Original Research Article

Evaluation Of Therapeutic Effect Of Rapid Maxillary Expansion On Obstructive Sleep Apnea In Adults: A Systematic Review

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ABSTRACT

A systematic review is conducted for adults with Obstructive Sleep Apnea treated with Rapid Maxillary Expansion. The objective was to evaluate the effects of various types of rapid maxillary expansion on the upper airway passage and which amongst the two types of RME is most effective in correction of OSA in adult patients. The data were obtained by clinical studies, we meant any study conducted with patients, either retrospective or prospective. The studies showing the outcomes of rapid maxillary expansion on obstructive sleep apnea in adults were included. The quality of each article was scored using an adapted version of 3 methods previously used by Fudalej and Antoszewska [25] Cozza *et al*[26] and Chen *et al*[27]. PubMed, Google Scholar and Science Direct like databases were used for to extract various studies. From the available data, we can conclude that increase in the Nasal Width is seen more in Surgically Assisted Rapid Palatal Expansion than in Miniscrew Assisted Rapid Palatal Expansion. Change in Nasal volume/area is more evident in Miniscrew Asisted Rapid Palatal Expansion than in Surgically Assisted Rapid Palatal Expansion and similarly change in nasopharynx area is more pronounced in Miniscrew Assisted Rapid Palatal Expansion than in Surgically Assisted Rapid Palatal Expansion. Apnea Hypopnea Index (AHI) decreases in both the groups i.e. Miniscrew as well as Surgically Assisted Rapid Palatal Expansion in same amount inferring that there is improvement in breathing.

Keywords: Rapid maxillary expansion, therapeutic effect, obstructive sleep apnea

INTRODUCTION

Obstructive Sleep Apnea (OSA) is a chronic sleep-related respiratory condition which is becoming more prevalent. During sleep, the pharyngeal airway narrows and becomes obstructed, resulting in OSA. It is a prevalent medical problem that affects 1% to 4% of children, with a higher frequency in boys than in girls, as well as 2% to 5% of women and 3% to 7% of men [2]. OSA develops among families, since many well-established risk variables have a hereditary basis [1-2]. The recommended treatment can alleviate symptoms and mitigate some of the related complications. However, many patients with OSA struggle with the first-line treatment, continuous positive airway pressure (CPAP), which has an unacceptably poor adherence rate. Non-CPAP treatments (for example, oral appliance therapy and upper airway surgery), lifestyle changes, particularly weight loss; pharmacological medications and surgery are effective in many patients, but their success is varied and unexpected [2]. Furthermore, maxillary expansion has been suggested in orthodontics to raise upper airway dimensions and hence reduce OSA symptoms. Overall, dental science is involved in a variety of OSA treatment modalities, including IOA, rapid maxillary expansion (RME) in children, surgically assisted rapid maxillary expansion (SARME) and Miniscrew assisted rapid maxillary expansion (MARME) in adults [3]. Therefore the main objectives of this systematic review were to evaluate the effects of various types of rapid maxillary expansion on the upper airway passage and which amongst the two types of RME is most effective in correction of OSA in adult patients.

Materials and Methods

With the objective to evaluate the therapeutic effect of rapid maxillary expansion on obstructive sleep apnea in adults, a search was performed in PubMed, Google Scholar and Science Direct, complemented by a hand search till November' 21 (Table-1). The keywords were chosen with the help of a senior librarian. To be accepted in this review, the application of rapid maxillary expansion on obstructive sleep apnea in adults should have been used in the clinical studies and mentioned in the abstracts. By clinical studies, we meant any study conducted with patients, either retrospective or prospective. The studies showing the outcomes of rapid maxillary expansion on obstructive sleep apnea in adults were included. Only articles in English were searched. Inclusion criteria were Randomized clinical trials (RCTs) and prospective and retrospective studies with concurrent untreated control groups (CCTs). Article in English language, only human clinical trial, Articles regarding the effects on upper pharyngeal passage in adult OSA patients, OSA and RME, OSA in adults and SARPE, MARPE, DOME. Exclusion criteria were Laboratory studies, descriptive studies, epidemiologic studies, case reports, case series, reviews, opinion, duplicate articles are excluded. The selection process was independently conducted by 2 researchers, and their results were compared to identify discrepancies. When the abstract did not provide enough information to make a decision, the articles were completely analyzed. Inter-examiner conflicts were resolved by discussion of each article to reach a consensus regarding all selection criteria.

