The effects of the headgear therapy on the airway dimensions in patients with class II malocclusion: A systematic review

Wpływ aparatu headgear na wymiary drogi oddechowej pacjentów z wadą zgryzu klasy II – systematyczny przegląd piśmiennictwa

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Abstract

Class II malocclusion may be caused by the maxillary protrusion or the mandibular retrusion. One treatment method is to use a headgear, which might affect the dimensions of the patient's airway. The aim of this study was to assess the effect of a headgear on the airway dimensions in class II malocclusion patients. A digital search and a manual search were conducted for English-language articles published from January 2000 to December 2018 about human clinical trials, including the usage of a cervical headgear in class II malocclusion patients who had measurable changes in the airway and/or jaw size. The synthesis methods of the study consisted of data concerning the study design, the type of treatment device, the patient's age at the start, the sample size, the treatment duration, the type of radiography, and the results of treatment; this data was extracted and compared. The quality of the selected articles was assessed. All of the studies had a high risk of bias, providing low-quality evidence of the effectiveness of the headgear therapy on the airway dimensions. The conclusions of the articles differed from each other and there were different mechanisms of changes in the jaw or airway dimensions. Therefore, further studies are required to find the clearest results showing the effect of a cervical headgear in class II malocclusion.

Key words: headgear, airway dimensions, class II malocclusion

Słowa kluczowe: headgear, wymiary drogi oddechowej, wada zgryzu klasy II

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Introduction

Patients with skeletal Class II malocclusion are characterized by excessive maxillary growth and/or mandibular deficiency.^{1,2} It has been shown that in Class II patients, the upper airway tends to be reduced^{3–5} and a correlation has been found between mandibular length and position and the size of the oropharynx and nasopharynx in these individuals.^{6,7} Furthermore, airway volume is decreased in Class II patients⁸ and the diminished upper airway plays an important role in oxygen saturation⁹ and in the development of obstructive sleep apnea (OSA), which is known as a sleep respiratory disorder.^{10,11} Since a significant relationship exists between the posterior airway and the position of the maxilla, mandible and soft palate¹², any alteration in the positioning of the skeleton might lead to changes in airway sizes.^{10,13}

Two major treatment options are available for Class II growing patients: functional appliances, which stimulate mandibular growth,¹⁴ and headgear treatment, which inhibits maxillary growth.¹⁵

Cervical headgear (CHG) with an expanded inner bow is commonly used for restricting maxillary forward growth and for arch expansion,^{16,17} and is typically designed for nighttime usage. The distal movement of the maxilla caused by such headgear seems to have an adverse effect on the size of the upper airway.¹⁸ However, it has been shown in some studies that CHG facilitates mandibular growth, which may lead to improved airway size.^{18–20} Some studies have shown that using CHG while sleeping decreases the size of the upper airway and may contribute to the occurrence of sleep apnea in patients with a history of OSA.^{19,21}

Studies concerning the effects of headgear therapy on upper airway dimensions have reported conflicting results and the systematic reviews are focused on the effect of stimulating mandibular growth on the airway size.^{22,23} Based on the PICO framework, this review of the literature was aimed at assessing the changes in airway dimensions in preadolescent Class II patients treated with functional headgear.

Material and methods

Search strategy

A search of 5 electronic databases – PubMed/Medline, Google Scholar, EMBASE, Web of Science and Cochrane – was carried out for relevant English-language studies published between January 2000 and December 2018 using the following keywords separately and in combination: [headgear] AND [cl II malocclusion OR maxillary protrusion OR mandibular retrusion] AND [airway dimension OR upper airway size OR upper air-

way width] AND [jaw growth]. In addition, a manual search was also performed for publications in dental and orthodontic-related journals from January 2000 to December 2018 that were not electronically identified (including “The International Journal of Adult Orthodontic and Orthognathic Surgery” and “The Journal of General Orthodontics”). No other restrictions were established, and the free-text strategy and Medical Subject Headings terms (MeSH) were applied in the search process. This systematic review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) as illustrated in Fig. 1.

