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Long-Term Stability of Growth Modification Treatment in Children with Obstructive Sleep Apnea; A Systematic Review

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Abstract

Background and Objective: The aim of this study is a systematic review on the long-term stability of growth modification treatment in children with obstructive sleep apnea (SA).
Methods: At first, all the papers (n=۸۷) related to keywords (growth modification, headgear, functional therapy, herbst, twin block, forsus, AHI, orthodontics, sleep apnea, systematic review, meta-analysis) were searched for English databases; PubMed, Scopus, Embase, google scholar and Cochrane Database of Systematic Reviews covering the period from 2000 through 2021 was studied. As a result to inclusion and exclusion criteria, papers related to growth modification treatment in children with sleep apnea were found and analyzed (n=5). Predefined inclusion and exclusion criteria were: papers related to growth modification treatment for children with SA, Children 7 to 11 years old with SA grade 2 and above, follow-up 10 months to 11 years old, use of functional appliance and headgear, papers were English, papers were original and all the papers were free full text.
Results: Of the 87 studies on growth modification treatment and sleep apnea, only 5 studies clinically evaluated the long-term stability of growth modification treatment on airway dimensions. Growth modification treatments for sleep apnea are very important and can play very significant role in health improvement. So, paying more attention to benefits of orthodontics therapeutic tools in sleep apnea is necessary. On important points is the orthodontist's active role play in screening the patients for this disease and advice oral appliance therapy, if needed.
Conclusion: The long-term stability of using orthodontic functional appliances in the treatment of sleep apnea in children demonstrated that the utilization of these tools can increase the width of airways in the oral cavity improving the respiratory condition in children eliminating problems associated with apnea.

Keywords: Growth modification, Headgear, Functional therapy, AHI, Sleep apnea

1. Introduction

Sleep in one of the main elements of health. Learning, memory, well-being, and morale are all influenced by the duration and quality of sleep. Experiencing a deep and effective nocturnal sleep is essential to start a good and energetic day.

Sleep disorders are considered as one of the most common health conditions. Sleep disorder, in turn influences patient's health. Diabetes, cardiovascular diseases, impaired vision, daytime drowsiness and increased rate of accidents can be mentioned as adverse effects of sleep deficiency.

The most common of these disorders are sleep-associated apnea with obstructive apnea during sleep being the most common [3]. Unfortunately, 82-98% of adults with sleep-associated apnea remain undiagnosed [4,5]. Obstructive apnea is associated with anatomical and non-anatomical etiologies [6,7] including fat accumulation around the neck, septal deviation, nasal polyp, tonsillar hypertrophy, mandibular deficiency, etc [8-10]. Mandibular deficiency can influence the airway dimensions through displacing the tongue, hyoid bone and muscles. Treatment of

this disorder may vary depending on the age of the patient and growth modifications can be used as a treatment option in children at growth age. Growth modifications include functional appliance that with moving the mandible anteriorly, can influence the airway dimensions through different ways which are as follows: 1-tongue, 2-hyoid bone, and 3-muscles [11]. A systematic study conducted by Xiang et. demonstrated that functional devices positively influenced the patency of the oropharyngeal airways with anterior movement of the mandible and anterior adaptive movement of the base of the tongue, hyoid bone, soft palate, through muscular functions of genioglossus and palatoglossus [12]. Another growth modification includes using a headgear to prevent excessive vertical growth of the maxilla and subsequent counterclockwise rotation of the mandible which result in decreased facial height leading to the opening of the oropharyngeal airway [13, 14]. This improvement, however, can be influenced by relapse decreasing the effectiveness of the growth modification on the sleep indexes (apnea-hypopnea index) and airway dimensions.

The aim of this study was to evaluate the long-term stability of growth modification treatment (headgear and functional therapy) in children with obstructive sleep apnea.

2. Methods

Analysis method and inclusion criteria were determined in advance based on PRISMA guideline.

