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VELOPHARYNGEAL AND GLOSSOPHARYNGEAL VOLUME CHANGES AFTER IMPLANT ANCHORED MAXILLARY EXPANSION

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ABSTRACT

Purpose: Evaluation of the changes of the segmented 3D model of the pharyngeal airway volume and surface area after using conventional and hybrid Hyrax (with micro implant) for maxillary expansion using MIMICS software.

Materials and methods: Sample size: 20 male patients with constricted maxilla dedicated for maxillary expansion as a part of orthodontic treatment plan. For each patient, written acceptance consent was taken to participate in the study. Selection criteria: - Age 12-14 years. - Absence of any: previous orthodontic intervention, breathing disorder, deformities that may affects the craniofacial structures. - Constricted maxilla indicated for Hyrax Rapid Palatal Expansion (RPX). The sample was divided into two groups: The first group (10 patients) was treated with conventional Hyrax appliance supported on first permanent molars bilaterally (dental anchorage). The second group (10 patients) treated with hybrid Hyrax supported on first permanent molar and first premolar bilaterally, this appliance incorporating two eyelets for additional skeletal anchorage with two micro-implants. For each patient enrolled in this study a full skull CT x ray was done just before the insertion of the Hyrax appliance and after 10 days of rapid palatal expansion at a constant rate for all patients. The full skull CT was processed via MIMICS software for segmentation, 3D modeling and measurements of the pharyngeal airway volume and surface area from the level of the hard palate to the lower border of the hyoid bone.

Results: -For both conventional and Hybrid Hyrax, Rapid Palatal Expansion resulted in statistically significant increase in the pharyngeal airway volume and surface area (1.87cm^3, 2.52cm^3, 1,68cm^2 and 2.48cm^2) respectively. -Greater increase in the pharyngeal airway volume and surface area in the second group due to incorporation of the micro-implants but the statistical differences between both groups was found to be non-significant.

Conclusions Both conventional and hybrid Hyrax produced significant increase in pharyngeal airway volume and surface area, this effect can be augmented by incorporating skeletal support (micro implant) in the Hyrax appliance.

KEY WARDS: Maxillary Expansion, Micro implant, Pharyngeal volume.

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INTRODUCTION

The association between Rapid Palatal Expansion (RPE) and the pharyngeal airway spaces was first described by Brown,[1]

Numerous studies of airway depend on somewhat limited two dimensional representation of the airway from lateral cephalograms. Magnetic resonance imaging (MRI) was used to quantify the volumetric changes of airway spaces but with many disadvantage as longer examination time and motion artifacts from breathing, carotid pulsations, and swallowing,[2]

Many software packages are now available to analyze the 3D model data of the pharyngeal airway volume and surface area obtained from CT or CBCT.

The pharyngeal structures and cranio-facial structures are significantly affected by each other's.[3,4] Also as stated by van Lunteren E et al 1987[5] , the position of the hyoid bone and its associated musculatures plays an important role in the dimensions of the pharyngeal airway.[6-9]

Solow hypothesis reported the limited value of lateral cephalometric x-ray in evaluating the pharyngeal airway dimensions and the effects of changes in tongue and head position on pharyngeal structures,[10] So in the present study the air way space related to the base of the tongue will be subtracted to eliminate the changes in airway volume in relation to the changes in tongue position.

Numerous articles have reported the advantage of rapid palatal expansion on breathing functions,[11-13] The lower the tongue position and the greater the maxillary constriction the more the severity of the obstructive sleep apnea.[14-16] Mario C J et al 2017[17] concluded that Rapid Palatal Expansion resulted in a significant expansion in maxillary sinuses, oropharynx and nasal cavity.

Due to this strong correlation between pharyngeal structures and the craniofacial structures so this study was aimed to evaluate the effects of micro-implant incorporation as skeletal anchorage with Hyrax appliance using MIMICS software ((Mterialise Interactive Medical Image Control System).

MIMICS developed by Materialise NV, a Belgian company specialized in additive manufacturing software and technology for medical, dental and additive manufacturing industries.

AIM OF THE WORK

Assessment of the volume and surface area of the pharyngeal airway in response to Rapid Palatal Expansion with conventional and hybrid Hyrax appliances from 3 dimensional model constructed by MIMICS software after sectioning and subtraction of the part related to the base of the tongue.

MATERIALS AND METHODS

Study design: prospective study.

