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THREE-DIMENSIONAL ASSESSMENT OF SHORT-TERM EFFECTS OF BONE-ANCHORED MAXILLARY PROTRACTION ON THE OROPHARYNGEAL AIRWAY VOLUME IN PATIENTS WITH UNILATERAL CLEFT LIP AND PALATE

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ABSTRACT

Objective: To assess three-dimensionally (3D) the short-term effects of Bone-anchored maxillary protraction (BAMP) with and without maxillary expansion on the oropharyngeal airway volume in patients with surgically repaired complete unilateral cleft lip and palate (UCLP).

Material and methods: Twenty growing Class III maxillary deficient patients (mean age 10.8±1.2) with complete UCLP were treated with BAMP protocol. The cone-beam computed tomography scans that were taken before start of treatment and after 9-months of treatment were retrieved from the archive of the Orthodontic Department, Ain Shams University. Patients were divided into two groups: Group I were treated with BAMP alone. Group II were treated with BAMP preceded by maxillary expansion. The oropharyngeal airway volume was measured before treatment and after 9 months. Statistical analysis was carried to find the difference between the two groups.

Results: The results showed no significant change in the oropharyngeal airway volume in Group I treated with BAMP alone. On the other hand, a significant increase in the oropharyngeal airway volume was observed in group II in which BAMP was preceded by maxillary expansion.

Conclusion: BAMP protocol alone was not able to produce significant change in the oropharyngeal airway volume in patients with complete UCLP. However, when it was preceded by maxillary expansion, a significant increase in the oropharyngeal airway volume was observed.

KEY WORDS: Maxillary deficiency; BAMP; oropharyngeal airway volume; cleft lip and palate.

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INTRODUCTION

Patients with cleft lip and palate (CLP) suffer from multiple and complex problems including early feeding and nutritional concerns, hearing deficiency, deviations in speech and resonance, dentofacial abnormalities, and psychological problems. These problems require different specialties to work in collaboration to achieve optimum treatment outcomes for the welfare of those debilitated patients.[1]

The presence of nasal deformities such as nasal septal deviation, nasal atresia, enlarged turbinates, and alar constriction are common findings in cleft patients.[2-4] These nasal deformities tend to decrease the size of the nasal airway and reduce the airway function. This can result in obligatory mouth breathing, which can further affect the development of the facial and dental structures. It was found that 68% of patients with CLP are mouth breathers.[3] Moreover, high incidence of snoring, and sleep apnea have been reported in children with CLP.[5]

Combination of maxillary constriction and maxillary deficiency is characteristic for patients with unilateral cleft lip and palate (UCLP) due to the stretching resulting from scarring produced by early surgical lip and palatal closure. Their treatment usually requires a combination of maxillary expansion and protraction.[6]

Maxillary expansion using different expanders has been well known to solve the problem of transverse maxillary deficiency. This could be done by removable expanders used in early stages or later by fixed ones like the hyrax and the fan-shaped expanders. Maxillary expansion was reported to increase the upper airway volume in cleft patients with no difference reported between different types of expanders.[7]

On the other hand, several modalities have been used to correct the antero-posterior (AP) maxillary deficiency, including facemask, reverse pull headgear, tandem appliance and recently bone-anchored maxillary protraction (BAMP).

Bone-anchored maxillary protraction (BAMP) is a recent modality that have been introduced solving the problem of patient cooperation that represents a big problem in cleft patients.[8,9] It has the ability to produce pure skeletal effects without any dentoalveolar compensations, by only being committed to the full-time wear of intra-oral elastics. It proved to be an effective treatment modality to correct midface deficiency in patients with UCLP whether maxillary expansion was carried or not.[10] This is because it acts directly at the level of bone, so the concept of the need to disarticulate the circummaxillary sutures needed before the use of the facemask is not mandatory with this smart protocol.