1. Study design

The search strategy was done due to PICO.

Population: Children with obstructive sleep apnea

Intervention: Growth modification treatment

Comparison: Control groups without any treatment

Outcome: long-term stability

2. Electronic search

Accurate searching strategies have been prepared for each searched database for identifying the papers eligible for inclusion in the review and meta-analysis. The databases PubMed, Scopus, Embase, google scholar and Cochrane were searched.

All existing titles and abstracts were read and those related to functional therapy, growth modification, or both were selected by two authors. In case the information provided by title and abstract was incomplete, the full paper was carefully read and evaluated to decide whether the study would be considered for further analysis or not. Exclusively the papers in English were assessed.

3. Search strategy

Searches were tailored to the specific databases from January 2000 to January 2021. An example of a search on PubMed is: ((("class II malocclusion") OR ("maxillary prognathism")) AND (("growth modification") OR ("headgear") OR ("functional therapy") OR ("Forsus") OR ("twin block") OR ("Herbst")) AND (("airway") OR ("airway dimension") OR ("airway volume") OR ("sleep apnea")"OR ("Apnea- hypopnea index") OR ("AHI")).

4. Selecting studies

The collected studies were evaluated in terms of inclusion and exclusion criteria by two referees independently. The inclusion criteria entailed children aged 7-11 years affected by respiratory apnea grade 2 or higher, a follow-up of 10 months to 11 years, the application of diverse functional and headgear appliances, and not being affected by craniofacial syndromes. The studies that did not meet the inclusion criteria were excluded.

The references of the research articles and review papers were evaluated for recognizing extra trials. Moreover, only the research articles were assessed and analyzed to prevent the evaluation of the data, which had been published several times. Data presentation in the current study, including the determination of the issue under study, data collection, analysis, and the interpretation of results were performed based on the PRISMA checklist of systematic reviews. The details of selection criteria according to the PRISMA checklist are shown in Figure 1.

5. Types of studies

In this search, it was attempted to identify all related studies that met the inclusion criteria regardless of the information source. In most studies, no control group was considered because it seemed unethical to prevent the treatment of children and adolescents with special diagnoses. Therefore, randomized controlled trials designs and controlled studies containing pre- and post-treatment data were taken into consideration. Moreover, randomized controlled trials (RCT) were regarded as potential studies. However, the data of the treatment group were exclusively considered.