Sample size: 20 patients

Grouping:

First group (1): conventional Hyrax group. (Figure 1A & 1B)

Second group (2): hybrid Hyrax group. (Figure 2A & 2B)

Inclusion criteria:

- All selected patients were males to avoid the difference in airway between male and female.
- Age 12 to 14 years old with narrow range of age to eliminate the effect of growth.
- All patients were free from any syndrome or congenital defects that may affect the craniofacial structures.
- No previous orthodontic treatment.
- No previous history of facial or cranial trauma.
- Absence of any breathing disorders or symptoms of Obstructive Sleep Apnea.

- All patients diagnosed with maxillary constriction which needs Rapid Palatal Expansion during their orthodontic treatment.

For each patient enrolled in this study:

- Written acceptance consent was taken before the start of treatment.
- Full skull computerized tomogram (CT) was done just before insertion of the Hyrax and immediately after its removal.
- The Hyrax was activated twice per day for ten days at a constant rate.

With the aid of MIMICS software the pharyngeal airway for each patient was transferred into three dimensional model by segmentation from the level of the hard and soft palate upward to the level of the lower border of the uvula downward. Then the volume and surface area was measured. (Figure 3-7)

Using the same software a sector related to the base of the tongue anteriorly and to a line connecting the tips of the uvula and epiglottis posteriorly was segmented and subtracted from total pharyngeal volume to exclude the variation related to the changes in tongue position.

All the obtained measurements of the pharyngeal airway volume and surface areas were statistically analyzed using SPSS package (21.0)®