Our PICO criteria were constructed as follows: 1. Participants: humans with Class II malocclusion. 2. Intervention/Exposure: cervical head gear therapy. 3. Comparisons: treatment with headgear vs. other Class II malocclusion treatments. 4. Outcome: the effect of headgear therapy on airway dimensions

Study selection and eligibility criteria

In order to select relevant studies, the extracted sources were evaluated by 2 independent reviewers. In case of disagreement, the final assessment was made by a 3rd reviewer. The criteria used to evaluate eligibility were defined according to the considered subject of the present article. The current article only considers original research with the following specifications: Randomized Controlled Trials (RCTs) in addition to cohort and cross-sectional sources discussing the impact of headgear therapy on the dimensions of the airway in Class II malocclusion, and human clinical studies focused on the use of headgear in patients with Class II malocclusion who did not have any respiratory problems before

Fig. 1. PRISMA diagram of the present study

the examination. Descriptive-type observational studies (e.g., case studies) and review articles, chapters of books, reports and studies focused on nonhuman cases were excluded from the current study. Moreover, the sources which did not consider changes in the size of the airway were not included in the present review article. In addition, only sources written in English were considered. The primary screening of the subjects and abstracts was performed on the basis of the above-mentioned criteria. It should be noted that all sample sizes were considered for this review study and that any duplicate sources were identified and removed. The data was then extracted from the eligible sources and the extracted information was analyzed in the next step of the study. The features of the studies used for review and the summary of their results are presented in Table 1.

Results

Study selection

The search initially retrieved a total of 54 citations. Following the primary screening of titles and abstracts and the final screening of full texts, 7 studies met the inclusion criteria and were included in the final evaluation.

Study characteristics

The data of study design, type of treatment device, patient's age at the start, sample size, treatment duration, radiographic type and the results of treatment were extracted and compared (Table 1).

Risk of assessment bias

All selected studies were judged to have a high risk of bias (Table 2), providing low-quality evidence on the effectiveness of headgear therapy on airway dimensions.

Data comparison

Use of headgear and diagnostic tool

Head gear was used in all studies alone or in combination with other devices. Two studies used an activator as well^{24,25} and 1 used Class II traction.²⁶ Each of the 7 articles selected cephalometry as a diagnostic tool.^{17–19,24–27}

Sample size

Different sample sizes were selected for the included studies, which ranged from 10 to 209 patients.^{17–19,24–27}

Patients' age

Some variation was found in the age of the patients. One study treated adults,¹² while the others treated children aged 7.2 to 11.9 years old^{17,18,24,26,27}; 1 did not mention the patients' age.²⁵

Treatment duration

The duration of treatment was different, varying from 3.5 months to 6.4 years^{17,18,24–27} and 1 study did not report the treatment duration time.¹⁹

Treatment outcome

The outcomes of head gear treatment were reported in different ways. Two studies did not report any changes in upper airway dimensions^{18,25}, 1 demonstrated an increase in the upper airway size,²⁶ while another reported a decrease in sagittal dimensions and no change in vertical dimensions.¹⁹ Four articles reported an increase in retropalatal^{17,27} and pharyngeal airway sizes.^{24,25} One experiment found a decrease in the size of the opening of the jaw after treatment.¹⁹ On the other hand, no significant change was mentioned in another study for anteroposterior displacement of the mandible.¹² Two studies evaluated changes of the hyoid bone.^{19,26} One of the studies reported a significant forward displacement of the hyoid,¹⁹ whereas the other one just mentioned a change in the position of the hyoid.²⁶ One article assessed the movement of the 3rd cervical vertebra and showed that it had moved forward significantly.¹⁹ ANB was one of the main parts that were investigated in the studies: 2 studies defined a reduction in ANB after treatment,^{18,24} while the other only mentioned a change in ANB.²⁶ In 1 paper, a significant change was reported for SNB, A and Wits.²⁶ Overjet, overbite and lip measurements had decreased in 1 study.²⁶ In 1 paper, pharyngeal width was assessed in OSA patients and a decrease was reported.²⁵ A significant posterior movement of the maxilla was demonstrated among the males in one experiment.²⁷ A decrease in the palatomandibular angle was reported in one study.²⁷

Discussion

The development and growth of dentoskeletal features are affected by several physiological factors, such as the circadian rhythm, fluctuations in hormone levels and metabolic activity.¹⁹ Class II malocclusion could be caused by a maxillary protrusion or a mandibular retrusion.¹⁸ The treatment protocol focuses on restricting maxillary growth and enhancing mandibular growth, which can affect the positions of the jaw and upper airway.¹⁸ Some studies have been performed to assess the outcomes of headgear therapy on upper airway dimensions in such patients.¹⁸