Controversial reports about the effect of maxillary protraction on the pharyngeal airway have been reported.[11-15] Most of these studies were 2D studies that used conventional cephalograms. Few recent studies used the computed tomography (CT) for 3D volumetric assessment of the pharyngeal air way after orthopedic facemask treatment which did not find any significant effect.[16,17]

However, no previous studies investigated the effect of BAMP protocol; as a recent treatment modality for maxillary protraction, on the pharyngeal airway volume of cleft patients, which is an important issue to investigate, due to its relevance to speech and respiration which are greatly affected in those patients.

Hence, the aim of this study was to assess three-dimensionally using cone-beam computed tomography (CBCT) the effect of BAMP with and without maxillary expansion on the oropharyngeal airway volume in a sample of patients with surgically repaired complete UCLP.

MATERIAL AND METHODS

The pretreatment and posttreatment CBCT scans of 20 growing patients (11 boys and 9 girls) with surgically repaired complete UCLP treated with BAMP protocol were retrieved from the archive of the Orthodontic Department-Faculty of Dentistry, Ain Shams University. The age of the selected patients ranged from 9 to 13 years with mean age= 10.8, SD=1.2. Patients were selected according to the following inclusion criteria:

Non-syndromic surgically repaired complete unilateral cleft of the lip, alveolar process and secondary palate; skeletal Class III mainly due to maxillary deficiency (SNA< 78˚); pre-pubertal stage of skeletal maturity according to cervical vertebral maturation (CVM) method (CS1-CS3)[18]; mixed dentition with erupted lower permanent lateral incisors or full permanent dentition stages; negative overjet or edge-to-edge incisor relationship; posterior crossbite whether unilateral or bilateral, no previous orthopedic or orthodontic treatment, and medically free except for the CLP deformity. None of the patients had previous history of tonsillectomy or adenoidectomy.

Patients were divided into 2 groups according to the amount of maxillary constriction: Group I were treated with BAMP protocol alone. Group II were treated with BAMP protocol preceded by maxillary expansion.

For patients in group I, the mean age was 10.3±0.9 years. The classic BAMP protocol was applied which involves surgical placement of 4 miniplates; 2 in the zygomatic buttress of the maxilla and 2 between the lower lateral incisor and canine, one on each side. After 3 weeks, orthopedic protraction was started by the application of intermaxillary Class III elastics attached to the hooks of the miniplates between both arches. The force level was set at 100g per side, increased to 200 g per side after 1 month then to 250 gm/side after 2 months.[8,9,19,20]

For group II the mean age was 11.3±1.4 years. Before the surgical placement of the miniplates, a fan-shaped maxillary expander (Rango screw-Leone Ortodonzia, Firenze, Italy) was prepared for every patient and delivered 2 weeks after surgical placement of the miniplates. Activation of the expander started by rapid maxillary expansion (RME) twice per day for 7 days after which the orthopedic protraction was started by the application of intermaxillary elastics the same way as group I. Expansion was continued by slow expansion 1 turn 3 times weekly together with protraction until the desired increase in the transverse dimension was achieved.

Patients were instructed to wear the elastics 24 hours per day and to maintain good level of oral hygiene to maintain the stability of the miniplates.

In both groups a lower removable posterior bite-plane was delivered for every patient 2-3 months after orthopedic protraction to avoid incisors interference (Fig.1).

Fig. (1) Maxillary protraction using Class III intermaxillary elastics attached to miniplates hooks, together with a lower removable posterior bite-plane.

For patients in Group I, if posterior crossbite was still present after correction of the AP discrepancy, expansion of the maxillary arch was considered.

The CBCT scans were taken for each patient 1 week after surgical placement of the miniplates (T1) and after 9 months of orthopedic protraction (T2) to evaluate treatment changes. For patients in Group II, the fan expander was removed before the final CBCT scan was taken.

All CBCT scans were acquired using ***i-CAT***® Next Generation (Imaging Sciences International, Hatfield, PA). Patients were seated in erect posture with upright head position, which was adjusted through the laser beams of the machine. They were guided to close in centric occlusion with their lips in relaxed posture, keeping their tongues resting on the palate, and avoiding swallowing and breathing during the scan. The exposure parameters were set at 5mA, 120 KVp, 0.3 mm voxel size, with a single 360° rotation and a total scan time of 8.9 sec.

