Al-Azhar Journal of Dentistry

Manuscript 1594

Pediatric dentistry and orthodontics Issue (Pediatric Dentistry, Orthodontics)

Evaluation of the Skeletal and Dental Maxillary Expansion of Cleft Lip and Palate Patients Using Differential Opening Expander with Rapid Protocol and Maxillary Protraction

Taghreed R. Alazzawi

Samir A. Ibrahim

Hatem H. Alahmady

Mohsena A. Abdarrazik

ORIGINAL STUDY

Evaluation of the Skeletal and Dental Maxillary Expansion of Cleft Lip and Palate Patients Using Differential Opening Expander With Rapid Protocol and Maxillary Protraction

Taghreed R. Alazzawi [a,*], Samir A. Ibrahim [b], Hatem H. Alahmady [c], Mohsena A. Abdarrazik [b]

[a] Graduate of Faculty of Dentistry, Aleppo University, Aleppo, Syria
[b] Department of Orthodontic, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt
[c] Department of Oral and Maxillofacial Surgery, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt

Abstract

Purpose: This study aimed to describe the maxillary skeletal and dental changes in growing cleft lip and palate (CLP) patients treated with rapid maxillary expansion (RME) using an expander with differential opening (EDO) and maxillary protraction. **Patients and methods:** Eight CLP patients, aged from 8 to 12 years old, with maxillary hypoplasia were treated by maxillary expansion using EDO activated according to the RME protocol, followed by 6 months of maxillary protraction. Pre-treatment (T1) and post-treatment (T2) cone-beam computed tomography were taken, and superimposition was done to evaluate the treatment outcomes. **Results:** There was a statistically significant increase in maxillary width and nasal cavity width in both the canine and molar regions, with a greater increase in canine region. There was a statistically significant increase in alveolar crest width and dental arch width in the molar region. The increases in anterior and posterior alveolar width were statistically significant, with more expansion achieved in the canine region. **Conclusion:** Using EDO in the RME protocol improves the maxillary constriction in growing CLP patients. This protocol increases the width of the maxilla, nasal cavity, alveolar crest, anterior and posterior alveolar bone, and dental arch. There was better control in achieving more expansion in the intercanine region than molar region which makes the EDO an adequate alternative to traditional dental arch expanders.

Keywords: Cleft palate, Differential opening expander, Maxillary expansion

1. Introduction

The most prevalent serial congenital defects that affect the orofacial region are cleft lip and palate (CLP). It may exist alone or in a variety of combinations with other congenital malformations, especially congenital cardiac disorders. Individuals with CLP frequently have anterior and/or posterior crossbites, a flattened cranial base, a deficient midface with a retruded maxilla, a lengthened jaw, and oral respiration. To attain both functional and aesthetic well-being, all those disorders need to be treated at the appropriate time and age. Coordinated care from a variety of specialties, including maxillofacial surgery, cosmetic surgery, phonic pathology, orthodontics, otolaryngology, genetic dysmorphology, prosthodontics, and others, is necessary for the successful management of a child born with a CLP [1–3].

Due to anatomical discontinuity and early surgical interventions made during lip and palate repair, most individuals with a complete unilateral or bilateral CLP show unfavorable growth of the craniofacial complex. Antero-posterior and transverse relationship anomalies are most frequently found, which leads to skeletal Class III malocclusion with a collapsed maxillary arch. However, the maxillary collapse is always more profound in the intercanine region than in the molar region [4].

Received 29 October 2022; accepted 26 January 2023.
Available online 19 July 2024

* Corresponding author. Al-Azhar University-Girls Branch, Faculty of Dental Medicine for Girls, Nasr City, Egypt.
E-mail address: taghreedalazzawi.p5821@azhar.edu.eg (T.R. Alazzawi).

https://doi.org/10.58675/2974-4164.1594

Before canine eruption, secondary alveolar bone grafting is indicated. Proper dentoalveolar preparations should be done first, those preparations include dentoalveolar expansion to improve the maxillary arch collapse and maxillary protraction to normalize the maxillary and mandibular arches relationship [5].