Table 1: Database, method of search and number of articles retrieved

Database	Search Strategy	Limits	Results	Selected
PubMed	OSA, OSA AND RME OR effects in upper pharyngeal passage, OSA in adults AND RME, OSA in adults AND MARPE, SARPE, DOME.	English language; humans, (not reviews, letters, abstracts, meetings and editorials); till November 2021.	1020	
Google Scholar	OSA, OSA AND RME OR effects in upper pharyngeal passage, OSA in adults AND RME, OSA in adults AND MARPE, SARPE, DOME.	English language; humans, (not reviews, letters, abstracts, meetings and editorials); till November 2021.	178	
Science Direct	OSA, OSA AND RME OR effects in upper pharyngeal passage, OSA in adults AND RME, OSA in adults AND MARPE, SARPE, DOME.	English language; humans, (not reviews, letters, abstracts, meetings and editorials); till November 2021.	249	

At first, all the searched articles were screened according to their title and potentially irrelevant articles were excluded. The abstracts were then read and analyzed according to the eligibility criteria and the full-text of selected articles was precisely reviewed. The final articles were

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selected. The reviewers contacted the authors in case of insufficient data regarding the aforementioned articles. A data extraction form was designed and two reviewers filled out the form independently.

Statistical analysis

Meta-analysis was carried out with selected studies for different variables-Nasal width, Nasal Height, Nasal volume, NASOPHARYNX and IHA. Observations at baseline and post intervention were obtained for all variables. Mean improvement of each variable was calculated for all studies (as per availability). Subgroup analysis was carried out using random-effect model. Overall estimates were obtained for each variable for MARPE & SARPE (with overall outcome). 95% confidence intervals were also obtained for each estimates with p-value. Heterogeneity test was also obtained using Tau-square and I-square value. Forest plots were also obtained with meta-analysis. Comparison of mean improvement of variables between two groups was made using independent t-test.

Results

After the electronic database search, 1020 studies were retrieved from PubMed, 249 from Google Scholar, 178 from Science Direct. After application of the initial inclusion and exclusion criteria and elimination of studies indexed in more than 1 database, 154 were retrieved. The full texts were accessed and all articles with patients (age <18 years), were excluded. Therefore, 15 studies fulfilling all inclusion and exclusion criteria were included in this systematic review. From the remaining articles, we independently extracted the following data: Authors name, Year of Publication, Type of Expansion Method, Nasal width, Nasal width, Nasal volume/area, Nasopharynx and AHI index. Expansion with MARPE was evaluated in 7 studies and SARPE was evaluated in 8 studies.

Results													
Sr. No.	**Authors**	**Year of Publication**	**Type of Expansion**	**Parameters**									
				Nasal Width		**Nasal Height**		**Nasal Volume (mm3)/AREA (mm2)**		**Nasopharynx**		**AHI (events/hr)**	
				T0	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**
1.	Soo Yeon Kim *et al.* [11]	2018	MARPE	0.67	1.20	-0.15	-0.02	10,822. 6± 2700.5 mm3	1710.2 ± 881.6 mm3	-	-	-	-
2.	Qiming Li *et al.* [12]	2020	MARPE	30. (5.8)	32.9 (5.5)	36.6 (3.5)	37.0 (3.6)	18110.7 (6236.8) mm3	21036.5 (4777.8) mm3	-	-	-	-
3.	Tingting Zhao *et al.* [13]	2019	MARPE	-	-	-	-	1.35 mm2	48.25mm2	90.83 mm2	217.99 mm2	-	-
4.	Jae-Sik Hur *et al.* [14]	2017	MARPE	-	-	-	-	2.69 cm2	3.73 cm2	2.95 cm 2	4.64 cm 2	-	-
5.	Abdal Hadi Kawaiah *et al.* [15]	2020	MARPE	-	-	-	-	97.3 mm2	61.4 mm2	-	-	56/hr	22/hr
6.	Joanna Song *et al.* [16]	2020	MARPE	32.4	35	-	-	16181.9 mm3	18122.1 mm3	4879. 2mm 2	587 4.6 mm 2	-	-
7.	Daniel Paludo Brunetto [17]	2017	MARPE	-	-	-	-	-	-	-	-	7.9	1.5
8.	Kasey Li *et al.* [10]	2018	SARPE	3.7 ± 0.8	4.9 ± 1.2	-	-	-	-	-	-	31.6 ± 11.3	10.1 ± 6.3
9.	Pedro Pileggi Vinha *et al.* [18]	2020	SARPE	2.42 ± 0.31	2.99 ± 0.26	-	-	-	-	3.58 ± 1.03 cm3	4.34 ± 2.32cm3	33.23 ± 39.54	14.54 ± 19.48
10.	Pedro Pileggi Vinha *et al.* [19]	2016	SARPE	-	-	-	-	-	-	-	-	33.2 ± 39.5	14.5 ± 19.4
11.	Pedro Pileggi Vinha *et al.* [20]	2015	SARPE	-	-	-	-	-	-	348.8 mm2	338.7mm 2	-	-
12.	V.A. Pereira-Filho [21]	2014	SARPE	-	-	-	-	13,060_3697 (11,012-15,100* mm3)	15,212_5721 (12,044-18,380) mm3	-	-	-	-
13.	Stanley Yung Chuan Liu *et al.* [22]	2017	SARPE	22.7 ±4.58	27.4 ±4.7	-	-	-	-	-	-	30.9 ± 27.1	14.2 ± 9.3
14.	Tomonori Iwasaki *et al.* [23]	2020	SARPE	22.41	26.68	-	-	-	-	16.00 cm3	18.20 cm3	17.8	7.82

