Two-dimensional Analysis of Oro-pharyngeal Airway Space Area in Patients with Bimaxillary Protrusion

Adesina BA[a],* Otuyemi Od[a], Kolawole Ka[a], Adeyemi At[b]

Abstract

Background: Bimaxillary protrusion or full mouth appearance is a dento-alveolar condition associated with proclination of upper and lower incisors with resultant aesthetic challenges. From literature reports, it has been suggested that posture of the oropharyngeal organs may have great influence on the positioning of dento-alveolar structures and vice-versa. Due to the physiological importance of oro-pharyngeal space, it is necessary therefore, to evaluate their relationship with dento-alveolar structures. The purpose of this study was to determine the relationship between oropharyngeal space and dento-alveolar position of incisors in patients with bimaxillary proclination and normal incisal relationship.

Method: Cephalometric radiographs were obtained from 100 orthodontic patients who were grouped into bimaxillary proclination (study group) and normal interincisal relationship as control group. Patients were equally assigned to either of the groups based on their interincisal angle. Radiographs were taken under a standardized condition, traced and analysed. The bimaxillary proclination and normal interincisal groups were defined as patients with interincisal angle of less than 108^0 and interincisal angle equal to or greater than 108^0 respectively. Oropharyngeal airway space area was also determined. Analysis of data was done using SPSS version 11 and computer programme for epidemiological analysis.

Results: The mean values of soft palate and oropharyngeal parameters were higher in subjects with normal interincisal relationship with the exception of soft palatal length and soft palatal thickness. However, all these differences were not statistically significant (P>0.05). Multiple regressions showed that none of the variables (palatal airway, lingual airway and pharyngeal space area) can act as a predictor for interincisal relationship.

Conclusion: The study concluded that there was no significant difference in oro-pharyngeal airway dimensions between bimaxillary proclination and normal interincisal relationship subjects. ***Keyword:*** oro-pharyngeal, Airway Space, Bimaxillary Protrusion, Cephalometric

ORIGINAL ARTICLE

Authors Affiliations

a. Department of Child Dental Health, Obafemi Awolowo University Teaching Hospitals' Complex Ile-Ife, Osun State, Nigeria.

b. Department of Child Oral Health, University College Hospital Ibadan, Oyo State, Nigeria.

Correspondence author

Adesina BA, Department of Child Dental Health, Obafemi Awolowo University Teaching Hospitals' Complex Ile-Ife, Osun State, Nigeria.

Introduction

Bimaxillary proclination is defined as a condition characterized by proclined upper and lower incisors[1] and increased procumbency of the lips[2,3]. It occurs in almost every ethnic group particularly in African-American and Asian populations[4,5,6] with a prevalence of 20% in Nigeria[7].

From literature reports, tongue size, tongue posture and oropharyngeal space have great influence on the positioning of dentoalveolar structure[8,9],[10]. Proffit and Field[11] documented the tendency for obstruction of oropharyngeal space in retrognathic patients with normal tongue mass and volume secondary to falling back of the tongue.

Many studies have assessed the anatomic conformation of the upper airway through various methods including sophisticated and expensive techniques such as Cine-computed tomography, Cone beam computed tomography, Fluoroscopy, Acoustic reflection, Fibreoptic pharyngoscopy, and Magnetic resonance imaging .[12,14,24,25] However, cephalometry is easily accessible, less expensive with reduced radiation and correlates with other investigations such as computed tomography (CT) or somnofluoroscopy carried out during wakefulness or sleep[13,14] . These other investigations are not readily available in developing countries like Nigeria despite the increasing number of clients who require orthodontic assessment and management. Thus, cephalometry remains the readily available means of investigating them.

Cephalometry has also been used for assessment of the airway in craniofacial syndromes, patients with obstructive sleep

apnoea (OSA) and following orthognathic surgery[15,12] and for evaluation of the airway in various dentofacial deformities[16].

There is paucity of data on the relationship of oropharyngeal space on the positioning of dentoalveolar structures in the Nigerian population especially those with bimaxillary proclination. It is also important to document these findings in those of African descent and compare with other races. The aim of this study was to determine the relationship between oropharyngeal space and dentoalveolar position of incisors in patients with bimaxillary proclination and normal incisal inclination .

Method

This study was a comparative analytical study carried out at the Orthodontic units of two University Teaching Hospitals in Nigeria. Ethical clearance was obtained from Research and Ethics committees of the two institutions. Written informed consent was freely obtained from the patients and their parents/guardians in case of minors following a clear explanation of the study objectives and approaches.

