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ORIGINAL ARTICLE

Evaluation of anteroposterior and vertical stability 25 years after Angle class II division 1 treatment with cervical headgear

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Abstract

Purpose The goal was to investigate long-term (minimum 20 years) skeletal and dental changes in Angle class II division 1 patients treated with full-fixed orthodontic appliances and cervical pull headgear.

Methods A longitudinal retrospective study was performed with 20 orthodontic patients, who were treated exclusively by one experienced clinician and whose treatment had been completed a minimum of 20 years ago. Former patients who had been treated from the mid-1970s to the early 1990s were actively sought. After the recall, 20 patients agreed to participate in the study. Lateral cephalometric radiographs at pretreatment (T1), posttreatment (T2), and long-term follow-up (T3) were digitized and measurements were performed. Angular variables used were SNA, SNB, ANB, OcclPl-FH, PalPl-FH, GoMe-FH, 1-NA, and Y axis. Linear measures were A-NPerp, Pg-NPerp, 1-NAmm, Wits, and LAFH.

Results From T1 to T2, a significant reduction ($p<0.01$) in ANB angle from 4.70 to 2.48° and in Wits value from 3.42 to 0.98 mm were observed. It was also noticed a significant increase ($p<0.01$) in LAFH from 62.02 to 67.39 mm, probably due to normal facial growth. From T2 to T3, these variables remained stable. No significant changes were observed for any other measure in any of the periods studied.

Conclusions In the assessed sample, Angle class II division 1 patients treated with cervical pull headgear presented cephalometric outcome stability of treatment, even after a long-term follow-up of a mean of 25 years postretention.

Keywords Cephalometry · Orthodontic appliances · Retention · Long-term treatment outcome · Malocclusion

Auswertung der anteroposterioren und vertikalen Stabilität 25 Jahre nach Angle-Klasse-II/1-Behandlung mit zervikalem Headgear

Zusammenfassung

Zielsetzung Ziel war es, langfristige (mindestens 20 Jahre) skelettale und dentale Veränderungen bei Angle-Klasse-II/1-Patienten zu untersuchen, die mit vollfixierten kieferorthopädischen Apparaturen und zervikalem Zug-Headgear behandelt worden waren.

Methoden Es wurde eine retrospektive Längsschnittstudie mit 20 kieferorthopädischen Patienten durchgeführt, die ausschließlich von einem erfahrenen Therapeuten behandelt worden waren und deren Behandlung mindestens 20 Jahre zurücklag. Es wurde aktiv nach ehemaligen Patienten gesucht, die von Mitte der 1970er- bis Anfang der 1990er-Jahre behandelt worden waren. Nach dem Recall erklärten sich 20 Patienten bereit, an der Studie teilzunehmen. Laterale kephalometrische Röntgenaufnahmen zu den Zeitpunkten vor der Behandlung (T1), nach der Behandlung (T2) und langfristiges Follow-up (T3) wurden digitalisiert und Messungen wurden durchgeführt. Die verwendeten Winkelvariablen waren SNA, SNB, ANB, OcclPl-FH, PalPl-FH, GoMe-FH, 1-NA und Y-Achse, lineare Maße A-NPerp, Pg-NPerp, 1-NAmm, Wits und LAFH.

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Ergebnisse Von T1 zu T2 wurde eine signifikante Reduktion ($p<0,01$) des ANB-Winkels von 4,70 auf 2,48° und des Wits-Wertes von 3,42 auf 0,98 mm beobachtet. Es wurde auch ein signifikanter Anstieg ($p < 0,01$) des LAFH von 62,02 auf 67,39 mm festgestellt, wahrscheinlich aufgrund des normalen Gesichtswachstums. Von T2 bis T3 blieben diese Variablen stabil. Für alle anderen Messgrößen wurden in keinem der untersuchten Zeiträume signifikante Veränderungen beobachtet.
Schlussfolgerungen In der untersuchten Stichprobe wiesen mit einem zervikalen Zug-Headgear behandelte Angle-Klasse-II/1-Patienten eine Stabilität des kephalometrischen Behandlungsergebnisses auf, selbst nach einem langfristigen Follow-up von durchschnittlich 25 Jahren nach Retention.

