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Evaluation of Pharyngeal Airway Volume in Cleft Palate Patients Treated With Differential Opening Expander With Alternate Rapid Maxillary Expansion and Constriction Protocol and Facemask

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Abstract

Purpose: Patients with cleft palate undergoing alternate rapid maxillary expansion and constriction (Alt-RAMEC) using an expander with differential opening (EDO) and protractor facemask had their pharyngeal airway (PA) volumes measured using cone beam computed tomography. **Patients and methods:** To measure the PA volume before and 6 months after treatment using cone beam computed tomography, a sample of eight cleft lip and palate patients aged 8–12 years underwent EDO and facemask protraction. Patients were included if they were growing, had mixed dentition, and had their maxillary first permanent molar erupt. Lip repair and palatal closure were performed previously. There was no history of orthopedic or orthodontic treatment, and both the parent and the patient were extremely cooperative. MIMICS medical (Materialise, Leuven, Belgium) was used for three-dimensional airway analysis. A paired-sample *t*-test was used to determine the significance of the changes in airway volume. **Results:** Following Alt-RAMEC and a protraction facemask, there were no appreciable changes in the PA volumes (*P* value > 0.05). Before treatment, the oropharyngeal airway volume was 9840.50 mm³, and after treatment, it was 10,698.25 mm³. The nasopharyngeal airway volume was 4132.83 mm³, and after treatment, it was 4557.13 mm³. **Conclusion:** The findings revealed that the effect of facemask protraction and maxillary Alt-RAMEC expansion with EDO on pharyngeal volumes was insignificant.

Keywords: Airway, Cleft, Expansion, Facemask, Pharyngeal

1. Introduction

Cleft palate, with or without cleft lip, is the most common congenital anomaly in the craniofacial region. Crossbites and maxillary retrusion are frequent in patients with cleft lip and palate (CLP) after the cleft is closed. In addition to functional challenges, patients with CLP who have midface retrusion frequently struggle with psychological, social, and emotional issues. Before secondary alveolar bone grafting, these individuals' developing malocclusion is frequently treated by maxillary extension and protraction [1].

Hass, Hyrax, Quid Helix, or Fan type expanders can be used for maxillary expansion in CLP patients,

but a more recent appliance expander with differential opening (EDO), which has two parallel-opening screws, is more advantageous because it enables varying degrees of expansion in the anterior and posterior regions of the maxillary dental arch [2]. One of the expansion protocols that differ from traditional rapid and slow procedures was developed by Liou and is called alternate rapid maxillary expansion and constriction (Alt-RAMEC) to disarticulate circummaxillary sutures without overly expanding the maxillary arch [3]. The main difference was that the Alt-RAMEC procedure involved repeated expansion and constriction over 7 weeks, with 1 week of expansion and 1 week of constriction, such as tooth extraction [4].

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In addition to effectively treating mild to moderate anterior crossbite, maxillary protraction with Alt-RAMEC improves the soft tissue profile and sagittal jaw relationship because it permits more protraction with more forward movement of the maxilla [5].

The pharyngeal airway (PA) volume in cleft patients was similarly affected by midface retrusion and deficit. Studies have shown that people with CLP had smaller oropharyngeal heights and airway volumes than people without cleft [6]. Many CLP patients continue to have nasal abnormalities and airway difficulties even after having their cleft malformations surgically repaired. Septal deviation, nostril atresia, turbinate hypertrophy, vomerine spurs, and alar constriction are examples of nasal anomalies. Airway complications lead to airway insufficiency, wheezing, obstructive breathing while asleep, and poor-quality sleep.

Furthermore, people with CLP are more likely to have high blood pressure, cardiac and neurological problems, and excessive daytime drowsiness. As a result, after expansion and protraction, measuring PA capacity in CLP patients is critical [7].

It is now possible to obtain three-dimensional (3D) pictures for reliable measurement of airway volume using cone beam computed tomography (CBCT) and imaging software.

The bulk of the literature's published studies focused on how rapid maxillary expansion and facemask (FM) therapy altered the size of the PA. PA volumes appeared to have changed significantly in some investigations [8], but not in others [9].

