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AAO Foundation Final Report Form
(a/o 1/3/2018)

In an attempt to make things a little easier for the reviewer who will read this report, please consider these two questions before this is sent for review:

- *Is this an example of your very best work, in that it provides sufficient explanation and justification, and is something otherwise worthy of publication? (We do publish the Final Report on our website, so this does need to be complete and polished.) This project is lacking the data on a control group which will be added to the manuscript before submitting for publication.*
- *Does this Final Report provide the level of detail, etc. that you would expect, if you were the reviewer? I believe the final manuscript including the control group data will be more appropriate for reviewers input as well as publication on the website.*

Please prepare a report that addresses the following:

Type of Award, Orthodontic Faculty Development Fellowship Award

Name(s) of Principal Investigator: Goli K. Parsi

Institution: Boston University

Title of Project: Evaluation of symmetry in volumetric and width changes in nasal cavity, nasopharyngeal and oropharyngeal compartments of the airway.

Period of AAOF Support 07/01/2017-06/30/2018

Amount of Funding: 20,000

Summary/Abstract:

Introduction: The objective of this study was to test the effect of Rapid Maxillary Expansion (RME) on right and left side of the nasal cavity. Volumetric changes in overall nasal cavity, nasopharynx, and oropharynx, linear minimum cross-section changes, and molar angulation in association with RME were also assessed.
Methods: CBCT scans before and after RME treatment for 28 subjects (17 females, 11 males, average age 9.86 ± 2.42 years) were collected from a previously de-identified database. All subjects were treated for maxillary constriction using banded hyrax expanders. Mimics software was utilized to segment the nasal and pharyngeal airways for volumetric analysis. Linear cross-sectional measurements and maxillary molar angulation were also assessed in reference to the RME procedure. A group of CBCT scans with similar span between time points as initial and

final scans age and sex matched to subject group were also evaluated.
Results: Posterior expansion as measured between right and left greater palatine foramen averaged 2.41 ± 1.03 mm ($p<0.01$). There were statistically significant volume increases in overall nasal cavity (2249.6 ± 2102.5 mm^3, $p<0.01$), right nasal cavity (968.8 ± 1082.7, $p<0.01$), left nasal cavity (1197.3 ± 1587.0, $p<0.01$), nasopharynx (1000.6 ± 917.7, $p<0.01$), and oropharynx (2349.2 ± 2520.8, $p<0.01$) after RME. When the volumes were compared between right and left sides, no significant differences were found at either initial or post-expansion stages, or between pre to post-expansion stages. For cross-sectional analysis, right nasal cavity (0.13 ± 0.07 mm, $p<0.01$) and left nasal cavity (0.11 ± 0.06 mm, $p<0.01$) showed significant increases. Initial maxillary molar angulations were not significantly correlated with initial nasal cavity volume on either side.
Conclusion: RME has significant benefits to increasing nasal and pharyngeal airway cavity volumes in all segments of the airway. Nasal cavity expands symmetrically. Linear minimum cross-section of the left and right nasal cavities showed highly symmetrical improvements. Initial maxillary molar angulation does not show a significant relationship to initial nasal cavity volume.

Detailed results and inferences:

1. All authors are currently reviewing the manuscript before submission for publication.
2. Describe in detail the results of your study. The intent is to share the knowledge you have generated with the AAOF and orthodontic community specifically and other who may benefit from your study. Table, Figures, Statistical Analysis and interpretation of results should be included:

    1. Within the 28-subject sample 3 subjects had bilateral crossbite, 4 had unilateral right crossbite, 4 had unilateral left crossbite, and 17 had no dental crossbite but were determined to need RME based on clinical assessment of maxillary skeletal width deficiency at the start of treatment. The linear distances between right and left greater palatine foramina showed significant increase by 2.41 ± 1.03 mm (range: 0.96-5.11 mm) after rapid maxillary expansion ($p < 0.01$).
    2. Statistically significant increases in overall and right and left nasal cavities, nasopharyngeal and oropharyngeal cavity volumes were noted (Table V). When the volumes were compared between right and left sides, no significant differences were found at either initial or post-expansion stages, or between pre to post-expansion stages (Table VI).
    3. For minimum cross-sectional width measurement, both the right and left nasal cavities showed similar widths of most constriction in the coronal plane. This was consistently located at the level of the middle turbinate for all but one subject, which was at a higher level of the inferior turbinate. Measurements showed highly symmetrical and statistically significant improvements following RME of 0.13 ± 0.07 mm and 0.11 ± 0.06 mm for right and left side respectively (Table VII).
    4. Maxillary right molar angulation averaged 79.7 ± 3.98 degrees (range: 73.4-86.6) while maxillary left molar angulation averaged 77.4 ± 4.41 degrees (range: 68.4-84.3). There was a statistically significant difference in molar angulation between the right and left maxillary molars (Table VIII) but there was no significant relationship between initial nasal cavity volume and molar angulations. (Table IX)
    5. When comparing experimental and control groups volumetric values for right and left nasal cavities and nasopharyngeal compartment showed significant difference which indicates that expansion had a significant effect regardless of growth. (Table X)
    6. The average time span between initial and post-expansion scans for our subjects was 2.07 years. Due to the age group of patients in our experimental group we expect that