The DICOM (Digital Imaging and Communications in Medicine) files were imported into ***InVivo 5*** version 5.2 software for volumetric analysis.

The MPR (Multiplanar reformatted images) screen was used to align the midsagittal plane through the middle of the nasal cavity dividing the axial cut into two equal halves. On the 3D volume rendered screen, volumetric assessment was performed using the air-way assessment tool by selecting consecutive points starting from the posterior nasal spine to the epiglottis and ending with a double click point to display the volume of the oropharyngeal airway (Fig.2).

Volumetric measurements were executed for both Group I and Group II and the values were tabulated in an excel sheet for statistical analysis.

To assess the reliability, all measurements were repeated by the same investigator twice within 1 month interval. Cronbach's alpha reliability coefficient results showed very good intra-observer agreement with Cronbach's alpha value not less than 0.800 for all the variables.

Statistical analysis

All Data were collected, tabulated and subjected to statistical analysis. Statistical analysis was performed by SPSS (version 20.0, IBM; Armonk, NY). Microsoft office Excel was used for data handling and graphical presentation. Quantitative variables were described by the Mean and Standard Deviation (SD). Shapiro-Wilk test of normality was used to test normality hypothesis of all quantitative variables for further choice of appropriate parametric and non-parametric tests. All the variables were found normally distributed allowing the use of parametric tests. Paired t-test was used for comparing T1 and T2 measurements within each group**.** Independent samples t-test was used for comparing the difference between the 2 groups. Significance level was set at $P < 0.05$.

RESULTS

Treatment changes after 9 months of applying the BAMP protocol for both groups were shown in Figure 3. The results shown in Table 1 and 2 showed an insignificant increase in the oropharyngeal airway volume in group I by a value of 0.08 cc. There was a significant increase in the volume of the oropharyngeal airway in group II by 2.73 cc. Independent samples t-test showed a significant difference between the 2 groups ($P < 0.05$).

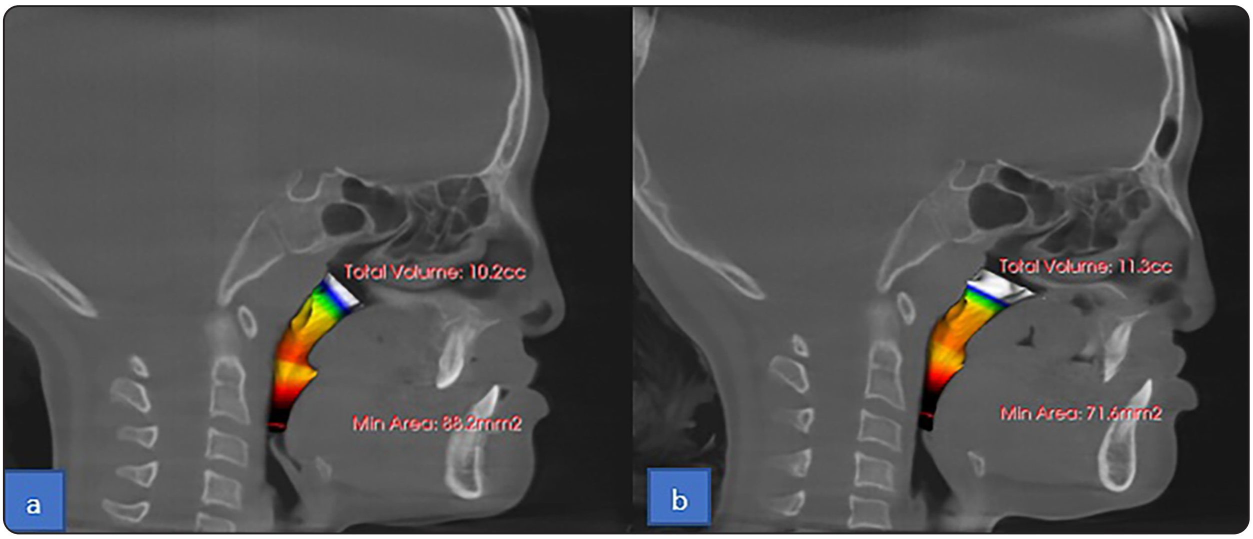

Fig. (2) Volumetric measurement of the pharyngeal airway in Group II; (a) before BAMP, (b) after BAMP