Schlüsselwörter Kephalometrie · Kieferorthopädische Apparaturen · Retention · Langfristiges Behandlungsergebnis · Malokklusion

Introduction

The main goals of orthodontic treatment are optimal occlusion, smile/facial esthetics and long-term stability [5]. Orthodontic outcome relapse is not well understood and the studies trying to elucidate this issue are contradictory and employ distinct methodologies [14]. The assessed literature mainly reports a set of various types of malocclusions which were sometimes treated with diverse approaches. It is also common to find cases treated by distinct clinicians or by residents of various postgraduate programs [20, 41]. Moreover, treatment objectives and outcomes are often not well described, making a proper comparison difficult. Regarding Angle class II malocclusion, the available literature lacks for consistent samples of cases being treated without extractions in the long-term.

Angle class II malocclusion may be corrected by a combination of the restriction or redirection of maxillary growth, distal movement of the maxillary dentition, mesial movement of the mandibular dentition, and enhancement or redirection of mandibular growth [15]. For this purpose, a large number of functional appliances of different designs, fixed or removable, have been used [36]. Experimental studies have shown that the forces for class II correction produced by extraoral traction cause posterior repositioning of the maxillary dental complex, as well as of maxilla itself, through a combination of sutural and periodontal remodeling [1, 13]. However, despite the apparent effectiveness in altering the growth direction [22], there is some controversy about the mechanisms involved in the success or failure of this treatment approach [23, 44].

It is well documented that the headgear appliance is effective in redirecting maxillary growth vectors inferiorly and posteriorly, thus improving maxillomandibular relationship [21, 24, 42, 43]. Cervical extraoral traction is also a well-established tool for correction of molar position, besides the possibility of increasing lower facial height [7, 16]. However, it has been stated that vertical skeletal changes can vary widely, during treatment or retention, and may not be precisely predictable in growing patients, depending on the skeletal pattern [3]. Studies mostly evaluated the effect of cervical headgear itself [4, 16] or in a heterogeneous sample of patients [4, 6]. It is assumed that insufficient information is available about the effect of the cervical headgear associated to full fixed appliance in nonextraction patients. Furthermore, it is extremely important to assess information about the long-term changes which occur once fixed appliances and headgear are discontinued.

The purpose of this study was to evaluate skeletal and dental changes of Angle class II division 1 patients treated without extractions and with full-fixed orthodontic appliances in combination with a cervical pull headgear, assessing data from a sample treated in the same manner by the same professional and followed up for a mean period of 25 years.

Materials and methods

The present study was performed using a nonprobability sampling method (convenience sample). To collect the sample, an experienced clinician (CJV) actively sought former patients who had been treated from the mid-1970s to the early 1990s with the following initial diagnosis criteria:

- Angle class II division 1 malocclusion with bilateral full class II molar relationship,
- Vertical skeletal pattern within a normal range (FMA = 25° ± 5) [40],
- Active growth potential (children/preadolescents below the peak of pubertal growth and no growth-related diseases),
- No congenital agenesis and
- No craniofacial anomalies or syndromes.

Treatment employed in those patients comprised:

- Nonextraction (excluding third molars),
- Cervical pull headgear (500 g/12 h/day) in combination with a 0.022″ × 0.028″ slot size edgewise standard fixed appliance with no tip or torque in the brackets and
- Absence of class II intermaxillary elastics use.

Regarding the headgear protocol, patients were instructed to wear the device until the right and left molar relationships were fully corrected (key occlusion), even if the full fixed appliance had been initiated. In with to the retention protocol, patients were instructed to use 1-year full time Hawley removable retainer for the upper and lower teeth and an additional 1-year night-only use.

Patient's records should present good quality lateral cephalograms and centric occlusion plaster study casts obtained at pretreatment (T1) and posttreatment (T2). Finally, the additional criteria were also verified for including the patient in the sample:

- Fulfillment of molar key occlusion at T2 (defined by the accurate occlusion of the mesiobuccal cusp of the upper first permanent molar in the groove between the mesial and the middle cusps of the lower first permanent molar) and
- Minimum of 20 years after treatment completion.