The orthopaedic treatment of choice for treating posterior crossbite and maxillary constriction in growing patients is rapid maxillary expansion (RME). Various appliances, including traditional expanders like the Haas, Hyrax, and fan-type expanders, as well as recent expanders like expander with differential opening (EDO), can be used to correct maxillary constriction [6].

Dalaire initially designed and popularized maxillary protraction using a Face Mask (FM) in 1972. Petit then updated it in 1982. In CLP growing patients, FM is frequently used to correct Class III malocclusion by anterior displacement of the maxilla and to restrict mandibular and condylar growth in an upward and forward orientation [7,8].

Images in two-dimensional (2D) radiographs frequently exhibit superimposition, magnification, and photo distortion. With the introduction of three-dimensional (3D) cone-beam computed tomography (CBCT), these problems have been solved [9]. In order to diagnose and treat patients with craniofacial defects, CBCT is a useful auxiliary tool. Moreover, CBCT is very helpful in planning for bone grafting, implants, and orthognathic surgery [10].

Therefore, this study was purposed to evaluate the skeletal maxillary expansion of CLP patients using EDO by rapid protocol. CBCT had been used to evaluate the treatment outcome by comparing the pre and post-treatment data.

2. Patients and methods

The sample was randomly selected for this study. According to sample size calculations with a power of 80% and alpha = 0.05, a total sample of 10 bilateral complete CLP patients aged from 8 to 12 years old with constricted maxillary arch was allocated from the Al-Azhar Cleft Lip and Palate Treatment Centre, Faculty of Dental Medicine for Girls, Al-Azhar University [11].

Ethical approval was obtained from the research ethics committee of the Faculty of Dental Medicine for Girls. The code number is REC-OR-22-01. Before trial commencement. Written informed consent was obtained from the participants' parents or legal guardians before intervention after an explanation of all procedures.

The included patients had complete CLP, no sex preference, and erupted permanent maxillary first molars. Patients had not received any surgically assisted RME, previous maxillary protraction, or fixed orthodontics. Uncooperative patients/parents were excluded [12].

Each case in the research sample was submitted for the following records pre-treatment (T1) and post-treatment (T2): Full orthodontic clinical examination and diagnostic sheet, upper and lower orthodontic impressions, intraoral and extraoral photographs, and full skull CBCT images.

A bonded expander with differential opening (Great Lakes Orthodontics, Tonawanda, NY) was used with 10 mm prefabricated screws. The two attached expansion screws were positioned transversely, one anteriorly at the level of the canine region and the other posteriorly at the level of the first molar region. The retentive arms of the screws were fixed in the acrylic connecting base with 0.9 mm^2 stainless steel reinforcing wire. A posterior bite plane was constructed with a 2 mm thickness to ensure the disarticulation of maxillary and mandibular dental arches. The acrylic splint was marked with red lines embedded on the right and left sides as a reference to mark the palatal cusp tips of maxillary posterior teeth to indicate the amount of overcorrection.

The position of the EDO screw was adjusted so that it is anteriorly as much as possible in the arch at the canine region and as close as possible to the depth of the palate to ensure the skeletal effect of the appliance and avoid patient discomfort during swallowing and speech.

The EDO appliance was cemented with glass ionomer cement (DEVONDENT GI cement, USA), mixed as per the instructions of the manufacturing company, and hand pressure applied on both sides of the maxillary arch until setting. In the first six days of activation, the anterior and posterior screws of the EDO were activated with an RME activation protocol of two quarter-turns in the morning and two quarter-turns in the evening. For an extra four days, only the anterior screw was activated, until achieving an overcorrection in the molar and canine regions (one quarter-turn of the expansion screw amounting to ~0.25 mm), resulting in 1 mm/day expansion [13].