Table 1. Studied drugs' general names, brand names, pharmaceutical forms, manufacturers and mg/mL on the market

Author/year	Study design	Device & treatment method	Radiography	Sample size	Age [years] at start	Treatment duration	Result
Kirjavainen et al. ¹⁷ 2007	For Class II malocclusion with an overjet of more than 2 mm, a protrusive maxilla by A-point's in front of nasion-pogonion-line	CHG (Khehne type) Outer bow bent 150 upward & a large inner bow expanded 10 mm larger than intermolar distance 500 g per side 12 to 24 h a day	Lat ceph	40	9.1	1.6 years	Retropalatal airway space: increased Nasopharyngeal space: increased or no sig change Oro and hypopharyngeal were narrowed
Hiyama et al. ¹⁹ 2001	Subjects were instructed to stay awake all night immediately before experiment to help ensure that they could fall asleep easily. Buccal tubes were bonded to buccal surfaces of bilateral maxillary first molars. Silver/silver chloride surface electrodes to record electroencephalograms for determining sleep stage were positioned with paste.	CHG Face bow & neck strap were used. The force was adjusted to 700 g.	Lat ceph	10	adult	-	Jaw opening: decrease Ant.post mandible displacement: no sig Upper airway (sagittal dimension): sig reduced Upper airway (vertical length): no sig Hyoid: sig fwd 3 rd cervical vertebra: sig fwd Mandibular symphysis & hyoid relationship: no sig
Aksu et al. ¹⁸ 2017	Class II patients whose upper airway sizes were not sig different at start & sagittal skeletal jaw relationships showed maxillary protrusion or mandibular retrusion. Divided into 3 groups: CHG, activator & control	CHG	Lat ceph	57	10.6	1.1 years	ANB: sig decrease Upper airway size: no sig
Hanggi et al. ²⁴ 2008	Inclusion criterion for study group was active treatment with a combined activator-high-pull headgear appliance of at least 9 months between 9 & 14 years of age. Only a moderate construction bite (typically 3–4 mm) was taken, resulting in some cases in a two-step activation.	Activator & HG	Lat ceph	64	10.4	at least 9 months	ANB: sig decrease Pharyngeal airway (area, length, smallest distance between tongue & post pharyngeal wall): sig increase
Zheng et al. ²⁹ 2014	Class II div 1 malocclusion were divided into 3 groups: HG & Class II traction, Class II traction & no treatment).	HG & Class II traction 300–350 g	Lat ceph	90	11.9	3.5 months	A-SNB, ANB, witts: sig changed L1MPL1NP & Z angle: sig increase OJ, OB, lower lip measurements: sig decrease Upper airway: sig increase PNS-V, PNS-U & T-V: sig increase Hyoid: change
Godt et al. ²⁵ 2011	3 groups: HG, activator & bite jumping appliance. Patients in HG group were divided into 6 subsets on basis of y-axis values	Activator & HG	Ceph	209	-	5.2 to 6.4 years	V dimension of pharyngeal width: small increase Upper airway: no change Pharyngeal width in OSA: decrease
Julku et al. ²⁷ 2018	Class II malocclusion treated with CH & randomized into early & late treatment groups.	CHG (Khehne type)	Lat ceph	67	7.2	4 years	Maxilla: sig posterior change (males) Palato-mandibular angle: decreased (early treatment in females & males) Retroglossal airway: increased (early treatment in males). Highly sig positive correlations between skeletal & upper airway dimensions (early in males)

CHG – cervical head gear; HG – head gear; non ext – non-extraction; sig – significant; fwd – forward; V – vertical; OSA – obstructive sleep apnea; Ceph – cephalometer.