From March 2012 to December 2016, a tireless attempt to make contact with patients fulfilling the inclusion criteria was performed. From those who accepted to participate in the study, written informed consent was obtained and a lateral cephalogram was taken at the time of the recall appointment (T3). At this stage, patients could not present any tooth loss or major dental rehabilitations. A set of three cephalograms was thus organized: the initial cephalogram taken before any treatment (T1); posttreatment cephalogram taken within 1–3 months of debonding (T2); and postretention cephalogram taken at the long-term recall (T3; Fig. 1).

Lateral cephalometric radiographs of each phase (T1, T2, and T3) were digitized using a HP Scanjet G4050 series scanner with a flatbed transparent materials adapter (Hewlett-Packard Development Company, L.P., Houston, TX, USA), at 200 dpi and 100% resolution. Using the Dolphin Imaging 11.7 Premium software (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA), a single examiner (SRBS), previously trained, marked the cephalometric points of interest in order to have the cephalogram and the selected angular and linear measures performed automatically. All radiographs had the magnification factor corrected with the aid of the previously mentioned software.

Eight angular and five linear measurements were used to describe sagittal and vertical relationships. Angular variables used were SNA, SNB, ANB, OcclPl-FH, PalPl-FH, GoMe-FH, Y axis and 1-NA°. Linear measurements used were Wits, A-NPerp, Pg-NPerp, 1-NAmm and LAFH. The angular and linear measurements are described in Table 1 and illustrated in Fig. 2.

This longitudinal retrospective study was performed in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and the Ethics Board of the Brazilian Ministry of Health (Resolution CNS/MS 466/2012) for researches involving humans. This project was approved by the independent ethics committee of The Federal University of Bahia Dental School (no. 62558616.5.0000.5024).

Method error

In order to calculate intraobserver error, a set of 30% of patient radiographs, randomly selected by using an online randomization program (https://www.random.org/), were reexamined after 2 weeks, and agreement rates were calculated by the use of kappa statistics. The new data were compared with those of the original collection, and agreement between them was 0.92 to variables SNA, ANB, 1-NA°, 1-NAmm, Wits, OcclPl-FH, and Y axis, and 0.91 to PalPl-FH, which means an almost perfect agreement. For the variables SNB, GoMe-FH, and LAFH, the kappa value was 0.88, for A-NPerp, 0.81, and for Pg-NPerp, 0.89, all of them expressing a substantial agreement. These kappa re-

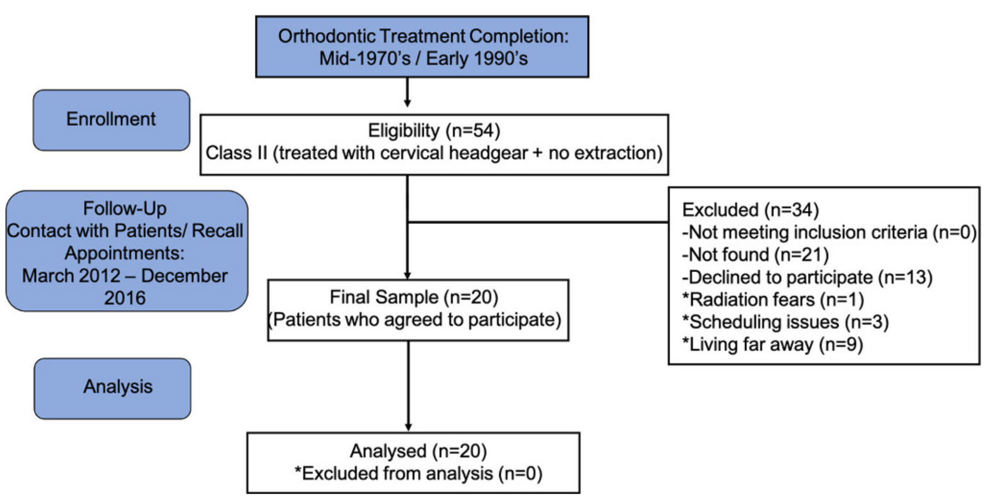

Fig. 1 Flowchart of sample selection and recruitment

Abb. 1 Probenauswahl und Rekrutierung, Flussdiagramm

Table 1 Angular and linear measurements used to describe anteroposterior and vertical relationships
Tab. 1 Winkel- und Streckenmessungen zur Beschreibung anteroposteriorer und vertikaler Beziehungen

