# Rapid Maxillary Expansion in Obstructive Sleep Apnea in Young Patients: Cardio-Respiratory Monitoring

Alfio Buccheri*/ Fabio Chinè**/ Giovanni Fratto***/ Licia Manzon****

***Objective(s):*** *Obstructive sleep apnea syndrome (OSAS) is a respiratory disorder which affects from 1 to 3 % of people during development. OSAS treatment may be pharmacological, surgical or based on application of intraoral devices to increase nasal respiratory spaces. The purpose of this study was to determine the efficacy of the Rapid Maxillary Expander in OSAS young patients by measuring cardio-respiratory monitoring parameters (AHI, the average value of complete and incomplete obstructed respiration per hour of sleep, and* $SAO_2$*, the percentage of oxygen saturation).* ***Study design:*** *The study was conducted on 11 OSAS young subjects (mean age 6.9±1.04 years), all treated with rapid maxillary expansion (RME). Cardio-respiratory monitoring (8-channel Polymesam) was performed at the beginning (diagnostic, T0) and after 12 months of treatment.* ***Results:*** *The mean values of cardio-respiratory parameters at TO were: AHI=6.09±3.47;* $SAO_2$*=93.09%±1.60. After 12 months of treatment, the mean values of the same polysomnographic parameters were: AHI=2.36 ± 2.24;*$SAO_2$*=96.81% ±1.60. These changes were associated with an improvement in clinical symptoms, such as reduction of snoring and sleep apnea.* ***Conclusion(s):*** *This study confirms the therapeutic efficacy of RME in OSAS young patients. This orthopedic-orthodontic treatment may represent a good option in young patients affected by this syndrome.*

***Key words:*** *Obstructive sleep apnea syndrome, Rapid maxillary expansion, Polysomnography*

## INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is a sleep disorder with multi-factorial etiology[1]. It is characterized by a total/partial obstruction of the airways when the subject is asleep. Among symptoms, diaphragm muscle activity, absence of oro-nasal airflow, oxymyoglobin desaturation and hypercapnia have been reported[1-5].

During development, OSAS affects 1-3% of 2-5 years-old children, regardless of gender[1]. Frequently, the causes of the disorder may be different from those in the adult. The pathogenesis may be due to an irregular function of the muscles dilating the oropharynx, such as the genioglossus muscle whose normal activity is in phase with inspiration. This altered muscular function (or altered control of the muscles from the nerves) leads to the collapse of the pharyngeal cavity[1-5]. Such problems are frequently associated to adenotonsillar hypertrophy. In addition, other concomitant anatomical factors may be: nasal stenosis, nasal polyp, macroglossia, rhinosinusitis, cleft palate, craniofacial anomalies associated to certain syndromes (Down, Pierre Robin Syndromes etc.), and obesity.

OSAS young patients have often characteristic clinical signs which include snoring, oral respiration (often diurnal and nocturnal), diurnal sleepiness (not as frequent as in the adult), hyperperspiration, recurrent airways infections (RAI), otitis, sleep disorders (i.e. urine incontinence and nightmares), diurnal and nocturnal hyperkynesia and behavioral disturbances such as irritability, anxiety, difficulty in consolidating memory, and reduced concentration and attention

Additional tools to diagnose (or exclude) OSAS are nocturnal polysomnography, examination of patient's anamnesis and the cardio-respiratory monitoring. Cardio-respiratory monitoring allows to measure parameters such as the apnea-hypopnea indicator (AHI, the average value of complete and incomplete obstructed respiration per hour of sleep), oxygen saturation ($SAO_2$) and snoring. Other recommended tests are: laterolateral telecranium radiography; fluoroscopy, which allows to determine the exact obstructed area; and echocardiography, to determine possible cardiopulmonary complications.