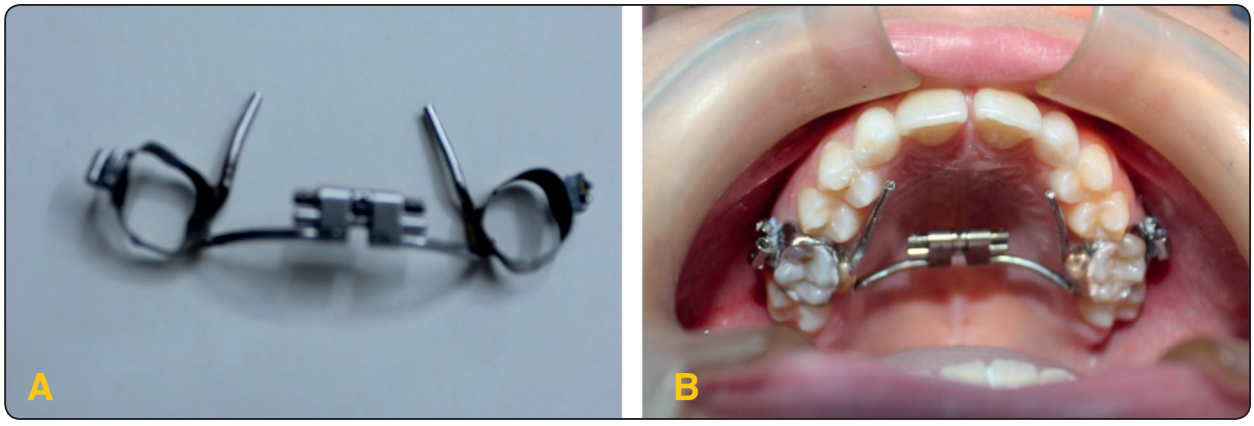

Fig. (1A) Teeth supported Hyrax (B): teeth supported Hyrax cemented in the

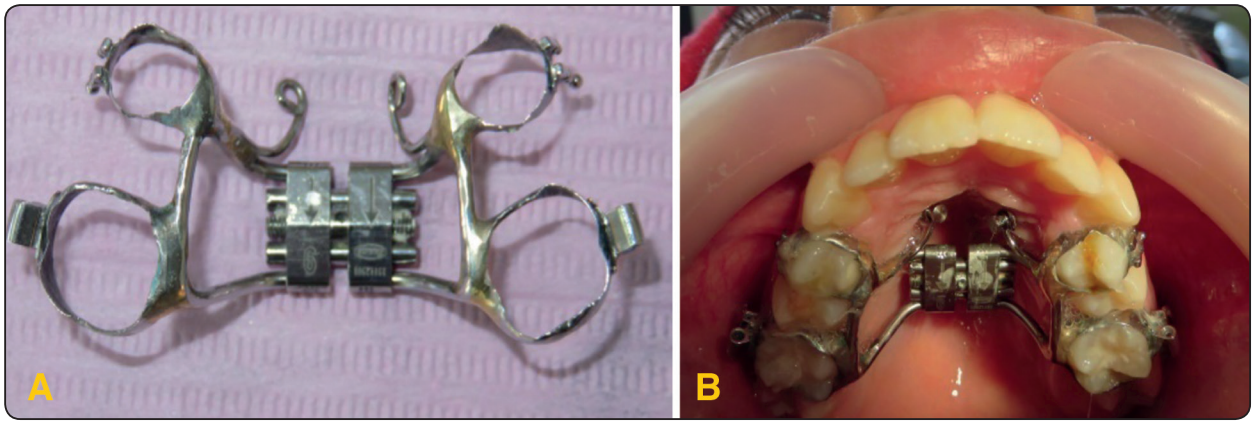

Fig. (2A) I mplant anchored Hyrax (B): implant anchored Hyrax cemented in the

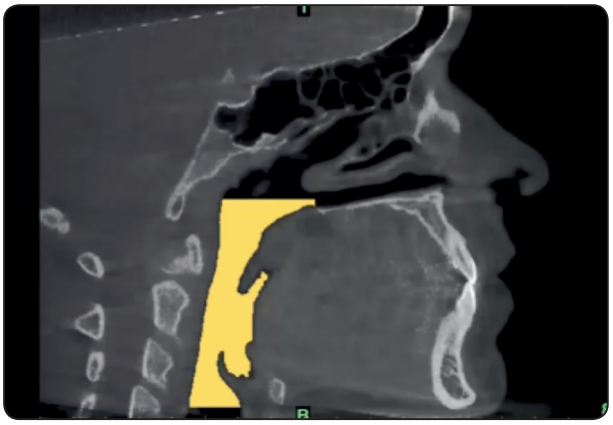

Fig. (3) Marking the pharyngeal airway by color

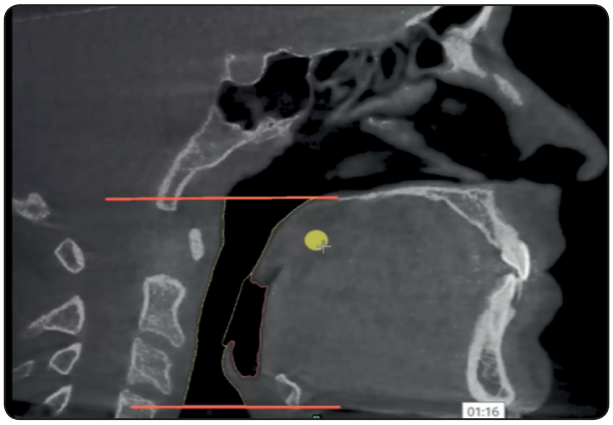

Fig. (4) Upper and lower limits of the pharyngeal airway

Fig. (5) Connected line from the tip of the uvula to the tip of the epiglottis

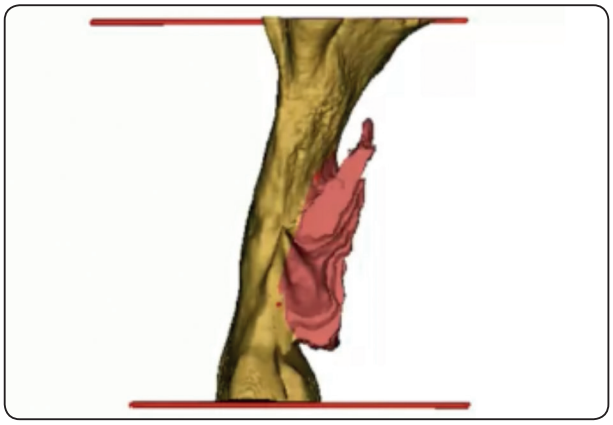

Fig. (6) 3D model of the pharyngeal airway before subtracting the area opposite the base of the tongue

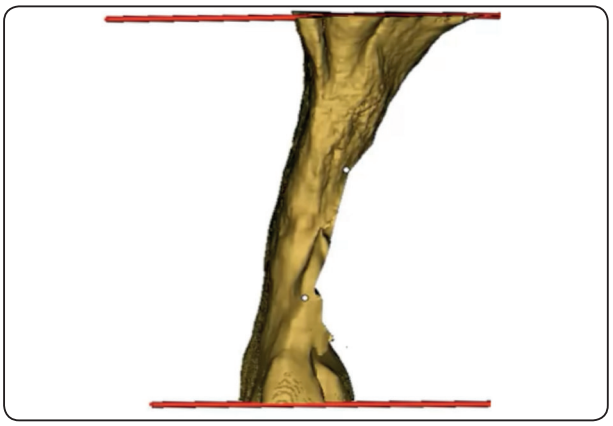

Fig. (7) 3D model of the pharyngeal airway after subtracting the area opposite the base of the tongue

RESULTS

For both before and after treatment (T0-T1) of the two main tested groups was subdivided into eight sub groups, four of them representing the volume and the other four subgroups representing the surface area of the upper pharyngeal airway

Descriptive statistics of the all tested subgroups before and after treatment was demonstrated in Table (1) and Figure (8,9). Paired t test showed that there was a significant increase in the upper airway volume of all tested subgroups after treatment ($p<0.05$).