Measurements	Description
Angular	
SNA	Angle between SN and NA lines
SNB	Angle between SN and NB lines
ANB	Angle between NA and NB lines
OcclPl-FH	Angle between occlusal and Frankfort horizontal planes
PalPl-FH	Angle between palatal and Frankfort horizontal planes
GoMe-FH	Angle between mandibular and Frankfort horizontal planes
Y Axis	Angle between SGn line and Frankfort horizontal plane
1-NA°	Angle between upper incisor axis and NA line
Linear	
Wits	Distance between perpendicular projections of A and B points onto the occlusal plane
A-NPerp	Distance from point A to a line passing through N, perpendicular to Frankfort horizontal plane
Pg-NPerp	Distance from Pg to a line passing through N, perpendicular to Frankfort horizontal plane
1-NAmm	Distance from the most anterior point of the upper incisor crown to NA line
LAFH	Lower anterior facial height = distance from ANS to Me

sults confirm the reproducibility and reliability of the measurements.

Statistical analysis

The statistical analysis of data was done using the Minitab version 17 software (Minitab Inc., State College, PA, USA). Initially, calculation of central tendencies and variabilities was carried out, and described by means and standard deviation. The Shapiro–Wilk test was used for assessing data distribution. Paired Student's t tests were employed to test for changes in means from T1 to T2, and from T2 to T3. Significance level was set at 5% ($p<0.05$).

Effect size statistics were calculated for changes occurring during active treatment and over the long-term posttreatment: an effect size of 0.2–0.5 indicates a significant change of small clinically relevant magnitude, 0.5–0.8 of moderate clinically relevant magnitude and values greater than 0.8 of large clinically relevant magnitude [11].

Results

The search revealed 54 orthodontic cases meeting the inclusion criteria. Thirty-four patients could not be found or refused to participate. Those who did not accept, reported living too far away, had scheduling conflicts, expressed radiation fears or simply refused to participate for unspecified reasons. Twenty patients agreed to attend the recall appointment and agreed to take part in the present research (14 females and 6 males).

The mean period of headgear use was 2 years/1 month and the average period of fixed appliance wear was 3 years/3 months. Total treatment average time was 4 years/4 months. Table 2 shows the overall and individual characterization of the patients included in the study by gender and age at the three times of examination and the total follow-up period. The mean ages at the evaluated times of examination were 11 years/9 months (T1), 16 years/4 months (T2), 43 years/3 months (T3). The overall long-term mean observation period at the recall appointment was 25 years.

Table 3 shows the mean angular and linear measurements of the 20 patients included in the study in the three phases evaluated. From T1 to T2, the measures of SNA, SNB, OcclPl-FH, PalPl-FH, GoMe-FH, 1-NA°, Y axis, A-NPerp, Pg-NPerp and 1-NAmm have changed with no statistically significant differences.

However, a statistically significant decrease of ANB (4.70 to 2.48), WITS (3.42 to 0.98) and a significant increase of LAFH (62.02 to 67.39) from T1 to T2 was observed. Regarding the long-term posttreatment changes, the ANB reduced a little bit further from T2 to T3 (2.48 to 2.34), but this change was not statistically significant. The Wits measurements revealed a raise from T2 to T3 (0.98 to 1.25), while the LAFH decreased (67.39 to 64.40). Both changes were not statistically significant.