The effects of the facemask and Alt-RAMEC procedures on PA alterations in cleft patients have also received little attention from published studies. Only one clinical prospective study on patients with clefts using CBCT and finite element modeling reported the effects of Alt-RAMEC and a facemask on the PA capacity, which had been significantly changed [10].

Two published trials for noncleft patients that evaluated the effect of Alt-RAMEC therapy with a protraction facemask on pharyngeal airway volume, one using 2-D radiography and the other using a 3D CBCT radiograph, and both revealed a significant increase [11,12].

The purpose of this study was to determine how facemask protraction and maxillary expansion by expander with differential opening using the Alt-RAMEC protocol affected the PA in patients with CLP using 3D CBCT because there has not been much research on airway volume in CLP patients using CBCT imaging.

2. Patients and methods

The Research Ethical Committee at Al-Azhar University's Faculty of Dental Medicine for Girls REC-OR-23-01 gave ethical approval for this study, which involved 8 CLP patients (8–12 years old) recruited from the Centre for CLP Treatment at Al-Azhar University and Sayed Galal Hospital in Cairo, Egypt.

The purpose of the research was discussed with the patients and their parents before starting treatment, followed by their parents signing a written informed consent form.

The following criteria were met by all patients: Growing patients with mixed dentition had their maxillary first permanent molar erupt. Lip repair and palatal closure were performed previously. There is no history of orthopedic or orthodontic treatment, and both the parent and the patient are extremely cooperative.

All patients underwent maxillary expansion using an expander with differential opening EDO (Great Lakes Orthodontics, Tonawanda, New York) using the Alt-RAMEC procedure and a protraction petit facemask. To activate or deactivate the two expander screws, the patient's parents were directed to turn them two-quarter turns in the morning and two-quarter turns in the evening daily for 7 weeks, 1 week of activation and 1 week of deactivation (Fig. 1).

After 7 weeks, the patients were told to keep the expander in their mouths for 6 months while wearing the facemask. Extra oral elastics from the ORMCO Z-pak elastics (3/8"), 14 Oz, 350 g each side were utilized at an angle of 20–30° downward from the occlusal plane. Patients were told to wear the facemask for 14–16 h (Fig. 2).

After 6 months, the expander was removed, and posttreatment records were taken. Pre- and post-treatment CBCT examinations were obtained with a Planmeca machine (Planmeca ProMax 3D Plus, Finland, USA), and the technical parameters for image acquisition were 90 kV, 12 mA, an image size

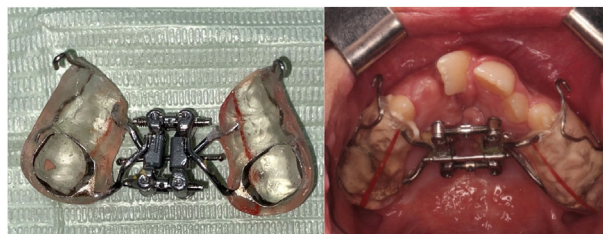


Fig. 1. Inside and outside the oral cavity photograph showing expander with differential opening.

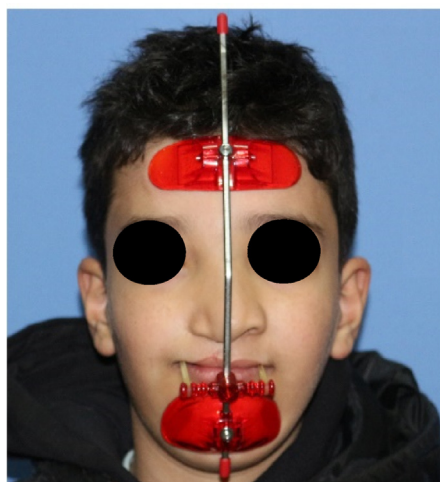


Fig. 2. Extra oral photograph showing petit facemask.

of 20 × 20 cm, and a voxel size of 200 μm for each patient. The Digital Imaging and Communications in Medicine (DICOM) data resulting from each CBCT scan were exported and analyzed by specialized software MIMICS medical (Materialise, Leuven, Belgium) for 3D airway analysis.

The Frankfort horizontal plane, which passed through the porion and orbitale, was used as the software's horizontal reference plane to reposition the skull. The midorbital point and nasion were perpendicularly connected to form the sagittal reference plane. The axial plane was constructed from nasion and is perpendicular to the horizontal and sagittal planes.