The selection of patients was based on the following criteria: Patients with full complement of permanent dentition (except for the third molars in some cases), Patients with class I or class II molar relationship, those with no apparent medical syndromes and disorders affecting the tongue and jaws, no history of mouth breathing or any other oral habits. Patients with obvious tongue deformity or previous tongue or pharyngeal surgery, those with crossbite or openbite, pregnancy and previous history of orthodontic treatment were excluded from this study.

Selected lateral cephalometric radiographs of 100 orthodontic patients aged 12 to 36 years were utilized. Cephalometric radiographs of all subjects were traced and analysed. The patients were grouped into two using the cephalometric norm for interincisal angle established for the Nigerian population by Isiekwe[1 7] . Subjects with interincisal angulations less than 108^0 were considered as having bimaxillary proclination while those with interincisal relationship equal to or greater than 108^0 were grouped as normal.

Radiographic Technique

Standard lateral skull cephalometric radiographs of each selected subject was taken in natural head position with the patient standing in the cephalostat (PantOS DG XP panoramic Dental X-ray system.

The radiograph was taken under standard conditions in which the ear rods of the cephalostat held the head in a mid sagittal plane at a fixed distance and parallel to the film. The x-ray tube was positioned at a constant distance of 5feet (150cm) from mid sagittal plane of the subject while the film was at a distance of 1foot (30cm) from the mid sagittal plane of the patient. Lead apron and neck shield were worn by the patient to minimize penetration of scattered radiation and to prevent primary beam directed at rapidly dividing cells such as the thyroid gland and the gonads.

Cephalometric Tracing

The cephalometric radiographs were traced manually by the author, using a 0.003” matte acetate tracing paper with the radiograph well secured on the illuminated viewing box by masking paper tape. Anatomical hard and soft tissue points and landmarks were located and traced out using HB pencil (figure 1). Oropharyngeal organ and intermaxillary space areas were calculated as shown in figures 2.

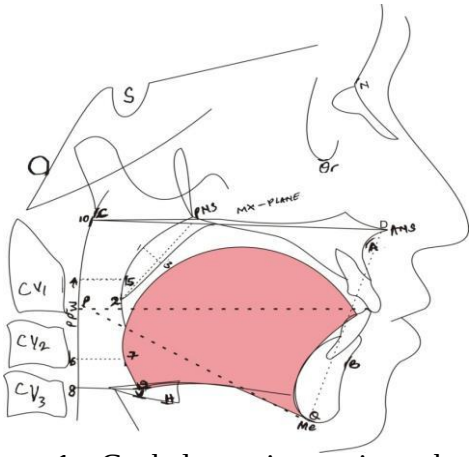

Figure 1. Cephalometric tracing showing Tongue, Soft palate, Oropharyngeal space, Pharyngeal space and intermaxillary space areas.

Cephalometric landmarks and definitions:

Intermaxillary space length (PPW-lower incisor tip).

Soft palate length (horizontal measure PNS-point 2).

Soft palate thickness (point 1-3).

Palatal angle (Angle formed by the maxillary plane and a longitudinal line drawn along the longitudinal length of soft palate).

Oropharyngeal area (space in between the narrowest palatal airway {4-5}and narrowest lingual airway{6-7}).

Pharyngeal space is bounded superiorly by a backward extension of the maxillary plane and inferiorly by a line through the tip of the epiglottis (8-9).

Intermaxillary space (IMS) is delineated by the trapezium drawn through the maxillary and mandibular planes, posterior pharyngeal wall and the lingual gingival aspect of the lower incisor.[CDQP].

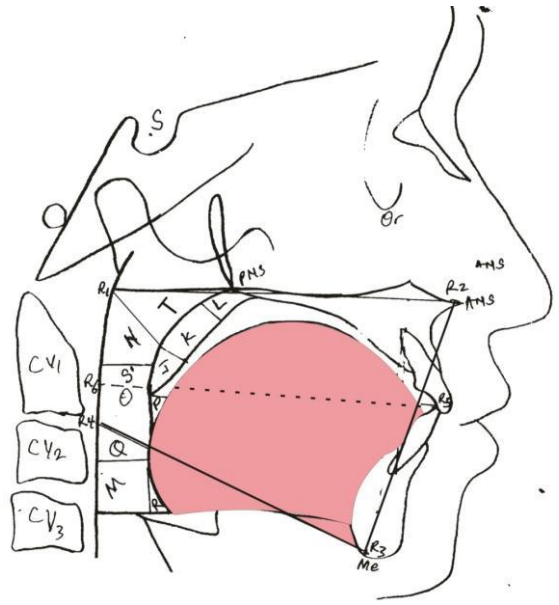

Figure 2. Cephalometric tracing showing soft palate and pharyngeal space areas

Pharyngeal organ areas were sectionalized into shapes as shown in figure 2 and area of each shape was then calculated using the appropriate formulae as shown below:

