ORIGINAL ARTICLE

CHANGES IN ORO-PHARYNGEAL AIRWAY DIMENSIONS AFTER TREATMENT WITH FUNCTIONAL APPLIANCE IN CLASS II SKELETAL PATTERN

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Background: Functional appliances have been used since many decades for the correction of mandibular retrognathism. Similar oral appliances are a treatment modality for patients with Obstructive sleep apnoea. Hence, interception at the right age with these growth modification appliances might benefit a child from developing long term respiratory insufficiency. Therefore, the purpose of our study was to assess the short term effects of Twin block appliance (CTB) on pharyngeal airway size in subjects with skeletal Class-II pattern in a sample of Pakistani population. **Methods:** A retrospective study was conducted from orthodontic records of 62 children (31 males, 31 females) with retrognathic mandibles using lateral cephalograms obtained at initial visit and after CTB treatment. Paired t-test was used to compare the pre-functional and post-functional treatment airway size. Independent sample t-test was used for comparison between the genders and statistical significance was kept at ≤ 0.05. **Results:** The upper airway width ($p<0.001$), nasopharyngeal depth ($p=0.03$) and upper airway thickness ($p=0.008$) was substantially improved after CTB treatment. Males showed a greater increase in upper airway width ($p=0.03$) and nasopharyngeal depth ($p=0.01$) in comparison to the females. **Conclusion:** Functional appliance therapy can improve the narrow pharyngeal airway of growing children presenting with deficient mandibles having Class-II skeletal pattern.

Keywords: airway, twin block, Skeletal Class II, pharyngeal passage, lateral cephalogram

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INTRODUCTION

The prevalence of dental and skeletal malocclusion varies from population to population. Skeletal class II malocclusion has been reported as the most common pattern of malocclusion in Pakistani population. Waheed-ul-Hamid *et al*[1] in his study concluded that amongst subjects having skeletal class-II malocclusion, 65% presented with the mandibular deficiency in comparison to the maxillary excess resulting in an unfavourable facial profile. Besides affecting the aesthetics of a pleasing profile, mandibular retrognathism is also associated with deficient chin projection, crowded arches and reduced airway dimensions.

The growth of dento-facial structures and pharyngeal dimensions have an interchangeable cause-effect relationship, where, restricted growth of the cranio-facial structures can result in narrowing of the pharyngeal airways, and reduction in the dimensions of the naso-pharyngeal area due to anatomical obstruction, can lead to altered cranio-facial growth.[2–4] Altered morphology of different oro-facial structures like shortened mandible, enlarged adenoids, tonsillar hypertrophy and macroglossia play a vital role in reducing the airflow through the nasopharynx and the oropharynx.[5–7] An elongated and hypertrophied soft palate can also impinge on the posterior airway at the level of the nasopharynx.[8] In addition, a retropositioned mandible or maxilla can push an enlarged tongue posteriorly to impinge on the retropharyngeal area resulting in breathing difficulties.[9]

Respiratory difficulties due to any of the above mentioned etiological factors result in a shift to oral mode of breathing which affects the growth of an individual. Narrow airway dimensions lead to a decreased production of stomatomedin hormone in a growing individual affecting the body growth and stature.[10,11] Abnormal mode of breathing also affects the maxillo-mandibular growth resulting in adenoid facies, skeletal Class II malocclusion and posterior crossbite.[12] The mandible growth resumes in a normal direction, once the obstruction of the airway is released and vice versa.

A growing child diagnosed with a class-II skeletal pattern due to mandibular micrognathism or retrognathism is ideally treated with functional orthopaedic appliances, whereas, orthognathic surgeries to advance the mandible is the only viable option of correcting a skeletal deformity in a non-growing adult. Growth modifying functional appliances can redirect the mandibular growth in a favourable direction, markedly augment the facial aesthetics and prevent oro-pharyngeal collapse by modifying the posterior position of the tongue.[13]

Functional appliances have been used since many decades for the correction of mandibular retrognathism. A wide variety of these appliances with various modifications are also commonly marketed as oral appliances in treating Obstructive sleep apnoea. Previous studies have reported significant improvement in few parameters of pharyngeal dimensions with multiple growth modifying appliances but very few studies have evaluated the effect of these appliances on naso-pharyngeal area, pharyngeal airway thickness along with pharyngeal airway dimensions.[13–16] According to our pertinent survey of the literature, very limited data is available on the changes in pharyngeal dimensions and pharyngeal airway thickness using Twin block appliance and variations has been found in the results of studies conducted on different populations,[17–18] hence the purpose of our study was to assess the short term effects of Twin block appliance (CTB) on pharyngeal airway size in subjects with skeletal class-II pattern in a sample of Pakistani population.

