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**AAO Foundation Final Report Form  
(a/o 6/30/2019)**

Type of Award: Orthodontic Faculty Development Fellowship Award

Name of Principal Investigator: Bingshuang Zou

Institution: Faculty of Dentistry, University of British Columbia

Title of Project: “Three-dimensional upper airway changes after maxillary protraction with alternative rapid maxillary expansion and constriction”

Period of AAOF Support (e.g. 07-01-19 to 06-30-21):

Amount of Funding: \$20,000

Summary/Abstract

**Abstract**

**Objective:** This retrospective study aimed to compare the three-dimensional upper airway changes after maxillary protraction (MP) with alternative rapid maxillary expansion and constriction (Alt-RMEC) versus conventional rapid maxillary expansion (RME) in growing Class III malocclusions.

**Materials and Methods:** Approval for the study protocol was obtained from the University of British Columbia Institutional Review Board (H19-01744). Case inclusion criteria were growing Class III patients consecutively treated by one orthodontist with RME or Alt-RMEC combined with facemask maxillary protraction to achieved a Class II molar relationship and a minimum overjet of 3mm. Pre-treatment (T1) and post-treatment (T2) cone-beam computed tomography (CBCT) scans were used to measure the nasopharyngeal, glossopharyngeal, and hypopharyngeal airway changes in terms of volume, sagittal and cross-sectional area. Skeletal and dental changes were measured on the cephalograms generated from CBCT. The changes after treatment and the comparison of the two groups were assessed. SPSS software (version 25; IBM, Armonk, NY) was used to analyze data. Shapiro-Wilk test was used to evaluate data distribution. Independent sample t tests or Mann-Whitney U tests were used to compare the differences between two groups at T1. Paired t tests or Wilcoxon rank tests were used to compare the changes before and after treatment in each group. Independent sample t tests or Mann-Whitney U tests were used to compare the difference between groups.

**Results:**

A total of forty-one Class III patients (mean age: 9.9 years; range: 7-12 years) were selected and divided into two groups: Group 1 (MP/RME) (15 F, 7 M, mean age  $9.7 \pm 1.2$  years) and Group 2

(RME/MP) (13 F, 6 M, mean age  $10.3 \pm 1.4$  years). All measurements showed excellent correlations ( $ICC > 0.90$ ) intra- and inter-observer reliabilities. All data were normally distributed. There was no significant difference between two groups in age, any cephalometric (Table 1) or 3D upper airway measurements (Table 2) at T1. Treatment duration in two groups also showed no significant difference.

The maxilla moved forward significantly after treatment in both groups (A-True vertical plane,  $1.90 \pm 2.22$  mm,  $P < 0.01$  vs  $2.36 \pm 1.56$  mm,  $P < 0.001$ ), but there was no significant difference between groups ( $P > 0.005$ ). All the other significant skeletal and dental changes associated with two treatment protocol also showed non-significant inter-group difference (Table 3).

Significant increase in the measurements of midsagittal area (MSA) and volume in the nasopharyngeal and total upper airway after treatment were observed in both groups. MSA and volume in other upper airway areas in Group 1 also showed significant changes, but the inter-group difference was not significant except that Group 1 had more significant volumetric change in the velopharynx than Group 2 ( $2411.0 \pm 3227.7$  vs  $649.1 \pm 1636.3$ ,  $P < 0.05$ ).

Table 1. Age, treatment duration, skeletal and dental measurements at T1 and comparison between two groups

Measurements	Group 1		Group 2		P value
	Mean	SD	Mean	SD	
Age (y)	9.66	1.23	10.28	1.45	0.143
Tx duration (m)	10.59	4.36	10.84	2.65	0.828
SNA (°)	80.66	2.88	80.33	4.58	0.782
SNB (°)	81.97	3.18	81.52	4.70	0.714
ANB (°)	-1.31	2.08	-1.18	1.23	0.807
FMA (°)	29.99	4.41	28.94	5.15	0.488
PP-FH (°)	3.21	4.24	1.49	4.96	0.238
Mx body length (mm)	35.89	3.61	36.19	3.85	0.796
Mn body length (mm)	69.93	5.07	71.77	4.04	0.211
Co-A (mm)	71.13	3.61	72.73	4.47	0.211
A-TV plane (mm)	55.69	2.37	56.95	2.50	0.105
A-FH (mm)	28.16	2.56	28.70	3.32	0.560
U1-FH (°)	109.97	7.30	110.81	6.08	0.695
U1-PP (mm)	23.50	2.43	24.11	2.06	0.399
U6-PP (mm)	13.01	5.69	14.37	4.96	0.422
IMPA (°)	82.6	6.74	82.07	6.24	0.788

