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Research Article

Value of Interceptive Orthodontic Treatment for the Management of Sleep Disordered Breathing: A Prospective Longitudinal Study

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Abstract

Background: The paediatric population has a high incidence of sleep-disordered breathing (SDB). One notable risk factor for SDB is the presence of craniofacial abnormalities. The aim of this study was to evaluate the prevalence of SDB by means of questionnaires in patients who received interceptive treatment, to determine whether there is a relationship between the nature and duration of treatment and the prevalence of SDB, and to correlate cephalometric changes with the type of orthopaedic treatment received and questionnaire results.

Materials and Methods: Prospective study of 203 patients who required interceptive treatment. Two sleep questionnaires (the Paediatric Sleep Questionnaire (PSQ) and the Sleep Disturbance Scale for Children (SDSC)) were used which were completed by the parents at baseline (T1) and after completion of interceptive treatment (T2). The results of the questionnaires were analysed, grouped according to the type of treatment received and related to 12 cephalometric variables on cephalometric radiography at T1 and T2.

Results: The prevalence of SDB at T1 was 21.2% according to PSQ and 33% according to SDSC. The mean age at T1 was 8.5 years and the mean duration of treatment was 13.8 months. Between 10.8% (PSQ) and 17.2% (SDSC) of patients showed improvement in SDB after interceptive treatment ($p<0.05$). Treatment led to statistically significant cephalometric changes in the variables of mandibular length, maxillary length and overbite, with no significant differences between treatment groups or in relation to questionnaire results.

Conclusion: Interceptive treatment achieves significant improvements in SDB. The type and duration of treatment do not affect the prevalence of SDB, although Rapid Palatal Expansion (RPE) is associated with a higher rate of improvement. The improvement in SDB is independent from the type of treatment and the cephalometric changes effected.

Keywords: Sleep-disordered breathing; Paediatric sleep questionnaire; Cephalometry; Interceptive treatment Orthodontic appliances

Introduction

Sleep-Disordered Breathing (SDB) is a syndrome of upper airway dysfunction characterised by snoring and/or increased respiratory effort secondary to increased upper airway resistance and pharyngeal collapsibility [1]. It has a high prevalence in childhood. The childhood prevalence of snoring is 3 to 27%, and that of sleep apnoea 1 to 10% [2]. Risk factors include tonsillar hypertrophy and the presence of craniofacial abnormalities, since a small maxilla and/or mandible may predispose children to sleep-disordered breathing.

The diagnostic gold standard for the diagnosis of Obstructive Sleep Apnoea-Hypopnoea Syndrome (OSAHS) is polysomnography, but due to its complexity and high cost, questionnaires have been developed as a screening method. Some of those most widely used in children are the "Paediatric Sleep Questionnaire" (PSQ, by Chervin et al.) [3] and the "Sleep Disturbance Scale for Children" (SDSC, by Bruni et al.) [4]. Cephalometry is also considered as an appropriate method to assess skeletal and soft tissue characteristics, and as a screening procedure for the diagnosis and investigation of predisposing factors for OSAHS [5,6].

The PSQ, developed by Chervin [3] (and translated to Spanish by Tomas Vila et al. [7], in 2007) for the diagnosis of sleep-disordered breathing, has a high diagnostic sensitivity and specificity (0.78 and 0.72, respectively), and a 91% agreement with diagnosis by polysomnography. It was subsequently validated in 2015 by the study by Bertran et al. [8] which reported a sensitivity of 0.714 and specificity of 0.521. Meanwhile, the Sleep Disturbance Scale for Children (SDSC) for the diagnosis of all sleep disorders was developed by Bruni in 1996 (sensitivity of 0.89 and specificity of 0.74) and validated by the Association of Sleep Disorders Centers (ASDC) [4], correctly identifying 73.4% of the control group and 89.1% of the group with SDB.