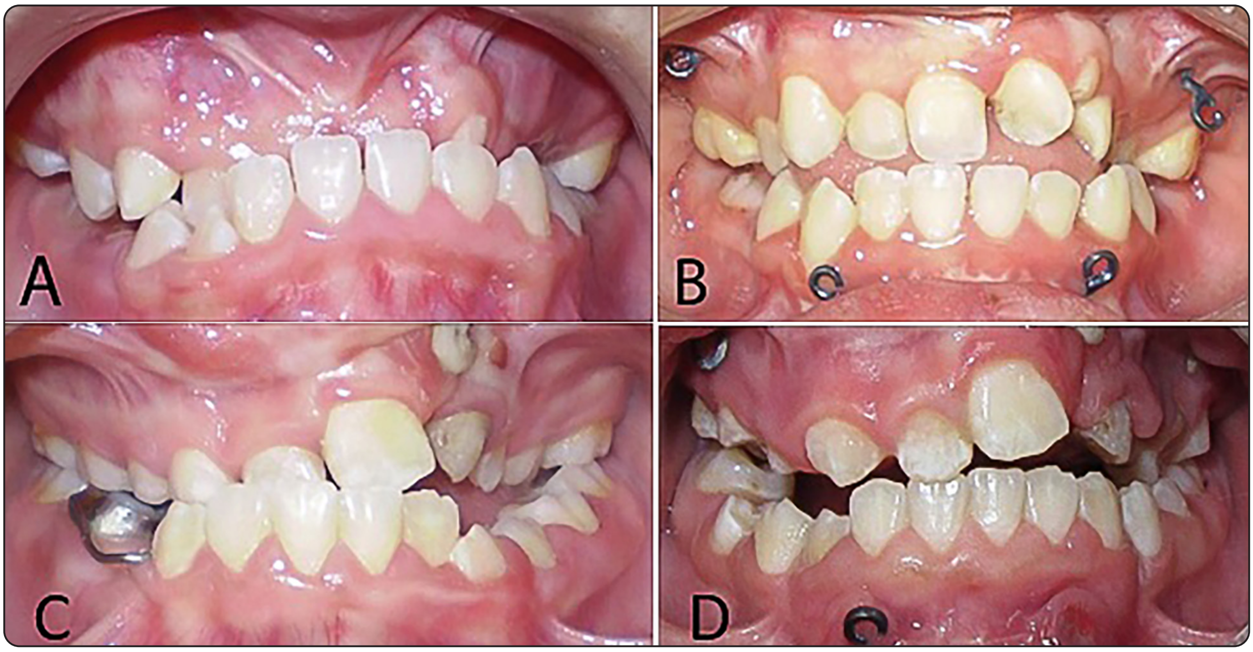

Fig. (3) Intra-oral views for patients treated with BAMP protocol: (A) Before and (B) after BAMP not preceded by maxillary expansion (Group I) (C) Before and (D) after BAMP preceded by maxillary expansion (Group II)

DISCUSSION

Treatment of patients with CLP represents a great challenge for the medical team concerned with their treatment, due to the diversity and complexity of the numerous problems they present that are inter-related in many cases. The psychological status of the patient and his parents is another major concern that affects the degree of commitment to treatment and cooperation, hence, the selection of the appropriate treatment strategy for every single problem.

The degree of facial deformity that patients with CLP suffer from depends on a number of factors including the severity of the existing defect, the surgical technique, the number of surgeries, and the surgical timing. These factors affect the degree of the resulting 3D maxillary collapse. Maxillary protraction is an integral part of treatment of cleft patients. It helps to move the maxilla forward which spontaneously eliminates mild posterior crossbite improving the transverse jaw relationship as well.[21] However, in the majority of cleft cases, most of the patients will still need maxillary expansion because of the early surgical palatal closure that affects the transverse dimension to a great extent. Therefore, for patients in group I, maxillary expansion was started for those who needed after taking the records of the 9-months investigation period.