Comparison of the mean differences of the main tested groups showed that there was a non-significant difference between conventional and hybrid Hyrax group (p>0.05) with a higher mean values for the hybrid Hyrax group than conventional Hyrax group. Table (2) and Figure (10).

TABLE (1): Comparison of all subgroups before and after rapid palatal expansion

Group		Mean ± SD	T-test Value	P-Value
SG1	T1	16.19 ± 0.97	5.192	0.001
	T0	13.98 ± 0.64		
SG2	T1	16.82 ± 0.87	7.664	0.00
	T0	13.86 ± 0.60		
SG3	T1	13.42 ± 0.78	7.715	0.00
	T0	11.55 ± 0.39		
SG4	T1	13.96 ± 1.02	8.674	0.00
	T0	11.44 ± 0.28		
SG5	T1	8.01 ± 0.39	33.799	0.00
	T0	6.27 ± 0.39		
SG6	T1	8.62 ± 0.35	70.855	0.00
	T0	6.11 ± 0.34		
SG7	T1	7.44 ± 0.34	11.105	0.00
	T0	5.76 ± 0.46		
SG8	T1	7.95 ± 0.34	54.137	0.00
	T0	5.48 ± 0.33		

Significance: (p<0.05).

SG1: TOTAL AIRWAY VOLUME GROUP (1) BEFORE SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG2: TOTAL AIRWAY VOLUME GROUP (2) BEFORE SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG3: TOTAL AIRWAY VOLUME GROUP (1) AFTER SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG4: TOTAL AIRWAY VOLUME GROUP (2) AFTER SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG5: TOTAL AIRWAY SURFACE AREA GROUP (1) BEFORE SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG6: TOTAL AIRWAY SURFACE AREA GROUP (2) BEFORE SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG7: TOTAL AIRWAY SURFACE AREA GROUP (1) AFTER SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

SG8: TOTAL AIRWAY SURFACE AREA GROUP (2) AFTER SUBTRACTING SPACE RELATED TO THE BASE OF THE TONGUE

TABLE (2): Comparison of mean difference between tooth and implant anchored Hyrax

Group	Mean difference ± SD	T-Value	P-Value
SG1	2.21 ± 1.34	1.3	0.208 n.s.
SG2	2.96 ± 1.22		
SG3	1.87 ± 0.76	1.74	0.099 n.s.
SG4	2.52 ± 0.92		
SG5	1.73 ± 1.16	1.54	0.143 n.s.
SG6	2.51 ± 1.11		
SG7	1.68 ± 0.48	5.03	0.000 sig.
SG8	2.48 ± 0.14		

Significance: (p<0.05).

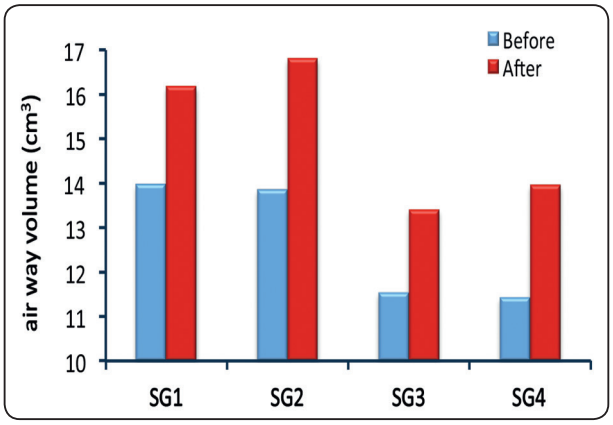

Fig. (8): Comparison of pharyngeal airway volume before and after rapid palatal expansion

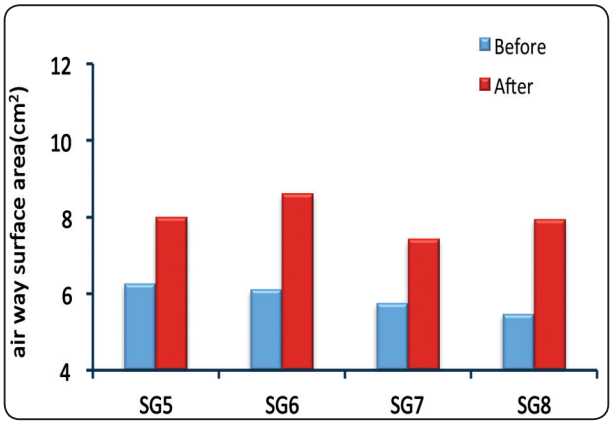

Fig. (9): Comparison of pharyngeal airway surface area before and after rapid palatal expansion