The first-line therapy is tonsillectomy and adenoidectomy;

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however, this approach does not eliminate sleep apnoea in all patients. A recent study [9] found that craniofacial abnormalities are a greater risk factor for OSAHS than obesity; it therefore makes sense to correct craniofacial abnormalities to improve the child's growth and to reduce snoring and sleep apnoea. Preliminary studies suggest that orthodontic treatment such as maxillary expansion or mandibular advancement with functional appliances may be effective for the treatment of sleep apnoea. Rapid maxillary expansion was first described in 1860, but only associated with OSAHS once it was found to reduce nocturnal enuresis, a sign and symptom of OSAHS in children [10]. Mandibular advancement appliances, which enhance mandibular growth, were introduced by Dr. Kingley in 1879. These treatment options are suitable alternatives for patients who are not eligible for surgery or cannot tolerate other methods: The first is maxillary expansion, which is used in patients diagnosed with a narrow upper jaw. The main benefit of this approach is that it reduces nasal resistance and repositions the tongue, thereby reducing the risk of obstruction. The second treatment option is mandibular advancement in order to correct skeletal and dental retrognathia and redirect mandibular growth downward and forward, this mandibular displacement can increase the oropharyngeal airway space [2]. Another option is maxillary advancement with or without maxillary expansion, as proposed by Stacey Quo [11] in 2019 and Sayionsu [12] in 2006; both conducted a pilot study in which they noted a slight improvement in SDB post-treatment.

In a previous study carried out by Vázquez et al. [13] in the Department of Orthodontics of Hospital Sant Joan de Déu in Barcelona, the prevalence of SDB in paediatric patients was 21.2% according to the PSQ and 33% according to the SDSC. Along these lines, we decided to continue the research with 3 main objectives: to reassess the prevalence of SDB by means of questionnaires in patients who received interceptive treatment; to determine whether there is a relationship between the nature and duration of treatment and the prevalence of SDB; and to correlate cephalometric changes with the type of orthodontic treatment received and questionnaire results.

Materials and Methods

The initial sample consisted of all the patients who visited the Department of Orthodontics of Hospital Sant Joan de Déu and required interceptive treatment between April 2016 and December 2017. Patients with craniofacial malformations, respiratory disorders, neurological disorders and a prior history of SDB were excluded from the sample.

The initial study population included 249 patients (T1). Two sleep questionnaires (PSQ and SDSC) were evaluated for each patient along with their anthropometric characteristics. An orthodontic assessment was performed (oral examination and cephalometric study) and the orthodontic treatment was then evaluated. Treatment options included maxillary expansion, mandibular advancement, maxillary advancement and expansion, maxillary advancement only and other methods. Forty-six patients either did not complete treatment or did not complete the second set of questionnaires, so that the final sample consisted of the 203 patients (T2) who also completed the PSQ and SDSC upon completion of interceptive treatment between 2017 and 2019. Of those 203 patients, 89 started the second treatment phase and underwent a new cephalometry. They were then grouped by type of treatment and the findings compared with the questionnaire results.

Sleep questionnaires

The questionnaires were completed by the patients' parents and/or legal guardians before (n=249) and after orthodontic treatment (n=203). The questionnaires used were:

- The Paediatric Sleep Questionnaire (PSQ) [3]: a 22-item questionnaire evaluating the presence of respiratory symptoms, enuresis, excessive sleepiness, headache, symptoms of hyperactivity and inattention. Possible answers are 'Yes', 'No' and 'Don't know'. The total score is calculated by dividing the number of affirmative answers by the total number of answers. The validated cut-off score is 0.33.

- The Sleep Disturbance scale for children (SDSC) [4]: a 26-item, five-point, Likert rating scale where 1 means "never" and 5 "always. Six of the items relate to sleep: difficulty initiating and maintaining sleep, respiratory symptoms, arousal disorders, night terror and nightmares, sleep/wake transition disorders, symptoms related to excessive daytime sleepiness and presence of hyperhidrosis. The total score ranges from 26 to 130 points, with a cut-off score of 39.

Parents were also asked whether the patients had undergone adenotonsillectomy either before or during orthodontic treatment.