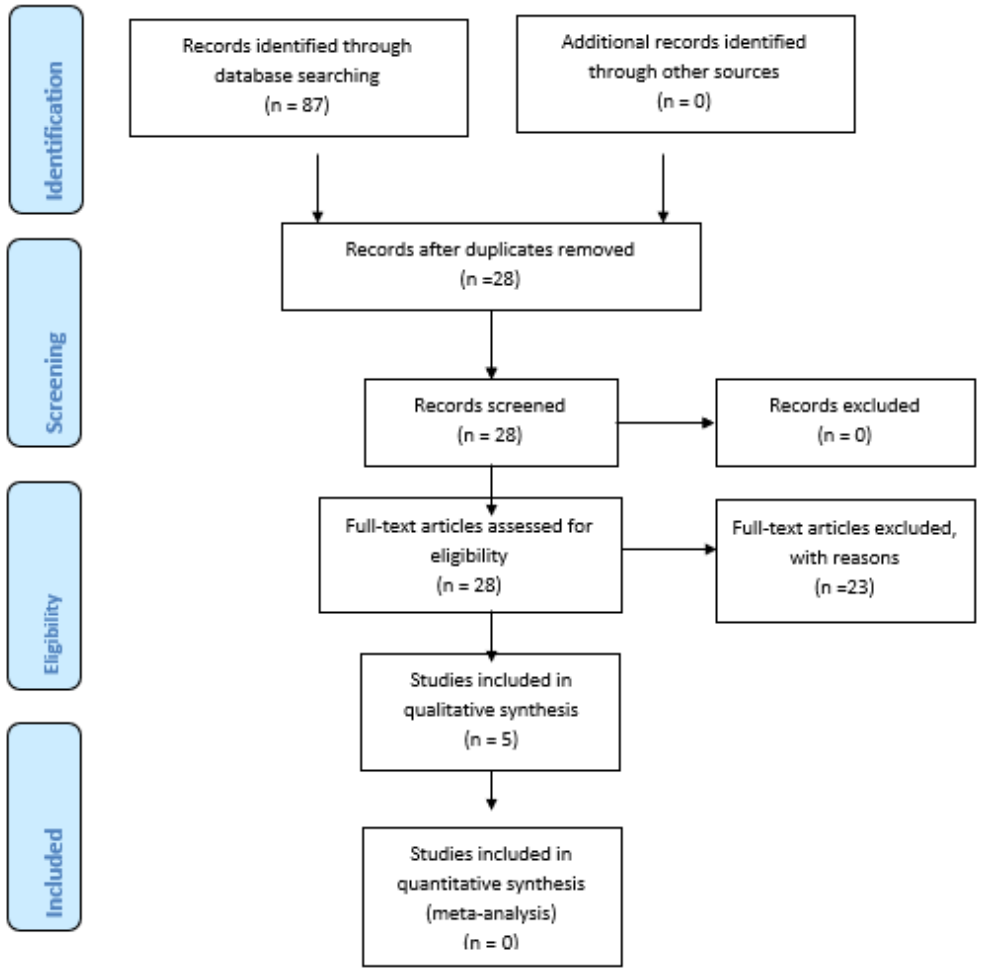

Figure 1. PRISMA flow-chart of selescted criteria for the included article reports

6. Participants

The participants were children and adolescents aged 7-11 years who used functional orthopedic appliances for the treatment of grade 2 or higher obstructive apnea in sleep and were not affected by craniofacial syndromes. There were no gender limitations.

7. Data extraction and management

The studies that met the inclusion criteria were entered into an excel database. The following information was extracted by each reviewer in the related database: publication year, title, study design, patients, methods, results, conclusion, and whether the full text has been extracted or not. Next, the qualitative evaluation of the papers retrieved in this report was discussed by the authors to reach a consensus. The outcome data were extracted by two referees for validation and control.

8. Duplicate data

The data which had been published several times were considered duplicates. In case of any doubt or ambiguity, the main article (the first study done) was always regarded as the final option for study. Consequently, any overestimation about the effect of intervention decreases due to the lack of duplicate data exceptions.

9. Missing or incomplete data

Strategies applied for missing or incomplete data are as follow:

1. contact the author if possible,
2. analyze only the existing data (i.e., neglect the missing data), and
3. Address the possible influence of missing data on the evaluated findings in the discussion section.

10. Types of interventions

Different functional appliances, such as twin block and Herbst utilized for the treatment of OSA in growing children and patients were evaluated.

3. Results

First, 87 papers (Figure 1) were retrieved from the databases, 59 of which were excluded due to duplication and/or irrelevance to the subject. In addition, 23 studies were omitted by two independent referees based on the inclusion and exclusion criteria, such as a follow-up of shorter than one year, not being affected by SA, and not being in the intended age range. Finally, five papers were included in the study, summaries of which are presented in Table 1.