*Alfio Buccheri· MD, Department of Maxillo-facial Surgery, S. Giovanni-Addolorata Hospital, Rome, Italy.
**Fabio Chinè ,MD, Private Practice.
***Giovanni Fratto, MD, Department of Dental Material, University of Rome "La Sapienza," Rome, Italy.
***Licia Manzon, MD, Department of Dental Material, University of Rome "La Sapienza," Rome, Italy.

Send all correspondence to:
Alfio Buccheri
viale Pola 23
00198, Rome, Italy
Phone.0039 3386469981
E-mail : alfio.buccheri@libero.it

OSAS short-term and long-term consequences in young patients may include psychophysical delay development or dysfunction, and cardiovascular or pulmonary alterations. Thus, the therapeutic approach is often multifactorial and requires the cooperation of different specialists: pediatricians, bronco-pneumologists, otolaryngologists, neurologists, maxillofacial surgeons and orthodontists.

In young subjects, adenotonsillectomy is the treatment of choice with very good results on OSAS symptoms and snoring resolution[1,6]. An alternative approach to surgical removal of tonsils and adenoids is the nasal administration of corticosteroids, in association to an antibiotic therapy. CPAP (nasal continuous positive airway pressure) therapy seems less appropriated in children because of the practical difficulties that a young patient may incur[1].

In addition to these therapeutic approaches, the orthopedic-orthodontic therapy has a major role in young patients affected by OSAS and snoring disorders[7-11]. OSAS young patients often have dental disorders which could affect respiration[11], such as mandibular retrusion and ogival palate with or without mono or lateral cross bite. In these cases, the use of Rapid Palatal Expander represents a good option to induce an orthopedic expansion of the palate and the upper jaw. Such expansion leads to an increase of the nasal respiratory spaces, thus producing benefits in ventilation[7-9,11,12].

Thus, the purpose of this study was to determine the efficacy of the Rapid Palatal expansion on OSAS symptoms by recording cardio-respiratory monitoring parameters (AHI, $SAO_2$) in a group of young patients before and after 12 months of treatment.

## MATERIALS AND METHOD

11 OSAS young patients were recruited at the S.Giovanni-Addolarata Hospital Odontoiatric Division in Rome. The sample cohort was composed of 8 males and 3 females and the mean age was 6.9±1.04 years (Table 1).

The subjects presented the following clinical signs: malocclusion (strained, high and ogival palate, cross-bite and mandibular retrusion); OSAS symptoms; snoring, apnea and nocturnal awakenings (as reported by the parents).

OSAS diagnosis was confirmed by the cardio-respiratory monitoring (8-channel polymesan) performed at the S.Giovanni-Addolorata Hospital. In compliance with the standard criteria approved by the American Academy of Sleep Medicine[4], the polysomnographic parameter used for inclusion in the cohort was an apnea-hypopnea indicator (AHI)>1.

In addition, we recorded another parameter, the percentage of oxygen saturation ($SAO_2$) which is the value of oxygen in the hemoglobin (expressed as percentage of saturated hemoglobin). $SAO_2$ also gives information on the level of oxygenation in the arterial blood.

Cardio-respiratory monitoring was performed at the beginning of the study (diagnostic, T0) and 12 months after application of the intraoral device.

### Rapid Palatal Expander

The intraoral device used in this study was a 2-band Rapid Palatal Expander anchored through *Leone* screw (A0620/13).

The expander activation procedure was composed of: (a) three turns of the screw at the time of installation; and (b) two turns of screw every day after.

Activations were performed during 10 and 20 days from the beginning of the study (T0), and were based on the requirements of the single patients.

### Statistical analysis

AHI and $SAO_2$ values registered before and after the application of the intraoral expansion device were compared with paired student's T test. A p-value <0.05 was considered statistically significant. Statistical analysis was performed using the Statview software from SAS Institute.

## RESULTS

The median palatine suture opening was present in all patients, as evidenced by the occlusal radiography and clinically by the upper median diastema.