MATERIAL AND METHODS

62 children (31 males, 31 females) consecutively treated with CTB at skeletal age CS3 were included in our study. The calculation of sample size was done keeping a 95% confidence interval, a statistical significance of 5%, a sample power of 80% and using data from a study conducted by Han *et al*[19] who reported a mean difference of 1.5±1.24 mm in lower airway width. Ethical clearance was obtained from institutional ethical review committee (ERC No. 2968-Surg-ERC-14) prior to the data collection. The inclusion criteria was: Subjects with skeletal cervical stage CS3 as diagnosed by lateral cephalograms, skeletal class-II malocclusion with backward placed mandible (ANB > 4°, SNB < 78°), normal SNMP angle in the range of 32±4°, Angle's class-II malocclusion on both sides and presence of good quality lateral cephalometric radiographs at the start of functional appliance treatment (T^0) and at the end of CTB treatment (T^1) who compliantly wore the appliance at least for 22 hours per day. Subjects were excluded on the following criteria: subjects with breathing difficulties, history of mouth breathing or nasal stenosis, airway surgeries, dento-facial syndromes, trauma and history of prior orthodontic treatment.

Lateral cephalograms for all the subjects were obtained with teeth in maximum intercuspation, standing in an upright position with FH plane being parallel to the floor. All radiographs were exposed from the same cephalostat with standard film to tube distance.

Manual tracing was done of the cephalograms and the following reference points were marked (Figure-1).

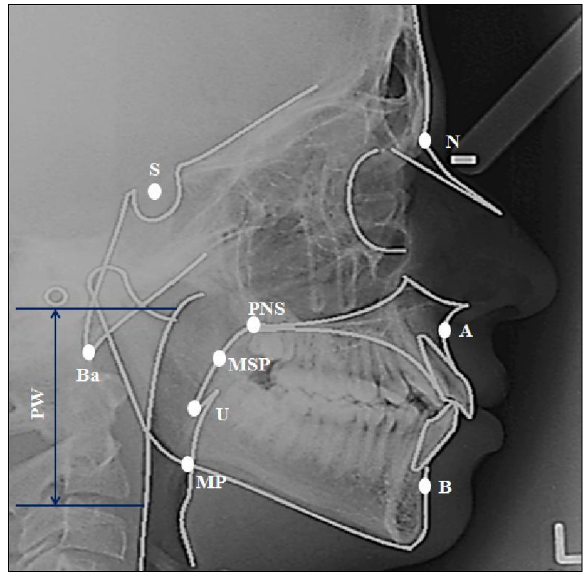

Figure-1: A: Point A, B: Point B, MSP: Centre of soft palate at the junction of PNS-U line, N: Nasion; intersection of fronto-nasal suture, PW: Posterior pharyngeal wall, PNS: Posterior nasal spine, U: Soft palate tip, MP: Juncture of lower margin of mandibular body and posterior border of tongue, S: Centre of sella turcica, Ba: Basion

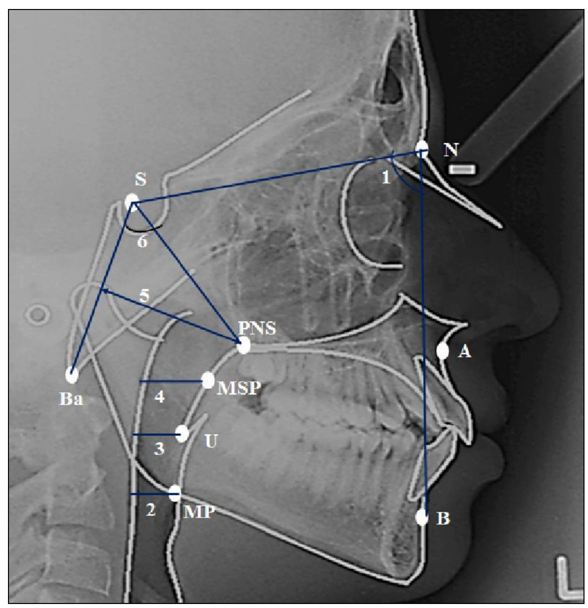

Figure-2: The airway measurements carried out on cephalograms

Planes/Angles	Definitions
1. SNB angle	The angle between Sella-Nasion line and point B (Normal=80±2°)
2. LAW	Lower airway width; the distance from MP to PW
3. MAW	Middle airway width; distance from U to PW
4. UAW	Upper airway width; distance from MSP to PW
5. D1	Thickness of upper airway; a perpendicular line dropped on Ba-S from PNS and distance of this line is measured
6. NA	Naso-pharyngeal depth angle; the angle between Ba, S and PNS

The intra-observer validity was calculated by re-tracing 35 unsystematically selected radiographs after 20 days of the initial assessment. The intra-class correlation coefficients (ICC) displayed >0.85 intra-examiner validity.