Table 1. Summary of article

No.	Author	Publication year	Study design	Target group	Mean age (year)	Intervention	Variable and measurement method	Follow-up (year/month)	Results
1	Arnim Godt et al.[15]	2011	Prospective cohort	Children	(27, 9, 24, 11, 38, 10)	Treatment by headgear, activator, and bite-jumping appliances	Cephalogram for evaluating changes in the width of upper airways	5 years	Minor changes in all three methods in the width of upper airways and the lack of significant difference between groups
2	Tomonori Iwasaki et al.[16]	2017	Longitudinal study	Children	7, 11	Treatment by Herbst appliance	Measuring the speed and pressure of pharyngeal airway ventilation by CFD (PA)	About 4 years	Using Herbst appliance leads to improved pharyngeal airway ventilation. These results may provide a beneficial assessment of obstructive apnea treatment during growth time.
3	Zhang et al.[17]	2013	Clinical trial	Children	7, 9	Using twin block appliance	Efficacy of treatment by cephalogram and Polysomnography	8, 10 months	Using the appliance can enhance sleep apnea.
4	Johanna Julku et al.[18]	2017	Randomized clinical trial	Children	7	Kloehn-type cervical headgear (CH)	Efficacy of treatment by cephalogram and radiologic imaging	1.5 years	CH application improved the status of the maxilla and reduced palato-mandibular angle. No injury was reported for this therapeutic technique.
5	Hänggi et al.[19]	2008	Randomized clinical trial	Children	4, 10	Treatment by activator-headgear and fixed functional appliance	Cephalogram for assessing the alterations in the measures of airways and mandibular angle	First time: 4 years after the initiation of the study Second time: 11 years after the initiation of the study	Application of activator-headgear can increase the measures of pharyngeal airway and this improvement lasted for a long time.

4. Discussion

Obstructive Sleep Apnea Syndrome (OSAS) is a relatively common sleep-associated apnea with a prevalence rate of 2-4% characterized by frequent partial or completes obstruction of the upper airways [20]. Respiratory effort occurs to terminate apnea following a reduction in arterial blood oxygen and cerebral excitement. Main clinical findings include daytime drowsiness and nocturnal loud snoring [21]. Approximately, 12-27% of children suffer from frequent snoring with 2-4% of them being affected by obstructive apnea-hypopnea syndrome [22, 23]. The most common clinical symptoms when awake include chronic mouth breathing, hyper nasality, chronic nasal secretions, and dysphagia. The majority of these children have adenoid faces [24]. Daytime drowsiness in children with sleep-associated apnea is three time more frequent than healthy children [25]. Nocturnal symptoms in these children include snoring, restlessness, and excessive perspiration during sleep, enuresis, and nightmares [24]. Misdiagnosis and late treatment are associated with adverse effects such as hyperactivity, lack of concentration, learning disabilities, developmental disability, and retarded growth [26]. Elimination of symptoms and adverse effects such as parasomnia in children with OSAHS following appropriate treatment may ensue [27].

Oral appliances are utilized to change the position of the mandible, tongue, and other airway structures improving the respiratory conditions of the patient [28]. Anterior movement of the mandible in patients with sleep-disordered breathing (SDB) can visibly improve the respiratory conditions [29]. Basics of splints used in sleep-disordered breathing (SDB) resemble those of the functional devices and maintain the mandible anteriorly improving the airways [30]. The aim of this study was to investigate and review the findings of other studies in terms of long-term use of orthodontic functional appliances in the treatment of the SA in children.

Based on the defined objectives and inclusion criteria, 5 studies were selected and their findings reviewed. The target group of

these studies consisted of children 7-11 years old with second degree apnea and above. Follow-up intervals of the treatment outcome varied from 10 month to 10 years and the studies were majorly conducted through longitudinal clinical trials. Measurement variables were majorly oral dimensions such as jaw angles as well as the width of the upper airway and the distance between the tongue with the posterior wall measured by cephalometric analysis and recorded accordingly. The impact of confounding variables such as high BMI was modulated or excluded.

