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Rapid Maxillary Expansion as a Standard Treatment for Obstructive Sleep Apnea Syndrome: A Systematic Review

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Abstract:
Objective: *The aim of this article is to establish the relevance of rapid maxillary expansion as a standard treatment for Obstructive sleep apnea syndrome.*
Methods: *Three databases, Cochrane, Medline and Embase, were searched electronically (from 1960 through September 2014) for relevant randomised control trials. Articles which met all the inclusion and exclusion criteria were collected and systematically analysed.*
Results and Conclusion: *Rapid maxillary expansion is an efficient and standard method of treatment for OSAS in children with narrow maxillary arch with malocclusions leading to OSAS and children with Down syndrome, and young adults with narrow maxillary arch with malocclusions leading to OSAS.*
Keywords: *rapid maxillary expansion – RME – sleep apnea – OSAS – obstructive sleep apnea syndrome*.

I. Introduction

Sleep apneais a type of sleep disorder characterized by pauses in breathing or instances of shallow or infrequent breathing during sleep.Thousands of individuals across the globe suffer from sleep apnea.There are three forms of sleep apnea: central (CSA), obstructive (OSA), and complex or mixed sleep apnea(1). In CSA, breathing is interrupted by a lack of respiratory effort; in OSA, breathing is interrupted by a physical block to airflow despite respiratory effort, and snoring is common.

Obstructive sleep apnea syndrome (OSAS) is defined as "the cessation of ventilation or occurrence of significant hypoventilation during sleep, characterized by episodes of partial or complete upper airway obstruction associated with hypoxemia and/or hypercarbia"(2). OSAS is characterised by sleep disturbances resulting in behavioural problems, poor school performance, failure to thrive (2),daytime fatigue, a slower reaction time, vision problems(3) and in very chronic cases pulmonary hypertension, and cor pulmonale. Thus there is a high probability for driving accidents and work-related accidents. Even death may occur from untreated OSA due to lack of oxygen to the body. Thus it becomes very essential to treat OSAS at an early stage as it significantly affects the quality of life of the individual.

The basic cause of OSAS is anatomical obstruction of airway. It can occur in various forms such as large adenoids or chronic mouth breathing which causes the tongue is be unable to mould to thepalate and this results in a narrow, high arched palate and poor maxillary growth, which can also result in narrow nasal passages, narrow dental arches and an anterior crossbite(4), lingual tonsils obstruction, especially in children who are overweight(5), and Down syndrome(6).

Diagnosis of OSAS is relatively difficult, as most individuals are rarely aware of the problem, even upon awakening. So it is often only noted by others rather than the patient themselves and occasionally suspected by clinicians based on symptoms if the subject reports to them. The diagnosis can only be based on a combination of subjective symptoms along with formal sleep study such as full-night polysomnography and presence of an anatomical obstruction.Polysomnography (PSG), is the gold standard for diagnosis(7) of OSAS. Polysomnography is a type of sleep study, which is multi-parametric and used in the study of sleep. An easier alternative for PSG in places where PSG is not available is Oximetry, which may be performed overnight in a patient's home(8).A diagnostic indicator for sleep apnea is Apnea Hypopnea Index (AHI).

Most common treatment for moderate to severe sleep apnea,is the use of a continuous positive airway pressure (CPAP) or automatic positive airway pressure (APAP) device(9). The CPAP machine generates the required air pressure to keep the patient's airways open during sleep. Its disadvantages are that it is uncomfortable and patient compliance is less which significantly affects the prognosis. Hencetreatments for OSAS which will eliminate the obstruction are: in case of enlarged adenoid or tonsils adenoidectomy and tonsillectomyand in case of pharyngeal obstruction uvulopalatopharyngoplasty can be done. These surgeries are most effective when diagnosis and intervention are made at early childhood.A newer alternatives for these surgeries is anti-inflammatory therapy for obstructive sleep apnea in children, it is a new a promising non-surgical treatment for children which requires further research(10).