The effect size calculations revealed that the changes of the ANB ($d=1.35$), Wits ($d=1.07$) and LAFH ($d=0.97$) that occurred from T1 to T2 were judged to be of large clinically relevant magnitude ($d>0.8$). From T2 to T3, all the measured changes showed d values of small clinically relevant magnitude ($d<0.5$).

Discussion

This longitudinal investigation was undertaken to verify if skeletal and dental changes occurring during treatment of Angle class II division 1 patients are stable after a long-term period postretention. The results showed that during active treatment (T1–T2) a significant reduction of the mean ANB angle from 4.70 to 2.48° and of the mean Wits value from 3.42 to 0.98 mm could be observed, expressing that both measurements for sagittal skeletal relationship achieved values within the normal range in the course of this time period. In addition, there was a significant increase in LAFH, probably due to normal facial growth. This change happened without rotation of the mandibular plane,

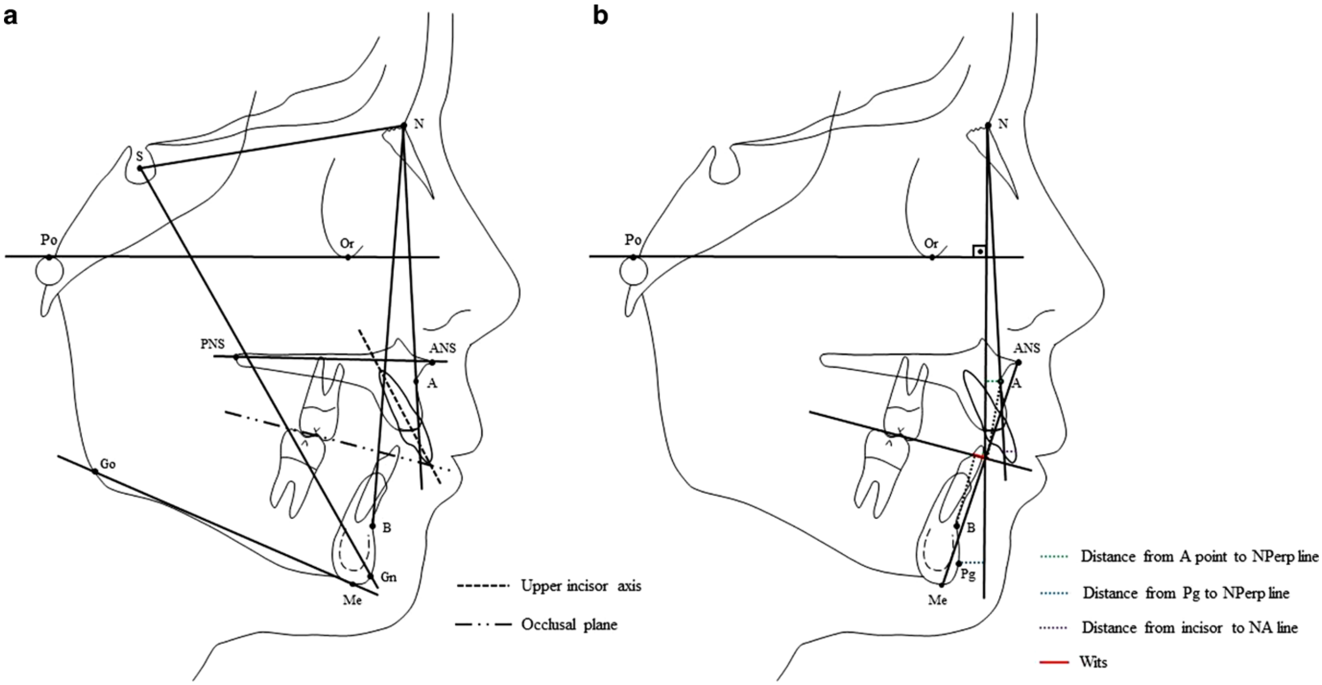

Fig. 2 Points, lines and planes used to determine **a** angular and **b** linear cephalometric measurements

Abb. 2 Punkte, Linien und Ebenen zur Bestimmung von kephalometrischen **a** Winkel- und **b** Streckenmessungen

since the measures for GoMe-FH and for the Y axis remained unchanged. These favorable results obtained with conventional orthodontic treatment assisted by a cervical headgear were very stable, even after a mean of 25 years postretention.