some growth occurred during this time period. To evaluate if the change in volume was solely due to growth changes we included an age matched control group with similar time span between pre and post-expansion scans and found significant difference in volumetric changes in right and left nasal cavities and nasopharyngeal compartment between the experimental and control groups. This indicates that expansion had a significant effect in volumetric changes of these compartments regardless of growth that occurred in the experimental group. There was no significant difference in the oropharyngeal volume which is indicative of RME having more pronounced effect on nasal cavity and nasopharynx than oropharyngeal volumes.

7. This study looked at the left and right nasal cavity volume changes following RME. We were unable to find any other study analyzing the symmetry of changes in the nasal cavity following maxillary expansion procedure. The results of this study found average increase of 968.8 mm^3 and 1197.3 mm^3 in the right and left nasal cavities respectively. This corresponded to a 26.53% increase in volume in the right nasal cavity and a 38.82% increase in volume in the left nasal cavity. T-test comparison of left and right nasal cavity found no significant differences in initial volume, post-expansion volume, or the changes that occurred from pre to post-expansion (T2-T1). This suggests that RME has a symmetrical effect on right and left nasal cavity volumes.

Table I. Demographic Information

Demographics	**Experimental group**	**Control group**	**P-value**
Gender % **Male** **Female**	 39.29 60.71	 45.00 55.00	0.77*
Age (Mean, SD)	9.86 (2.43)	10.41 (1.60)	0.1**

*chi-square test
**Student t-test

Table V. Volumetric Analysis Before (T1) and After (T2) RME.

Volumetric Variable	**T1 mean ± SD (mm^3)**	**T2 mean ± SD (mm^3)**	**T2-T1 mean ± SD (mm^3)**	**95% C.I. (mm^3)**	**P-value**	**Percent Increase**
Overall Nasal Cavity	7971.6 ± 1801	10082.90 ± 2551.73	2249.6 ± 2102.5	1361.8 – 3137.4	<0.0001	30.82
Right Nasal Cavity	4094.90 ± 1079.66	5063 ± 1323.3	968.8 ± 1082.7	549 – 1388.6	<0.0001	26.53
Left Nasal Cavity	3813.10 ± 1138.28	4970.3 ± 1564.43	1197.3 ± 1587	569.5 – 1825.1	0.0006	38.82
Nasopharynx	2815.88 ± 1037.34	3816.44 ± 1053.21	1000.6 ± 917.7	629.9 – 1371.2	<0.0001	43.92

Oropharynx	7645.22 ± 2311.72	9994.40 ± 3511.89	2349.2 ± 2520.8	1308.6 – 3389.7	<0.0001	33.76

T1 (initial), T2 (post-expansion), CI Confidence Interval, Significant P-value at α <0.05

Table VI. Initial, Post-Expansion, and Difference Comparison for Right and Left Nasal Cavity Volumetric Analysis.

Volumetric Variable	Mean Difference Left to Right Side (mm^3)	95% C.I. (mm^3)	P-value
Initial Nasal Cavity	-281.8	-763 - 200	0.24
Post-Expansion Nasal Cavity	-71.57	-688.1 – 544.9	0.81
T2-T1 Nasal Cavity	-242	-967 – 483.1	0.49

T1 (initial), T2 (post-expansion), CI Confidence Interval, Significant P-value at α <0.05

Table VII. Minimum Cross-sectional Width Measurement Before (T1) and After (T2) RME.

Cross-Section Variable	**T1 mean ± SD (mm)**	**T2 mean ± SD (mm)**	**T2-T1 mean ± SD (mm)**	**95% C.I. (mm)**	**P-value**
Cross-Sectional Width Right	0.34 ± 0.09	0.47 ± 0.12	0.13 ± 0.07	0.10 – 0.16	<0.0001
Cross-Sectional Width Left	0.33 ± 0.08	0.45 ± 0.11	0.11 ± 0.06	0.09 – 0.14	<0.0001

T1 (initial), T2 (post-expansion), CI Confidence Interval, Significant P-value at α <0.05

Table VIII. Maxillary Molar Angle Analysis and Comparison.