Chronic obstruction due to soft-tissue hypertrophies may eventually become associated with mouth breathing which can lead to facial imbalances, if it occurs during the developmental stages of an individual.Hence, adenotonsillectomy and uvulopalatopharyngoplasty are not enough to treat the anatomic changes. Facial orthopedic techniques are required for morphological and functional recovery. Most frequent morphological changes comprise of narrow, high arched palate and poor maxillary growth, which can also result in narrow nasal passages, narrow dental arches, long and narrow face, labial incompetence, retrognathic mandible, and a lower tongue rest position(11). Of these it is known that that subjects with maxillary constriction have increased nasal resistance features typically seen in OSA patients.Maxillary constriction is also associated with alterations in tongue posture which could result in retroglossal airway narrowing, another feature of OSAS. Thus correction of maxillary constriction plays a pivotal role in long-term treatment of OSAS. This is achieved by rapid maxillary expansion. Rapid maxillary expansion (RME) is an orthodontic treatment for maxillary constriction which increases the width of the maxilla and reduces nasal resistance(12). RME can be done by using intraoral appliances or surgically - surgical rapid maxillary expansion (SRME). Some intraoral appliances commonly used are hyrax expander and Issacson expander.(13) There mechanism of action is as following: when heavy and rapid forces are applied to the teeth the forces affect lesser of tooth movement and instead get transferred to the sutures lines of the bones.When the force exceeds the sutural resistance and the limit of forces needed for orthodontic tooth movement the sutures open up and cause maxillary arch expansion. The tooth movement is relatively very less in comparison to maxillary expansion(13).

The aim of this article is to establish the relevance of rapid maxillary expansion as a standard treatment for Obstructive sleep apnea syndrome.

II. Materials And Methods

Three databases, Cochrane, Medline and Embase, were searched electronically (from 1960 through September 2014) for relevant randomised control trials concerning the effects of rapid maxillary expansion techniques on patients with obstructive sleep apnoea (OSA). The search was conducted for keywords “rapid maxillary expansion sleep apnoea” which resulted in thirty-five articles. The search was then narrowed down to include only “human clinical trials”. Five clinical trials were found through this search. (Table 1). These clinical trials have been systematically reviewed in this article.

Table 1: Articles Which Met The Inclusion And Exclusion Criteria

Author	year	Aim	Sample size	Method	Conclusion
Villa MPet al(14)	2011	to determine whether RME is effective in the long-term treatment of OSA	Ten children	Ten children who completed a 12-month therapeutic trial using RME were followed up for 24 months and evaluated based on analyses of objective and subjective data obtained.	RME may be a useful approach in children with malocclusion and OSAS
Guilleminault Cet al(15)	2011	to perform a power analysis and determine the number of subjects necessary to have an appropriate response	Thirty-one children	group 1 received surgery followed by orthodontics, while group 2 received orthodontics followed by surgery	This preliminary study emphasizes the need to have more than subjective clinical scales for determination of sequence of treatments
Miano Set al(16)	2009	To evaluate NREM sleep microstructure in children with obstructive sleep apnea syndrome (OSAS) before and after one year of rapid maxillary expander (RME) treatment by means of the cyclic alternating pattern (CAP)	Nine children with OSAS	All subjects underwent an overnight polysomnography in the sleep laboratory after one adaptation night, as a baseline evaluation; children with OSAS were recorded again after one year of RME treatment	RME treatment almost normalized sleep architecture and improved sleep respiratory disturbances; however, sleep microstructure and respiratory parameters did not completely recover. The persistence of increased CAP rate in slow-wave sleep associated with an increase of A1 index might reflect a partial failure of orthodontic treatment. On the other hand, the rebound of A1 subtypes might be an indirect sign of an attempt to normalize sleep that has been disturbed by the respiratory events.

de Moura CP et al(17)	2008	To assess the effects of rapid maxillary expansion on ENT disorders in 24 children with Down syndrome	twenty-four children with Down syndrome	Randomly allocated to receive either rapid maxillary expansion or not. Each group received ENT and speech therapy assessments before expansion and after the device had been removed.	Rapid maxillary expansion resulted in a reduction in hearing loss, yearly rate of ENT infections and parentally assessed symptoms of upper airway obstruction, compared with no treatment. These findings are probably related to expanded oronasal space, due to rapid maxillary expansion.
Cistulli PA et al (13)	1998	The aim of this pilot study was to investigate the effect of rapid maxillary expansion in OSA.	Ten young adults with mild to moderate OSA	All patients underwent treatment with RME, six cases requiring elective surgical assistance. Polysomnography was repeated at the completion of treatment.	RME may be a useful treatment alternative for selected patients with OSA

III. Results

1. Fourteen children with dental malocclusions and OSA syndrome (OSAS) confirmed by polysomnography were chosen and treated over a 12-month therapeutic trial period using RME. After which ten children were followed up to 24 months. All subjects underwent an overnight polysomnography at the baseline, after 1 year of treatment and 24 months after the end of the orthodontic treatment. After treatment, the apnea hypopnoea index (AHI) decreased and the clinical symptoms had resolved by the end of the treatment period. Twenty-four months after the end of the treatment, no significant changes in the AHI or in other variables were observed (14)

