INTEGRATIVE JOURNAL OF MEDICAL SCIENCES
ISSN: 2658-8218
MBMJ

2022, Volume 9, ID 609
DOI: 10.15342/ijms.2022.609

REVIEWS

Orthodontic management of Obstructive Sleep Apnea : A Systematic Review

Ahlam Assali, Houda Neani, Loubna Bahije, Fatima Zaoui, Abdelali Halimi
Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dentistry, Mohammed V University, Rabat, Morocco

ABSTRACT
Background: Obstructive Sleep Apnea (OSA) is considered a real public health problem, often unrecognized or underdiagnosed, requiring multidisciplinary care, including orthodontics that plays an essential role in the screening and managing ventilation. **Objective:** Our study aims to explain the vital place of orthodontic therapies, whether orthopedic or surgical, in the multidisciplinary management of OSA and the improvement of nasal breathing through a systematic review
Material and methods: The literature search was performed in the following databases: PubMed, Science Direct, and Cochrane Library. The investigation was limited to publications written in English and French from 2010 to January 2022.
Results: Based on the keywords, eighty-three references were initially identified. After eliminating duplicates, the number of articles was reduced to seventy-nine. Studying the titles and abstracts made it possible to select fifty articles. After reading the complete text, sixteen publications were included in this systematic review. Eight studies have investigated rapid maxillary expansion (RME), five have evaluated mandibular advancement (MA), and three have investigated the effect of genioplasty in children with OSA. **Conclusion:** The orthodontic arsenal is well suited and highly beneficial for OSA treatment, whether orthopedic, orthodontic, or surgical correction of jaws.
KEYWORDS: Obstructive sleep apnea, Rapid maxillary expansion, Mandibular advancement appliance, Genioplasty, Upper airway, Children.

Correspondence: Dr Ahlam Assali, Address : Orthodontics and Dentofacial Orthopedics department, Mohamed V university, Allal El Fassi Avenue, Mohammed Jazouli Street, Al Irfane - BP 6212 Institut Rabat, Morocco.
Email: ahlaamassalii@gmail.com

INTRODUCTION

Obstructive sleep apnea (OSA) is an increasingly common pediatric, chronic disease defined by the American Academy of sleep medicine as a sleep-related breathing disorder characterized by repetitive episodes of complete or partial upper airway obstruction leading to a short-term cessation of ventilation or significant reduction of airflow during sleep. (1, 2)

The prevalence of OSA among children is defined to be ranging from 1% to 4% (3, 4). However, some risk factors include obesity, increasing age, craniofacial morphology, genetics, and syndromes… It may induce a reduction of pharynx size or a rise in airway collapsibility, which leads to a higher prevalence of the pathology (5). The severity of obstructive sleep apnea is classified based on the AHI (Apnea-Hypopnea Index). Categories are mild (AHI between 5 and 15), moderate (AHI between 15 and 30), and severe (AHI superior to 30). (6),(7)

Because of its complications and impact on children's quality of life, OSA is considered a real public health problem, often unrecognized or underdiagnosed. Requiring multidisciplinary care, including orthodontics, plays an essential role in screening the pathology through its craniofacial manifestations, and secondly, helping improve ventilation thanks to a sizeable therapeutic arsenal ranging from orthopedics to orthognathic surgery. Our study aims to explain the important place of orthodontic therapies, whether orthopedic or surgical, in the multidisciplinary management of OSA and the improvement of nasal breathing through a systematic review.

MATERIALS AND METHODS

Research strategy:

The systematic search was performed based on an electronic search of several databases (Pub Med, Science Direct, Cochrane Library) covering publications from 2010 to 2021. The search was made with reference to the acronym PICOS and limited to the following keywords in English and French: orthodontics AND obstructive sleep apnea AND children (table1)

Selection criteria :

Inclusion criteria: - Articles published from 2010 to 2021; - Full text accessible; - Articles published in English or French; - Original article, prospective, retrospective, longitudinal or cross-sectional studies, cohort study, case-control study, randomized control trials; - Growing patients with OSA ; - Conventional orthodontic, orthopedic, or surgical treatment.

Exclusion criteria:

- A case reports; - Literature revues; - Studies including the only patient who have been removed third molars; - Studies with unclear outcomes of interest

Quality assessment:

- The selected articles were scored based on the proposed criteria "National Institutes of Health, Department of Health and Human Services, USA (8). The risk of bias in studies was assessed independently by the authors. Any disagreement was resolved by discussion with the examiner. Among the criteria used by these authors, we find sample randomization, comparison between the effects of the intervention, validation of measures, inclusion and exclusion criteria, and statistical analysis. Regarding the risk of bias for each study analyzed, the documents containing all the points mentioned above (9-13) were rated as "low risk," those for which the number of points in between (6-8) was rated as "medium risk," a high risk "is assigned to studies that meet or less than five criteria.

In studies that investigated rapid maxillary expansion: The risk of bias was considered low in five studies and medium in three studies (Table 2).

In studies who investigated mandibular advancement: The risk of bias was considered low in the five studies (table 3).

In studies who investigated genioplasty: The risk of bias was considered low in one study and medium in two others. (Table 4).

RESULTS

- Based on the keywords, 83 bibliographical references were initially identified. After eliminating duplicate references, the number of articles was reduced to 79. Studying the titles and abstracts made it possible to select 50 articles. After reading the complete text, 16 articles were included in this systematic review.
- Eight studies have investigated rapid maxillary expansion (Table 5), five studies have evaluated the effect of mandibular advancement (Table 6), and three studies have investigated the impact of genioplasty in children with OSA (Table 7).