Variable	Mean (Degrees)	SD (Degrees)	Min (Degrees)	Max (Degrees)	P-Value
Maxillary Right 1st Molar Angle	79.7	3.98	73.4	86.6	--
Maxillary Left 1st Molar	77.4	4.40	68.4	84.3	--

Angle					
Maxillary Right to Left Molar Angle Comparison	2.28	4.54	-4.90	10.76	0.01

Significant P-value at $\alpha < 0.05$

Table IX. Pearson Correlation Coefficient Table for Relationship Between Initial Maxillary Molar Angulation and Initial Volume.

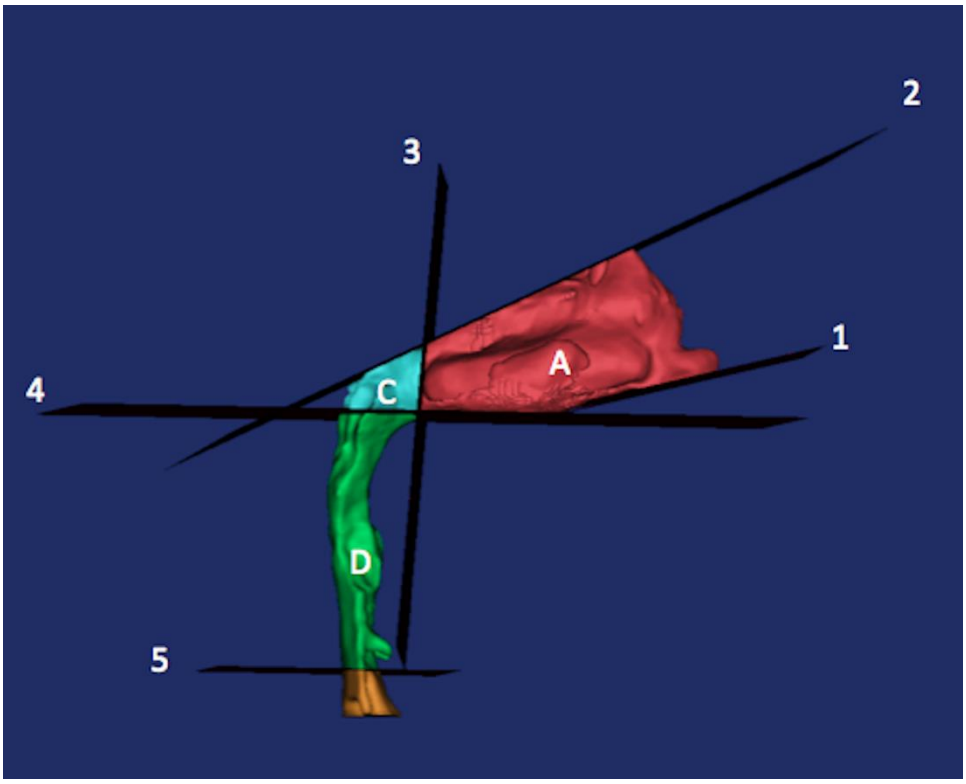
	Maxillary Right Molar Angle	**Maxillary Left Molar Angle**
Right Nasal Cavity Initial Volume	0.06143 0.7562	0.22048 0.2596
Left Nasal Cavity Initial Volume	0.15498 0.4310	0.31790 0.0992

CC Correlation Coefficient, Significant P-value at $\alpha < 0.05$

Table X. Volumetric Analysis between the experimental and control group

Volumetric Variable	**Experimental group** **Mean, SD, (mm^3)**	**Control group** **Mean, SD, (mm^3)**	**Experimental – control** **Mean difference, SD, (mm^3)**	**95% C.I. of the mean difference (mm^3)**	**P-value**

Overall Nasal Cavity	2249.6 ± 2102.5	372.3 ± 1456.1	1877.2 ± 753.9	753.9 – 3000.5	0.002
Right Nasal Cavity	968.80 ± 1082.70	349.90 ± 826.70	618.9 ±985.10	38.37 – 1199.40	0.0372
Left Nasal Cavity	1197.3 ± 1587.00	22.436 ± 1313.4	1174.9 ± 1477.7	296.9 – 2052.9	0.0099
Nasopharynx	1000.6 ± 917.7	191.4 ± 855.9	809.2 ± 274.8	274.8 – 1343.6	0.0039
Oropharynx	2349.2 ± 2520.2	2244.0 ± 4345.1	105.1 ± 3448.0	-1980.9 – 2191.2	0.92