### Polysomnographic parameters

*AHI*

Student's T test showed a significant effect of the treatment on AHI parameter (df: 10; p<0.01) (Fig. 1). We found that AHI values after the treatment were significantly lower (2.36±2.24) than those recorded at T0 (6.09±3.47)

Individual AHI values before and after application of rapid palatal expander are shown in Table 1. The table shows that 10 subjects had an improvement in the number of Apneas/Hyponeas per hour of sleep. Specifically, 5 patients were completely healed (AHI <1) while other 5 patients showed moderate improvements (AHI<5). Only 1 patient did not show signs of improvement, since the AHI value did not change over time.

**Table 1. AHI and $SAO_2$ value before and after Rapid Palatal Expander therapy in OSAS young patients. OSAS: Obstructive sleep apnea syndrome; AHI: apnea-hypopnea indicator; $SAO_2$: oxygen saturation**

| Patients | Age *(Years)* | AHI | | $SAO_2$ | |
|---|---|---|---|---|---|
| | | *Before therapy* | *After therapy* | **Before therapy** | **After therapy** |
| 1 | 7 | 9 | 0 | 82% | 93% |
| **2** | 6 | 1 | 0 | 87% | 96% |
| **3** | 5 | 13 | 5 | 98% | 98% |
| **4** | 6 | 8 | 0 | 96% | 98% |
| **5** | 8 | 6 | 4 | 88% | 99% |
| **6** | 7 | 5 | 3 | 96% | 97% |
| **7** | 7 | 6 | 1 | 96% | 97% |
| **8** | 8 | 8 | 4 | 92% | 98% |
| **9** | 8 | 1 | 0 | 96% | 96% |
| **10** | 6 | 4 | 3 | 97% | 97% |
| **11** | 8 | 6 | 6 | 96% | 96% |

OSAS: Obstructive sleep apnea syndrome; AHI: apnea-hypopnea indicator; $SAO_2$: oxygen saturation

*$SAO_2$*

Student's T test showed a significant effect of the treatment on $SAO_2$ parameter (df: 10; $p<0.05$) (Fig. 2). We found that $SAO_2$ percent values after the treatment were significantly higher (96.81%±1.60) than those recorded at T0 (93.09%±5.18) (Fig. 2).

Individual $SAO_2$ values before and after application of rapid palatal expander are also reported in Table 1. 7 patients showed improvements. Patients also received respiratory benefits, as shown in the anamnesis provided to the parents before and after the treatment.

## Clinical evaluation

Subjects also showed an improvement in their clinical symptoms confirmed by the cardio-respiratory monitoring, such as a severe reduction in snoring and sleep apnea (Fig. 3).

**Figure 1. AHI mean values before and after 12 months of treatment with Maxillary Expansion therapy in OSAS young patients. Data are the mean±SEM. AHI: apnea-hypopnea indicator. Asterisk (*) indicates significant difference between the groups. **p<0.01.**

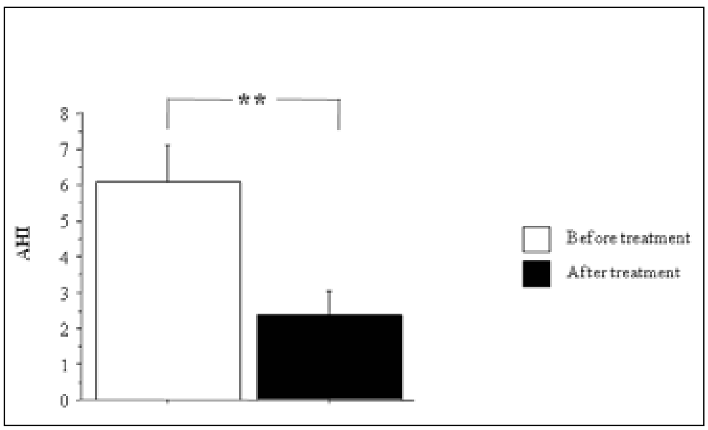
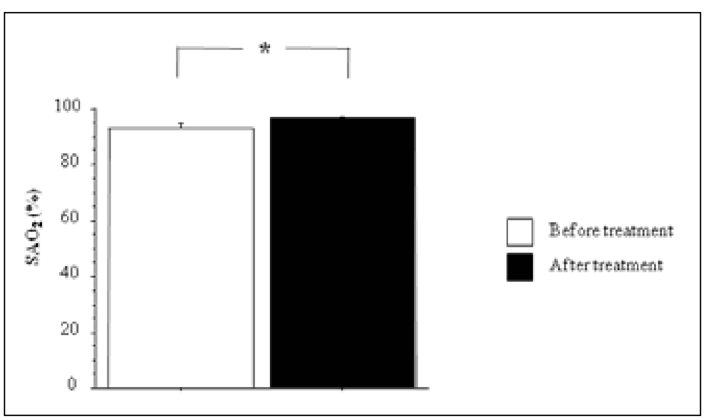