Orthopedic cervical headgear treatment has been reported to be a suitable method to manage Angle class II division 1 malocclusions [25, 27, 29, 44]. However, even after more than 70 years after the first report of using this device [26], a lack of evidence exists regarding the skeletal and dental changes achieved, especially in the long-term [32]. In respect to the promoted sagittal changes, the clearest consensus concerns an inhibitory effect on maxillary anterior growth [18, 36, 39]. In our study, the SNA angle and A-NPerp measure remained unchanged during active treatment and also after the long-term evaluation. Other authors reported a slight reduction in SNA angle, suggesting a backward movement of the maxilla [15, 25, 27, 29, 30, 37]. The consequence of this appliance on mandibular development is less clear, with the majority of studies suggesting no effect [15, 37] and some of them stating increased forward growth of the mandible to some extent during treatment [23, 25, 36]. In this investigation, mean SNB angle and Pg-NPerp value presented a slight increase during treatment, which was not statistically significant, remaining unchanged after 25 years of follow-up. This slight increase of the SNB angle, in conjunction with a subtle decrease of the SNA angle, probably explains the reduction of the ANB angle and Wits measurement. This reduction was also verified by other authors [3, 8, 10, 15, 25, 28, 29, 36, 37] demonstrating that the therapy assists in improving the skeletal sagittal relationship.

The outer face bow of the headgear should be bent upwards relative to the horizontal plane to prevent excessive tipping and extrusion of the first molars [26]. Using this protocol, an excellent control over the occlusal, palatal, and mandibular planes may be achieved with little, if any, adverse effect on the vertical dimension. In our research, OcclPl-FH, PalPl-FH, GoMe-FH, and Y axis angles were unchanged at the end of orthodontic treatment, suggesting a good vertical control associated with growth within the normal range in all patients, and remained unchanged after the long-term follow-up period. Similar results were reported in previous publications [15, 17, 25, 27, 28, 33, 37]. Other authors, however, using the same protocol, verified an anterior downward tipping of the palatal plane [27]. Studies also have shown that cervical traction might be effective in redirecting maxillary growth inferiorly [4, 34]. This fact, in conjunction with the regular facial growth, could be the reason for the significant increase in lower anterior facial height observed in this study, with an increase in LAFH measurement from 62.02 to 67.39 mm at the mean during treatment. This increase also remained stable after long-term evaluation.

The performed orthodontic treatment did not have a marked effect on the inclination and position of the upper incisors, since the 1-NA angle and 1-NA linear measurements showed no significant changes during treatment

Table 2 Patient characterization by gender and age at pretreatment (T1), posttreatment (T2), and postretention (T3) phases, and the follow-up period after the end of orthodontic treatment (T3–T2)
Tab. 2 Patientencharakterisierung anhand von Geschlecht und Alter vor der Behandlung (T1) und danach (T2) sowie in der Nachretentionsphase (T3) und in der Follow-up-Zeit nach Ende der kieferorthopädischen Behandlung (T3–T2)