The anterior boundary of the PA is a vertical plane that passes through the posterior nasal spine and is parallel to the sagittal plane. The inferior border was a plane tangent to the most caudal medial projection of the third cervical vertebra, perpendicular to the

sagittal plane, and the posterior border was the posterior wall of the pharynx. The PA was separated into upper and lower compartments by a plane perpendicular to the sagittal plane that passed through the posterior nasal spine and the lower medial border of the first cervical vertebra [13,14] (Fig. 3).

3. Result

Version 23.0 of SPSS Inc., Chicago, Illinois, USA, was used to analyze the data. A paired sample *t*-test was used to determine the significance of the changes in airway volume.

The age range of the patients who received treatment was 10.07–1.16 years. 37.5% of the population was female and 62.5% were male (Table 1). No significant changes were seen in any of the PA volumes following Alt-RAMEC and protraction facemask (*P* value > 0.05) at a 95% confidence level. However, an increase in oropharyngeal airway volume after treatment was observed ($9840.50 \pm 3202.92/10,698.25 \pm 3250.11 \text{ mm}^3$) with a mean difference of 0.857 and an increase in nasopharyngeal airway volume ($9840.50 \pm 3202.92/10,698.25 \pm 3250.11 \text{ mm}^3$) with a mean difference of 0.424. *P* value greater than 0.05 (Table 2, Fig. 4).

Table 1. Distribution of baseline characteristics within the study group.

Baseline characteristics	Total (n = 8)
Sex, n (%)	
Female	3 (37.5)
Male	5 (62.5)
Age (years)	
Range	8–12
[Mean ± SD]	10.07 ± 1.16

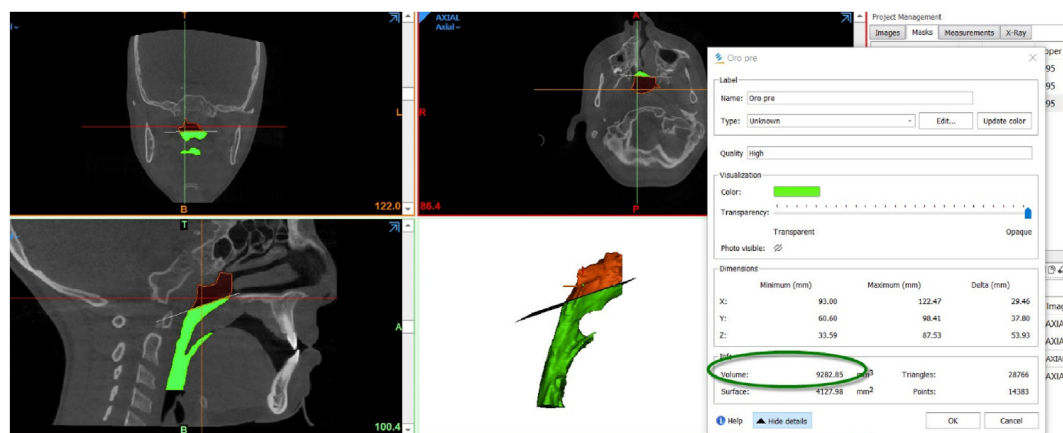


Fig. 3. Screenshots from the medical programme MIMICS display the segmentation and airway volume measurement. Volumes of the oropharyngeal and nasal airways are shown in green and orange, respectively.

Table 2. Volumes of the pharyngeal airways before and after treatment are compared.

	Pre-treatment	Post-treatment	Paired sample <i>t</i> -test		
			MD±SE	<i>t</i> -test	<i>P</i> value
Oro pharyngeal volume (mm ³)	9840.50 ± 3202.92	10,698.25 ± 3250.11	−857.8 ± 1342.8	−0.639	0.543
Naso pharyngeal volume (mm ³)	4132.83 ± 1595.89	4557.13 ± 1806.28	−424.4 ± 512.2	−0.828	0.435
Total pharyngeal volume (mm ³)	13,973.25 ± 4219.19	15,255.38 ± 3855.34	−12.823 ± 1715.08	−0.748	0.479

P value greater than 0.05 was considered insignificant.