Table 2. Parameters used for quality assessment

Study	Randomization	Control group	Blind	Follow-up	Estimated risk of bias
Kirjavainen et al. ¹⁷	unclear	yes	yes	yes	high
Hiyama et al. ¹⁹	unclear	no	unclear	yes	high
Aksu et al. ¹⁸	unclear	yes	unclear	yes	high
Hanggi et al. ²⁴	yes	yes	unclear	yes	high
Zheng et al. ²⁹	unclear	yes	unclear	yes	high
Godt et al. ²⁵	unclear	no	unclear	yes	high
Julku et al. ²⁷	yes	no	unclear	yes	high

Effect on the upper airway

The effect of CHG on the upper airway is limited to the nose, nasopharynx and retropalatal area.¹⁷ Although nasal breathing can be improved by increasing the lateronasal width and retropalatal airway, this effect may not be clinically significant.¹⁷ A few studies have investigated the features of the upper airway in a supine position — which is similar to sleep positions — because these features and the position of the tongue depend on the position of the body.^{26,28} During sleep, the involvement of tonic muscles is reduced, depending on the stage of sleep.^{26,28} The respiratory phase plays an important role in the position and morphology of the oropharynx.¹⁹ Based on this rule, Hiyama et al. recorded all cephalograms at the end of expiration.¹⁹ A decrease in the upper airway sagittal dimension after using CHG might affect the respiratory function during sleep.¹⁹ Kirjavainen et al.¹⁷ demonstrated that the retropalatal area was wider after CHG treatment in children; however, Godt et al.²⁵ reported minor or no changes in anteroposterior pharyngeal width. On the other hand, 1 study declared that there are various sizes of airways among patients and this is independent of the skeletal parameters since the mechanism is more complex; for example, different positions of the tongue or catch-up growth and its effect on oropharyngeal dimensions.¹⁸ Therefore, there are considerable individual differences in normal growth and in the response to treatment.²⁴

Effect on the mandible

Some studies have demonstrated that CHG induces a forward displacement of the mandible in conscious patients; therefore, dilation of the upper airway can be achieved by applying pressure on the back of the neck with the neck strap.¹⁹ Previous studies have reported that pushing the surrounding soft tissue of the neck anteriorly may cause passive superoanterior rotation of the mandible, regardless of the neuromuscular mechanism.¹⁹ Mandibular position is affected by sleep stage, and during NREM sleep it opens progressively more.¹⁹ Utilizing CHG during sleep does not cause significant forward mandible displacement; on the contrary, such displacement in conscious patients can facilitate mandibular growth.¹⁹ Therefore, clinicians must pay attention to the instructions accompanying the CHG.¹⁹

Hiyama et al. suggested that the mandible does not move anteroposteriorly and that only a counterclockwise mandible rotation was noticed, which also led to an increase in the dimensions of the upper airway.¹⁹ On the other hand, a decrease in N-Me after wearing CHG confirms this counterclockwise rotation. In the cases of obstructive sleep apnea, the mandibles were more open than the mandibles of normal cases during sleep and such jaw opening during sleep was suggested to potentially result in the obstruction of the upper airway in patients with OSA.¹⁹

Effect on the maxilla

Though there is a common assumption that CHG restricts the growth of the maxilla in the forward direction, no restriction in the growth of the palatal plane (ANS-PNS) was observed — on the contrary, palatal plane length increased.¹⁷ The restriction of the maxillary growth after treatment is limited to the alveolar process, which can affect the growth of the nose.¹⁷ Hanggi et al. reported that the combined activator and high-pull headgear had a significant impact on the maxilla.²⁴

Effect on the angle of soft and hard tissue

Although it has been demonstrated that the angle between the palatal plane and the tip of the soft palate decreased during treatment, this alteration does not correlate with a change in the dimensions of the retropalatal airway space.¹⁷ Some of the decrease in this angle is due to the anterior downward rotation of the palatal plane instead of a change in the position of the uvula.¹⁷

Effect on the hyoid

In children with Class II malocclusion, the hyoid bone position was higher; however, after CHG treatment it moved forward but not higher.¹⁹ On the other hand, the third vertebra moved forward as well and resulted in the same distance between the hyoid and the third vertebra.¹⁹ Therefore, the vertical length of the upper airway cannot be affected by wearing CHG.¹⁹ The hyoid bone gradually moved forward and downward from mixed dentition to permanent dentition.²⁹

Conclusions

Considering the discrepancies in the literature, it can be concluded that the dimensions of different parts of the upper airway – such as sagittal dimension, vertical length and retropalatal width – demonstrated various responses to headgear treatment and that individual differences in normal growth play an important role in the response to treatment. Most of the studies agree that headgear therapy does not move the mandible anteroposteriorly and that only counterclockwise mandible rotation may be noticed. This can lead to an increase in the size of the upper airway, though the maxillary growth is limited to the alveolar process after CHG treatment.

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