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Cephalometric analysis

The data were completed with a cephalometric study of the patients before (n=203) and after (n=89) interceptive treatment. All images were obtained using the same cephalometric X-ray equipment. Cephalometric analysis was performed using NemoCeph® software. A series of points and planes were used to make linear and angular measurements, all of which were carried out by the same technician. Twelve cephalometric variables were determined according to the Steiner, Tweed, Ricketts and McNamara analysis.

- *Facial axis angle (º):* posterior-inferior angle formed by the basicranial axis (Ba-Na) and the facial axis (Pt-Gn). Describes the general facial growth pattern. The value obtained from this measurement allowed to classify the facial growth pattern of the patients into mesofacial, brachyfacial or dolichofacial.

- *Mandibular plane angle (º):* angle formed by the tangent to the lower border of the mandible and menton (Me-Go) and the Frankfort plane (FH). Provides information about mandibular growth and mandibular anatomical shape.

- *Facial convexity (mm):* distance from point A to the facial plane (Na-Pg).

- *ANB (°):* A-point-Nasion-B-point angle: indicates the anterior-posterior discrepancy between the maxilla and mandible, indicating the skeletal class.

- *SNA (°):* Angle formed by the Sella, Nasion and A-point. Indicates the anterior-posterior location of the maxilla with respect to the base of the skull.

- *SNB (°):* Angle formed by the Sella, Nasion and B-point. Indicates the anterior-posterior location of the mandible with respect to the base of the skull.

- *Mandibular length (mm):* determined from Condylion (Co), the most posterior and superior point of the contour of the mandibular condyle, to the anatomical Gnation (Gn), the most antero-inferior point on the mandibular symphysis.

- *Maxillary length (mm):* linear distance from Condylion (Co) to point A of the maxilla.

- *Upper incisor to palatal plane angle (UIPP,°):* angle formed by the upper incisor axis with the palatal plane

- *Lower incisor to mandibular plane (IMPA,°):* angle formed by the long axis of the lower incisor and the mandibular plane.

- *Overjet (mm):* distance between the incisal edge of the maxillary incisor and the vestibular aspect of the mandibular incisor measured along the occlusal plane.

- *Overbite (mm):* distance between the incisal edge of the mandibular incisor and the incisal edge of the maxillary incisor, perpendicular to the occlusal plane.

Type of treatment

The patients were divided into five groups according to the treatment received: Patients treated by maxillary expansion (quad-helix, Hyrax Rapid Palatal Expander (RPE) or removable Hawley retainer), mandibular advancement (Sander Guides or Twin-Block appliance), Rapid Maxillary Expansion (RME) and maxillary advancement (RME with hybrid Hyrax RPE-facemask combination), maxillary advancement only (facemask), and the last group, called "other treatments" which grouped treatments such as extraoral headgear, brass wire, utility arches, traction of incisors, etc.

Statistical analysis

The data obtained were analysed using SPSS software (Armonk, NY: IBM Corp.). A descriptive statistical analysis of the data was performed. Baseline intergroup comparisons for age were performed using paired t-tests. A chi-square (χ^2) test was used to compare the sex ratios between groups. Pre- and post-treatment sleep questionnaires were correlated using the Kappa index. Analysis of Variance (ANOVA) was used to analyse the differences between treatment groups according to the type and duration of treatment. Since the cephalometric values showed normal distribution, parametric tests (Student's t-test for quantitative data) were used for analysis. A p value <0.05 was considered significant.

Ethical approval and informed consent

The study was approved by the ethics committee of Hospital Sant Joan de Déu in Barcelona under number PIC-84-17 [13]. All patients who participated in the study and whose data were used in the writing of this article gave their informed consent.

Table 1: Sample distribution.

	T1	T2
N	249 patients	203 patients
Age	8.52 years ±1.30	10 years
	(min. 6 years, max. 14 years)	(min. 8 years, max. 16 years)
Sex	126 boys (50.6%) and 123 girls (49.30%)	96 boys (47.3%) and 107 girls (52.7%).