In the same appliance, 2 vertical hooks were soldered buccally distal canine to act as the intraoral part of a Petit FM; the forehead pad and chin cap were adjusted to fit the patient's face, and patients were instructed to wear the facemask for a minimum of 18 h/day. The extra oral elastics (ORMCO Z-pak elastic) were used with a protraction force of 450 g per side on the maxilla, controlled by a force gauge (Morelli force gauge, Brazil), and replaced

once a day [14]. After over correction was achieved, the screw was consolidated with GI cement, and (EDO and FM) were maintained for a consolidation period of 6 months [11] (Fig. 1).

The bonded EDO appliance and facemask were removed following the consolidation period, and any remaining glass ionomer cement materials on the tooth were cleaned. An impression was then taken for the construction of a retention appliance, and finally, post-treatment records and a full skull CBCT (T2) were obtained.

The retention appliance was a transpalatal arch with custom made palatal circumferential wire and soldered hooks for the facemask in molar orthodontic bands. The retainer was cemented with glass ionomer. The patients were advised to use the facemask for retention at night only for one year.

A full skull CBCT was taken by a Planmeca Pro-Max digital machine for each patient prior to any expansion (T1) and 6 months after termination of treatment (T2). Superimposition according to cranial base was done for T1 and T2 with the 3D Slicer software, version 4.10.2 (www.slicer.org), and CBCT analysis was done to evaluate skeletal maxillary changes after expansion treatment (Fig. 2).

The following parameters were evaluated on the CBCT landmarks:

(1) Maxillary Width (MxW): The horizontal distance from the right outer border of the buccal cortical plate to left outer border of the buccal cortical plate at the level of the hard palate in the first molar area and the most anterior appliance-supporting teeth.
(2) Nasal Cavity Width (NCW): The horizontal distance between the most lateral points on the nasal cavity at the level of the intersection between the nasal cavity and the maxillary sinus floor in the first molar area and the most anterior appliance-supporting teeth.
(3) Alveolar Crest Width: the horizontal distance from the right palatal alveolar crest to the left palatal alveolar crest in the first molar area.
(4) Dental Arch Width (AW): The horizontal distance from the right palatal cusp tip of the maxillary first molar to the left palatal cusp tip of the maxillary first molar.
(5) Maxillary Alveolar Width Anterior: The horizontal distance from the center of the palatal root canal of right anterior appliance-supporting teeth to the center of the palatal root canal of left anterior appliance-supporting teeth.
(6) Maxillary Alveolar Width Posterior: the horizontal distance from the center of the palatal root canal of the right maxillary first molar at the level of root separation to the center of the palatal root canal of the left maxillary first molar.

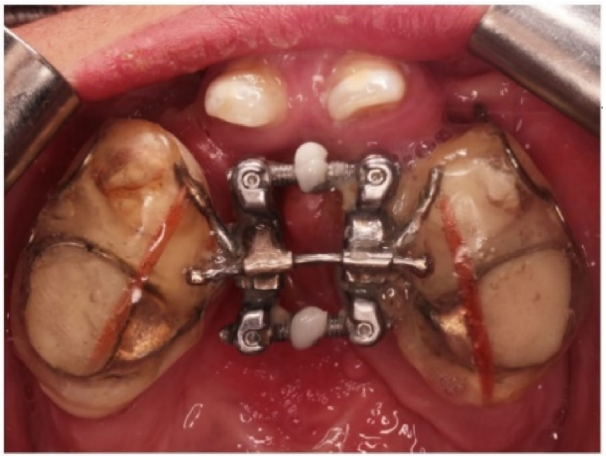

Fig. 1. Consolidation of expander with differential opening.