All the data was double entered and computed in IBM SPSS Statistics version 20.0 for Windows (IBM Co., Chicago III). Means and SD were calculated for all the measured parameters before and after intervening with the appliance. Paired *t*-test was run for comparison of the pre-treatment (T^0) and post-treatment (T^1) airway size. To compare the mean difference in airway size between the genders, Independent sample *t*-test was applied keeping *p*-value of ≤0.05 as statistically significant.

RESULTS

The mandibular position and airway widths were calculated on lateral cephalograms as shown in Table 1. Paired *t*-test was applied for comparing the measurements after CTB treatment and a significant increase was observed in the SNB angle (*p*=0.005), upper airway width (*p*<0.001), nasopharyngeal depth (*p*=0.03) and the upper airway thickness (*p*=0.008).

Upon stratification of the results on the basis of gender, a significant increase in upper airway width (*p*<0.001), the middle airway width (*p*<0.001), and the nasopharyngeal depth (*p*=0.01) was observed in the males as shown in table-2, whereas, only a statistically significant increase in upper airway thickness (*p*<0.001) was noted among the females (Table-3). The difference in airway size between the males and the females after twin block therapy showed that there was a greater increase in the upper airway width (*p*=0.03) and nasopharyngeal depth (*p*=0.01) in the males as compared to that of the females (Table-4).

Table-1: Changes in airway size after twin block therapy

Variables	T° (Mean±SD)	T¹ (Mean±SD)	p
SNB (degree)	74.32±2.94	75.89±3.42	0.005*
UAW (mm)	12.06±1.31	13.20±2.02	<0.001**
MAW (mm)	9.45±3.31	10.12±2.44	0.08
LAW (mm)	10.08±2.34	10.60±3.12	0.08
NA (degree)	58.24±6.75	57.27±5.83	0.03*
D1 (mm)	33.17±4.27	34.05±3.58	0.008*

n=62, *p≤0.05, **p≤ 0.001, Paired *t*-test

Table-2: Changes in airway size in males after twin block therapy

Variables	T° (Mean±SD)	T¹ (Mean±SD)	p
UAW (mm)	12.29±1.29	13.96±1.58	<0.001**
MAW (mm)	9.70±2.05	10.98±2.46	<0.001**
LAW (mm)	9.93±1.91	10.59±2.60	0.133
NA (degree)	58.93±7.33	56.80±5.43	0.01*
D1 (mm)	34.09±5.09	34.54±4.05	0.43

n=31, *p≤0.05, **p≤0.001, Paired *t*-test

Table-3: Changes in airway size in females after twin block therapy

Variables	T° (Mean±SD)	T¹ (Mean±SD)	P
UAW(mm)	11.82±1.32	12.44±2.15	0.09
MAW (mm)	9.20±4.23	9.25±2.12	0.94
LAW (mm)	10.24±2.72	10.61±3.61	0.38
NA (degree)	57.54±6.16	57.74±6.25	0.55
D1 (mm)	32.25±3.07	33.56±3.03	0.001*

n=31, *p≤0.05, **p≤0.001, Paired *t*-test

Table-4: Comparison of change in airway size between males and females after twin block therapy (T^1–T^0)

Variables	Males n=31	Females n=31	p
UAW (mm)	1.67±1.73	0.62±1.97	0.03*
MAW (mm)	-1.27±1.35	-0.05±3.89	0.10
LAW (mm)	-0.66±2.38	-0.37±2.34	0.63
NA (degree)	2.13±4.50	-0.19±1.79	0.01*
D1 (mm)	-0.45±3.19	-1.31±1.52	0.18

*p≤0.05 Independent sample *t*-test

DISCUSSION

Dento-facial orthopaedics using rapid palatal expansion devices, protraction or retraction headgears and functional appliances in growing individuals not only result in correction of the skeletal discrepancy but have a wide influence on the surrounding soft tissue musculature.[20,21] Similarly, orthognathic surgeries and adjunctive facial reconstruction procedures also improve the soft tissues along with correcting the jaw deformity. This study confirmed the effects of functional orthopaedic appliances on the size and dimensions of pharyngeal airway.