Table 2: Results of the questionnaires. *1 drop-out. **2 drop-outs. ***Statistically significant (p<0.05).

	Questionnaire	PSQ, "Pediatric Sleep Questionnaire"	SDSC, "Sleep Disturbance scale for Children"
T1	**N**	203	202*
	Positive, N (%)	43 (21.2%)	67 (33%)
	Negative, N (%)	160 (78.8%)	135 (66.5%)
T2	**N**	203	201**
	Positive, N (%)	27 (13.3%)	42 (20.7%)
	Negative, N (%)	176 (86.7%)	160 (78.8%)
T1-T2	**Still no SDB**	154 (75.95%)	124 (61.1%)
	Worse	6 (3%)	10 (4.9%)
	Persistent SDB	21 (10.3%)	31 (15.8%)
	Improved	22 (10.8%)***	35 (17.2%)***
T1-T2		16 (7.9%)	25 (12.3%)

Results

The initial study sample consisted of 249 patients and the final study sample of 203 patients, 96 boys and 107 girls, with a mean age of 8.52±1.30 years. Most of them (95.6%) were of Caucasian ethnicity. The time between T1 and T2 was two and-a-half years (Table 1).

At T1, 15% of the sample had previously undergone adenotonsillectomy. None of the patients underwent a tonsillectomy during the study, therefore, this is not a variable that could have affected the results at T2. Regarding nutritional status, 69% of the sample had a normal Body Mass Index (BMI) (normal weight), and no statistically significant differences were observed when studying the relationship between nutritional diagnosis and the presence of SDB.

The results of the Paediatric Sleep Questionnaire (PSQ) and Sleep Disturbance Scale for Children (SDSC) completed by the parents at baseline and after interceptive treatment were evaluated.

Cohen's kappa coefficient (κ) was calculated to assess the degree of concordance between the two questionnaires, which was found to be moderate (0.479). The correlation between questionnaire results and dentofacial characteristics was therefore performed separately for each questionnaire.

After counting the questionnaire scores, the prevalence of SDB (positive SDB) at T1 was estimated at 21.2% according to the PSQ and 33% according to the SDSC, *vs.* 13.3% and 20.7%, respectively, at T2. The sleep questionnaires before and after interceptive treatment were compared, showing concordance between baseline and end PSQ scores, as well as between baseline and final SDSC scores (*Chi-square*

Table 3: Distribution of the sample according to treatment received (n=203).

Treatment Received	N = 203	%	Treatment time (months)
Maxillary expansion	122	60.1	13.46
Mandibular advancement	26	12.8	13.85
Maxillary expansion and advancement	23	11.3	13.91
Maxillary advancement	3	1.5	13.67
Other treatments	29	14.3	15.17

Table 4: Questionnaire results by type of expansion.

	QH (n=50)		RPE (n=28)		Removable (n=44)	
	PSQ	SDSC	PSQ	SDSC	PSQ	SDSC
Still no SDB	41	32	17	13	32	30
Worse	2	2	0	1	2	5
Persistent SDB	4	5	7	8	5	4
Improved	3	11	4	6	11	5

test).

After interceptive treatment (T2), the PSQ and SDSC scores showed a statistically significant improvement of 10.8% and 17.2%, respectively. That is to say that comparison of baseline and end PSQ scores found that 154 patients (75.9%) remained free from SDB, 22 (10.8%) improved, 21 (10.3%) still had SDB and 6 (3%) got worse. Comparison of baseline and end SDSC scores (2 patients dropped out) found that 124 (61.1%) patients remained free from SDB, 35 improved (17.2%), 31 (15.8%) still had SBD and 10 (4.9%) got worse, $p<0.05^*$ (*Pearson's chi-squared test*).