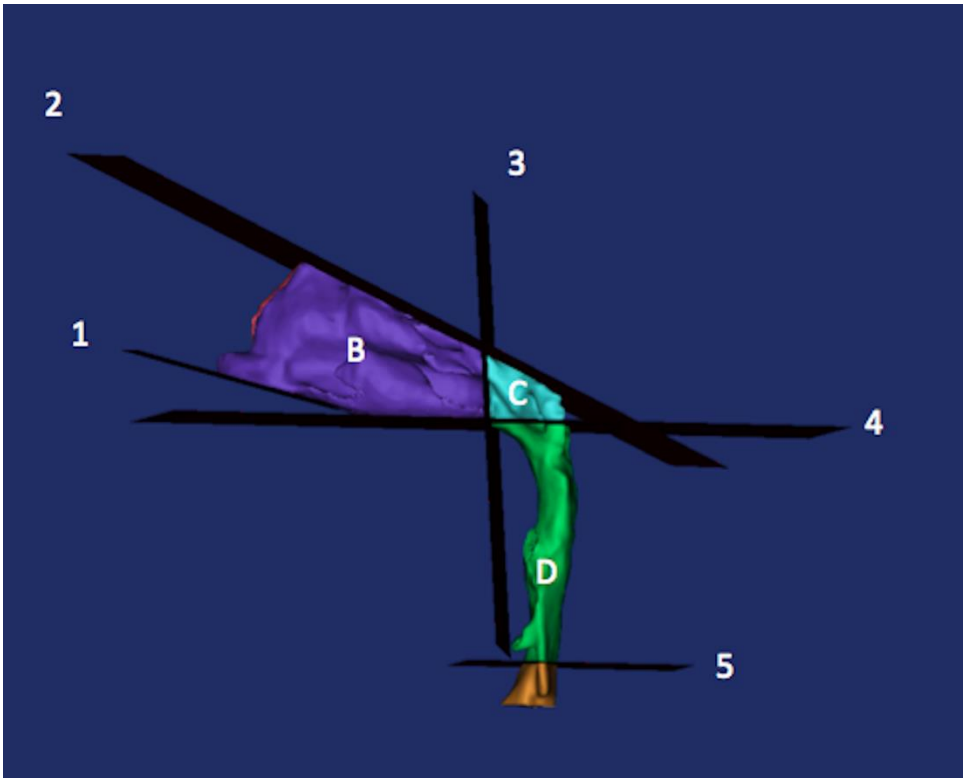


Figure 3: Segmented Airway right and left side 1) Pronasal plane 2) Superior plane 3) PNS vertical plane $) PNS plane 5) C3 plane. A: Right Nasal Cavity B) Left nasal Cavity C) Nasopharyngeal compartment D) Oropharyngeal Compartment

Figure 4: The narrowest portion of the right and left nasal cavity was then measured using the ruler tool in Mimics software

Response to the following questions:

1. Were the original, specific aims of the proposal realized? Yes
2. Were the results published?
   No, all authors are reviewing the manuscript before submission for publication. AAOF will be acknowledged for the significant contribution to this project.
3. Have the results of this proposal been presented? Partial results were presented at the AADR meeting in March 2018 in FL and AAOF was acknowledged.
4. To what extent have you used, or how do you intend to use, AAOF funding to further your career?

The funding from the AAOF made this project possible by helping us get training for a software used to segment the airway in this project. Also, a major portion of this funding helped me get training in sleep dental medicine which now I am in the process of attaining board certification in the field and incorporating orthodontic treatment modalities in addressing sleep disordered breathing in children and adults. I thank OFDFA for helping me make this project and a previous project that was recently accepted for publication in IJOMS possible.

Educational report:

As part of the educational aspect of this program I attended the 2017-2018 Dental Sleep Medicine mini-Residency at Tufts university. This AAOF award fund covered the tuition for the course and helped me gain knowledge in this growing field especially that two of the long term research projects I currently mentor and conduct involve evaluation of breathing disorders and Obstructive Sleep Apnea particularly in children and adolescents. Attending this course made me more aware of the sleep disordered breathing problems that can be addressed with orthodontic intervention at an early age and I am currently working towards obtaining diplomate status with American Academy of Dental Sleep Medicine.

Part of this funding also helped with a customized one-day training conducted at Boston University on features of the Mimics® software version 19.0 (Materialise, Leuven, Belgium) which was used for this research project as well as a few other ones in our department.

Teaching Skills report:

I continue to be the course director for Biomechanics at the Department of Orthodontics at Boston University and give biomechanics lectures to first year orthodontic residents. I have also been giving several lectures on the same topic to residents in the Department of Pediatric Dentistry. I started the ABO review course over 2 years ago with the objective being help our second year residents prepare for the ABO examination. Topics from the recommended reading list for the written and the clinical ABO exam are covered in this course.

Clinical Skills report:

As a full time faculty at Boston University Orthodontics Department I continue to supervise patient care as well as gaining experience in private practice 2 days a week. To enhance my clinical knowledge and skills, I attended several continuing education courses in Clear Aligner treatment, Face course and the McLaughlin
course.