Palatal angle: J+K+L

Oropharyngeal area : O+P+Q

Pharyngeal space : R+M+Q+O+P+S+N+T

Intermaxillary space area:

$$\frac{R1R4 + R2R3}{2} \times R5R6$$

Reliability and error analysis

Ten randomly selected cephalometric tracing were retraced after 2 weeks of the initial tracing by the author in order to test for intra-examiner reliability in selecting cephalometric landmarks and measurements of the linear and angular values.The measurements were completed twice on two seperate occasions. The Kappa statistics, which is a chance-corrected measure of agreement, was used to evaluate the consistency. Kappa coefficient of agreement (K) is the ratio of proportion of times that one or more examiners agree[18].

$$K=\frac{P(A)\ P(E)}{1\ P(E)}$$

P(A) is the proportion of times that the examiners agree and P(E) is the proportion of times that agreement could be expected by chance. If there is complete agreement within or between examiners then K=1, whereas if there is no agreement among the raters, then K=0. Kappa values of the intra-examiners reproducibility for the cephalometric tracings were between 0.82 to 0.87, which showed strong agreement.

Data Analysis

All data generated were statistically analysed using SPSS Version 11(SPSS Inc., Chicago, IL, U.S.A) and WINPEPI version 1.44.[19]. Analysis done included frequency, mean and standard deviation. Mean measurements were then compared using t test and multiple analysis of variance (ANOVA). Multiple regressions (Model fit) were used to evaluate oropharyngeal space influence on bimaxillary proclination. Statistical significance was inferred at $p< 0.05$

Results

Results of the dental relationship of incisors showed that there were statistically significant differences in the mean values of dental measurements between patients with

ORIGINAL ARTICLE

normal incisor relationship and those with bimaxillary proclination. Most of parameters measured were higher in the bimaxillary group with the exception of interincisal angle (Table 1)

The mean values of soft palate parameters with the exception of palatal angle were higher in bimaxillary proclination group with no significant diference between the two groups. However, measurements of other oropharyngeal organs (soft palate, oropharyngeal area, lingual and palatal airways) were higher in normal incisor proclination group, no significant difference was observed in any of the parameters (Table 2).

Table 3 shows a weak correlation in the oropharngeal variables and intermaxillary space parameters.

Multiple regression analysis shows neither the tongue nor oropharyngeal organs have significant effect on the type of incisor relationship (Table 4).

ORIGINAL ARTICLE

Table 1: Comparison of dental measurements in patients with normal incisor relationship and bimaxillary proclination

Dental	Normal incisor relationship (N=50)		Bimaxillary proclination relationship (N=50)		t	p
	Mean	SD.	Mean	SD		
Linear measurements(mm)						
Overjet	3.22	1.18	6.62	2.63	-	
Intermaxillary space area	49.98	7.87	53.04	8.19	8.35	<0.01
Angular measurements(degree)					1.91	0.06
Upper incisor to max plane	116.38	7.42	126.64	7.26	-6.99	<0.01
Lower incisor to Mand Plane	96.64	8.30	106.94	7.98	-6.33	<0.01
Interincisal angle	118.44	7.86	99.26	6.16	13.58	<0.01

Table 2: Comparison of soft palate and oropharyngeal measurements in patients with normal incisor relationship and bimaxillary proclination.

Soft palate and oropharyngeal measurements	Normal incisor relationship (N=50)		Bimaxillary proclination relationship (N=50)		t	P
	Mean	SD.	Mean	SD		
Linear Measurement (cm)						
Soft palatal thickness	0.92	0.14	0.94	0.15	-0.85	0.40
Soft palatal length	4.17	0.51	4.19	0.50	-0.14	0.89
Minimum palatal airway	0.78	0.36	0.73	0.29	0.71	0.48
Minimum lingual airway	1.62	0.37	1.12	0.38	0.56	0.58
Area (cm^2)						
Soft palatal area	2.38	0.79	2.30	0.64	0.53	0.60
Oropharyngeal area	1.88	1.03	1.65	0.85	1.23	0.22
Pharyngeal space area	5.39	2.04	5.29	1.34	0.26	0.79
Angle (degree)						
Palatal angle	135.20	7.04	134.66	6.46	0.40	0.69

Table3: Correlation tests of oropharyngeal space and dentoalveolar position of incisors.