According to the current study, a noticeable improvement was seen in the skeletal class-II pattern with Twin block therapy which is in concordance with multiple other studies.[13,22] A substantial improvement in the SNB angle demarcating the mandibular relationship with cranial base indicates that the antero-posterior mandibular discrepancy in reference to the cranial base was mainly improved by anterior repositioning of the mandible.

The present study reports that the upper airway width, upper airway thickness and nasopharyngeal depth were considerably improved after CTB treatment whereas middle and lower pharyngeal dimensions were not affected with functional appliances. The increase in upper airway space is similar to the change reported by multiple other studies. The authors found an increase of 1.67 mm in upper airway width which was comparable to 2 mm increase found by Han *et al*[19] in their study conducted on skeletal class-II subjects who had undergone treatment with Bionator. Ozbek *et al*[15] in their study reported an increase in upper, middle and lower airway dimensions whereas few other studies found an increase only in the superior and inferior pharyngeal dimensions.[23,24] The disparity in our findings and the findings of multiple other studies reported in the literature might be due to racial differences or inability of controlling the vertical growth pattern which could act as a potent confounder.

The nasopharyngeal depth in our study turned out to be noticeably increased which is almost equivalent to that found by Vinoth *et al*[24] and Restrepo *et al*.[25] However, some differences were noted in the above measurements in the studies done by Jena *et al*[13], Han *et al*[19] and Erbas B.[26] On the contrary, we also observed a significant improvement in the upper airway thickness which differs from a previous study conducted on pharyngeal airways using the same appliance.[27] The changes observed in the nasopharyngeal depth and upper airway thickness may be due to a combination of functional appliance treatment and remaining growth of an individual. Future investigations with presence of a control group and a prospective study design are necessary to justify these changes.

When airway dimensions were evaluated for the gender dimorphism, the upper airway width, the middle airway width and nasopharyngeal depth were significantly increased in the males whereas only the upper airway thickness was found to be significantly increased in the females. When the results were compared between the genders, the dimensional changes occurring after CTB treatment in the males showed a mild increase in the upper airway width and nasopharyngeal depth as compared to that of the females. The results reported by Abu Allhaija and Al-Khateeb[28] differ in this aspect since they found no significant gender-bias in the airway dimensions. Our study suggests an overall greater dimensional change in the pharyngeal dimensions of the males after CTB treatment along with a greater stability of these results.

The results observed in our study and the specific changes seen in upper airway dimensions and naso-pharyngeal depths are surprising as the effects of CTB primarily affect the mandibular position. Dental arch expansion achieved with CTB along with the stretch of supra-hyoid musculature and repositioning of tongue accompanying the forward mandibular posture can lead to improved pharyngeal airway dimensions. On the other hand, the catch up growth of an individual might also accentuate the improvement obtained by functional appliances, further enhancing the respiratory dimensions.

Due to the ethical concerns, no control group was included in the study to eliminate the potential changes in pharyngeal dimensions associated with the growth of an individual. Besides this, 2D lateral cephalograms were used for assessing a 3D pharynx which limits the changes taken place in only vertical and antero-posterior direction. The literature states that even though lateral cephalograms are two dimensional images, the validity of this image for analyzing the airway still remains a viable tool as it reduces the cost and radiation dose and gives accurate measurements.[11,30] The Body Mass Index (BMI) of the children could be a confounding factor as obesity is a potent cause of respiratory distress, but could not be included in the study due to a retrospective study design.

Hence, the authors suggest that the substantial improvement in the sagittal relation between the jaws and pharyngeal airway due to myo-functional therapy can be used as an adjunctive treatment in patients suffering from airway obstruction with retrognathic mandible.

CONCLUSIONS

Our study results suggest that an increase in the upper airway width, nasopharyngeal depth and upper airway thickness occurs from functional appliance treatment. Moreover, males show a greater increase in the above mentioned dimensions as compared to the females. Long term observations using a control group are still needed to establish the use of functional appliances as an interceptive treatment modality in growing children with narrow pharyngeal airways.

AUTHOR'S CONTRIBUTION

BA conducted the entire study under the supervision of AS and MF.

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