According to the PSQ, there was a difference of 7.9% (10.8-3% = 7.9%) between T1 and T2, explained by the fact that 10.8% of the patients improved and 3% got worse, while the rest showed no change. According to the SDSC, there was a difference of 12.3% (17.2-4.9% = 12.3%) between T1 and T2, explained by the fact that 17.2% of the patient improved and 5% got worse, while the rest showed no change (Table 2).

With regard to treatment type, of 203 patients, 122 underwent maxillary expansion, (60.1%), 26 mandibular advancement (12.8%), 23 RME with maxillary advancement (11.3%), 3 maxillary advancement alone (1.5%), and 29 received other treatments (14.3%) (Table 3). Treatment time was similar between all groups (ANOVA) with a mean duration of 13.81 months of treatment; the "other treatment" group showed the highest variability (15.17 months of treatment); therefore, treatment time did not affect the results of the pre- and post-treatment PSQ or SDSC questionnaires.

Patients who underwent maxillary expansion showed an improvement of 9% according to the PSQ and 18% according to the SDSC, *vs.* 16% according to both questionnaires for those who underwent mandibular advancement, and 13% and 17.4%, respectively, for those who underwent RME with maxillary advancement. Note that no patient treated with mandibular advancement showed worsening of SDB. The maxillary advancement group was not analysed as it comprised only 3 patients, a sample size considered too small to for statistical analysis; neither was the highly heterogenous group of 29 patients who received "other treatments".

Table 5: Mean and Standard Deviation (SD) of cephalometric changes at T1 and T2. Statistical test: "Student's t-test" $^*p<0.005$.

Cephalometric Variables	T1		T2		*p* value
	Mean	SD	Mean	SD	
Facial Axis	89.70°	4.44	89.23°	4.22	0.059
Mand PL. Angle	26.01°	5.68	26.16°	5.09	0.654
Convexity	2.91mm	3.47	2.58mm	2.97	0.154
ANB	3.42°	3.36	3.04°	2.67	0.74
SNA	80.92°	3.6	80.82°	3.82	0.639
SNB T1	77.46°	4.03	77.42°	5.25	0.914
Mandibular Length	107.88mm	6.52	112.87mm	13.92	0.000*
Maxillary Length	84.24mm	5.95	87.75mm	10.68	0.001*
Max. Incisor -Palatal Plane	111.27°	7.93	110.70°	7.35	0.48
IMPA	90.10°	7.13	89.94°	8.09	0.777
Overjet	4.45mm	4.71	4.47mm	2.5	0.964
Overbite	-17mm	2.9	2.48mm	2.31	0.001*

Of the 122 patients who underwent maxillary expansion, 50 wore a Quad-Helix (QH), 28 a Rapid Palatal Expander (RPE) and 44 removable orthodontic appliances.

According to the results of the PSQ questionnaire, of all the maxillary expansion treatments, RPE showed the highest rate of improvement, with 4 of 28 patients (14.28% of the sample) showing improvement. Furthermore, none of the patients in the RPE group showed worsening of SDB.

According to the results of the SDSC questionnaire, the rates of improvement were similar in the RPE and Quad-Helix (QH) groups, since 22% of the patients who wore a QH or RPE showed an improvement in SDB after orthopaedic treatment (Table 4). The type of expansion had no effect on the outcomes of the PSQ or SDSC questionnaires (*Chi-square test*).

End-of-treatment cephalometric X-rays were obtained for 89 of the 203 patients for whom pre- and post-treatment questionnaires were available. The mean age of the patients at the time of the CEPH X-rays was 8.5 years (range 6-14 years) at T1 and 10 years (range 8-16 years) at T2. Comparison of the 12 cephalometric variables of the overall sample at T1 and T2 revealed a high level of correlation (Table 5). The three variables for which statistically significant differences were observed were mandibular length (p=0.000), maxillary length (p=0.001) and overbite (p=0.001). Cephalometrically, no statistically significant differences were observed between treatment groups (*Wilcoxon test*) or between the pre- and post-treatment PSQ and SDSC questionnaires (*Kruskal-Wallis*) of the overall sample (n=89). The observed changes were due to the natural biological growth of the patients (Table 6).