Measurements	Overjet (mm)	Upper incisor to max plane (degree)	Lower incisor to Mand Plane dd(degree) (degree)	Integrated (degree)	Oropharyngeal area 2 (degree)	Intermaxillary space2area(cm) (cm)
Linear measurements(cm)						
0verjet	1	0.454*	0.381*	-0.515*	-0.147	0.045
2 Area (cm)						
Oropharyngeal area	-0.147	0.044	-0.280*	0.074	1	0.354*
Pharyngeal space area	-0.082	0.121	-0.104	-0.013	0.531*	0.558*
Intermaxillary space area	0.045	0.324*	0.197*	-0.314*	0.354*	1
Angle (degree)						
Interincisal angle	-0.515 *	-0.694*	-0.677*	1	0.074	-0.314*
Lower incisor to Mand Plane	0.381*	0.318*	1	-0.677*	-0.280*	0.197*
Upper incisor to max plane	0.454*	1	0.318*	-0.694*	0.044	0.324*

** Correlation is strong at the 0.05 level (2-tailed).*

Table 4: Multiple Regressions of the various predictors on incisor relationship

Variables	Coefficients Beta	t	Std. Error	p	95% CI
(Constant)		3.147	1.570	<0.01	2.067 8.328
Linear Measurement (cm)					
Overjet	0.312	4.618	0.013	<0.01	0.032 0.083
Intermaxillary space length	0.004	0.039	0.069	0.97	-0.099 0.202
Minimum palatal airway	-0.02	-0.26	0.012	0.79	-0.027 0.020
Minimum lingual airway	-0.097	-1.20	0.011	0.23	-0.035 0.009
Area (cm^2)					
Oropharyngeal area	-0.035	-0.550	0.034	0.58	-0.072 0.069
Angle (degree)					
Upper incisor to max plane	-0.049	-0.596	0.005	0.55	-0.012 0.006
Lower incisor to Mand Plane	-0.053	-0.654	0.004	0.52	-0.013 0.004
Interincisal angle	-0.702	-6.214	0.005	<0.01	-0.040 -0.021

ORIGINAL ARTICLE

Discussion

This study determined the relationship between oropharyngeal space and dentoalveolar position of incisors in patients with bimaxillary proclination and compared with those with normal incisor relationship.

Posteriorly displaced tongue has been reported to be responsible for reduction of oropharyngeal space thereby obstructing the airway, especially in retrognathic mandible where there is reduction in tongue space[20]. It could therefore be assumed that in bimaxillary proclination condition where there is an increase intermaxillary space area which gives more room for the tongue to express itself anteriorly, this could therefore result in increase oropharyngeal space area. In terms maxillary space dimensions (intermaxillary length and area) as expected, were higher in bimaxillary proclination group. This is in agreement with report of Turnbill and Battagel[23] and it is largely due to the degree of proclination of upper and lower incisors. The more the degree of proclination, the longer the expected intermaxillary space length based on its definition (Length of the occlusal plane between its intersection with the lingual shadow of upper or lower incisor and posterior pharyngeal wall) [20].

The present investigation showed that despite the increase in intermaxillary length and space area in subjects with bimaxillary proclination, there was no significant difference in soft palate and oropharyngeal space measurements when compared with patients with normal incisor relationship. The mean values of most oropharyngeal measurements were generally higher in patients with normal incisor relationship which is contrary to expectation. This may be due to functional and physiological adaptation of the posterior pharyngeal wall to the anterior positioning of the tongue in bimaxillary proclination subjects.

The higher mean values observed in soft palatal thickness and soft palatal length in bimaxillary dentoalveolar proclination is in agreement with the report of Yildirim et al[22]. This may be associated with reduced compressive force on the soft palate by the tongue when it is anteriorly positioned in bimaxillary proclination individuals. Mean values for both minimal lingual and minimal palatal airways were lower in bimaxillary group. This is contrary to Turnbill and Battagel[23] where the airways decreased with increase in intermaxillary space length and area.