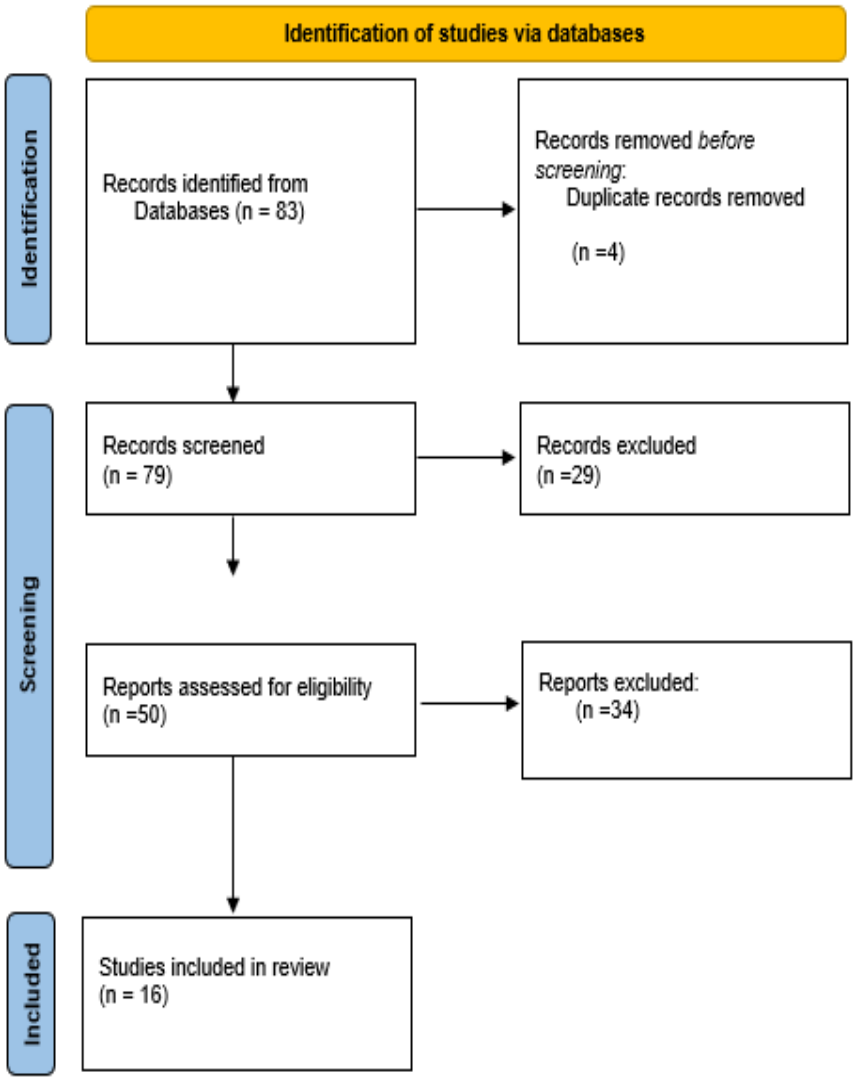

Figure 1: Flow diagram demonstrating literature search, study inclusion and exclusion

Population	Growing patients
Intervention	Rapid maxillary expansion (RME), Mandibular advancement (MA), Genioplasty
Comparaison	Before and after rapid maxillary expansion, mandibular advancement, and genioplasty in OSA children
Out come	Breathing improvement following rapid maxillary expansion, mandibular advancement, and genioplasty treatment in children with OSA
Studies	Comparative studies: clinical trials, retrospective studies, cohort studies…

Table 1: PICO question

Quality assessement	Pirelli and al. 2015	Villa and al. 2015	Fatsuca and al. 2015	Villa and al. 2014	Caprioglio and al . 2014	Marino and al. 2012	Guilleminault and al. 2013	Villa and al. 2011
Research question	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Study population	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Groups recruited from the same population and uniform eligibility criteria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Justification of sample size	No	No	No	No	No	No	No	No
Exposure assessed before measurement of results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sufficient time to see an effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Different exposure levels of interest	NA	NA	NA	NA	NA	NA	NA	NA
Exposure measurements and assessment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Repeated exposure assessment	Yes	Yes	Yes	Yes	No	Yes	No	No
Outcome measures	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blinding of exposure assessors	No	No	No	No	No	No	No	No
Follow-up rate	No	No	No	No	NA	No	NA	NA
Statistical analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Results	9	9	9	9	8	9	8	8

Table 2 : Quality criteria of included studies about rapid maxillary expansion

Quality assessement	Schutz and al 2011	Zhang and al 2013	Machado-Junior and al 2016	Idris G. and al 2018	Modesti-Vedolin and al 2018
Research question	Yes	Yes	Yes	Yes	Yes
Study population	Yes	Yes	Yes	Yes	Yes
Groups recruited from the same population and uniform eligibility criteria	Yes	Yes	Yes	Yes	Yes
Justification of sample size	No	No	No	No	No
Exposure assessed before measurement of results	Yes	Yes	Yes	Yes	Yes
Sufficient time to see an effect	Yes	Yes	Yes	Yes	Yes
Different exposure levels of interest	NA	NA	NA	NA	NA
Exposure measurements and assessment	Yes	Yes	Yes	Yes	Yes
Repeated exposure assessment	Yes	Yes	Yes	Yes	Yes
Outcome measures	Yes	Yes	Yes	Yes	Yes
Blinding of exposure assessors	NA	NA	NA	NA	NA
Follow-up rate	No	No	No	No	No
Statistical analysis	Yes	Yes	Yes	Yes	Yes
Results	9	9	9	9	9