15.	Mohamed Abdelwahab *et al.* [24]	2019	SARPE	-	-	-	-	96.66 ±29.67	128.60 ±37.39	-	-	23.26 ± 20.86	7.54 ± 5.30

Quality assessment

After quality analysis, articles were classified as 11 as medium quality and 4 as low quality (Table V).

Table 2: Quality Assessment of the Selected Articles

Sr. No.	Authors and year of publication	Sample Design (0-3)	Sample Size (0-1)	Sample Description (0-2)	Error Analysis (0-1)	Statistical Analysis (0-2)	Quality Score (0-9)	Judged Quality Standard
1.	Soo Yoon Kim 2018 [11]	0	0	1	0	2	3	Low
2.	Qiming Li *et al*. 2020 [12]	0	1	1	0	2	4	Medium
3.	Tingting Zhao *et al*. 2019 [13]	0	0	2	0	0	2	Low
4.	Jae-Sik Hur *et al*. 2017 [14]	0	0	1	0	2	3	Low
5.	Abdal Hadi Kawaiah *et al*. 2020 [15]	0	1	2	0	2	5	Medium
6.	Joanna Song *et al*. 2020 [16]	0	1	2	0	2	5	Medium
7.	Daniel Paludo Brunetto *et al*. 2017 [17]	0	0	2	0	0	2	Low
8.	Kasey Li *et al*. 2018 [10]	0	1	2	0	2	5	Medium
9.	Pedro Pileggi Vinha *et al*. 2020 [18]	0	1	2	0	2	5	Medium
10.	Pedro Pileggi Vinha *et al*. 2016 [19]	1	1	2	0	2	6	Medium
11.	Pedro Pileggi Vinha *et al*. 2015 [20]	1	1	2	0	2	6	Medium
12.	V.A. Pereira Filho 2014 [21]	0	1	2	0	1	4	Medium
13.	Stanley Yung Chuan Liu *et al*. 2017 [22]	1	1	2	0	1	5	Medium
14.	Tomonori Iwasaki *et al*. 2020 [23]	0	1	2	0	2	5	Medium
15.	Mohamed Abdelwahab *et al*. 2019 [24]	0	1	2	0	2	5	Medium

It was observed that there isn't enough evidence available to compare all the parameters of expansion methods. Most of the studies performed have considered only one of the parameter and has assessed its effects on adult OSA patients. The most commonly affected parameter is nasal volume/area and the AHI index. Different studies showed different changes in different parameters which were taken into consideration. Most of them concluded that it does depend on the method of expansion for its changes in nasal width, height, volume and AHI index. According to each criterion for quality analysis, the following results were obtained:

- **Study design:** Only 4 studies were prospective clinical trial and rest were retrospective studies described in detail.
- **Sample size:** The authors of all the 11 studies performed sample-size calculation or had sample sizes larger than or equal to 15 patients.
- **Selection description:** 12 studies gave proper sample description including age, sex, expansion method used, OSA etc.

- **Error analysis:** None of the studies performed and described the method error results.
- **Statistical analysis:** The authors of 11 studies performed detailed analysis.