In this regard, Amin Godt et. Al (2011) reported the use of three appliances namely headgear, activator, and bite-jumping in the treatment of upper airway conditions is children. These researchers scheduled a 5-year follow-up for children who selected these treatment options; also, they examined the changes in the upper airways using cephalometric data. The results showed that minute changes were observed in all three methods and the difference was minimal (pharyngeal width for headgear, activator, and bite-jumping appliance were 0.78 ±3.70 mm, 2.07 ±4.60mm and 2.03 ±3.81mm, respectively) which was statistically nonsignificant [15]. On the other hand, in a longitudinal study, Tomonori Iwasaki et. al (2017) found that treatment using Herbst managed to improve the velocity and pressure of ventilation of pharyngeal airways (PA) , and this may help enhance apnea during growth periods; The change in oropharyngeal airway velocity in the Herbst group was 1.95 m/s and significantly larger than that in the control group (0.67 m/s)[16]. Xiang et. al (2013) selected 46 children with SA with the mean age of 9.7 years and BMI of 181 kg/m^2 and divided them into two groups. They used twin-block appliance for the treatment of children in one group and scheduled follow-ups for 10.8 of them on average. One control group was also selected.
The effectiveness of treatment using cephalometry and polysomnography was investigated and the snoring rate, data obtained from the two-channel encephalogram, rate of airflow, data obtained from electrooculogram and electrocardiogram in sleep clinic were recorded. The rate of saturated arterial oxygen (SaO2) was measured and recorded with the use of pulse oximetry. The results showed that the mean index of AHI decreased from 14.08 ± 4.25 to 3.39 ± 1.86 ($p<0.01$) in the experimental group and the lowest value of SaO2 increased from 77.78 ± 3.38 to 93.63 ±2.66 ($p<0$ 01). It was concluded that the use of appliances can improve SA [17]. Johanna Julki et. al (2017) included 67 children aged 7 years with SA in a randomized clinical trial. They used **Kloehn-type cervical headgear** (CH) as a treatment modality for one group of participants and evaluated the results using cephalometry and radiographical images in a 2-staged follow-up.

The findings showed that using this treatment modality improved the position of the maxilla and the palato-mandibular angle (PL-ML) decreased compared with the primary angle at the beginning of the study (T_1= 28.4°± 4.47, T_2= 27.6°± 5.13, P= 0.516) . There have been no reports of physical damages in this study [18]. Hänggi et al. (2008) investigated the results of using activator-headgear combination in 10-year-old children with apnea through designing a randomized clinical trial. In this study, 67 children were selected and randomly divided into two groups. Dimensions of the airway and the oral cavity (such as the distance of the tongue to the posterior wall and jaw angles) were measured primarily at the beginning of the study, and subsequently 4 and 11 years following the study. As concluded, using activator-headgear combination can increase the airway dimensions maintaining a long-term improvement; the pharyngeal airway change from during T_1 to T_3 was 16.0 ± 7.6 mm. But the pharyngeal airway change in control group from during T1 to T3 was 10.4 ± 8.1mm [19].

The findings of the present study showed that 4 studies (80%) out of 5 studies demonstrated positive outcomes with respect to various appliances regarding the improvement of respiratory conditions in children. The mean follow-up interval of these 4 studies was 4.25 years (10 months to 11 years) which is considered to be acceptable for long-term investigation indicating its long-term effectiveness.

Different dependent variables were studied in the findings which were mainly associated with oral dimensions and a study used AHI or apnea-hypopnea index which prevented us from quantitative comparison of the findings, thus the results were compared in a general and qualitative fashion. Controlling some of the confounding variables such as obesity was one of the advantages of the majority of studies. These studies did not report adverse effects or patient's complaint which was considered noteworthy. The studies used different metrics and measurements for evaluation; different parts of the airway tract were assessed in the included studies so a pooled outcome measurement was not possible.

Conclusion

Literature review in terms of long-term impact of using orthodontic functional appliances in

the treatment of sleep apnea in children demonstrated that the utilization of these tools can increase the width of airways in the oral cavity improving the respiratory condition in children eliminating problems associated with apnea. Considering the small number of available studies and their insufficient sample size, conducting broader studies which evaluate dependent variables for a precise judgment and conclusion seems necessary. Therefore, conducting long-term longitudinal studies with large samples for measuring important variables is recommended.

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