Table 3 : Quality criteria of included studies about mandibular advancement

Quality assessement	Frapier L. and al 2010	Frapier L. and al 2011	Bedoucha V. and al 2015
Research question	Yes	Yes	Yes
Study population	Yes	Yes	Yes
Groups recruited from the same population and uniform eligibility criteria	Yes	Yes	Yes
Justification of sample size	No	No	No
Exposure assessed before measurement of results	Yes	Yes	Yes
Sufficient time to see an effect	Yes	Yes	Yes
Different exposure levels of interest	NA	NA	NA
Exposure measurements and assessment	Yes	Yes	Yes
Repeated exposure assessment	Yes	No	No
Outcome measures	Yes	Yes	Yes
Blinding of exposure assessors	NA	NA	NA
Follow-up rate	Yes	No	No
Statistical analysis	Yes	Yes	Yes
Results	10	8	8

Table 4 : Quality criteria of included studies about genioplasty

Rapid maxillary expansion (RME) :

Author	Study design	Objective	Patients	Methods	Outcomes analysed	Results
Pirelli and al. 2015 (9)	Prospective case series (non-randomized study)	To evaluate the long-term efficacy of rapid maxillary expansion (RME) in a group of children with obstructive sleep apnea (OSA).	-31 Caucasian children -Mean age: 8.68 years (range: 6–12 years)	An ambulatory PSG and Computerized tomography (CT) imaging were performed at entry and at final evaluation	AHI, LSAT	-PSG showed a change in the mean AHI from 12.20 ± 2.6 to 0.4 ± 1.6 and oxygen saturation from 78.9 ± 8.6% to 95.1 ± 1.9% - CT imaging confirmed the stability and maintenance of the anatomical changes induced by the orthodontic treatment
Villa and al. 2015 (10)	prospective case control	-To confirm the efficacy of rapid maxillary expansion in children with OSA -To evaluate retrospectively its long-term benefits in a group of children who underwent orthodontic treatment 10 years ago	-40 patients - Mean age : 6.2+/- 1.7(range 4 - 10 years)	-Cephalometric evaluation before 12 months of therapy with RME(T0) - Polysomnographic assessment after RME (T1) - Questionnaire and clinical evaluation, 10 years after the end of treatment (T2)	AHI, LSAT	- The AHI decreased significantly from T0 to T1 (4.7 ± 4.4 ev/h vs 1.6 ± 1.4 ev/h) - Mean overnight oxygen saturation (96.8 ± 1.5% vs 97.5 ± 1.8%) increased significantly. - At T2 : Night-time and daytime symptoms were decreased compared to T0 but they were not modified by the end of the treatment through the following 10 years.
Fatsuca and al. 2015 (11)	prospective case series	To evaluate changes in airway volume and respiratory performance in patients undergoing RME	-15 patients -mean age : 7.5 +/- 0.3 years	-cone beam computed tomography and polysomnography examination before rapid maxillary expansion and after the removal of the maxillary expander 12 months later	AHI, LSAT	- The upper, middle, and lower airway volumes were significantly increased 2305 mm3, 1144 mm3, and 1915 mm3, respectively. Similarly, oxygen saturation was increased (+5.3%) and AHI was improved (-4.2 events).
Villa and al. 2014 (12)	prospective case control	-To evaluate the outcome of surgical treatment (Adenotonsillectomy : AT) and of orthodontic treatment (application of endo-oral rapid maxillary expansion) in children with OSA	-52 patients →25 children underwent AT (group 1) and 22 children underwent RME by an endo-oral device applied (group 2) and 5 children underwent both treatments (group 3)	All the groups underwent a PSG at the baseline, before either surgical or orthodontic treatment (T0) and 1 year after treatment (T1)	AHI, MSAT	Both treatments help to improve OSA: Group 1: AHI (ev/h) decreased from 17.25±13.94 (T0) to 1.79±1.82 (T1) and Mean overnight oxygen saturation (%) increased from 96.11±2.68 (T0) to 97.50±1.14 (T1) Groupe 2 : AHI (ev/h) decreased from 5.81±6.05 (T0) to 2.64±3.11 (T1) and Mean overnight oxygen saturation (%) increased from

			- mean age 5.03±2.03 years			96.56±1.47 (T0) to 97.42±1.84(T1) -Subjects who underwent RME treatment were found to have a higher posttreatment AHI than those who underwent AT even though they had a mild form of disease prior to treatment
Capriogl io and al . 2014 (13)	Prospectiv e study	To investigate the effects of RME on the airway correlating airway volumes computed on CBCT and PSG examinations (SpO2 and AHI) in patients with OSA	-22 caucasian patients -Mean age : 7.1 +/- 0.6 years	-Cone beam computed tomography scans and polysomnography exams were collected before placing the appliance (T0) and after 12 months (T1).	AHI – Oxygen saturation- total airway volume	-Significant improvement in the AHI from 5.7 +/-1.2 (T2) to 1.4 +/- 0.6 (T1) -significant increases of total airway volume -significant increases of total oxygen saturation from 89.8%+/- 1.1(T0) to 95.5% +/-1.6 (T1)
Marino and al. 2012 (14)	retrospecti ve case series (Randomiz ed control trial)	to evaluate the effects of rapid maxillary expansion (RME) in a group of OSAS preschool children	-15 children (8 boys and 7 girls) -mean age: 5.94 ± 1.64 years	Lateral cephalograms were analysed at the start of treatment with RME (T0). All subjects were revaluated after a mean period of 1.57 ± 0.58 years (T1).	AHI-CEPHALOGR AM	-24.8% reduction in AHI - significantly increase in SNA and SNB angle - OSAS preschool children with retrognathic jaws could benefit from RME treatment
Guillem inault and al. 2011 (15)	retrospecti ve case control (Randomiz ed control trial)	To investigate the effects of RME in a group of OSAS children	-31 children - mean age :6.5± 0.2 years	-All children had a night of nocturnal recording at entry and after each treatment phase (polysomnograph y)	AHI ,LSAT	Before RME : AHI of 7.9+/-3.2 (ev/h) and lowest SaO2 % of 93.9+/- 1.4 After RME : AHI of 3.1+/- 2.3 (ev/h) and lowest SaO2 % of 97.0 +/- 1.1
Villa and al. 2011 (16)	prospectiv e case series	To evaluate the long-term outcome in the same group of young children with dental malocclusions and OSA syndrome (OSAS) successfully treated with RME	-14 children - mean age : 6.6±2.1 years	- an overnight polysomnography at the baseline (T0), after 1 year of treatment(T1) and 24 months after the end of the orthodontic treatment using RME (T2)	AHI, MSAT	- AHI (n/h) 6.3±4.7 (T0) ,2.4±2.0(T1) , 2.3±1.7 (T2) - SaO2 (%) 95.8±1.8 (T0) 97.0±2.8(T1) 97.7±1.0 (T2) - RME may be a useful approach in children with malocclusion and OSAS, as the effects of such treatment were found to persist 24 months after the end of treatment