Patient	Gender	Age			Follow-up
		T1	T2	T3	T3–T2
1	F	11 y 8 m	15 y 2 m	41 y 5 m	26 y 3 m
2	F	10 y 11 m	14 y 7 m	36 y 8 m	22 y 1 m
3	M	12 y	20 y	52 y 3 m	32 y 3 m
4	F	11 y 6 m	16 y 7 m	44 y 6 m	27 y 11 m
5	F	10 y 8 m	15 y 3 m	35 y 7 m	20 y 4 m
6	F	13 y 2 m	18 y 1 m	46 y	27 y 11 m
7	M	11 y 5 m	17 y 9 m	42 y 6 m	24 y 9 m
8	F	12 y 1 m	17 y 2 m	54 y 5 m	37 y 3 m
9	F	11 y 1 m	15 y 9 m	39 y 5 m	23 y 8 m
10	F	12 y 9 m	17 y 4 m	46 y 2 m	28 y 1 m
11	F	10 y	14 y 4 m	44 y 4 m	30 y
12	F	11 y	14 y 1 m	41 y 1 m	27 y
13	F	12 y 1 m	15 y	41 y 1 m	29 y 1 m
14	M	10 y	16 y 1 m	39 y 2 m	22 y 6 m
15	F	14 y 6 m	16 y 1 m	40 y 1 m	24 y
16	M	12 y 11 m	17 y 6 m	40 y	22 y 6 m
17	F	10 y 3 m	16 y 1 m	45 y 4 m	29 y 3 m
18	F	13 y 2 m	14 y 7 m	52 y 5 m	37 y 8 m
19	M	14 y 7 m	18 y 7 m	39 y 2 m	20 y 5 m
20	M	13 y 5 m	16 y 7 m	43 y 7 m	27 y
Overall (mean)		11 y 9 m	16 y 4 m	43 y 3 m	25 y

F female, *M* male. Follow-up period: *y* years and *m* months

and also remained unchanged at the follow-up evaluation. It is therefore suggested that correction of the overjet, present in our patients with Angle class II division 1 malocclusion, was a result of changes in maxillary and mandibular growth rather than changes in incisors inclination. This absence of significant changes related to the upper incisors may be partially explained by the relatively good pretreatment angular and linear position in our patients. A greater protrusion and anterior inclination of the upper incisors is a characteristic of class II division 1 malocclusion which was not verified in our group of patients. Similar findings have been reported in other studies [18, 25, 28]. On the other hand, some authors have found an increase in the anterior inclination of both the upper and lower incisors after headgear use [19, 29], probably because they adjusted the bow to be at least 2 mm in front of the incisors, preventing the lip from exerting pressure on the teeth. Finally, it was also reported an uprighting of the maxillary incisors, with posttreatment inclination similar to cephalometric norms [15, 31].

The present sample was composed of 20 patients at a mean age of 11.9 years, similar to most of the researched literature, which investigated patients with average ages between 10.1 and 13.2 years [8, 27, 28, 30, 35]. This age range is quite favorable for the application of extraoral forces, and this may explain the good results obtained at the end of treatment. Another aspect that should be highlighted is the long follow-up period, greater than 20 years for all cases, and an average of 25 years. The majority of articles that address the stability of class II division 1 treatment presented a much lower mean follow-up ranging from 2 to 14 years [3, 10, 14, 15, 18, 27, 37].

Advantages and disadvantages are expected for any kind of treatment. Headgear therapy has proved to effectively assist in managing class II malocclusion in growing patients [43]. Classical and more recent research has demonstrated both dentoalveolar and skeletal effects induced by the use of extraoral forces applied to the maxillary bone [21, 24, 42, 43]. Headgear is a very versatile device, permitting a varied sort of adjustments to fit to the specific morphological and growth pattern of the patient. Additionally, the appliance does not represent a high cost for treatment and is not considered difficult to be installed by the orthodontist and/or worn by the patient [2]. However, success of the therapy is highly dependent on patient compliance [12]. In addition, there is an increasing concern of children and parents regarding social and psychological aspects and many orthodontists have tried more esthetic/discrete options or

Table 3 Mean angular and linear measurements of patients at pretreatment (T1), posttreatment (T2), and postretention (T3) phases
Tab. 3 Mittlere Winkel- und Streckenmessungen in den Phasen vor (T1) und nach der Behandlung (T2) sowie nach der Retention (T3)