**Figure 2. $SAO_2$ percentage mean values before and after 12 months of treatment with Maxillary Expansion in OSAS young patients. Data are the mean(%)±SEM. $SAO_2$: oxygen saturation. Asterisk (*) indicates significant difference between the groups. *p<0.05.**




## DISCUSSION

This study provides evidence for a positive effect of rapid palatal expander in young patients affected by OSAS. We found that after 12 months of treatment our patients showed an improvement of respiratory functions, as measured by polysomnography parameters (AHI and $SAO_2$) and observed clinically.

These data are in line with previous studies showing that the Rapid Maxillary Expansion (RME) reduces nasal resistance to the airflow by increasing the respiratory space of the nasal cavities. This effect is more evident in the lower portion of the nasal cavity which carries the majority of inhaled air[8-15]. A consequence of increased nasal respiration is that adenoids tend to return to a physiological atrophic state[16] and the tonsils become smaller, thus contributing to increase the respiratory space[16-19]. It is worth to mention that, in this syndrome, the air is vortically inhaled to compensate the narrow respiratory space, and thus the tonsils are massively exposed to air neither purified nor heated by the nose.

Another effect of RME could be that of a volumetric "expansion" of the pharyngeal space, although this assumption remains controversial. Some studies report no evidence for an increase in the pharyngeal space after the expansion[20-22] while others have evidenced that RME (with or without a Delaire facial mask) causes a volumetric space increase. In particular, this increase pertains to the nasopharyngeal, rather than the oropharyngeal, part and reduces the pharyngeal pressure during inspiration[23-27].

RME effects might be due to the metabolic activation of the soft tissues surrounding the expanded bone areas[28-30]. In fact, maxillary expansion, by increasing the rhinopharyngeal space, may also lead to a diagonal expansion of the pterygoid processes of the sphenoid bone[29] where the upper portion of the pharynx is located (Fig. 4)[30]. The expansive mechanism produces a tension in the tissues surrounding the upper pharyngeal space, increasing the upper respiratory space[27]. Thus, it is plausible that maxillary expansion, by increasing the upper respiratory space and reducing adenoids and tonsils masses, may contribute to reduce either the risk for pharyngeal collapse and, as a result, OSAS symptoms.

Another positive effect of maxillary expansion could be that of a better lingual posture, which allows to obtain an increase of the retrolingual air space[15,16,18,28-31]. Moreover, it has been demonstrated that the maxillary expansion might have stable effects over time on the function of the soft palate[4], with a direct impact on the space volume of the first airways[13-16].

## CONCLUSION

In conclusion, the present study further confirms the therapeutic efficacy of the RME in OSAS young patients. In addition, in cases of contraction of the transversal diameter of the upper maxillary section, RME may prevent RAI and reduce the risk of pharyngeal collapse during sleep.

As in young patients it is important to modify as soon as possible this "altered respiratory type", the orthopedic-orthodontic therapy may represent a good adjuvant treatment to obtain respiratory advantages by correcting the malocclusion. A multi-disciplinary diagnostic and therapeutic approach is nonetheless recommended to ensure better and more complete outcome.