A fan shaped expander was selected for this study because it produces a pattern of expansion that fits the pattern of maxillary constriction found in patients with UCLP. It has been reported that those patients experience more constriction in the anterior premolar region than in the posterior molar region, where in the majority of patients, the first permanent molars were found to erupt in a good buccolingual relationship.[22]

Maxillary expansion does not only correct the posterior crossbite, which improves the skeletal and dental transverse relationships, but it was reported also to increase the pharyngeal airway volume which improves the respiratory capacity improving both breathing and speech.[7,23,24]

BAMP was first introduced by Hugo de Clerck as an alternative for facemask therapy for the correction of maxillary deficiency.[8,9] Recent studies investigated its effects in patients with CLP and it proved to be an effective treatment modality.[10,25,26]Although most of patients with CLP need maxillary expansion for the correction of the transverse maxillary collapse, however, a recent study concluded that BAMP protocol was able to protract the maxilla and the whole midface even when it was not preceded by maxillary expansion, which facilitates the protraction process in the traditional facemask treatment.[10] However, the effect of BAMP on the airway has not been investigated before, hence the aim of this study. The results were compared to the available data about the effect of facemask therapy; the gold standard for maxillary protraction, on the pharyngeal airway.

The results of this study did not show any significant increase in the oropharyngeal airway volume after treatment with BAMP alone. On the other hand, there was a great controversy in the results of previous studies investigating the effect of facemask therapy on the airway volume. Most of these studies were 2D studies based on lateral cephalograms. Lee et al [11], Sayinsu et al[12], and Kaygisiz et al[13] found out a significant improvement in the airway dimensions after maxillary protraction. These studies did not include a control group and assumed that there was no increase in the airway volume due to normal growth. However, Mucedero et al reported that although the facemask therapy produced favorable skeletal maxillary and mandibular changes with or without maxillary expansion, it was not associated with any significant changes in the sagittal oropharyngeal and nasopharyngeal dimensions.[14] Similarly, Baccetti et al investigated the effect of facemask combined with bite block therapy and did not find any significant changes in the oropharyngeal and nasopharyngeal sagittal airway dimensions when compared with untreated class III subjects.[15]

Few studies investigated the effect of facemask therapy on the airway changes in 3D. Pamporakis et al using CBCT scans reported an insignificant increase in the upper and lower airway. Oppositely, it decreased the normal expected increase of the pharyngeal airway volume when compared with the results of normal individuals of the control group.[16] Husson et al used CT images in their volumetric assessment of the airway and concluded that facemask therapy without expansion had no additional effects on the oropharyngeal airway other than those induced by normal growth.[17]

Hence, from the results of this study combined with the results of previous studies we can conclude that the procedure of maxillary protraction, whether carried by using the traditional facemask or the more recent BAMP protocol, alone, does not affect the oropharyngeal airway volume. On the other hand, whenever maxillary expansion was carried, an increase in the oropharyngeal airway volume was noticed. Therefore, the study recommends associating the BAMP protocol with maxillary expansion whenever possible, not for the aim to disarticulate the sutures and facilitate the protraction process, but to help to increase the airway volume which can reduce the respiratory difficulty facing patients with complete UCLP.

Limitations

This study has a number of limitations that should be considered, including the small sample size and absence of a control group. Presence of a control group was important to exclude that the changes that happened might be due to normal growth and development of these growing patients. However, the control group was not considered due to ethical issues: it would have been deprived the patients from being treated in this critical timing needed to correct the numerous skeletal problems they are suffering from.

CONCLUSION

BAMP protocol alone was not able to produce a significant increase in the oropharyngeal airway volume in patients with complete UCLP. However, when it was accompanied by maxillary expansion significant increase in the oropharyngeal airway volume was noticed.

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