Discussion

This study was an attempt to evaluate the prevalence of SDB using questionnaires in healthy patients who underwent interceptive treatment in the hospital setting. It also aimed to assess whether there is a relationship between the type and duration of treatment and the prevalence of SDB, and to correlate cephalometric changes with the

Table 6: Correlation between questionnaire results, treatment received and cephalometric changes. NS=not significant.

Treatment	Questionnaire	Questionnaire Results				Change In
		No SDB	Worse	Persistent SDB	Improving	Cephalometric Variables
Expansion (N=37)	PSQ	31	0	3	3	NS
	SDSC	22	3	6	6	NS
Mand. Advance (N=22)	PSQ	15	0	3	4	NS
	SDSC	13	0	5	4	NS
Max. Advancement and Expansion (N=12)	PSQ	9	0	1	2	NS
	SDSC	7	1	2	2	NS

orthopaedic treatment received and questionnaire results.

While adenoidectomy is known as the first-line treatment for childhood apnoea, orthodontic treatment can help treat obstructive sleep apnoea syndrome in children as it can help clear the airways, thus improving patients' sleep and preventing health, behavioural and facial aesthetic problems. However, comparison with the results of other studies shows that the prevalence of paediatric SDB varies according to the sample selection and diagnostic criteria used. The prevalence in our study was greater than in other studies [2-16] which may be due to the fact that the study sample had malocclusion and also because questionnaires were used as the diagnostic method.

In this study, the PSQ and SDSC questionnaires were chosen over polysomnography as the diagnostic method because they are easy to complete, easily accessible and inexpensive. In addition, authors such as Vila [5] in 2006 or Joosten [17] in 2017 endorsed them as an appropriate tool both for the screening of patients who require additional tests and for epidemiological research.

Our patients were treated with different appliances according to the malocclusion presented at baseline. This is the study with the longest follow-up time (13.46 months) and the largest sample of patients treated with maxillary expansion (N=122). The type of treatment did not affect the results of the PSQ or the SDSC questionnaires, which showed a similar rate of improvement (around 9-18 %) for all three treatments reviewed (expansion, mandibular advancement and maxillary advancement).

In the literature reviewed, maxillary expansion was the most common procedure performed by far [18-20], and the fixed rapid palatal expander was the orthodontic appliance of choice. All authors agreed that RME showed beneficial effects in children with OSAHS and can be considered as useful for the treatment of sleep disordered breathing, although quantitative data comparison was not possible because most use the Apnoea-Hypopnea Index (AHI) as a measure of OSA severity instead of questionnaires. In this study, the type of expansion had no effect on the results of the questionnaires, although we can assert that the use of RPE was associated with the highest rate of improvement both according to the PSQ and the SDSC, although the difference was not statistically significant.

Numerous studies suggest that mandibular advancement may be an interesting therapeutic option with great potential. This study found that 16% of patients improved after treatment with mandibular advancement. Our data are consistent with those of Villa in 2002 [21], Cozza in 2004 [22] and Barros Schütz in 2011 [23] who noted a reduction in AHI after mandibular advancement in studies very similar to ours.

Interestingly, there are only few clinical trials in the literature correlating maxillary expansion and protraction with SDB. Stacey Quo [11] and Sayionsu [12] 2006 each carried out a pilot study, and while they used different traction methods, treatment led to a slight improvement in all cases.

The difficulty of correlating cephalometric variables with severity/prevalence of SDB can be attributed to several factors. First, that cephalometry is carried out with the patient standing up and awake, while OSAHS occurs during sleep, with patients in the decubitus position. Second, cephalometry is a two-dimensional projection of a three-dimensional structure which also does not provide much information on soft anatomical structures [24].

Although the relationship between SDB and orthopaedic treatment has been widely described in the literature, we found no articles which followed our exact purposes. While anatomical deficiencies are a predisposing risk factor for the development of SDB, to date, no cephalometric analyses have been validated (or if so, they are not widely accepted) to evaluate a potential link between craniofacial abnormalities and SDB. It proved difficult to find studies evaluating posttreatment cephalometric changes, although there was a trend towards increased upper airway space.