**Figure 3. Cardio-respiratory monitoring performed before and after orthopedic-orthodontic therapy. Note the drastic reduction of apneas- hypopnea after treatment with Rapid Maxillary Expansion.**

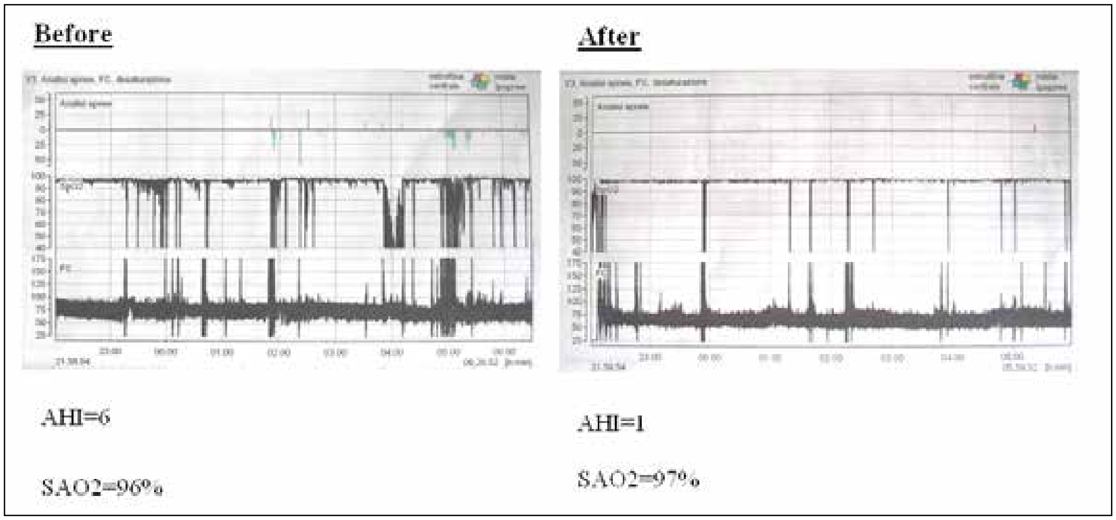


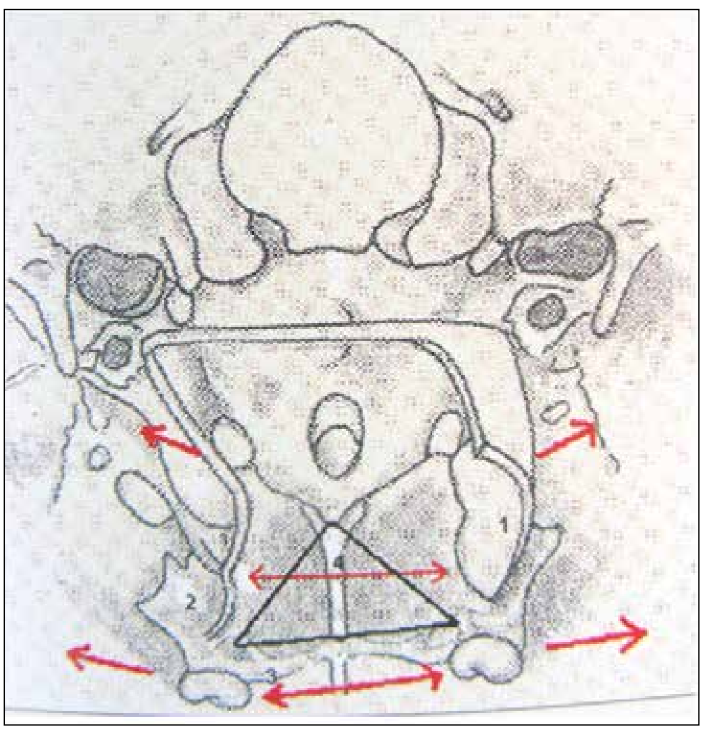

**Figure 4. Pharyngeal insertions on the base of skull and simulation of the triangular expansive mechanism caused by Rapid Maxillary Expansion.**

