Changes in the Pharyngeal Airway Spaces and Hyoid Bone Position Associated with Surgically Assisted Rapid Maxillary Expansion

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Abstract: The aim of this study was to assess changes in pharyngeal airway, hyoid bone position in patients who had surgically assisted rapid maxillary expansion (RME) in cases of skeletal maxillary constriction. Fifteen patients with skeletal maxillary constriction with age ranged from 20 to 22.4 years. All patients had presurgical orthodontic treatment for six months. Lateral cephalograms were taken before and after surgery. Parameters indicating the upper and lower pharyngeal airway and the hyoid bone were evaluated. The results of the present study showed that; significant increased of the SPAS (superioposterior airway) by 5mm and significant increase of the vertical airway length (VAL) by 3.8 mm. The hyoid bone position was changed as indicated by significant increased of (H-C3) and (H- VRP) distances by 2.8mm and 4.5mm respectively, and significant decreased of (H-RGn) distance by 1.3 mm. While the movement of the hyoid bone in superior position indicated by significant decreased of (MPH) and (H-C3Me). **Conclusion:** From the results of the present study the following could be concluded; 1) the surgically assisted rapid maxillary expansion RME significantly improve the upper pharyngeal airway. 2) No significant changes were observed in the lower pharyngeal airway spaces. 3) The hyoid bone moved anteriorly and superiorly after treatment. 4) Surgically assisted RME treatment tends to normalize hyoid bone position.

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1. Introduction

Several problems were associated with maxillary constriction that include occlusal disharmony, esthetics cross bite and functional problems such as narrowing of the pharyngeal airway[1,2] Several studies have investigated that maxillary constriction may play a role in the etiology of obstructive sleep apnea (OSA)[3,4] Several studies showed that patients with OSA have abnormal cephalometric dentofacial morphologies.[1,2,7] Other studies were also showed tendencies toward reduced cranial base length and angle, large ANB angle, steep mandibular plane, elongated maxillary and mandibular teeth, narrowing of the upper airway, long and large soft palate, large tongue.[5,6] tendencies toward retrognathia,.[8] long face, micrognathia, and inferior positioning of the hyoid bone.[9] Rapid maxillary expansion (RME) was used in patients with transverse maxillary constriction.[10,11]

Many studies were reported that maxillary expansion increases the volume of the nasal cavity, increases the nasal cavity width, lowers the palatal vault, straights the nasal septum, and reduces the nasal airflow resistance, and improves the nasal respiration.[12-17] Improved nasal airflow and resolution of obstructive sleep-disordered breathing have been reported in adults undergoing surgically assisted RME.[18]. Many studies were reported that hyoid bone position may be affected by upper airway resistance. It has also been shown that the hyoid bone becomes progressively lower as airway resistance increases. Hyoid bone position changes with age and descends during growth and maintains its position between C3 and C4.[19] Although snoring subjects had lower hyoid bone position at all ages, the hyoid position became lower with increasing age, regardless of snoring status.[20]. The maxillary constriction was associated with nasal resistance and Rapid Maxillary Expansion (RME) decreases nasal resistance, it is possible that RME affects hyoid bone position and the pharyngeal air way space. So the aim of this study was to assess changes in pharyngeal airway, hyoid bone position in patients who had surgically assisted rapid maxillary expansion (RME) in cases of skeletal maxillary constriction.

2. Material And Methods

Subjects

The sample consisted of 15 patients with skeletal maxillary constriction and posterior cross bite. All subjects were non growing adults and the main age before surgery was ranged from 20 to 22.4 years. The patients were selected from Orthodontic Department and oral and Maxillofacial Surgery department, Faculty of Dentistry Al-Azhar University

Cairo (boys). The surgery was done At Said Galal Hospital, Oral and Maxillofacial Surgery Department, Faculty of Dentistry Al-Azhar University Cairo (boys). All subjects were free of any craniofacial anomalies syndromes, sever asymmetry or clefts.

Patients had a hyrax-type maxillary expander banded on the maxillary first premolars and first molars. The patients were monitored weekly for appropriate activation of the appliance. Hyrax was turned 1-2 times per day (0.25–0.5 mm) until the required expansion was achieved, that is, slight overcorrection of the crossbite (average time, 4–6 weeks), and then was stabilized. The hyrax was used for retention for at least 3 months after-expansion. Most patients had no orthodontic treatment until after the fixed retention period.