Measurement	T1		T2		*p*-value[a]		T3		*p*-value[b]	
	Mean	SD	Mean	SD		*d*[c]	Mean	SD		*d*[d]
SNA	82.45	3.29	81.51	3.99	0.421	0.28	81.47	3.45	0.973	0.01
SNB	77.76	3.27	79.03	3.75	0.261	0.38	79.13	3.68	0.933	0.02
ANB	4.70	1.64	2.48	2.03	0.001	1.35	2.34	1.96	0.825	0.06
OcclPl-FH	3.95	2.77	3.49	3.42	0.643	0.16	3.07	3.76	0.714	0.12
PalPl-FH	–3.82	4.04	–3.21	3.91	0.628	0.15	–3.93	3.86	0.559	0.18
GoMe-FH	23.60	3.69	23.40	4.19	0.870	0.05	22.73	4.43	0.626	0.15
Y axis	56.38	2.55	56.49	3.50	0.906	0.04	56.59	3.53	0.932	0.02
1-NA°	29.08	7.74	28.57	5.34	0.810	0.06	26.51	5.90	0.254	0.38
Wits	3.42	2.28	0.98	2.33	0.002	1.07	1.25	2.66	0.730	0.11
A-NPerp	2.51	2.78	1.54	3.67	0.355	0.34	1.17	3.04	0.727	0.1
Pg-NPerp	–1.97	5.13	0.49	6.35	0.187	0.47	0.48	5.72	0.996	0
1-NAmm	6.44	2.78	5.76	2.50	0.421	0.24	5.69	2.16	0.920	0.02
LAFH	62.02	5.53	67.39	6.75	0.009	0.97	64.40	8.21	0.217	0.44

SD standard deviation
[a]*p*-value between T1 and T2 phases, [b]*p*-value between T2 and T3 phases, [c]*d* = (T1–T2) effect size, [d]*d* = (T2–T3) effect size

noncompliance approaches [2, 9]. A relatively recent publication confirmed a decline in the use of the headgear in the USA and Canada; even so, the findings showed that 62% of the interviewed orthodontists were still using this kind of therapy. The relevant reason for their decision was the emphasis on headgear use during their residency [38]. In this context, it is hoped that the present research may encourage orthodontists to continue to use headgear therapy, since additionally to the good outcomes, the therapy has proved to be stable according to our findings.

Limitations of the present study are important to be highlighted. The research is retrospective/longitudinal and might introduce selection bias, such as the difficulty of carrying out comprehensive analyses in order to identify possible sociodemographic, environmental or genetic factors that could confound the evaluation. To minimize this problem, an extensive search for patients who met the inclusion criteria was performed. Although a considerable number were found, only 20 patients accepted to join the study. The bias and the power presented by nonprobability samples are usually not possible to be measured; however, convenience in some retrospective long-term researches in health sciences are justified by the ease of research, ready availability and cost effectiveness. Other limitation is the lack of untreated class II malocclusion control patients with similar ethnic background. Although untreated class II control collections are available for use, the authors of the present study assumed that a proper comparison would not be possible. Finally, it is worth noting that the assessed sample did not comprise severe class II patients with vertical growth within the normal range (justifying the use of cervical pull). Transmission of the results to patients displaying distinct occlusal and growth patterns should be made with caution. Detailed occlusal aspects of the sample have also been evaluated and will be shared in a distinct work due to organizational and size issues.

Conclusion

The presented results suggest a tendency for stability of cephalometric measurements of Angle class II division 1 patients treated with cervical pull headgear combined with conventional fixed appliances, even after a long-term follow-up of 25 years postretention. All analyzed angular and linear variables remained practically unchanged when comparing the posttreatment (T2) and postretention (T3) time points. Significant posttreatment changes due to growth and/or aging were not observed in the assessed sample. This observation may lead to the speculation that Angle class II division 1 growing patients with normal vertical relationship hold good qualification for a good treatment outcome and long-term stability after cervical headgear treatment.

Compliance with ethical guidelines

Conflict of interest S. R. Braga Santos, T. Martins de Araújo, C. J. Vogel, M. Bastos de Oliveira, M. A. Vieira Bittencourt and E. Braga declare that they have no competing interests.

Ethical standards This longitudinal retrospective study was performed in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and the Ethics Board of the Brazilian Ministry of Health (Resolution CNS/MS 466/2012) for researches involving humans. This project was approved by the independent ethics committee of The Federal University of Bahia Dental School (no.

62558616.5.0000.5024). From those who accepted to participate in the study, written informed consent was obtained.

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