**Lateral Pharyngeal wall**

**Internal wing of pterygoid process**

**Hard Palate**

**Posterior nasal aperture**




(Modified from Cimino A. ,Ferrara P. Manuale di Otorinolaringologia. Società Editrice Universo ;1985)

## REFERENCES


1. Hopps E, Caimi G. Obstructive Sleep Apnea Syndrome: Links Betwen Pathophysiology and Cardiovascular Complications. Clin Invest Med 38: E362-70, 2015.
2. Kats ES, White DP. Genioglossus activity in children with obstructive sleep apnea during wakefulness and sleep onset. Am J Resp Crit Care Med 168: 664-670, 2003.
3. Zettergren-Wijk, Linder-Aronson S, Nordlander B, Agren K, Svamborg E. Longitudinal effect on facial growth after tonsillectomy in children with obstructive sleep apnea. World J Orthod 3(1):67-72, 2002.
4. Villa MP ,Rizzoli A , Miano S. Efficacy of rapid maxillary expansion in children with obstructive sleep apnea syndrome :36 months of follow-up. Sleep breath 15: 179-184, 2011.
5. Zhang W, Si LY. Obstructive sleep apnea syndrome (OSAS) and hypertension: pathogenic mechanisms and possible therapeutic approaches. Ups J Med Sci 117: 370-382, 2012.
6. Weissbach A, Leiberman A, Tarasiuk A, Goldbart A, Tal A. Adenotonsillectomy improves enuresis in children with obstructive sleep apnea syndrome. Int J Pediatr Otorhinolaryngol 70: 1351-1356, 2006.
7. Pirelli P, Saponara M, Attanasio G. Obstructive Sleep Apnoea Syndrome (OSAS) and rhino-tubaric disfuntion in children: therapeutic effects of RME Therapy. Prog Orthod 6: 48-61, 2005.
8. Pirelli P, Saponara M, Guilleminault C. Rapid Maxillary expansion in children with obstructive sleep apnea sindrome. Sleep 27: 761-766, 2004.
9. Eichenberger M, Baumgartner S. The impact of rapid palatal expansion on children's general health: a literature review. Eur J Paediatr Dent 15: 67-71, 2014.
10. Zhu Y, Long H, Jian F, Lin J, Zhu J, Gao M, Lai W. The effectiveness of oral appliances for obstructive sleep apnea syndrome: A meta-analysis. J Dent 43: 1394-1402, 2015.
11. Cozza P, Polimeni A, Ballanti F. A modified monobloc for the treatment of obstructive sleep apnoea in pediatric patients Eur J Orthod 26: 523-530, 2004.
12. Enoki C, Valera FC, Lessa FC, Elias AM, Matsumoto MA, Anselmo-Lima WT. Effect of rapid maxillary expansion on the dimension of the nasal cavity and on nasal air resistence. Int J Pediatr Otorhinolaryngol 70: 1225-1230, 2006.
13. Simoni F, Villano A, Gandini P. Valutazione clinico-sperimentale delle modificazioni indotte dall'espansione rapida del mascellare superiore (RME) in soggetti con rinolalia. Ortognatodonzia Italiana; 13: 119-124, 2006.
14. Machado-Júnior AJ, Zancanella E, Crespo AN. Rapid maxillary expansion and obstructive sleep apnea: A review and meta-analysis. Med Oral Patol Oral Cir Bucal. Mar 31:0. [Epub ahead of print] 2016.
15. Vinha PP, Eckeli AL, Faria AC, Xavier SP, de Mello-Filho FV. Effects of surgically assisted rapid maxillary expansion on obstructive sleep apnea and daytime sleepiness. Sleep Breath 20: 501-508, 2016.
16. Tapia IE, Marcus CL, McDonough JM, Kim JY, Cornaglia MA, Xiao R, Allen JL. Airway Resistance in Children with Obstructive Sleep Apnea Syndrome. Sleep 39: 793-799, 2016.