Table 2. Upper airway measurements at T1 and comparison between two groups

Measurements	Group 1		Group 2		P value
	Mean	SD	Mean	SD	
Nasopharynx					
CSA (mm <sup>2</sup> ) @ PNS	398.5	158.2	409.4	166.9	0.831
MSA (mm <sup>2</sup> )	111.8	72.5	102.2	64.9	0.660
Volume (mm <sup>3</sup> )	3154.3	1562.3	2956.8	1503.8	0.684
Velopharynx	0.657				

CSA (mm <sup>2</sup> ) @ Uvula	170.5	87.2	193.7	79.7	0.383
MSA (mm <sup>2</sup> )	246.4	50.4	265.6	66.6	0.300
Volume (mm <sup>3</sup> )	5077.9	2118.5	5624.6	2398.9	0.443
Glossopharynx					
CSA (mm <sup>2</sup> ) @ Et	207.0	80.9	222.9	93.5	0.564
MSA (mm <sup>2</sup> )	170.3	77.4	202.5	83.7	0.208
Volume (mm <sup>3</sup> )	2916.1	1768.7	3690.5	2059.2	0.203
Hypopharynx					
CSA (mm <sup>2</sup> ) @ Eb	198.3	70.3	234.8	81.0	0.130
MSA (mm <sup>2</sup> )	79.2	39.7	93.6	47.0	0.296
Volume (mm <sup>3</sup> )	1839.8	1099.6	2216.9	1301.3	0.321
Total					
MSA(mm <sup>2</sup> )	612.6	160.9	663.2	195.5	0.369
Minimum CSA (mm <sup>2</sup> )	75.8	54.6	84.4	50.9	0.606
Volume (mm <sup>3</sup> )	13092.0	5258.7	14497.4	6124.4	0.434

Table 3. Skeletal and dental changes after treatment (T2-T1) and comparison between two groups

Measurements	Group 1		Group 2		P value
	Mean ± SD	P value	Mean ± SD	P value	
SNA (°)	2.82 ± 1.73	0.000*	2.15 ± 1.64	0.000*	0.212
SNB (°)	-0.15 ± 1.29	0.593	-0.94 ± 2.18	0.078	0.162
ANB (°)	2.97 ± 1.72	0.000*	3.08 ± 1.43	0.000*	0.825
FMA (°)	1.00 ± 2.86	0.114	2.02 ± 3.08	0.010*	0.280
PP-FH (°)	-1.81 ± 2.74	0.005*	0.00 ± 2.55	1.000	0.035
Mx body length (mm)	1.12 ± 2.96	0.090	2.00 ± 4.22	0.054	0.441
Mn body length (mm)	1.45 ± 2.29	0.007*	2.25 ± 2.88	0.003*	0.330
Co-A (mm)	3.03 ± 2.13	0.000*	2.95 ± 2.16	0.000*	0.912
A-TV plane (mm)	1.90 ± 2.22	0.001*	2.36 ± 1.56	0.000*	0.448
A-FH (mm)	1.50 ± 2.47	0.009*	1.07 ± 2.64	0.094	0.588
U1-FH (°)	3.95 ± 5.45	0.003*	4.01 ± 5.74	0.007*	0.979
U1-PP (mm)	1.35 ± 2.58	0.022*	0.84 ± 1.28	0.010*	0.433
U6-PP (mm)	2.01 ± 2.43	0.001*	1.97 ± 2.97	0.010*	0.958
IMPA (°)	0.29 ± 5.25	0.798	-1.12 ± 3.57	0.187	0.328

\*Indicates significant differences between two groups (P<0.05).