Surgical Technique

Maxillary vestibular incision from first molor to the first molar another side “Degloning” incision. The mucoperiosteal elevator will be used to expose the maxilla till the infraorbital fromoin till pterygoid junction posteriorly. The osteotomy starts from maxillary tuberosity to the other side above the apices of the teeth about 5 mm. Releasing the maxilla ”mobilizing the maxilla” by using different shape of osteatome releasing the maxilla as in Le fort 1 surgery but leaving the maxilla hanging on lateral nasal wall or maxillary pterygoid junction. Splitting the maxilla by using thin straight osteotome between the two incisors. perpenducliar to the maxillary bone directed to the mid palatal suture. Check the expander by activating the expander and check the effect of expansion by space noted between the two incisors. The surgical sites were then irrigated thoroughly and closed with resorbable sutures. The surgical technique is shown in Figure (1).

Cephalometric Analysis

Lateral cephalometric were taken in natural head position before treatment (T1) and after retention period (T2) with exposure values of 60 KVp, 10 mA, and 0.12 seconds. All cephalometric landmarks were pencil traced on acetate paper and the lines and the angles were measured to the closest to 0.01 mm and 0.1 degrees. All measurements were repeat traced by the same investigator from randomly selected radiographs and showed that no significant differences was found between the first and second tracing.

A horizontal reference plane (HRP) was drown 7 degree superior to sella-nasion at the sella and a vertical references plane (VRP) was drown perpendicular to (HRP). The hyoid bone position determined by the perpendicular distances from the most superioanterior point of the hyoid (hyoidale) to (HRP) and (HRV) and the hyoid triangle (MPH, HRGN, and H-C3Me). The pharyngeal airway space was determined by measuring (SPAS) superior posterior airway space, (MAS) middle airway space, (IAS) inferior airway space and (VAL) vertical airway length.[21-23] The pretreatment, and after surgery cephalometry are shown in figure (2). landmarks and measurements are shown in table (1) and figure (3).

Statistics

The data were calculated and analyzed using SPSS software (statistical package for social science version 10.0). Descriptive statistics (mean and standard deviation) were calculated for each parameter before treatment (T1) and after retention period (T2). The differences between the parameters were analyzed using Paired T- test. Before and after treatment lateral cephalometric head films from 10 randomly selected subjects were traced and superimposed with measurements records on two different occasion. The combined method error (ME) in the change of the different measurements were calculated according to Dahlberg's formula ME = $\sqrt{\Sigma d^2/2n}$, where (d) is the differences between two measurements of cephalometric values and (n) is the number of the subject.

Table 1: definition of the cephalometric measurements

Variables		Definition
Planes	HRP	Horizontal reference plane
	VRP	Vertical reference plane
Hyoid bone	MPH	Distance along perpendicular from H to MP
	HRGN	Distance between H and RGN
	H-C3	Distance between H and C3
	H-C3Me	Distance along perpendicular from H to C3-Me line
	H-HRP	Perpendicular distance from HRP to hyoidale point (the most superioanterior point of the hyoid bone)
	H-VRP	Perpendicular distance from VRP to hyoidale point
Oropharynx	SPAS	Superioposterior airway space (width of airway behind the soft palate along line parallel to (Go-B) plane.
	MAS	Middle airway space (width of the airway along a line parallel to (Go-B)line through P.
	IAS	Inferior airway space (width of the airway along (Go-B)line.
	VAL	Vertical airway length (distance between PNS and EB).