Discussion

Patients with OSA struggle with the first-line treatment, continuous positive airway pressure (CPAP), which has an unacceptably poor adherence rate, while on other hand Non-CPAP treatments (for example, oral appliance therapy and upper airway surgery), lifestyle changes, particularly weight loss; pharmacological medications and surgery are effective in many patients, but their success is varied and unexpected 2. Furthermore, maxillary expansion has been suggested in orthodontics to raise upper airway dimensions and hence reduce OSA symptoms. The purpose of this systematic review is to evaluate the therapeutic effect of rapid maxillary expansion on obstructive sleep apnea in adults on basis of scientific evidences from the existing literature on all the peer-reviewed orthodontic journals according to the Cochrane collaboration principles. In a systematic review, it is important to evaluate the quality of the articles and allow inclusion of better quality articles in the systematic review to decrease the heterogeneity among them, with the goal of presenting more reliable data. In health field investigations, which involve patient treatments, significant degrees of clinical, methodological and statistical heterogeneity are expected because of the nature of these studies and the different variables involved and the entire systematic review project must address this issue [28]. Pedro Pileggi Vinha [19] conducted a prospective clinical trial for to evaluate the effects of surgically assisted rapid maxillary expansion (SARME) on obstructive sleep events and daytime sleepiness in adults with obstructive sleep apnea syndrome (OSAS), and he confirmed it with full-night polysomnography (PSG) after SARME that there is decrease in AHI from 33.2±39.5 to 14.5±19 [4]. Events/hr and these findings concur with that of Abdal Hadi Kawaiah *et al.* [15] where he studied the effects of MARPE on Adult OSA patients found out that by application of MARPE, AHI Index decreased from 57 events/hr to 22 events/hr and nasal area reduced from 97.3 mm 2 to 61.4 mm 2. Similarly in another article by author Pedro Pileggi Vinha [20] where he aimed to determine whether surgically assisted rapid maxillary expansion (SARME) would promote pharyngeal enlargement in adults or not and found out that area of nasopharynx decreased from 348.8 mm 2 to 338.7 mm 2 and these findings did not concur with that of Joanna Song *et al.* [16] where after MARPE treatment using CBCT imaging confirmed that nasopharynx area increased from 4879.2 mm 2 to 5874.6 mm 2, nasal width increased from 32.4 to 35 mm and nasal volume increased from 16181.9 mm 3 to 18122.1 mm 3. Kasey Li *et al.* [10] in his retrospective study aimed to evaluate the results of an endoscopically-assisted surgical expansion (EASE) in expanding the maxilla for to treat obstructive sleep apnea (OSA) in adolescent and adults, where he took thirty three adult patients with OSA, maxillary transverse deficiency and narrow pharyngeal passage and found out that apnea hypopnea index (AHI) improved from 31.6±11.3 to 10.1±6.3 events/hr by improving nasal breathing and OSA by widening the nasal floor. Similarly, Pedro Pileggi Vinha *et al.* [18] investigated about the changes induced by surgically assisted rapid maxillary expansion (SARME) on palate and pharynx morphology and the correlation of these changes with the improvement of obstructive sleep apnea (OSA) by taking sixteen adult OSA patients with reduced transverse maxillary width and found out that nasal width increased from 2.42 ± 0.31mm to 2.99 ± 0.26mm, nasaopharynx area increased from 3.58 ± 1.03 cm3 to 4.34 ± 2.32 cm3 and AHI index reduced from 33.23 ± 39.54 to 14.54 ± 19.48 events/hr concluding that there is transverse maxillary widening along with palatal lowering thus reducing OSA and expanding the airway. Stanley Yung-Chuan Liu *et al.* [22] reported that nasal width increased from 22.7 ± 4.58mm to 27.4 ± 4.7mm and AHI index reduced from 30.9 ± 27.1 to 14.2 ± 9.3 events/hr after using DOME concluding that it widens the maxilla of adult OSA patients having the high arched palate and normal occlusion and similar to this were the findings by Tomonori Iwasaki *et al.* [23] where he used rhinomanometry augmented computational fluid dynamic (CFD) modeling, in adult subjects with OSA who were intolerant of continuous positive