2. Thirty-one children diagnosed with OSA based on clinical symptoms and polysomnography (PSG) findings and also had presence of both narrow maxillary complex and enlarged tonsils were selected and randomized into 2 groups. Group 1 received surgery followed by orthodontics, while group 2 received orthodontics followed by surgery. At the end of the study group 2 patients showed an overall significant improvement in the PSG findings compared to baseline and compared to treatment 1, without any group differences (15)

3. Nine children with OSAS aged 4-8 years were selected and age-matched normal controls were included in the study. All children had an endo-oral RME device applied. After one year of treatment the OSAS group showed a longer duration of time in bed and sleep period time, a reduction in number of stage shifts compared to baseline recordings, and the apnea-hypopnea index decreased significantly. There was also an increase in CAP rate associated with an increase of A1 index during slow-wave sleep (16).

4. Twenty four children with Down syndrome were randomly allocated to receive either rapid maxillary expansion or no treatment. Each group received ENT and speech therapy assessments before expansion and after the device had been removed. At the end of the study it was observed that Rapid maxillary expansion resulted in a reduction in hearing loss, yearly rate of ENT infections and parentally assessed symptoms of upper airway obstruction, compared with no treatment (17).

5. Ten young adults with mild to moderate OSAS and maxillary constriction on orthodontic evaluation were included in the study. All patients underwent treatment with RME, six cases requiring elective surgical assistance. Polysomnography was repeated at the completion of treatment. Nine of the 10 patients reported improvements in snoring and hypersomnolence (13).

DICUSSION:

1. Villa MP et al conducted a 36 month follow up clinical trial in order to evaluate the effectiveness in the long-term treatment of OSAS. The clinical trial initiated with fourteen children (mean age of 6.6 ± 2.1 years) who had dental malocclusions such as deep, retrusive or crossbite at the orthodontic evaluation and OSAS. This was confirmed by overnight polysomnography taken before onset of treatment. All these children were treated using RME for a period of 12 months. Another overnight polysomnography was taken at this stage. Of the fourteen children ten of them who completed the treatment were followed up for 24 months, and an overnight polysomnography was repeated at the end of the follow up period. The mean age of the children was now 9.7 ± 1.6 years by the end of follow-up. The study was done by analysing objective and subjective data over this 36-month follow-up period. The results showed that after treatment, the apnea hypopnoea index (AHI) decreased and the clinical symptoms had resolved by the end of the treatment period. Twenty-four months after the end of the treatment, no significant changes in the AHI or in other variables were observed (14).

The Apnea–Hypopnea Index or Apnoea–Hypopnoea Index (AHI) is an index used to indicate the severity of sleep apnea. It is represented by the number of apnea andhypopnea events per hour of sleep(18). The AHI is calculated by dividing the number of apnea events by the number of hours of sleep. Based on the AHI values OSA severity is defined as mild for AHI ≥ 5 and < 15, moderate for AHI ≥ 15 and ≤ 30, and severe for AHI > 30/hr(19).

2. Guilleminault C et al conducted a clinical trial of thirty-one children, 14 boys and 17 girls with a mean age of 6.5 ± 0.2 yearsat entry were selected. These children were diagnosed with OSAS based on clinical symptoms and polysomnography (PSG) findings and they had the presence of both narrow maxillary complex and enlarged tonsils. All of the subjects were to be treated with surgery as well as RME. But the order of treatment was varied. They were randomized into 2 groups: group 1 received surgery followed by orthodontics, while group 2 received orthodontics followed by surgery. The surgical intervention performed in this study was adeno-tonsillectomy. Following treatment each child was examined by an ENT, an orthodontist, and a sleep medicine specialist. They were evaluated based on validated pediatric sleep questionnaire and PSG which was done at the beginning and after each treatment phase. Statistical analyses were ANOVA repeated measures and t tests. Results for group 1 showed that there was improvement of both clinical symptoms and PSG findings. However none of the children presented normal results after treatment 1, at the exception of one case. There was also no significant difference in the amount of improvement noted independently after surgery. Whereas in group 2 an overall significant improvement was seen in PSG findings compared to baseline and compared to group 1, without any group differences in the subjects. Thus this preliminary study emphasized the need to have more than subjective clinical scales for determination of sequence of treatments(15).