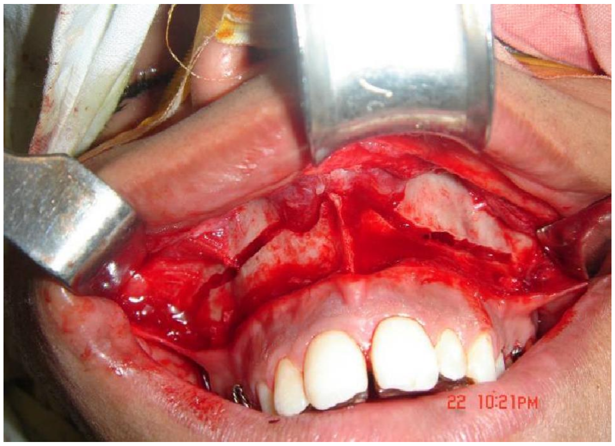
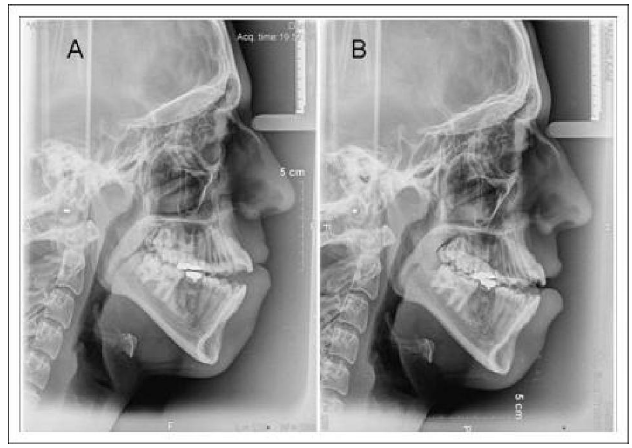


Figure (1) The surgical technique



Figure(2) A-pretreatment lateral cephalometry
B- After surgically assisted RME

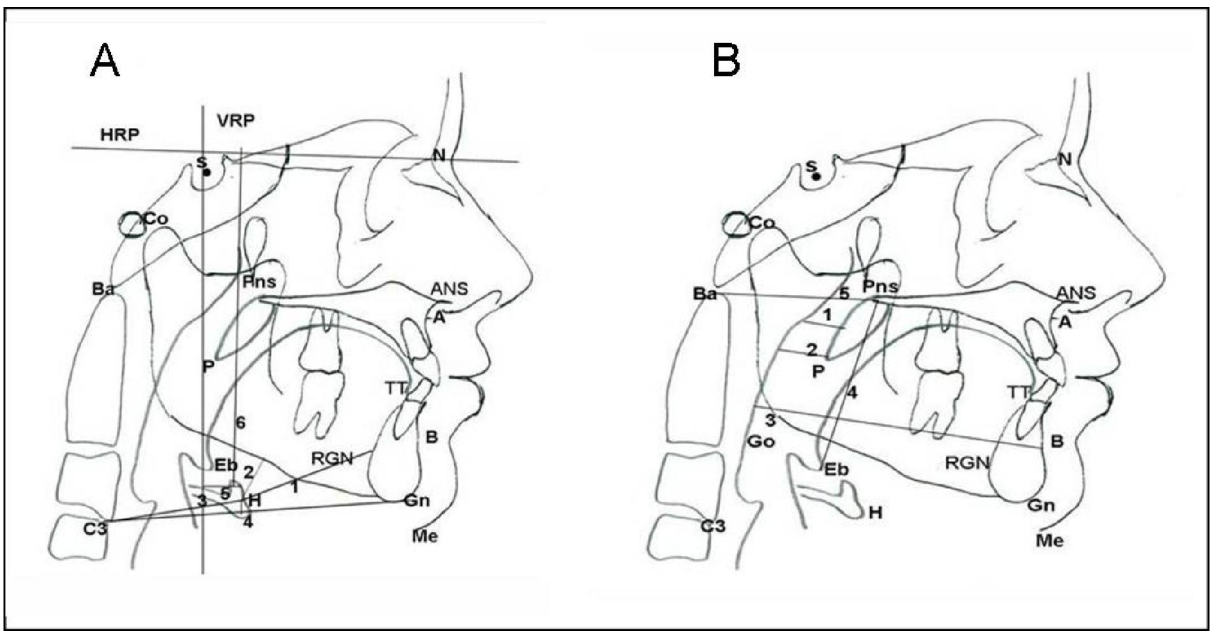


Figure (3) Cephalometric points, landmarks and measurements
A-Hyoid; 1; H-RGN. 2; MPH. 3; H-C3. 4; H-C3Me. 5; H-VRP. 6; H-HRP
B- Airway; 1;SPAS. 2;MAS. 3;IAS. 4;VAL

3.Results

Comparison between pretreatment and after treatment of all variables are shown in table (2).