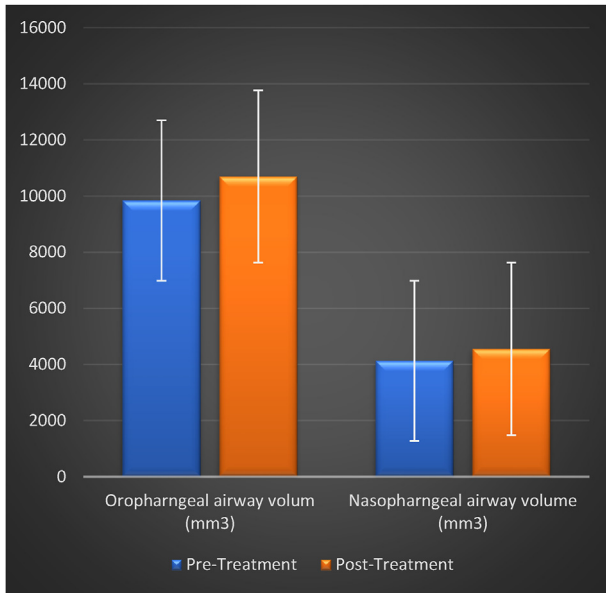


Fig. 4. A clustered column chart comparing pharyngeal airway volume before and after treatment.

4. Discussion

The study aimed to investigate the effects of facemask protraction and Alt-RAMEC expansion on the PA volume in CLP patients. In the present study, no control group was included since delaying therapy for patients with CLP is unethical.

The literature contains few studies that discuss the impact of FM therapy and the Alt-RAMEC protocol on PA volume alterations. For noncleft patients, there was a study that used cephalometric 2-D radiographs to evaluate the impact of Alt-RAMEC in combination with FM therapy on PA volume and used a full coverage hyrax expander. Their findings showed a statistically significant increase in upper PA dimensions ($P < 0.001$), but not in lower pharyngeal dimensions ($P > 0.05$) [11].

After undergoing both rapid maxillary expansion (RME) and (Alt-RAMEC) followed by FM therapy, another study employed CBCT to assess and compare changes in the PA. No significant changes were detected in any of the PA volumes in the RME/FM group. The Alt-RAMEC/FM group experienced a considerable rise in lower and total PA volumes

(1011.19 and 1601.21 mm³, respectively), while there was no significant increase in upper PA volume [12].

The use of Alt-RAMEC and a facemask on patients with cleft palates has only been studied once in a clinical prospective trial, as far as the authors know. With a specially constructed fan-shaped expansion screw, they used CBCT to measure the dimensions of the pharyngeal airway. Following a 6-month facemask, there was a 9-week period of daily expansion and constriction of 1 mm per day. When pharyngeal volume changed, there was a significant difference ($P > 0.05$), with a mean difference of 1.57 [10].

In this investigation, a different expander and Alt-RAMEC protocol were applied. With the Alt-RAMEC technique, 7 weeks of expansion and constriction were performed. To accomplish varying degrees of expansion in the anterior and posterior parts of the dental arch, an expander with the differential opening was employed, followed by 6 months of protraction.

This study demonstrated a nonsignificant increase in oropharyngeal airway volume (9840.5–10,698.25 mm³) with a mean difference of 0.857 and a nonsignificant increase in nasopharyngeal airway volume (4132.83–4557.13 mm³) with a mean difference of 0.424. *P* value greater than 0.05.

This study's heterogeneous sample group, which included both unilateral and bilateral CLP as well as cleft palate alone, as well as potential variations in expander design, maybe the reason why the results of the present study differed from the other study [10].

The anatomy of the patient's pharynx, as well as the varied techniques and borders the author chooses to measure the airway volume, are some of the key differences between the findings of research on PA volume following protraction and expansion in CLP patients.

4.1. Conclusion

PA volumes are slightly increased by the Alt-RAMEC expansion technique and facemask, which is regarded to be insignificant.

4.2. Recommendation

Further studies using different expander devices and protocols are recommended to improve PA

volume in cleft patients. Increase sample size and use a homogeneous sample group for unilateral or bilateral cleft.

Ethics information

The Research Ethical Committee at Al-Azhar University's Faculty of Dental Medicine for Girls REC-OR-23-01 gave ethical approval for this study.

Funding

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Conflict of interest

There are no conflicts of interest.

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