Conclusion

Despite the increase in intermaxillary space length and area in bimaxillary proclination whereby the tongue is expected to be displaced forwards, there was no significant difference in oropharyngeal dimensions. Oropharyngeal dimensions were generally increased in normal incisor group. Intermaxillary space area was found to have strong positive correlation in patients with bimaxillary proclination. However, none of the oropharyngeal organs could act as predictor for bimaxillary proclination.

Contributors

Adesina B. A. Was partly responsible for the study design acquisition analysis and interpreting the data, writing & final approval of the study Otuyemi O. D. was responsible for the concept, study design, acquisition, analysis, interpreting writing & editing.

Kolawole was partly responsible for the study design, analysis, interpreting, writing editing. Adeyemi was partly responsible for acquisition of data.

References

1. McCann J., Burden D.J. An investigation of tooth size in Irish people with bimaxillary dental protrusion. Eur J Orthod 1996; 18: 617-621.
2. Bill D.A., Handelman C.S., BeGole E.A. Bimaxillary dentoalveolar protrusion: Traits and Orthodontics correction. Angle Orthod 2005; 75: 333-339.
3. Hussein E., Mois M.A Bimaxillary protrusion in the Palestinian Population. Angle Orthod 2007; 77: 817-820.
4. Lew K. Profile changes following orthodontic treatment of bimaxillary protrusion in adults with the Begg appliance. Eur J Orthod 1989; 11: 375-381.
5. Tan T.J. Profile changes following orthodontic correction of bimaxillary protrusion with a preadjusted edgewise appliance. Int J Adult Orthod Orthognath Surg 1996; 11: 239-251.
6. Kurz C. The use of lingual appliances for correction of bimaxillary protrusion. Am J Orthod & Dentofac Orthop 1997; 112: 357-363.

7. Isiekwe M.C. The prevalence of bimaxillary protrusion in a Nigerianpopulation. Odonto Stomatolgic Tropicale 1990; 13: 9-12.
8. Houston W. J. B., Stephen C. D, Tulley W. J. A Textbook of Orthodontic 2nd Edition, Wright, U.K. 1992; 2 -17.
9. Kumar T.V.A, Kuriakose S. Ultrasonographic evaluation of effectiveness of circumoral muscle exercises in adenotosillectomized children. J Clin Ped Dent 2004; 29: 49-55.
10. Singh G. Textbook of Orthodontics. 2nd Edition; Jaypee Brothers, New Delhi 2007; 53- 2001.
11. Profit W. R., Field H. W. Contemporary orthodontics, 3rd Edition; JR Mosby U.S.A 2000; 113 - 190.
12. Samman N., Mohammadi H., Xia J. Cephalometric norms for the upper airway in a healthy Hong Kong Chinese. Hong Kong Chinese Med J 2003; 9: 25-30.
13. Maltais F, Carrier G, Cormier Y, Series F. Cephalometric measurements
14. in snorers, non-snorers, and patients with sleep apnoea. Thorax 1991;46: 419-423.
14. Pepin J.L, Ferretti G., Veale D. Somnofluoroscopy, computed tomography and cephalometry in the assessment of the airway in obstructive sleep apnoea. Thorax 1992; 47:150- 156.
15. Yu L.F, Pogrel M.A, Ajayi M. Pharyngeal airway changes associated with mandibular advancement. J Oral Maxillofac Surg 1994; 52:40-43.
16. Dahl E., Kreiborg S., Jensen B.L, Fogh-Andersen P. Comparison of craniofacial morphology in infants with incomplete cleft lip and infants with isolated cleft palate. Cleft Palate J1982;19:n 258-266.
17. Isiekwe M. C. A Cephalometric study of incisor angulations in a Nigerian population. Br J Orthod 1989; 16:177-181.
18. Cohen J. A coefficient of agreement for nominal scales. Educ. Psychol. Measurement 1960; 20: 37-46
19. Abramson J.H. The WINPEPI Computer programs for epidemiologists. SPSS 11; Chicago, Illinois 2006.
20. Cohen A.M., Vig P.S. A serial growth study of the tongue and Intermaxillary space. Angle Orthod 1976;46: 332337.
21. Hans M.G., Nelson S., Luks V.G., Lorkovich P., Baek S. Comparison of two dental devices for treatment of obstructive sleep apnea syndrome (OSAS). Am J Orthod & Dentofac Orthop 1997; 111: 562-570.
22. Yildrim M., Fitzpatric M.F.,Whyte K.F., Jalleh