three groups on the basis of ANB angle i.e. anteroposterior positioning of maxilla and mandible. The study sample included subjects in age range of 16-25 years having skeletal class I and class II malocclusion. Excluded from the study were cephalograms lacking distinctness of structures in the image, previous history of trauma, orthognathic surgeries, Subjects with obvious hyperplasia of tonsils and adenoids on cephalometric films. The lateral cephalograms in occlusion for the study subjects were obtained in Natural Head Position (NHP). The SNA, SNB and ANB parameters were used to divide the sample into sagittal patterns i.e. Group Ia (Normal maxilla and normal mandible), Group Ib (with prognathic maxilla and retrognathic mandible) and Group Ic (with normal maxilla and retrognathic mandible). These three groups were compared for pharyngeal airway width measurement at various levels (Figure 1), soft palate measurements and inclination (Figure 2) and hyoid bone position (Figure 3). The pharyngeal airway was evaluated by measuring the pharyngeal width at different levels using Arnett/Gunson face airway and bite airway analysis (FAB)[5].

1. **Width of the nasopharynx (WNP) (mm):** The width of the nasopharyngeal airway (WNP) was measured by drawing a line perpendicular to the true vertical line that passed through point A , and then the distance between the crossing points of the same line with the anterior and the posterior walls of the airway was measured.
2. **Width of oropharynx (WOP) (mm):** The width of the oropharyngeal airway (WOP) was measured by extending occlusal plane line posteriorly crossing the anterior and the posterior walls of the airway.

3. **Width of hypopharynx (WHP) (mm):** The width of the hypopharyngeal airway (WHP) was measured at point B level , and landmarks were put on the front and the back walls of the pharynx.
4. **Width of deep pharynx (WDP) (mm):** The width of the deep pharyngeal airway (WDP) was measured at the Pogonion level, between the front and the back walls of the pharynx.

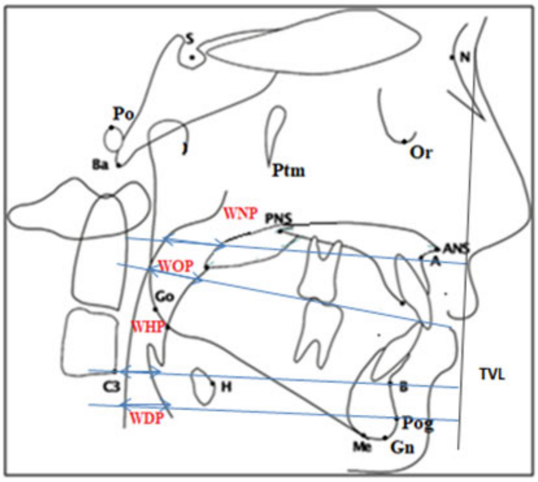


Figure 1. Pharyngeal airway width measurements

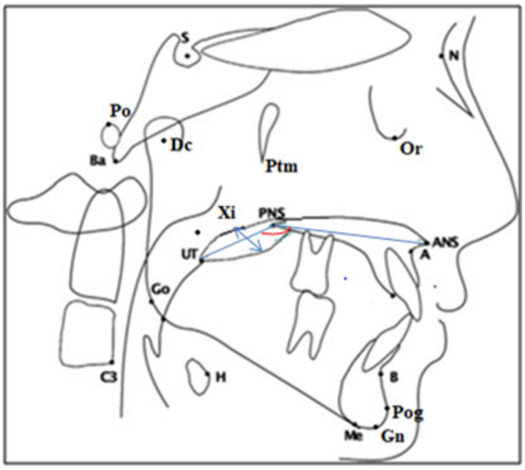


Figure 2. Soft Palate related cephalometric measurements

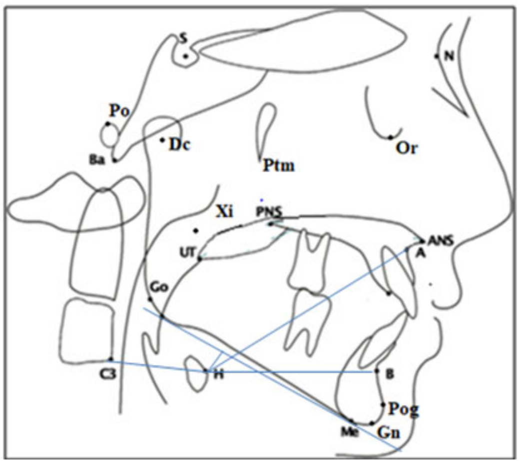


Figure 3. Cephalometric parameters for measuring hyoid bone position

The following parameters describing soft palate morphology were used in the present study (Figure 2)[6]:

1. **PNS-UT (Uvula Length):** Distance from posterior nasal spine to uvula tip in millimeters.
2. **MAX U (maximum uvula thickness):** Maximum thickness of uvula perpendicular to uvula length in millimeters.
3. **U Ang (Inclination of soft palate with respect to palatal plane):** The angle between uvula length (PNS-UT) and Palatal plane (ANS-PNS).