3. Silvia Miano et al conducted a study of 9 children with OSAS vs. a control group of normal children with 13 healthy children matched for age, location of residence (urban area), race (Caucasian descent) and socioeconomic status. The study group initially consisted of 14 children but was later reduced to 9 due some artifacts which occurred during the PSG recording of 5 subjects. These 9 children met the following inclusion criteria: clinical signs of malocclusion (all presented with a high, narrow palate associated with deep bite, retrusive bite or crossbite); signs and symptoms of OSAS, including habitual snoring, apnea, and restless sleep witnessed by parents; and patients with an obstructive apnea/hypopnea index >1 proven by laboratorypolysomnography, and no previous history of treatment for OSAS. These children were subjected to "endo-oral RME device" applied which was a fixed two-band RME appliance with an expansion screw fitted to the second deciduous molars of the upper jaw. The treatment was done for a 12 month period. All patients underwent monthly follow-up assessments till the end of treatment with RME. At the end of the study results showed that treatment was effective in improving sleep architecture measures: children slept longer with a lower number of stage shifts than they did before the treatment. There was also a significant improvement of respiratory parameters with a significantly lower AHI score. Thus the results indicated the efficacy of RME application in paediatric OSAS. Results also showed that at baseline, the OSAS group had a higher CAP rate during slow-wave sleep and an increased A2 index compared to normal controls. After one year of RME application, children with OSAS showed an increase in CAP rate associated with an increase of A1 index during slow-wave sleep (16).

4. Down syndrome (DS) is a genetic disorder caused by the presence of all or part of a third copy of chromosome 21. Hence it is also called as trisomy 21(20). It is by far the most well-known chromosomal disorder and also the most common one (21). It occurs one per thousand births each year(22). Those who are affected by downs syndrome nearly always have physical and intellectual disabilities(23). This syndrome has multiple systemic complication. One among them is ENT complications. Ear, nose, and throat (ENT) problems are common in individuals with Down syndrome. Some are problems with chronic ear infections and chronic middle ear effusions with associated hearing loss, airway obstruction, and sleep apnea, as well as problems with chronic rhinitis and sinusitis(24) ENT symptoms occur due to craniofacial, functional, and immune system abnormalities found in patients with Down syndrome(25).

De Moura CP et al conducted a study to assess the effects of rapid maxillary expansion on children with downs syndrome, especially in relation to the ENT effects. Phenotypical Down syndrome includes pharyngeal and maxillary hypoplasia and, frequently, constricted maxillary arch with nasal obstruction. This study was designed to include twenty four children with Down syndrome who were randomly allocated into two groups. One group received rapid maxillary expansion and the other group was the control group who did not receive treatment. Each group received ENT and speech therapy assessments before expansion and after the device had been removed. Results showed that in the rapid maxillary expansion group, the yearly ENT infection rate was reduced when assessed after device removal ($p < 0.01$). The parents of rapid maxillary expansion children reported a reduction in respiratory obstruction symptoms. Audiological assessment revealed improvements in the rapid maxillary expansion group ($p < 0.01$). Cephalometry showed increased maxillary width in the rapid maxillary expansion group. Thus it can be said that these findings are probably related to expanded oronasal space, due to rapid maxillary expansion(17).

5. Cistulli PA et al conducted a study to assess the effect of rapid maxillary expansion in OSAin young adults. Ten subjects with mild to moderate OSAS and evidence of maxillary constriction on orthodontic evaluation were chosen for the study, of which eight subjects were male and 2 female. Their mean age being 27 +/- 2 [sem] years. They also had an apnea/hypopnea index-AHI of19 +/- 4 and minimum SaO2 of 89 +/- 1%. All patients underwent treatment with RME, of which six of the subjects required elective surgical assistance.

Polysomnography was repeated at the completion of treatment. Results showed that nine of the ten patients reported improvements in snoring and hypersomnolence. There was a significant reduction in AHI (19 +/- 4 vs 7 +/- 4, $p < 0.05$) in the entire group. In seven patients, the AHI returned to normal (i.e., = < 5); only one patient showed no improvement. These preliminary data suggest that RME may be a useful treatment alternative for selected patients with OSA (13).Most studies of sleep apnea were done on children, this study is unique as it was conducted to assess effects of RME on an older age group. This study thus proved RME to be effective even when used for young adults.

IV. Conclusion

Thus,to conclude all articles point towards the improvement of various parameters of OSAS with the use of rapid maxillary expansion. Therefore rapid maxillary expansion could be an efficient and standard method of treatment for OSAS in children with narrow maxillary arch with malocclusions leading to OSAS and children with Down syndrome, and young adults with narrow maxillary arch with malocclusions leading to OSAS.RME is to be performed along with adenotonsillectomy where morphological changes are seen to improve the prognosis. However, the sequence of the two treatments is still inconclusive. RME can be used as a sole treatment for OSAS where patients have only altered morphology due to reasons like habitual mouth breathing.

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