Table 5 : results of studies investigating rapid maxillary expansion

AHI, apnea-hypopnea index; SaO2 oxygen saturation ,LSAT, lowest oxygen saturation; MSAT,mean oxygen saturation

Mandibular advancement :

Author	Study design	Objective	Patients	Methods	Outcomes analysed	Results
Idris G. and al 2018 (17)	Crossover randomized controlled trial	To test the short-term effectiveness of a mandibular advancement splint (MAS) for the management of OSA in children	-18 children -mean age: 9.8+/-1.1years →9 Children had a mandibular advancement appliance: →9 children : Control group (did not undergo any type of treatment for OSAS)	-Twin-Block was chosen as the active intervention -Home-based polysomnographic data were collected before and after each treatment period	AHI, minSaO2, SQ	-significant decrease of AHI from 2.8 +/- 3.0 to 1.9+/- 2.1(ev/h) -MinSaO2 showed a significant increase (+3.4%) from 85.4%+/-11.3 to 90.6%+/-5.2 compared to control group -PSQ scores descreased -Quality of life improved
Modesti - Vedolin and al 2018 (18)	Non randomized clinical trial	To evaluate the treatment efficacy of a mandibular advancement intraoral appliance (MOA) for treatment of obstructive sleep apnea syndrome (OSAS) in children	-18 children -mean age : 8.39 years old (range : 5-12 years)	obstructive sleep apnea syndrome evaluation by a portable monitoring device before and after treatement	- RDI- blood oxygen saturation (SpO2)	-The mean RDI reduced significantly in all patients (55%) -The average oxygen saturation had a significant reduction -SpO2 significantly increased in 7.6% after the MOA use -sleep quality improved
Machado-Junior and al 2016 (19)	randomized controlled prospective clinical trial	to evaluate mandibular advancement appliance in children with OSA	-16 children →8 Children had a mandibular advancement appliance : -mean age: 8.13±0.99 years →8 children : Control group (did not undergo any type of treatment for OSAS)	polysomnography before and after 12 consecutive months of use of the mandibular advancement devices for both the experimental and the control subgroup	AHI	AHI decreased from 1.66 ± 0.28 to 0.30 ± 0.23in one year after implementing use of mandibular advancement devices, in comparison with the group that did not use these devices.
Zhang and al 2013 (20)	non-randomized controlled trial (prospective)	to investigate the effects of twin block (TB) appliance on children with OSA and mandibular retrognathia	-46 children -Mean age : 9.7±1.5 years	-Patients were instructed to wear the twin block oral appliance. -The efficacy of treatment was determined by monitoring the PSG and cephalometric changes before and after appliance removal.	-AHI, LSAT (minSaO2), airway space -cephalogram	-Significant decrease of AHI from 14.08±4.25 to 3.39±1.86 -Lowest SaO2 increased significantly from 77.78 ± 3.38 to 93.63 ± 2.66 - A significant increase in the superior posterior airway space, middle airway space

						-Increase of SNB (°) from 76.40±3.12 to 79.02±2.77
Schutz and al 2011 (21)	non-randomized controlled trial (prospective)	To examine modifications in sleep pattern and in craniofacial morphology of young patients with mandibular retrognathism and OSA	-16 subjects -mean age : 12.6 years +/- 11,5 months (range : 9 to 14 years of age)	- Two radiographs in an upright position were taken for each patient: before and 12 months after Herbst treatment -four PSGs: adaptation night, baseline, after 5 months (before additional sagittal advancement), and 12 months after Herbst treatment -Magnetic resonance imaging (MRI) before and after treatment.	-AHI ,RDI - SQ -airway space -Cephalogram	-AHI decreased from 4.8±4.2 to 1.3±1.8 -Significant reduction in RDI from 7.3 ± 5.6 to 1.3 ± 1.8 , sleep architecture improved, and a total increase in airway volume -SNB angle increased (2.50°) -ANB angle diminished by 2.6° compared to pretreatment values.

Table 6 : results of studies investigating mandibular advancement

AHI, apnea-hypopnea index; SaO2 oxygen saturation ,LSAT, lowest oxygen saturation; MSAT,mean oxygen saturation, RDI, respiratory disturbance index,SQ,Sleep Questionnaire

Genioplasty

Author	Study design	Objective	Patients	Methods	Outcomes analysed	Results
Bedoucha V. and al 2015 (22)	comparative retrospective study	to evaluate the development of the oropharyngeal structures in young hyperdivergent patients with OSA who had undergone functional genioplasty	24 patients average age of 11 years 11 months	cephalometric measurements of the oro- and nasopharyngeal zones before and after genioplasty	- cephalogramm	-genioplasty led to significantly greater projection of the symphysis -a significantly greater increase in the velopharyngeal space
Frapier L. and al 2011 (23)	prospective study	to determine whether combined functional genioplasty and orthodontic treatment can be beneficial in management of oral ventilation	-25 patients -Mean age 14.6 +/- 1.4 years	The functional before-after impact of genioplasty was examined in a clinical setting using polysomnography	-SQ - AHI -SpO2 cephalogram	-Three to 6 months after genioplasty, the mode of ventilation shifted significantly from oral to nasal - Respiratory events and sleep pattern became normal - AHI decreased from 1.8 (0.1–6) to 1.5 (0–5.6) - It improves the obstructive disorder and its manifestations during sleep
Frapier L. and al 2010	prospective	to assess whether genioplasty	-25 patients	Cephalometric Comparison was made on the	Cephalogramm (SNB,ANB)	Genioplasty performed during the growth promotes