17. McNamara JA Jr, Lione R, Franchi L, Angelieri F, Cevidanes LH, Darendeliler MA, Cozza P. The role of rapid maxillary expansion in the promotion of oral and general health. Prog Orthod 16: 33, 2015.
18. Bianchi A, Betti E, Tarsitano A, Morselli-Labate AM, Lancellotti L, Marchetti C. Volumetric three-dimensional computed tomographic evaluation of the upper airway in patients with obstructive sleep apnoea syndrome treated by maxillomandibular advancement. Br J Oral Maxillofac Surg 52: 831-837, 2014.
19. Mucedero M, Baccetti T, Franchi L, Cozza P. Effects of maxillary protraction with or without expansion on the sagittal pharingeal dimension in class III subjects. Am J Orthod Dentofacial Orthop 135: 777-781, 2009.
20. El H, Palomo Jm. Three-dimensional evaluation of upper airway following rapid maxillary expansion :a CBCT study. Angle Orthod 84: 265-273, 2014.
21. Pamporakis P, Nevzatoglu S, Kucukkeles N. Three-dimensional alterations in pharyngeal airway and maxillary sinus volumes in class III maxillary deficiency subjects undergoing orthopedic facemask treatment.Angle Orthod 84: 701-707, 2014.
22. Monini S, Malagola C, Villa MP, Tripodi C, Tarentini S, Malagnino I, Marrone V, Lazzarino AI, Barbara M. Rapid Maxillary Expansion for the treatment of nasal obstruction in Children Younger than 12 Year. Arch Otolaryngol Head Neck Surg 135: 22-27, 2009.
23. Chang Y, Koening lJ, Pruszynski Je, Bradley TG, Bosio Ja, Liu D. Dimensional changes of upper airway after rapid maxillary expansion :a prospective cone beam computed tomography study. Am j Orthod Dentofacial Orthop 143: 462-470, 2013.
24. Aloufi F, Preston CB, Zawawi KH .Changes in the upper and lower pharyngeal airway spaces associated with rapid maxillary expansion. ISRN Dent 2012: 290964, 2012.
25. Zeng J, Gao X. A prospective CBCT study of upper airway changes after rapid maxillary expansion .Int Pediatr Othorhinolaryngol 77: 1805-1810, 2013.
26. Ortu E, Giannoni M, Ortu M, Gatto R, Monaco A. Oropharyngeal airway changes after rapid maxillary expansion:the state of art Int J Clin Exp Med 7: 1632-1638, 2014.
27. Ortiz-Monasterio F. Mandibular distraction in respiratory distress in infants. Atti II International Meeting "Distraction Osteogenesis of the Facial Skeleton" Bologna 26-28 September 2002.
28. Iwasaki T, Saitoh I, Takemoto Y, Inada E, Kakuno E, kanomi R, Hayasaki Y, Yamasaki Y. Tongue posture improvement and pharyngeal airway enlargement as secondary effects of rapid maxillary expansion :a cone beam computed tomography study Am J Orthod Dentofacial Orthop 143: 235-245, 2013.
29. Cozza P. Espansione rapida palatale :terapia del deficit trasversale scheletrico del mascellare superiore .Firenze. ISO. Leone Spa; 2010.
30. Cimino A. and Ferrara P. Manuale di Otorinolaringologia. Società Editrice Universo; 1985.
31. Villa MP, Bernkopf E, Broia V, Montesano M, Paggi B, Ronchetti R. Randomized controlled study of an oral jaw positioning appliance for the treatment of obstructive sleep apnea in children with malocclusion. Am J Respir Crit Care Med 165: 123-127, 2002