The pharyngeal airway showed significant improvement after surgically assisted rapid maxillary expansion as indicated by significant increase of the SPAS (superioposterior airway) by 5mm and significant increase of the vertical airway length (VAL) by 3.8 mm. The middle and inferior air way spaces (MAS and IAS) were showed non significant changes.

The Hyoid bone was moved in anterior and superior position after surgically assisted rapid maxillary expansion. The movement of the hyoid bone in anterior position as indicated by significant increased of (H-C3) and (H- VRP) distances by 2.8mm and 4.5mm respectively, and significant decreased of (H-RGn) distance by 1.3 mm. While the movement of the hyoid bone in superior position indicated by significant decreased of (MPH) and (H-C3Me).

Table (2) Comparison between pretreatment and after treatment of all cephalometric variables

	Pretreatment T1		Post-treatment T2		Mean Differences	T-value	Sig.
	Mean	SD	Mean	SD			
Hyoid bone							
MPH	15.2	1.11	11.53	1.14	3.6	8.9	0.001***
HRGN	40.6	1.28	39.3	1.15	1.3	2.9	0.01**
H-C3	39.03	1.23	41.83	1.88	-2.8	-4.8	0.001***
H-C3Me	3.08	0.57	2.14	0.59	0.94	4.37	0.001***
H-HRP	124.56	1.63	124.26	1.66	0.3	0.49	0.62NS
H-VRP	6.8	1.42	11.3	1.34	-4.53	-8.96	0.001***
Oropharynx							
SPAS	6.73	1.66	11.8	1.82	-5.06	-7.94	0.001***
MAS	7.6	1.72	7.86	2.26	-0.26	-0.36	0.71NS
IAS	11.5	1.8	11.23	1.97	0.27	0.38	0.7NS
VAL	56.73	1.83	60.53	1.68	-3.8	-5.9	0.001***

NS; non significant ** Statistically significant at (*P*<0.01) level
***** Statistically significant at (*P*<0.001) level**

4. Discussion

This study evaluated the changes in hyoid bone position and pharyngeal airway spaces among adult patients undergoing orthodontic treatment with surgically assisted RME. Previous studies[15,24] were done on the adolescence and not receiving surgical assisted RME and showed that subjects receiving RME for orthodontic purposes had a much higher nasal resistance before treatment than subjects not receiving RME. Abnormalities in the craniofacial region were considered as predisposing factors to obstructive sleep apnea OSA by its adverse effects on the oropharyngeal airway. The maxillary constriction might play a role in the pathophysiology of OSA because maxillary constriction is associated with low tongue posture that could result in oropharynx airway narrowing, which is a risk factor for OSA.[1,2,25] Furthermore, narrowed posterior air space, elongation of the soft palate, mandibular deficiency, and inferiorly placed hyoid bone relative to the mandibular plane might also considered as an important factors in the pathophysiology of OSA.[1,2] In the present study, the surgically assisted expansion RME produced a significant increase in the upper pharyngeal airway, as indicated by significant increase of (SPAS) and (VAL) by 5.06mm and 3.8 mm respectively. This conclusion is in agreement with previous studies that found that Rapid maxillary expansion RME has been reported to be associated with an increase in nasal cavity width and significant reduction in the nasal airway resistance and increasing the upper airway.[(12,17,26)]

In this study The Hyoid bone was moved in anterior and superior position after surgically assisted rapid maxillary expansion. This results were in agreement with the previous studies[20,27] were found that the hyoid to mandibular plane distance increased in the non-RME group and decreased in RME group. Previous studies [20,28,29] that reported association between low hyoid bone, long tongues, and obstructive apnea, as well as snoring in adults. Reducing maxillary transverse deficiency which related to airway obstruction could improve airway function and potentially normalize hyoid bone position.

Finally, a three dimensional reading using advanced digital imaging techniques could provide researchers with a better understanding of the dynamic changes in the pharyngeal airways and hyoid bone position throughout orthodontic treatment.

Conclusion

From the results of the present study the following could be concluded;

1- The surgically assisted rapid maxillary expansion RME significantly improve the upper pharyngeal airway.
2- No significant changes were observed in the lower pharyngeal airway spaces.
3- The hyoid bone moved anteriorly and superiorly after treatment.
4- Surgically assisted RME treatment tends to normalize hyoid bone position.

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