The hyoid bone position (Point H: Most anterosuperior point of hyoid bone) was measured using following parameters (Figure 3)[6]:

- **H-A:** Linear distance of hyoid bone (Point H) to point A.
- **H-B:** Linear distance of hyoid bone (Point H) to point B

1. **H-MP:** Perpendicular drawn from mandibular plane to most anterosuperior point of hyoid bone (Point H) and is measured as linear distance from point H to Mandibular plane (Go-Me).
2. **H-C_3:** Linear distance of hyoid bone (Point H) to point C_3 (Most anteroinferior point on body of third cervical vertebra).

Statistical analysis

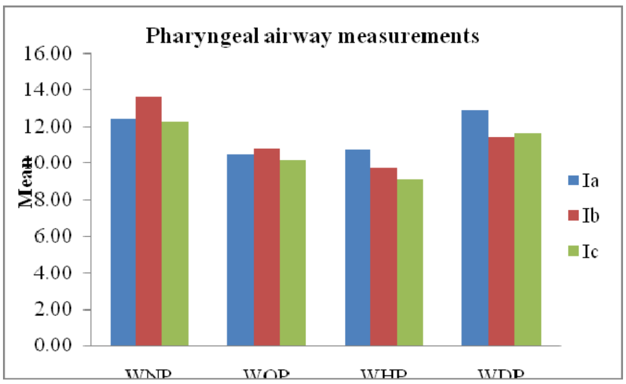
Since the data was normal, one way ANOVA test was used followed by complementary Tukey test was used.

RESULTS

The intraclass correlation coefficient showed excellent replicability (0.98) for intra and interexaminer error determination.

a) Determination and comparison of pharyngeal space widths

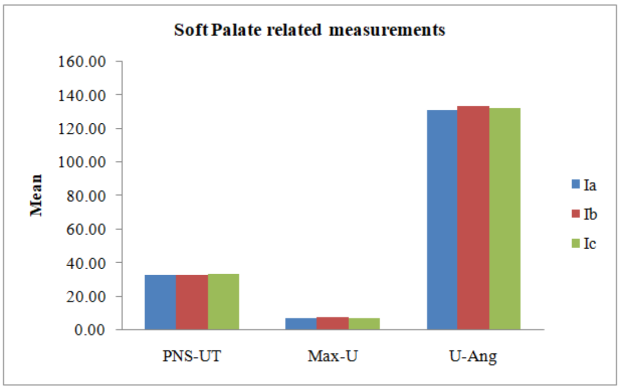
On Comparing the widths of nasopharyngeal (WNP) and oropharyngeal spaces among the 3groups, it was found to be statistically insignificant with group Ib (13.64mm) having widerwidthof nasopharynxthan Iaand least for Ic (12.24mm) **(Ib>Ia>Ic).** Widths of the hypopharyngeal space (WHP) among the 3 groups was found to be statistically insignificant with Ia (10.76mm) having wider width of hypopharynxthan Iband least inIc (9.12mm) **(Ia>Ib>Ic).** Widths of deep pharyngeal space (WDP) among the 3 groups itwas found to be statistically insignificant with Ia (12.90mm) having wider width of the deeppharynxthanIcand leastinIb (11.44mm) **(Ia>Ic>Ib) (Graph 1).**



Graph 1. Comparison of widths of pharyngeal spaces among three sagittal groups

b) Determination and comparison of soft palate morphology

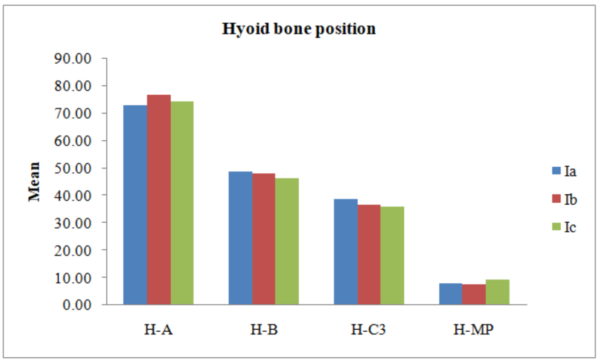
Comparison of the uvula length (PNS-UT) among the 3 groups showed statistically in significant results with group Ic (33.69mm) having more uvula length followed by Ib and smallest length in group Ia (32.71mm) **(Ic>Ib>Ia).** The maximum thickness of uvula was found to be statistically insignificant with uvula widest in group Ib (7.80mm), followed by Ia and lesser width in group Ic (7.26mm) **(Ib>Ia>Ic).** The uvula inclination with respect to palatal plane was found to be statistically insignificant with uvula more posteriorly inclined ingroup Ib (133.84^0), followed by Ic and vertical inclination in group Ia (131.14^0)**(Ib>Ic>Ia) (Graph 2).**