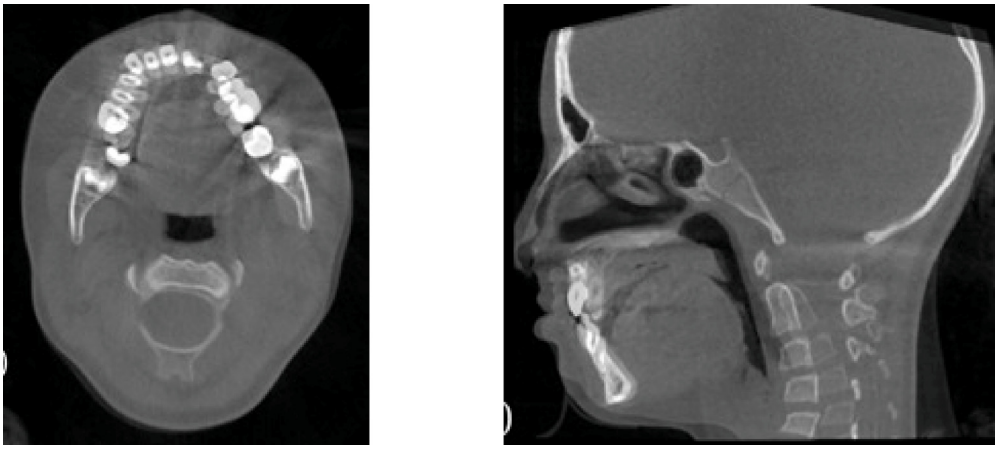

Fig. 2. Cone beam computed tomography superimposition.

2.1. Statistical analysis

For normally distributed data, an independent sample *T* test was used to compare the treatment effects (T1 and T2). The Shapiro–Wilk test was used to test the normality of the data, with a *P* value of 0.05 regarded as statistically significant (95% significance level). Statistical analysis was performed with IBM SPSS Statistics Version 20 for Windows.

3. Results

The results of this study were presented as descriptive statistics and comparisons of CBCT measurements before (T1) and after (T2) expansion comparing anterior maxillary changes to posterior maxillary changes.

There was a statistically significant increase in mean anterior maxillary width by 4.2 mm and mean posterior maxillary width by 3.2 mm post-treatment. There was statistically significant increase in mean anterior nasal cavity width by 3 mm and mean posterior nasal cavity width by 2.3 mm post-treatment. There was statistically significant increase in ACW by 4.1 mm and dental AW by 5.6 mm in the molar region. The increase in anterior and posterior alveolar width was statistically significant by a mean value of 4 mm and 3.8 mm, respectively.

There was a statistically significant increase in all transverse skeletal measurements after RME with EDO. However, the changes were more significant in the anterior (intercanine) region than the posterior (intermolar) region. Table 1.

4. Discussion

Patients with surgically repaired CLP frequently have maxillofacial growth abnormalities with skeletal Class III malocclusion, which exposes those patients to psychological, social, and functional challenges [15].

Patients with CLP may have a maxillary deficit, which is typically accompanied by scars from doing palate repair during infancy [16]. A triangular-shaped dental arch is the result of transverse maxillary constriction. In contrast to the intermolar distance, the intercanine distance decreases more noticeably with growth, which subsequently indicates more anterior than posterior expansion [12].

With a parallel-opening screw positioned in the center of the palate, traditional RME expanders (Hyrax and Hass) widen the maxilla and the arch perimeter. The side effect of overexpansion of the molar region, in conjunction with the correction of the intercanine width, is decreasing the thickness of

Table 1. Descriptive and comparative statistics of cone beam computed tomography skeletal measurements before pre-treatment and after post-treatment expansion using paired T-test.