Several authors such as Marino et al. [25], have found an association between cephalometric characteristics and SDB, observing that patients who showed an improvement in SDB postmaxillary expansion also showed a significant increase in SNA and SNB. Unlike these authors who also observed a significant increase in nasopharyngeal airway space, we were unable to assess nasopharyngeal diameter in this study due to the absence of a standardised breath intake/breath-holding protocol during cephalometric radiography.

In 2013, Flores-Mir et al. [26] conducted a large systematic review and meta-analysis which concluded that some variables (such as the angle between the mandibular plane and Sella-Nasion lines, SNB and ANB) suggest that children with SDB show a more vertical growth pattern and are more likely to have Class II malocclusions. Nevertheless, the authors advise caution when considering the results due to the limited number of cephalometric variables they were able to include in their analysis.

Within this principle, note that while patients who received interceptive treatment in our study showed statistically significant post-treatment cephalometric changes in terms of mandibular and maxillary length and overbite, we cannot assert that the skeletal changes observed were due to interceptive treatment; instead, we believe that the changes were likely due to natural biological growth of the patients. Also, perphaps due to the small sample size, the improvement in SDB observed was not statistically significant.

Stacey-Quo et al. [11] recently, in 2019, contemplated attempting maxillary traction with skeletal anchorage as an approach for the treatment of SDB, since their study found significant changes in SNA, the Sella-Nasion/palatal plane, and the mandibular occlusal plane after treatment. However, they mention that more long-term 3D studies are required to gain a more complete overview for air flow and volumetric change analysis.

There is growing evidence that orthodontic treatment benefits healthy children with craniofacial abnormalities. Randomised studies indicate a significant improvement after treatment, although a Cochrane review found the quality of the studies to be too low to justify a change in treatment guidelines.

Conclusion

- Interceptive treatment significantly improves the prevalence of SDB in the paediatric population.

- The PSQ and SDSC questionnaires used for its measurement show moderate concordance.

- The type and duration of treatment do not affect the prevalence of SDB, although RPE is associated with a higher rate of improvement.

- Mandibular advancement was never associated with worsening of SDB.

- The improvement in SDB cannot be correlated with the type of treatment and the cephalometric changes effected.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