Graph 2. Comparison of Soft Palate measurements among three sagittal groups

c) Determination and comparison of hyoid bone position

On comparing the distance of hyoid bone from point A (H-A) among the 3 groups in sagittal plane it was found to be statistically insignificant with group Ib (76.84mm) having increased distance of hyoid bone from point A, followed by Ic and leastin group Ia (73.10mm) **(Ib>Ic>Ia).** The distance of hyoid bone from point B(H-B)amongthe3groups was found to be statistically insignificant with group Ia (48.86mm) having increased distance of hyoid bone from point B, followed by Ib and least in group Ic (46.24mm) **(Ia>Ib>Ic).** The distance of hyoid bone from point on third cervical vertebrae(H-C_3) among the 3 groups was found to be statistically insignificant with Ia (38.76mm) having increased distance of hyoid bone from point C3, followed by Ib and least in group Ic (36.03mm) **(Ia>Ib>Ic).** The distance of hyoid bone from mandibular plane was found to be statistically insignificant with Ic (9.21mm) having increased distance of hyoid bone from mandibular plane followed by Ia and least in group Ib (7.70mm) **(Ic>Ia>Ib) (Graph 3).**



Graph 3. Comparison of hyoid bone position among three sagittal groups

DISCUSSION

Few studies have noted a relationship between dentofacial pattern and reduced airway capacity, consisting of a retro positioned maxilla and mandible with vertical maxillary excess in many sleep apnea patients[7]. It is found that more anterior positioning of maxilla in the subjects leads to wider widths of upper pharyngeal airways. Dunn et al[3], and Linder-Aronson[8]found that nasal obstruction leading to mouth breathing was related to the width of the nasopharynx; the narrower the nasopharynx, the less adenoidal enlargement was needed to obstruct the nasopharyngeal airway. Kerr[9] reported retropositioned mandible subjects showed smaller nasopharyngeal dimensions than normally positioned mandible subjects. Solow et al[10] considered that the compensatory mechanism i.e. increased craniocervical angle in patients with OSA could be interpreted as a physiological adaptation which lifts the base of the tongue and soft palate from the posterior pharyngeal wall to alleviate obstructive condition. Kimetal[11], Alvesetal[12] and Mutoetal[13] found WOP was decreased in retrognathic mandible. It may be due to the reason that sagittal skeletal type predisposes pharyngeal obstruction as a result of the decreased size and posterior position of the mandible. Zhe Zhong[14] et al reported no significant differences in widths of pharyngeal spaces between normal class I and retrognathic mandible which supported our study that there was no statistically significant differences between two. A study by Sosa[15] et al supported ourstudy that there are no clear cut relationship between nasopharyngeal area and class Iand class II, division 1 malocclusions. Wenzel et al[16] reported no correlations between airway size and mandibular morphology, although a significant relationship was observed between changes in nasopharyngeal size and maxillary prognathism which is also found in our study.

In the present study soft palate length was found to be more in skeletal class II groups with retrognathic mandible than inclass Imalocclusion groups. This increase in length of soft palate could be due to backward and downward position of the tongue which compresses the soft palate posteriorly and results in increased length and thickness of soft palate. Thickness of soft palate was more in class II subjects. Soft palate was inclined more horizontally in class II subjects. Velum angle (i.e. soft palate angulation with respect to palatal plane) was found to be more in class II cases with retrognathic mandible and soft palate was more vertically placed with decrease angulation in class I cases.

The hyoid bone and its musculature occupies a key role in regulation of the pharyngeal airway[17] and its position is affected by mandible and tongue location. In the present study on comparison among 3 sagittal groups it was found that hyoid bone was positioned closer to point B (H-B) and C_3 (H-C_3) in class II malocclusion subjects (having retrognathic mandible). These findings are supported by the fact that a posteriorly positioned mandible seem to replace tongue and hyoid bone inferoposteriorly and hence, affects the airway dimensions. The inferior and posterior position of the hyoid bone is seemed to be influenced by position of mandible. Laterally, the middle constrictor muscle attaches the hyoid to the pharyngeal wall and therefore hyoid position and constrictor muscle tone influences the oropharyngeal volume[18]. A low position of the hyoid is one of the distinguishing cephalometric features of OSA.

Summary and Conclusion

Nasopharyngeal and oropharyngeal spaces were more in class II malocclusion subjects with prognathic maxilla and retrognathic mandible and smallest in class II malocclusion subjects with normal maxilla and retrognathic mandible.

i. Whereas width of hypopharynx and deep pharynx was found to be widest in class I malocclusion subjects and lesser in class II malocclusion subjects.
ii. Soft palate / velum length was found to be more in class II malocclusion subjects with retrognathic mandible than in class I malocclusion subjects.
iii. In class II malocclusion subjects with prognathic maxilla and retrognathic mandible the soft palate thickness and angulation was found to be maximum.
iv. Hyoid bone was positioned closer to mandibular plane in class II subjects with prognathic maxilla than in cases with normally positioned maxilla.

Limitations and suggestions

1. It is a retrospective 2D cephalometric study that evaluated only pharyngeal airway linear widths.
2. Volumetric measurements were not feasible in a two dimensional lateral cephalograph. As a small change in linear measurements can result in a substantial volumetric change that could affect airway resistance.

Ethical approval: Ethical approval was obtained from the Institutional ethical committee. Certificate has been attached. Name of the institute has been mentioned in the method section.

Patient consent: Signed consent form from patient files archived in department were obtained as consent form.

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