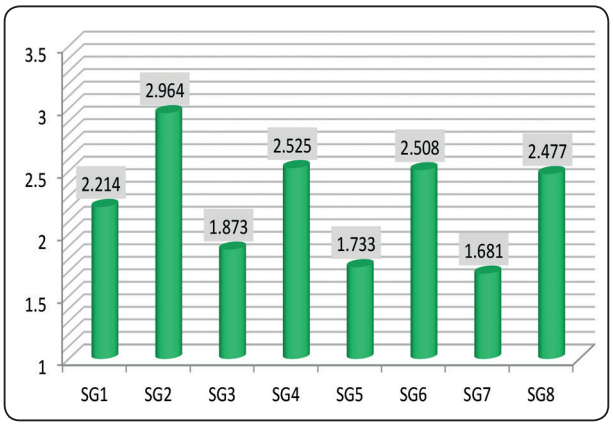

Fig. (10): Comparison of all subgroups before and after rapid palatal expansion

DISCUSSION

Due to the close correlation of pharyngeal airway to the craniofacial structures, pharyngeal airway volume assessment is considered important for orthodontists, pediatric dentists, ENT, speech therapists.

In the present study full skull CT X-ray was used for better and easy application of MIMICES software despite the older researches on pharyngeal airway dimensions from lateral cephalometric x-ray found that cephalometric films are significantly reliable and reproducible in determining airway dimensions.[18-20]

Although numerous previous studies investigated the pharyngeal airway volume and surface area after RME [21-29] very little researches constructed a 3D model for pharyngeal airway structure using recent software program like MIMECS which used in the present study. Andre W et al 2012[30] investigated MIMICS, i-CAT scanner, OsiriX, Dolphin3D, and ITK-Snap software and found that MIMICS software is more accurate and more reliable than other soft wares as InVivo Dental and Ondemand3D for upper airway assessment, with less than 2% error.

Burkhard J P M et al 2014[31] studied the 3D design of the posterior airway space before and after orthognathic surgery and tested the reliability of OsiriX64-bit, Switzerland; Mimics, Belgium; BrainLab, Germany and concluded that all programs are reliable and precise methods of measurements.

Little studies pay attention to the effect of changes in tongue position on the pharyngeal airway volume. [32,33] Despite that limited evidence was found between upper pharyngeal airway and head position[32] On the other hand Ono et al 2000[34] with the use of magnetic resonance image studied the effects of head positions on the volume of the pharyngeal airway and found that a significant increase in volume of the pharyngeal retro-glossal region when the patient rotated his head.

Harvey et al 2017 [35] assessed the relationship of the palate to the tongue using the Friedman Tongue Position grading system and concluded that this grading system was objectively supported by CBCT results, So to eliminate the effect of changes in tongue position a part of the pharyngeal airway related to the base of the tongue was sectioned and subtracted from the total volume.

In the present study the conventional and micro implant anchored Hyrax appliances were compared. Both appliances produced a significant increase in pharyngeal airway volume with greater volumetric increase for implant anchored Hyrax than teeth supported Hyrax 2.52 cm3 and 1.87 cm3 respectively these finding came in accordance with numerous previous studies on a similar appliances with hybrid Rapid Palatal Expansion.[36-38]

Similar findings with this current study, Hura J S et al 2017 [39] studied a group of adult patients suffering from obstructive sleep apnea with moderate to severe constriction of the maxillary arch and treated with mini-screw-anchored rapid palatal expansion and concluded that this treatment intervention considered a successful treatment protocol for such cases.

Also in accordance with the results of the present study Yeon Kim S et al 2018 [40] stated that the volume of the naso-pharynex increased after the use of implant anchored Rapid Palatal Expansion with stable results for one year after treatment.

CONCLUSIONS

On the basis of the results obtained from the present study, the following observations were noted:

- The upper pharyngeal airway significantly increased in volume due to Rapid Palatal Expansion especially when micro-implants were additionally incorporated in the appliance.
- A greater but still statistically non-significant differences in airway volumetric and surface area changes for both conventional and hybrid Hyrax appliances.

RECOMMENDATIONS

- Further longitudinal studies are needed over samples with larger size to study the stability over a longer period of time.
- Differences in both response and stability between males and females are needed to be evaluated.

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