Variables	Descriptive statistics				Paired Differences (T2–T1)				*T*-value	Significance (2-tailed)
	T1		T2		Mean	S.D.	95% Confidence Interval of the Difference			
	Mean	S.D.	Mean	S.D.			Lower	Upper		
Anterior Maxillary Width (AMxW)	38.4788	5.37733	42.7050	6.02329	4.2262	2.9940	1.72318	6.72932	3.992	0.005
Posterior Maxillary Width (PMxW)	54.9825	4.82160	58.1863	4.46081	3.2037	1.6898	1.79097	4.61653	5.362	0.001
Anterior Nasal Cavity Width (ANCW)	25.3438	4.61876	28.3800	4.91453	3.0362	1.0984	2.11791	3.95459	7.818	0.000
Posterior Nasal Cavity Width (PNCW)	23.8150	4.23020	26.2063	4.38419	2.3912	.99932	1.55580	3.22670	6.768	0.002
Posterior Alveolar Crest Width (PACW)	29.6425	4.71895	33.8413	5.09234	4.1987	1.6425	2.82558	5.57192	7.230	0.001
Posterior dental Arch Width (PAW)	37.0850	5.63919	42.7425	5.37352	5.6575	1.8816	4.08444	7.23056	8.504	0.003
Alveolar Width Anterior (AWA)	26.1605	4.30701	30.2275	4.48544	4.0670	1.2659	3.00861	5.12539	9.086	0.000
Alveolar Width Posterior (AWP)	34.4475	3.93086	38.2625	3.63113	3.8150	1.2832	2.74220	4.88780	8.409	0.001

NS, Nonsignificant ($P \leq 0.05$); *P*-value, Probability value; SD, Standard deviation; sig, Significance.
T1 = before expansion.
T2 = after expansion.

the buccal alveolar bone plate and increasing the risk of bone dehiscence and gingival recessions. The fan-type expander, on the other hand, focuses alterations on the front part of the dental arch with little change in the molar region, making it ineffective for treating posterior maxillary collapse [17].

Due to the presence of double expansion screws that can be independently controlled to promote a greater expansion in one region than the other in accordance with patient needs, EDO is a suitable alternative to traditional expanders when a greater amount of expansion is required in the anterior region than the posterior region [6,12,13,17].

Therefore, the objective of this study was to evaluate the skeletal maxillary expansion effect of using a differential opening expander with the RME protocol in CLP patients.

The most important orthopedic change in maxillary expansion technique is the increase in maxillary width. In the current study, there was a statistically significant increase in anterior maxillary width and posterior maxillary width, with more expansion in anterior maxillary width. These findings were in contrast with other studies, which reported a greater expansion in the posterior region when banded rapid maxillary Hass type or Hyrax expanders were used in patients with bilateral CLP using CBCT to evaluate outcomes [18]. However, these findings were similar to the results from a previous study [19] when using EDO versus Hyrax expander in patients with bilateral CLP with CBCT showed more increase in anterior region than posterior region when used expander with differential opening.

In the present study, the NCW showed significant increase in the anterior and posterior regions, with a greater increase in anterior region. These results were in accordance with another study [18], which showed an increase in anterior NCW more than posterior NCW when using Hass or Hyrax expanders with rapid protocol in bilateral CLP patients, and also with a previous study [20] when using Hyrax or a fan type with rapid expansion in unilateral CLP patients. Other studies [19,20] have shown posterior NCW increases more than anterior NCW when using rapid EDO in bilateral CLP patients and inverted mini-Hyrax with rapid protocol in unilateral CLP patients. This result explains the concept of a study [21] that stated that RME is an effective approach to breathing problems such as sleep apnea-hypopnea syndrome.

In the current study, there was a statistically significant increase in ACW. This finding was in accordance with another study [18], which found an increase in ACW when using Hass or Hyrax expanders in bilateral CLP patients with rapid expansion, and with a previous study [19], which found a greater increase in ACW when using EDO than Hyrax expanders in bilateral CLP patients.

Regarding the dentoalveolar arch width, in the present study, there was a statistically significant increase in AW during RME. This result was in agreement with another study [18] when using traditional expanders and with a study [19], which found a greater increase in AW when using EDO than the Hyrax expander in bilateral CLP patients.

According to the present study, there was statistically significant increase in anterior and posterior alveolar width, with more expansion in the anterior region. These results, supported by a previous study [20], showed an increase in anterior and posterior alveolar width with more anterior increases following RME using fan-type or inverted mini Hyrax expanders in patients with CLP and with another study [22] when using Hyrax expanders in unilateral CLP patients. These results were in agreement with the previous study [17], showed an increase in anterior and posterior alveolar width with more anterior increases following EDO and Hyrax expander with noncleft patient.