(24)	monocentric study (comparative prospective study)	performed at an earlier age can impact mandibular growth in children with OSA	- mean age: 14.6 +/- 1.4 years	overall population ,before and after genioplasty (at 1, 6, 12 and 18 months) .		change in the direction of mandibular growth towards anterior rotation with a sagittal gain, which is beneficial for increasing pharyngeal dimension and improvement of ventilation.

Table 7 : results of studies investigating genioplasty

AHI, apnea-hypopnea index; SaO2 oxygen saturation , SQ,Sleep Questionnaire

DISCUSSION

Obstructive Sleep Apnea (OSA) is a common sleep disorder with a profound effect on health and quality of life.

Moreover, this disease induces several craniofacial modifications, such as the adenoidal face, long face syndrome, narrower maxilla, deeper palatal height, retrusive mandible, deficient chin.

Thus, orthodontists should be aware of craniofacial manifestations of this disorder and competent enough to recognize its signs and symptoms. Furthermore, orthodontic arsenal, whether orthopedic or surgical correction of jaws, is well suited and highly beneficial for OSA treatment, thanks to their expertise and knowledge regarding the growth and development of orofacial and dentofacial structures. Our study aims to explain the critical place of orthodontic therapies, including rapid maxillary expansion, mandible advancement, and genioplasty, in the multidisciplinary management of OSA and the improvement of nasal breathing through a systematic review.

- **Rapid maxillary expansion**

Rapid maxillary expansion is an effective orthopedic-orthodontic therapy for skeletal transversal maxillary constriction in young patients, aiming to increase maxillary width by opening the mid-palatal suture and lateral displacing the maxillary bones. Besides its effects on the maxillary bone, the rapid maxillary expansion also affects the surrounding front maxillary, zygomaticomaxillary, zygomaticotemporal, and pterygopalatine sutures. An increase in nasal cavity width is observed, and a decreased nasal resistance and improved airflow. (25, 26)

The relationship between rapid maxillary expansion and the decrease of IAH remains unclear because only limited studies have evaluated this treatment for its efficacy in ameliorating OSAS symptoms.

Caprioglio et al. in 2014 (13), through their three-dimensional investigation of the upper airway, found that RME treatment was effective in increasing pharyngeal airway and MSV in patients with bilateral maxillary deficiency the same for Erdur and Al (27) in 2020, Almuzian and Al en 2015 (28). Lin and AL in 2020 (29) carried out a meta-analysis including 14 studies since 2018 to compare the effectiveness of all interventions in pediatric OSA's resolution. They reported that rapid maxillary is helpful in the improvement of breathing and hypoxemia. Pirelli and Al (9) in 2015 have investigated the effect of rapid maxillary expansion in 31 children with OSA involving a narrow maxilla, and they reported after 12 months follow-up that into adulthood present they still present stable, long-term results post RME treatment for pediatric OSA in accordance with Villa and al in 2015 (10), and Fatsuca and al. 2015 (11)

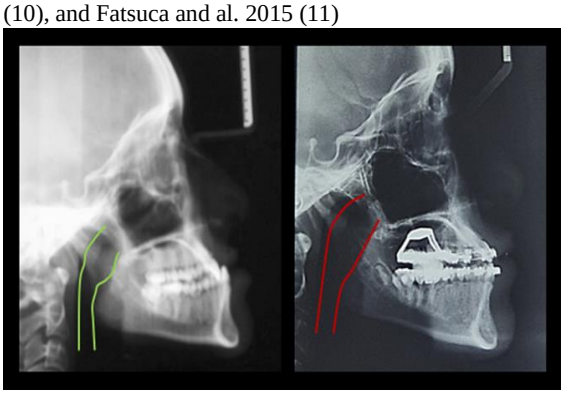

Figure 2 : Headfilms before and ongoing orthodontic treatment following rapid maxillary expansion

- **Mandibular advancement:**

Obstructive sleep apnea is often associated with a retrognathic mandible responsible for narrowing the upper airway. Therefore, functional appliances used to treat children with skeletal cl II due to mandibular retrognathism can also benefit OSA management. They put the mandible in a forward position. These functional appliances are removable intra-oral devices that alter the muscular forces against the teeth and respective basal bones. This altered neuro-muscular action affects bony growth and occlusal development. It's considered mandibular advancement devices frequently used to treat adult OSA to prevent the collapse between the oropharynx and tongue during sleep.

Functional appliances may lead to variable effects on the dentoalveolar and skeletal structures. However, The Herbst appliance is the most commonly used for stimulating mandibular growth. When the mandible grows forward, the tongue is displaced anteriorly either directly by the forward movement of the muscle or indirectly by advancing the mandible and moves away from the soft palate, which undergoes dimensional and angular changes such as the increase in the oropharyngeal depth and thickness increasing the airway space and to facilitate the superior respiratory system, reduced snoring and im¬proved airflow (30, 31, 32)

Through the years, numerous studies have aimed to investigate the effectiveness of skeletal class II functional

appliances in the resolution of OSA. Among them, Villa and Al in 2002 (33) compared an active oral appliance group with six months follow up to no treatment group and. they consecutively found favorable results in the treated group for apnea/hypopnea index, night-time symptoms (habitual snoring, restless sleep) and daytime symptoms (sleepiness, irritability, tiredness, oral breathing).