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airway pressure (CPAP) or oral appliance therapy and concluded that nasal width increased from 22.41mm to 26.68mm, nasopharynx volume increased from 16 to 18.20 cm 3 and AHI index decreased from 17.8 to 7.82 events/hr concluding that it contributes to reduction of OSA severity by expansion in maxilla. Mohamed Abdelwahab *et al.* [24] assessed the effect of distraction osteogenesis maxillary expansion on the internal nasal valve's objective parameters and correlated its findings with subjective outcomes reported that nasal volume increased from 96.66 ±29.67 to 128.60 ± 37.39 and AHI index decreased from 23.26 ± 20.86 to 7.54 ± 5.30 events/hr inferring that DOME objectively widens the internal nasal valve and it is significantly correlated with subjective improvements (NOSE scores). V.A. Pereira-Filho 21 evaluated the volume changes in the upper airway with Cone beam computed tomography (CBCT) volumetric images at three predefined time points after SARPE and found that nasal volume increased from 13,060 ± 3697 (11,012-15,100 mm 3) to 15,212 ± 5721 (12,044-18,380) mm3 and Qiming Li *et al.* [12] evaluated the changes in dimensions and volume of upper airway before and after mini implant assisted rapid maxillary expansion (MARME) and observed change of increase in nasal width from 30.6 (5.8) to 32.9 (5.5) mm, nasal height from 36.6 (3.5) to 37 (3.6) mm and nasal volume from 18110.7 (6236.8) mm3 to 21036.5 (4777.8) mm 3 leading to expansion of nasal osseous width and maxillary width. Enlarged nasal width at the PNS plane contributed to the increase in nasopharynx volume but the Enlarged maxillary width showed no direct relation with increased volume yet it was unclear about the association between changes of the upper airway and vertical skeletal pattern because of complex structures. Jae-Sik Hur *et al's.* [14] investigated about the effects of miniscrew assisted rapid palatal expansion (MARPE) on the changes in airflow in the upper airway (UA) of an adult patient with obstructive sleep apnea syndrome (OSAS) using computational fluid-structure interaction analysis found out that there is an increase in nasal volume from 2.69 cm2 to 3.73 cm2 and nasopharynx area increased from 2.95 cm2 to 4.64 cm2 concluding that it improves airflow and decreases resistance in UA and hence it is an effective treatment modality for adult patients with moderate OSAS. Soo Yoon Kim [11] evaluated changes in the volume and cross-sectional area of the nasal airway before and 1 year after nonsurgical minis crew-assisted rapid maxillary expansion (MARME) in fourteen young adults and found out an increase in nasal height from 0.67 to 1.20mm, nasal width decreased from -0.15 to 0.02mm and increased nasopharynx area from 10,822.6± 2700 [5]. mm3 to 1710.2 ± 881.6 mm3 demonstrating that the volume and cross-sectional area of the nasal cavity increased after MARME and were maintained at 1 year after expansion. Tingting Zhao *et al.* 2019 [13] studied the effects of maxillary skeletal expansion on upper airway airflow through computational fluid dynamics analysis and concluded that nasal volume area increased from 1.35 mm2 to 48.25 mm2 and nasopharynx area increased from 90.83 mm2 to 217.99 mm2 showing significant increase in the pharyngeal cross sectional area together with reduction in upper airway resistance in the nasal cavity and similarly Daniel Paludo Brunetto 17 demonstrated a MARPE technique on adult patient as an interesting alternative to SARPE that showed decrease in AHI index from 7.9 to 1.5 events/hr inferring that it has important occlusal and respiratory benefits following the procedure, without requiring any surgical intervention.

CONCLUSION

Even though there are insufficient studies in the existing literature regarding the effects of Miniscrew Assisted Rapid Palatal Expansion (MARPE) and Surgically Assisted Rapid Palatal Expansion (SARPE) on adult patients with Obstructive Sleep Apnoea (OSA); we can conclude from the available data that increase in the Nasal Width is seen more in Surgically Assisted Rapid Palatal Expansion than in Miniscrew Assisted Rapid Palatal Expansion. Change in Nasal volume/area is more evident in Miniscrew Assisted Rapid Palatal Expansion than in Surgically Assisted Rapid Palatal Expansion and similarly change in nasopharynx area is more pronounced in Miniscrew Assisted Rapid Palatal Expansion than in Surgically Assisted Rapid Palatal Expansion. Apnoea Hypopnoea Index (AHI) decreases in both the groups i.e. Miniscrew as well as Surgically Assisted Rapid Palatal Expansion in same amount inferring that there is improvement in breathing.

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