However, a previous study [20] using a Hyrax expander with a unilateral CLP patient showed posterior alveolar width, expansion more than anterior alveolar width a result that was different from the previous study [22]. Variations in the methodology, might explain this difference. In noncleft patient study [17] showed increase of posterior alveolar width when used Hyrax expander with RME protocol more than posterior alveolar width when used EDO.

There was a significant increase in all maxillary transverse dimensions (skeletal and dental) at the anterior and posterior regions; however, the increase was more remarkable at the anterior region when using EDO. These results were supported by a previous study [12] that promoted a change in maxillary dental arch size and shape with a greater intercanine than intermolar increase.

Recent maxillary expanders with differential opening were invented specifically to achieve varying degrees of expansion in the intercanine region and intermolar region of the maxillary arch in individuals with complete unilateral or bilateral CLP.

4.1. Conclusions

The use an expander with differential opening EDO with a RME protocol improves the maxillary constriction in growing bilaterally complete CLP patients. This protocol increases the width of the maxilla, nasal cavity, alveolar crest, anterior and

posterior alveolar bone, and dental arch. There was better control in achieving more expansion in the intercanine region than in the molar region, which makes the EDO is a good treatment option for CLP patients.

4.2. Recommendations

RME with EDO was a great benefit in cases of maxillary constriction, especially with an anterior constricted palate in CLP patients, and further investigations are needed to evaluate the long-term stability of cases treated by RME with CLP patients.

Funding

No funding was received for this research.

Conflicts of interest

The authors declare that they have no conflict of interest.

Acknowledgments

Authors would like to thank Dr. Amira Helmy and Dr. Sara Salah, Master students at orthodontic department, Faculty of Dental Medicine for Girls, Al-Azhar University for helping in sample collection.