References

1. American Thoracic Society. Standards and indications for cardiopulmonary sleep studies in children. Am J Respir Crit Care Med. 1996; 153: 866–878.
2. Huynh NT, Desplats E, Almeida FR. Orthodontics treatments for managing obstructive sleep apnoea syndrome in children: A systematic review and meta-analysis, Sleep Medicine Reviews. 2016.
3. Chervin, et al. Paediatric Sleep Questionnaire. Arch Otolaryngol Head Neck Surg. 2007; 133: 216-222.
4. Bruni O, et al. The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. J Sleep Res. 1996; 5: 251-261.
5. Armalaite J, Lopatiene K. Lateral teleradiography of the head as a diagnostic tool used to predict obstructive sleep apnea. Dento Maxillo Facial Radiology. 2016; 45: 20150085.
6. Faber CE, Grymer L. Available techniques for objective assessment of upper airway narrowing in snoring and sleep apnoea. Sleep & Breathing. 2003; 7: 77–86.
7. Tomas Vila M, Miralles A, Beseler B. Spanish version of the Pediatric Sleep Questionnaire (PSQ). A useful instrument in investigation of sleep disturbances in childhood. Reliability analysis. An Pediatr. 2007; 66: 121-128.
8. Bertran K, Mesa T, Rosso K, Krakowiak MJ, Pincheira E, Brockmann PE. Diagnostic accuracy of the Spanish version of the pediatric sleep questionnaire for screening of obstructive sleep apnea in habitually snoring children. Sleep Medicine. 2015; 6: 631–636.
9. Ikävalko T et al. Craniofacial morphology but not excess body fat is associated with risk of having sleepdisordered breathing the PANIC study (a questionnaire-based inquiry in 6-8-year-olds). Eur J Pediatr. 2012; 171: 1747–1752.
10. Timms DJ. Rapid maxillary expansion in the treatment of nocturnal enuresis. Angle Orthod. 1990; 60: 229–233.
11. Quo S, Lo LF, Guilleminault C. Maxillary protraction to treat pediatric obstructive sleep apnea and maxillary retrusion: a preliminary report. Sleep Medicine. 2019; 60: 60–68.
12. Sayinsu K, Isik F, Arun T. Sagittal airway dimensions following maxillary protraction: a pilot study. European Journal of Orthodontics. 2006; 28: 184–189.
13. Vázquez-Casas I, Sans-Capdevila O, Moncunill-Mira J, Rivera-Baró A. Prevalence of sleep-related breathing disorders in children with malocclusion. J Clin Exp Dent. 2020; 12: e555–e560.
14. Tsukada E et al. Prevalence of childhood obstructive sleep apnea syndrome and its role in daytime sleepiness. PLoS ONE. 2018; 13: e0204409.
15. Abtahi S, Witmans M, Alsufyani NA, Major MP, Major PW. Pediatric sleep-disordered breathing in the orthodontic population: Prevalence of positive risk and associations. Am J Orthod Dentofacial Orthop. 2020; 157: 466–473.
16. Bixler EO et al. Sleep disordered breathing in children in a general population sample: prevalence and risk factors. SLEEP. 2009; 32: 731–736.
17. Joosten KF et al. How Do We Recognize the Child With OSAS? Pediatric Pulmonology. 2017; 52: 260– 271.
18. Guilleminault C, Monteyrol PJ, Huynh NT, Pirelli P, Quo S, Li K. Adenotonsillectomy and rapid maxillary distraction in pre-pubertal children. Sleep Breath. 2011; 15: 173–177.
19. Pirelli P, Saponara M, Guilleminault C. Rapid maxillary expansion before and after adenotonsillectomy in children with obstructive sleep apnea. Somnologie. 2012; 16: 125–132.
20. Hoxha S, Kaya-Sezginer E, Bakar-Ates F, Köktuürk O, Toygar-Memikoğlu U. Effect of semi-rapid maxillary expansion in children with obstructive sleep apnea syndrome: 5-month follow-up study. Sleep and Breathing. 2018; 22: 1053–1061.
21. Villa MP, Bernkopf E, Pagani J, Broia V, Montesano M, Ronchetti R. Randomized Controlled Study of an Oral Jaw-Positioning Appliance for the Treatment of Obstructive Sleep Apnea in Children with Malocclusion. Am J Respir Crit Care Med. 2002; 165: 123–127.
22. Cozza P, Gatto R, Balalnti F, Prete L. Management of obstructive sleep apnoea in children with modified monobloc appliances. European journal of paediatric dentistry. 2004; 1: 24–29.
23. Barros Schütz TC, Dominguez GC, Pradella M, Crosara T, Tufik S. Class II correction improves nocturnal breathing in adolescents Angle Orthodontist. 2011; 81: 222–228.
24. Stipa C, Cameli M, Sorrenti G, Ippolito DR, Pelligra I, Alessandri-Bonetti G. Relationship between cephalometric parameters and the apnoea–hypopnoea index in OSA patients: a retrospective cohort study. European Journal of Orthodontics. 2020; 42: 101-106.
25. Marino A, Ranieri R, Chiarotti F, Villa MP, Malagola C. Rapid Maxillary expansion in children with Obstructive Sleep Apnoea Syndrome (OSAS). European Journal of Paediatric Dentistry. 2012; 13: 57-63.
26. Flores-Mir C, Korayem M, Heo G, Witmans M, Major MP, Major PW. Craniofacial morphological characteristics in children with obstructive sleep apnea syndrome. A systematic review and meta-analysis. JADA. 2013; 144: 269–277.