Idriss and Al in 2016 (17) have investigated the effects of an oral appliance (OA), with and without mandible advance, in the treatment of obstructive sleep apnea syndrome (OSA) and reported that mandibular advancement in children by oral appliances offers an effective treatment for OSA . these results are in agreement with those of Blanco and Al in 2005 (34) Cozza and Al in 2004 (35), Kim and Al in 2014 (36) Serra-Torres and Al in 2016 (37)

Vedolin and Al in 2018 (18) assessed mandibular advancement in 18 young children with OSA. They found out that intra¬oral appliance has demonstrated to be ef¬fective in the reduction of obstructive sleep apnea and sleep bruxism in a pediatric population with no worsening in signs and symptoms of temporomandibular disorders in accordance with the study of Yanyan and Al in 2019 (38) who carried out a meta-analysis which agreed with the results of the previous studies and showed supportive evidence for MAA treatment in pediatric mild to severe OSA.

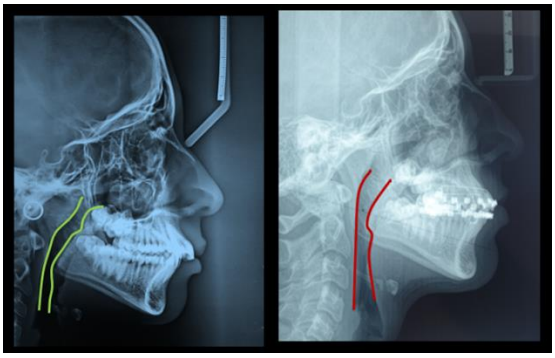

Figure 3 : Headfilms before and ongoing orthodontic treatment following mandibular advancement

- **Genioplasty :**

In moderate forms of OSA early ENT, physiologic and orthopedic management can offer a favorable prognosis and effective results. However, when the disease is more severe and more challenging, with a very pronounced vertical pattern and complex lip seal without labial and chin muscle hyperactivity, genioplasty can provide an adjunct to orthodontic treatment for the correction of mandibular vertical excess. Early genioplasty performed during growth can improve esthetic and functional results and provide stability as it encourages spontaneous lip closure without excessive demands on the peri-oral muscles, particularly the mentalis. (24) It also helps the switch from mouth breathing to nasal breathing if tongue posture, both at rest and functionally, is normal and if ENT problems are eliminated. It is also important to link early genioplasty with maxillofacial rehabilitation to improve the tone and elevation of the genioglossus muscle. (39). Nevertheless, two factors seem to be particularly important to study when deciding to implement genioplasty: Direction of the osteotomised fragment shifting and the amount of advancement (40)

According to several studies, genioplasty significantly reduces the apnea-hypopnea index in adults suffering from mild to moderate OSA. However, the role of genioplasty in improving children's breathing is limited. It derives only from a few assessments such as Bedoucha and Al in 2015(41), who state that early genioplasty performed during growth can help correct nasal breathing by the recalibration of the upper airway at the oropharyngeal level. This is consistent with Frapier et al. 2011 (23) and Chamberland et al.2015(42).

Frapier and Al in 2010 (24) and 2011 (23), reported that genioplasty performed during the growth promotes change in the direction of mandibular growth towards anterior rotation with a sagittal gain, which is beneficial for increasing pharyngeal dimension and improvement of ventilation, Chamberland and al. reported same results in 2015 (42).

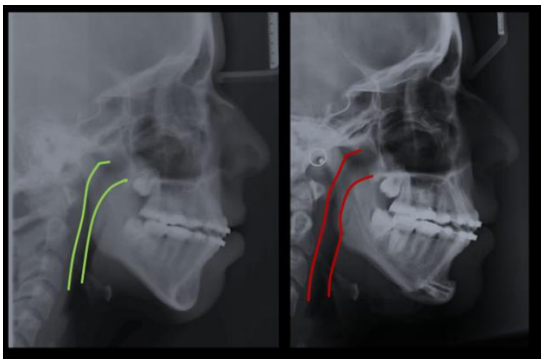

Figure 4 : Headfilms before and on completion of orthodontic treatment following genioplasty

CONCLUSION

OSA is a real public health problem, often unrecognized or underdiagnosed, requiring multidisciplinary care, including orthodontic treatment that plays an essential role in breathing improvement. In fact, studies agreed that either rapid maxillary expansion, mandibular advancement, or early genioplasty induce in several ways the management of OSA and improvement of nasal breathing. However, more investigations are needed to support those results.

ACKNOWLEDGMENTS

None.

AUTHORS' CONTRIBUTIONS

The participation of each author corresponds to the criteria of authorship and contributorship emphasized in the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly work in Medical Journals of the International Committee of Medical Journal Editors. Indeed, all the authors have actively participated in the redaction, the revision of the manuscript, and provided approval for this final revised version.

COMPETING INTERESTS

The authors declare no competing interests with this case.

FUNDING SOURCES

None.