References

[1] Vyas T, Gupta P, Kumar S, Gupta R, Gupta T, Singh HP. Cleft of lip and palate: a review. J Fam Med Prim Care 2020;9: 2621–5.
[2] Salari N, Darvishi N, Heydari M, Bokaee S, Darvishi F, Mohammadi M. Global prevalence of cleft palate, cleft lip and cleft palate and lip: a comprehensive systematic review and meta-analysis. J Stomatol Oral Maxillofac Surg 2022;123: 110–20.
[3] Shrestha A, Takahashi M, Yamaguchi T, Adel M, Furuhata M, Hikita Y, et al. Three-dimensional evaluation of mandibular volume in patients with cleft lip and palate during the deciduous dentition period. Angle Orthod 2020; 90:85–91.
[4] Palikaraki G, Makrygiannakis MA, Zafeiriadis AA, Benetou V, Sanoudos M, Bitsanis I, et al. The effect of facemask in patients with unilateral cleft lip and palate: a systematic review and meta-analysis. Eur J Orthod 2021;43: 69–79.
[5] Gregório L, de Medeiros Alves AC, de Almeida AM, Naveda R, Janson G, Garib D. Cephalometric evaluation of rapid and slow maxillary expansion in patients with BCLP: secondary data analysis from a randomized clinical trial. Angle Orthod 2019;89:583–9.
[6] Massaro C, Garib D, Cevidanes L, Janson G, Yatabe M, Lauris JRP, et al. Maxillary dentoskeletal outcomes of the expander with differential opening and the fan-type expander: a randomized controlled trial. Clin Oral Invest 2021;25:5247–56.
[7] Lim LI, Choi JY, Ahn HW, Kim SH, Chung KR, Nelson G. Treatment outcomes of various force applications in growing patients with skeletal Class III malocclusion. Angle Orthod 2021;91:449–58.
[8] Adobes Martín M, Lipani E, Alvarado Lorenzo A, Bernés Martínez L, Aiuto R, Dioguardi M, et al. The effect of maxillary protraction, with or without rapid palatal expansion, on airway dimensions: a systematic review and meta-analysis. Eur J Paediatr Dent 2020;2:262–70.
[9] Antony DP, Thomas T, Nivedhitha MS. Two-dimensional periapical, panoramic radiography versus three-dimensional cone-beam computed tomography in the detection of periapical lesion after endodontic treatment: a systematic review. Cureus 2020;12:773–6.
[10] Cardinal L, Da Rosa Zimermann G, Mendes FM, Andrade IJr, Oliveira DD, Dominguez GC. Dehiscence and buccal bone thickness after rapid maxillary expansion in young patients with unilateral cleft lip and palate. Am J Orthod Dentofacial Orthop 2022;162:16–23.
[11] Maino G, Turci Y, Arreghini A, Paoletto E, Siciliani G, Lombardo L. Skeletal and dentoalveolar effects of hybrid rapid palatal expansion and facemask treatment in growing skeletal Class III patients. Am J Orthod Dentofacial Orthop 2018;153:262–8.
[12] Pugliese F, Palomo JM, Calil LR, De Medeiros Alves A, Lauris JRP, Garib D. Dental arch size and shape after maxillary expansion in bilateral complete cleft palate: a comparison of three expander designs. Angle Orthod 2020; 90:233–8.
[13] Massaro C, Janson G, Miranda F, Aliaga-Del Castillo A, Pugliese F, Lauris JRP. Dental arch changes comparison between expander with differential opening and fan-type expander: a randomized controlled trial. Eur J Orthod 2021; 43:265–73.
[14] Alrejaye N, Gao J, Hatcher D, Oberoi S. Effect of maxillary expansion and protraction on the oropharyngeal airway in individuals with non-syndromic cleft palate with or without cleft lip. PLoS One 2019;14:0213328.
[15] Zhang Y, Jia H, Fu Z, Huang Y, Wang Z, Guo R, et al. Dentoskeletal effects of facemask therapy in skeletal Class III cleft patients with or without bone graft. Am J Orthod Dentofacial Orthop 2018;153:542–9.
[16] Terumi Ozawa O, Daniela Salzedas C, Beatriz Oliveira L, Sathler R, Baessa G, Garib D. Efficacy of rapid maxillary expansion associated with maxillary protraction in patients with unilateral complete cleft lip and palate. Cleft Palate Craniofac J 2020;57:872–6.
[17] Alves ACM, Janson G, Mcnamara JAJr, Lauris JRP, Garib DG. Maxillary expander with differential opening vs Hyrax expander: a randomized clinical trial. Am J Orthod Dentofacial Orthop 2020;157:7–18.
[18] De Almeida AM, Ozawa TO, Alves ACM, Janson G, Lauris JRP, Ioshida MSY, et al. Slow versus rapid maxillary expansion in bilateral cleft lip and palate: a CBCT randomized clinical trial. Clin Oral Invest 2017;21:1789–99.
[19] Garib D, Lauris RC, Calil LR, Alves AC, Janson G, De Almeida AM, et al. Dentoskeletal outcomes of a rapid maxillary expander with differential opening in patients with bilateral cleft lip and palate: a prospective clinical trial. Am J Orthod Dentofacial Orthop 2016;150:564–74.
[20] Figueiredo DSF, Bartolomeo FUC, Romualdo CR, Palomo JM, Horta MCR, Andrade I, et al. Dentoskeletal effects of three maxillary expanders in patients with clefts: a cone-beam computed tomography study. Am J Orthod Dentofacial Orthop 2014;146:73–81.
[21] Sánchez-Súcar AM, Sánchez-Súcar FB, Almerich-Silla JM, Paredes-Gallardo V, Montiel-Company JM, García-Sanz V, et al. Effect of rapid maxillary expansion on sleep apnea-hypopnea syndrome in growing patients. A meta-analysis. J Clin Exp Dent 2019;11:759–67.
[22] Veloso NC, Mordente CM, De Sousa AA, Palomo JM, Yatabe M, Oliveira DD, et al. Three-dimensional nasal septum and maxillary changes following rapid maxillary expansion in patients with cleft lip and palate. Angle Orthod 2020;90:672–9.