Table 4. Upper airway changes after treatment (T2-T1) and comparison between two groups

Measurements	Group 1		Group 2		P value
	Mean ± SD	P value	Mean ± SD	P value	
Nasopharynx					
CSA (mm <sup>2</sup> ) @ PNS	91.2 ± 148.5	0.009*	24.6 ± 114.7	0.362	0.121

MSA (mm <sup>2</sup> )	45.9 ± 41.0	0.000*	45.7 ± 42.8	0.000*	0.988
Volume (mm <sup>3</sup> )	1507.5 ± 1305.8	0.000*	1466.6 ± 1246.1	0.000*	0.919
Velopharynx0.657					
CSA (mm <sup>2</sup> ) @ Uvula	78.8 ± 160.0	0.031*	-3.3 ± 114.5	0.901	0.070
MSA (mm <sup>2</sup> )	50.1 ± 68.2	0.002*	12.2 ± 45.4	0.189	0.059
Volume (mm <sup>3</sup> )	2411.0 ± 3227.7	0.002*	649.1 ± 1636.3	0.101	0.038*
Glossopharynx					
CSA (mm <sup>2</sup> ) @ Et	56.2 ± 139.4	0.072	-2.4 ± 85.8	0.906	0.120
MSA (mm <sup>2</sup> )	37.4 ± 80.8	0.042*	10.0 ± 52.0	0.413	0.212
Volume (mm <sup>3</sup> )	1394.4 ± 2866.2	0.033*	18.4 ± 1914.7	0.967	0.083
Hypopharynx					
CSA (mm <sup>2</sup> ) @ Eb	34.9 ± 82.8	0.061	-6.3 ± 69.2	0.694	0.094
MSA (mm <sup>2</sup> )	30.9 ± 64.7	0.036*	7.6 ± 47.2	0.490	0.202
Volume (mm <sup>3</sup> )	856.9 ± 1867.2	0.043*	329.1 ± 1305.2	0.286	0.308
Total					
MSA(mm <sup>2</sup> )	159.7 ± 213.8	0.002*	83.4 ± 115.8	0.006*	0.173
Minimum CSA (mm <sup>2</sup> )	61.8 ± 100.9	0.009*	25.8 ± 75.6	0.155	0.209
Volume (mm <sup>3</sup> )	6083.6 ± 8266.3	0.002*	2577.5 ± 4159.5	0.015*	0.102

\*Indicates significant differences between two groups (P<0.05).

Conclusions: Maxillary protraction following different expansion protocols seem to have similar effects on the forward movement of the maxilla and the volume of nasopharyngeal and total upper airway.

Response to the following questions:

1. Were the original, specific aims of the proposal realized?

Yes, the original specific aims were to evaluate the changes in the upper airway after maxillary protraction with Alt-RMEC and compare with that with traditional RME in skeletal Class III malocclusions as a result of maxillary deficiency. The conclusion of the project was maxillary protraction following different expansion protocols showed similar effects on the forward movement of the maxilla and the volume of nasopharyngeal and total upper airway.

2. Were the results published?

- a. If so, cite reference/s for publication/s including titles, dates, author or co-authors, journal, issue and page numbers
- b. Was AAOF support acknowledged?
- c. If not, are there plans to publish? If not, why not?

The results have not been published, but I have been working on a manuscript to have

the results published in the orthodontic journal. AAOF support will be acknowledged.

3. Have the results of this proposal been presented?
  - a. If so, list titles, author or co-authors of these presentation/s, year and locations
  - b. Was AAOF support acknowledged?
  - c. If not, are there plans to do so? If not, why not?

The results have not been presented, but I'm aiming to have the results presented at the annual Angle Society Meeting Northwest Component Scientific Poster-board Session 2022 Feb 9-11. AAOF support will be acknowledged.

4. To what extent have you used, or how do you intend to use, AAOF funding to further your career?

Funding from the AAOF OFDFA has enabled me to pursue my academic career. As a junior faculty member looking to make a career in academics, this award has relieved my educational debt is in line with the mission of the AAOF. This financial assistance in the form of an Orthodontic Faculty Development Fellowship Award has been helping me to further develop my role as a teacher and researcher at this early stage of my career.