REFERENCES

[1] Osmane AM, Carter SG, Carberry CJ, Eckert DJ. Obstructive sleep apnea: current perspective. Nature and science of sleep. 2018 Jan 23; 10:21-34. DOI: 10.2147/nss.s124657

[2] Kulshrestha R, Tandon R, Kinger S, Rohmetra A , Vikram Singh R . Obstructive sleep apnea in orthodontics: An overview. Int J Orthod Rehabil. 2016;7(3):115-8. DOI: 10.4103/2349-5243.192536

[3] Aubertin G. Le syndrome d'apnées obstructives du sommeil chez l'enfant. Rev Pneumol clin. 2013; 69: 229—236. [Accessed 2022 Jan 13]. Available from: http://www.sams.asso.dz/pdf/articles/9.pdf

[4] Spicuzza L, Caruso D, Di Maria G. Obstructive sleep apnoea syndrome and its Management. Ther Adv Chronic Dis. 2015 Sep;6(5):273-85. DOI:10.1177/2040622315590318

[5] Veasey SC, Rosen IM. Obstructive Sleep Apnea in Adults. N Engl J Med. 2019 Apr 11; 380(15):1442-1449. DOI:10.1056/nejmcp1816152

[6] Jaradat M , Rahhal A . Obstructive Sleep Apnea, Prevalence, Etiology & Role of Dentist & Oral Appliances in Treatment: Review Article. Open J Stomatology. 2015; 5(7): 187-201. [Accessed 2022 Jan 13]. Available from: https://www.scirp.org/journal/PaperInformation.aspx?PaperID=58047&#abstract

[7] Hudgel DW. Sleep Apnea Severity Classification – Revisited. Sleep. 2016 May 1; 39(5): 1165-6. DOI:10.5665/sleep.5776

[8] National Institutes of Health. Quality Assessment of Case-Control Studies. Department of Health & Human Services. USA: Mar 2014.

[9] Pirelli P, Saponara M, Guilleminault C. Rapid maxillary expansion (RME) for pediatric obstructive sleep apnea: a 12-year follow-up. Sleep Med. 2015 Aug; 16(8):933-5. DOI:10.1016/j.sleep.2015.04.012

[10] Villa MP, Rizzoli A, Rabasco J, Vitelli O, Pietropaoli N, Cecili M, et al. Rapid maxillary expansion outcomes in treatment of obstructive sleep apnea in children. Sleep Med. 2015 Jun; 16(6):709-16. DOI:10.1016/j.sleep.2014.11.019

[11] Fatsuca R, Perinetti G, Zecca PA, Nucera R, Caprioglio A. Airway compartments volume and oxygen saturation changes after rapid maxillary expansion: a longitudinal correlation study. Angle Orthod. 2015 Nov;85(6):955-61. DOI:10.2319/072014-504.1

[12] Villa MP, Castaldo R, Miano S, Paolino MC, Vitelli O, Tabarrini A, et al. Adenotonsillectomy and orthodontic therapy in pediatric obstructive sleep apnea. Sleep Breath. 2014 Sep; 18(3):533-9. DOI:10.1007/s11325-013-0915-3

[13] Caprioglio A, Meneghel M, Fastuca R, Zecca PA, Nucera R, Nosetti L. Rapid maxillary expansion in growing patients: correspondence between 3-dimensional airway changes and polysomnography. Int J Pediatr Otorhinolaryngol. 2014 Jan;78(1):23-7. DOI:10.1016/j.ijporl.2013.10.011

[14] Marino A, Ranieri R, Chiarotti F, Villa MP, Malagola C. Rapid maxillary expansion in children with obstructive sleep apnoea syndrome (OSAS). Eur J Paediatr Dent. 2012 Mar;13(1):57–63.

[15] Guilleminault C, Monteyrol PJ, Huynh NT, Pirelli P, Quo S, Li K. Adenotonsillectomy and rapid maxillary distraction in pre-pubertal children, a pilot study. Sleep Breath. 2011 May;15(2):173–177. DOI:10.1007/s11325-010-0419-3

[16] Villa MP, Rizzoli A, Miano S, Malagola C. Efficacy of rapid maxillary expansion in children with obstructive sleep apnea syndrome: 36 months of follow-up. Sleep Breath. 2011 May;15(2):179-84. DOI:10.1007/s11325-011-0505-1

[17] Idris G, Galland B, Robertson CJ, Gray A, Farella M. Mandibular advancement appliances for sleep-disordered breathing in children: A randomized crossover clinical trial. J Dent. 2018 Apr;71 :9-17. DOI:10.1016/j.jdent.2018.01.006

[18] Modesti-Vedolin G, Chies C, Chaves-Fagondes S, Piza-Pelizzer E, Lima-Grossi M. Efficacy of a mandibular advancement intraoral appliance (MOA) for the treatment of obstructive sleep apnea syndrome (OSAS) in pediatric patients: A pilot-study. Med Oral Patol Oral Cir Bucal. 2018 Nov 1;23(6):e656-e663. DOI:10.4317/medoral.22580

[19] Machado-Júnior AJ, Signorelli LG, Zancanella E, Crespo AN. Randomized controlled study of a mandibular advancement appliance for the treatment of obstructive sleep apnea in children: A pilot study. Med Oral Patol Oral Cir Bucal 2016;21(4):e403-e7. DOI:10.4317/medoral.21072

[20] Zhang C, He H, Ngan P. Effects of twin block appliance on obstructive sleep apnea in children: A preliminary study. Sleep Breath. 2013 Dec;17(4):1309-14. DOI: 10.1007/s11325-013-0840-5

[21] Schütz TC, Dominguez GC, Hallinan MP, Cunha TC, Tufik S. Class II correction improves nocturnal breathing in adolescents. Angle Orthod. 2011 Mar; 81(2):222-8. DOI:10.2319/052710-233.1

[22] Bedoucha V, Boutin F, Frapier L. Impact of genioplasty during puberty on the upper airways. Int Orthod. 2015 Dec;13(4):421-35. DOI:10.1016/j.ortho.2015.09.005

[23] Frapier L, Picot Mc, Gonzales J, Massif L, Breton I, Dauvilliers Y, et al. Ventilatory disorders and facial growth: Benefits of early genioplasty. Int Orthod. 2011 Mar; 9(1): 20-41. DOI:10.1016/j.ortho.2010.12.005

[24] Frapier L, Jaussent A, Yachouh J, Goudot P, Dauvilliers Y, Picot MC. Impact of genioplasty on mandibular growth during puberty. Int Orthod. 2010 Dec; 8(4):342–59 . DOI: 10.1016/j.ortho.2010.09.007

[25] Belkhiri A. Obstructive sleep apnea syndrome (OSAS) in children and the contribution of orthodontist in the treatment. Intern J Applied Dent Sci. 2021;7: 216-219. DOI: 10.22271/oral.2021.v7.i2d.1210

[26] Bucci R, Montanaro D, Rongo R, Valletta R, Michelotti A, D'Antò V. Effects of maxillary expansion on the upper airways: Evidence from systematic reviews and meta-analyses. J Oral Rehabil. 2019 Apr;46(4):377-387. DOI: 10.1111/joor.12766

[27] Erdur EA, Yıldırım M, Karatas RM, Akın M. Effects of symmetric and asymmetric rapid maxillary expansion treatments on pharyngeal airway and sinus volume: A cone-beam computed tomography study. Angle Orthod. 2020 May 1; 90(3):425-431. DOI:10.2319/050819-320.1

[28] Almuzian M, Xiangyang Ju, Almukhtar A, Ashraf A, Al-Muzian L, McDonald JP. Does rapid maxillary expansion affect nasopharyngeal airway? A prospective Cone Beam Computerised Tomography (CBCT) based study. Surgeon. 2018 Feb;16(1):1-11. DOI: 10.1016/j.surge.2015.12.006

[29] Lin SY, Su YX, Wu YC, Chang JZ, Tu YK. Management of paediatric obstructive sleep apnoea: A systematic review and network meta-analysis. Int J Paediatr Dent. 2020 Mar; 30(2):156-170. DOI: 10.1111/ipd.12593

[30] Modesti-Vedolin G, Chies C, Chaves-Fagondes S, Piza-Pelizzer E, Lima-Grossi M. Efficacy of a mandibular advancement intraoral appliance (MOA) for the treatment of obstructive sleep apnea syndrome (OSAS) in pediatric patients: A pilot-study. Med Oral Patol Oral Cir Bucal. 2018 Nov 1; 23(6):e656-e663. DOI: 10.4317/medoral.22580

[31] Basyuni S, Barabas M, Quinnell T. An update on mandibular advancement devices for the treatment of obstructive sleep apnoea hypopnoea syndrome. J Thorac Dis. 2018 Jan; 10(1), S48-S56. DOI: 10.21037/jtd.2017.12.18

[32] Carvalho FR, Lentini-Oliveira DA, Prado LBF, Prado GF, Carvalho LBC. Oral appliances and functional orthopaedic appliances for obstructive sleep apnoea in children. Cochrane Database Syst Rev. 2016 Oct 5; 10(10): CD005520. DOI: 10.1002/14651858.cd005520.pub3

[33] Villa, Maria ,Bernkopf, Edoardo , Pagani, Jacopo ,Broia, Vanna , Montesano, Marilisa ,Ronchetti, Roberto. (2002). Randomized Controlled Study of an Oral Jaw-Positioning Appliance for the Treatment of Obstructive Sleep Apnea in Children with Malocclusion. January 2002.American Journal of Respiratory and Critical Care Medicine 165(1):123-7. DOI: 10.1164/ajrccm.165.1.2011031

[34] Blanco J , Zamarrón C, Abeleira Pazos MT, Lamela C, Suarez Quintanilla D. Prospective evaluation of an oral appliance in the treatment of obstructive sleep apnea syndrome. Sleep Breath. 2005 Mar; 9(1):20-5. DOI: 10.1007/s11325-005-0003-43

[35] Cozza P, Polimeni A, Ballanti F. A modified monobloc for the treatment of obstructive sleep apnea in paediatric patients. Eur J Orthod. 2004 Oct; 26(5):523-30. DOI: 10.1093/ejo/26.5.523

[36] Kim YK, Kim JW, Yoon IY, Rhee CS, Lee CH, Yun PY. Influencing factors on the effect of mandibular advancement device in obstructive sleep apnea patients: analysis on cephalometric and polysomnographic parameters. Sleep Breath. 2014 May; 18(2):305-11. DOI: 10.1007/s11325-013-0885-5

[37] Serra-Torres S, Bellot-Arcís C, Montiel-Company JM, Marco-Algarra J, Almerich-Silla JM. Effectiveness of mandibular advancement appliances in treating obstructive sleep apnea syndrome: A systematic review. Laryngoscope. 2016 Feb; 126(2):507-14. DOI: 10.1002/lary.25505

[38] Yanyan M, Min Y, Xuemei G. Mandibular advancement appliances for the treatment of obstructive sleep apnea in children: a systematic review and meta-analysis. Sleep Med. 2019 Aug; 60:145-151. DOI: 10.1016/j.sleep.2018.12.022

[39] Santos Junior JF, Abrahão M, Gregório LC, Zonato AI, Gumieiro EH. Genioplasty for genioglossus muscle advancement in patients with obstructive sleep apnea-hypopnea syndrome and mandibular retrognathia. Rev Bras Otorrinolaringol 2007; 73(4):480-6. DOI:10.1016/s1808-8694(15)30099-9

[40] Elhaddaoui R, Bahoum A, Azaroual MF, Garcia C, Zaoui F, Halimi A, et al. A predictive model of advancement genioplasty in Class III bimaxillary surgical cases. Int Orthod. 2018 Sep; 16(3):530-544. DOI: 10.1016/j.ortho.2018.06.009

[41] Bedoucha V, Boutin F, Frapier L. Impact of genioplasty during puberty on the upper airways. Int Orthod. 2015 Dec; 13(4): 421-35. DOI: 10.1016/j.ortho.2015.09.005

[42] Chamberland S, Proffit WR, Chamberland P. Functional genioplasty in growing patients. Angle Orthod. 2015 May; 85(3):360-73. DOI: 10.2319/030414-152.1